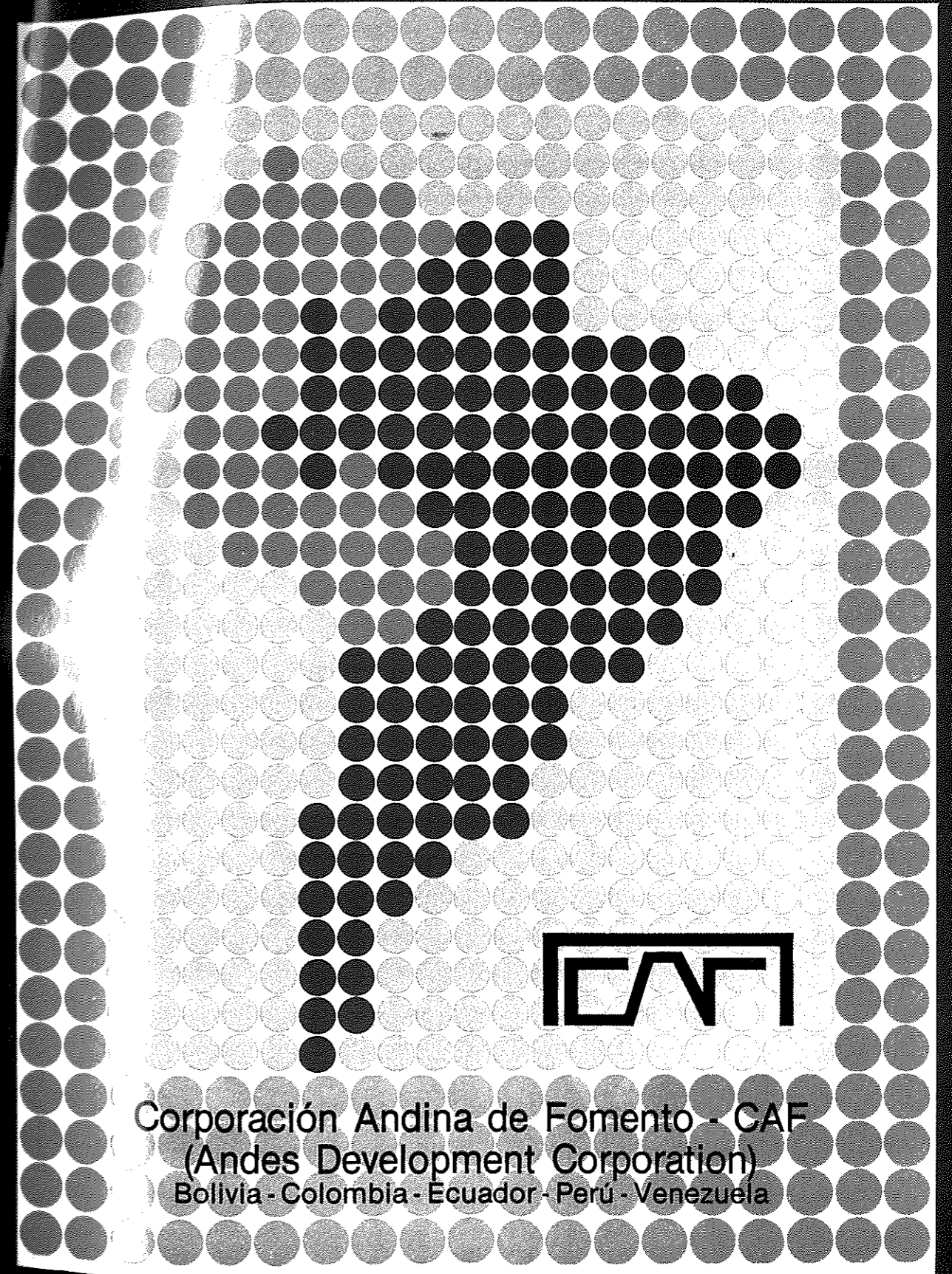


Energy Projects for the Integration of the Andes Region

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Corporación Andina de Fomento - CAF
(Andes Development Corporation)
Bolivia - Colombia - Ecuador - Perú - Venezuela

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Santafe de Bogotá, December 1993

PRESENTATION

In 1992, during my first year as Executive President of the Corporación Andina de Fomento, I ordered the execution of an Action Plan for the participation of CAF in Physical Infrastructure Projects and Frontier Integration.

The development of this plan included, on its first stage, the identification and compilation of physical integration projects in the areas of energy and roads as we considered this to be the first step to define, in the short term, the necessary mechanisms to accelerate the integration in these fields.

The result of this work, carried out by highly qualified consultants from the five Andean countries, is contained in two books: one of them, about road projects, published in January of this year; and the other one, which is in your hands, that includes 44 projects of the energy sector, especially in the electricity, oil and gas areas.

I am very proud to present this edition as it is the first step to a more transcendental one: to make real most of the projects contained herein.

The subregion, thanks to the richness of its natural resources, offers an enormous potential for energy development that has a continuous growing demand.

In all countries, important efforts are being made to increase the energy supply by means of the proper selection of sources and the improvement of efficiency levels.

However, it is necessary to work under the concept of a team in order to avoid scattered efforts. The energy interconnection will allow to take care of the needs of a new productive apparatus in a more efficient way and to improve people's standards of living under conditions that are compatible with the environment.

Most of these projects require high investments, for which it is convenient to make a careful selection of them. It is the responsibility of the Ministers

of Energy of the Andean area to make the necessary analysis to establish priorities, financial feasibility and technological implementation.

Afterwards, CAF will evaluate the situation of each project and will provide the necessary support for the financial negotiations before the international credit institutions.

In this way, we have initiated an aggressive stage for the promotion and development of the financing of the physical integration of the subregion, making CAF the fundamental support of this integration and providing a real basis to contribute, in vital areas, to the social and economic development of the member countries.

L. Enrique García R., *Executive President of Corporación Andina de Fomento.*



Mr. L. Enrique García R., Executive President of the Andes Development Corporation, CAF.

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INTRODUCTION

GUILLERMO VEGA ALVEAR

Guillermo Vega Alvear: Civil Engineer from the Universidad Nacional de Ingeniería, Perú. Graduate Degrees from the Centro Panamericano de Evaluación de Recursos Naturales (Brazil), the Politécnico de Milán (Italia) and Programa de Alta Dirección de Empresas (PAD-IESE).

- Entrepreneur and Businessman in the Construction Sector in several countries in Latin America.
- Awarded with the FIIC Medal, the highest honor from the Federación Interamericana de la Industria de la Construcción, due to his contribution to the development of the construction in Latin America.

THE ANDEAN SUBREGION AS AN ECONOMIC REALITY

At the beginning of the 90s, five Latin American countries: Bolivia, Colombia, Ecuador, Perú and Venezuela committed themselves in an integration process the main point of which is the Cartagena Agreement.

These five countries of the Andean Subregion cover among themselves an area of 4 million 718 thousand square kilometers and have a population of almost 94 million inhabitants. It is a very young population, as half of them are 20 years old or less, and only 3.8% of the total population is over 65.

The five countries are interconnected by an incipient network of roads, the integration and development projections of which have been described in the book "Proyectos Viales de Integración Andina", recently edited by the CAF.

Due to the lack of a sufficient network of roads operationally efficient, the commercial trade in the subregion is low (1.800 million dollars in 1991 versus 29.464 million dollars exported by the Subregion to the rest of the world in that year).

The energy integration in its different ways, that is, the electrical interconnection and the oil and gas interconnection, is incipient, and among some countries it does not even exist.

Likewise, each country has made an individual effort in the exploitation of its energy resources, doubling in many cases the logistic expenses in the exploration-exploitation of resources located in the borderline areas.

The purpose of this book is to provide a global view of the interconnection possibilities of the different energy resources among the five countries of the Andean Subregion, and compiles in this effort the initiative and work of many professionals during many years.

POPULATION DENSITY OF ANDEAN GROUP COUNTRIES

Countries	Inhabitants	(km ²)	Inh/(km ²)
BOLIVIA	7.314.000	1.098.581	6.6
COLOMBIA	32.978.000	1.141.748	28.9
ECUADOR	10.782.000	275.830	39.1
PERU	22.332.000	1.285.215	17.4
VENEZUELA	19.735.000	916.445	21.5
GRAN NATIONS	93.141.000	4.717.819	19.7

REGISTERED FOREIGN INVESTMENT

(Millions of dollars)

Countries	1986	1987	1988	1989	1990	1991	1992*
BOLIVIA	597	598	605	606	608	—	—
COLOMBIA	2.672	2.992	3.011	3.270	3.500	3.602	3.852
ECUADOR	1.371	1.440	1.487	1.544	1.600	1.643	—
PERU	1.165	1.190	1.190	1.198	1.286	1.301	1.302 ¹
VENEZUELA	1.950	2.143	2.516	3.086	3.578	3.749	4.244 ²
GRAN NATIONS	7.755	8.363	8.809	9.704	10.572	—	—

1/ To May of 1992

2/ To August of 1992

NET INTERNATIONAL RESERVES - CENTRAL BANK

(Millions of dollars)

Countries	1987	1988	1989	1990	1991	1992*
BOLIVIA	168	161	19	132	193	227
COLOMBIA	3.540	3.794	3.867	4.501	5.420	7.768
ECUADOR	—151	—176	203	603	760	782
PERU	43	—352	357	531	1.304	2.001
VENEZUELA	9.376	8.771	7.411	11.642	14.105	12.728
GRAN NATIONS	12.976	10.198	11.857	17.409	22.782	23.506

* Preliminary figures

Information: JUNAC, Systems Unit

FOREIGN DEBT

(Millions of dollars)

Countries	1990	1991*	1992*
BOLIVIA ¹	4.200	4.028	3.900
COLOMBIA	17.556	16.975	16.779
ECUADOR	11.856	12.270	12.133
PERU	19.762	20.735	21.333
VENEZUELA	31.000	33.000	31.000
GRAN NATIONS	84.374	87.008	85.145

1/ The total Bolivian external debt is estimated.

FOB EXPORTS TO THE WORLD

(Millions of dollars)

Countries	1986	1987	1988	1989	1990	1991*	1992*
BOLIVIA	640	570	597	819	923	851	766
COLOMBIA	5.108	5.024	5.026	5.739	6.765	7.244	7.052
ECUADOR	2.186	1.928	2.193	2.354	2.714	2.851	3.008
PERU	2.359	2.477	2.646	3.438	3.313	3.329	3.484
VENEZUELA	8.664	10.539	9.958	12.914	17.692	15.219	14.073
GRAN NATIONS	18.957	20.538	20.420	25.264	31.407	29.484	28.383

INTERSUBREGIONAL FOB EXPORTS

(Millions of dollars)

Countries	1986	1987	1988	1989	1990	1991*	1992*
BOLIVIA	24	31	28	50	60	82	100
COLOMBIA	281	405	358	309	373	778	1.014
ECUADOR	43	125	177	183	188	204	174
PERU	146	157	188	198	214	269	270
VENEZUELA	161	215	221	300	494	479	825
GRAN NATIONS	655	933	972	1.038	1.329	1.812	2.184



Head Office of the Corporación Andina de Fomento - CAF, Caracas, Venezuela

CAF AND THE ANDEAN INTEGRATION

The Corporación Andina de Fomento (CAF) was created as the financial organ of the Andean integration; today it has a broader command and has the functions of a Development Bank, Foreign Trade Bank, Investment Bank and Promotion Agency.

As a Development Bank, CAF grants medium and long-term credits for the execution of qualified projects by its priority and merits. The operations of the Corporation are made both with the public and private sectors of the membership countries.

As a Foreign Trade Bank, CAF finances the non traditional exports of the membership countries among themselves or towards third party markets, through the Sistema Andino de Financiamiento del Comercio (SAFICO) (Andean System for Commerce Financing). Through the Mecanismo de Confirmación de Cartas de Crédito (MECOFIN) (Letters of Credit Confirmation Mechanism) it facilitates the imports of goods, services or necessary materials necessary for the subregional industrial development.

As an Investment Bank, CAF may participate in the equity of high level integrational projects. The contribution, in these cases, is seed equity, the principal function of which is to consolidate new corporations. Once this purpose is met, the equity of CAF is removed in order to use it again with this same purposes in new projects.

As a Promotion Agency, CAF plans studies oriented to the identification of investment opportunities with results that are communicated among countries; supplies technical and financial assistance for the preparation and execution of multinational or complementary projects; promotes capital investments and technology; and promotes the organization, expansion or conversion of enterprises. CAF stimulates the participation of the private sector in the creation of andean multinational companies and in the revival of the intersubregional trade.

The Corporación Andina de Fomento has now started, combining several of the functions that it has been performing, an aggressive stage of promotion and financing activity in the physical integration of the subregion.

Likewise, it will constitute the fundamental support of the physical integration, and will provide the real bases to obtain the political and economical integration of the subregion.

CAF ACTION PLAN

The President of the Corporación Andina de Fomento, Dr. L. Enrique García R., shortly after assuming his position, established the implementation of an Action Plan for the Participation of CAF in the Frontier Integration and Physical Infrastructure Projects that includes, in its first stage, the identification and collection of the physical integration projects and the road and energy sectors, and especially in the later, in the areas of electricity, oil and gas.

An excellent team of high level Consultants has carried out the collection and evaluation of these projects, and as a complement, these projects have been compared against the sectorial emergency plans of the five countries, and for their compatibility, we have relied on the Organización Latinoamericana de Energía (OLADE) (Latin America Energy Organization), at CAF's request.

ELECTRICITY

Each one of the five countries has resolved, separately and according to its own sectorial programs, the construction of its generation and transmission infrastructure in the electric sector.

This conception brings, as a consequence, two special situations if you want to see the Andean Group as a whole. The first one, that there is a disproportion between the installed capacity and the real demand among the different countries, which makes it possible to solve the problem through global interconnection. But the second situation is as the transmission networks were designed, with a national criteria in each country, it is necessary, in certain cases, to redesign the present national networks, to allow the necessary interconnection in the frontier areas in the size that the real demand so requires.

Looking at the figures shown in the Venezuela report, we will see that the total installed capacity is 18.500 MW, whereas the maximum present demand is 9.000 MW.

projected for 9.000 additional MW, that is that there will always be between 5.000 and 10.000 MW of excess installed capacity in the system.

In the case of Colombia, the electricity rationing was due mainly to a deficit of 800 MW in the capacity of thermic generation, which they are presently trying to correct.

Ecuador needs to solve a thermic generation problem of about 350 MW to avoid the electricity rationing in critical periods, and North Peru would solve its problem with 100 additional MW. If we add up the total required by North Peru, Ecuador and Colombia, it would come up to only 1.250 MW, a much smaller figure than the excess of installed capacity in Venezuela, and for this reason, the interconnection programs proposed would widely solve the electricity rationing.

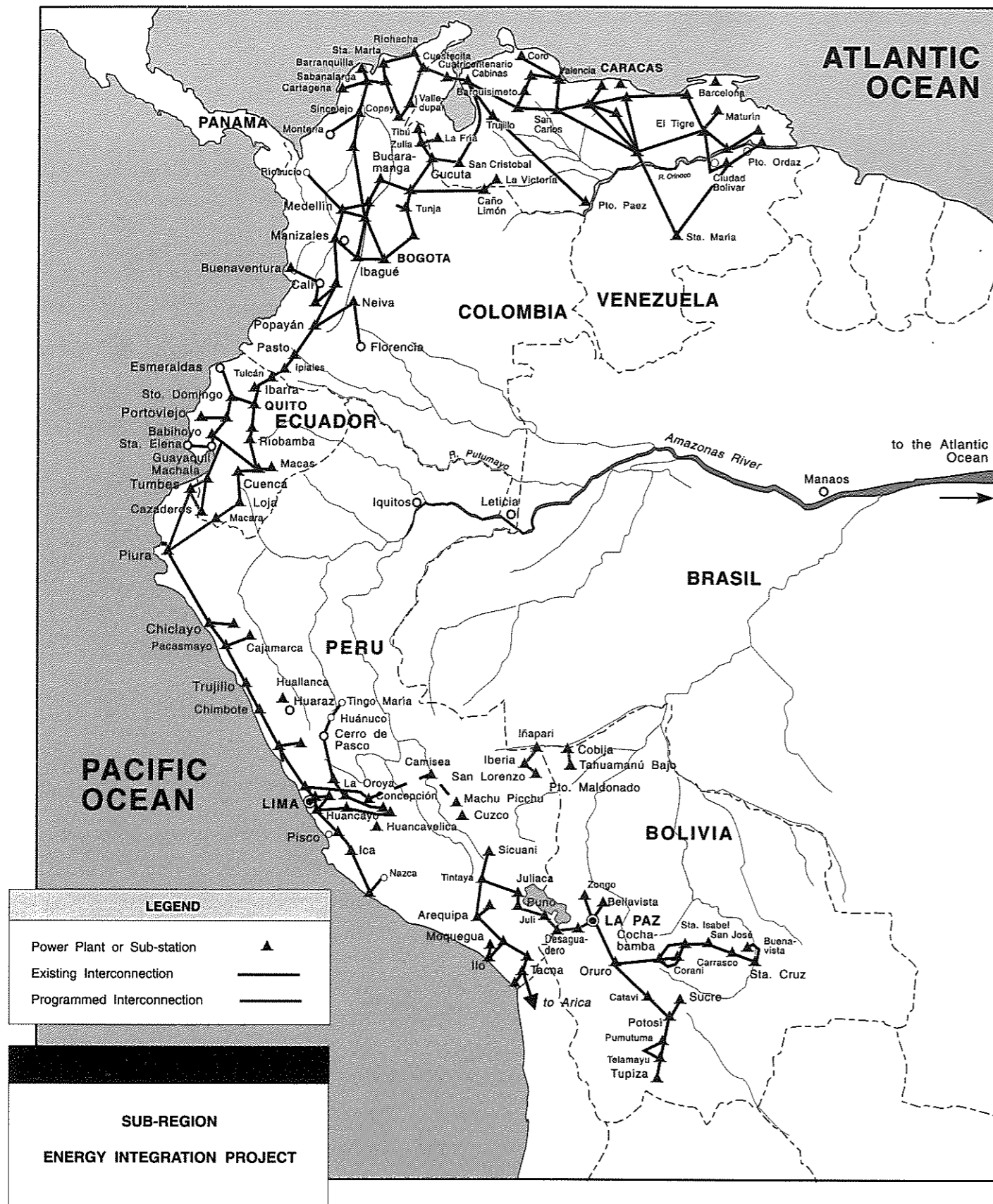
The deficit in South Peru may be covered by any of the three alternatives that are being proposed, either by using gas from Bolivia, supplied via Desaguadero or Arica, or an interconnection of electrical networks making the corresponding cycle corrections.

These thoughts lead us to the certainty that the electrical interconnection of the Andean Group Countries is now an indispensable necessity.

ELECTRICAL INTERCONNECTION "MASTER PLAN"

In this sense, we suggest the elaboration of an Electrical Interconnection Master Plan among the five countries, that considers the analysis of the following subjects:

1. Preferred interconnection areas.
2. Required improvements in the present internal networks of each country, to make possible the proposed interconnections and an estimate of the necessary investments.
3. Analysis of the present status of the electrical infrastructure in each country.
4. Establishment of a sequence for the development of these interconnection program.



OIL

In the oil and liquid hydrocarbons field, up to the moment, only national exploitation and exploration programs exist, and there are no concrete programs known for joint works in the frontier areas that, nevertheless, should be promoted.

There are three areas in which we have found possibilities of integration and that are of great importance.

The first one refers to the unification of efforts for logistic effects in order to optimize the costs and the results of the oil exploitation and exploration operations in the frontier areas.

The second one is the possibility of interconnecting pipelines to optimize its use. This is a typical case between the transecuatorial and Colombian pipeline, and it will be very important to consider the same possibility for the exploitation of the southern and eastern Ecuatorial fields which are closer to the north Peru pipeline which is not being fully used.

The third area of liquid hydrocarbons colaboration refers to long term purchase programs. This means to establish financial mechanisms that would help to establish long term liquid hydrocarbons purchase programs, making the operations with third party countries in order not to involve the trade balance between the purchasing and selling countries.

A typical case of this situation is the sales of liquid hydrocarbons to Colombia by Venezuela. A third party country that needs Colombian products (there are several countries interested in Asia) may guarantee the payment of the Venezuelan liquid hydrocarbons triangulating the operation, thus allowing a safe supply without affecting the trade balance between the two countries. Multilateral Banks may support the transaccion guaranteeing the operations.

With the same criteria, the sales of crude that are made by Ecuador and Colombia to Peru, could be analyzed.

COAL

Coal is a natural resource that has been barely exploited in the Subregion. Venezuela and specially Colombia have the major development programs and in some cases in frontier areas. A cooperation program could also be established there, which will allow the identification of the efforts that both countries could make to optimize the cost and the results of the coal exploitation and exploration operations in the frontier areas in both countries.

It is important to initiate a research and development policy of the coal potential in the Subregion, which should have a much greater participation in energy generation in the Andean countries.

It should be kept in mind that 56% of the commercial energy generated in the United States is produced from coal, and in the Andean Subregion the participation of coal in energy generation is almost none.

GAS

The recent findings of gas in Colombia, in the Cusiana field, make the interconnection of the gas pipes from Colombia and Venezuela almost unnecessary to optimize its exploitation, as in both cases they represent huge reserves.

- 10 The most outstanding case which needs to be reconsidered before the most recent information and events, is the exploitation of the Camisea fields in Peru.

According to the latest information, the requirements of the industrial market in Sao Paulo for the year 2005 will be 80 million m³/day of new supply. The gas sales agreement that Bolivia has signed with Brazil will allow sales that in the best case will be able to supply 30 million m³/day, and the possibility of supply from North Argentina may come up to a supply to Brazil of 20 million m³/day.

This shows that Brazil will have an uncovered demand of about 30 million m³/day in a short term.

For this reason, it should be seriously evaluated the possibility of interconnecting Camisea in Peru with a gas pipeline that without touching the mountains would take the gas directly to the Santa Cruz (Bolivia) area, to complete the supply that Brazil may require.

These new circumstances justify the new vision regarding how the initial exploitation of the Camisea field should be seen.

An expected export of these size towards a stable market, makes it feasible not only to develop the fields but besides, it also allows to consider again the supply of natural gas to other areas of the Peruvian coast as production with marginal costs.

In the meantime, Bolivia and Chile have recently come to an agreement on the sale of Bolivian gas to Northern Chile. This gas interconnection should be evaluated considering the possibility of extending the gas pipeline from Arica to Ilo, a new important development center in Southern Peru which represents today a potential market of electrical energy of 150 MW for its mining development, with bigger projections for the development of the Peru-Bolivia Industrial Free Zone.

Both in the case of electrical and gas interconnections, it is important to establish and standardize fair polynomial formulas for the sales price, that will facilitate these negotiations, which will be more frequent in the future.

OTHER ENERGY SOURCES

Considering the other energy sources, for example geothermic energy, bioenergy, solar energy and eolic energy, its use in the different Andean Group Countries is still very little and probably the one that has the highest exploitation potential and that could contribute with its resources to reinforce the interconnection program is the geothermic energy.

Therefore, we suggest that a research program that helps verify the probable reserves of geothermic energy, in the areas where this natural resource has been found, be started.

IDENTIFIED PROJECTS

CAF Consultant's team has identified 44 projects from the energy sector with an integration impact among the five Andean Group countries.

This book presents all the projects selected to show the options that exist for the energy integration of the Subregion.

In successive meetings of the Ministers of Energy from the frontier countries, an analysis procedure of all these projects will be established to determine their priority, so that in the next meeting of Latin American Ministers of Energy, the Ministers of the Andean Group present the list of projects that are considered to have more priority, and the financing of which will be requested.

An important factor that will be taken into consideration at the moment of selecting the most convenient financing, is the possible participation of the private sector in the investment and management of some of the projects. The privatization of the infrastructure is strongly taking place in several countries and there are multilateral credit organizations that are considering new financing alternatives, for example, B.O.T. (Bill Operate and Transfer).

OLADE VISION

We would like end this book with a summary prepared by the Organización Latinoamericana de Energía (OLADE) regarding the perspectives and projections of the energy sector in the countries of the Andean Subregion.

BOLIVIA

Integration energy projects

JORGE O'CONNOR D'ARLACH

Jorge O'Connor D'Arlach: Mechanical Engineer - Bolivia.

- Graduate Degree from the Confederation of British Industries en "Hydroelectrical Central Stations", in the Center for Advanced Engineering Study, Massachusetts Institute of Technology, Cambridge, Massachusetts, U.S.A.

- He has been the General Manager of Bolivia's National Electricity Company, Minister of Hydrocarbons and Energy and Bolivia's Ambassador in Brazil.

1. BOLIVIA'S ENERGY SECTOR

Bolivia's energy sector is based on hydrocarbons, electric energy and non conventional energies. As with other sectors, like Transportation and Communications, it is developing under an integrationist point of view, especially in the gas sector with its present exports to Argentina, proximate integration with Brazil resulting from the recent Agreements signed, and the negotiations within the scope of the Economic Complementation Agreement with Chile.

The top priority of the hidrocarbons policy of Bolivia is to incorporate oil and condensed reserves to increase the production of liquids, that due to the characteristics of the fields, requires to diversify and amplify the local and external markets of natural gas.

In the case of the electric subsector, the main objective is to supply electricity to the highest number of

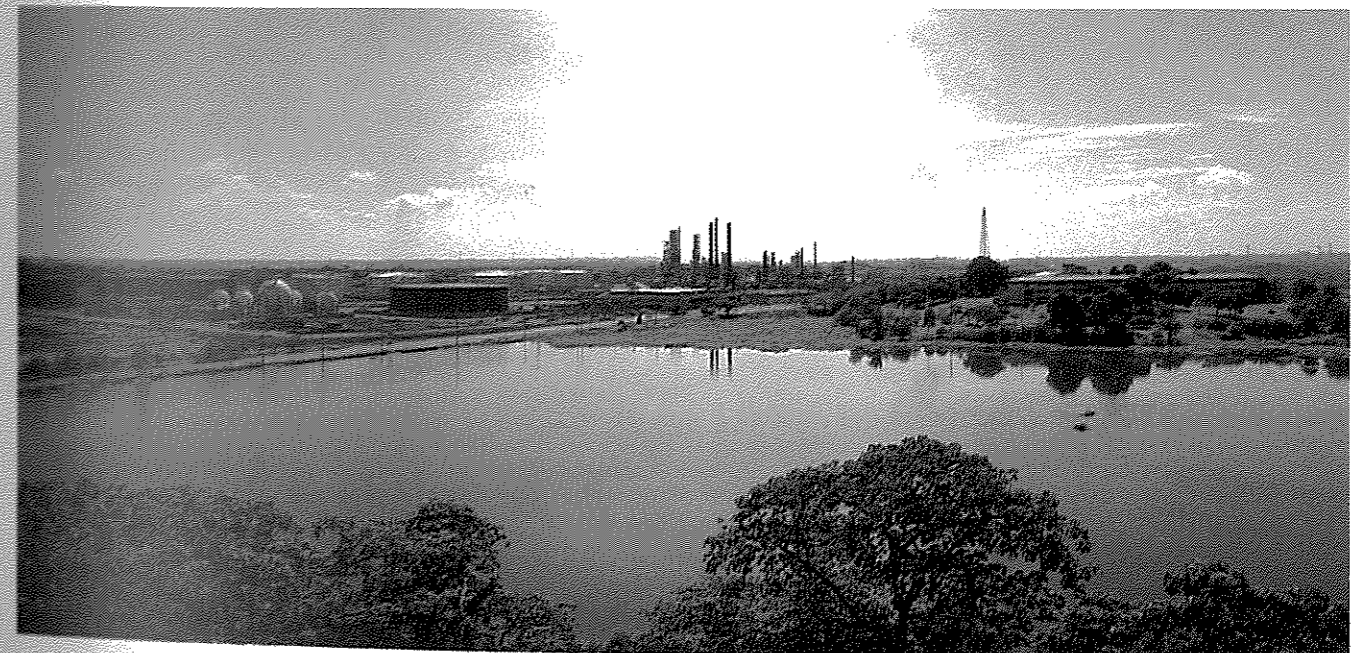
users in a sufficient, trustworthy, opportune way and at the lowest cost possible, without affecting the financial wealth of the companies of the sector.

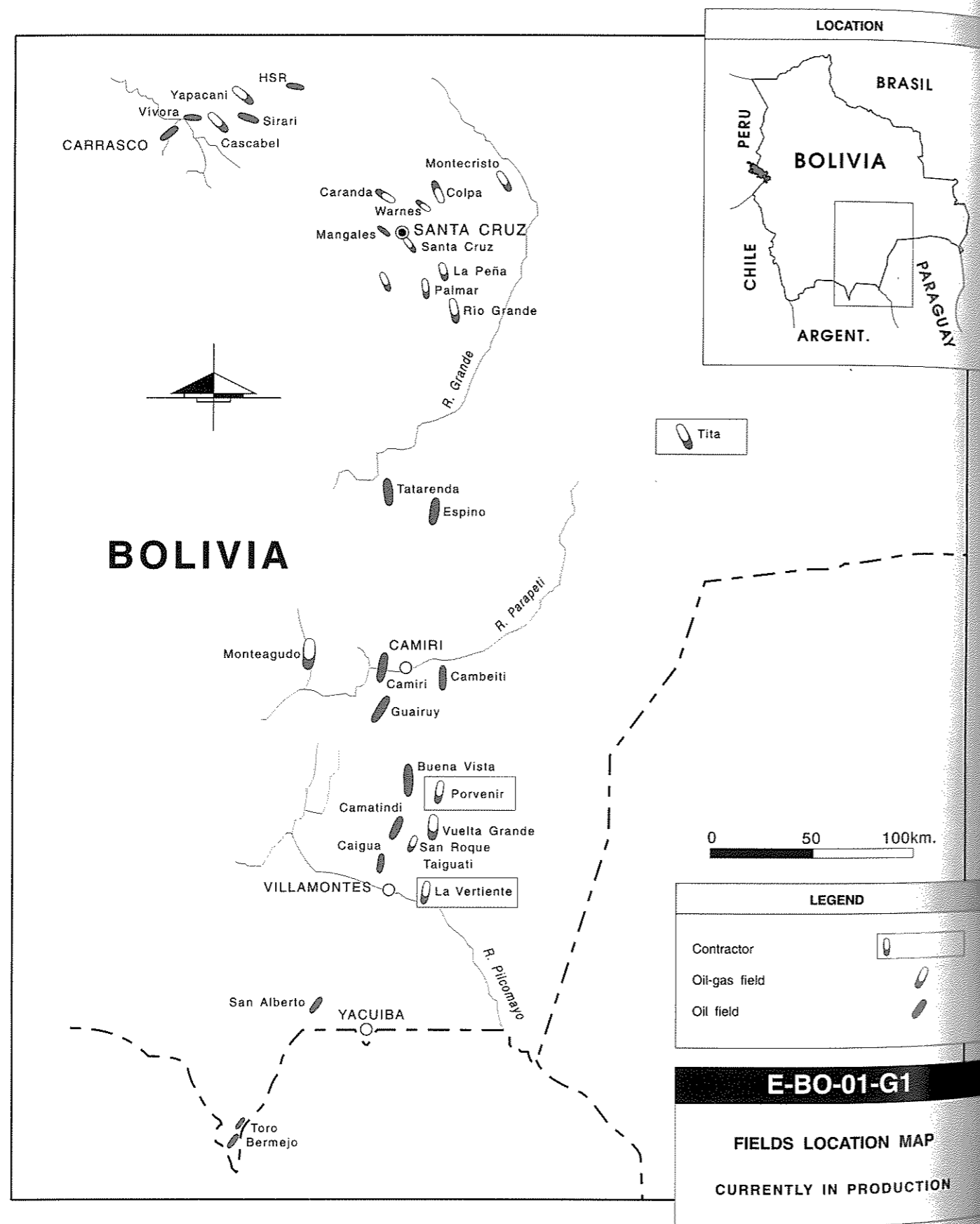
1.1 Hidrocarbons

The remaining proved reserves of hidrocarbons¹ are of 4.18 BPC (10¹²PC) (cubic feet) and 118 MMBbl (10⁶ Bbl) of natural gas and oil, respectively (see map E-BO-01-G1).

The hidrocarbon reserves discovered until 1990² are of 2.003 millions of equivalent barrels, corresponding only a 25% to oil and condensed and 75% to natural

1. Bulletin 1/93, January, 1993. Plan Nacional de Energía (Energy National Plan) La Paz, Bolivia).
2. La Política Sectorial de Hidrocarburos (The Sector Policy of Hydrocarbons) May, 1992, Müller & Asociados, La Paz, Bolivia.





gas. In this sense it can be said that Bolivia is mainly a gas country.

The useful sedimentary area^{1, 2} has an area of about 520.000 Km², of which a 30% has not been explored yet. Today a 25% is under operation by Yacimientos Petrolíferos Fiscales Bolivianos YPFB, a 25% under the character of operation contracts with the private sector, a 5% in negotiation for the subscription of new contracts and a 45% of free areas. It is important to point out, that the areas called Llanura Chaco-Beniana Faja Subandina and Altiplano begin in the frontier with Peru and they extend up to Southern Bolivia.

The pipeline network of YPFB in operation has a length of 6.925 Km, the main part of which corresponds to the export infrastructure with the oil pipeline to Arica, on the Pacific Ocean, and the gas pipeline to Argentina.

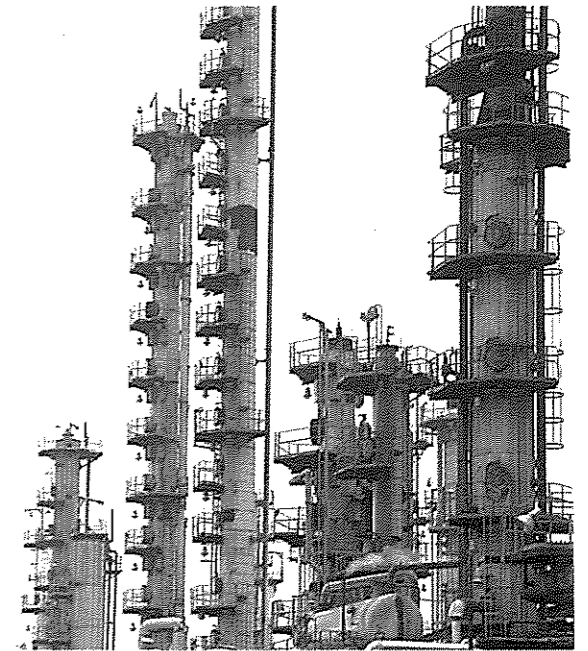
In 1991, the internal consumption of oil derivatives and natural gas³ was 9.188 MBbl and 28 MMMPC (cubic feet), respectively.

In this moment, the country is self-sufficient in liquid hydrocarbons; the derivatives imports and exports are not important.

In the subject of natural gas, Bolivia is self-sufficient and has exported to Argentina for more than 20 years with average daily exports in 1992 of 206 MMPCD¹. The original contract ended in April 1992 having agreed on an extension of same until the end of 1993. It is expected, however, that the Bolivian gas exports will continue for a longer period, with a possible gradual reduction in volume.

On the other hand, the Gas Agreement signed with Brazil in August 17, 1992, and complemented on February 17, 1993, has important implications in the

¹ Bulletin 2/92, March, 1992. Plan Nacional de Energía (Energy National Plan) La Paz, Bolivia).

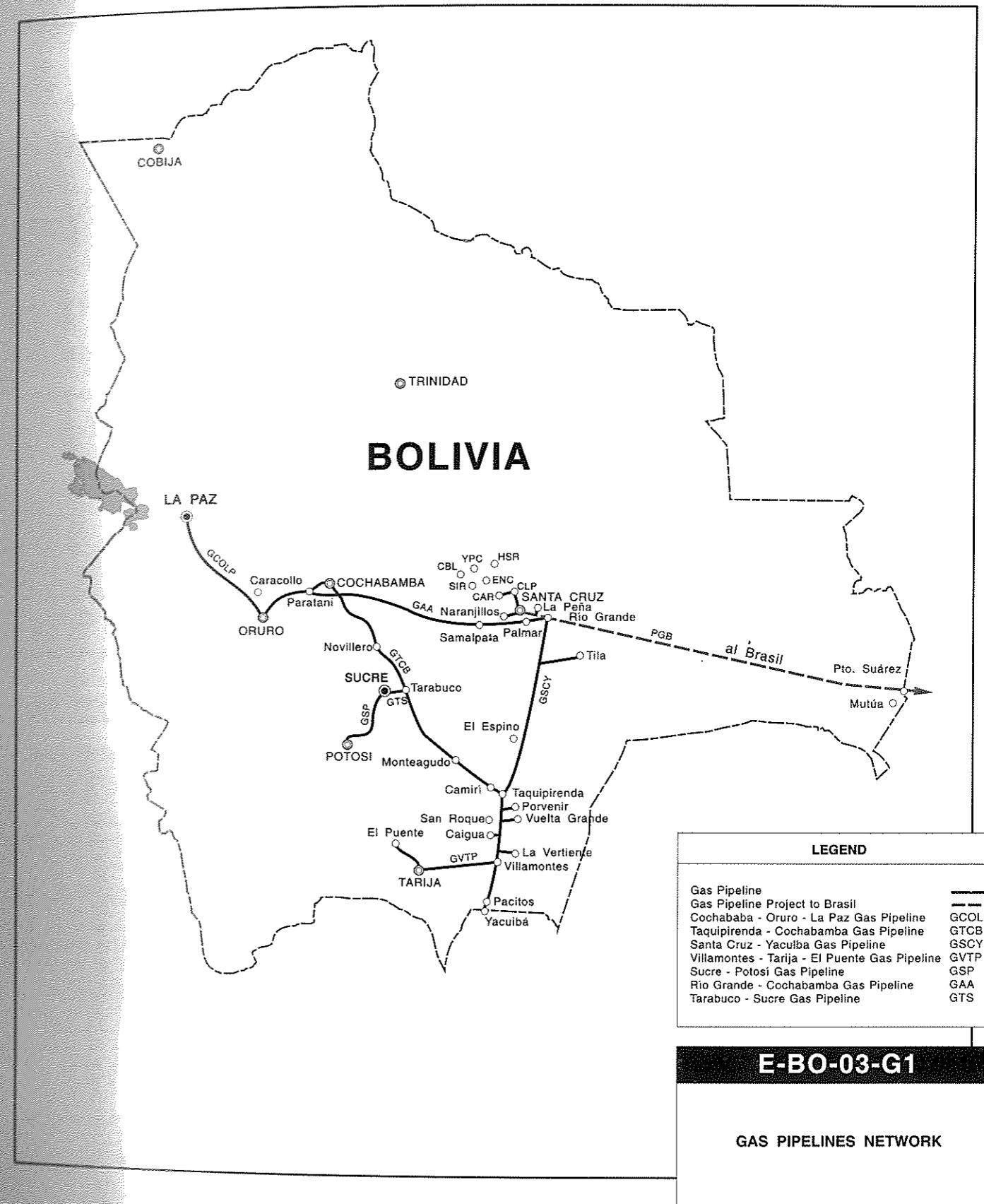
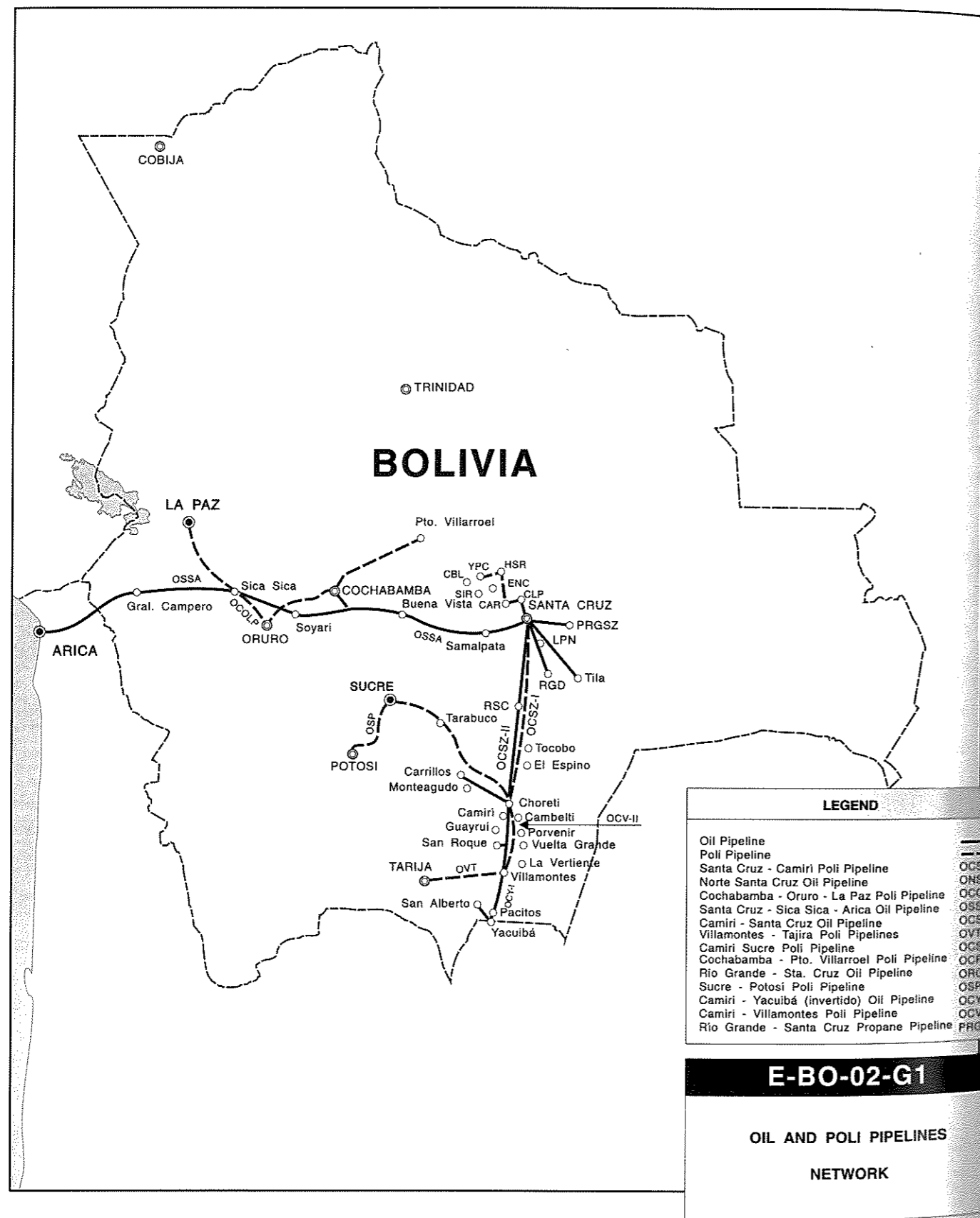


design of the Bolivian Energy Strategy. The flow of 16 MMM3D (565 MMPCD) of natural gas for 20 years, will be supported in a substantial increase in the development and exploration work to dispose of a sufficient production that guarantees the supply of international markets and the increase in the internal demand.

Besides, the new sales project of natural gas to Northern Chile will continue, promoting the construction of a gas pipeline that connects the Southeast Bolivian fields with Tocopilla and Antofagasta on the Pacific Ocean.

Besides, YPFB, the following companies operate under the character of operation contract: Tesoro, Occidental, Texaco, Exxon, Mobil, Maxus, Sun Oil, Sol Petróleo, Phillips Petroleum, Santafé, Chevron, Pluspetrol, Perez Companc and the Bolivian Companies Sopetrol and Petrolex, among others.

In maps E-BO-02-G1 and E-BO-03-G1, the oil pipelines



and polipipeline network as well as the gas pipeline network are shown respectively.

1.2 Electric energy

According to the outstanding Electricity Code, both the generation for its own consumption (self-consumption), and the public service, understood as the generation, transmission and distribution of electric energy for its sale to third parties, may be done by individuals, partnerships, local or foreign.

The Electricity Code states that the electric energy fares, both for national and foreign enterprises, be fixed in a way that it is possible to recover costs, including depreciation, and additionally provide a 9% profitability and revalued fixed investments.

The main operating enterprises are the Empresa Nacional de Electricidad S.A. (ENDE), a state company, created by the Bolivian Government in 1962 and Com-

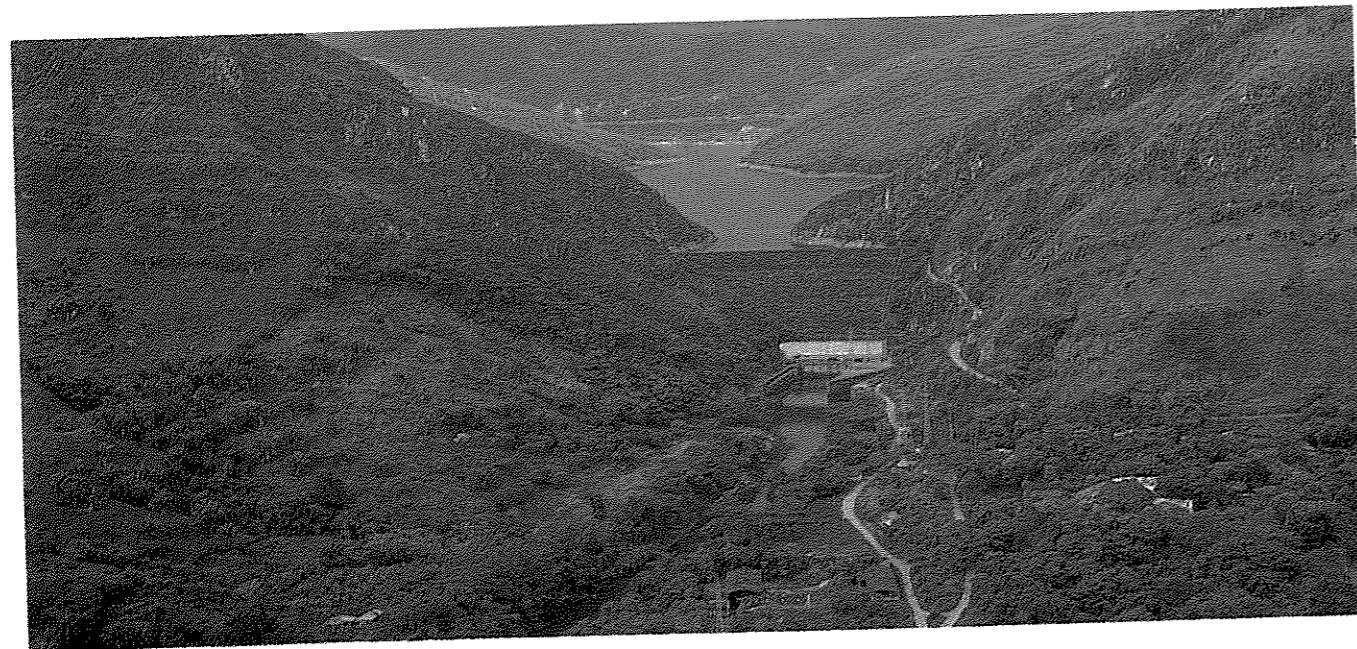
pañía Boliviana de Energía Eléctrica (COBEE), a foreign investment from Canada, working in Bolivia since 1925.

The gross hydroelectric potential of Bolivia is estimated in 334.100 MW, the economically usable part in 39.870 MW, the inventory in specific projects in 10.700 MW and the operating hydroelectric potential up to the moment in 308 MW according to information furnished by ENDE⁴.

The installed thermoelectric and hydroelectric power in Bolivia¹ is 725.5 MW contributed by ENDE with 437.9 MW, COBEE with 142.2 MW, self-producers with 108.1 MW and other public service companies with 37.3 MW.

In 1992 the total electric energy generation¹ was 2.402 Gigawatts per hour (GWh) with a 56% from hydroelec-

4. Memoria Anual (Annual Report), 1990. Empresa Nacional de Electricidad (Electricity National Company). Cochabamba, Bolivia.



tric sources and a 44% from thermoelectric sources; it was made with a 56% contribution from ENDE, 32% from COBEE, 10% from self-producers and a 2% from other public service companies.

Map E-BO-04-G1 shows the main central stations and transmission lines in operation.

2. ENERGY INTEGRATION PROJECTS WITH PERU

The projects found and designed due to this work and that are briefed immediately, make believe that there could be enough conditions to move the energy integration with southern Peru, taking into account the Bolivian natural gas, and the hydrocarbon and electric energy transportation infrastructure that Bolivia has.

2.1 Study of the electric energy supply in the Bolivia-Peru frontier

This study⁵ was financed by the Banco Interamericano de Desarrollo (BID) and was finished in December 1990. It's main objective was to make an inventory of possible projects in the electric sector on all the evaluated area, on the basis of an analysis of the electric energy demand. These projects are based mainly on renewable energy resources, as the hydroelectric and non conventional energy ones (solar, eolic, biomass).

The area evaluated by this study is shown on map E-BO-05-G1; it partially includes the departments of

5. Abastecimiento de Energía Eléctrica en la Región Fronteriza Bolivia-Perú (Electric Energy Supply in the Bolivia-Peru Border), December, 1990. Empresa Nacional de Electricidad (National Electricity Company), Cochabamba, Bolivia.

Puno, Tacna, and Madre de Dios in Peru, as well as La Paz and Pando in Bolivia, with an area of 157.000 Km² in Peru and 74.000 Km² in Bolivia, which covers three well differentiated areas from an economic and climate point of view, called Areas 1,2 and 3 from South to North, and with the following description:

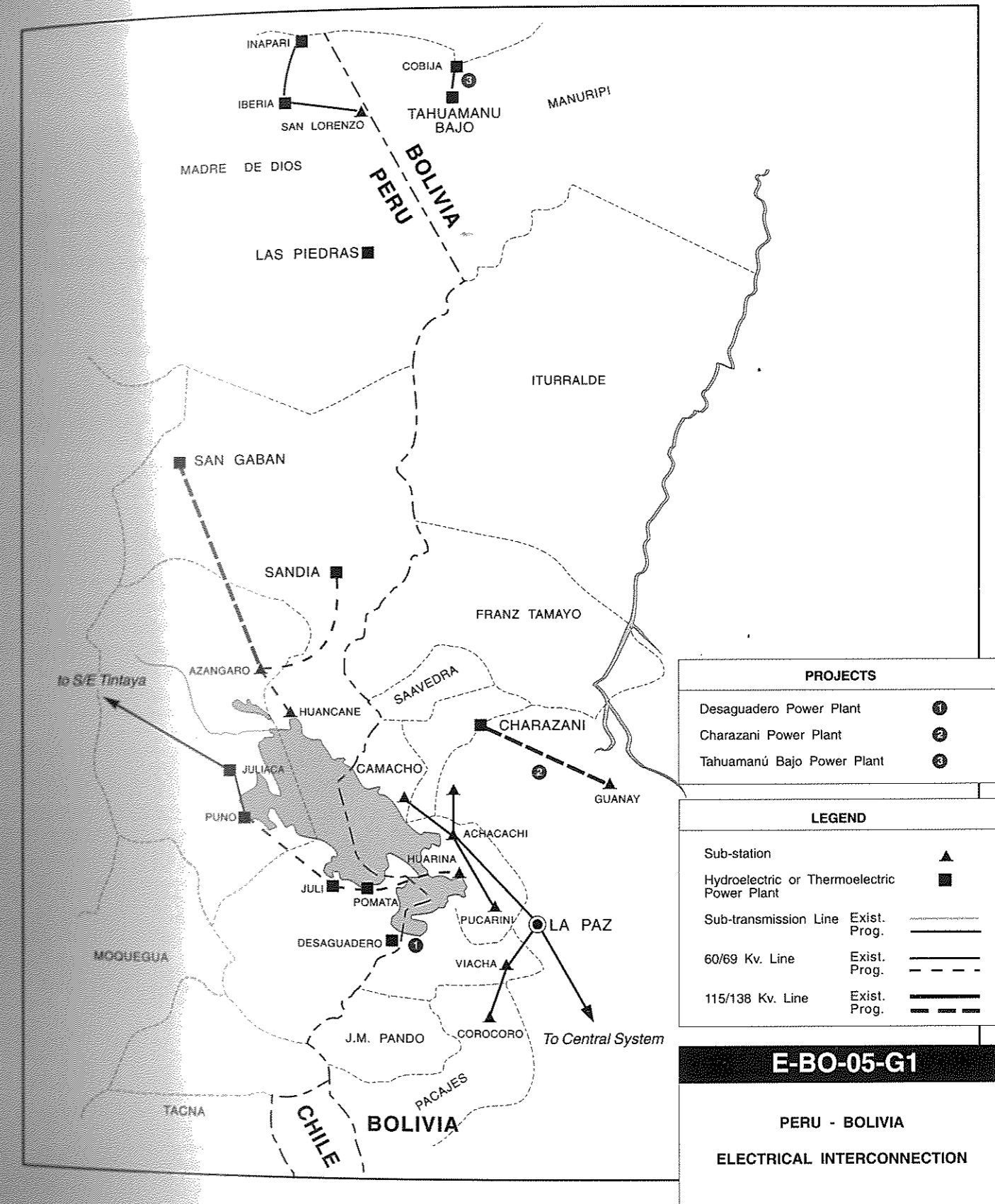
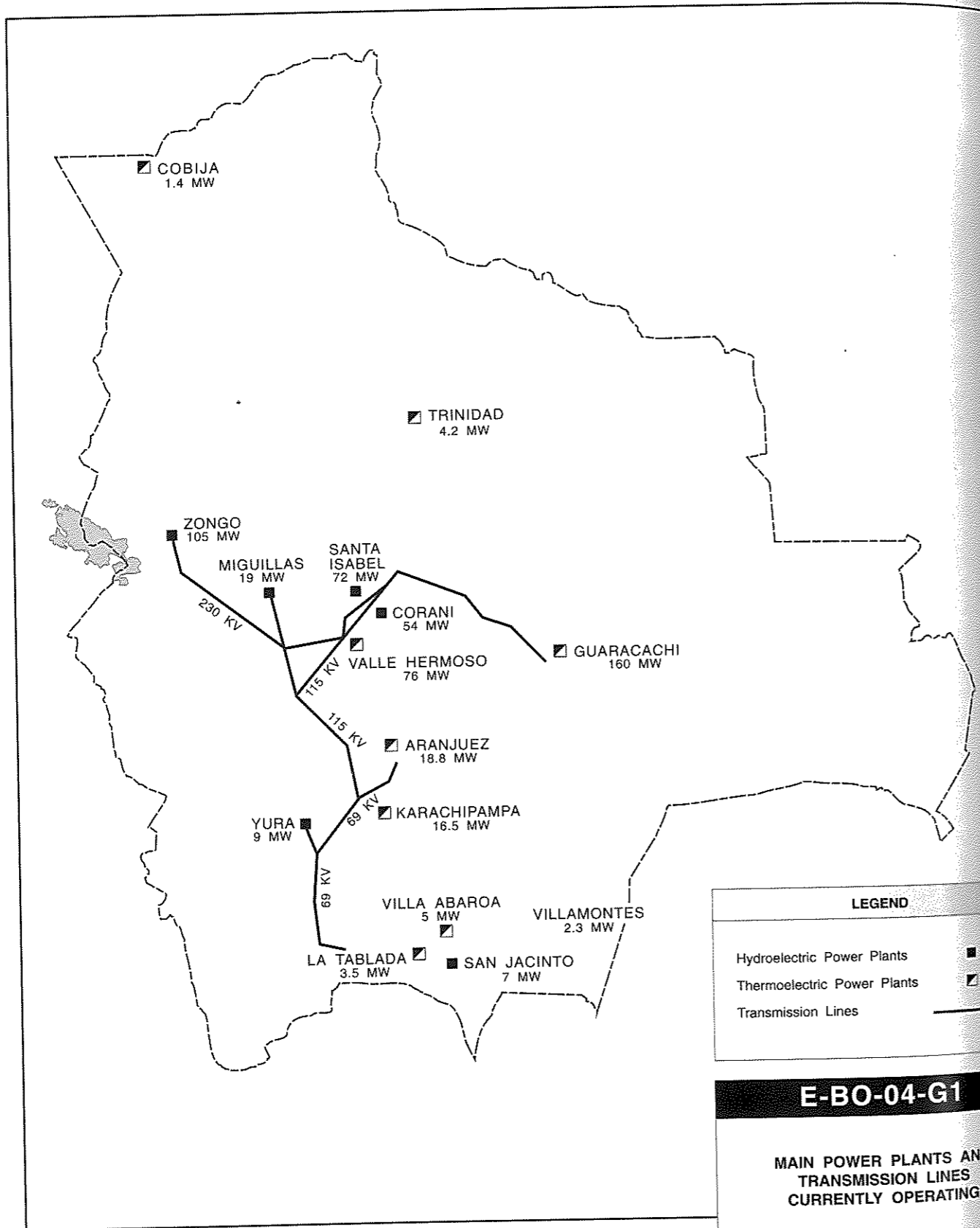
Area 1: Called "Altiplano", basically corresponds to the Peruvian-Bolivian provinces located around the Titicaca Lake and all its area of influence includes the provinces of J. Manuel Pando, Muñecas (partially), Pacajes, Camacho, Omasuyos, Los Andes, Ingavi and Manco Capac in the department of La Paz in Bolivia, as well as the provinces of Huancané, Chucuito and Yunguyo in the department of Puno and the corresponding areas of the plateau of the provinces of Tarata and Tacna in Peru.

The plateau is the most populated area and with the most potential demand of energy. The access to the populated areas is generally acceptable in all the area; the energy potential is relatively low regarding hydroelectric resources, due to the lack of slopes and the relative scarcity of water especially in the dry season.

The potential regarding solar and geolic energy is quite high; especialy, the solar energy should represent a good possibility to supply electricity in isolated towns.

Area 2: It is called "Cordillera and Pie de Monte", corresponds to the most mountainous region of this area. It covers mainly the Bolivian provinces of Saavedra, Franz Tamayo and Muñecas (partially) in the department of La Paz, as well as the Peruvian provinces of Sandia and Carabaya in the department of Puno and it is characterized by considerable hydroelectrical potential.

Its access is quite acceptable, at least in the dry season and for the purposes of recognition or study.



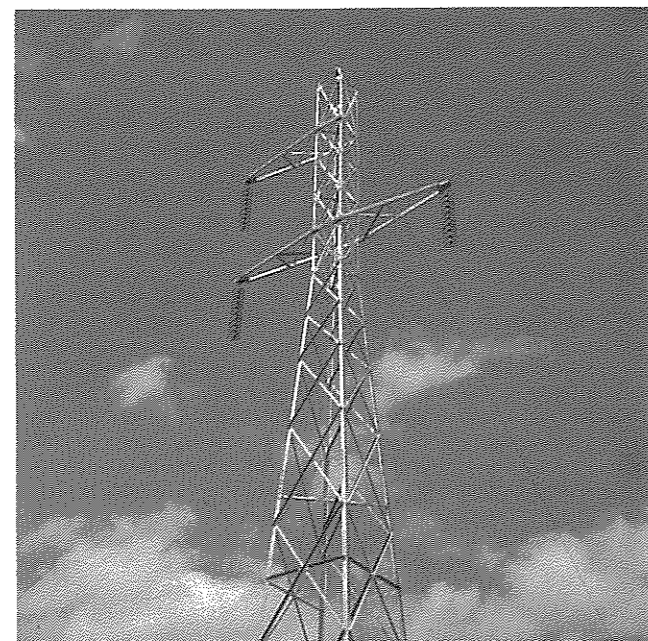
The population is very scarce with a reduced potential demand, with the exception of some mines with a demand of several tens or hundreds of KW.

Area 3: It is called "Selva"; corresponds to the provinces Nicolás Suárez and Manuripi in the department of Pando, as the total department of Madre de Dios, in Bolivia and Peru respectively.

This area is ecuatorial of tropical, almost all covered by the Amazone jungle. Most of the area is deserted; however, some small cities are beginning to develop, like Puerto Maldonado in Peru and Cobija in Bolivia.

This area has a sizeable energy and economic potential; its development relies on problems of terrestrial access. Rivers are of great volume, but wide, difficult to access and unknown; this makes recognition difficult and of course, the realization of any hydroelectric project is too.

The energy potential regarding the biomass is huge. Today several small central stations are being set up



in Peru (especially based on gas), in isolated towns; the economic growth of the area will cause great future demands, that would lead us to consider central stations of higher power.

From the analysis of the areas being studied, it has been concluded that the yearly demands that must be satisfied in the consumption centers that will exist by the year 2000, would be, in Bolivia, 25.800 MWh (90% in the plateau Area 1 and 10% in Cobija-Area 3), or approximately 10 MW with a charge factor of 30% and of 34.200 MWh in Peru (30% in the plateau - Area 1 and 70% in Madre de Dios - Area 3), or approximately 13 MW with a charge factor of 30%.

For the private charges, there is a potential of 92.000 MWh per year in Bolivia and 168.000 MWh in Peru. However, it has been concluded that a great part of this potential corresponds to gold mines in the region of Puerto Maldonado, that because of its variability and location are not considered in the next phase of this analysis.

As a result of the study, three hydroelectrical projects were chosen in the Bolivian area, two, on the Charazani River (Area 2) and one on the Tahuamanu (Area 3).

A. PROJECTS ON THE CHARAZANI RIVER

On the Charazani River, in the Province of Saavedra, (Area 2) in the department of La Paz, three utilization schemes were identified with installed capacities of 25, 40 and 50 MW, respectively.

The examined schemes of 25 and 40 MW are, technically and economically, very much alike. On the basis of its economic cost and its size, the utilization of 25 MW would seem the most convenient with the following technical characteristics: a river intake of the underneath type, one sand clearer, conveyance works including a tunnel, balance chimney and forced pipes

and one central station with three Pelton units, with energy production of 147 GWh per year and guaranteed power of 5 MW at a generation cost of 0.041 US\$/KWh (discount rate = 12%).

The connection studies with the Bolivian network, in a next phase of evaluation, could modify the comparison. However, two alternatives have been studied for the connection of the Charazani central station: up to the Proyecto Larecaja system, presently at the beginning of its execution process by ENDE, or towards Mina Matilde, near the Titicaca Lake, to contribute with the feeding of the frontier areas. Evacuation through Larecaja seemed to be the most convenient with a elevating substation in the central station of 2 x 15 MVA and a line of 115 KV 80 Km long up to the Guanay substation.

B. PROJECTS ON THE LOW TAHUAMANU RIVER

This project is located on this river on the the town of Cachuelita, 47 Km South from the city of Cobija



(Area 3); it contains a mobil barrage with three floodgates and a machinery house equipped with two bulb units of 1 MW each. The total yearly energy that could be produced would be between 14 GWh and 12.9 GWh, the guaranteed power is of 1.3 MW. The generation cost will be between 0,088 US\$/KWh and 0,102 US\$/KWh.

Map E-BO-06-G1 shows the transmission lines, as well as the possible hydroelectric and transmission projects.

C. FEASIBILITY STUDY OF THE TAHUAMANU HYDROELECTRIC PROYECT

This study, finished in March 1992, was made by ENDE and includes complimentary studies and updating of the electric energy demand projection, topography, hydrology, geology, environmental considerations, optimal use of energy and power, revision of the development scheme of the proyect and study of two additional locations for the reservoir.



Only the demand of the Cobija-Villa Bush-Porvenir isolated system was considered due to the impossibility to obtain information on the demand of the towns of Villa Pitación and Brasilea y Brazil, which obviously changes the economic feasibility of the project.

It is advised to set up a pluviometric station in the area.

2.2 Energy integration with south Peru based on bolivian natural gas

2.2.1 Antecedents

This project has been identified because of the present study requested by the Corporación Andina de Fomento; it is just an idea based on the following considerations:

- Bolivia has proved reserves of natural gas, developed and being exploited or ready for exploitation, that are very much above the ones necessary to satisfy the internal demand in a reasonable period of time.
- The gas pipeline network in operation has a length of 2,838 Km and goes up to Viacha, at 80 Km from Desaguadero, town in the frontier with Peru.
- The Bolivian interconnected transmission system of high tension goes up to Kenko, near the city of La Paz, at 80 Km from Desaguadero.
- In South Peru, there is great demand for liquid hydrocarbons, which could be replaced by natural gas.

As a matter of fact, in accordance with the information presented in the study "Mercado Interno de Hidrocarburos para la Región Sur del Perú" made by Sandra Chevarría Lazo, it is mentioned that the principal user of liquid hydrocarbons in this region are

Southern Peru Copper Corporation (Southern) with consumption of 6.395 BPD, and the electricity public service company with 1.271 BPD, from a total of 10.768 BPD considering 1988 as a base year.

In order to increase the information about the potential market for hydrocarbons and electric energy from Bolivia in South Peru, interviews with the executives of ELECTROPERU and SOUTHERN were made in March 1992.

ELECTROPERU would consider it convenient to incorporate a thermic support of about 25MW, without considering SOUTHERN needs, that will be complemented with the construction, as of the second semester of 1993, of the transmission line of Tintaya-Socabaya, the cost of which is estimated in 35 million dollars.

In this moment, the electrical energy requirements of the mining-metalurgic complex of SOUTHERN are covered by a central station with steam turbines in Ilo, with 172 MW of installed power, but with a boiler capacity of about 100 MW being this the highest power. This central station utilizes residual oil and takes advantage of the heat produced by the melting ovens, having generated 681 GWh in 1990.

SOUTHERN electric network, formed by the circle Ilo-Toquepala-Cuajone and connected with the Sistema Interconectado del Sur Este (SISE), supplies energy to the cities of Moquegua, Ilo and the refinery of Minero-Peru, and receives electricity in Toquepala.

Due to the obsolescence of some components of the central station, the maintenance costs are high; in addition, the price of the residual oil went up to US\$62 per barrel, causing the costs of generated electric energy to be growing and be booked at US\$43,67 per MWh in 1990 and US\$73 per MWh in 1991.

SOUTHERN projects to expand its activities in Southern Peru, for which it would install a new boiler

in 1994 to increase its generation capacity in 40 MW and to come up to 152 MW in 1995.

2.2.2 Possible schemes of the project

The initial idea was to install a central station of 200 MW equipped with gas turbines in Desaguadero, generating at 60 cycles/second, being it the frequency used in Peru, fed with natural gas through an 80 Km extension of the gas pipeline between Viacha and Desaguadero, which would be interconnected with the ELECTROPERU network.

However, in the "Perfil Gasoducto al Desaguadero" (Desaguadero Gas Pipeline Profile) elaborated by YPFB in January 1992, it has been concluded that the present system of gas pipelines at the Northwest of the country, including the expansion being executed, does not have the capacity to transport the required additional volume for a central station of 200 MW (62 MMPCD) or of 100 MW (31 MMPCD).

Taking into account the conclusions of this project profile and other investigations carried out by the Consultant and by engineers of YPFB and ENDE, at the Consultant's request you can think of the following schemes for this project:

A. 200 MW CENTRAL STATION IN DESAGUADERO

It would include the construction of a new gas pipeline between the natural gas production field at Carrasco, in the department of Cochabamba, and Desaguadero (772 Km), running parallel to the existing Altiplano gas pipeline to La Paz, with the exception of the new sections between Carrasco-Oconi and Viacha-Desaguadero, 80 Km each.

Two options for the execution are considered: the first one consists of the construction of a 12 duct and 302 Km between Carrasco and Parotani, complemented

by the 471 Km and 14 section between Parotani and Desaguadero and a 6.940 HP compression station; the second one consists of a 16 diameter gas pipeline, without compression stations, with an estimated investment of 75.6 and 85.2 million dollars, without scaling or interests during the construction, respectively. In the E-BO-07-G1 map, Transport Capacity and Enlargement, you can see the pipeline design.

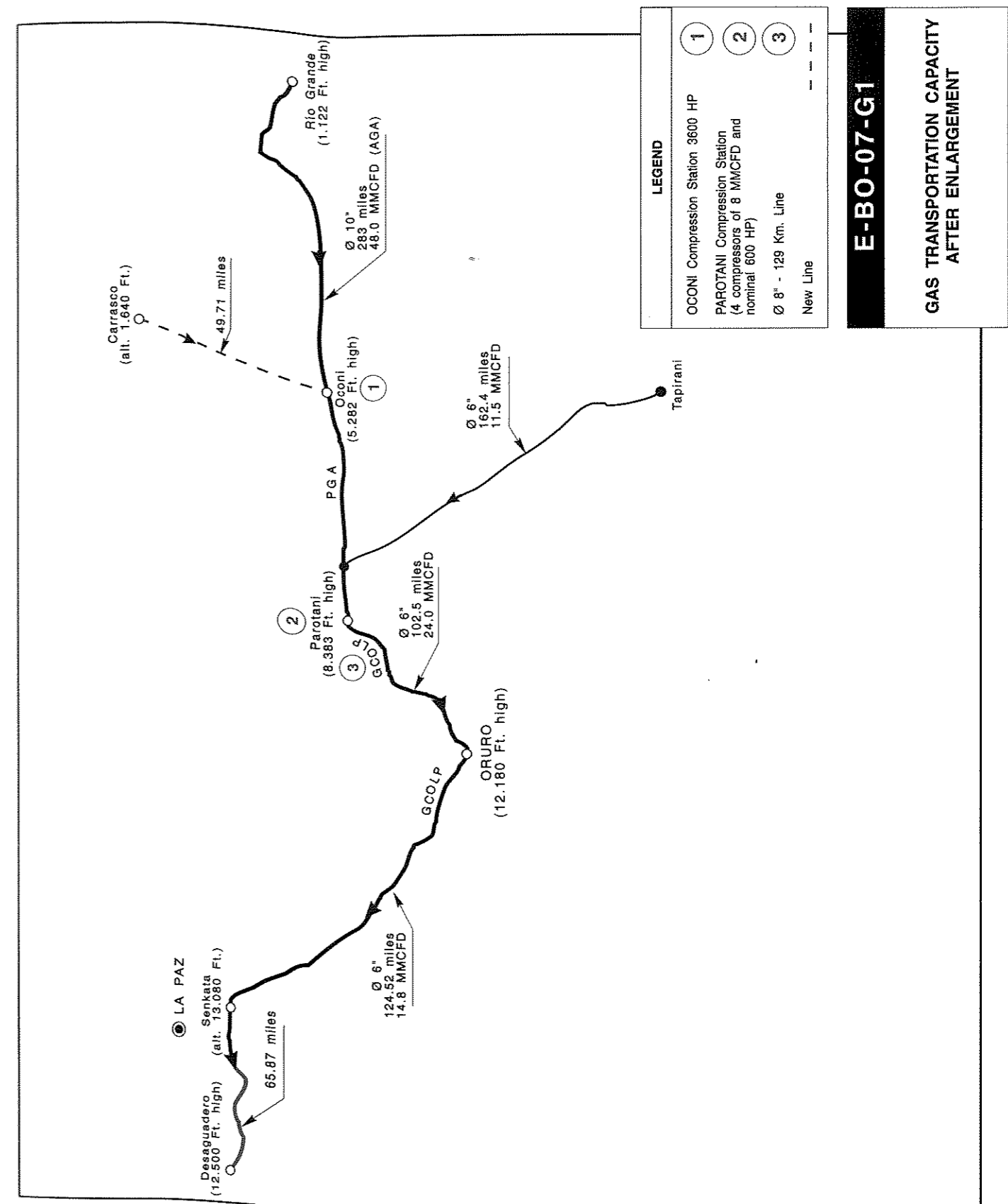
For the power of the turbines, it must be taken into account that Desaguadero is located at 3.800 meters over the sea level and, for this reason, in order to have 200 MW effective power, a central station of 300 nominal MW in ISO conditions is required.

At the Consultant's option, the 200 effective MW of the Desaguadero Central, would require an investment of approximately 132 million dollars, if we add the 85.2 million dollars estimated by YPFB for the 16" gas pipeline between Carrasco and Desaguadero, it is estimated for the integrated project will be of 271.2 million dollars, disregarding scaling or interests during the construction.

B. A 100 MW CENTRAL STATION IN DESAGUADERO

According to the profile of the Desaguadero gas pipeline mentioned above, it is concluded that for this option it would be advisable to build a 12 gas pipeline between Carrasco and Desaguadero with an investment of approximately 63.43 million dollars.

The cost of a central station with 100 effective MW gas turbines in Desaguadero, is estimated in 66 million dollars, making the investment of the integrated project come up to 129.43 million dollars, without considering scaling or interest during the construction.



C. A 50 MW CENTRAL STATION IN DESAGUADERO

According to investigations made by the Consultant and the Dirección General de Hidrocarburos del Ministerio de Energía e Hidrocarburos de La Paz (General Direction for Hydrocarbons of the Ministry of Energy and Hydrocarbons of La Paz), and through it and YPFB, it would be possible to take 16 MMPCD of natural gas from Viacha to Desaguadero, with an approximate investment of 18 million dollars in pipeline, compression installations and construction costs, without considering scaling or interest during the construction.

The cost of a central station with 50 effective MW gas turbines in Desaguadero, is estimated in 33 million dollars, making the investment of this scheme of the project come up to 51 million dollars, without considering scaling or interest during the construction.

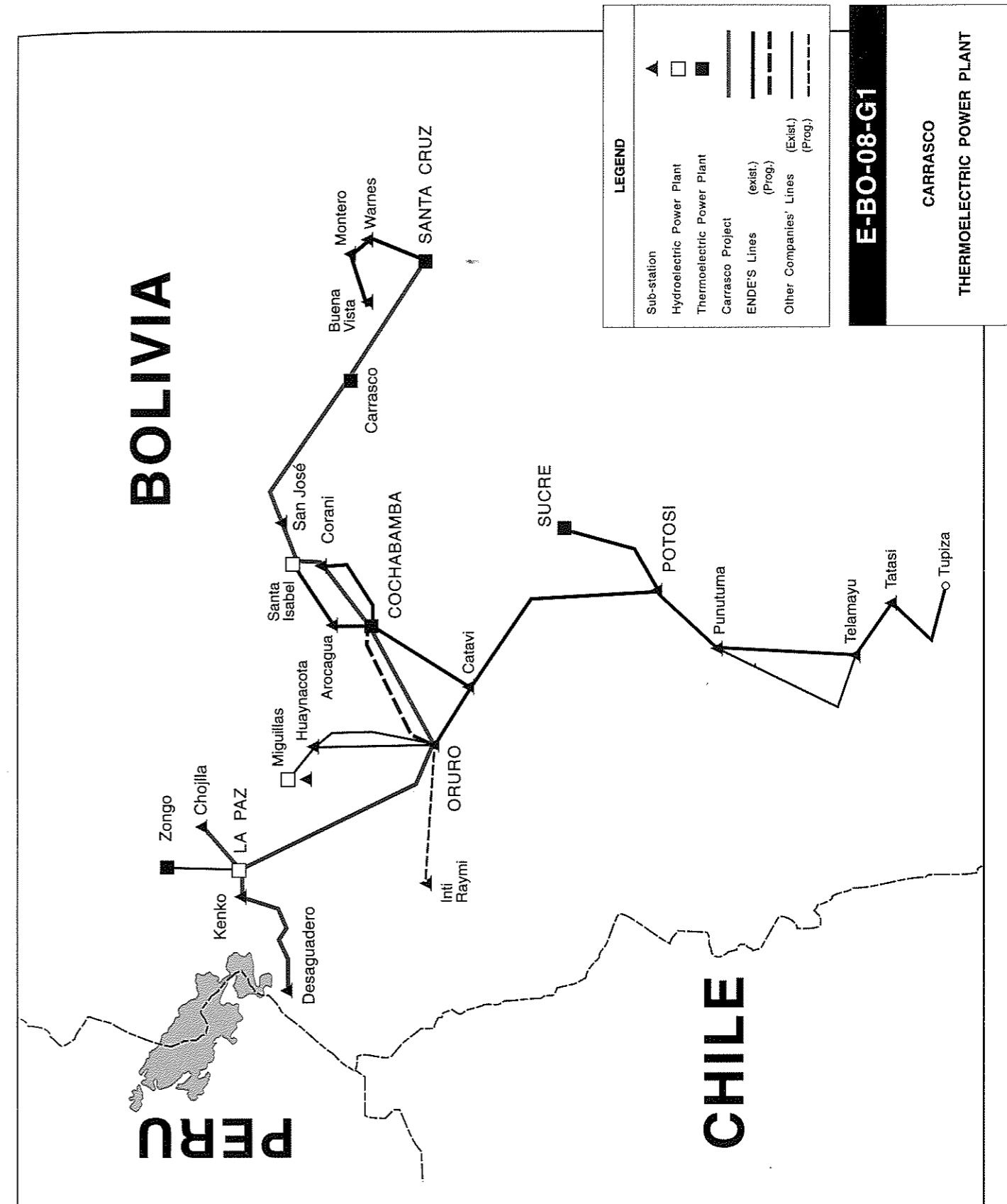


D. A 50 MW CENTRAL STATION IN CARRASCO

Another scheme that could be considered would be the installation of a thermoelectrical central station directly in the Carrasco field and the transmission of generated energy to La Paz, using the transmission lines of the Sistema Interconectado Nacional, complemented with the line to be constructed between La Paz and Desaguadero and a substation to change the frequency from 50 to 60 Hz (see map E-BO-08-G1).

The approximate investment for a 55 effective MW electrical or 73 central station in Carrasco, would be 30 million dollars (it is estimated for 55 effective MW and not for 50, to take into account the transmission losses).

According to preliminary estimates made by ENDE engineers, at the Consultant's request, the following works would be needed to carry 50 MW from Carrasco to Desaguadero:



- To anticipate three years the changing of tension, from 115 KV to 220 KV, of the San José-Cochabamba-La Paz line, with a cost of 8.64 millions due to the anticipation of the project.
- An 80 Km line between La Paz (Kenko) and Desaguadero, at 115 KV, with an investment of 5 million dollars.
- Different equipment (capacitors and others) with a US\$1 million investment.
- A frequency transformation substation in Desaguadero, 60 MVA, 115 KV, with a US\$10 million investment.

The estimated total investment for this project scheme is 54.64 million dollars, without considering scaling or interest during the construction.

E. GAS PIPELINE TO ILO

A project scheme that could possibly be analyzed, would be taking a mayor diameter gas pipeline, for example 20 inches, with a transportation capacity without intermediate compression stations, of about 140 MMPCD, from Carrasco or Río Grande to Ilo, to substitute the residual oil presently used by SOUTHERN and generate the missing electrical energy in the ELECTROPERU network.

This gas pipeline, which is more than 1.000 Km long, has as an advantage the fact that most of it runs parallel to the existing infrastructure between the production fields and La Paz, so access paths and most of the common works such as bridges and embankments could be used.

However, a project of this kind should have a useful life of at least 25 years, to allow its amortization, so a detailed analysis should be made, complemented with consultations and negotiations with the Peruvian

Government and the corresponding corporations and entities, to make sure that there are no superpositions with the future Peruvian gas markets, for example the one which could be produced in Camisea.

If we considered that the Camisea gas volumes that could be taken to Ilo, together with Bolivian gas, could be used in the making of methanol, compressed natural gas, or as raw materials of a petrochemical industry, and that because of the great volumes needed for this type of projects, in order to obtain scale economies, the Peruvian and Bolivian gas would not be competitive but complementary, there would be favorable perspectives for this project scheme.

3. PRIORITIES OF THE INTEGRATION ENERGY PROJECTS

Notwithstanding that the energy integration projects based on the Bolivian natural gas are in a more preliminary state than the ones identified in the Estudio de Abastecimiento de Energía Eléctrica en la Región Fronteriza Boliviana-Peruana (Study of the Electrical Energy Supply in the Bolivia-Peru Border), the Consultant believes that they must have a higher priority than the latter for the following reasons:

- The study of the border covers a too restricted area, in which the city of La Paz is not included in Bolivia, nor the cities of Puno, Tacna, Moquegua, Ilo or Arequipa, nor the SOUTHERN metalurgic mining complex in Perú (see Annex 7).
- The objectives of the study, were not exactly energy integration, but the location of energy projects based on renewable energy, in the border area shown on Annex 7, in order to promote its development. The study does not consider the use of natural gas.
- Notwithstanding the above, the projects identified in the study, when promoting the development of

the border areas, directly affect the integration process.

As to the projects based on the Bolivian natural gas, the following points may be considered:

The pipeline project from the Bolivian gas fields to the port of Ilo is the one that would have the greatest integration effects and that could encourage the growth of South Peru in a short period of time, including the port of Ilo, where a free zone has been granted to Bolivia. However, in view of the size and need of a more efficient coordination and negotiation with Peru, and due to the uncertainty that presently exists about it, a minor priority is assigned to it.

In regard to the electrical energy supply project based on the Bolivian natural gas, a higher priority is assigned to the 50 MW, as it allows a mayor use of the existing installations (either the gas pipeline to Viacha or the Sistema Interconectado Nacional to La Paz); besides, this power level may be rapidly absorbed by the market of South Peru, as long as favorable agreements are met regarding prices and assuming that the Tintaya-Socabaya transmission line is built in Peru.

The project profile, according to priorities, are described in the Annexes mentioned below (Annex 1, corresponds to the first priority; Annex 2, corresponds to the second one, and so on).

Annex 1. Profile of the Thermoelectrical Central Project in Carrasco 55 MW.

Annex 2. Profile of the Thermoelectrical Central Project in Desaguadero 50 MW.

Annex 3. Profile of the Thermoelectrical Central Project in Desaguadero 200 MW.

Annex 4. Profile of the Thermoelectrical Central Project in Desaguadero 100 MW.

Annex 5. Profile of the Project for the Pipeline from Bolivia to Ilo.

Annex 6. Profile of the Río Charazani 25 MW Project.

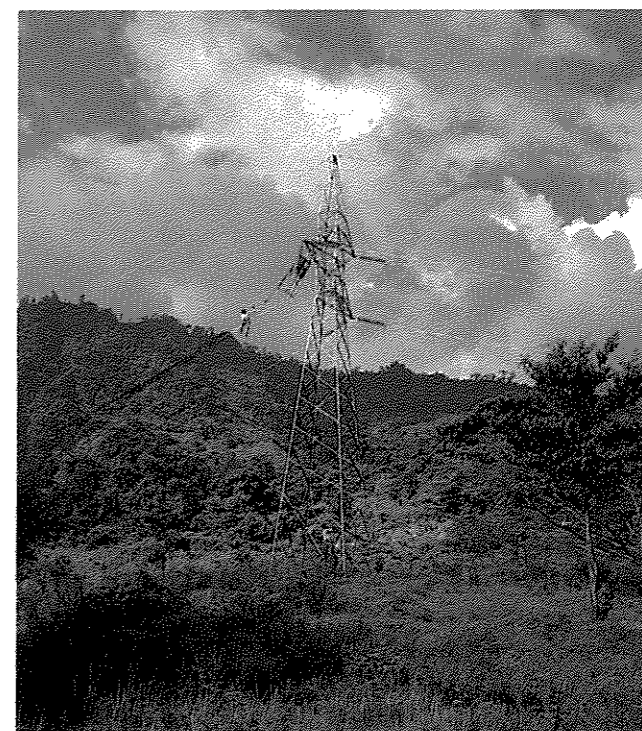
Annex 7. Profile of the Río Charazani 40 MW Project.

Annex 8. Profile of the Río Tahuamanu Bajo Project.

ANNEX 1

Thermoelectrical Central Project in Carrasco-55 MW

- a) **Location:** Thermoelectrical Central in Carrasco, province of Carrasco in the Department of Cochabamba: transmission lines between Car-



rasco and Desaguadero, Province of Ingavi in the department of La Paz, a substation for frequency transformation in Desaguadero.

- b) **Brief description of the project.** Thermoelectrical central near the gas production field of Carrasco, with turbines fed by natural gas, in situ effective generation power of 55 MW.

Raising tension substation, to connect with the 230 KV transmission line, Santa Cruz-San José in the province of Chapare in the Department of Cochabamba, which runs near Carrasco.

Tension change in the San José-Corani (14 Km) line which is built and operates at 115 KV, to 230 KV.

Construction of transformation substations to advance the modification in the operating tension of the transmission lines between Corani and Kenko, near the city of La Paz, from 115 KV to 230 KV (these lines were built for 230 KV, although they are operating presently at 115 KV with the exception of the Valle Hermoso-Vinto sector, of 152 Km, which was built and operates at 115 KV. In this moment, a new parallel line is being constructed between Valle Hermoso and Vinto at 230 KV, which will operate at the beginning at 115 KV).

Transmission line between Kenko and Desaguadero, of 80 Km, at 115 KV.

Frequency transformation substation, in Desaguadero, of 60 MVA, to 73 at 115 KV.

- c) **Present status of the project.** Preliminary study.
- d) **Approximate investment:** 54.64 million dollars, disregarding scalation or interest during the construction period.
- e) **Quality benefits:** Will allow to rapidly reduce the electrical energy deficit in South Peru and maybe will partially replace the more expensive electrical

energy generated on the basis of liquid fuels, as that of Southern Peru Copper Corporation, for example.

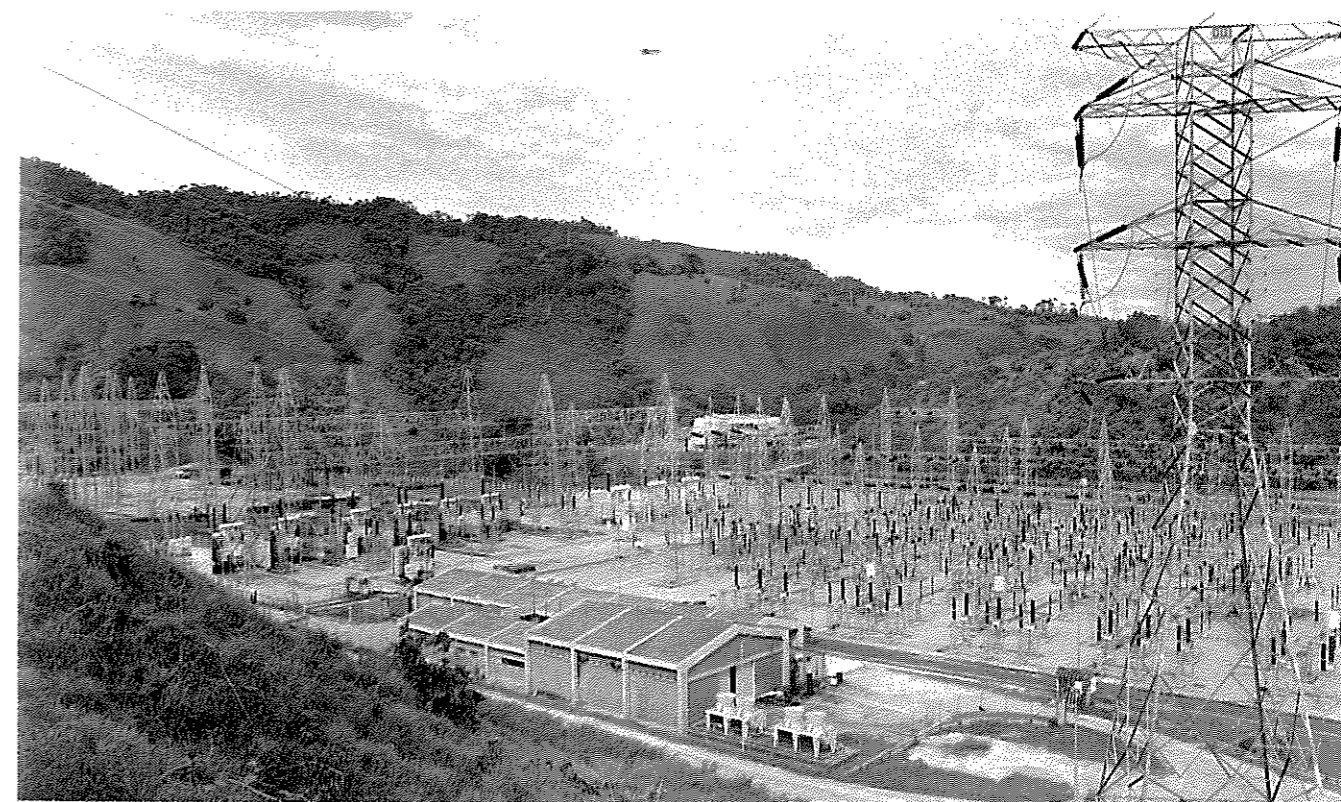
Will allow a higher use of the Bolivian gas, from fields in production or about to produce, mostly using the infrastructure already built like the Sistema Interconectado Nacional Boliviano for the transmission of electrical energy.

- f) **Comments or suggestions:** Does not include the additions and improvements in the transmission systems of electrical energy of South Peru which could be necessary, as the Puno-Juliaca line and the Tintaya-Socabaya line.
- g) **Location plan and area of influence:** The Carrasco field is shown in map E-BO-08-G1; the city of La Paz, the town of Desaguadero and the influence area in South Peru are shown in map E-BO-06-G1).

ANNEX 2

Thermoelectrical Central Project in Desaguadero-50 MW

- a) **Location:** Thermoelectrical central in Desaguadero, Province of Ingavi in the Department of La Paz; gas pipeline between Viacha and Desaguadero (80 Km, both located in the Ingavi Province in the Department of La Paz. Location of gas compression station, not defined.
- b) **Brief description of Project:** Thermoelectrical central in Desaguadero, with turbines fed with natural gas, in situ effective power, 50 MW, generation frequency 60 Hz.
- Gas pipeline from Viacha to Desaguadero (80 Km) and compression station. Both installations designed so that 16 MMPCD of natural gas can reach Desaguadero.



- c) **Present status of the project:** Preliminary study.
- d) **Approximate investment:** 51 million dollars without considering scalation or interest during the construction.
- e) **Quality benefits:** Will allow to rapidly reduce the electrical energy deficit in South Peru and maybe will partially replace the more expensive electrical energy generated on the basis of liquid fuels, as that of Southern Peru Copper Corporation, for example.

Will allow a higher use of the Bolivian gas, from fields in production or about to produce, mostly using the infrastructure already built, such as the

gas pipelines between the production fields of natural gas and Viacha, 80 Km from Desaguadero, in the border with Peru.

- f) **Comments and suggestions:** Does not include the additions and improvements in the transmission systems of electrical energy of South Peru which could be necessary, as the Puno-Juliaca line and the Tintaya-Socabaya line.

It is necessary to confirm the feasibility to take 16 MMPCD of natural gas to Desaguadero using the existing gas pipes to Viacha.

- g) **Location plan and area of influence:** The towns of Viacha and Desaguadero and the influence area of

the project, in South Peru are shown in the map E-BO-06-G1.

ANNEX 3

Thermoelectrical Central Project in Desaguadero - 200 MW

- a) **Location:** Thermoelectrical central in Desaguadero, in the province of Ingavi in the Department of La Paz; gas pipeline between Carrasco, natural gas production field in the province of Carrasco in the Department of Cochabamba, and Desaguadero.
- b) **Brief description of the project:** Thermoelectrical central, with turbines fed with natural gas, in Desaguadero, in situ generation of effective power of 200 MW, generation frequency of 60 Hz.

Gas pipeline 16 inches in diameter between Carrasco and Desaguadero (772 Km).

- c) **Present status of the project:** Preliminary study.
- d) **Approximate investment:** 217.2 million dollars, without considering scalation or interest during the construction.
- e) **Quality benefits:** Will allow to rapidly reduce the electrical energy deficit in South Peru and maybe will partially replace the more expensive electrical energy generated on the basis of liquid fuels, as that of Southern Peru Copper Corporation, for example.

Will allow a higher use of the Bolivian gas, from fields in production or about to produce, mostly using the infrastructure already built, such as the access paths and other common works of the gas pipeline between the production fields and La Paz.

- f) **Comments and suggestions:** Does not include the additions and improvements in the transmission

systems of electrical energy of South Peru which could be necessary, as the Puno-Juliaca line and the Tintaya-Socabaya line.

In further stages of this project study, it should also be considered the alternative of building a 12 inch diameter gas pipeline between Carrasco and Parotani (302 Km), a 14 inch diameter gas pipeline between Parotani and Desaguadero (471 Km) and a compression station of 6.940 HP, which requires a lower investment, but higher operating expenses.

- g) **Location plan and area of influence:** The town of Desaguadero, as well as the influence area of the project in South Peru, are shown in map E-BO-06-G1 and the sector of the gas pipeline between Carrasco and Desaguadero in map E-BO-08-G1.

ANNEX 4

Thermoelectrical Central Project in Desaguadero-100 MWa)

- a) **Location:** Thermoelectrical central in Desaguadero, in the province of Ingavi in the Department of La Paz; gas pipeline between Carrasco, natural gas production field in the province of Carrasco in the Department of Cochabamba, and Desaguadero.
- b) **Brief description of the project:** Thermoelectrical central, with turbines fed with natural gas, in Desaguadero, in situ generation of effective power of 100 MW, generation frequency of 60 Hz.

Gas pipeline 12 inches in diameter between Carrasco and Desaguadero (772 Km).

- c) **Present status of the project:** Preliminary study.
- d) **Approximate investment:** 129.43 million dollars, without considering scalation or interest during the construction.

- e) **Quality benefits:** Will allow to rapidly reduce the electrical energy deficit in South Peru and maybe will partially replace the more expensive electrical energy generated on the basis of liquid fuels, as that of Southern Peru Copper Corporation, for example.

Will allow a higher use of the Bolivian gas, from fields in production or about to produce, mostly using the infrastructure already built, such as the access paths and other common works of the gas pipeline between the production fields and La Paz.

- f) **Comments and suggestions:** Does not include the additions and improvements in the transmission systems of electrical energy of South Peru which could be necessary, as the Puno-Juliaca line and the Tintaya-Socabaya line.

- g) **Location plan and area of influence:** The town of Desaguadero, as well as the influence area of the project in South Peru, are shown in map E-BO-06-G1 and the sector of the gas pipeline between Carrasco and Desaguadero in map E-BO-08-G1.

ANNEX 5

Project of the Pipeline from Bolivia to Ilo

- a) **Location:** Gas pipeline between Carrasco, gas production field in the province of Carrasco in the Department of Cochabamba, and the port of Ilo in the department of Moquegua in Peru.
- b) **Brief description of the project:** Gas pipeline 20 inches in diameter and 1171 Km long, with an initial transportation capacity of about 140 MMPCD without compression stations.
- c) **Present status of the project:** Idea of the project.

- d) **Quality benefits:** Will allow to generate electrical energy in South Peru, nearer the charge centers, which will diminish the losses due to electrical energy transmission. Will permit to reduce the deficit of electrical energy in South Peru and will allow to replace the liquid fuels used by important users, such as Southern Peru Copper Corporation, not only in its electrical energy generating central of more than 100 MW, but also of its metalurgical industry, both located in the port of Ilo.

Will allow a higher use of the Bolivian gas, from fields in production or about to produce, mostly using the infrastructure already built, such as the access paths and other common works of the gas pipeline between the production fields and La Paz.



- e) **Approximate investment:** It has not been estimated, it could be about 560 million dollars.
- f) **Comments or Suggestions:** It is necessary to discuss this project in detail with Peru to avoid possible superpositions, as for example with the gas of Camisea. Uses of gas in Ilo could be analyzed, as in the process of Methanol, compressed natural gas, petrochemicals or other which require huge volumes of gas to take advantage of the scale economies, so that the Bolivian and Peruvian gas are not competitive but complementary.
- g) **Location plan and area of influence:** The design of the Carrasco-Desaguadero gas pipeline are shown in the map E-BO-08-G1. There is not a defined design for the Desaguadero-Ilo sector.

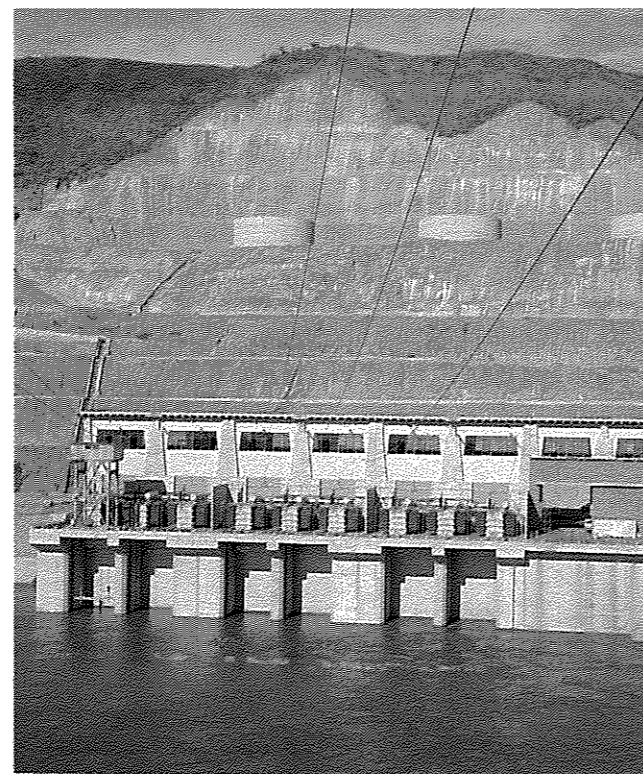
ANNEX 6

Río Charazani 25 MW Project

- a) **Location:** Río Charazani, in the province of Saavedra in the Department of La Paz.
- b) **Brief description of the project:** Hydroelectrical central. Water intake from the river of the underneath type, sand clearer (55 meters long), pressure tunnel, (length: 5.500 m, inside diameter: 2.2 m), balance chimney, machinery house equipped with three groups of Pelton type generators (3 x 8330 KW). Volume of water design: 8 cubic meters per second; gross fall: 440 Mts; 25 MW of installed power; 5 MW of guaranteed power.

Associated transmission: 115 KW Charazani substation with two 15 MVA transformers; 115 KW line, 80 Km, from Charazani to Guanai. Enlargement of the Guanay 115 KW substation.
- c) **Present status of the project:** Advanced preliminary study.

- d) **Approximate investment:** 42.5 million dollars in the hydroelectrical central, more than 10.07 million dollars in the associated transmission. Approximate total investment: 52.57 millions dollars.
- e) **Quality benefits:** Will represent a source of abundant and stable energy for the present and future users of a potentially rich region, but presently depressed, in the department of La Paz, in the border with Peru, and that in this way will increase its growth and integration process.
- f) **Comments and suggestions:** It has been estimated that the cost of energy produced could be about 41 US\$/MWh, at a 12% yearly discount rate.
- g) **Location plan and area of influence:** The location of the central, the transmission line and the area



of influence of the project are shown in the map E-BO-05-G1.

ANNEX 7

Río Charazani 40 MW Project

- a) **Location:** Río Charazani, in the province of Saavedra in the Department of La Paz.
- b) **Brief description of the project:** Hydroelectrical central. Water intake from the river of the underneath type, sand clearer (55 meters long), pressure tunnel, (length: 10000 Mts, inside diameter: 2.2 Mts), balance chimney, forced pipes (length 1250 Mts, diameter 1.4 Mts), machinery house equipped with four groups of Pelton type generators (4 x 10000 KW).

Volume of water design: 8 cubic meters per second; gross fall: 670 Mts; 40 MW of installed power; 8 MW of guaranteed power, producible energy: 222 GWh/year.

Associated transmission: 115 KV Charazani substation with two 25 MVA transformers; 115 KV line, 80 Km, from Charazani to Guanai. Enlargement of the Guanay 115 KV substation.

- c) **Present status of the project:** Advanced preliminary study.
- d) **Approximate investment:** 72.56 million dollars in the hydroelectrical central, plus 10.31 million dollars in the associated transmission. Approximate total investment: 82.86 millions dollars.
- e) **Quality benefits:** Will represent a source of abundant and stable energy for the present and future users of a depressed area, but potentially rich, in the department of La Paz, in the border with Peru, and that in this way will increase its growth and integration process.

- f) **Comments and suggestions:** The study of the electrical energy market in the area of influence of the project must be updated and studied in detail, to optimize its implementation chronogram.
- g) **Location plan and area of influence:** The location of the hydroelectrical central of the transmission line and the area of influence of the project are shown in map E-BO-08-G1 and in map E-BO-06-G1.

ANNEX 8

Río Tahuamanu Bajo Project

- a) **Location:** This project is located on the Tahuamanu Bajo River, in the city of Cachuelita, 47 Km South of Cobija, capital of the department of Pando.

The Tahuamanu River is the borderline between the provinces of Nicolás Suárez and Manuripi in the department of Pando. It has its source in Peru and flows into the Orthon river, tributary of the Beni River.

- b) **Brief description of the project:** Hydroelectrical central. Mobil barrage consisting of three radial flood gates 20 Mts. long and 9 Mts. high. Machinery house equipped with two Kaplan turbines "S" bulb type (2 x 1250 KW).

Water volume design: 54 cubic meters per second; net fall 5.77 Mts; installed power 2.5 MW.

- c) **Present status of the project:** Prefeasibility.
- d) **Estimated Investment:** The following is the criteria taken into account:

Calculation of costs corresponding to January 1991, without considering the increases due to inflation.

Costs for acquisition of land are not included. Scavenging is not included during the construction.

Engineering and supervision costs are estimated by 12%.

The summary of the work costs, in thousands of dollars, without including the transmission line and substation, is the following:

Movable dam	4.360.50
Detour of the river	881.56
Power house	3.468.74
Subtotal	8.710.80
Engineering and supervision (12%)	1.045.30
Contingencies (15%)	1.463.42
Total	11.219.52

e) **Quality benefits:** Will represent a stable source of energy, based on renewable resources, for the city of Cobija, the towns of Villa Busch and Porvenir and nearby areas, and will increase the growth of this area in the department of Pando, in the border with Peru, and the integration process.

f) **Comments or suggestions:** In the preliminary study it is estimated the cost of the associated transmission (Tahuamanu 24 KW substation; 2,5 MVA transformers, a 39 Km 24 KW line from Tahuamanu to Cobija) in 590 thousand dollars.

The prefeasibility study must be complemented including Brasilea and Villa Pitacio, in Brazil, in the study of electrical energy market.

g) **Location plan and area of influence:** The location of the hydroelectrical central, of the associated substation and the area of influence of the project are shown in map E-BO-05-G1.4.

4. CONCLUSIONS AND RECOMMENDATIONS

As a result of this summary and conception of this integration energy projects with Peru, it has been concluded that energy will increase the integration between both countries, will promote its development and will increase the possibilities of new investments in the region.

In view of the analysis made, it is recommended to:

1. Effect the prefeasibility studies of the projects for the 55 MW Thermoelectrical Central in Carrasco and the 50 MW Thermoelectrical Central in Desaguadero.
2. Effect the prefeasibility studies of the projects for the 200 MW Thermoelectrical Central in Desaguadero; 100 MW Thermoelectrical Central in Desaguadero and Gas Pipeline from Bolivia to Ilo.
3. Investigate the Peruvian interest in some of the projects studied according to the two recommendations mentioned before.
4. Effect the prefeasibility studies of the projects: 25 MW Charazani River and 40 MW Charazani River.
5. Complement the prefeasibility study of the Tahuamanu Bajo River project, including the markets of Brasilea and Villa Pitacio in Brazil.

COLOMBIA

Integration energy projects

ALBERTO VASQUEZ RESTREPO

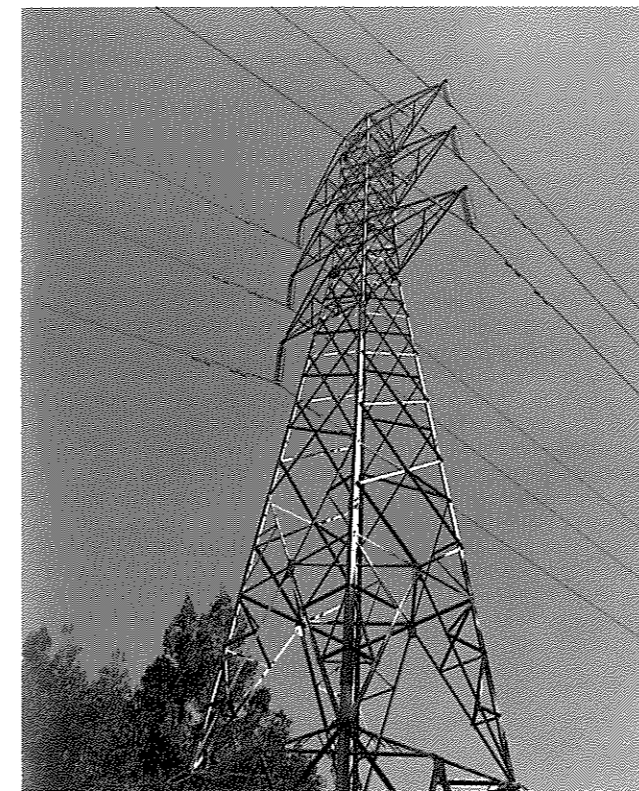
Alberto Vásquez Restrepo: Mining and Civil Engineer - Colombia.

- Has been the manager of Empresa de Energía de Medellín (Energy Company of Medellín) and Empresa de Energía de Bogotá (Energy Company of Bogotá) and National President of Cámara Colombiana de la Construcción (Colombian Chamber of Construction).
- Minister of Mines and Energy, Colombian Ambassador before the European Communities and Governor of Antioquia.

1. ENERGY INFRASTRUCTURE

During the 70s and at the beginning of the 80s, the amplification of the energy infrastructure in Colombia had its mayor activity in the electrical subsector and, in a minor degree, in the coal and hydrocarbon subsectors.

In a medium term, it is expected to improve the balance, between generation, transmission and distribution, in the electrical subsector, and to amplify the generating capacity. Simultaneously, in the hydrocarbon sector, it is expected to increase the transportation volume due to the natural increase of the demand; at the same time, the potential exploita-



tion of Cusiana and Alto and Medio Magdalena as well as the necessary expansion of the refining structure indicate an important growth of the transportation and exports. In the case of natural gas, it is expected to expand its networks considerably, at a national level, during the next years. Regarding coal, the production goals and exports require the upgrading of the railway and adaptation of ports.

1.1 Electrical subsector

In hydroenergy, the potential available is estimated by 93,000 MW. In 1992, the effective installed capacity of the interconnected system was 8,488.7 MW, of which 79.6% came from hydroelectrical sources and 20.4% from thermic ones. From the total thermic sources, 52.8% corresponded to gas plants, 29.1% to coal and 18.1% to turbogas¹ (see map E-CO-01-G1).

The expansion plan of the Interconnected System for the period of 1992-2001 includes the following complementary projects to the electrical interconnection with Venezuela: El Guavio and Río Grande II, Urrá I, La Miel II and Porce II, approved for construction, and Nechí, Fonce and Porce III, which have design studies. Likewise, there is a thermoelectrical project to be defined, up to 300 MW. These projects would be complemented with the Programa de Recuperación de Unidades (PRU) (Unit Recuperation Program), which includes projects that with their rehabilitation and power increase will contribute to the increase of the normal capacity to about 250 thermic MW and 70 hydraulic MW. (See Chart 1).

Long term planning studies are also being carried out, which will allow to review the Expansion Plan and incorporate turbogas and combined cycle projects.

1. See ISA; Colombian Electrical Sector, February 1993.

ATLANTIC OCEAN

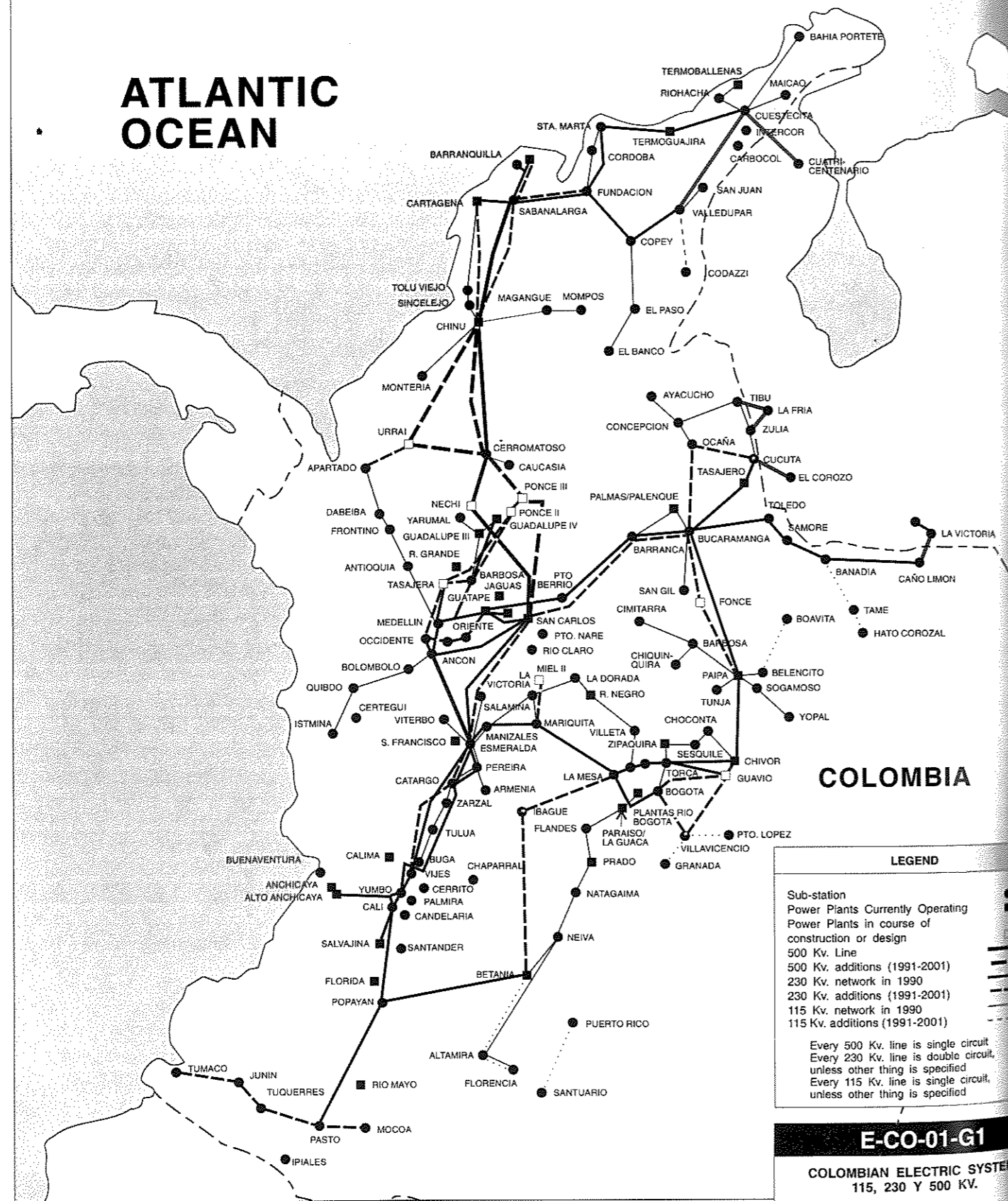


Chart 1
Expansion Plan for Generation and Transmission
Period 1993-2000

Year	Centrals	Type	Capacity Installed —in MW—	Status
1993	El Guavio	H	1000.0	C
1993	Río Grande II (Niquía)	H	22.5	C
	Río Grande II (La Tasajera)	H	300.0	C
1998	Urrá I	H	340.0	D(4)
1999	La Miel II	H	380.0	D(4)
	Porce II	H	590.0	D(4)
2000	Nechí	H	590.0	F(5)
2001	Fonce	H	420.0	F(5)
2002	Porce III	H	760.0F(5)	

- (1) H: Hydroelectrical Central.
(2) C: Construction, D: Design, F: Feasibility.
(3) The Río Grande II Project includes two centrals: La Tasajera and Niquía.
(4) Projects authorized for construction.
(5) Projects authorized for design. Besides, the Riachón (90 MW) project desing was authorized as well as the revision of the La Miel and Calima III (240 MW) designs, and the design of the thermic centrals of San Jorge and Tibita, and also the thermic units of 150 MW of Amagá, Cartagena IV, Paipa IV (150 MW) and Zipa VI (150 MW).

The electrical system expansion plans in Colombia were made to satisfy the requirements of the demand up to 1996; however, there is a delay in starting up two important hydroelectrical projects (El Guavio, with 1,000 MW, and Río Grande, with 300 MW).

In the El Guavio hydroelectrical project, in spite of the delays in its execution, due mainly to problems deriv-

ed from the construction of the civil works because of unfavorable geological conditions, two units of 200 MW began to operate in December 1992 and January 1993, another unit began to operate in March and the other two units will begin to operate in May and June 1993. The Río Grande project was expected to begin operating in 1989; however, it is estimated that it will begin to operate in October 1993².

Colombia suffered a severe energy rationing in 1992, and because of this the authorities from the energy sector promoted a short and long term series of actions, with the purpose of reducing the energy shortage, being the following the most important ones:

- Accelerate the recuperation of 345 MW from the thermic centrals.
- Installation of additional thermic generation by Ecopetrol. Three combined cycles, of 50 MW each one, are expected; and by the end of 1992, 29 MW corresponding to the turbogas cycle from the first group was started up.
- Assure the availability of natural gas for the supply to the Turbo-Chinú Central from the Corporación Eléctrica de la Costa Atlántica (CORELCA) (Atlantic Coast Electrical Corporation) which will allow to dispose of 66 additional MW.
- Accelerate the starting up of El Guavio project in a stepped way up to completing 1.000 MW in June of this year.
- Accelerate the interconnection with Venezuela. It is important to mention that the energy transfers between both countries began operating in November 1992, with a transfer of power of 100 MW, which was expected to increase to 150 MW by the end of 1993.

2. See ISA; Interconexión Eléctrica S. A.; Colombian Electrical Sector, February 1993.

E-CO-01-G1

COLOMBIAN ELECTRIC SYSTEM
115, 230 Y 500 KV.

(1991 - 2001)

SOURCE: INTERCONEXION ELECTRICA S.A.



1.2 HYDROCARBON SUBSECTOR

The proved oil reserves, with the development and discovery of the Cusiana Field and the findings in the Casanare plains, reached 3,142 million barrels³.

The latest oil discoveries, which demonstrate the success in the application of the present oil association contracts with foreign companies, have considerably widened the Colombian oil horizons. In fact, the reserves in the Samoré Plains, could be similar to those in Caño Limón (1.500 million barrels), although the definite studies are not available yet. It is worth mentioning that, in 1993, exploration investments for

US\$1,200 millions are expected, in comparison with US\$328.2 millions which came to Colombia the year before and US \$144.7 millions, in 1991³.

Today, the oil production is approximately 0.5 million barrels per day. Colombia has six refining centers, being the most important Barrancabermeja, with 180 thousand barrels per day and Cartagena, with 70 thousand barrels per day, which come to 259 thousand barrels per day, and a average available capacity of 87%. The duct network has a total length of 9,034 Km of which 75% belongs to the public sector and 25% to the private sector. In this way, the total transportation capacity exceeds 800 thousand barrels per day⁴.

3. LATOIL; No. 053, United Kingdom, 03-1993.

4. OLADE - IPSA; The Andean Group; A Vision of the Energy Sector, 1992.



In the next quinquennium, it is expected to develop the fields of the Casanare plains, a gas plant, a refinery of 100.000 barrels per day, a gas pipeline network with the corresponding home delivery network, an oil pipeline for the Casanare crude exports, and some petrochemical projects.

Regarding gas, the proved reserves of which reached 3.86 BPC (1012 PC) in 1992, it has been decided to use it in a massive way. An expansion plan that would cover approximately 70.000 users, by 1975⁵, is expected.

5. OLADE - SIEE; Version of March 1993.

Likewise, a program to replace motor gasoline has been designed, with the use of compressed natural gas in the transportation sector. The goal is to take care of 7.300 vehicles from the public service by 1995, mainly buses, compared to 1.150 vehicles that were taken care of in 1990.

Once the evaluation of the new gas findings has been completed, especially in Cusiana, it will be possible to measure the supply of important consumption centers which lack sufficient gas such as Bogotá, Medellín and Cali.

1.3 Coal subsector

Colombia has the highest coal resources in Latin America and the Caribbean and experience in this area which could be used by the other Andean countries. The proved coal reserves were 6,488 million tons in 1992, while the production was 23,5 million tons⁵.

In the international context, the country is an important thermic coal exporter. For this purpose, the private investment, foreign and local, is being promoted; at the same time, the development of an integral infrastructure for transportation and shipment is being supported, the so called coal paths, in order to facilitate the production both for big projects and for small and medium mining.

In 1990, it was estimated the present and future projects would require about US\$2,000 (sic) in the next five years. Among the principal mining projects are: La Loma, in Cesar, that projects productions of 10 million tons; Calenturitas, San Luis and Amagá.

2. ELECTRICAL INTERCONNECTION PROJECTS IN COLOMBIA-ECUADOR

Background

In February 1978, a two-year agreement was subscribed, which was renewable at the parties' convenience for equal periods, between the companies EMELNORTE from Ecuador and CEDENAR from Colombia, to exchange electrical energy for a maximum of 3 MW. This agreement was increased for delivery up to 12 MW in May 1980.

In October 1986, commercial conditions were established and the agreements before mentioned were verified, for power and energy purchases from the CEDENAR system to EMELNORTE. It was also agreed to supply the energy at tensions of 13.8 and 34.5 KW, a tolerance of approximate 5% variation in the nominal tension was accepted, a minimum power factor in CEDENAR of 0.90, and it was established that the charge should be evenly distributed among the phases. The parties agreed to effect the respective maintenance of their systems up to the border.

The sales price for this service should be invoiced with the following values (October 1986):

Charge for power: S/ 4.50 KW-month

Charge for energy: S/ 1.80/KWh.

These tariffs had to be adjusted monthly with a 2% increase and should be revised every year. The invoices would be done monthly and would be paid in sucres within the following 30 days of its presentation. Between 1988 and 1990, the transfers amounted to an average 12.4 million KWh per year and 2.2 MW/month of power.

In December 1990, it was mutually established an average sales price of S/ 36.41 KWh for the total amount supplied to CEDENAR during the year of 1990.

It was verified, likewise, the need to effect the necessary studies for a new agreement of electrical energy exchange between EMELNORTE and CEDENAR.

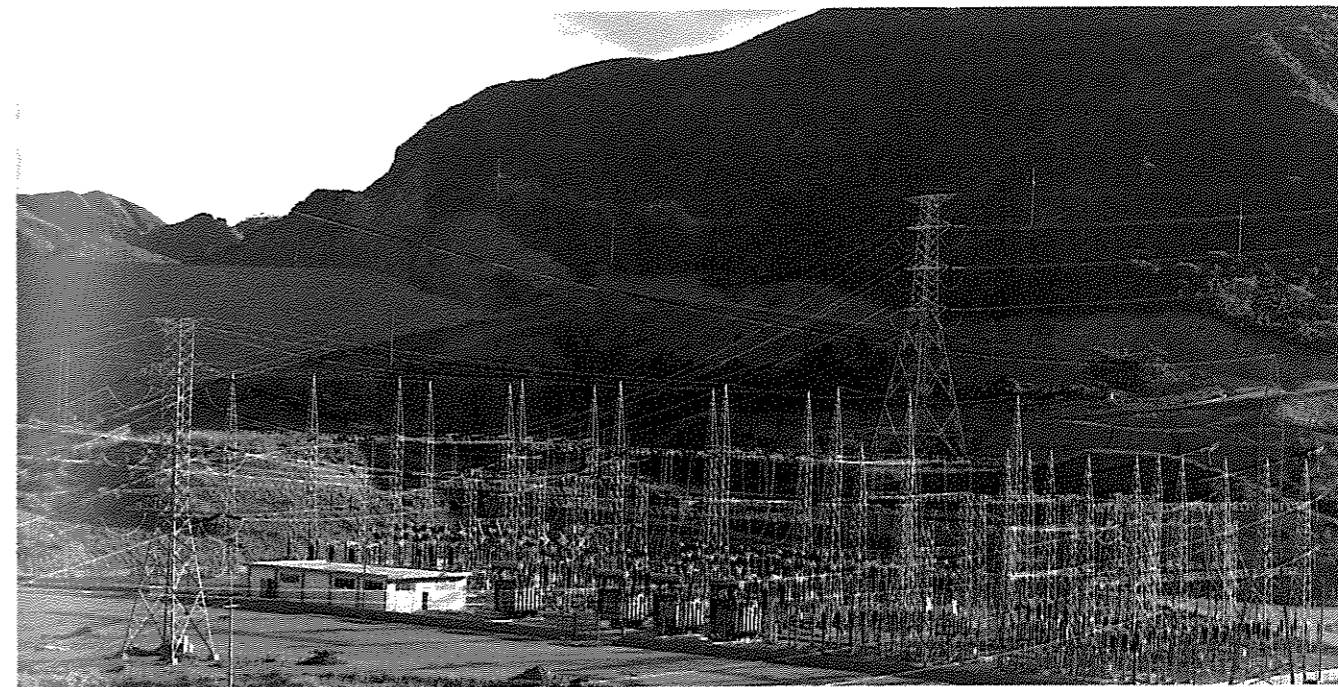
As a follow-up of these actions, in May 1991, it was agreed in Quito to: polish the planning of the distribution and subtransmission of the systems of the frontier areas, establish tentatively the requirements of the transfers of energy and power and the planning of the systems and evaluate an energy purchase tariff for future exchanges, that will allow to establish different situations both in normal transfer periods, as in emergency and overcapacity situations, as well as to study the possibility of interchanges of physical units and not financial.

Project 1: Colombia-Ecuador Interconnection through the 34.5 KV line

- Location:** The project is located in the South of Colombia, in the department of Nariño (Ipiales) and North of Ecuador, in the province of Carchi (Tulcán).
- Description of the project:** The process considers the delivery of 20 MW, of which 5 MW were supplied on the first stage, 5 additional MW will be delivered on the second stage, and 10 MW on the final one; all at a tension level of 34.5 KV.

For the second stage, it is required on the Colombian side to change the conductor and a sector of 2.5 Km of the line in 34.5 KV, and also the electrical transformers of the Panamericana substation in Ipiales. The measurement system⁶ will be installed on the Ecuadorian side.

6. CIER; Bulletin from the Regional Electrical Integration Commission No. 248, November 1992.



For the Colombo-Ecuadorian interconnection in 34.5 KV and delivery of 10 MW corresponding to the third stage, it is necessary to build the new line: Tulcán (Ecuador) - Ipiales (Colombia), in 34.5 KV.

- Present status:** The works for the initial 5 MW were already completed in 1992, and as of April 1992, the energy transmission was started; notwithstanding, in May of the same year, the transfers were stopped, because CEDENAR supplied Ipiales without any problem.

For the second stage, with respect to Ecuador, the tension exchange from 34.5 to 69 KV in the line Ibarra-Tulcán was finished in December 1992. To finish the work, it is required to effect minor works on the line: change the tension level from 34.5 to 69 KV in 4 Km, from the Tulcán substation to El

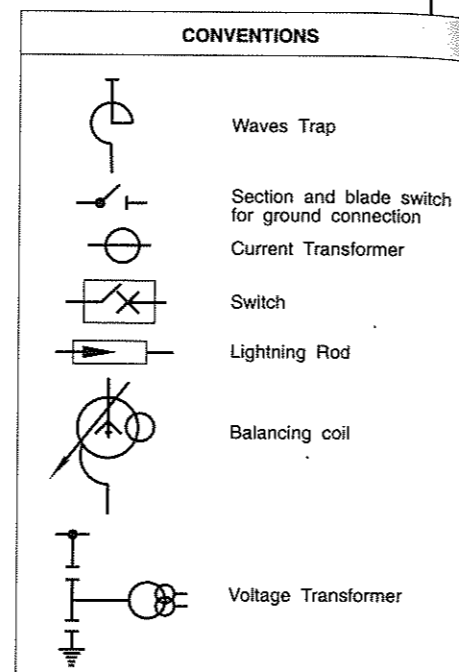
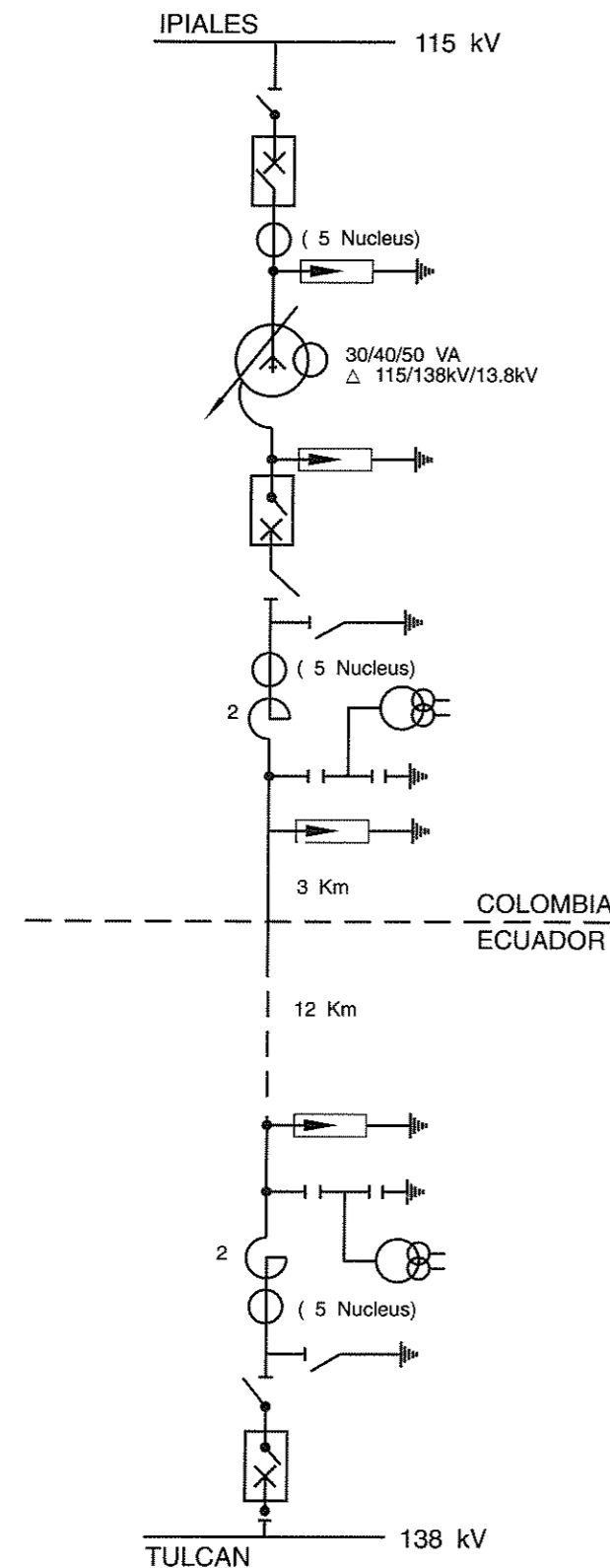
Rosal substation (both located in Tulcán, Ecuador); and install a 69/34.5 KV transformer in El Rosal substation, in order to allow the energy transport to Colombia. Regarding Colombia, financing is required by ICEL and CEDENAR.

- Approximate investment:** On the second state, the investment will come up to US\$19,846 (sic). For the third stage, the total cost of the project comes up to US\$258.932.

Project 2: Frontier interconnection Colombia-Ecuador at 115/KW

(See diagram E-CO-02-G1)

- Location:** Interconnection at 115/138 KV is located between the towns of Ipiales (Colombia) and Tulcan (Ecuador).



TYPICAL EQUIPMENT SPECIFICATIONS

123kV, 800A, 12.5 kA short circuit switch
800/10A I transformer
Class 96, ZnO, lightning rod
3 winding transformer, Δ connection for auxiliary services 30/40/50 MVA, OA/FA/FD
Class 96, ZnO, Lightning rod
145 kV, 800A, 12.5kA short circuit switch
145kV, 800A, 12.5kA short circuit section switch
800/10A I transformer
800A, .32 mH waves trap, 100-400 kHz
138/ $\sqrt{3}$ kV/ 115/ $\sqrt{3}$ Volts. V transformer
Class 96, ZnO, Lightning rod
ACSR WIRE, 30/7, LARK, 397,5 MCM, 593 A

E-CO-02-G1

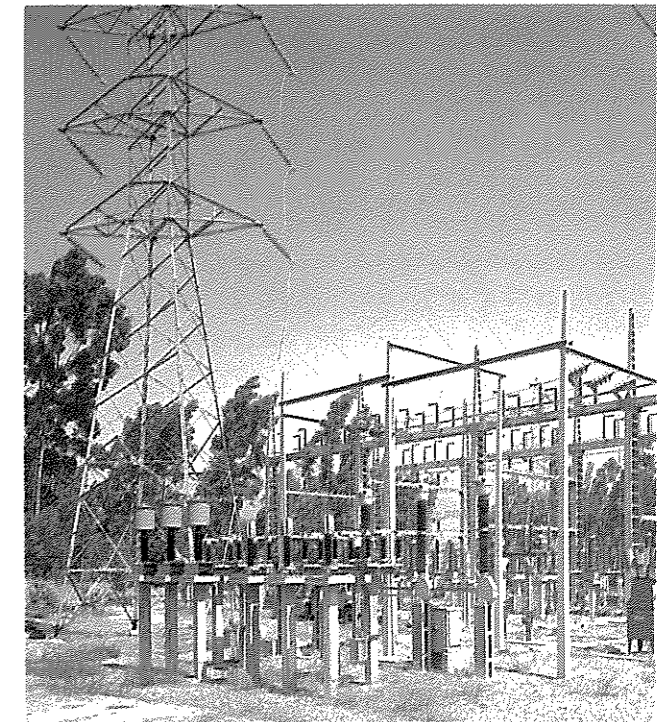
**UNIFILAR DIAGRAM
COLOMBIA - ECUADOR
INTERCONNECTION
115/138 kV**

b) **Description of the Project:** The project consists of the starting up of a 15 Km line between Ipiates and Tulcan, to transfer 40 MVA at 138 Kv between the systems of CEDENAR and EMELNORTE, for which it is required to build the Panamericana interconnection substation (Ipiates) of 50 MVA and 115/138 KV.

The preliminary technical characteristics are the following:

1. Transmission line: Ipiates-Tulcán
Tension level: 138 KV
Approximate length: 15 Km, of which 12.4 are in Ecuador and 2.6, in Colombia.
Type of structure: Metalic (towers)
No. of circuits: One.
2. Expansion of the Tulcán substation: It is required to install a line module at 138 KV in main barrage and transfer.
3. Expansion of the Ipiates substation. It is required the installation of:
 - A line module at 138 KV in simple barrage.
 - One (1) transformer module at 115 KV in simple barrage.
 - One (1) transformer 138/115 KV of 40 MVA.

According to the technical analysis made, the construction of the line at 138 KV Ibarra-Tulcán, is a part of the development plan of the electrical system of Ecuador. It is basic for the execution of the interconnection project Tulcán-Ipiates, due to the fact that without this line it is impossible to acquire the necessary energy transfers. For this reason, it is recommended that INECEL accelerates the execution of this project.



c) **Present Status:** This Colombo-Ecuadorian electrical interconnection project is on the drawing board.

The borderline crossing was defined jointly between INECEL and ICEL; also exchange of information was made between the two entities, in order to effect the work design.

Up to this moment, the preliminary routes are planned, the isolation of the line, and the mechanical design of the structures. The civil works (foundations), the plans and designs for the expansion of the substations associated to the project (Panamericana S/E and Tulcán S/E), are still to be defined.

Notwithstanding, before a decision is made, it is suggested to make a study of technical, economical and financial feasibility of the project.

Project 3: Electrical interconnection Colombia-Ecuador at 230 KV between Quito and Pasto

- d) **Approximate investment:** The total cost of the project is US\$4.2 millions, at the prices of December 1989. The cost estimate did not consider import taxes (tariff and Law 75) nor sales taxes (IVA).

The obtainment of financial resources has been made separately, so it is considered convenient that INECEL and ICEL present the project jointly before CAF and/or other entities.

- c) **Expected benefits:** Both for the projects at 34.5 KV and for the ones at 115/138 KV the benefit is mutual, due to the fact that more reliability is expected from EMELNORTE AND CEDENAR systems and this allows to take care of emergencies or difficult situations as the recent electrical rationing in Ecuador and Colombia.

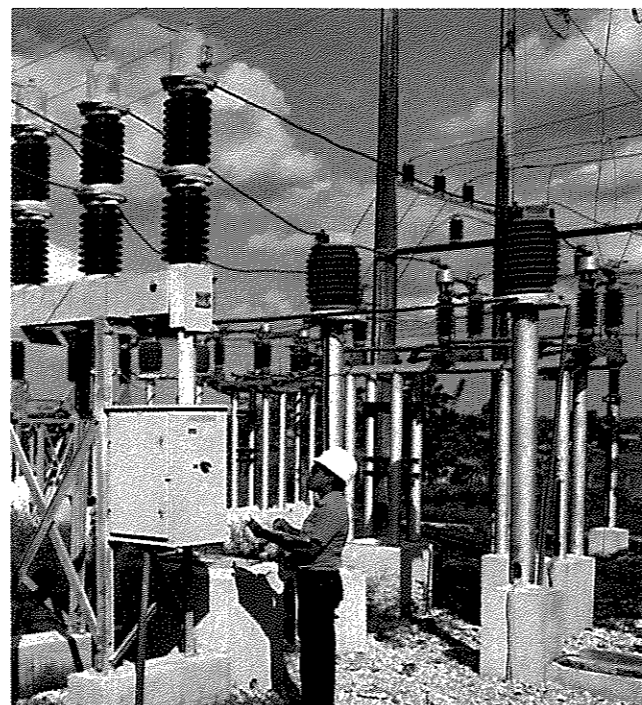
Given that the electrical systems taken care of by EMELNORTE and CEDENAR are located at the furthest end of the electrical systems of Ecuador and Colombia, the interconnection helps improve the tensions and make the electrical systems more stable.

Likewise, when assuring the electricity supply to the frontier area, the integration and welfare of the inhabitants of the province of Carchi, Ecuador, and of the department of Nariño, Colombia, are helped.

point in Colombia would be the substation of Jamondino in Pasto.

- c) **Present status:** There are no studies that would determine the technical-economical convenience of this interconnection alternative between Colombia and Ecuador. The project is on the drawing board.
- d) **Expected benefits:** The 230 KV interconnection would allow to integrate both electrical systems, especially the South region of Colombia and the North region of Ecuador.

Through this project, the reliability of the two electrical projects would improve, power and energy exchanges could be made and it would help to overcome emergency situations. At the same time, the needs for investment on generation capacity would decrease, with financial benefits for both countries.



Project 4: Chiles (Colombia) and Cerro Negro-Tufiño (Ecuador) Geothermic Program

(See map E-CO-03-G1)

- a) **Background:** In 1982, the Energy Ministers of Colombia and Ecuador signed the Complementary "Agreement of the Scientific and Technical Cooperation Agreement between the Governments of the Republic of Ecuador and Colombia for the Geothermic exploitation of the frontier area of Chiles-Cerro Negro-Tufiño".

According to the document, both governments would jointly develop the exploration of the above mentioned area of geothermic interest. In addition, the document mentioned that both governments would name ICEL and INECEL as executing entities of the project.

In 1984, the "Agreement for the Establishment of a Fiduciary Fund between the Italian Government and OLADE for the Geothermic Prefeasibility Studies of the Binational Project Chiles-Cerro Negro-Tufiño between the Republics of Colombia and Ecuador", was signed, based on which the Italian Government supplied a financial contribution of US\$ 1.1 millions for the project.

In 1985, OLADE, ICEL and INECEL signed a "Non-Refundable Technical Cooperation Agreement" in which OLADE is committed to supporting ICEL and INECEL in the execution and evaluation of the prefeasibility results of the project, for which there were contributions from the Italian Government of US\$ 1.1 millions and US\$ 225 thousand from ICEL and INECEL.

After 1986, the geoscientific prefeasibility investigations were started, which ended by the end of 1987 with the delivery of the final report by the Italian company Aguater.

- b) **Description of the project:** The area studied covered 1.800 Km² distributed on both sides of the Colombia-Ecuador border, where geovolcanic, hydrogeological, geochemical and geophysical investigations were made. Geophysical investigations included gravimetry, magnetometry, geoelectrical and magnetotelluric studies.

The results of the geoscientific investigations indicated the possible presence of a thermic water reserve between approximately 1.550 and 2.000 Mts. deep.

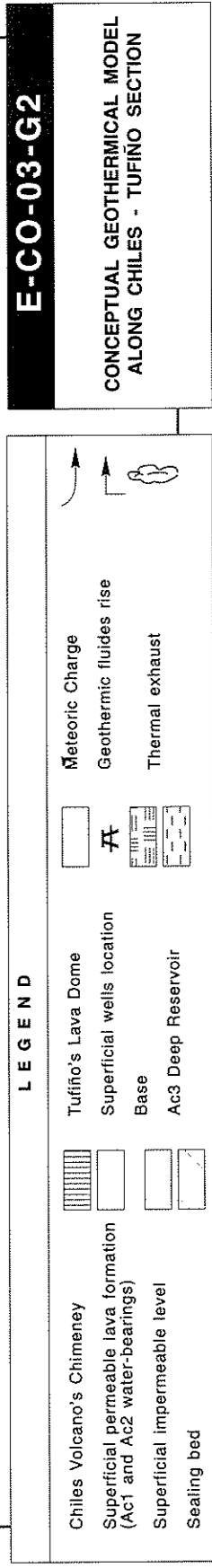
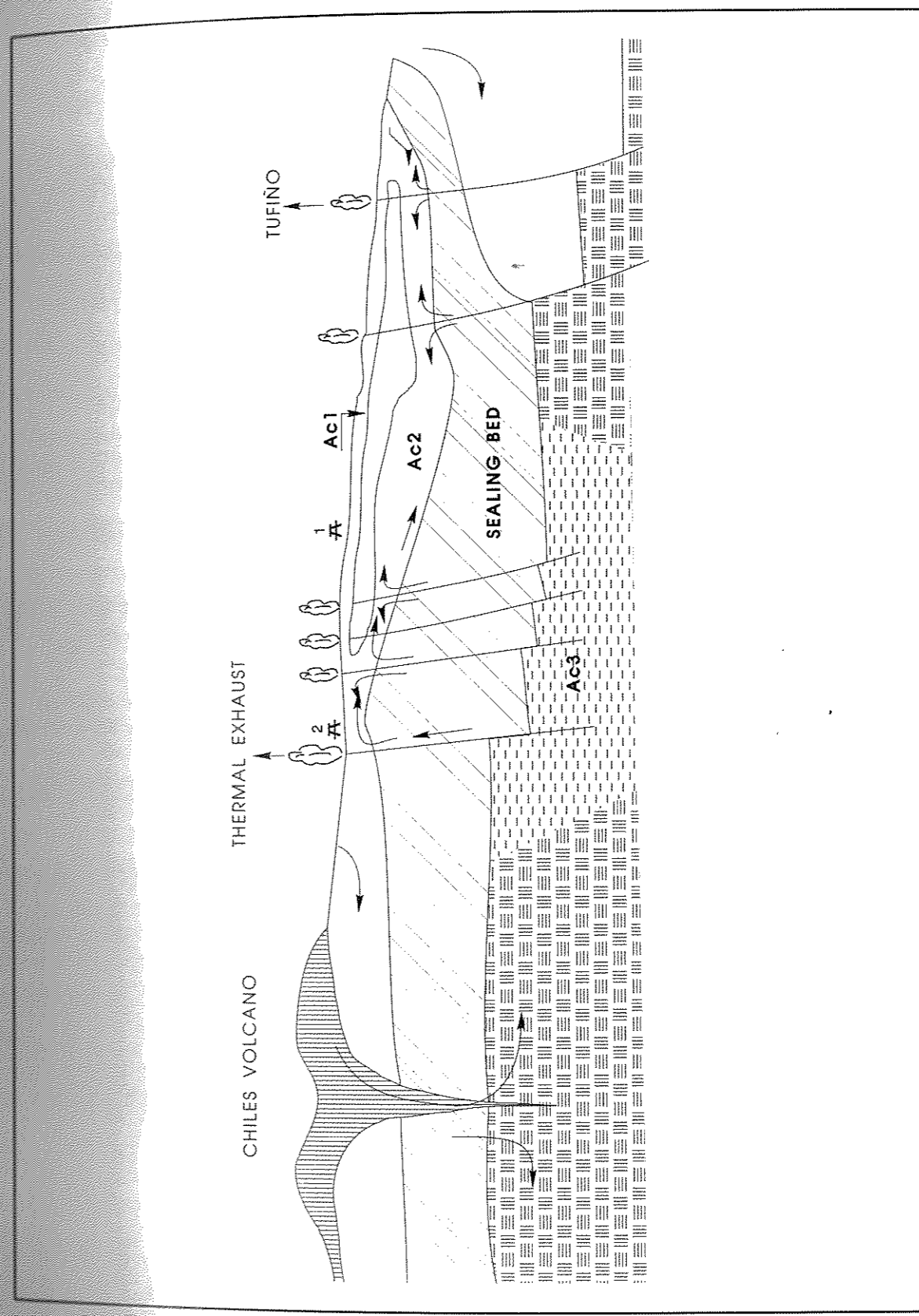
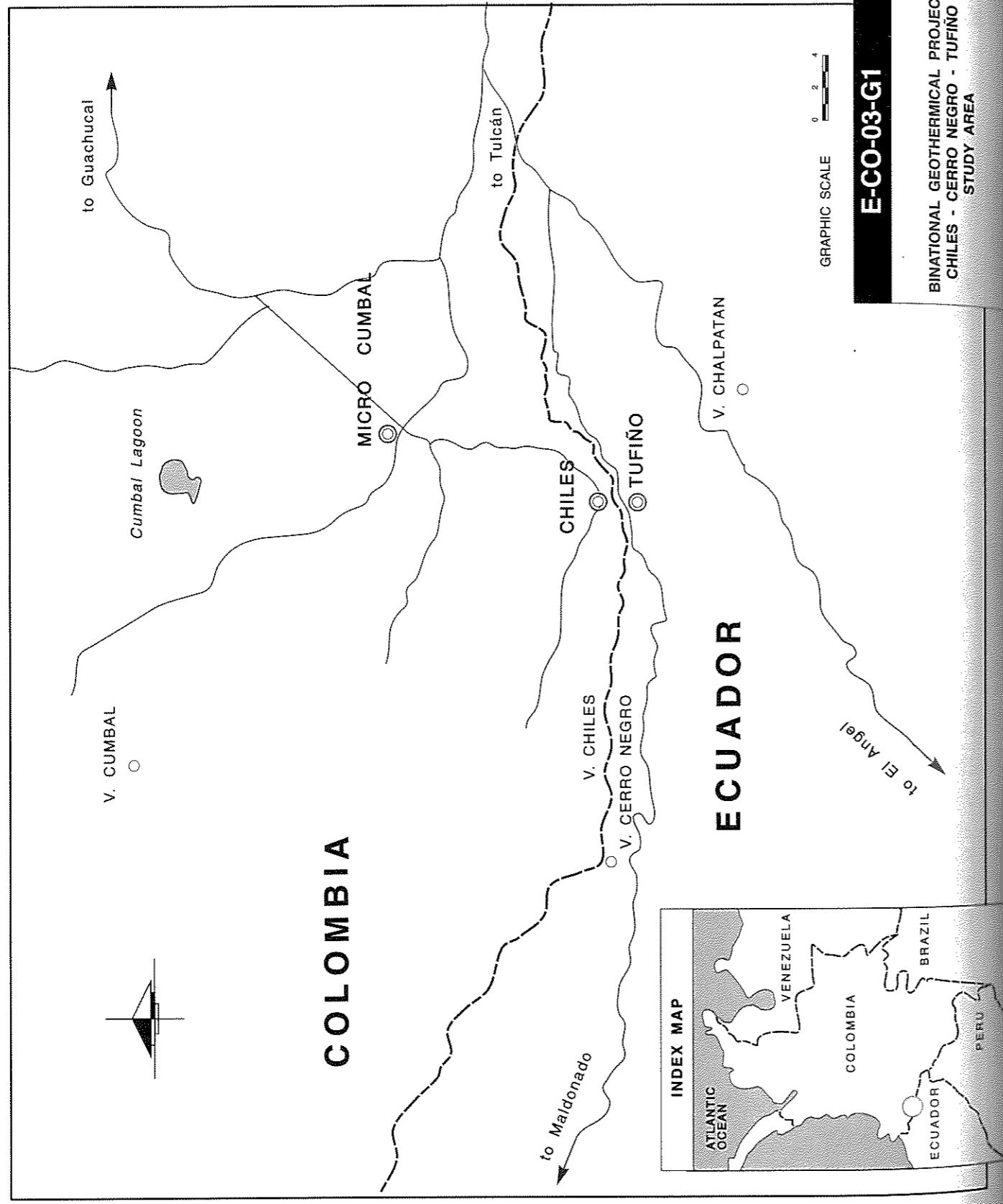
In order to evaluate the presence and industrial interest of the thermic water reserve, three drillings of 450 Mts. were recommended. Initially, one would be made in Colombia and the other in Ecuador; the third one would be executed depending on the results obtained from the latter.

The area studied is characterized by an intense tectonic activity associated with a volcanism of a calco-alkaline nature that has persisted for a very long period of the Superior-Miocene Inferior Pliocene until recent times.

The petrological data about the volcanoes in the Chiles and Cerro Negro area suggest the presence of a not very deep feeding magmatic system that may act as an adequate heat source for a geometrical system of high entalpia. This way, it is difficult to estimate its depth accurately.

With the information available today, a geothermic model for the project is tentatively proposed, presented in the chart E-CO-03-G2.

- c) **Present Status:** The project, the final objective of which is the installation of an electrical generation plant, has several phases. In the first one, called prefeasibility, OLADE has recommended making a complementary geochemical and geophysical evaluation that would allow to determine the



geothermic possibilities of the area. The continuation of the subsoil investigation will continue depending on the investigation results, with the drilling of exploratory wells of approximately 2.000 Mts. deep. Up to this moment, the project depends on obtaining financial resources.

- d) **Approximate investment:** Approximately US\$ 200.000 are required to conclude the first prefeasibility stage, US\$ 12.4 millions for the feasibility stage and US\$ 12.1 millions to develop a 5 MW central.
- e) **Expected benefits:** It would be possible to have an alternate source of electrical energy generation in the department of Nariño, which would be beneficial to all the Colombia-Ecuador border region.

Besides, it would furnish new feeding to the Colombian interconnected system, which would allow to improve the voltage of the CEDENAR system.

Project 5: La Plata Microcentral

- a) **Location:** The project is located in the Colombian-Ecuadorian border, in the department of Nariño (Colombia) and the province of Carchi (Ecuador).
- b) **Description of the project:** In the Colombia-Ecuador binational encounter, which took place in 1991, the EMELNORTE Company informed about the construction of La Plata microcentral, which would give service to thirteen towns in the Ecuadorian area, near the towns of San Juan, La Unión and Talambí in Colombia, which would benefit about 400 families.

Given the human integration of towns, EMELNORTE suggested supplying them with energy and establishing an agreement for the construction of networks, its recovery and maintenance and the invoicing of the service.

According to the latest evaluations made by technicians from the Instituto Nacional de Energía (INE), and EMELNORTE from Ecuador, the installed capacity of the microcentral would be 150 KV (initially, it was designed for 300 KV). This situation would hinder the development of a binational project, as it would only have the capacity to transfer only 20 remaining KV from Ecuador to Colombia. At the same time and in order to supply the Colombian frontier towns, it would be important to make the geothermic project Chiles-Cerro Negro-Tufiño, as it was mentioned above.

- c) **Present status:** There are no feasibility studies or design, and the interconnection costs have not been determined either.
- d) **Expected benefits:** The electrical supply would be guaranteed to the Colombian towns that are isolated from the interconnected system, that otherwise would require more expensive ways of producing electricity such as diesel plants.



3. INTERCONNECTION PROJECTS IN COLOMBIA-VENEZUELA

(See map E-CO-04-G1)

Background

Since the beginning of the 60s, conversations to interconnect the electrical systems from Colombia and Venezuela were initiated in order to effectuate power and electrical energy exchanges. The first agreement was signed between the Compañía Anónima de Administración y Fomento Eléctrico CADAPE (Venezuela) and Centrales Eléctricas del Norte de Santander S.A. CENS (Colombia).

In 1964, the assembling of two subtransmission lines at 13.8 and 34.5 KV began, with a total length of 14 Km and a 15 MW capacity. The lines interconnected the substations of Cúcuta (Colombia) and San Antonio de Táchira (Venezuela).

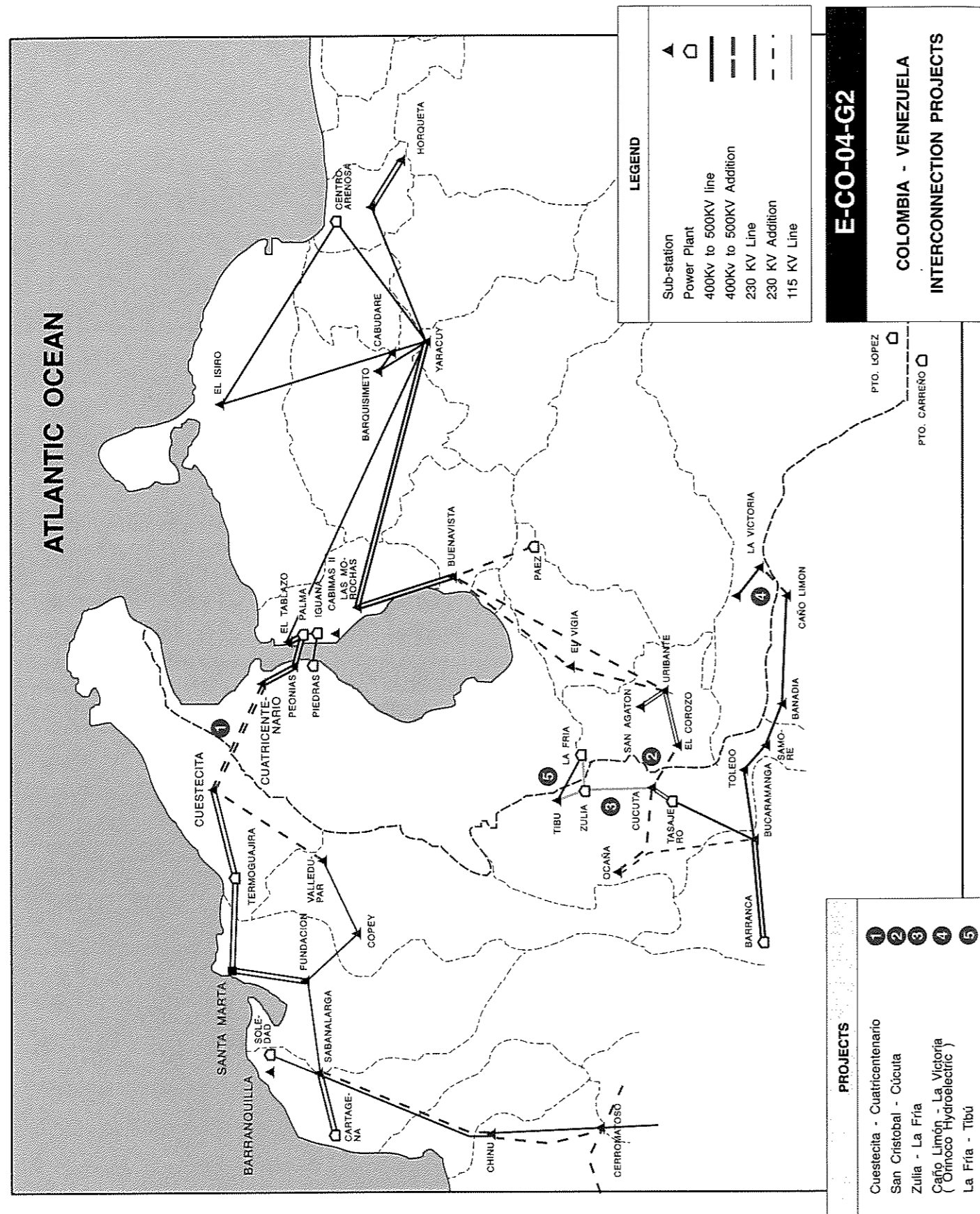
By 1969, a line at a 115 KV level began to operate,

29 Km long and with a 40 Mw capacity, which joined the Planta Termoeléctrica del Zulia, in Santander del Norte, and Planta Termoeléctrica Táchira, an interconnection that has served as support to both countries in emergency situations. During the last years, this interconnection has been fundamental for Colombia, as it has permitted to guarantee the supply to Aguachica and Ocaña regions.

In 1975, another agreement was signed between CADAPE and the Intendency of Arauca in order to furnish energy to the city of Arauca from the Guasdalito plant (Apure State in Venezuela) through a 13.8 KV distribution line.

These exchanges took place until the end of 1989, when the Bucaramanga-Arauca line, property of Interconexión Eléctrica S.A. ISA went into service.





Project 1: 230 KV interconnection between the substations of Cuestecita (Colombia) and Cuatricentenario (Venezuela)
(See map E-CO-05-G1)

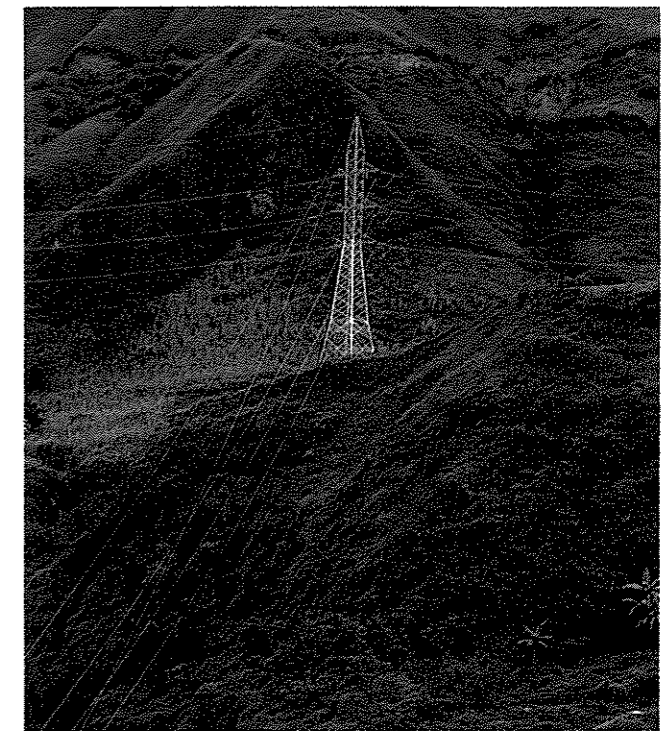
- a) **Location:** The project is located in the North Zone of Colombia (in the Department of La Guajira) and West Venezuela in the region surrounding the city of Maracaibo.
- b) **Brief description of the project:** The project consists of the assembly of a 230 KV line, 130 Km long, of which 45 are in Colombian territory and the other 85, in the Venezuelan area; the enlargement of the Cuestecita substation in the Department of La Guajira (Colombia) and the construction of the Cuatricentenario substation in the Zulia State (Venezuela).
- c) **Present status:** The first satge of the electrical interconnection between both countries was inagurated in November 1992, with the establishment of a simple circuit 230 KV line between Cuestecita and Cuatricentenario, with a 100 MW capacity. In December 1993, it was increased to 150 MW, due to the installation, in the Cuestecita substation, of a capacitance compensation of 78 Mvar. In December 1994, with the new Cuestecita-Valledupar 230 KV line, the transportation capacity will be increased to 200 MW.

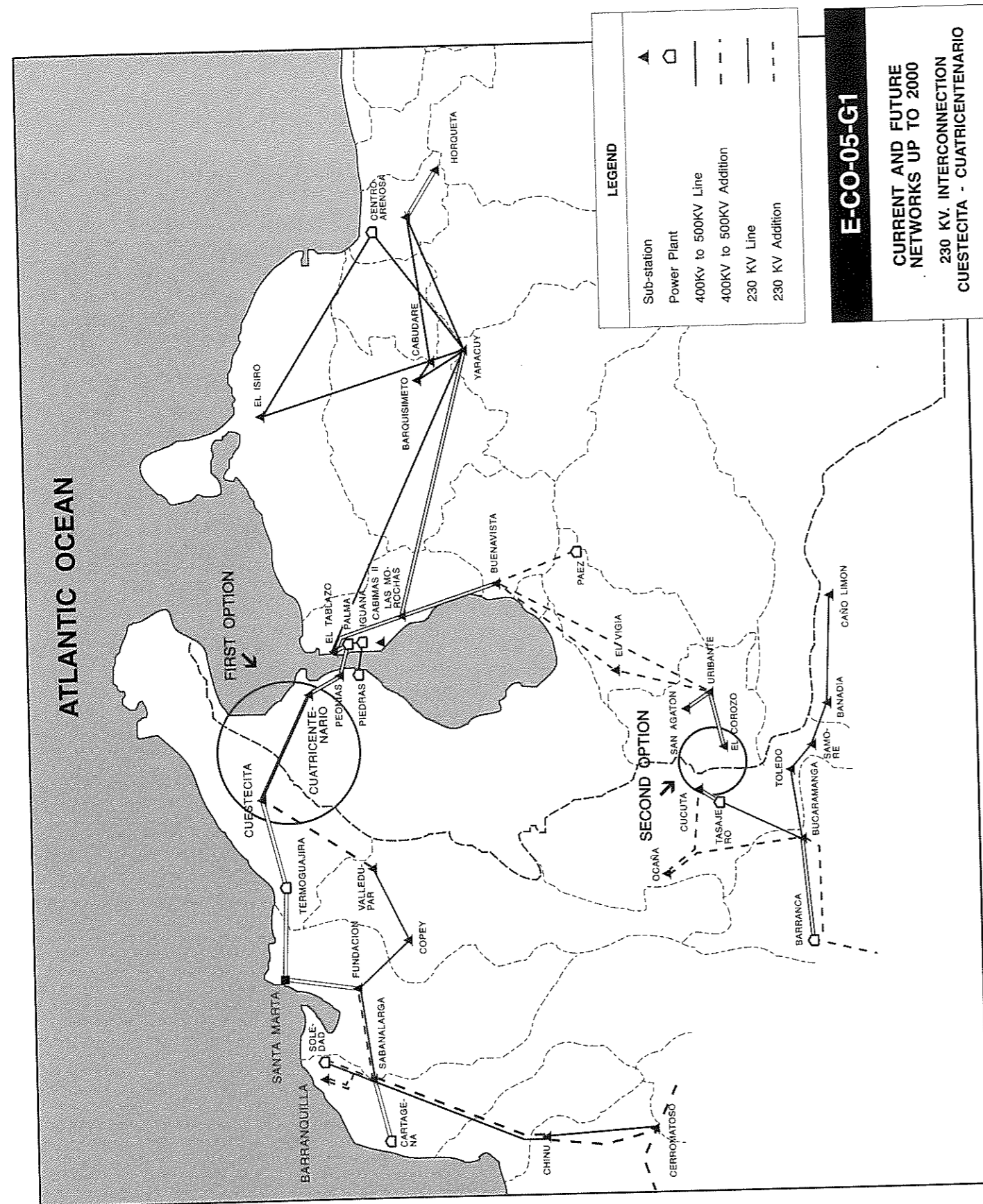
- d) **Investment:** This project had a cost of US\$ 29.4 millions. The cost of the work in the Colombian

side was of US\$ 10.4 millions, which were financed with their own resources bay ISA and loans from the national government, FEN and EXIMBANK. The cost of the work in Venezuela was of US\$ 13 millions.

Project 2: Second interconnection project at 230 KV between Colombia and Venezuela
(See map E-CO-05-G1)

- a) **Location:** The project is located in the Colombian Venezuelan frontier region, between la Guajira and Maracaibo.
- b) **Description of the project:** Consists of the construction of a second 230 KV transmission line





between the substations of Cuatricentenario (Venezuela) and Cuestecita (Colombia), 130 Km long.

Besides, the project requires the installment of a 230 KV line, 400 Km long, in the CORELCA system.

- c) **Present status:** The convenience of building the second second isolated circuit of 400 KV to be initially operated at 230 KV, is being studied, which would permit higher power and energy exchanges.

Project 3: Electrical interconnection at 230 KW between El Corozo S/E in San Cristobal (Venezuela) and San Mateo S/E in Cúcuta (Colombia)

(Ver mapa E-CO-05-G1)

- a) **Location:** The project is located in the Colombian-Venezuelan frontier, between the cities of Cúcuta in Colombia and San Cristóbal in Venezuela.
- b) **Description of the project:** The project would consist of the installation of a double ternary line at 230 KV, 39 Km long on the Venezuelan side, and 10 Km on the Colombian side. The maximum transportation capacity of the line would be 300 MW. In the case of Colombia, it would be required the construction of a new transmission line, at 230 KV, between Cúcuta and Bucaramanga, and in the Venezuelan electrical system, the completion of the Complejo Hidroeléctrico Urbante-Caparo.
- c) **Present status:** The construction and its financing has not been defined, especially in the additional works in Colombia and Venezuela. There are no studies on feasibility and design.
- d) **Approximate investment:** The cost of the project is approximately US\$ 20 millions.

Project 4: Improvement of the 13.8 KV and 115 KV interconnections
(See map E-CO-05-G1)

- a) **Location:** The project is located on the Colombian Venezuelan frontier, in the regions of Norte de Santander in Colombia and the state of Táchira in Venezuela.

b) **Description of the project:**

Interconnection at 115 KV.

The present 115 KV line, located between the Zulia plant in Colombia and La Fria Central in Venezuela, 29.8 Km long, and with a maximum capacity of 85 MW, is limited to 50 MW due to restrictions in the Norte de Santander network.

In order to use its full capacity, it would be necessary to install a reactive compensation of about 29 Mvar in the cities of Cúcuta and Ocaña, which would be placed in the distribution networks.

Interconnection at 13.8 KV

It consists of installing a line between the substations of Sevilla (Cúcuta) and San Antonio (Táchira), 13.8 Km long, and a maximum capacity of 8 MW. This line would be isolated for a tension level of 34.5 KV.

The import capacity could be increased to 20 MW, if it is energized to 34.5 KV, for which it would be required a module in San Antonio.

- c) **Present status:** There has been nor decision or financing to carry out the reactive compensation in Colombia and the purchase of the module in Venezuela.
- d) **Estimated investment:** For Colombia, the cost of

the reactive compensation is of approximately US\$ 300.000.

- e) **Expected benefits:** The improvements of this project would result in an increase of the capacity of power transference, with a marginal investment, which would benefit the binational integration and the electrical systems of Santander and Norte de Santander in Colombia and the state of Táchira in Venezuela.

4. HYDROCARBON PROJECTS

Project 1: Colombia-Venezuela gas pipeline

- a) **Location:** The gas pipeline would begin in the East region of Venezuela and would go up to Cúcuta and then would continue to Bucaramanga, Bogotá, Cali and Medellín.
- b) **Description:** It is intended to construct a gas pipeline between Colombia and Venezuela for a maximum supply of 200 MMPCD.

This gas pipeline would allow to replace electricity, propane, and cocinol, which is used at home for cooking and heating up water. It would also replace propane, fuel oil and kerosene which is used in the industrial sector; and gasoline, in transportation, through the use of compressed natural gas (CNG).

- c) **Present Status:** There is a study made by the Organización Latinoamericana de Energía (OLADE), with financial support from CAF (June 5, 1992). Although it is not a prefeasibility analysis, it allows to conclude that under certain circumstances, the gas interconnection project is technically and economically viable.

The Colombian-Venezuelan Grupo de Trabajo de

Gas which met in Bogotá on October 1, 1992, made some observations to the gas interconnection:

- The negotiation value for the two countries, of 2.52 US\$/MBTU (frontier price) shown in the OLADE study, does not include royalties or income tax, established in the Venezuelan tax system, which should be included in a feasibility study that mentions a financial evaluation.
- The present scenario considers a reduction of the production level of hydrocarbons previously estimated (90-91), which causes an important decrease in the availability of gas for the domestic market.
- Under the scenario presently considered, the



possible supply of 60 MMPCD of gas from Venezuela to Colombia, would depend on reducing the volumes assigned to injection in the fields (secondary recovery of crudes) or from other sectors which would have to burn exportable liquids.

- From the above, it is assumed that under the present scenario, there would not be exportable gas from the Eastern Venezuela to Colombia (60 MMPCD for twelve years).
- d) **Expected benefits:** The consumption structure of energy in Colombia would improve, as the electricity consumption —inefficient on many occasions— could be replaced by natural gas. Besides, the Consejo Nacional de Política Económica y Social

(CONPES) recently approved a plan of intensive use of gas, that has as an objective to take this fuel to the Colombian homes at an accelerated pace.

Project 2: Other possibilities for gas pipelines

In the long term, and at a conceptual level, it has been foreseen the gas interconnection between Venezuela-Colombia and Mexico through Central America and the construction of a possible gas pipeline that goes from Colombia to Ecuador.

However, these projects do not count on a solid support basis. Initially, a preliminary analysis is needed to define its technical and economical possibilities.

Project 3: Self-supply of fuels

In the meetings of the Grupo de los Tres (Colombia-Venezuela-Mexico) and the Colombia-Ecuador binational encounters the following alternatives, which are worth studying for their technical economical feasibility, have been mentioned:

Gas Liquified from Petroleum

- Supply of GLP from Venezuela and Mexico to Colombia.
- Supply to the department of Nariño, by Ecuador (short term).
- Supply through Buenaventura for Cauca and Valle (medium term).

Gasoline and Diesel

- Possibility of supplying gasoline from Venezuela to Colombia (long term).

- Supply to the department of Nariño, by Ecuador (short term).
- Supply to Leticia through barges with 3.000 barrels/month (short term).

Crude

- Sales to the Pacific area of Orto crude (short term). A market study is required and the capacity enlargement of storage and cargo.
- Coordinate marketing schemes.

Fuel Oil

- Establish a joint venture with Colombia in a short term, to process the reduced crude from the Peninsula of Santa Elena in Ecuador, the same one that is obtained from the refining in the plant of La Libertad, from the mixture of crudes from the fields of the Peninsula and the East.

5. COAL PROJECTS

Project 1: Integration of the Infrastructure for coal exports

See map E-CO-06-G1)

- Location:** The project is located in the departments of Guajira and Norte de Santander in Colombia and the states of Zulia and Táchira in Venezuela.
- Description:** It is intended to jointly use the infrastructure available in this subsector, so that Colombia and Venezuela can increase their coal exports.

Regarding Colombia, there is a coal potential in Norte de Santander. These resources need a port in order to effect foreign sales. It is expected to use the Venezuelan infrastructure to get to a port in the Venezuelan Gulf.

Regarding Venezuela, the development of coal in the area of Guasare, near Guajira, with an expected production of 10 million tons of coal per year, requires an adequate port infrastructure. There is the possibility of using El Cerrejón complex, for which Venezuela would have to build a railway from the mine to El Cerrejón.

The coal mines of Guasare, exploited by CARBOZULIA, a subsidiary of Petróleos de Venezuela S.A. (PDVSA), are the most important in Venezuela. This mine is located in the North-West of the Zulia State, 100 Km from Maracaibo in the district of Mare. To increase the production of 2.5 million tons of coal per year, great investments, of more than US\$ 1.000 millions, are required in railways, ports and adaptation of the mine to reach the objective of 10 million tons of coal per year.

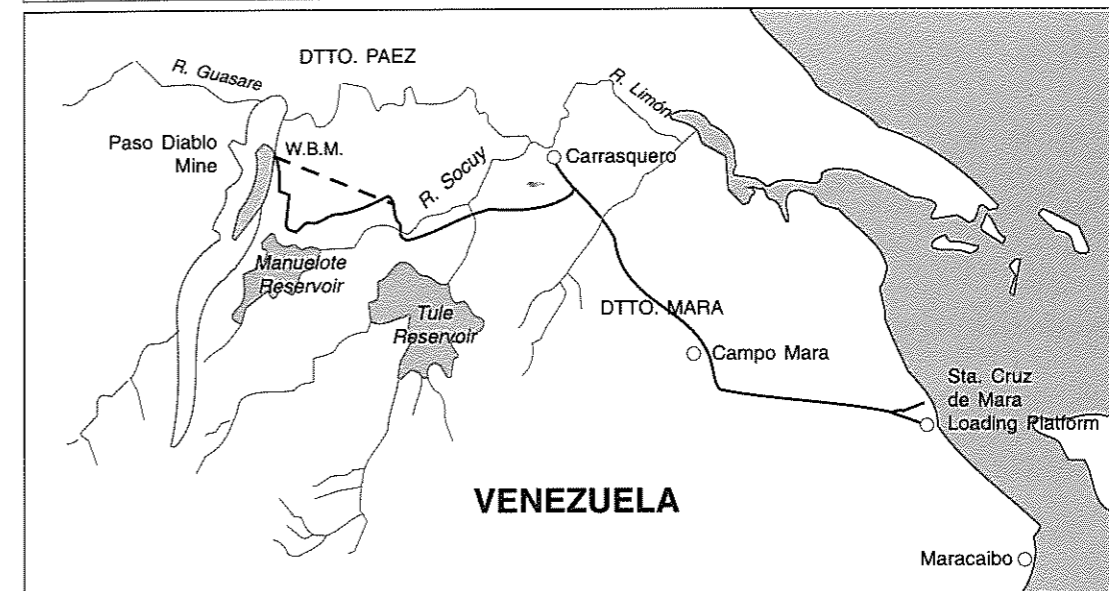
Also in the Department of Norte de Santander the coal mines had a great development with the inauguration in 1983 of the 150 MW thermic central of Tasajero and the establishment of the coal trading company CarboNorte.

With this background, the coal exploitation began and in the second half of the 80s, coal exports to Europe were started. To this effect, the road and port infrastructure of the Maracaibo Lake was used. Anyway, the export potential may be high if there is an appropriate infrastructure as well as the assurance of its permanent use at the agreed prices.

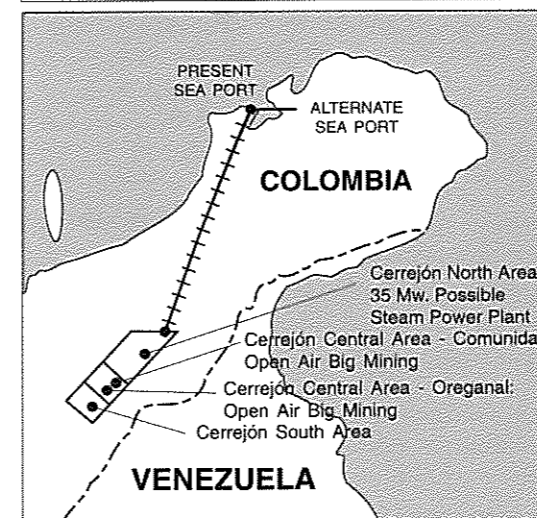
In regard to Guajira, there is the infrastructure of El Cerrejón Norte, which could be used in other projects. Besides, if the production of El Cerrejón is increased, the Venezuelan projects could be taken care of.

- Present status:** CARBOCOL considers the project attractive. However, they do not have specialized studies, that would allow to estimate the necessary

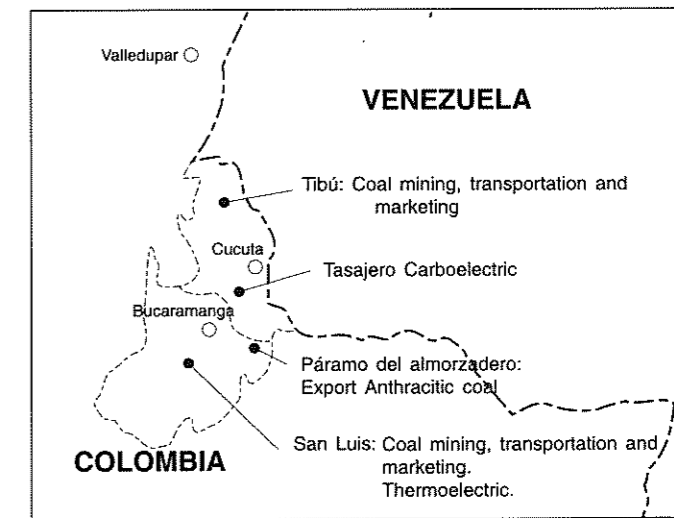
ZULIA'S COAL TRANSPORTATION



EXPORT MODERN GREAT MINING



DIFFERENT QUALITIES OF COAL FOR EXPORT AND INTERNAL CONSUMPTION



E-CO-06-G1

COMPLEMENT
SUBSTRUCTURE FOR COAL
EXPORTING

investments. Therefore, a preliminary vision is required to concrete the project and define its feasibility before continuing with the prefeasibility stage.

6. RECOMMENDATIONS

The major possibilities for the development of binational energy projects with Venezuela and Ecuador are found in the electrical subsector. For this reason, most of the short and medium term integration actions could be carried out in this sector, within CAF's expectations.

An analysis of the projects reveals as a common characteristic the lack of financial economical and technical feasibility studies, and therefore, of the respective designs. It is important to point out that many of the projects justify its convenience in the first analysis.

From Colombia's point of view, the electrical interconnections with Venezuela and Ecuador are more advantageous to increase its electrical self-sufficiency, rather than the establishment of an equivalent generation capacity with new hydroelectrical or thermal plants.

In case the proposed interconnections take place, as well as the improvements in the existing lines, a transmission capacity of 647 MW with Venezuela and 370 MW with Ecuador would be obtained, for a total of 1,017 MW that represents approximately 15% of the country's demand; that is, the consumption increase in the following three years, according to the

latest analysis, would be taken care of. However, some of the mentioned interconnections, like the 220 KW between Colombia and Ecuador and the second circuit with Venezuela on the North coast, are foreseen at a long term and require feasibility studies to determine its economical possibility in view of the high investments required.

It is recommended to finance feasibility studies for the projects included in this document which lack them and also desing studies, depending on the results of the feasibility studies, due to the supply situation of Colombia at a short and medium term.

It is suggested, likewise, to finance the projects on the improvement of 12.8, 34.5 and 115 KV lines already operating, in the Colombo-Ecuadorian and Colombo-Venezuelan frontier.

Likewise, it is convenient to finance the continuation of the prefesability studies of the Colombo-Ecuadorian geothermic project, according to the results of the preliminary studies already made, and in view of the convenience to diversify the use of energy sources with non conventional ones. The project would allow to include the geothermic resources of the frontier area to the energy supply of Colombia and Ecuador, through the installation of geothermoelectrical generation plants that would help replace the use of hydrocarbons in electrical generation.

In the coal and hydrocarbon areas, the possible projects are still on the drawing board. Therefore, it is recommended to keep on studying them, in order to obtain more information and a preliminary estimate of costs and economical and technical advantages.

ECUADOR

Integration energy projects

HANS COLLIN MORALES

Hans Collin Morales: Mechanical Engineer - Ecuador

- He has been an executive of Empresa Eléctrica de Ecuador and Empresa Cemento Nacional S.A.
- General Manager of the Instituto Ecuatoriano de Electrificación and President of the Comisión de Integración Eléctrica Regional (CIER).

1. GENERAL

Since 1972, when oil production and exportation began to a great extent, this raw material has been of vital importance in the socio-economic development of the country.

According to figures from Banco Central del Ecuador, in 1992, oil and derivatives represented 10.5% of the gross national product (GNP) and had a porcentaje participation of about 50% in the current income of the state budget.

In 1992, total exports were US\$ 3.007.5 millions, of which crude oil and derivatives represented 44.4%.

This resource significantly contributes in the struc-

ture of energy balance, both in the supply as in the demand. According to provisional figures, in 1992, the primary energy production was 141.3 million barrels equivalent to petroleum (bep), of which 85.5% corresponded to crude oil, 6.4% to biomass, 5.6% to liquid gas and 2.5% to hydroelectrical energy¹.

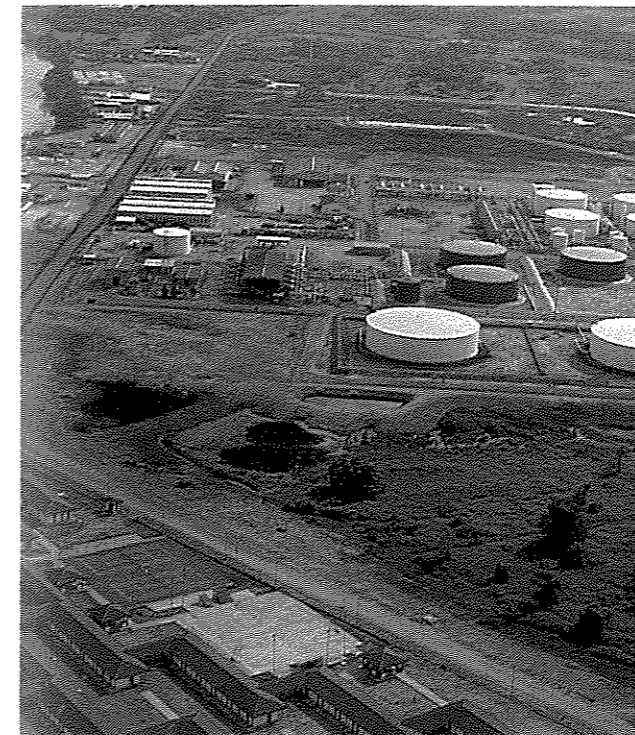
The final energy consumption was 42.6 million beps. Of this total, 70.5% corresponded to the demand for oil derivatives; 21.3%, to biomass; and 8.2%, to electricity².

1.1 Hydrocarbons Subsector

In December 1992, the total oil reserves (proved and probable) was 3.286 million barrels, of which 2.014 millions come from production fields and 1.272 millions, from reserve camps. Besides, there are possible reserves of 835 millions².

A 66% correspond to medium crudes; 10%, to light crudes; and 24%, to heavy crudes, without considering those of a lower grade of 15 API, that today are not commercially exploitable. From the total estimated reserves, 1% is on the Coast Region fields, and 99% in the Amazon Region.

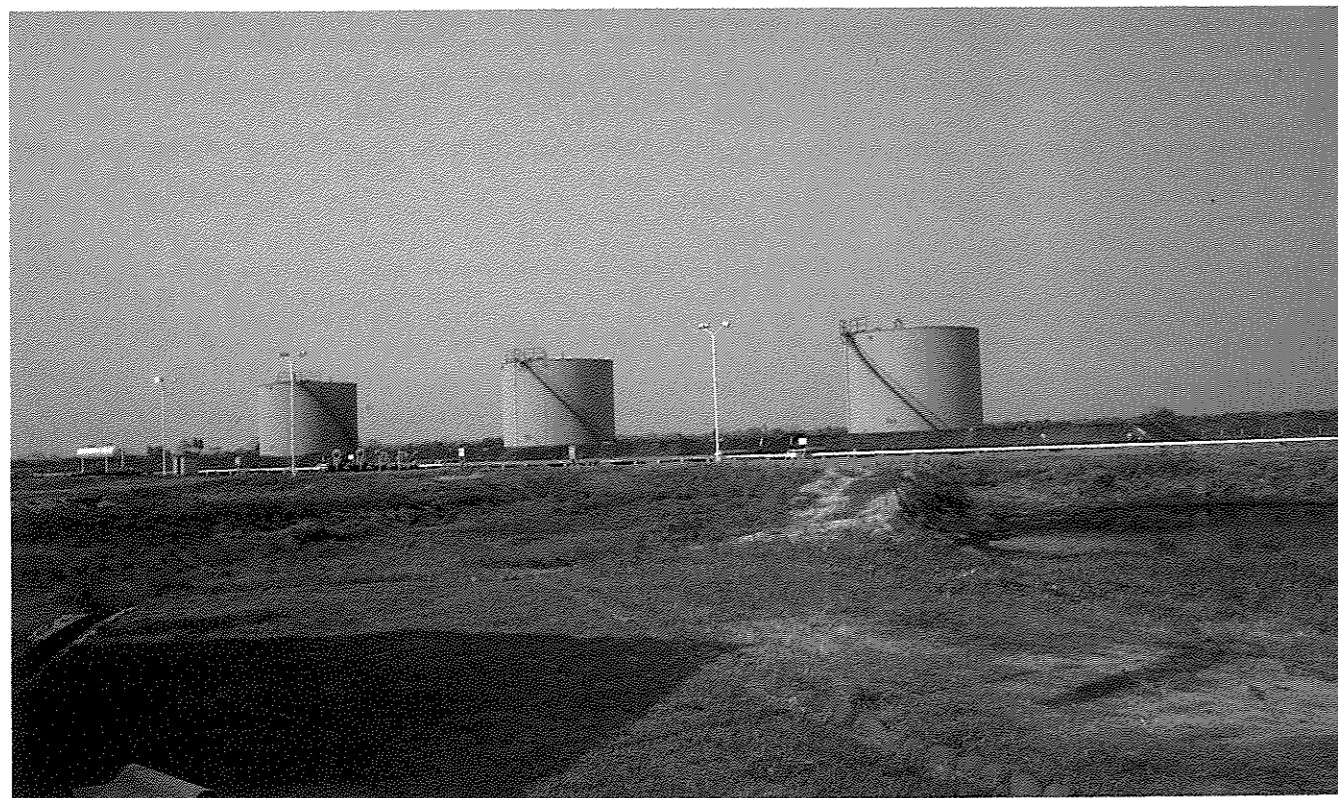
In accordance with a study made by the Instituto Francés de Petróleo (October 1992), the total reserves are 4.100 million barrels, of which 2.982 millions are proved developed reserves and 1.098 millions are proved not developed reserves³.



1. OLADE-SIE: Energy balances, Ecuador , 1992.

2. The figures of the oil reserves were taken from the study Oil Reserves in Ecuador (Marzo 1993), made by an interinstitutional commission in which PETROECUADOR, Ministry of Energy and Mines, National Direction of Hydrocarbons and the National Council of Development participated.

3. Petroleum French Institute; OGI Special, March 1, 1993.



The national production in 1991 was 109.4 million barrels, of which 59.6 million barrels were exported by Empresa Estatal Petróleos del Ecuador S.A. (PETROECUADOR), Texaco, Gulf and City, and 49.8 million barrels were for the local market⁴. Several private local and foreign companies participate in this activity under different types of contract, especially through service contracts for exploration and exploitation of hydrocarbons.

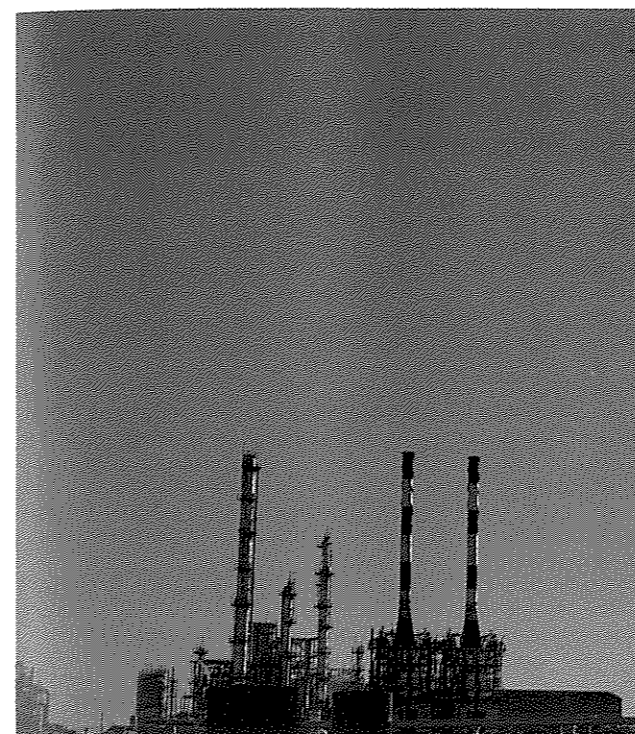
For transportation of oil from the East region to the consumption centers and the maritime export terminal

4. See PETROECUADOR, Hydrocarbon activity 1972 to 1991 Quito, February 1993.

in the port of Balao, there is the Sistema de Oleoducto Transecuatoriano (SOTE), with a design capacity of 400.000 barrels/day. Today, the effective capacity is 325.000 barrels/day and an enlargement is foreseen for additional transportation of heavy crudes. This infrastructure is complemented with the oil pipeline Lago Agrio-San Miguel-Orito, with an operating capacity of 35.000 barrels, connected with the Oleoducto Transandino de Colombia⁵.

Ecuador has six industrial plants with an installed capacity of 154.460 barrels/day being Esmeraldas the biggest and most complete with a capacity of 90.000

5. OLADE; Energy-Economic Information System (SIEE).



barrels/day and a load of 78.561 barrels/day. Additionally, there are the refineries of La Libertad (39.500 barrels/day), Amazonas (10.000 barrels/day), Lago Agrio (1.000 barrels/day), the Cautivo plant (9.500 barrels/day) and the Shushufindi gas processing plant, with a capacity of 4.460 barrels/day⁵.

Besides PETROECUADOR, the companies Occidental, Maxus, Oryx, Texaco-Pecten, Tripetrol, Elf-Aquitaine, Esso-Hispanoil, Petrocanadá, Petrobras, Unocal and Arco, operate under the nature of service companies.

1.2 Electrical Subsector

The electrical subsector during the period 1981-1990 grew at an annual pace of 11.5%, due to the great investments made to increase the installed capacity, especially the hydraulic.

Ecuador has great unexploited hydroelectrical resources with a theoretical potential of 93.460 MW, of which 21.520 MW correspond to a technical and economic potential available⁵.

For 1992, the installed electrical capacity was 2.266 MW (65% hydraulic and 35% thermic). The main generation centrals are Paute, Pisayambo and Agoyán.

During the same year, the electrical consumption was 5.605.4 GWh. Of this total, 37.1% corresponded to the industrial sector; 37.1%, to the residential sector and the remaining 25.8%, to the commercial sector².

At the beginning of 1992, the country suffered rationing, due to an energy deficit caused by the lack of water availability in the basins of the rivers where the great centrals are installed and due to the lack of thermoelectrical equipment; this was overcome by the opportune measures taken by the government.

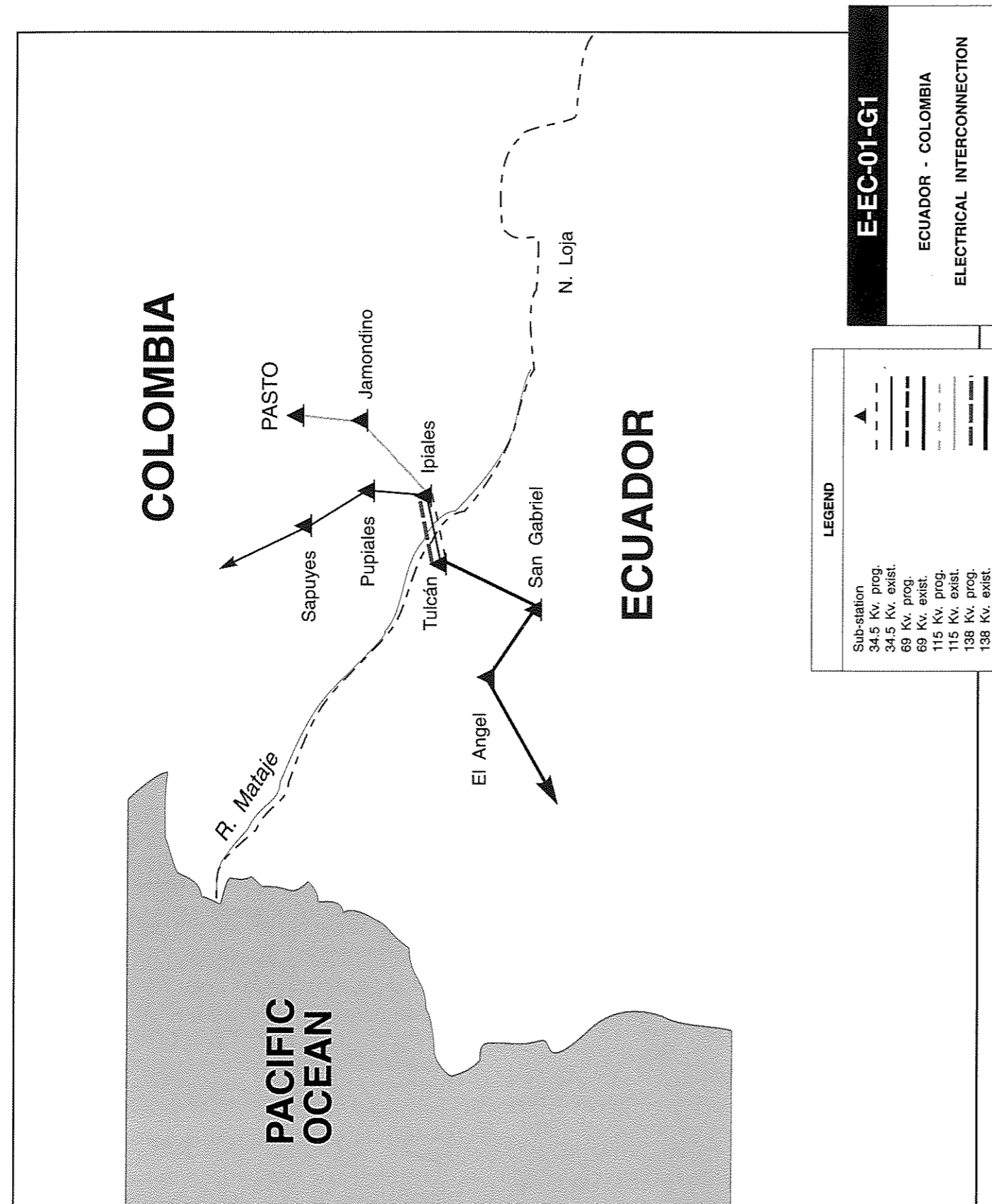
2. ELECTRICAL PROJECTS

Project 1: Ecuador-Colombia electrical interconnection

(See map E-EC-01-G1)

- Location:** The project includes the electrical integration of the North of the frontier province of Carchi (Ecuador) and the South of the Department of Nariño (Colombia).
- Description:** In February 1978, an agreement was signed initially for two years and renewable at the parties convenience for equal periods, between Empresa Eléctrica Regional Norte S.A. (EMELNORTE) from Ecuador and Centrales Eléctricas de Nariño (CEDENAR) from Colombia, to exchange electrical energy up to a maximum of 3 MW.

In 1985, with the cooperation of the Comisión de



Integración Eléctrica Regional (CIER), the negotiations between the Instituto Ecuatoriano de Electrificación (INECEL) and the Instituto Colombiano de Electrificación (ICEL) began to increase this interconnection at higher levels of voltage and electrical charge, in such a way that it would not be restricted only to satisfying frontier problems but bigger regions. In October 1986, the exchange of electrical energy was agreed on between the frontier systems, and commercial conditions were established for the purchase of energy and power.

In February 1992, an integration plan of five stages between both countries was defined.

In a short term, the process considers the delivery of a maximum 20 MW, of which 5 MW will be supplied on the first stage; 5 additional MW, on the second stage; and 10 MW, on the third one.

In a medium term, on the forth state, it will be necessary to install a second ternary over the 138 KV line between Quito-Ibarra and build a 138 KV line between Ibarra and Tulcán, which will allow to transfer up to 40 MW to Colombia. INECEL, has the materials but will not do the work because of lack of financing to contract its construction.

In a short term, on the fifth stage, an interconnection would be made between Quito and Pasto at a tension of 230 KV, 250 Km long.

- c) **Present status:** The work for the initial 5 MW were completed, and as of April 1992, the transmission of energy was started from Ecuador to Colombia. However, in May of the same year, the transfers were stopped, as CEDENAR was able to supply Ipiates in a normal way.

In order to cooperate in the integration process and transfer the remaining capacity (5 and 10 additional MW), in December 1992, the change of tension from 34.5 to 69 KV ended on the Ibarra-Tulcán

line. To finish the project, it is necessary to make minor works on the line: change the tension level from 34.5 to 69 KW in 4 Km, from the Tulcán substation to El Rosal substation (both located in Tulcán); and install a 69/34.5 KV transformer in El Rosal substation in order to allow energy transportation to Colombia.

- d) **Estimated investment:** To finish the necessary works of the 69 KW line (4 additional Km and the installation of a 69/34.5 KV transformer), an investment of 800 million sucres is estimated, that is, approximately US\$ 400.000. As agreed in binational meetings, the debt of CEDENAR with EMELNORTE for energy transportation (150 million sucres, or nearly US\$ 75.000), could be compensated by providing the transformer.

On the fourth stage, the required investment for the installation of a second ternary over the 138 KW line between Quito-Ibarra and the construction of a 138 KV line between Ibarra-Tulcán is US\$ 4 millions.

- e) **Expected benefits:** The latest restrictions of electrical supply in the Andean subregion, forced the countries to seriously consider the interconnection and the rational use of their generation reserves, in such a way that shortage in one country can be replaced by the capacity of the other ones, and in this decision, economic and investment considerations have little effect. The losses due to lack of electrical energy are unmeasurable and affect any country economically and socially. Besides, the transfer of energy from one country to the other can be programmed in cases of normal operation and/or preventive maintenance of the generating units.

- f) **Comments and suggestions:** Ecuador has had for many years interconnection negociatios with Colombia, so these projects are acceptable to the



public opinion, although its knowledge should be promoted at a political level to avoid concern on the part of control entities of the government about the fact that the energy sold would affect the reserves, electrical service or the energy future of the country.

The most important decisions in these integration schemes are the ones related to the dynamic stability of the electrical systems of each country, the tariffs and their collecting system, and mainly the decision making in the transfers of normal energy, which must be adequately and properly effected, because relying on integration and not installing excessive generation reserves, may be a risk that some countries are not willing to take.

Finally, it is important to mention that the estimated cost of interconnection in a short term is minimum compared to the benefits that can be obtained from a simple interconnection between both countries, that would allow to soften emergency situations as the present ones.

Project 2: Ecuador-Peru electrical interconnection

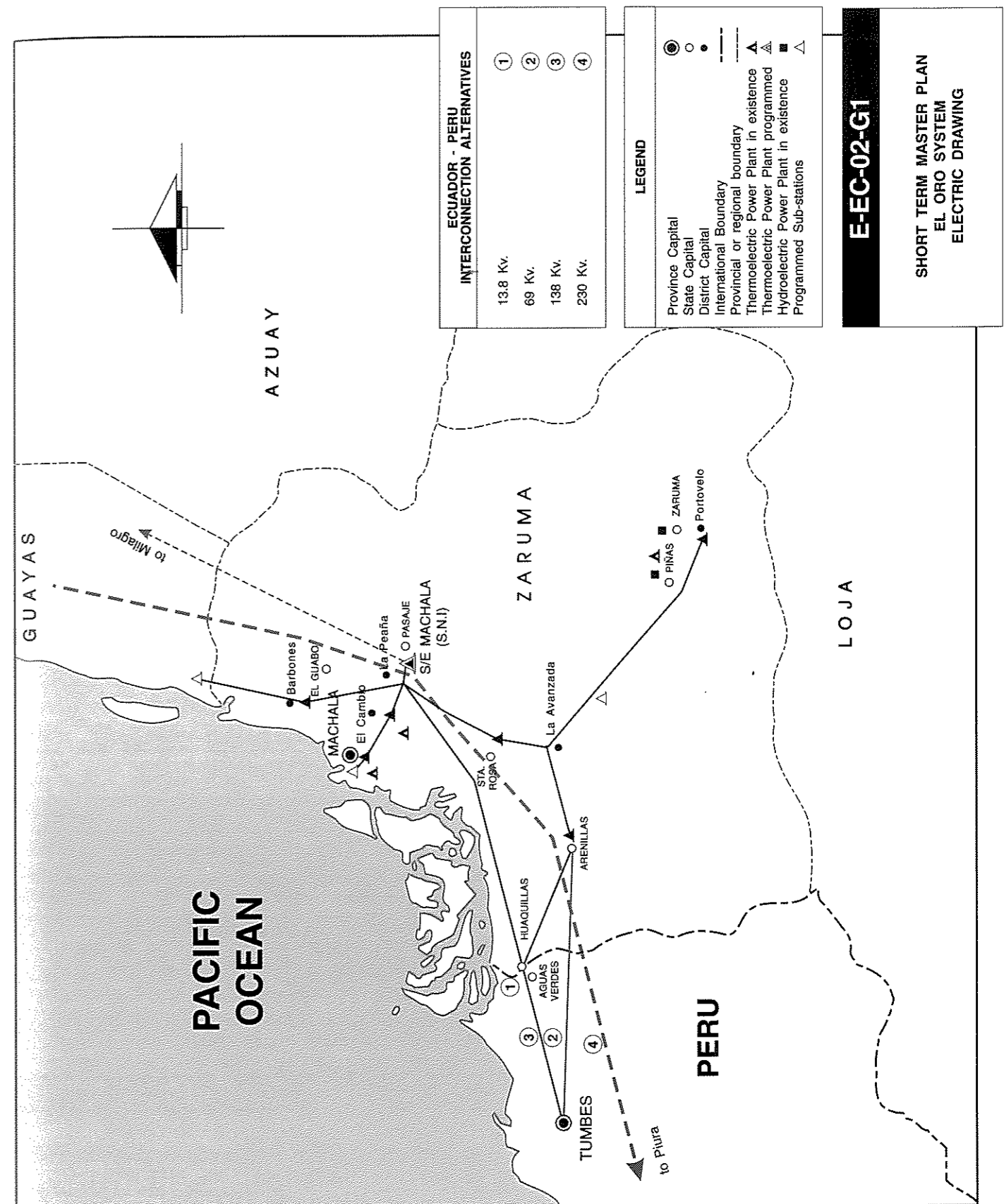
(See map E-EC-02-G1 and chart E-EC-02-G2)

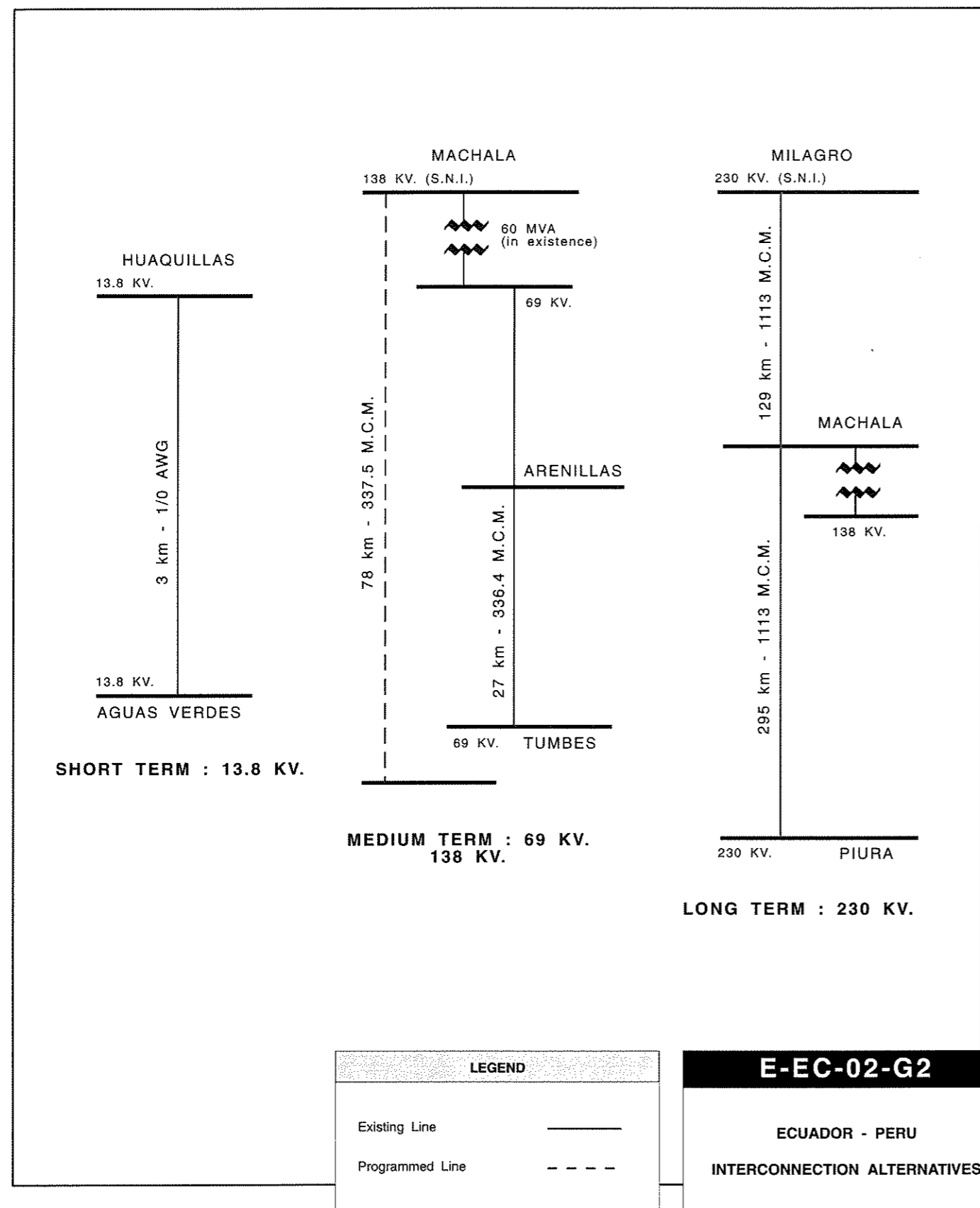
- Location:** The project is located in the provinces of El Oro and Loja, South Ecuador, and in the provinces of Tumbes and Piura, North Peru.
- Description:** Peru requires an energy supply in the North, because it has no national interconnection system that would allow this service at a low cost.

Ecuador has a transmission line at 138 KV in double ternary, with capacity of 100 MVA, from the province of Guayas to El Oro; and another one from the province of Azuay to Loja in the South of the country, with the same capacity. With its frontier transmission systems, the electrical service can be partially given to Peru. However, the lines today installed in Ecuador have only the capacity to deliver the energy required by such provinces, so any additional delivery over 5 MW needs modifications in the substations, the construction of additional transmission lines, the increase of conductors or in the conductor ternaries.

With a transmission line at 13.8 KV, that could be installed in a short time between Huaquillas (Ecuador) and Aguas Verdes (Peru), it would be possible to transfer 1.5 MW and increase to 5 MW potencial electric energy.

With the construction of a new transmission line between Arenillas and Huaquillas, at 69 KV, there





would be a transmission capacity of 20 MW up to Tumbes.

The energy needs in North Peru, specifically the area of the department of Piura, that requires 100 MW, can be satisfied from the Province of El Oro in Ecuador. However, to accomplish this it is necessary the construction of a new transmission line at 230 KV or 138 KV from the province of Guayas to El Oro.

For the area of North Peru, located near the province of Loja (Ecuador), there are no figures about electrical energy consumption and they seem to be very low; due to the situation, the transmission lines of the Empresa Eléctrica Sur could be enough to supply this service.

- c) **Present status:** The conditions of energy demand in Ecuador do not allow to deliver immediately more than 5 MW to Peru. For this reason, the conversations on electrical integration have been suspended and have been very difficult. Today, there is no electrical integration, reliable budgets, or specialized studies.
- d) **Estimated investment:** Up to the present moment, it is impossible to determine the probable investments, as the necessary studies have not been made.
- e) **Expected benefits:** It is completely justified in this area to make at least the necessary studies to analyze the advantages inherent to a solid interconnection between the two countries and particularly to a simple interconnection in a short term between the frontier areas.

The electrical integration would reflect in the development of the agricultural industry in North Peru while for Ecuador it would be a source of foreign exchange income. Additionally, in case of installing a thermic generation plant at remainder

in North Peru (Talara), Ecuador would have a generation reserve whenever its hydraulic generation system were affected by the low-water mark. This decision would require a transmission line in both countries, with enough capacity to transmit all this generation to the Sistema Nacional Interconectado of Ecuador.

- f) **Comments and Suggestions:** The immediate interconnection, which is technically possible between the regional electrical companies of Ecuador and Peru, would establish the principles of reliability between both parties. Afterwards, in a medium term, a more ample generation and interconnection program could be started. To promote this situation between the governments, and electrical companies, it would be possible to count on the collaboration of the Comisión de Integración Eléctrica Regional (CIER), that clusters the electrical companies of the South American region and therefore those of Ecuador and Peru.

At the same time, Ecuador is designing a new transmission system to the province of El Oro, that will begin functioning in 1997, and in this way will cover the demand of this area until the year 2005. The present line of 100 MW will be insufficient by 1997. This situation will determine that any electrical energy supplied to Peru by the immediate interconnection, without taking measures for enlargement of the existing systems in the Ecuadorian side, will be restricted as the national consumption increases.

Based on the projections made, it is important that the service be decided on and the possible electrical interconnection with Peru be included in the Ecuadorian study with the use of the transmission system that takes care of the province of El Oro.

Project 5: Multiple use of the waters of Puyango and Tumbes rivers

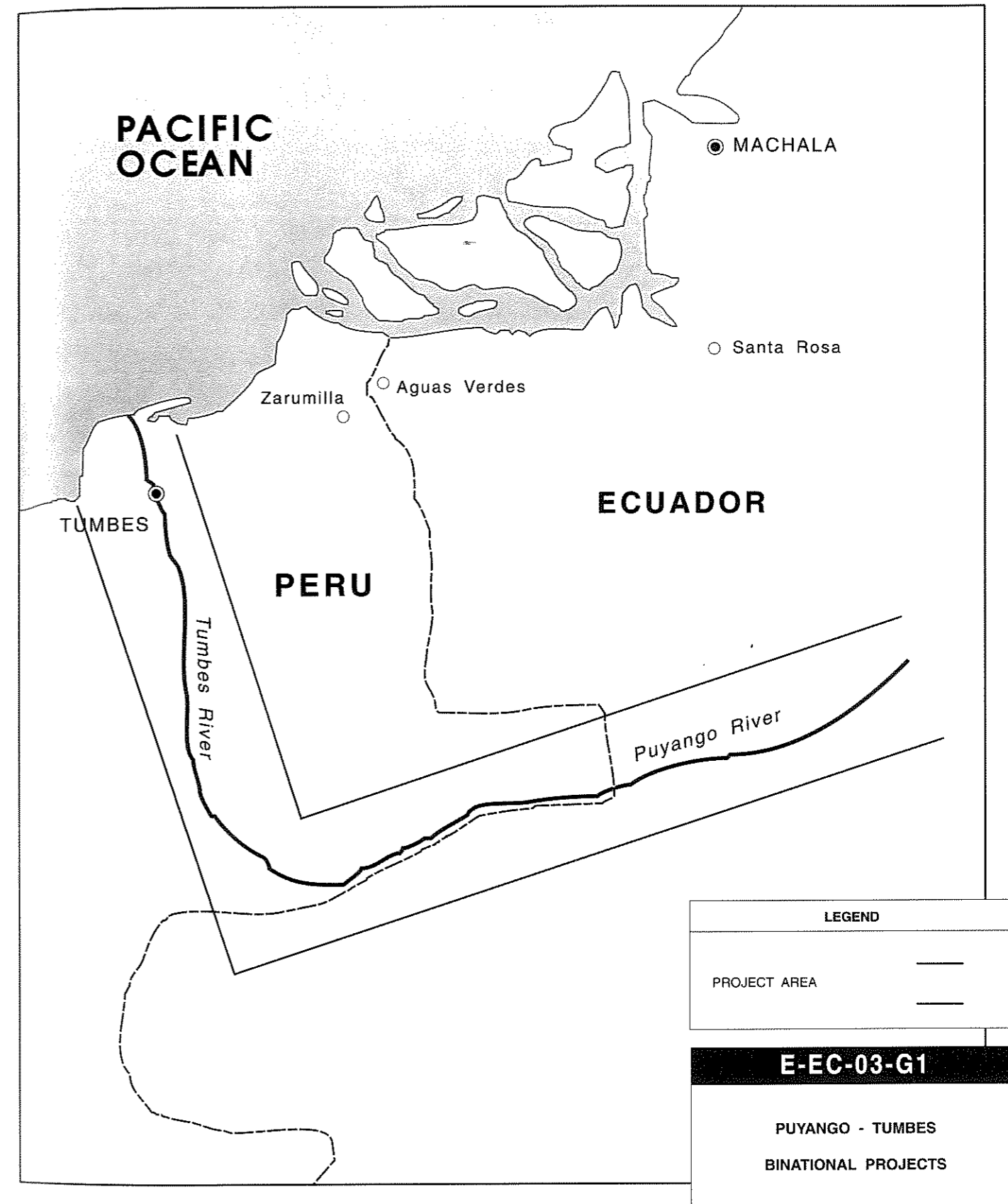
(See map E-CO-03-G1 and E-EC-04-G1)

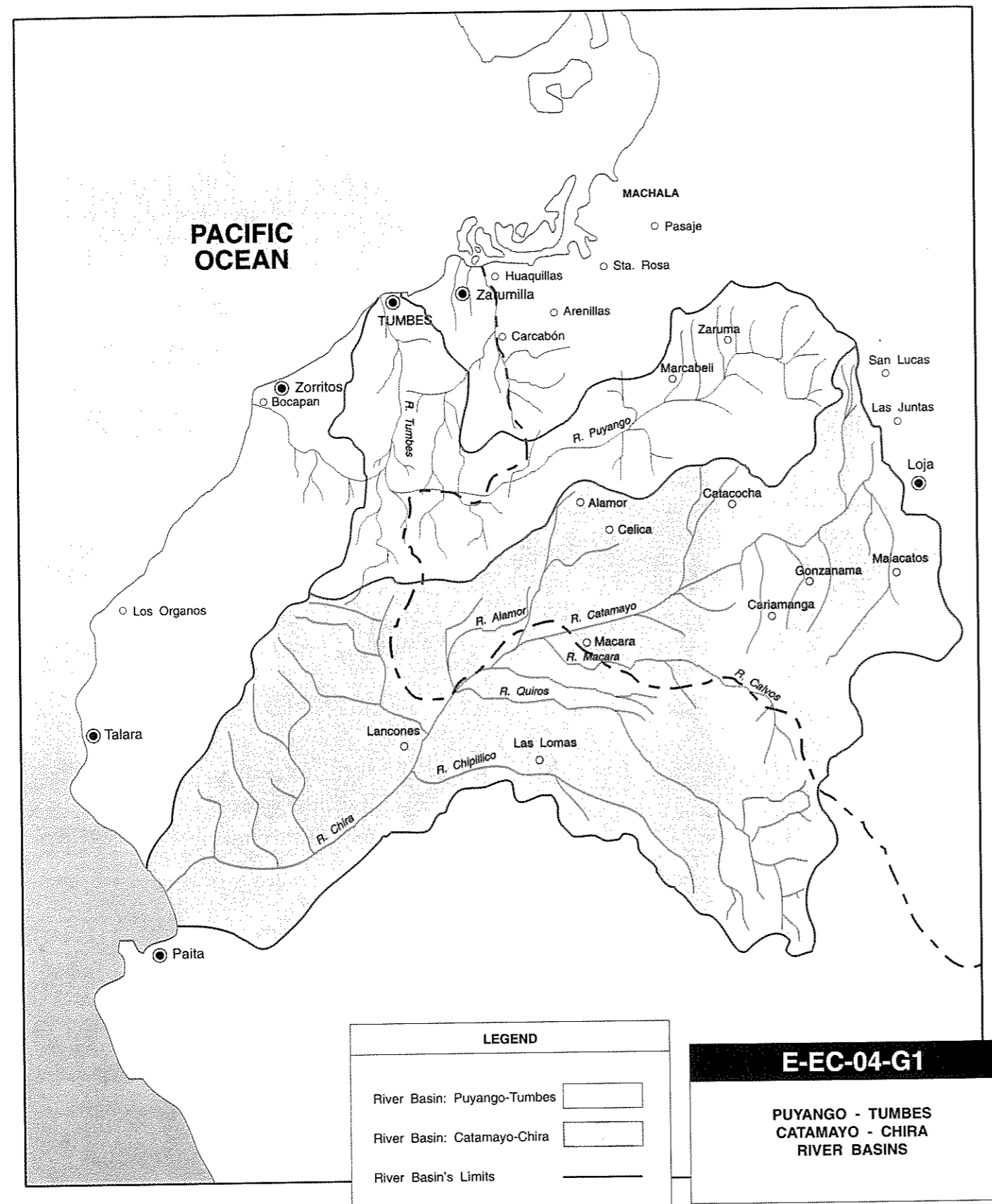
- a) **Location:** The hydrographical basin of the Puyango-Tumbes River is divided into three areas. The High Basin, that begins in the source of the river, in the mountains of Chila and Cerro Negro, in Ecuador, up to the town of Rica Playa in Peru; the Low Basin, that goes from Rica Playa up to a few kilometers before its mouth in the Pacific Ocean, and the Coast Region, that is an estuary area, where the sea integrates with the rivers.
- b) **Description:** The project is one of the Ecuadorian-Peruvian binational programs for the best use of

the hydrographic river basins Puyango-Tumbes and Catamayo-Chira, with the purpose of effecting agricultural development, controlling floods, and generating electricity through the use of the waters of the frontier rivers, a possibility that has been studied for more than twenty years.

There is a Binational Commission which operates with two National Subcommittees. In Ecuador, the responsible entity is the Programa de Desarrollo del Sur (PREDESUR) which has other 57 development projects in the South region. The Subcomité Nacional Ecuatoriano del Proyecto Puyango-Tumbes is in charge of the coordination and processing of the project.

The project consists of the daming and pumping





the frontier river waters and making of artificial lakes, most of them in Peru (see maps E-EC-05-G1 and E-EC-06-G1). In this place, the waters would be taken for the irrigation of about 70.000 hectares of agricultural land on both countries for the processing of drinkable water, reduction of flood risks, development of pisciculture and electrical generation with two hydroelectrical centrals of 150 MW of total capacity (one on each country), with its corresponding transmission lines. The project does not include local distribution lines.

c) **Present status:** The project of the hydroelectrical central has its feasibility study, which was financed by the Corporación Andina de Fomento and the Interamerican Development Bank, and prepared by

the technicians of the Instituto Ecuatoriano de Electrificación (INECEL).

d) **Estimated investment:** The investment would be shared by the two participating countries. The proportion of water use by each country would be taken as reference. The budget, which has been taken from one of the seven alternatives analyzed by PREDESUR, is US\$ 1.922.7 millions, of which US\$ 1.182.7 millions correspond to Ecuador and US\$ 740 millions, to Peru.

The estimated costs are based on the existing indexes in June 1990 and compared to similar projects, as the definite design, that would permit to make a more exact budget, is not ready yet. The

infrastructure works for the distribution of irrigation waters have not been considered either, nor the preparation of land previous to its agricultural use, or the mechanization of crops.

- e) **Expected benefits:** The development of this project is convenient for the two countries, as it would allow to obtain irrigation waters, control the floods, develop pisciculture, etc. with an employment increase, both in the arid area of North Peru and in the Southern area of Ecuador, which has one of the highest demographic and economic growth in the country; it would also contribute to the acceleration of the agricultural development through irrigation projects in an important area of the Gulf of Guayaquil (see map E-CO-07-G1).

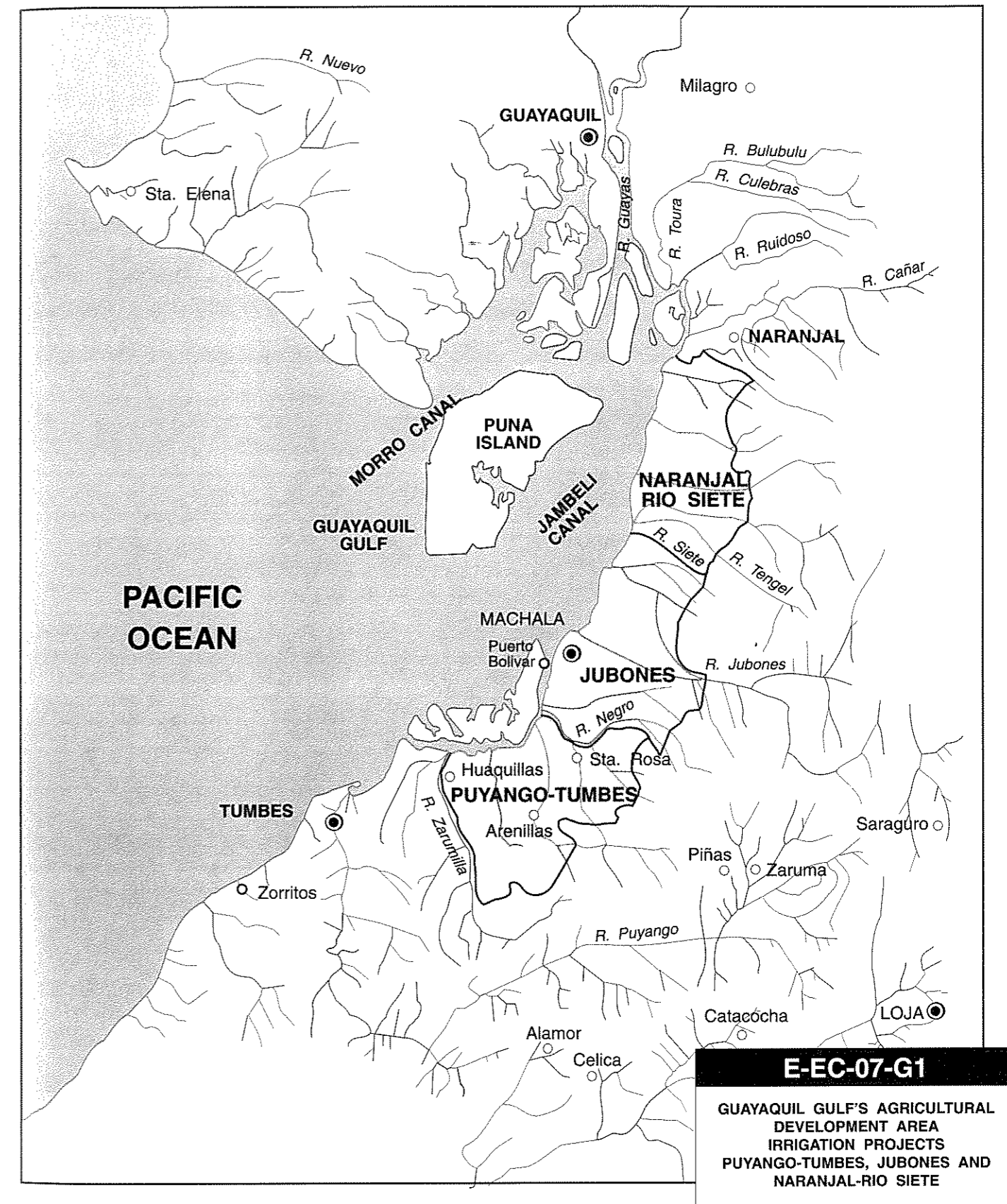
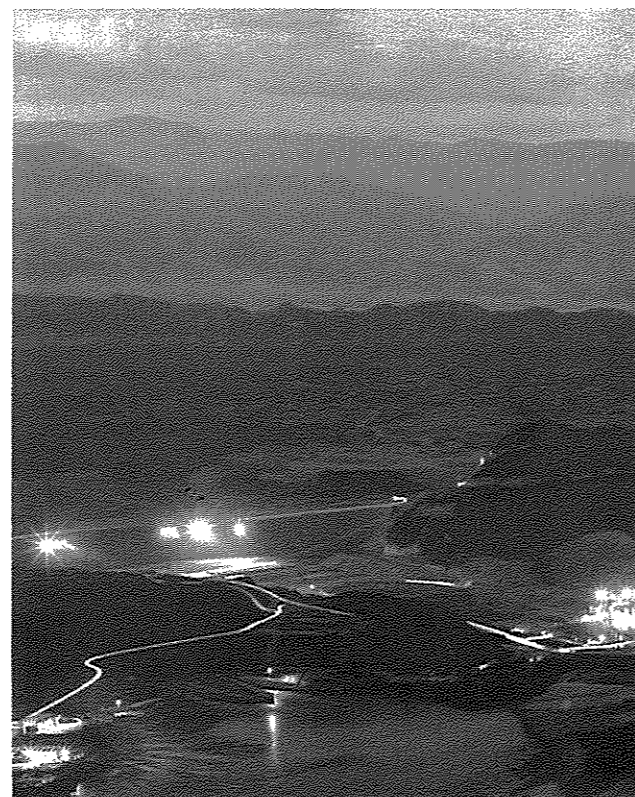
The project is also important for Ecuador as it would allow the country to have a generation plant in one of the extremes of its electrical transmission system and would assure a more adequate control of the stability of the interconnected system. It is valuable for Peru, as it can give electrical service to an area which today is assisted with thermic generation with a high maintenance and operation cost (see graphic E-CO-08-G1).

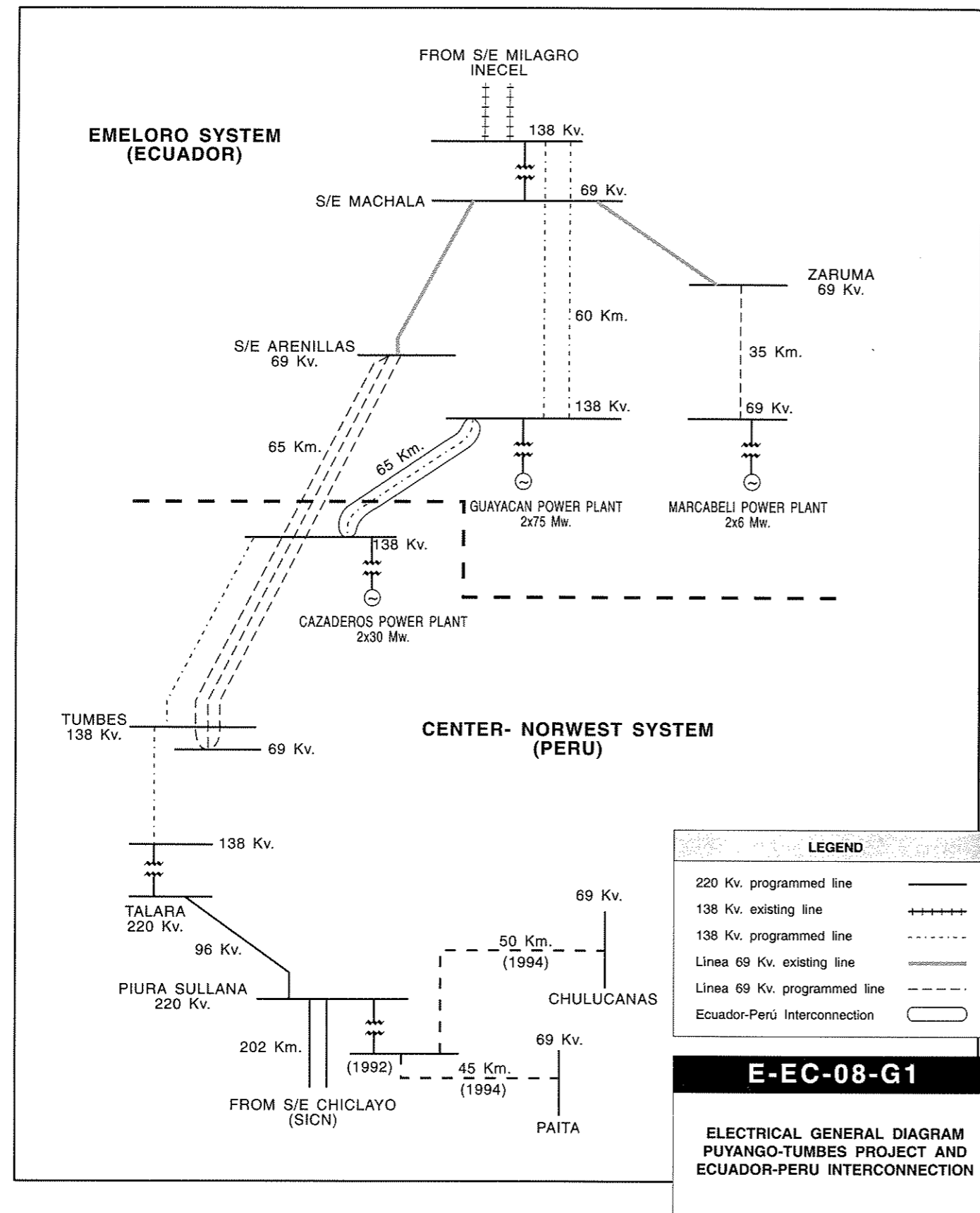
- f) **Comments and Suggestions:** The high cost of the project could result in having to execute it by stages and in that moment, there would be a coordination problem in the use and distribution of the waters of the frontier rivers because today the waters that are being used by both countries in their respective territories would have to be dammed for the use of the country or system to be executed or the country that executes it first. A study of this situation has not been made and it is considered convenient to make it now as a transitory alternative to the total execution of the project.

Although it is true that frontier integration agreements have been signed, and there has been

progress in the negotiation of this project, it is also true that the National Security issue on both countries is one of the most difficult subjects to deal with and agree on before the project is started on a stable and permanent execution.

Ecuador has not included in its investment plans for the Ecuadorian electrical sector the Puyango-Tumbes project, due to the fact that its opportune execution is not certain and because if the project is executed only for electrical energy generation it would not be profitable; besides, INECEL has other projects of lower investment and higher profitability in other hydrological basis in Ecuador already studied.





3. HYDROCARBON PROJECTS

Project 6: Oil-gas energy integration Colombia, Ecuador and Peru

- a) **Location:** The hydrocarbon reserves and exploitation areas are located in the Eastern area of Colombia, Ecuador and Peru (this country also has oil resources in the Talara sector in the coastal region, although not of an exportable size).

In the case of Ecuador, the total oil reserves (proved and probable) are estimated in 3.286 millions of barrels; of this amount, 1% corresponds to the fields of the coastal region and 99% to the

Amazon region. All these reserves are located in the sedimentary basins of Napo, Pastaza and Progreso (Santa Elena Peninsula).

b) **Description:**

Alternative for oil integration between Ecuador and Peru: The project would consist of transporting the Ecuadorian crude through the Peruvian pipeline Rio Tigre - Talara which is under utilized. The reserves of heavy crudes are calculated in 804 million barrels, 153 millions have an API under 15 degrees, that with the available present technology is considered the exploitable limit.

The crudes from Southern Ecuador, which are heavy and semiheavy, require special treatments



or mixtures with other lighter crudes so that they can be pumped through a pipeline. This situation would result in a project to install a pipeline between Ecuador and Puerto Tigre, plants of thermic treatment of mixture of crudes the costs of which have been studied by Ecuador that confirms that it would not be a profitable project and for this reason, the studies have not been continued.

Besides, according to geological studies, Peru has oil in the regions of Lancones and Tumbes. In case of a future exploitation, a secondary pipeline is required to link it to the principal one. For this, an alternate pumping system would be required through Ecuador, due to security reasons or for the regular maintenance of its pipeline.

Alternative for oil integration between Colombia and Ecuador: Due to the earthquake of March 1987, that destroyed part of the Sistema de Oleoducto Transecuatoriano (SOTE), Ecuador saw the need to build the oil pipeline Lago Agrio - Río San Miguel to connect it to the Oleoducto Transandino de Colombia (OTA) on the basis of a mutual agreement with the Colombian Company ECOPETROL, and so be able to evacuate the production of the Amazon region to the port of Tumaco, and from it, supply the country refineries by the maritime way.

This oil pipeline has a capacity of 35.000 barrels/day, although it could go up to 55.000 barrels/day. The capacity of the Colombian oil pipeline Orito-Tumaco is 100.000 barrels/day and its expansion has not been considered, as its capacity is under utilized and the oil pumping is not permanent but occasional.

Colombia and Ecuador have signed exchange agreements on geological and seismic studies that each country has made in the Eastern frontier areas and which possibly have petroleum. Likewise, the Fronteras project is being developed,

with a 95% contribution from Ecuador and 5% from Colombia.

Ecuador is capable of supplying oil derivatives to South Colombia, which does not have a nearby refinery, and therefore, its transportation costs increase the price of the final product.

Alternative for gas integration (GLP and natural gas): The country is deficient in the production of gas liquified from petroleum (GLP) and has to import to cover the consumption at a national level.

In 1991, the external purchases of GLP were 2.3 million barrels all coming from Venezuela. This represented a 52.5% of the total internal consumption, which was 4.5 million barrels. There is an interest in improving the production and efficiency of the Esmeraldas refinery, which would be the first step to reduce the imports of liquified gas.

At the same time, it would be convenient to study the possibility of building deposit centers in the Ecuadorian ports with the necessary infrastructure for the maritime delivery and reception of liquified gas, which would allow a commercial exchange with the Andean countries, to both consumers and producers.

At the same time, depending on the possibilities for development of Campo Amistad, located in the Gulf of Guayaquil, Ecuador could replace the oil derivatives by natural gas to send them to the electrical generation and industrial consumption especially in the city of Guayaquil.

In fact, according to the "Estudio de Prefactibilidad sobre la Utilización del Gas Natural del Golfo de Guayaquil" (Prefeasibility Study about the use of Natural Gas from the Gulf of Guayaquil), made by SOFREGAZ in September 1988, the proved reserves of natural gas of Campo Amistad varied between 0.12 (Dirección Nacional de Hidrocar-

buros, 1983) and 0.30 (De Golyer & Mac Naughton, May 1976) BPC. The usage of gas in the major industries would permit to reduce in the international market and especially on the Andean market, 173.00 (sic) tons/year of fuel oil and 10.000 tons/year of diesel oil, equivalent to a natural gas consumption of 20 MMPCD, according to the figures of the study.

c) **Present status:** Ecuador, as most of the Andean countries, except for Venezuela, does not have an optimized infrastructure for the handling of quick, safe and low cost transportation, storage, etc. of the oil derivatives or crudes that it may receive or export to its neighbor countries. Projects for networks of distribution of natural gas do not exist either.

d) **Estimated investment:** Up to the moment, there is no capacity to make an estimate of the required

investments, as there are no definite projects or study plans.

e) **Expected benefits:** The Andean countries have oil reserves that vary in quantity and quality. As it is a non renewable resource, any country may enter in a rationing or massive imports stage. Therefore, it would be very convenient the existence of agreements and infrastructures which would make possible a common market on oil and its derivatives in the Andean region, which would reduce the economical impact in the shortage that these products may cause.

f) **Comments and suggestions:** It is considered that OLADE and CAF may be of great help in order that the member countries of the Andean Group develop the idea of a stable exchange, with established rules, of the trade of oil and derivatives, promoting national meetings to start these



agreements; afterwards, and once the philosophy has been accepted, and subject to the laws necessary for each country, the institutions that trade oil in each country will continue the application process.

Project 7: Binational Geothermic project Tufiño-Chiles-Cerro Negro

- a) **Location:** The project is located in the area of Chiles (Colombia) and Cerro Negro-Tufiño (Ecuador).
- b) **Description:** Prefeasibility studies (phase one) made by ICEL and INECEL in the 1981-1983 period, came to the conclusion that this sector presents high possibilities for the existence of a steam reserve.

Based on these considerations, the Italian government and the Organización Latinoamericana de Energía (OLADE) signed, on August 8, 1984, the Acuerdo para el Establecimiento de un Fondo de Fideicomiso para los Estudios de Prefactibilidad Geotérmica del Proyecto Geotérmico Binacional Tufiño-Chiles-Cerro Negro. The geoscientific investigations, the activities of which ended in December 1987, confirmed the geothermic interest in the area and it was recommended a program for shallow drilling in order to evaluate the potential of the geothermic resources.

Due to lack of financing, the project activities have been stopped. Only in 1990, INECEL made a theoretical evaluation of the potential of the geothermic area, having as a result that the potential available would be 138 MW. However, it is important to mention that with the data available it is not possible to make an exact estimate of the geothermic potential of this area, as there is no information about the hydraulic, geothermic and thermodynamic characteristics of the deposit.

With the project, it is intended to take advantage of the possible presence of a thermic water reserve of high entalpia at an approximate depth between 1.500 and 2.000 meters. The possible existence of a geothermic deposit of this type was defined by a gas issue in Chiles-Agua Hedionda, with an approximate temperature between 200° and 230° centigrades. In this place was located the area with the highest probability of deep thermability.

- c) **Objectives:** Include the geothermic resource from the frontier area to the energy supply in Colombia and Ecuador, by the installation of geothermoelectrical generation plants that would contribute to replace the use of hydrocarbons in electrical generation. The modular development inherent to the geothermoelectrical generation will allow to make step-by-step investments and expand the supply to cover the increasing demand of electrical energy in the frontier zone.

The efficiency of the geothermoelectrical plants is very high, and as they are completely independent from the hydrological cycles, the energy flow that they deliver to the electrical system is permanent during the year long (the charge factors exceed by 85%). This makes geothermy a beneficial complement for hydraulic generation.

- d) **Present status:** The project, the final objective of which is the installation of an electrical generation plant, has several phases. On the first phase, of prefeasibility already developed, OLADE recommends making a complementary geochemical and geophysical evaluation that will allow the study of geothermic possibilities in the area. The continuation of the investigation of the subsoil will depend on the results of these evaluations, with the drilling of three exploratory wells of approximately 2.000 meters deep.

Up to this moment, the project needs resources for its financing.

- e) **Estimated investments:** Resources are needed for US\$ 200.000 to end the first stage of prefeasibility; US\$ 12.4 millions for the feasibility stage and US\$ 12.1 millions for the development of a 5 MW central.

- f) **Expected benefits:** The project is the first one that would be made by two countries in Latin America and the Caribbean, with the purpose of taking mutual advantage of a non renewable energy resource, that allows step-by-step investments and which is shared in frontier areas.

- g) **Comments and suggestions:** It has been proposed the shallow drilling of three wells, as the existence of a geothermic deposit in Chiles-Cerro Negro is not clearly defined, and it is necessary to obtain information that would precisely show the existence of same.

However, when comparing the cost of the three proposed wells (between US\$ 300 and 600 thousand each, depending on their depth), it is advisable that before making these wells, the convenience of reviewing the geophysical studies of resistivity in the area of Agua Hedionda be analyzed and the possibility of making, instead of three gradient wells, one or two deeper wells (2.000 meters approximately), depending on the results of the suggested geophysical studies.

As the geothermic area of Tufiño-Chiles-Cerro Negro shows the highest possibilities for geothermic development, it is recommended to continue its study until its real geothermic potential is defined.

PERU

Integration energy projects

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1. ENERGY DIAGNOSIS

The country has an important energy potential which has not been sufficiently evaluated or developed. In accordance with the information available in the Sistema de Información Económica Energética (SIEE) (Economic Energy Information System) from (OLADE), the level of proved reserves of fossil fuels in 1991, was approximately 1855 million barrels equivalent to petroleum (BEP) distributed: petroleum 20%, natural gas 65%, and mineral coal 15%.

The proved reserves of oil were 380.9 million barrels. At the production pace of 1992, and in case no new discoveries are made, the country could have this resource for the next nine years.

Regarding natural gas, the reserves reached 7.1 billions of cubic feet (BPC). During the 80s, no priority was given to the use of this energy resource, as the reserves known seemed to be small and far from the consumption centers and did not justify the development cost or the infrastructure to take the gas to the users. The situation changed after the discovery of the Camisea deposit, the potential of which is estimated by over 12 BPC.

In 1992, the primary energy production was 83.5 million BEP, 6.2% less than the year before, due to the reduction in the production of oil and hydroelectric energy.

Since 1978, Peru has been a net exporter of oil;



however, due to the fall in the level of reserves and production during the last years, the country imported crude since 1987; in 1992, became a net buyer of oil and derivatives (especially diesel oil), with a volume of 10.6 and 5.1 million barrels, respectively.

The infrastructure for the refining of hydrocarbons in Peru is based on six refineries with a total capacity of 186.000 barrels a day. The Pampilla refinery has the highest capacity, covering more than 50%. The Talara plant contributes with 35%, and it is of special interest because it supplies the petrochemical complex.

The technical characteristics of the refineries, as well as the quality of the national oil, makes it mandatory to mix it with imported oil, in order to produce derivatives in accordance with the structure of the national demand.

The country has a considerable hydroelectrical potential of 62.530 MW, according to calculations made in 1992. The total installed capacity increased to 4.101 MW, of which 58% corresponded to hydroelectrical resources and 42%, to thermoelectrical, most of all based on diesel oil. The generation of electrical energy was 13.132 GWh during the same year (hydraulic 74% and thermic 26%).

The proved reserves of mineral coal are 27 million tons; the proved ones, are 125 millions, and the possible ones, 1.170 million tons. The low-quality coal, peat, and lignites may be important locally, except for the deposit of Tumbes, that due to its location would merit more important studies. The Goyllarisquizga deposits could be an important potential in the worldwide offer of anthracite coal. The main problem is the transportation infrastructure towards the consumption centers.

The final energy consumption reached 72.3 millions of bep in 1992, 2.8% less than the year before. Consumption is characterized by its great dependency on oil derivatives, that represent about 50%; the electrical



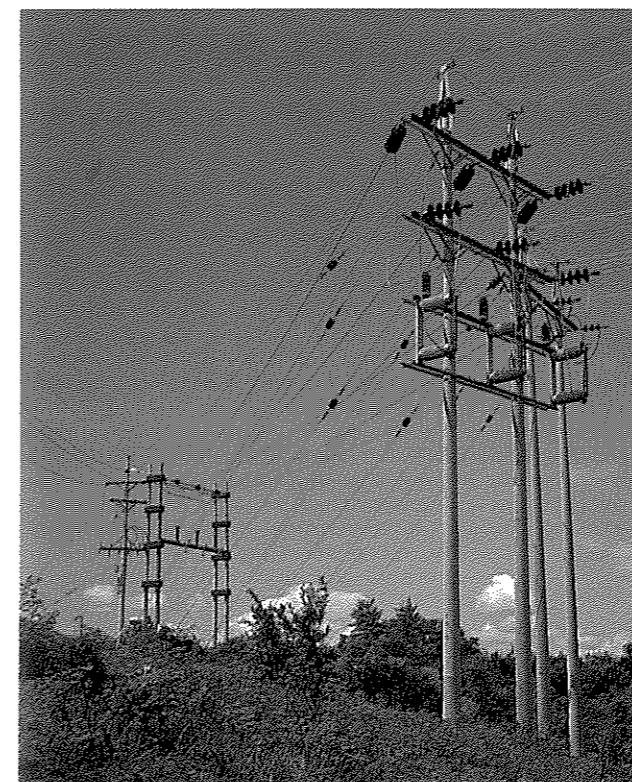
energy represents 9.6%. The residential, commercial, and public sectors as a whole, concentrate the highest consumption (46.6% of the total), afterwards come the productive sectors with 26% and transportation, with 25%.

It is important to point out that the dry season was extremely severe, and affected the demand, especially during the summer (May to October). Due to the substantial reduction in the hydroelectrical generation by the Sistema Interconectado Centro-Norte, beginning in May 1992, a severe rationing program was implemented.

Besides, since 1991, relevant changes have been made in the energy sector. In the hydrocarbon subsector, regulations were changed to allow the foreign and local private investment in all activities; the first steps

have been taken in order to sell the state-owned company, PETROPERU, to private investors, and the progressive deregulation of prices has been encouraged so that they can be finally determined by the market.

In the electricity subsector, the Ley de Concesiones Eléctricas (Law of Electrical Concessions) was approved in 1992, through which it is intended to constitute a concession system to handle the generation activities, transportation, distribution and marketing the energy at a national level with the participation of the private sector. The Reglamento del Fondo de Desarrollo Eléctrico de Interés Social (Rulings for the Electrical Development Fund of Social Interest) was also approved, to promote the development of rural electrification projects and isolated areas of the country.



2. ENERGY PROJECTS OF INTERNATIONAL INTEGRATION

The possibilities for international integration in the energy field of Peru with Bolivia and Ecuador, have not been developed in the past. This has happened due to the prevailing policies in the international relations, to the small demand in the frontier areas and to the criteria on autonomy based on the abundance of outstanding energy sources in the development plans.

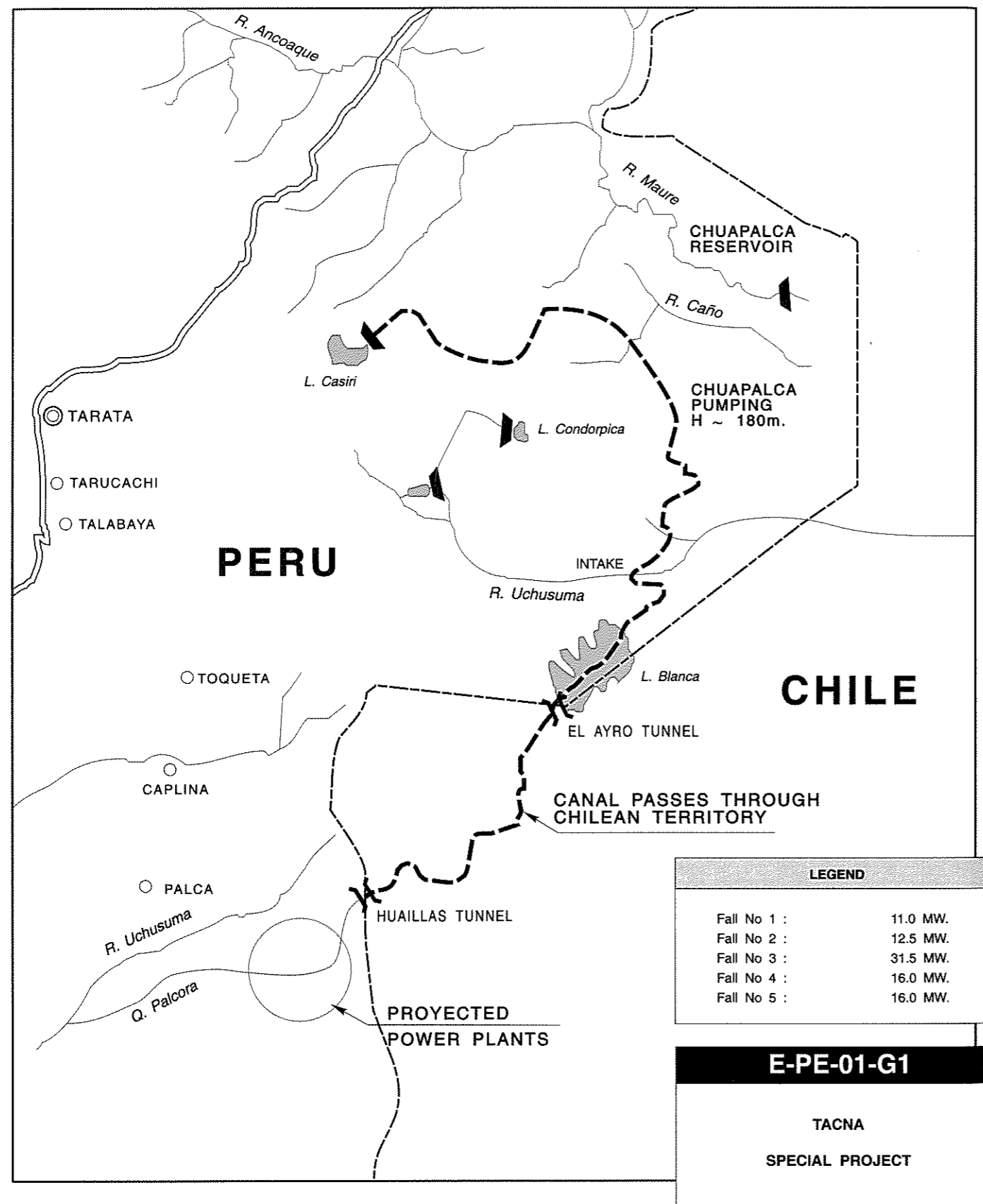
The scenario has greatly changed due to the stagnate in the electrical production and the reduction of the hydrocarbon offer, as well as the elimination of energy subsidies.

The serious energy deficit requires a great effort in investments to rebuild the productive infrastructure. At the same time, it needs the application of an energy supply plan that must include the international integration, especially due to the shorter term that would demand the use of energy sources of the neighbor countries already being used, which means to optimize its usage and reduce costs.

Also the weather phenomenon due to the drought and the floods which affect several countries in the subregion reinforces the importance of the electrical interconnection concept of sources located in different hydrographical basins, as a way to guarantee the service.

From this perspective, it is interesting to see that, as to the electrical service, Northwest Peru is the area with the most serious problem with the present rationing and with an uncovered power demand of 100 MW; thanks to the Paute hydroelectrical project, Ecuador has a surplus of power which could be used for mutual benefit.

In regard to oil, the Peruvian deficit could be covered



Project 2: Expansion of the energy purchase agreement from ELECTROPERU (PERU) TO ENDE S.A. (Bolivia)

(See map E-PE-02-G1)

- a) **Location:** The project is located on the Peruvian-Bolivian frontier, in the department of Puno, and it covers the provinces of Yunguyo and Chucuito.
- b) **Description:** It is operating in this moment. For this purpose, on April 4, 1988, through the Supreme Decree No. 004-88 EM/DGE, ELECTROPERU was authorized to negotiate with ENDE S.A. the purchase of energy to supply the provinces of Yunguyo and Chucuito, in the department of Puno. Along with these areas, there are about 70 more that do not dispose of electrical energy.

According to an intention agreement signed between ELECTROPERU AND ENDE, two stages have been established:

- **First Stage:** It would be carried out by extending the Copacabana network to Kasani and Desaguadero. A delivery of 400 KW in Yunguyo and 100 KW in Desaguadero would be agreed on.

- **Second Stage:** It would be started one year after the first one.

1.600 KW would be delivered in Kasani and 400 KW, in Desaguadero. This stage includes the Desaguadero-Zepita-Coyani and the Desaguadero-Kelluyo network as well as the Yunguyo-Pomata-Juli network. On this second stage, it is required to install in the Bolivian network, a 69/25 KV substation in Huarina and also a 25 KV line.

An increase on the capacity mentioned would require to expand the network to 69 KV in Bolivia.

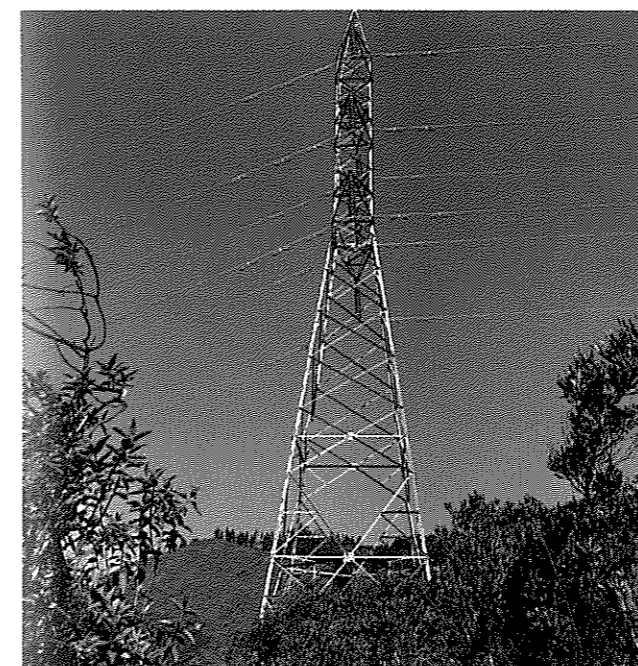
- c) **Present state:** The project is presently on an operation phase. The first stage has been covered and its continuation has not been defined yet.

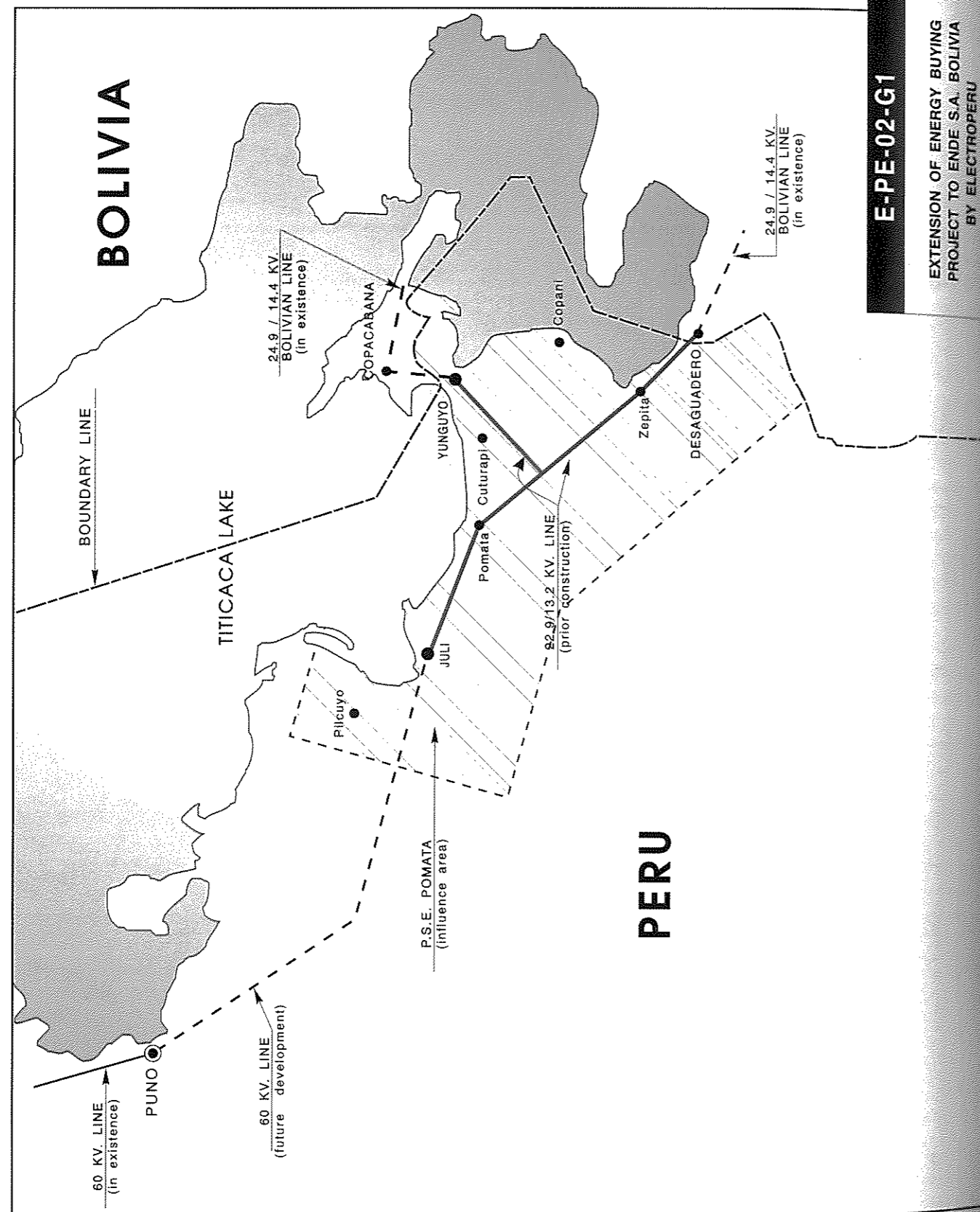
To this respect, it is expected to effect two important variations:

1. To expand the area with the purpose of electrifying the rural areas near the frontier.
2. To install a 50 to 60 Hz converter station that covers all the supply coming from Bolivia, in order to avoid the formation of an island of a different frequency in Peru.

- d) **Estimated investment:** A US\$ 2 million investment has been estimated, which includes the installation of a frequency converter.

- e) **Expected benefits:** Bolivia would be able to sell energy surplus, while Peru would be able to electrify towns located far away from the Puno-Juliaca network.





Project 3: Electricity generation based on bolivian natural gas for south Peru

- a) **Location:** The project is located in the Peruvian area of Desaguadero, where the Bolivian natural gas would be taken, at an approximate distance of 80 Km from its most distant point, in the Viacha Cement Factory.
- b) **Description:** The thermic plant to be installed in Desaguadero could be developed in 50 MW modules until completing 200 MW, depending on the demand and the available gas volumes.

The energy generated would be delivered to Juliaca, Southern Peru, 180 Km far away from Desaguadero, at a tension of 220 KV, to be delivered to the Southern interconnected system, through the existing Juliaca-Tintaya line and the section Tintaya-Socabaya, to be constructed, in order to interconnect the Southeast and Southwest systems.

At a prefeasibility level, it is possible to propose other alternatives that should be carefully studied.

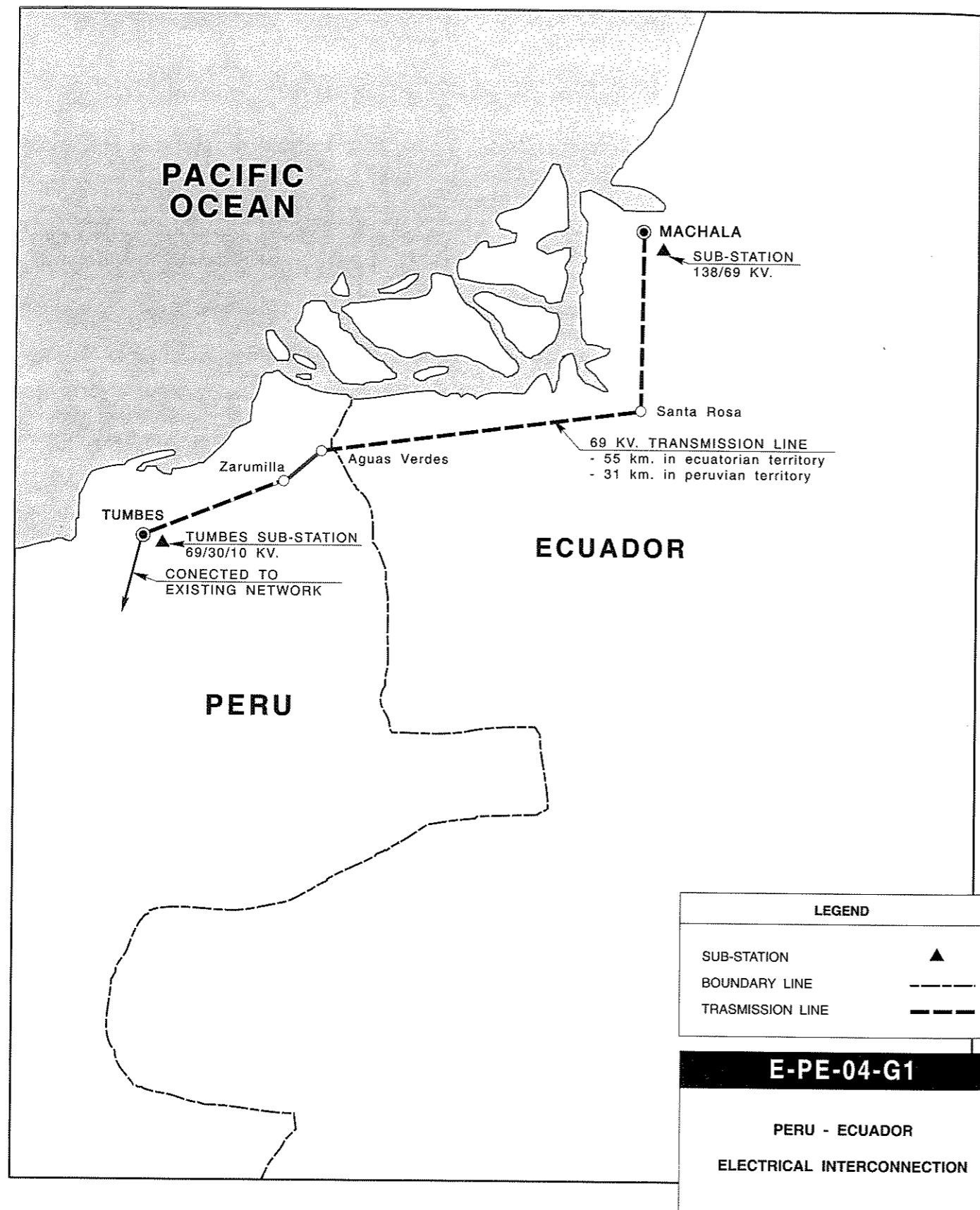
One alternative consists of taking a gas pipeline to Ilo, to replace the petroleum burned in Toquepala, place a gas turbine central in order to cover the point and probably half the basis.

The project would be useful not only to generate electricity but also to generate heat in the different factories in the area, which in some of the places could turn into co-generation.

It is also important that Bolivia participate in the Ilo gas pipeline project, in a way that installations be complemented in order to share exports of the Camisea gas.

- c) **Present status:** The Tintaya-Socabaya line is the only one that has feasibility studies; the rest of the study has to be completely developed, with the conception mentioned above.
- d) **Estimated investment:** In the section of the Tintaya-Socabaya line, there is a budget estimate of US\$ 50 millions.
- e) **Expected benefits:** The electrical energy demand in South Peru, which does not have a supply source in the short term, would be covered.

Also a higher possibility of obtaining natural gas in the Sistema Interconectado Sur (Southern Interconnected System) would be obtained.



Project 5: Puyango-Tumbes binational project (See map E-PE-05-G1)

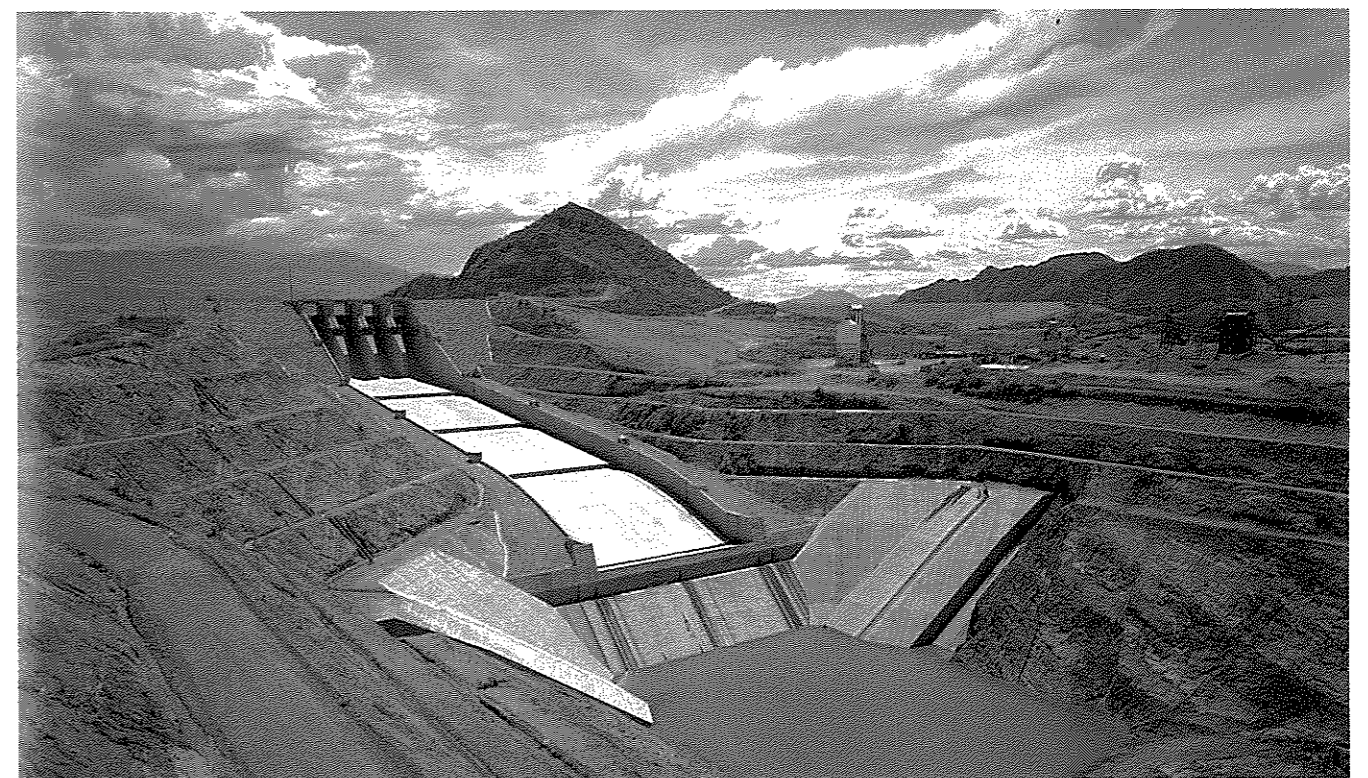
- Location:** The project is located in Northeast Peru, in the department of Tumbes and Southwest Ecuador, in the province of El Oro.
- Description:** The project is one of the Peruvian-Ecuadorian binational programs for the use of the Puyango-Tumbes and Catamayo-Chira hydrografical basins, with the purpose of effecting an agricultural development, control the floods and generate electricity through the use of the waters of the frontier rivers.

It consists of the banking and pumping of the water of the frontier rivers and the creation of artificial lakes, most of them in Peruvian territory.

The waters would be taken for the watering of almost 70.000 hectares of agriculture land from both countries, for the processing of drinkable water, the reduction of flood risks, the development of pools for pisciculture and the generation of electricity with two 150 MW hydroelectrical centrals of total capacity (one in each country).

c) **Present status:** The project of the hydroelectrical central has its corresponding feasibility study.

d) **Estimated investment:** The investment would be shared by the participating countries. The proportion in the use of waters by each country would be taken as a reference. The budget estimated by PREDESUR from Ecuador, comes up to US\$ 1.922.7 millions, of which US\$ 1.182.7 millions correspond to Ecuador and US\$ 740 millions, to Peru.





Project 6: Purchase and/or transportation of ecuadorian crude oil through the north peruvian oil pipeline
(See map E-PE-06-G1)

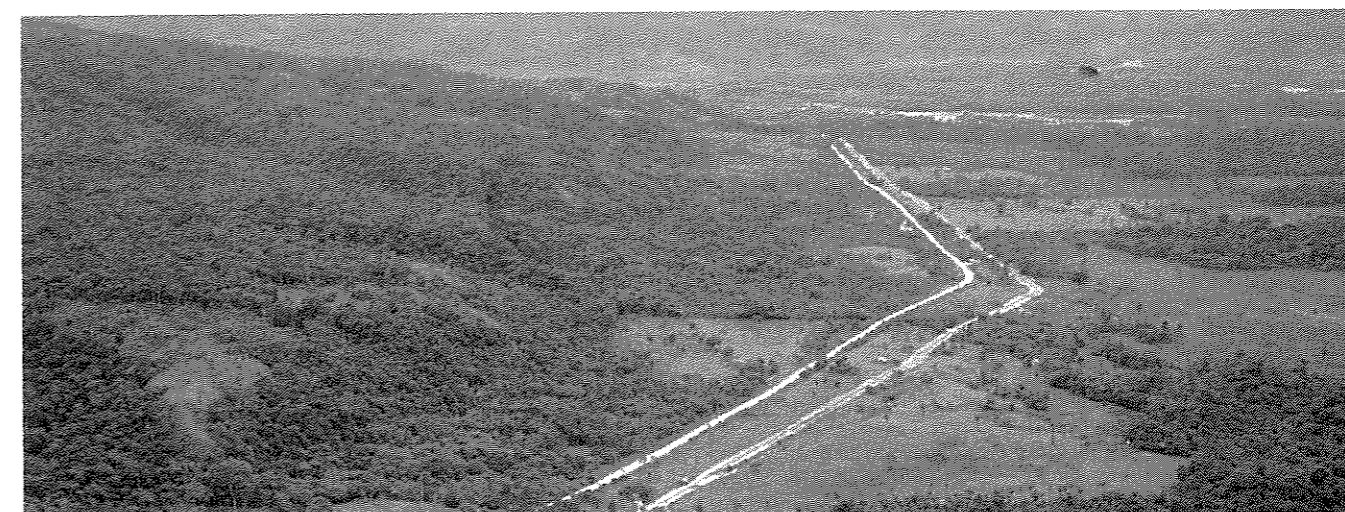
- a) **Location:** The project is located in North Peru, in the frontier with Ecuador, near the city of Andoas —department of Loreto— which is the initial point of the Northern branch of the North Peruvian oil pipeline.
- b) **Description:** The idea is to transport the Ecuadorian crude produced in the fields near the border through the North Peruvian pipeline and its Northern branch. In this way, the investments that would be needed by Ecuador to transport the crude to the coast, would be avoided or postponed.

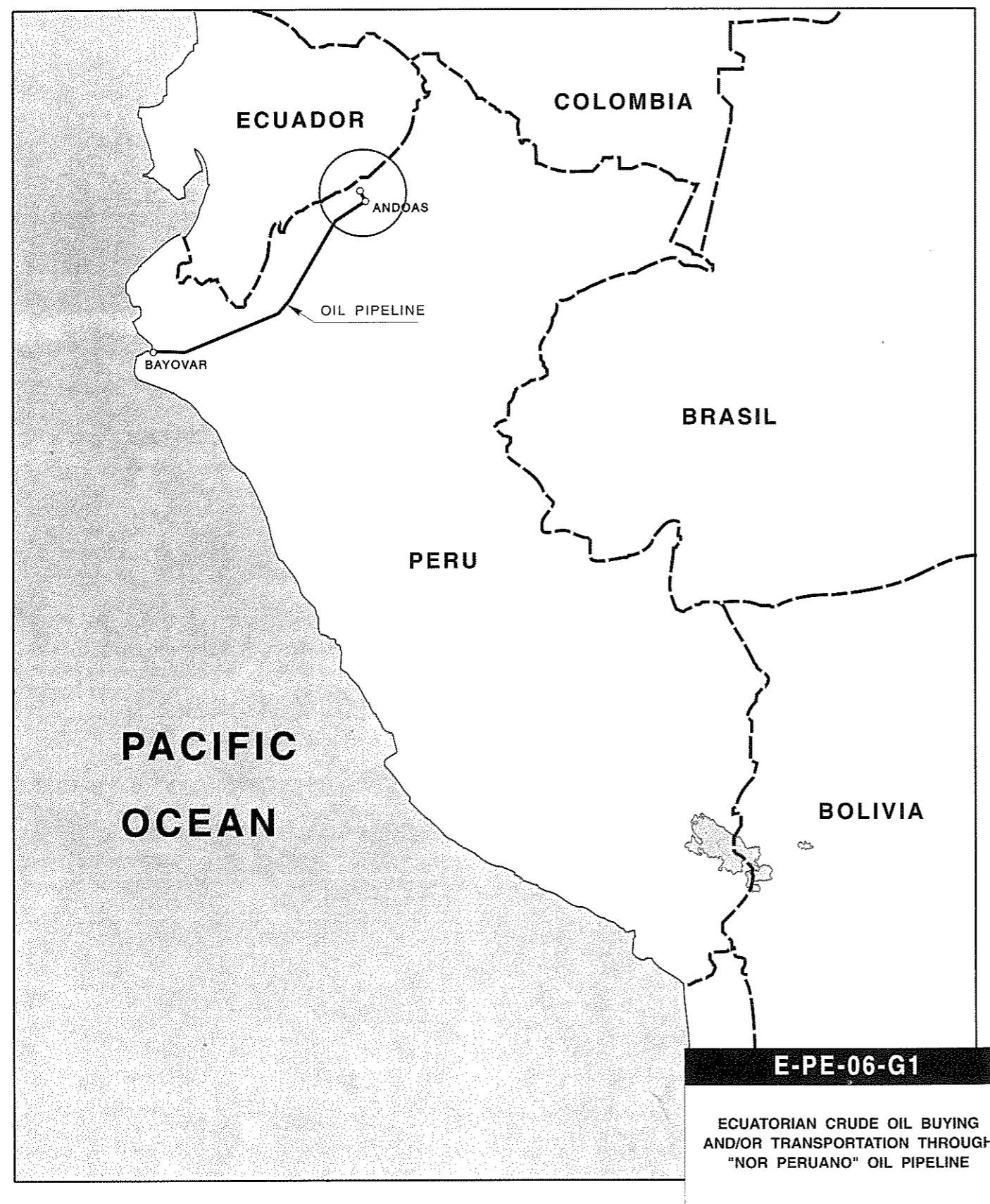
Another alternative would be to buy the Ecuadorian crude directly at the frontier and then transport it through the oil pipeline for its utilization. In this way, the Peruvian deficit of 1.5 million barrels per

month, with an approximate value of US\$ 30 millions, would be covered.

The project would benefit both countries, as it would optimize the use of the existing infrastructure, as the Peruvian oil pipeline has, in its Northern branch, a capacity of 100.000 barrels per day, with an effective use of 55%.

- c) **Present status:** It is in the preliminary stage of analysis and its development depends to a great extent on the foreign policy agreements between Ecuador and Peru.
- d) **Estimated investment:** There are no definite figures regarding the additions to be made to the existing infrastructure.
- e) **Expected benefits:** The project would have a great economical effect for both countries due to the efficiency increase in the use of the existing system, which would mean savings in the operating expenses and financial costs, because of the investments that could be postponed.





Project 7: Exploitation of gas and condensates of Camisea

- a) **Location:** The project is located in South Peru, in the department of Cuzco, where a big deposit of gas and condensates was discovered in 1983, located at an approximate distance of 370 Km from the Peruvian city of Inapari, located in the Brazil-Peru border.
- b) **Description:** The development of the Camisea gas project requires a great investment and an adequate market, for which its binational use would contribute to comply with these requirements. The objective would be to supply with natural gas and liquefiable gas as the GLP the regions of Acre and Rondonia in Brazil and South Peru.

It would have the advantage of initiating the exploitation of the Camisea deposit on its first stage, with an assured market and a lower investment than the one of the integral project, which would help in its financing.

- c) **Present status:** There are only information and studies from Shell (the company that discovered the deposit) that have confirmed the size and characteristics of the deposits. Regarding its binational use, only preliminary conversations have taken place between the governments of Brazil and Peru and between the companies PETROBRAS and BRASPETRO with PETROPERU.
- d) **Estimated investment:** The approximate investment for the exploitation infrastructure of the field, the transportation to Cuzco and South Peru and towards the frontier is 600 million dollars.
- e) **Expected benefits:** The situation of the market would be solved by the integration of the demand. On its first stage, this would make possible the beginning of the project. It could be combined with parallel and/or future stages of transportation of liquids and gas to the Peruvian coast to supply the requirements of these regions.

VENEZUELA

Integration energy projects

GUSTAVO R. CORONEL

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1. INTERPRETATION OF THE ENERGY SITUATION IN VENEZUELA AND COLOMBIA

In the Andean countries, Venezuela has the most uniform geographical distribution of energy resources, although it has a strong concentration in the hydraulic potential in the Southeast part of the country.

This is an important issue due to the fact that besides the energy resources that a country owns, it is necessary to consider its territorial distribution as they are frequently located far away from the consumption centers. This is the case of Chile, that has its hydrocarbon resources in the South and its big consumption centers in the center and North of the territory. Likewise, Peru has its hydrocarbon reserves in the jungle, East from the Andes, and its consumption centers on the Pacific coast, West from the Andes. Colombia also has these differences and also Ecuador, at a lower rate.

1.1 The Venezuelan situation

Venezuela is well known for its great energy surplus. In the present moment, it is a net exporter of energy and, and because of its energy potential, it will continue doing so in the medium and long term.

1.1.1 Hydrocarbons

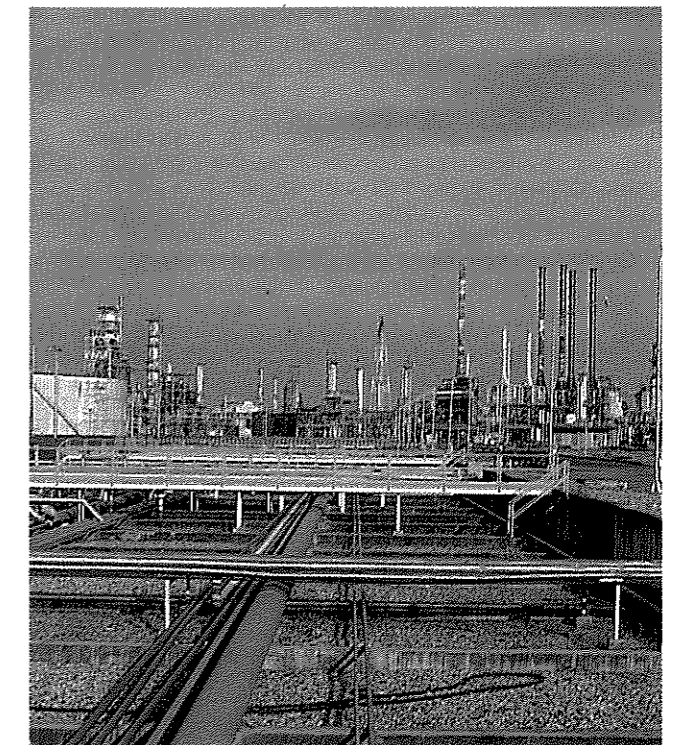
By the end of 1992, the proved petroleum reserves came to 62.5 thousand million barrels, a similar figure to the one accomplished in 1991. The proved crude reserves are the largest in the world apart from the ones in the Middle East, not taking into account the

great deposits of heavy crudes and bitumen estimated by 260 thousand barrels, placed in the Orinoco zone.

Venezuela has large proved reserves of natural gas which were estimated by 22.4 thousand million barrels of petroleum in 1992. This year, the production of crudes and condensates was 2.37 millions of barrels/day, while the natural gas offer was 4.310 MMPCD².

The total external sales exceeded 2.05 million barrels/day and produced an income of US\$ 11.4 thousand millions. In accordance with the present policy to increase the exports of heavy crudes, PDVSA ex-

2. OLADE, Sistema de Información Económico Energético (SIEE), (Energy Economic Information System).



1. The information related to the hydrocarbons part was taken from PDVSA; contact Newsletter No. 31, January, February 1983.

ported 690.000 barrels/day of heavy crude in 1992, which represented an increase of 100.000 barrels/day in regard to the previous year.

The PDVSA refineries in Venezuela and the ones located outside its territory processed an average 1.9 million barrels/day in 1992. It is important to point out that the Venezuelan petroleum industry works with several refineries located in the national territory, in the Caribbean subregion, and that it has investments in several refineries in the United States, Germany, Switzerland and Belgium.

1.1.2 Electricity

The electrical system is composed of four principal enterprises: EDELCA (ELECTRICIDAD DEL CARONI) with its hydroelectrical generation center in the Southeast area; ELECAR (ELECTRICIDAD DE CARACAS), in the metropolitan area of the capital; ENELVEN, in the area of the Maracaibo city; and CADAFE (CORPORACIÓN DE ADMINISTRACIÓN Y FOMENTO ELÉCTRICO), which is located all over the country. These enterprises have effectively interconnected their systems (see map E-VE-01-G1).

In 1992, the total installed capacity came to 18.741 MW, which is basically hydraulic (57%) and the rest is thermic (43%). The maximum demand was about 9.000 MW, and it is expected to increase to 11.000 MW for 1995 and to 16.000 MW, approximately, for the year 2000, which means a year-to-year growth rate of 6-7%.

The Raúl Leoni hydroelectrical central, located in Guri, in the Southern part of the country, has an installed capacity of 10.000 MW and has an important surplus that is sent to the North and Center (the dry season is between the months of December and April). In the Western area, there are smaller hydroelectrical plants such as the Uribante-Caparo complex, which includes the 300-MW San Agatón central, in the Táchira state, and the Páez Plant, in the Mérida State, which has a 240 MW capacity.

In the center of the country there are important thermal plants, with a total capacity of about 5,000 MW. The most important are Planta Centro, with 2,000 MW and Nueva Tocoa, with 1,200 MW.

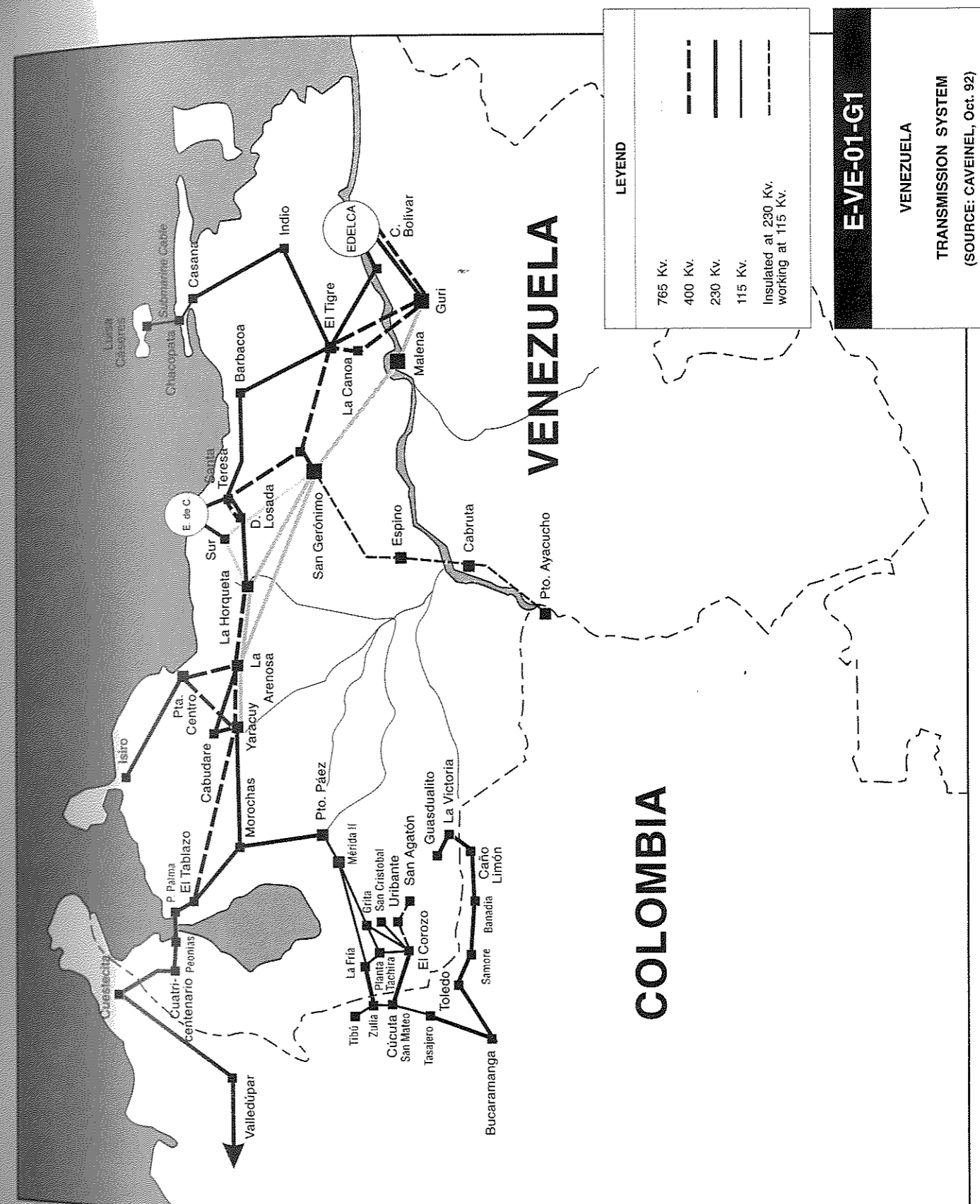
The electrical energy transportation systems, which connect Guri with the center of the country (approximately 650 Km), have transmission networks with tension levels at 230, 400 and 765 KV. The central and Western regions are interconnected through a main transmission system at 230 and 400 KV, approximately 300 Km long, and secondary systems at 230, 138, and 115 KV up to the most important consumption centers.

In regard to hydroenergy, the country has a potential of 83.5 GW, and it is expected to add 9,000 additional MW until the year 2005, in the Southern area near Guri. There will also be a moderate enlargement of the thermic plants in the center of the country, in order to increase the reliability of the system, which will use mainly natural gas as fuel.

In this way, Venezuela will have a considerable surplus of electrical energy during the next 15 years and will be, therefore, a net exporter of this resource.

1.1.3 Coal

The proved reserves of this mineral are near 3 thousand million tons². In 1992, the coal production was 3.1 million tons, most of them exported to Europe. In comparison to the other energy sources previously mentioned, coal is a secondary energy resource, or at least an incipient one. The difference in prices compared to other resources such as oil derivatives, in the international and local market, discourages the local use of this resource.



1.2 THE COLOMBIAN SITUATION

1.2.1 Hydrocarbons

The hydrocarbon activity has recently been very successful in Colombia. From an importer country in the 70s, it has turned into a net exporter with about 200,000 barrels/day. The production has grown from 130,000 barrels/day in 1978 to about 500,000 barrels/day.

These results are due to a continued and attractive association program with the international oil companies, which have taken the proved oil reserves to a level of 3.142 million barrels³ and those of natural gas, to 109.1 thousand millions of cubic meters.

3. LATOIL, No. 053, United Kingdom, 03-1992.



The recent discovery of the Cusiana field, in the Casanare region, is of great importance and adds between 800 and 1,000 million barrels to the proved reserves. Before the discovery of the Caño Limón and Cusiana fields, the oil deposits found in Colombia were small, which represented an expensive oil development.

Due to the above, it is possible to say that the country's profile is the one of a net oil exporter, in the short and medium term.

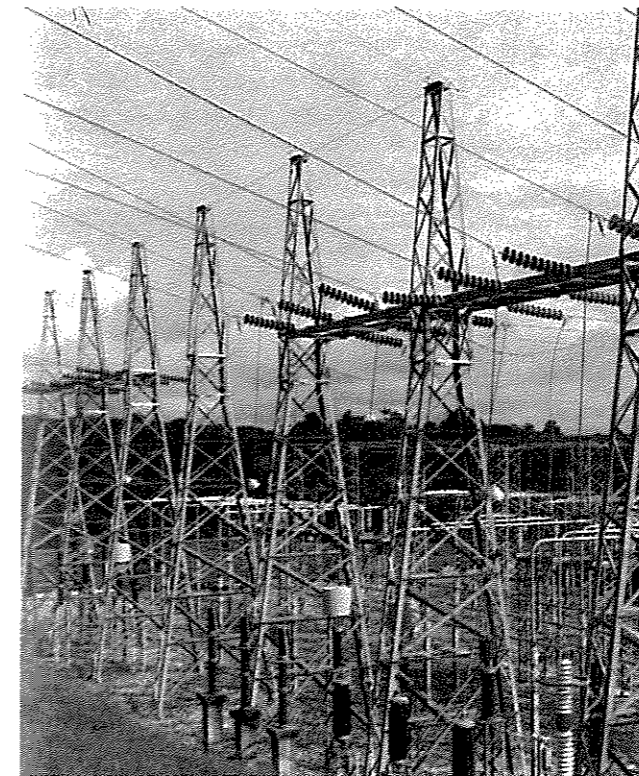
However, in regard to the refining infrastructure, the situation is not as solid. Although Colombia has a refining capacity of 259,000 barrels/day, it has to import derivatives. It seems to be that the refining systems are not the most adequate to optimize the processing of crude, and the geographical location of the plants impedes an optimal economic supply to all the regions of the country.

1.1.2 Electricity

The Colombian electrical system is formed by local and regional public entities, which had a participation on the electrical market during 1992 as follows:

- Empresa de Energía de Bogotá (EEB), with a 28% of the market and a 14% of the installed generating capacity, in the central area of the country⁴.
- Empresas Públicas de Medellín (EPM), with a 22% of the market, and a 16.2% of the installed capacity, also in the central area of the country.
- Corporación Autónoma Regional del Valle del Cauca (CVC), with a 13% of the market and a 10% of the installed capacity, in the same area.

4. ISA, Sector Eléctrico Colombiano (Colombian Electrical Sector), February 1993.



- Corporación Eléctrica de la Costa Atlántica (COR-ELCA), with a 16% of the market in the North.
- Instituto Colombiano de Energía Eléctrica (ICEL), with a 21% of the market, in the rest of the country.
- Central Hidroeléctrica en Betania, with a 5.9% of the installed capacity.

Besides, there is a company in charge of the planning and operating coordination of the integrated system, Interconexión Eléctrica S.A. (ISA), which is the owner of the interconnection lines and of more than the 29.5% of the installed generation capacity.

For 1992, the electrical installed capacity was 8,488 (sic) and was mainly hydraulic (79.6%).

Despite the size of the existing hydraulic resources, (the available potential of hydroelectricity is 93 GW), they are concentrated in the central area of the country. Almost all the dams and hydroelectrical centrals have little or no regulation capacity, which makes them vulnerable to long periods of drought.

The following emergency decisions were taken in 1992 due to the crisis in the electricity supply:

- Purchase of energy and additional power from Venezuela.
- Purchase of energy and additional power from Ecuador.
- Quick acquisition of loans for US\$ 150 millions from the Interamerican Development Bank, in order to finish the El Guavio Hydroelectrical central and accelerate the required interconnections.

1.2.3 Coal

The Colombian coal subsector has had fast progress during the last 10 years. The proved reserves (6,488 million tons in 1992) and the production (23.5 million tons in the same year) give the country the profile of a net exporter.

However, the geographical location of the coal deposits makes its domestic use expensive and unattractive, in the short term, in the central area of the country, which has serious energy supply problems. It seems obvious that the Colombian coal will be an important export item in the short and medium term.

2. COMMERCIAL AND ECONOMIC INTEGRATION EFFORTS

2.1 General View

From different points of view, the economic and commercial integration between Venezuela and Colombia is the most successful one in the Andean subregion. Since January 1992, because of the favorable regulations to establish the common market, the two countries have rapidly progressed in the purpose of establishing a commerce free zone and a uniform tariff.

Venezuela lowered the tariff barriers in January and Colombia did too in February 1992, which created a common market of more than 50 million people. Colombia imports about 1,300 products from Venezuela. The trade between the two countries increased to over US\$ 800 millions in 1992 and it is expected to reach US\$ 1.200 millions in 1993. Fifteen percent of these products have an agroindustrial origin, 25%, chemical and 60%, metalmechanical. The products with the highest demand are: polyethylene, dodedibenzene, aluminum alloys, iron and steel plates, urea and sodium triphosphates. Colombia exports a great variety of agriculture and industrial products to Venezuela. Generally speaking, Colombia's presence in Venezuela is significant, with more than 60 companies operating in the country, while Venezuela has an important financial investment in Colombia.

2.2 Energy Integration Potencial

The energy integration has progressed more slowly than the commercial and economic integration, because, among other reasons, the energy projects are usually so large that they require several years for their execution.

In the next five years, Venezuela will try to increase

its oil production from 2.37 to 3.5 million barrels/day; and Colombia, from 0.5 to 1.0 million barrels/day with the development of the Cusiana field and the discoveries in Casanare. For this reason, and considering the possibility of increasing the daily oil production and the development of the gas and petrochemical industry, both countries could complement their oil industries to obtain a real increase on their market.

From another point of view, unlike Venezuela, Colombia has serious energy supply problems in several areas in the country. This is due to the irregular geographical distribution of its resources and the predominance of hydroelectricity in some centrals that makes them vulnerable to intense and long droughts.

For this reason, besides the energy integration between the two countries, they should look for the possibility of effecting major sales of energy surplus from Venezuela to Colombia in the short and medium term. This sale would mean benefits for Colombia such as:

- a) Savings on its own resources, especially on natural gas, in the Atlantic area.
- b) Postponing some expensive thermic generation projects of electricity in the same area.
- c) Higher reliability in the supply.

Venezuela, could dispose of its surplus for the neighboring market, as long as it is not necessary to make high investments, which would mean additional income for the country.

Venezuela is highly interest in supplying energy resources to Colombia. From the Venezuelan point of view, these transactions should be made at market prices and keeping in mind the investments, especially the necessary ones to make possible the energy supply to Colombia. Without a doubt, the investments and costs involved in the energy supply must be accepted

and shared in the necessary proportion, for which the capital assignments may be used as a reference and/or the tariffs previously established. This economic aspect is crucial, as Colombia has historically showed interest in receiving energy at prices similar to those held by Venezuela for its local market, which are strongly subsidized.

There have been several energy integration projects between Venezuela and Colombia, which are mentioned below.

3. HYDROCARBON PROJECTS

(See maps E-VE-02-G1 and E-VE-03-G1)

Project 1: Colombia-Venezuela gas pipeline⁵

At the meeting held in Maiquetía (Venezuela) in January 1992, the presidents of Colombia and Venezuela agreed to promote the gas interconnection in both countries.

The gas integration is a project that not only involves the energy sector parties but also presents the advantages of being planned within a wider framework defined by the economic integration process which is taking place between the two countries. This makes this initiative a real integration project, and not only a commercial transaction for the purchase and sale of gas.

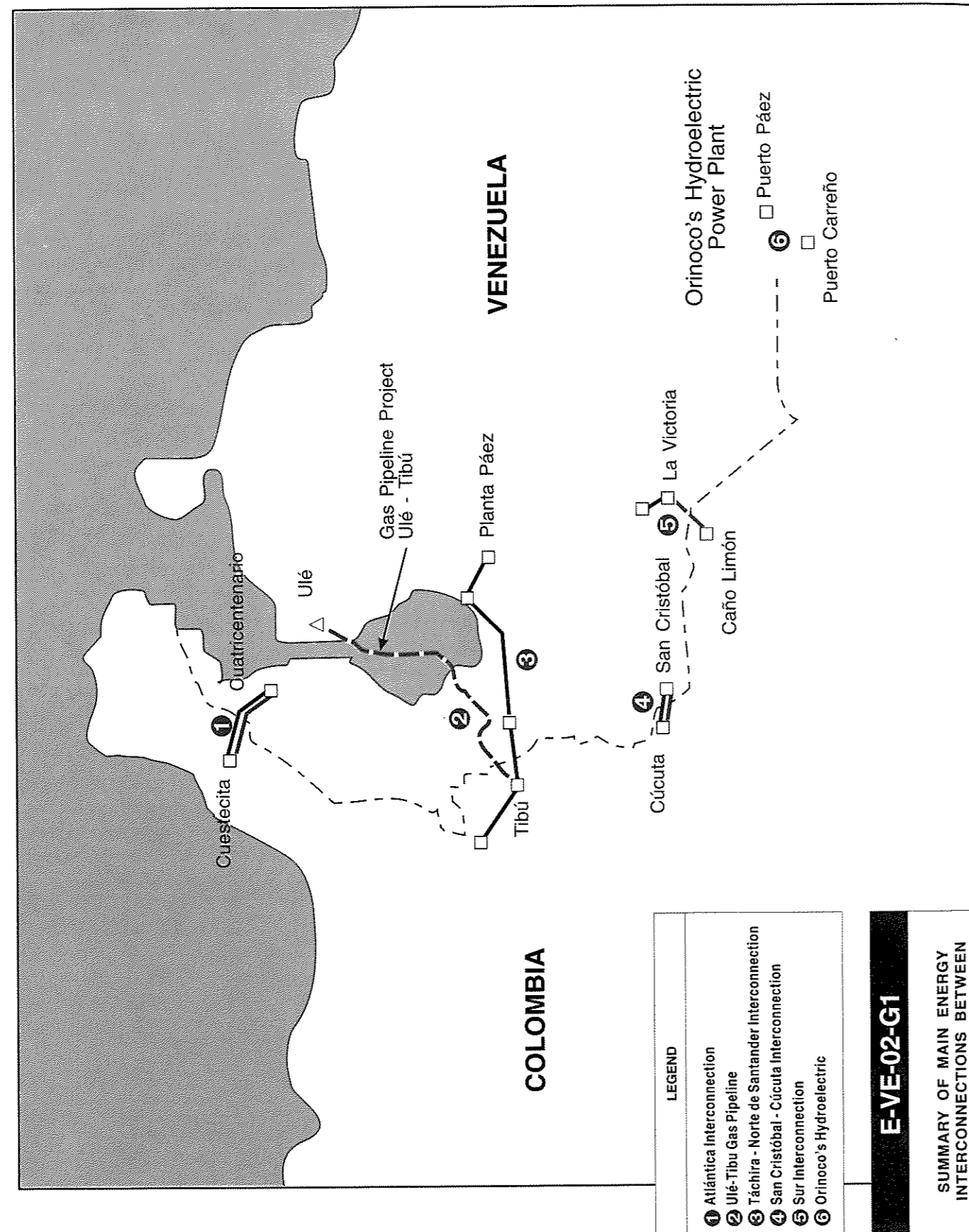
In regard to the market situation, in 1992 the gas reserves in Colombia were 109.1 thousand millions of cubic meters. The most important gas deposit, located outside the coast in the Guajira Department, supplies the needs of the Atlantic coast, Santander, and the rest of the country.

5. See OLADE, Proyecto de Integración Gasífera Colombia-Venezuela (Colombia-Venezuela Gas Integration Project) Quito, June 5, 1992.



Venezuela has one of the most important natural gas proved reserves in the world located (1990), 25.5% in the West, 74.4% in the East, and the remaining 0.1% in the South of the country. The proved reserves have grown in the last ten years, from 1.262 to 3.635.9 thousand millions of natural gas cubic feet in 1992. The gas production is mostly of the associated type, so its availability is closely linked to the oil activity. In this sense, the Venezuelan gas production, besides depending on the proved reserves, may have additional restrictions.

The availability of gas to be exported to Colombia will depend on the explicit or implicit policy for the handling of the gas subsector. Likewise, if the refineries, industries and thermoelectrical centrals could increase their efficiency in the use of natural gas as a fuel to satisfy their energy requirements, a considerable amount of this hydrocarbon could be used



for exports. In the long term, Venezuela could supply Colombia with a bigger amount of gas, near 200 MMPC/day, once the interconnection of their West and East gas pipeline systems is made.

There are two alternatives to interconnect Colombia and Venezuela:

1. The Ule-Maicao route. This gas pipeline would be 170 Km long in Venezuela, and 60 additional kilometers in Colombia in order to interconnect it to its national network; and
2. The Ule-Tibú route. The length in this case would be 330 Km in Venezuela and 137 additional kilometers in Colombia in order to interconnect it to its national network.

Venezuela offered up to 60 MMPCd of gas in a twelve-year period, beginning in 1993. This supply is supported by an accelerated growing scenario in the production of crudes. In the case of the first sketch, it would be at a pressure of 65 psig (manometric pounds per square inch); a higher pressure would require a compression station in the border where the transfer would be made; and no local market would be supplied along the new gas pipeline.

In accordance with a study made by OLADE, if the additional benefits that Venezuela would obtain with the alternative of delivering gas in Tibu were not considered, there would be an advantage, at the cost level, in delivering the Venezuelan gas via Maicao.

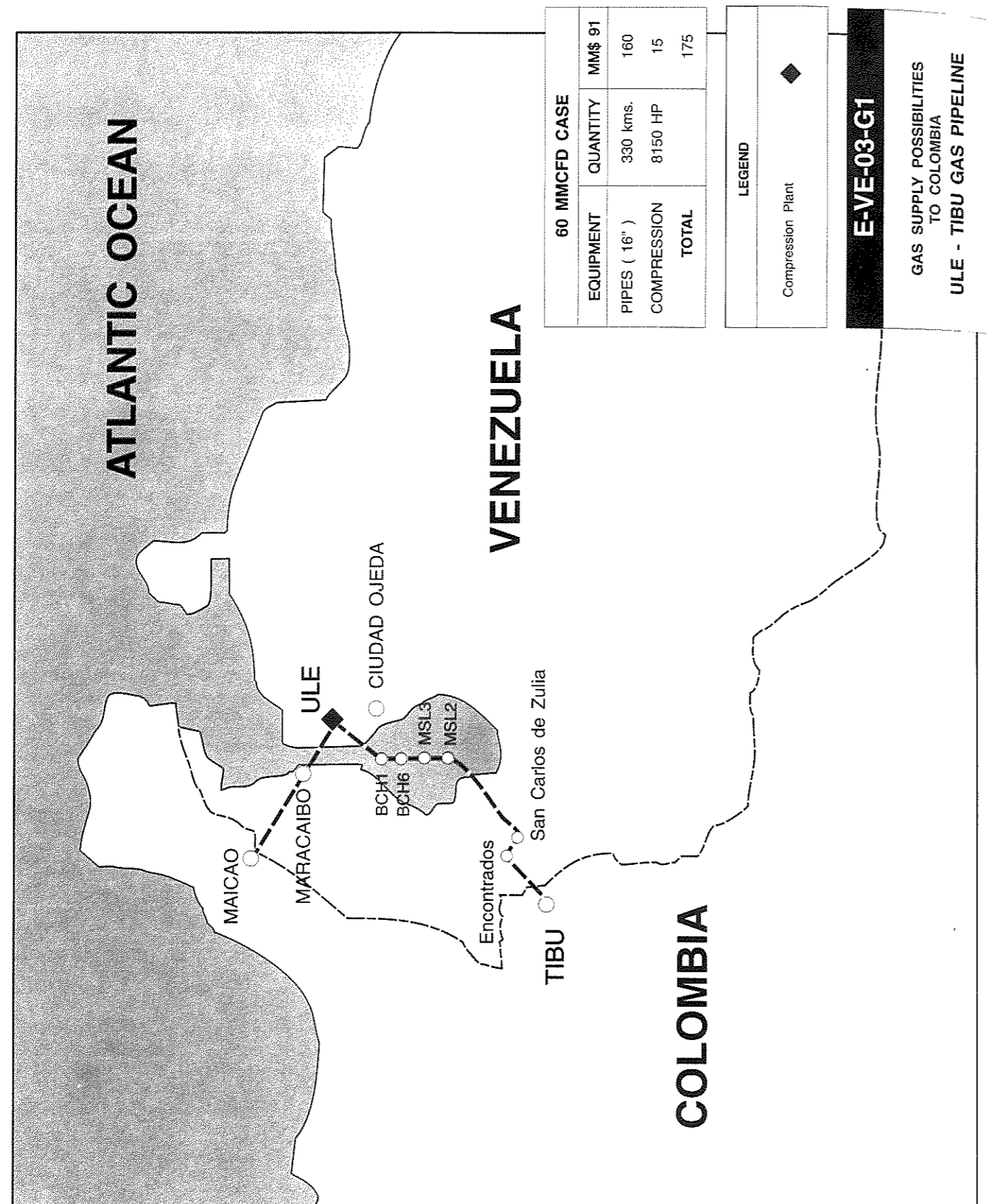
Anyway, the gas development program in Colombia has some uncertainties both by the demand and by the supply. For this reason, it would be important to confirm the potential of the gas deposits, especially in Guajira and Cusiana. Also, from the political and institutional point of view, it would be necessary to clearly specify the rules regarding the investment, taxes, and price level, which must be stable in the future, in order to attract the gas program to the in-



terested parties, especially the private investors, both for the Colombian market and for the interconnection project.

The technological factor could be of great importance: first, to create reserves (improving the management of the gas and oil production) and second, to improve the final use of energy (introducing for example gas-another fuel dual equipment). Given that the size of the import requirements in Colombia can be handled by the supplier, 200 MMPC/d as a maximum, and that they may decrease with time, once the Cusiana deposit begins operating, the possibility or flexibility in the Venezuelan market, if it were necessary to replace fuel by gas, would be reduced and of a short duration.

Finally, although some uncertainties persist on some



of the values assigned to the variables used for evaluation, it is clearly concluded that the gas interconnection project is technically, economically, financially and commercially viable.

However, the Colombo-Venezuelan Grupo de Trabajo de Gas (Gas Work Team) which met in Bogotá on October 1, 1992, made several comments on the project.

The Venezuelan group made a presentation over the feasibility of the project and mentioned that the gas balances in the East showed a deficitary situation, for which the following conclusions were made:

- The present scenario considers a reduction in the hydrocarbon production level previously calculated (90-91), which causes a radical reduction in the availability of gas for the local market.

- On this basis, the gas situation is precarious, causing a loss of crude reserves (injection) or the consumption of exportable liquids.
- From the above it is concluded that under the present scenario there would not be gas for exports from West Venezuela to Colombia (60 MMPCD for 12 years).

On this point, the Colombian group stated that the natural gas recently discovered could supply additional volumes which would not make the initial imports of this fuel urgent. However, it was mentioned that the complementation of the Venezuelan gas to satisfy the uncovered demand was convenient for the Mass Plan.

Project 2: Supply of liquid hydrocarbons from Venezuela to Colombia

In the area of liquid hydrocarbons supply to Colombia, there is not a solid binational energy integration process yet.

However, there is the possibility of building an asphalt plant in Puerto de la Cruz, in Venezuela, in association with Corpoven and the Venezuelan company VENOCO, in order to export this product to Colombia. It is also being considered to pump Orimulsión, from South Venezuela to Tibú in Colombia. The compressed natural gas for automobile use (GNC) has received some attention, although Colombia already has valuable experience in this area. The liquid gas transportation, from the José Anzoátegui plant, by ship to the Colombian Atlantic Coast or by land to Cúcuta, may also be an alternative.

Colombia seems to be interested in acquiring Venezuelan liquid Hydrocarbons at reasonable commercial prices; the problem may be in the definition that both countries have about this concept. For Venezuela, the reasonable price is the international

price, while for Colombia it would seem to be the one that Venezuela uses for its local market, which is subsidized. If Venezuela sold gasoline at its local market price, Colombia would have significant profits on each imported litre. Anyway, Colombia imports today between 20 to 25 thousand barrels/day of hydrocarbon products from Venezuela, at international prices, so it would be possible to establish mutual beneficial agreements.

Likewise, other possible sales from Venezuela to Colombia include the basis for lubricants, diesel and kerosene for industrial use.

Other ideas such as the construction of a propane pipeline from José Anzoátegui (East Venezuela) to Bajo Grande (West Venezuela), to San Cristobal (border) and Tibú (Colombia) would not be economically justifiable, due to the size of the investment.

Also the difference in relative prices is an important aspect, as there are significant differences in the prices of oil derivatives, (liquified gas, gasoline and medium distilleds), which must be balanced, in order to effectively integrate the energy supply on both sides of the border.

Project 3: Supply of CORPOBRICK from Venezuela to Colombia

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CORPOVEN, in conjunction with the Centro de Investigación y Desarrollo Tecnológico (INTEVEP) (Technological Development and Investigation Center), have perfected an energy source called CORPOBRICK.

This product, brick shaped, has a calorific value 27% higher than coal, and 11% higher than Orimulsión, the new fuel that PDVSA is developing for the generation of electricity and other industrial uses.

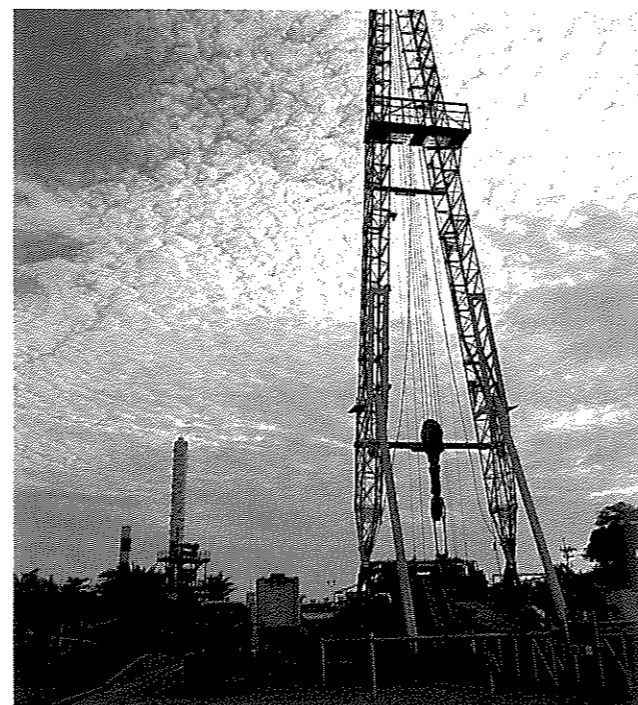
This manufactured energy brick is made of a mixture

of bitumin from the Orinoco area and fragments of Uverito pine. This mixture is almost ready for the market and may advantageously replace vegetable coal used in Colombia in the East and central areas.

Project 4: Joint exploration and production of gas

The project considers the possibility of making a joint exploration and development of hydrocarbon deposits which may be in the frontier area of both countries, based on an agreement between the state oil companies Petróleos de Venezuela S.A. (PDVSA) and Ecopetrol, from Colombia.

Through this possible binational activity, the required infrastructure for the development of the deposits



could be rationalized, which would avoid the duplication of efforts and investments.

In the past, these actions could have been made in the case of hydrocarbon developments in the Colombian plains and the Venezuelan area of Apure.

4. ELECTRICAL PROJECTS

Project 1: Interconnection between the Cuestecita (Colombia) and Cuatricentenario (Venezuela) substations (See maps E-VE-02-G1 and E-VE-04-G1)

The 230 KV interconnection line between Colombia and Venezuela, was built based on an agreement between the two countries, in order to improve the energy supply reliability in the Zulia and Atlantic region, respectively, to increase the possibility of optimizing the use of energy resources and to act as a support in emergency situations.

The execution of studies, design, investment and construction was made by Interconexión Eléctrica S.A. (ISA), by Colombia, and Electrificación del Caroni C.A. (EDELCA) by Venezuela. The operation and maintenance will be the responsibility of both entities.

The project is located in the North area of Colombia (in the department of Guajira) and in the Northeast of Venezuela in the area of influence of the city of Maracaibo, and has a 230 KV simple circuit transmission line, 130 Km long of which 45 are in Colombia and 85, in Venezuela; the enlargement of the Cuestecita substation and the construction of the Cuatricentenario substation.

The electrical interconnection was started up in November 1992, with 100 MW transportation capacity, that will be increased to 150 MW in December 1993, with the installation of compensation capacitance (78

Mvar) in the Cuestecita substation. Afterwards, with the new 230 KW line between Cuestecita and Valledupar, there will be a power transfer potential of up to 200 MW.

This project has a cost of US\$ 29.4 millions of which US\$ 16.4 millions correspond to Colombia, which are financed with own resources from ISA and loans from the national government, FEN and EXIMBANK. The cost of the work of the Venezuelan sector is US\$ 13 millions.

On a second stage, it is possible to foresee the amplification of the interconnection, through the construction of a second circuit at a tension level (400 KW or 230 KV), to be defined in accordance with the exchange levels (firm, optimizable and of emergency), established between the electrical systems of both countries.

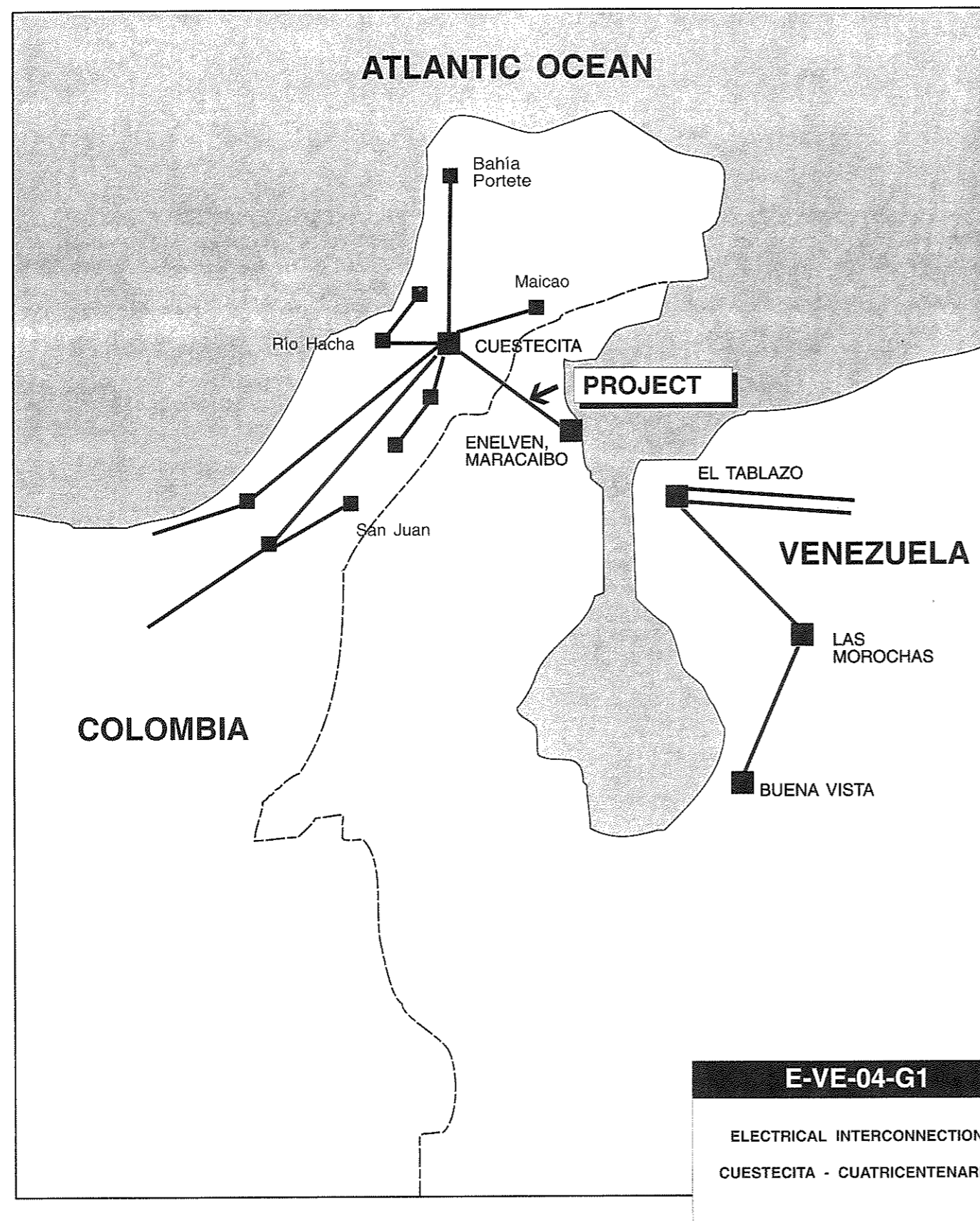
Up the moment, the interconnection agreements or binational supplies have been made based on the premise that the electrical systems in both countries must be independently planned from each other, which has meant the transfer of the energy surplus and electrical power that may eventually exist in any of the systems. However, it would be convenient to explore the possibilities of the joint planning by both countries, which would result in coordinated investments both in transmission systems and in generation, as well as the efficient use of the energy resources.

Project 2: Interconnection between San Cristobal in Venezuela and Cucuta in Colombia

(See map E-VE-02-G1)

In 1983, a Technical Commission of professionals from CADAPE from Venezuela and ICEL and Centrales Eléctricas de Santander S.A. (CENS) from Colombia

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made a study (230 KV Colombia-Venezuela Interconnection —first phase), where it was concluded that the interconnection between the electrical systems of the mentioned companies was convenient, because they operate in neighbor areas and have electrical charge peaks at different hours. In the same way, it was recommended to reserve, in the substations of San Mateo, in Cúcuta, and El Corozo, in San Cristobal, the outgoing modules for a 230 KV interconnection line.

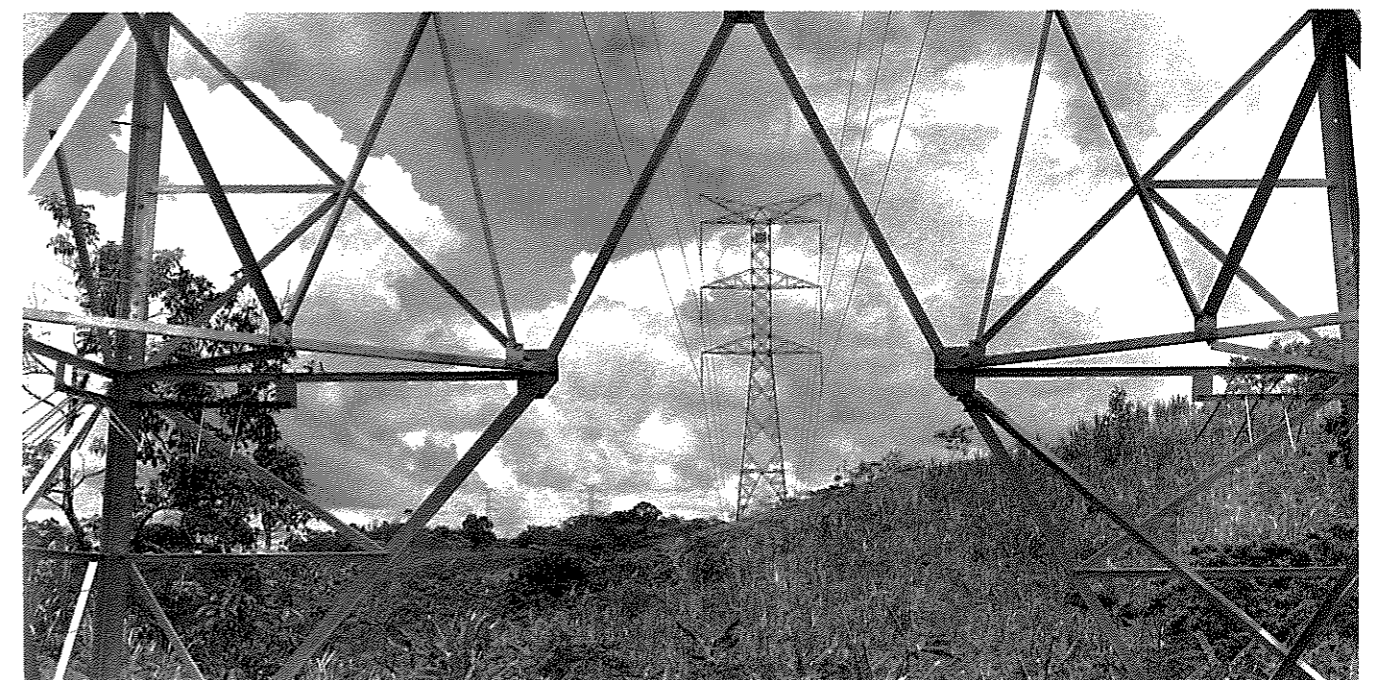
This project had been postponed until 1992. Due to the rationing of electrical energy in Colombia, it was considered again.

The project would consist of the installation of a double-ternary line of 230 KV, 39 Km long in Venezuela and 10 Km long in Colombia, and it would require an investment of US\$ 10 millions. The max-

imum transportation capacity of the line would be 300 MW. In Colombia, the construction of a new transmission line at 230 KV, would be required between Cúcuta and Bucaramanga.

Today, both countries are considering the convenience of its development and it depends on the completion of the Uribante-Caparo project in the Andean area in Venezuela. It would be convenient that both countries carry out a coordinated planning of their medium and long term plans of generation expansion and transmission.

Finally, it is important to point out that because of the rationing in the Colombian electrical system a distribution feeder at 13.8 KV (isolated at 34.5 KV) was started up, in order to feed the urban areas of Cúcuta, in the border with Venezuela, with a maximum transference of 8 MW. The transportation capacity



could be increased to 20 MW, if it is energized to 34.5 KW, for which a module in the San Antonio substation is required.

Project 3: Interconnection between the Zulia substation in Colombia (Norte de Santander) and the La Frial substation in Venezuela (Táchira)

(See map E-VE-02-G1)

Since 1969, there has been an electrical interconnection at a 115 KV level, 30 Km long, between the Planta Termoeléctrica Táchira, located in the town of La Fría, in Venezuela, and the Planta Termoeléctrica del Zulia, of CENS of Colombia, near the town of Tibú.

The maximum capacity of power transference through that interconnection (85 MW), is presently limited to 50 MW due to restrictions in the Norte de Santander network. In order to take advantage of the potency of this transmission line, Venezuela has totally rehabilitated the Central Termoeléctrica Táchira of 250 MW (it uses gasoil as fuel), in order to guarantee the supply. Colombia would have to install reactive compensation of about 20 Mvar in the distribution networks in the cities of Cúcuta and Ocaña.

Eventually in the future, this interconnection will allow Venezuela to use the generation surplus from Colombia, with which it would be possible to reduce the gasoil consumption in the Planta Termoeléctrica Táchira.

Project 4: Interconnection through South Venezuela

(See map E-VE-02-G1)

The existence of a 230 KV line up to the petroleum fields of Caño Limón, in the Colombian East Plains near the Venezuelan frontier towns, increases the possibility of a stronger interconnection in this area.

Since 1992, due to the electrical rationing in Colombia, the company ELECENRO, an affiliate of CADAFE and the Empresa Electrificadora del Departamento del Arauca, initiated conversations to study the convenience of building a 34.5 KW second line from the Venezuelan town of Guasdalito, located in the state of Apure, up to the border which would allow power transferences of 10 MW.

Project 5: Hydroelectrical joint projects on the frontier in the Orinoco river

(See map E-VE-02-G1)

In a very long term, the binational hydroelectrical development in the Southern area may be the subject of several interconnection projects. In this context, OLADE recommends accelerating the prefeasibility studies for the construction of a hydroelectrical plant in the Orinoco River in order to use its potential jointly.

3.2 Coal projects

Project 1: Rationalization of the operations

The integration possibilities in the coal subsector seem to be less promising because of the high development of the subsector in Colombia and the incipient level in Venezuela.

In this moment, a great amount of Colombian coal is channeled through La Ceiba port, located at the Maracaibo Lake. The transportation of great volumes of Venezuelan coal and afterwards of Colombian coal, by railroad from the Zulia area towards a port of deep water in the Gulf of Venezuela is one of the possibilities studied by Carbozulia.

In this context, it is convenient to study all the opportunities that may exist between both countries, in order to handle the coal operation efficiently.

Project 2: Defense of coal prices

Colombian coal has the lowest prices on the international markets despite its high quality. This is due to its late introduction to the world trade, which could also happen with the Venezuelan coal. It is suggested considering the possibility of promoting an organization that would defend coal prices, as it is done by the Oil Producing Export Countries (OPEC). An organization that may work in this matter would have the secondary effect, but not less important, of defending the prices of other energy sources, including oil.

5. FINAL COMMENTS

The profiles of the projects presented in this report have a wide range of priorities and require more ac-

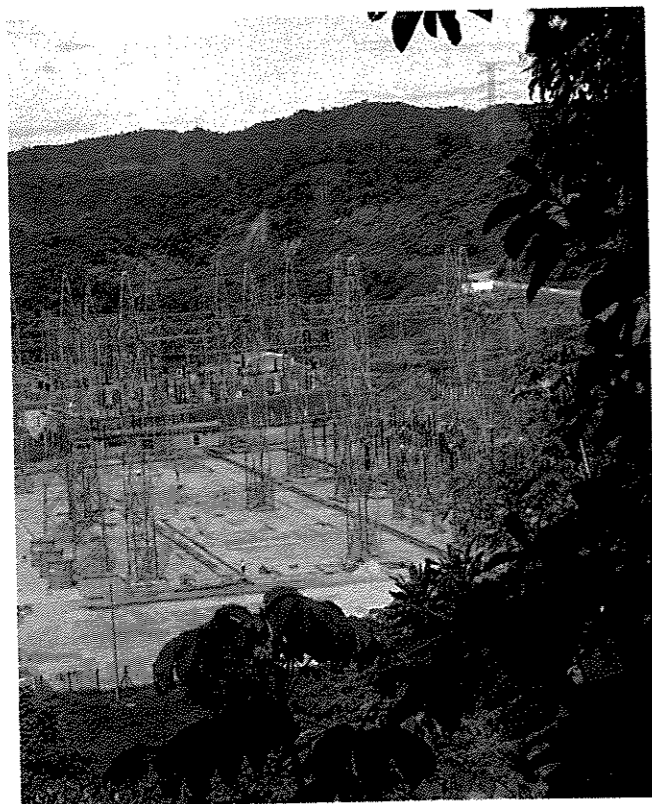
curacy for their definition. These profiles cover from projects being executed to others which are still on a conceptual stage, just ideas. Most of them require high investments in infrastructure and others may be developed with low financial resources. Some are typical cases of interconnection, others are based on the principle that Venezuela has a great energy surplus that may be transferred to Colombia. Likewise, some projects are relevant, because they could develop the industrial binational market in the medium term.

On this first stage, the priority list is the following:

1. Interconnection Master Plan in the electrical subsector between Venezuela and Colombia.

This is not an existing project, but should be the most important in the list.





2. Cuatricentenario-Cuestecita electrical interconnections.

Both the associated complementary works to the service on line (capacitance compensation in Cuestecita and 230 KV line between Cuestecita and Valledupar) as the new 230 or 400 KV line.

3. Electrical interconnection of the Andes.

4. Colombia-Venezuela gas pipeline.

5. Electrical interconnections in the South border.

6. Rationalization of the operations in the transportation of binational coal for exports.

The other projects should be efficiently carried out, although they do not have the same priority. However, it is necessary to state that not always the urgent projects have the highest priority. In this sense, it is necessary to warn about the possibility of deviating the integration program between Venezuela and Colombia exclusively towards projects oriented to the solution of emergency situations of energy supply, especially on the Colombian side.

OLADE

The andean energy integration before a new century

• Chapter prepared by OLADE —Organización Latinoamericana de Energía—, (Latin American Energy Organization), at CAF's request, to present certain complementary criteria regarding the energy integration projects, which are compiled in this document.

1. INTRODUCTION

In a world where the energy industry, especially the hydrocarbon industry, becomes international and the competition for capital investment and capital risk increases, the governments have initiated the undefeatable task of updating the energy legislation, as well as modernizing the state-owned companies.

The strategy of opening the economy, compatible with that of consolidating and modernizing the state companies within a regulatory framework, that praises both the public and private management, tries to attract the subregional, regional and extraregional capital to participate actively in the development of the sector.

It is very important to be aware that the effort to be made is a long-term one. The existing obstacles may be defeated and the structural changes introduced, even if they require time, mostly in a sector as the energy one which has a highly owned inertia. The results of these changes will be seen with a low intensity by the end of the 90s and with a higher depth in the next century; but to accomplish this, it is necessary to act quickly.

The Andean integration appears as a fundamental mechanism to get involved in the new international order and offers the opportunity to carry out joint developments, improve the cooperation between countries, rationalize investments, diversify economical and political ties, and move towards energy self-sufficiency within a framework of efficiency and competitiveness.

Due to the financial restrictions of the countries and the great investment needs that the energy sector requires to take care of its growth and economical development, it is indispensable to support the integration and energy complementation projects,

which may even cause changes in the matrix of the supply and demand of energy sources.

The great investments required by the energy industry in the Subregion until the year 2000, the same of the Andean foreign debt of approximately 90.000 million dollars, could only be made with the mutual effort of the private and state initiative. The opportunities for a better participation of the private sector, are not only in the activities of the sector, but also through the production of capital goods in the subregion, as well as with the contribution of specialized services.

In fact, the present development of the Andean industry, supplier of goods, capital goods and services to the energy activity, indicates an important level of technological progress in many activities. Through the integration, the use of the industrial capacity and existing services will increase, which will allow substantial reductions of contracts from outside the subregion.

2. THE INTEGRATION AND ENERGY COMPLEMENTATION AMONG THE ANDEAN COUNTRIES

The Organización Latinoamericana de Energía (OLADE) has had the opportunity to prepare this chapter, based on the works presented to the Corporación Andina de Fomento (CAF), by the consultants Gustavo Coronel, Alberto Vásquez R., Hans Collin, Juan Incháustegui and Jorge O'Connor D., from Venezuela, Colombia, Ecuador, Perú, and Bolivia respectively, as well as with the information available in the Permanent Secretariat. The projects identified will greatly help in the integration process and energy complementation in the subregion.

In this context, OLADE recommends some actions and suggests some projects that will contribute to enrich the integration possibilities.

In this regard, it is important to mention that in the framework of the international gas agreements recently signed by Bolivia, the possibilities of integration of this country with Peru, deserve a new evaluation based on the expansion of the Bolivian energy system and the development possibilities of Camisea in Peru. For this reason, the integration options between both countries are presented with more details, than for the rest of the binational considerations.

2.1 Colombia and Venezuela

From different points of view, the economic and commercial integration between Venezuela and Colombia is the most successful in the Andean subregion. Since January 1992, due to favorable rulings to establish a common market, the two countries have rapidly advanced on the purpose of establishing a trade free zone and agreeing on a uniform tariff.

However, it must be accepted that the energy integration has moved more slowly, among other reasons, due to the fact that the size of the energy projects may require execution and conception periods of several years.

Nevertheless, in the short and medium term, there is the possibility to optimize the use of the infrastructure and the available energy resources on both sides of the border, with investments and costs exceeded by the benefits that would be obtained.

In the long term, the possession of huge and different natural resources, offers Colombia and Venezuela the possibility of a mutual energy complementation, contributing in this way to solve the requirements of future investment that will be required by the national energy sectors.

In this context, and taking as a basis the identification of projects made by the consultants Gustavo Co-

ronel and Alberto Vásquez Restrepo in Venezuela and Colombia, respectively, it has been concluded that there are conditions to increase the integration programs and energy complementation between both countries.

In this regard, it is recommended considering the following actions:

1. The electrical interconnection agreements and binational supply have been made up to the moment, under the premise that the electrical systems from both countries must be planned independently, making possible only the transfers of energy and power surplus that eventually may exist in one of the systems, under emergency conditions in any of the two countries.

On this basis, it is highly recommendable to evaluate the convenience of developing a mutual planning and operational complementation, between the electrical companies from Colombia and Venezuela, which would allow both to optimize the investments in the generation and transmission stages, and to use the energy resources efficiently and rationally.

2. The possibility of building a gas pipeline between both countries justifies periodical evaluations based on aspects such as the offer of the Venezuelan resource; of the policies oriented to the massification of natural gas in Colombia, in a short term; and eventually, the possibility of facing, in the long term, the mutual supply to Central America and Mexico.
3. In order to increase the supply of oil derivatives effectively from Venezuela to Colombia, it is advisable to evaluate the possibility of establishing a mechanism to establish the prices, which reflects the conditions of the international market and the opportunity cost of these products in both

countries. This concept could be applied to the electrical subsector.

4. Considering the possibility that coal recovers its importance as an energy resource in the world economy, it is important to initiate evaluations in order to optimize the investments in the productive and transportation infrastructure in both countries.

2.2 Colombia and Ecuador integration

The energy integration between Colombia and Ecuador is oriented to the short term in the electrical energy interconnection projects. In fact, in October 1986, the exchange of electrical energy was agreed between the frontier systems and commercial conditions were established for the purchase of power and energy by CEDENAR to EMELNORTE. In February 1992, a wide electrical integration plan of several stages was defined, as it has been described in the work prepared by the CAF consultants.

About the hydrocarbon subsector, the most important fact was the construction of the Lago Agrio-Río San Miguel oil pipeline which was connected with the Colombian Transandino oil pipeline, due to the damages suffered by the Transecuatoriano oil pipeline as a result of the earthquake of March 1987.

In this context, and as a complement of the evaluation made by the consultants Alberto Vásquez Restrepo and Hans Collin, from Colombia and Ecuador respectively, it is recommended initiating the Plan Binacional de Contingencia (Contingency Binational Plan) to control the crude spills and to protect the ecosystem in frontier areas.

Besides, it is important to point out that Carbocol, from Colombia, has prepared a cooperation program to promote the use of coal in Ecuador. This program includes technical assistance to allow the participa-

tion of Colombian coal in the energy matrix in Ecuador, and at the same time carry out a preliminary study of the reserves and projects that have the highest potential use of this resource. The activities proposed would include the gathering and analysis of the existing information and a diagnostic report to define priorities and possible use in the coal areas.

The energy integration process started with the electrical interconnection and the use of the Colombian oil pipeline by Ecuador, has other alternatives that deserve to be studied.

In this sense, it is important to point out the following aspects:

1. The estimated cost of the electrical interconnection, in the short term, at a level of 34.5 KV (up to 20 MW as a maximum) between Colombia and Ecuador, is minimum compared to the benefits which both countries would obtain. Additionally, this interconnection would help emergency situations to some extent such as those that occurred during the last two years on both sides of the border.
- Regarding the medium and long term electrical interconnections (at 138 and 230 KV), it would be advisable to conceive them in a planned and coordinated way, and promote that their financing be obtained jointly.
2. It is advisable to evaluate the technical possibility of amplifying the capacity of the Maldonado minicentral, located in Ecuador, to count on a decentralized system of electric generation which can offer service to the towns of San Juan, La Union and Talambí in Colombia, and increase the socio-economic level of the rural people in the frontier.
3. It is suggested to study carefully the subject of the contingency binational plan. To do it, binational

technical commissions could be appointed, in order to define agreements in this matter.

4. Given that markets are complementary, it is recommended moving the initiatives oriented to the effective mutual commercialization of crudes and petroleum derivatives.
5. As the geothermic area of Tufiño-Chiles-Cerro Negro has the possibility of incorporating the geothermic resource from the frontier area to the energy supply of Colombia and Ecuador, it is recommended continuing its study until its real geothermic potential is known.

Additionally, it is possible to do a prefeasibility study in the area known as El Azufra de Túquerres in Colombia, the geothermic development of which could supply this frontier area with energy. According to the technical information available today, the geothermic potential of El Azufra would exceed Tufiño-Chile-Cerro Negro's.

6. With the possibility of replacing the use of petroleum derivatives, especially in the Ecuadorian industrial sector, it is advisable to initiate the technical-economical evaluations oriented to the incorporation of the Ecuadorian energetic matrix, the supply and consumption of coal, within the framework of the initiative of Carbocol from Colombia.

2.3 Ecuador and Perú integration

The integration possibilities between Ecuador and Peru in the energy sector have not been actively developed due to low energy demand in the frontier area and to the traditional autonomy concepts, adopted by each country and that are supported by the abundance of resources.

Today, the scenario has changed significantly not only

because of limitations in the expansion of the hydrocarbon and electrical sectors, but also due to the need of optimizing the financial operations and promotion of investments.

In fact, the present energy deficit requires a great investment effort to enlarge and modernize the production infrastructure, transportation and distribution of energy. In this sense, it is opportune to evaluate the application of an energy supply plan that includes projects and integration mechanisms and also binational complementation.

In this context complementing the work done by the consultants Hans Collin and Juan Incháustegui, from Ecuador and Peru respectively, it is suggested to develop in the hydrocarbon sector the following initiatives:

a. Exploration and production of hydrocarbons in the frontier area

Peru has 18 sedimentary basins related to petroleum, nine of which are shared with their neighboring countries, of which four are shared with Ecuador. These four are the basins of Tumbes-Progreso and Lancones on the coast; and the basins of Santiago and Marañón in the jungle.

On the Ecuadorian side, almost all the reserves are located in the Amazon region, especially in the basins of Napo and Pastaza.

Ecuador and Peru are developing exploration and production activities in the frontier area, so there is technical information and a complementary infrastructure available that may benefit both countries.

In this regard, and considering the possibility of finding common deposits and sharing them, to which the subject of the environment would be added, it is advisable to find a mechanism that introduces the

concept of energy complementation and guarantees the development of the frontier oil activity in a framework of common benefit for both Ecuador and Peru.

b. Contingency binational plan

Due to the environmental impact that the different phases of the hydrocarbon activity cause, the oil companies in Ecuador and Peru could agree on contingency binational programs to control eventual oil spills and to protect the ecosystem in frontier areas.

Likewise, the first steps could be taken for the extension of this type of agreement towards marine waters in order to have common mechanisms that would allow them to take care of eventual emergencies caused by crude spills in the sea, an aspect that has been critical in the last years in other parts of the world.

Integration, in this matter, would result in technology improvement, shared concern and responsibilities not only in relation to tropical forests and sources of drinking water, but also to the communities involved in the frontier area.

c. Interconnection of the hydrocarbon transportation network in the frontier area

The intensification of the exploration activity and of the development of fields on both margins of the frontier line, are reflected in the execution of the Paacocha-Tiputini project in the Southeast Ecuador, since November 1992, with the drilling of the Ishpingo 1 well. The expected investment is US\$ 280 millions and includes, besides the normal drilling, exploration and development work, the construction of an oil pipeline, 300 Km long, to transport the crude to Lago Agrio, where the Transecuatoriano oil pipeline begins and goes to the coast.

This enlargement of the transportation system would allow to consider the possibility that in an eventual discovery in the Peruvian area near Tiputini, Peru may transport its crude through the Ecuadorian network.

In the same way, it is convenient to evaluate the interconnection of the Ecuadorian fields up to Puerto Tigre, where the North Peruvian oil pipeline begins, the transportation capacity of which is approximately 100,000 barrels/day, presently used by a 55%. This alternative would allow to reinforce the Ecuadorian exportation system, optimizing the use of the existing infrastructure both for Peru and Ecuador, as well as the chronogram of the future investments to be made in these pipelines.

From the analysis above, it is concluded that there are conditions to initiate in a short term a complementation and integration program between both countries.

On this matter, the following actions are recommended:

1. Considering that the electrical extension at a low level between Huaquillas (Ecuador) and Aguas Verdes (Peru) is technically possible in a short term, it is recommended starting the integration process on this basis, in order to establish the reliability and complementation principles between the parties, and starting afterwards a broader generation and interconnection program.
2. The complexity in the execution of a project of the size of the Puyango-Tumbes project, makes it advisable to constitute a coordinating entity that develops a strategy oriented to the definition of an institutional framework, under which the project would be executable.
3. In view of the probable intensification of oil activities in the frontier area, it is highly advisable to

agree on a contingency program for the control of oil spills and environmental protection.

This initiative could be implemented in the framework of the program Desarrollo Petrolero Sustentable en la Amazonia (Petroleum Development Supported in the Amazon Region), promoted by the Tratado de Cooperación Amazónica (TCA) (Amazon Cooperation Treaty) and OLADE.

4. Exploration and production of hydrocarbons in the frontier area can be complemented with the optimization of the transport infrastructures of Peru and Ecuador.

2.4 Bolivia and Peru

2.4.1 Background

The environment in which the Bolivian energy activity, in general, and the hydrocarbon activity, in particular, will develop in a near future, is planned in accordance with the new reality of the emerging international gas agreements, through which Bolivia will continue exporting this resource, at least for the following twenty years.

In fact, both the agreement signed with Brazil on August 17, 1992, and complemented on February 17, 1993, as well as the inclusion of the energy integration in the Acuerdo de Complementación Económica (Economic Complementation Agreement), recently signed between Bolivia and Chile, have important implications in the strategy of natural gas usage.

Besides, the development of Camisea in Peru, a natural gas deposit and condensate discovered in 1984, will demand, for its execution, the possibility of reaching markets demanding important volumes of natural gas for very long periods of time.

2.4.2 Gas reserves

The Bolivian proved reserves¹ are 4.18 BPC (1012 cubic feet); the probable reserves², at 1-01-92, are 2.33 BPC; and the possible reserves², to be discovered until the year 2000 by YPFB, according to the exploratory ten-year plan and development of new fields, are 4.37 BPC. The total of these volumes, makes think that the Bolivian gas reserve is enough to supply the growing demand of the local market, as well as the international markets of Brazil, Chile, and maybe Argentine, in case of amplifying the present contract outstanding until the end of 1993.

Additionally, it would be important to consider, on the Peruvian side, that the level of recoverable reserve, technically and economically in Camisea, is 10.8 BPC.

2.4.3 Demand

According to the agreement between Bolivia and Brazil, the gas volume to be exported during the following twenty years is 3.8 BPC. During the same period, the Bolivian internal market will consume approximately 1 BPC; YPFB will demand for its operations a volume of 1.4 BPC, to which should be added the possible increase in the exports to Argentine, that with the present volumes of 210 MMPCD, equals 0.08 BPC per year.

Additionally, the agreement to supply natural gas to North Chile with an estimated average volume of 100 MMPCD, would demand 0.73 BPC in a period of 20 years.

1. Bulletin 1/93, January 1993, Plan Nacional de Energía (Energy National Plan), La Paz Bolivia.

2. La Política Sectorial de Hidrocarburos (Hydrocarbons Sectorial Policy). May 1992, Muller and Asociados. La Paz, Bolivia.

2.4.4 The Brazilian market

It is important to point out the importance of the Brazilian market; in fact, according to the estimations of a study made by ESMAP -Banco Mundial (World Bank) and PNUD³, the demand of natural gas in the state of San Pablo will reach 0.27 BPC per year (740 MMPCD) by the year 2000. If besides considering the San Pablo market, the Minas Gerais, Rio de Janeiro, Espiritu Santo, Santa Catarina, Mato Grosso do Sul, Paraná and Rio Grande do Sul, are considered, the Brazilian demand by the year 2000 would be 0.78 BPC per year (2.137 MMPCD). Because of the huge size of this market, it is estimated that the Brazilian and Bolivian production, and eventually the Argentinian production, can hardly supply this demand, for which the possibility of including other natural gas production sources should be evaluated.

3. BOLIVIAN-PERUVIAN INTEGRATION

In the energy framework above mentioned, OLADE estimates that based on the expansion alternatives of the Bolivian energy sector and the incorporation and development of the gas deposit of Camisea in Peru, there are unimprovable conditions to gradually face an ambitious energy, complementation, and integration program between both countries.

3.1 Electrical subsector

Apart from the minor increases expected in the Bolivian interconnected system, as well as in the isolated systems, the expansion of the installed power is based on the development of the following major projects:

3. Análisis de Oferta y Demanda del Gas Natural en el Estado de San Pablo (Analysis of the Supply and Demand of Natural Gas in the State of San Pablo), March 1992. Esmap-Banco Mundial/PNUD. Technoplan - Tecnología e Planeamiento. San Pablo, Brasil.

a. New Natural Gas Thermoelectrical Central

The starting up of a new ENDE⁴ thermoelectrical central is expected by 1995, with 40 initial MW to be expanded in a period of 8 years to 400 MW, which will be located in the influence area of the gas infrastructure in a compatible way with the best use of the 230 KV interconnection line between Santa Cruz and Cochabamba.

b. Misicuni Hydroelectrical Central

Within the framework of the Plan Nacional de Mínimo Costo (National Plan of Minimum cost), for the supply of drinking water and irrigation for the Cochabamba Valley and in a compatible way with the Plan Nacional de Electrificación (Electrification National Plan) for the supply of electrical energy to the national interconnected system, ENDE, that is responsible for the energy component of the project, has foreseen the setting up of the Central Hidroeléctrica de Misicuni⁴ with an installed capacity on its first stage of 80 MW and an energy production of 325 GWh, beginning in 1998.

c. Enlargement of Centrals in Zongo

According to the agreement signed with the Compañía Boliviana de Energía Eléctrica COBEE⁵, the installed power in the Zongo Valley, near the city of La Paz, should be increased by 1995 with approximately 62 MW, through the enlargement of the centrals of Zongo, Botijlaca, Cuticucho and Santa Rosa. Afterwards, the construction of the centrals of Tiquimani and Huaji will be made.

4. Obras: Expansión de los Sistemas Eléctricos (Works: Expansion of Electrical Systems) 1989 - 1993. Empresa Nacional de Electricidad ENDE SA. Cochabamba, Bolivia.

5. Resolución Suprema RS 207640, May 1990, La Paz, Bolivia.

The increase in the generation capacity of electrical energy in the short and medium term, especially with the construction of the new thermoelectrical mentioned in numeral a) and the enlargement in the Zongo Valley, allow to foresee that the Bolivian interconnected system would have a surplus to supply part of the energy demand in the influence area of the Peruvian Bolivian border according to:

d. The Titicaca Lake Area and South Peru

Through the development and execution of complementary works that allow to extend the interconnected system from the city of La Paz (Kenko) up to the border, especially Desaguadero, the demand of electrical energy in South Peru could be satisfied. To do this, the following could be recommended:

- Increase from 40 to 60 MW the first stage of the new thermoelectrical central mentioned in numeral a) and if possible, anticipate its setting up for 1994.
- Anticipate the enlargements programmed in the Zongo Valley.
- Anticipate the exchange of tension from 115 to 220 KV in the Cochabamba-La Paz line and build the 115 KV line between La Paz and Desaguadero to connect the border with the national system.

The development of this concept would make it possible to initiate, in a short term, the electrical complementation between the Bolivian system and the Sistema Interconectado del Sureste (SISE) of Peru, with an initial transfer of 25 MW. Additionally, there would be a surplus for other potential consumers like the Southern Peru Copper Corporation metalurgic mining complex located in South Peru.

As reference, it is important to point out that in the framework of the electrical interconnection between

South Peru and North Chile, the feasibility studies to transfer 12 MW to Peru, were finished.

e. Interconnection in the area called Cordillera and Piedemonte

Beginning this year, the most significant enlargement of the electrical frontier will be started, with the execution of the electrification project of Larecaja⁴ in the department of La Paz, consisting of the construction of 125 Km at 115 KV; 500 Km of lines at 34.5 KW and distribution networks in the principal influence towns of the project. This transportation networks of electricity will go North, up to the town of Mapiri, and will continue from this point to the West to the towns of Consata and Pollayunga, near the frontier with Peru.

If priority were given to the electrical complementation with the Peruvian provinces of Sandia and Carabaya in the department of Puno, through the enlargement of the Larecaja project, as well as the execution of the electricity supply project to Desaguadero mentioned in the clause above, it would be highly advisable to evaluate the development of one of the hydroelectrical alternatives⁶ over the Charazana river, identified in the frontier study made by ELECTROPERU and ENDE.

This alternative of complementary generation, that would evacuate its production through the Guanay substation, would strengthen the Larecaja subsystem and its enlargement to the Peruvian provinces.

f. Interconnection in the frontier area of Selva

The short-term supply of the unsatisfied demand in the provinces of the Peruvian department of Madre

6. Abastecimiento de Energía Eléctrica en la región fronteriza Bolivia-Peru (Electrical Energy Supply in the Bolivia-Peru Frontier Area) December 1990. ELECTROPERU - ENDE.

de Dios bordering Bolivia could be made from the thermic central (isolated system) of the Bolivian city of Cobija, which counts today with a 1 MW capacity, which could be increased with the installation of new diesel generating units.

The great potential demand existing in the area, both on the Peruvian side and on the Bolivian side, could be satisfied with the integrated project of Camisea, as it can be seen later or through the execution of the Tahamanu River hydroelectrical project⁶, which would additionally allow to satisfy the demand of the frontier towns of Brasilea and Villa Pitación in Brazil.

3.2 Oil subsector

The Bolivian areas of oil interest, called Llanura Chaco-Beniana, Faja Subandina and Altiplano begin in the border with Peru and extend to South Bolivia; the principal operations near the frontier line are the following:

a. Madre de Dios (Bolivia) contract

The most important exploratory operation near the border with Peru, is being executed in the Llanura Chaco-Beniana, under a contract with the firms Occidental, Diamond Shamrock and Phoebus Energy; it has an area of 2.000.000 hectares in the North of the department of La Paz and in part of the department of Pando. According to the terms of the contract, during the next three years, two exploratory wells at least will be drilled, with a minimum investment of 12 million dollars.

b. Madidi (Bolivia) contract

In the Faja Subandina, in the department of La Paz, a operating contract was signed with the Texaco, Shell and Mobil companies which covers an area of

1.482.500 hectares, with a minimum investment in the initial exploration stage, of 7 million dollars.

c. Block S-2 Basin of the Titicaca Lake (Peru)

In 1990, a contract was signed with the company Vera-Gutiérrez Exploración-Producción SA (VG), to work in an area of 500.000 hectares in the Peruvian basin of the Titicaca Lake, where there used to be a production of shallow wells. The Russian company Sojuskarta, from Moscow, started geochemical evaluation works as a subcontractor of VG.

From the exploratory activities mentioned above, is has been concluded that integration activities may take place under the following premises:

- The areas of Madre de Dios and Mapiri, are located in areas faraway from the Bolivian oil infrastructure. The definition of commercial findings would defer from that of discoveries in traditional areas and of relative easy access to the existing networks, for which any complementation with the Peruvian side would make feasible the transportation and production operations.
- Especially in the case of the development of the Madre de Dios contract, the possibilities to generate supplying conditions in the frontier area with Brazil, can be complemented with the Camisea project.
- The development of oil activities in the Peruvian basin of the lake, allow to foresee in a short term an exchange of geological information, as well as the setting up of a contingency plan and alleviate the environmental impact in case of initiating exploratory and production drilling operations.

3.3 Gas subsector

The gas subsector could present, according to the considerations mentioned in the points of reserves, demand and potentiality of the Brazilian market, the most significant long term area of integration and energy complementation between the two countries.

In fact, the development of Camisea in Peru and its interconnection with the Bolivian export system, coincides with the central object of the Bolivian energy policy, that is trying to turn this country into an important natural gas distributor in the subregion.

The beginning of operations to develop Camisea requires⁷, due to the size and geographical location of the deposit, a conception of the project based on a market big enough, able to absorb both the production of natural gas and liquefiabiles, in a competitive way.

PETROPERU's initiative of developing Camisea with the installation of a plant to separate liquids and the construction of a 200 MW thermoelectrical central that would feed the central-North interconnected system, as well as the construction of pipelines up to the Brazilian-Bolivian-Peruvian border to supply the estates of Acre, Rondonia and Amazon in Brazil with natural gas, liquefiabiles and generate electricity in Iñapari or Rio Banco, could find its most important complement that will eventually make the Camisea

development feasible, in the extension of the gas pipeline up to Rio Grande in Bolivia, which is the lung of the Bolivian gas system and the beginning of the gas pipelines for exports towards Argentina and Brazil.

This would release the gas production in the Southeast Bolivian fields, to supply without production and reserve restrictions the market of North Chile, which could be increased with the interconnection to South Peru and the possible future development of other alternatives of natural gas usage as the GNL and its petrochemical industrialization.

4. CONCLUSIONS AND RECOMMENDATIONS

From the analysis above it has been concluded that there are conditions to begin an intense integration program an energy complementation between Peru and Bolivia.

In this respect, the following fundamental actions are recommended:

1. Carry out prefeasibility studies for the electrical energy supply in the frontier area, based on the expansion projects of the Bolivian interconnected system for the supply of the South Peru region, the Cordillera and Piedemonte, as well as the Selva area by means of the enlargement of the isolated thermic system of the city of Cobija.
2. Promote the evaluation of the Camisea development, including its interconnection to the Bolivian export system.

7. Una Estrategia para el Inicio del Desarrollo de los Yacimientos de Camisea (A Strategy for the Beginning of the Development of the Camisea Deposits) January 1992, Organización Latinoamericana de Energía OLADE. Quito - Ecuador.