CEPAL/MEX/SRNE/77/8/Rev.1

August 1977

TERMS OF REFERENCE FOR THE PREPARATION OF A STUDY ON COSTS, MARKET AND TRANSMISSION SYSTEMS FOR THE REGIONAL ELECTRIC INTERCONNECTION PROJECT OF THE CENTRAL AMERICAN ISTHMUS

77-8-427-30

INDEX

		Page
1.	Introduction	1
2.	Scope of the study	2
3.	Administrative procedures	3
4.	Cost of hydroelectric projects	8
5.	Cost and technical characteristics of thermoelectric plants	17
6.	Market study	20
7.	Transmission studies	22
Annex:	Regional electric interconnection project of the Central American Isthmus	33

1. Introduction

The studies comprised in the present Terms of Reference form part of the Electrical Interconnection Project of the Central American Isthmus, which is presently being carried out by CEPAL/MEXICO, at the request of the Central American countries and Panama, with the latter's participation and the financial support of the following institutions:

Central American Bank for Economic Integration (CABEI)
Inter-American Development Bank IDB)
United Nations Development Programme (UNDP)

The general aims of the interconnection project are:

a) To evaluate the overall benefits of an eventual interconnection of the electrical systems of the countries of the Central American Isthmus;

b) To optimize a long-term generating additions programme to meet the individual electrical demands of the six countries separately, and to cover the regional demands for several alternatives of interconnection;

c) To define medium and long-term transmission network programmes required by the country's individual systems and the different interconnection alternatives;

d) To evaluate the benefits of the proposed interconnections for each individual country and for the region as a whole;

e) To formulate a medium and long-term programme for electric interconnection.

In order to provide a better understanding of the general project objectives, the following document is attached as annex :

Electrical Interconnection Project for the Central American Isthmus (Description of activities)

/The present

The present Terms of Reference refer only to the studies which will be assigned to the consulting firm. The general direction coordination and supervision of the works of the consultants shall be undertaken by CEPAL/Mexico. Funds provided by the Inter-American Development Bank(IDB) and administered by the Central American Bank for Economic Integration (CABEI), will be used to finance the studies. The corresponding contracts shall, therefore, be made between CABEI and the consulting firms under the technical guidance of CEPAL-Mexico. The consultant will, at all times, deal with CEPAL/CABEI as a single operational unit, through CEPAL.

2. Scope of the study

The study will include the following:

a) Estimation of investment, operation and maintenance costs for hydroelectrical projects;

b) Determination of investment, operation and maintenance costs and technical characteristics of alternate thermoelectrical units;

c) Updating of electrical market forecasts, and

d) studies of transmission systems, and definition of the basis for national and regional load dispatch centers.[1/]

Points 4, 5, 6 and 7, and schedules 1 and 2 include a detailed description of the scope of the studies, specific activities to be performed, basic information to be furnished to the consultant, procedures to be adhered to as well as presentation of cost breakdowns.

1/ The region should be understood to comprise the six countries.

/3. Administrative

3. Administrative procedures

3.1 Conditions to be met for the study

The consultant selected should meet the minimum conditions set henceforth:

a) Be a duly-established and well-organized consulting firm with ample experience in studies similar to the ones proposed herewith;

b) Must have proven practical experience in all aspects of the studies envisaged;

c) In the case of a joint venture, no modification in its structure will be allowed while the contract is being negotiated and signed, nor any modifications of the commitments acquired with CEPAL/CABEI be introduced as a result of a contract;

d) The consultants on a joint venture will be individually and jointly responsible for the commitments made and for the study produced;

e) The consultant may issue subcontracts for the implementation of part of the work related to the study, but to do so, prior consent by CEPAL/CABEI will be required.

3.2 Inquiries

The interested party may request any clarification of these Terms of Reference by submitting them to CEPAL Headquarters. The latter will provide the requested additional information, will clarify the Terms of Reference, and introduce any necessary modifications.

CEPAL/CABEI will promptly provide any clarification or additional information requested by the consultant.

3.3 Submittal of proposal

An original and two copies of the consultant's proposal should be submitted to CEPAL in two sealed envelopes, and should include the information requested in these Terms of Reference. The first envelope

/will contain

will contain the technical proposal plus the percentages for overhead, fee and social costs involved (if any); the second should include a breakdown of the estimated cost of the study.

The proposal and related information may be submitted either in Spanish or English, as well as any additional information or comment which the consultant may wish to furnish in connection with the Terms of Reference.

3.4 Contents of the proposal

In addition to the information described in points 4, 5, 6 and 7, the proposal should include the following:

a) The consultant's background and experience in similar studies;

b) A description of the methodology proposed for the execution of the study envisaged;

c) A description of the functional organization for the team of experts and backstopping personnel in charge of the studies, including their curricula vitae; a proposal for complementary studies which may be required to supplement the basic data; a tentative time schedule of project activities; an estimate of man-months required for each activity, both at headquarters and in the field (see schedule 1 and 2, attached);

d) A summarized description of computer facilities available to the consultant which may be required for the study and programs proposed for the study;

e) Any observations and modifications the consultant may propose on these Terms of Reference.

3.5 Opening of proposals

On a predetermined hour and date, all proposals are to be opened. Such action will not imply the acceptance by CEPAL/CABEI of the complete and satisfactory fulfillment of the requirements set in these Terms of Reference. Once the opening procedure is initiated, CEPAL/CABEI

/will not

will not accept any modifications of the consultant's proposal. The consultant should, therefore, provide all his alternate proposals in the original envelope submitted.

3.6 On the procedure for proposal evaluation

CEPAL/CABEI will examine in minute detail all the information contained in the proposals, and will evaluate them in accordance with their best interests and taking into consideration the following factors:

a) The experience had by the consultant in similar undertakings;

b) Methodology and working programme proposed for the completion of the studies;

c) Organization and technical qualifications of the personnel proposed by the consultant for the study, as well as the backstopping support to be provided by the firm's headquarters;

d) The proposed schedule of activities and completion dates of each project.

Immediately after a decision has been reached, CEPAL/CABEI will notify the selected firm, so that both parties may reach a satisfactory agreement.

During negotiations the following as well as other pertinent aspects are to be considered:

Scope, magnitude and objective of the work

During negotiations the parties will request all the necessary clarifications to achieve full understanding of their rights and obligations.

Completion dates and penalties

The time limits as well as the penalties applicable in case of delays by the consultant in the timely completion of each part of the study will be defined.

/Payment

Payment procedures

It includes determination of study costs, advance payments and their relationship to project progress; guarantees and final payment upon completion of the contract, etc.

Reasónable price

Due to the intellectual nature of the work, and although the price will not be a determining factor in the awarding of the contract, it will still be necessary for the consultant to prove that his price will be reasonable and fair.

Failure to negotiate

Should CEPAL/CABEI be unable to reach an agreement with the consulting firm selected, they may declare unilaterally the negotiations as terminated without reimbursing any expenditures which the consultant may have incurred. CEPAL/CABEI will then invite the next-in-line consulting firm to initiate new negotiations.

Should a single proposal only be submitted, CEPAL/CABEI will have the right to award the contract if such a proposal meets all the necessary requirements.

3.7 General provisions

CEPAL will closely follow and supervise the work of the consulting firm, who will be expected to justify each and every one of its undertakings. To such an effect CEPAL may, at any given time, send its officials to the firm's headquarters or any other place where the work is being undertaken. It should also be noted that CABEI and IDB may also request information at any time and visit the consultant's

/headquarters

headquarters to request any information they may deem necessary. The consultant will comply with such requests at the earliest possible.

3.8 Intellectual property

All intellectual property rights connected with the study, as a result of the total payment agreed upon, will be transferred to CEPAL by the consulting firm. The latter will have no rights to the documentation produced except to include it as background information of its professional activities.

CEPAL will, however, give due credit to the consultant's contribution in all instances where the information is utilized.

4. Cost of hydroelectric projects

Scope of work

The main objective of the study is to provide reliable information on a uniform basis used for the selection of investment models in order to recommend with economic criteria the most convenient projects to be developed in each of the alternate studies.

A. The consultants are requested to estimate the investment, operation and maintenance costs of about 63 hydroelectric projects which have been identified in the six Central American countries, including, besides the basic alternative studied for each project, 3 or 4 additional alternatives with varying installed capacities.

B. A detailed summary of the projects to be considered is shown in tables 1 and 2. It has been estimated that feasibility studies are being undertaken for 8 of these projects; 23 are in a prefeasibility study process and 32 in inventory stage. Of the 63 projects, 15 correspond to Guatemala, 4 to El Salvador, 11 to Honduras, 8 to Nicaragua, 19 to Costa Rica and 6 to Panama.

It is foreseen that in some of the cases the number of projects in evaluation process as well as their names may be modified in accordance with the preliminary analysis that CEPAL is elaborating.

C. CEPAL will provide the consultants with all information available regarding the projects as well as with any other data it may obtain from the electrical companies of the Central American Isthmus. This information should cover the following:

1. Feasibility studies for 8 projects.

2. Prefeasibility studies for about 23 projects. These studies contain at least: site survey, project layout, construction schedule and estimate of the investment costs. In about 18 projects, costs have been

/deducted

deducted and computed from the bill of quantities and have detailed estimates, although this bill of quantities is not always explicit in the report. In the remaining 5 projects the bill of quantities are partial and their costs have been deducted through the application of empiric formulas where these costs are functions of parameters of the development scheme proposed.

3. Preliminary studies for about 32 projects. In the case of Guatemala (10 projects), the cost studies have been made using unit quantities as well as empirical formulas. The costs for the projects in Nicaragua (6) have been estimated through empirical curves of cost, and quantities for the main civil elements. At present there is no data basis for the cost estimates regarding the projects of Costa Rica (14) and Panama (2).

It is understood that the topographic information in which these studies were based is irregular and that they are based mostly on 1:50 000 mapping.

4. The various alternatives of capacity to be installed for each project as mentioned in A. In general, these alternatives will be selected in a way that the development layout is not modified, nor the dimensions and main characteristics of the project are varied (dams, type of power-house, tunnels and channels outline, etc.). As a result variation of power will only affect the dimensions in elements which are directly related with the flow or the capacity (as intakes, conduits, turbine-generators, discharge works, power-house, etc.)

5. Studies cost and technical characteristics carried out by CEPAL.

D. Regarding project investment costs the consultants will provide the following:

1. Estimated direct cost - local and foreign currency separately - of the various project components for the 3 or 4 alternatives of installed capacity. These costs will be as of December 1976. Costs must show in detail unit quantities and prices for every element of

/the project

the project, if possible. Cost shall reflect the existing conditions for each country and the consultant should explain whether the same or different average unit costs be used for each of the 6 countries. In these elements, for which the cost is usually estimated through graphs or formulas (as for turbines, generators, penstocks, etc.), the consultant may use a similar procedure only if there is no other practical way to estimate the cost in a direct manner. Table 3 presents a typical case of cost breakdown. The consultant may use a similar table.

2. A description of the methodology adopted to calculate quantities (cubications), or cost estimates, including formulas or graphs, when these methods can be used, and the unit costs applied for each country.

3. A description of the criteria adopted to define the physical contingency factors to be used in the completion of the cost of each project component. These should take into account the degree of definition of the project and the uncertainties associated to each component (geology in the case of dams, appearance of groundwater in case of excavations; abnormally high distances for the transportation of materials and equipment, etc.).

4. Estimate of engineering and administration costs for each project.

5. Priority in time for the different projects, showing nearest date in which each project can be put into service, including feasibility studies and construction period implied.

6. Construction and investment programmes for each project, or typical schedules indicating the project where each one may be applied.

7. Annual operation and maintenance costs for each plant, explaining the criteria adopted for its calculation.

E. The consultants will not be required to visit the project sites nor to modify existing layouts and general characteristics of the development scheme.

Table 1

Table 1

HYDROELECTRICAL PLANTS TO BE CONSIDERED IN REGIONAL ELECTRICAL INTERCONNECTION PROJECTS OF THE CENTRAL AMERICAN ISTHMUS

State of project	Guatemala			El Salvador			Honduras		
	Name	Capacity (MW)	Energy 1/ (GWh)	Name	Capacity (MW)	Energy 1/ (GWh)	Name	Capacity (MW)	Energy 1/ (GWh)
Feasibility				San Lorenzo	180	757	El Cajón	296	1 756
							Remolino	128	746
							Naranjito	84	354
Prefeasibility	Xalala	276	1 054	Paso del Oso	40	142	Wampu	270	1 110
	El Carmen	113	329	El Tigre	540	1 557	Cuyamel	700	2 670
	Serchil	150	346	Zapotillo	120	405	Piedras Amarillas	210	810
	Chulac	426	1 848				Wampu I	50	190
	Chicoc	206	1 323				Río Frío	40	160
							Culuco	75	290
							Los Chorros	95	360
							Guacamaya	60	270
Evaluation	Sauce	122	304						
	Polochic-Matanzas	183	608						
	Atitlán	101	319						
	Semuc	112	659						
	El Arco	91	563						
	Tzucanca	60	371						
	Corral	64	485						
	San Juan	101	514						
	Estrella Polar	116	719						
	Chacchilá	54	105						

State of project	Nicaragua			Costa Rica			Panamá		
	Name	Capacity (MW)	Energy 1/ (GWh)	Name	Capacity (MW)	Energy 1/ (GWh)	Name	Capacity (MW)	Energy 1/ (GWh)
Feasibility	[illegible]palar	330	1 520	Guayabo	153	1 198	Fortuna	278	1 420
				Siquirres	300	2 000			
Prefeasibility	[illegible]so Real	50	225	Ventanas-Garita	80	182	Changuinola	609	2 841
				Palomo	38	150	Teribe I	296	1 600
				Boruca	760	4 530	Teribe II	264	1 600
Evaluation	Corriente Lira	154	573	Durika	185	720	Tabasará	112	740
	Kojolka	135	501	Wonyet	190	800	Coclé del Norte	50	220
	[illegible]s	94	346	Ayil	175	900			
	[illegible]was	123	457	Duchi	210	1 000			
	Salto Grande	78	288	Tayutic-Pacuare	220	950			
	Kico	63	235	Turrialba	210	1 000			
				Angostura	100	750			
				Carrillo	225	1 085			
				Turrúbares	100	510			
				Purrires-Turrubares	160	800			
				El Brujo	220	1 000			
				Kicha	180	700			
				Huacás	225	880			
				Saré	180	615			

1/ Mean annual energy.

Table 2

HYDROPROJECTS. SUMMARY

	Total	Feasibility	Prefeasibility	Evaluation
Total				
Number	63	8	23	32
MW	11 610	1 749	5 468	4 393
GWh	53 460	9 751	23 992	19 717
Guatemala				
Number	15	-	5	10
MW	2 175	-	1 171	1 004
GWh	9 547	-	4 900	4 647
El Salvador				
Number	4	1	3	-
MW	880	180	700	-
GWh	2 861	757	2 104	-
Honduras				
Number	11	3	8	-
MW	2 008	508	1 500	-
GWh	8 716	2 856	5 860	-
Nicaragua				
Number	8	1	1	6
MW	1 027	330	50	647
GWh	4 145	1 520	225	2 400
Costa Rica				
Number	19	2	3	14
MW	3 911	453	878	2 580
GWh	19 770	3 198	4 862	11 710
Panamá				
Number	6	1	3	2
MW	1 609	278	1 169	162
GWh	8 421	1 420	6 041	960

Table 3

HYDROELECTRIC PROJECT. TYPICAL COST ESTIMATE

(US Dollars)

	Quantity	Unit price	Total
Access road and relocations			
Access to site			
New	50 km	50 000.00	2 500 000
Improved	20 km	25 000.00	500 000
Local roads and tunnels		L.S.	1 500 000
Land, relocations and reservoir			
Clearing	42 km^2	1 000.00	42 000
Diversion and control of water			
Cofferdams	3 255 600 m^3	0.30	977 000
Tunnel and portals 2-8 $m^{\emptyset}$	1 330 m^3	6 550.00	8 711 500
Open excavation	12 000 m^3	3.35	40 000
Pumping and clean-up		L.S.	772 000
Dam: Rockfill (from req'd excavation)	4 079 000 m^3	0.30	1 223 500
Rockfill (from quarry)	12 294 000 m^3	2.80	34 423 000
Earthfill			
Impervious core	4 134 321 m^3	2.70	1 116 250
Filters	746 945 m^3	2.70	2 017 000
Stripping and excavation	557 500 m^3	1.80	1 003 500
Foundation preparation		L.S.	1 685 000
Spillway			
Excavation	3 004 863 m^3	3.00	9 014 500
Concrete			
Ogee and piers	29 606 m^3	60.00	1 776 500
Chute slab and wall	36 772 m^3	80.00	2 942 000
Gravity walls	2 720 m^3	60.00	163 000
Bucket	13 989 m^3	60.00	839 500

/Table 3 (continues)

Table 3 (Conclusion)

	Quantity	Unit price	Amount
Gates and hoists	6 -12w x 15 h	L.S.[a/]	2 268 000
Power water conductors			
Excavation, intake	95 550 m^3	3.35	320 000
Tailrace	126 540 m^3	3.35	424 000
Intake concrete	26 551 m^3	140.00	3 717 000
Intake tunnels 4-6.5 $m^{\emptyset}$	11 200 m	4 900.00	5 880 000
Steel liner	827 320 kg	2.40	1 985 500
Tailrace tunnels 2-10 $m^{\emptyset}$	1 470 m	8 950.00	13 156 500
Gates and hoists		L.S.[a/]	2 500 000
Powerstation			
Excavation		[illegible]	
Concrete		L.S.[a/]	9 320 000
Turbine, governors and valves		L.S.[a/]	18 400 000
Generators		L.S.[a/]	15 800 000
Misc. Mechanical equipment		L.S.[a/]	3 950 000
Misc. electrical equipment		L.S.[a/]	7 000 000
Misc. equipment and structures		L.S.[a/]	-
Switchyard			
Excavation and fill		L.S.[a/]	756 000
Elec. equipment and structures		L.S.[a/]	2 700 000
Operators' Village		L.S.[a/]	4 300 000
Subtotal direct cost			174 147 500
Contingency 25 ± %			43 537 000
Total direct cost			217 684 000
Engineering and owners overhead 15 ± %			32 652 000
Total construction cost			250 336 000

a/ Lump sum generally obtained from graphs or formulas.

/5. Cost

5. Cost and technical characteristics of thermoelectric plants

Scope of work

The object of the study is to provide economic and operation functional data of the thermoelectric alternatives to be proposed in conjunction with the hydroelectric projects to the optimization programmes and the technical characteristics to be used during the process of simulated operation of the system.

A. The consultants are requested to estimate the investment, operation and maintenance costs for a reasonable number of commercial sizes within a wide range of capacities regarding typical steam plants for base load services combined cycle plants and gas turbines as follows:

Plan Type	Capacity Range (MW)
Steam oil fired	50 - 1 000
Steam coal fired	50 - 1 000
Combined cycle	50 - 300
Gas turbine	25 - 100

B. December 1976 price levels shall be used. The consultant shall indicate:

1. Costs of the principal components of each type of plant subdivided in (national and foreign currency) and including separately engineering, administration costs and physical contingence expenses. The consultant may use a breakdown as indicated in table 2.1 or a similar one.

   In the case of steam plants, a sea-side location with sea-water refrigeration will be considered, as well as plentiful fresh water for other processes. Additional costs will also be taken into account for the following cases:

   i) Sea-side located plants where fresh water is scarce and where it may be necessary to install a sea-water desalination equipment.

/ii) Plants

ii) Plants located where plenty fresh water is available but without sufficient water for refrigeration. Refrigeration towers and ventilators will be considered in this case.

In the case of gas turbines they should be stationary type, open cycle, generator refrigerated by water in closed-circuit and with an air-cooler system. These plants should be assumed located at sea-level and at 1 000 m altitude.

In every case estimate costs should include electrical and security equipment, transformers, high and low-voltage power substations, etc.

2. Operation and maintenance costs for each type of plant. Fixed operation costs, varying maintenance costs and fuel costs will be estimated separately. These two ultimate factors should be estimated as function of the annual plant factor.
3. Economical data such as useful life, time of project's execution and annual investment programmes.
4. Technical operational characteristics such as annual plant factor, minimum load operation level, curve of heat rate, possibility of overload for a short time, probability of forced outage rate, scheduled maintenance, disponibility, estimated useful life etc. and other characteristic that the consultant may deem worthy of interest during the planning phase.

CEPAL will provide the consultants with the following information

1. Fuel characteristics
2. Fuel costs for typical cases

/Table 4

Table 4

THERMOELECTRIC PLANTS. TYPICAL COST BREAKDOWN

(Millions of dollars)

	Total	Local currency	Foreign currency
Total			
Civil projects and cranes			
Mechanical equipment			
Electrical equipment and substation			
Maritime and local transportation			
Installation and starting of operations			
Subtotal			
Contingencies			
Engineering and administration			

6. Market study

Scope of work

The object of this study is as follows:

i) To revise, and/or expand, and/or update, as may be the case, the existing market studies, on a common macroeconomic basis, so that the data provided for the long-term planning models may be comparable;

ii) To include in the projections important isolated loads, i.e. mining and industrial developments to be installed during the period of study;

iii) Provide characteristics of demand for basic load centers, to be considered in the nergy transfer studies and the corresponding transmission network studies. The miminum required are 100 load centers.

A. The consultants are requested to review and update the power market for each of the six Central American countries for the period 1983-2000.

B. The consultants will provide:

1. Description of the method to verify the energy and power demand forecast;
2. Annual energy and power demand for each country and for the load centers (existing and future) specified for each country;
3. Typical monthly load duration curve for the years 1983, 1986, 1990 and 1994, for each country.

C. CEPAL will provide the consultants with the following information:

1. Existing load forecast for each country;
2. A list of the isolated loads to be added for the same period;
3. Historical data on load duration curves of demand, peak demands, load factors, annual generation available for each country and existing load centers;
4. Proposed new load centers for each country.

/ADMINISTRATIVE

ADMINISTRATIVE PROCEDURES

(Applicable to points 4, 5 and 6)

1. The consultant shall teletype a brief report at least every month
2. The consultant shall provide the client with a written advance report every two months
3. A final draft report must be provided (20 copies in Spanish) 6 weeks before the final report is delivered
4. The final report must be delivered after 6 months of the beginning of the study. The consultant shall provide the client with 100 copies in Spanish so that he can attach it to the study as an annex to his own final report.

7. Transmission studies

Scope of work

The objectives of the transmission studies are as follows:

i) To establish as accurately as in the rest of the study - prefeasibility -, the costs of the international interconnection network to be developed in order to effect the interchange of energy and power defined in other stages of the study;

ii) To define long-term characteristics of the international regional transmission system in such a way that the countries of the Central American Isthmus may decide on the execution of partial interconnections so that they can be integrated in the future to the regional system;

iii) To estimate the operational costs of the interconnection network and to establish the basic requirements related with the national and international dispatching centers.

A. Coverage

The transmission studies shall cover the development of the national electric systems of each of the six countries in the Central American Isthmus, namely, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama for the period 1983-1994. In the first place, the transmission needs of the autonomous growth of the above mentioned national systems will be considered. Then, the alternatives of the transmission systems required to tie the six countries for the following programmes of additional generation capacity are to be studied:

1. The six countries will expand their generating capacity to supply at least 100% of their maximum load demand each year.

2. The six countries will expand their generating capacity to supply at least 80% of their maximum load demand each year.

/3. The expansion

3. The expansion of the generating capacity will be optimized for the six countries as a single area.

In all the (3) cases above, the operation of the entire regional interconnected system shall be optimized as a whole and power interchange between countries will be on an economic generation basis.

In total there shall be six transmission studies for the national systems and three for the regional systems.

B. Work to be done by consultants

The consultants shall develop the optimized bulk power transmission plans for the nine systems mentioned before. These plans shall be referred to four typical years 1983-1986-1989-1994 (or any other four as defined by CEPAL). The investment (local and foreign) and operating cost for each plan are to be estimated with prices as of December 1976. The specific task to be done shall include a preliminary information about standard construction and operating cost estimating for several typical lines and substations at 230, 345 and 500 kV, and:

1. For the National Studies

i) The elaboration - for the horizon year of the study (1994) or any other year as defined by CEPAL - of several technical equivalent transmission alternatives from which the least-cost should be selected as the base case for the further studies described below. 2/

ii) Load flow studies to establish transmission requirements. 3/

iii) Fault or short-circuit studies to verify substations design. 4/

iv) Stability studies. 5/

2/ The method to be used should be presented by the consultant and approved by CEPAL.
3/ These studies will be made only as required and in accordance with the planning criteria proposed.
4/ Ibid.
5/ Ibid.

/2) For the

2. For the regional studies

i) The elaboration - for the horizon year of the study (1994) or any other year as defined by CEPAL - of several technical equivalent transmission alternatives from which the least-cost should be selected as the base case for the further studies described below.

ii) Load flow studies to establish transmission requirements.[6/]

iii) Fault or short-circuit studies to verify substations design.[7/]

iv) Stability studies.[8/]

v) Verification of the possible transmission routes together with CEPAL and the national electrical authorities (from existing maps or visits to the countries as required).

vi) The consultant will collaborate with CEPAL in developing the economic justification of the electric interconnection systems proposed.

3. Load dispatching

As a separate task independent but related to the transmission study the consultant will develop the general philosophy, characteristics and requirements to establish regional and national dispatching centers for the economic and coordinated operation of the regional integrated systems and their associated telecommunication system.[9/] The work for this part of the study includes at least the following:

i) A brief review of the general philosophy governing the design and operation of a regional dispatching center and the national dispatch centers to enable the integrated and economic operation of the six countries as a single area.

ii) Discussion of the features of the Central American electrical systems that might influence the design and operation of a regional dispatch center.

iii) Discussion of the features distinguishing the regional control center from the individual national centers.

6/ These studies will be made only as required and in accordance with the planning criteria proposed.

7/ Ibid.

8/ Ibid.

9/ The consultant should take into account the existing and planned local dispatching centers and communication.

/iv) A list

iv) A list of dispatching and control functions which should be performed by the regional dispatch center and the national control center with a brief discussion of the equipment necessary to perform those functions.

v) Discussion of the different communication systems available and their relative merits with a recommendation of the most suitable one to the Central American countries.

vi) A single schematic diagram showing the general elements of the total dispatch and telecommunication systems.

vii) Block diagram showing the functional elements and their iterrelationship for the national centers and for the regional dispatch facility.

viii) A tabulation of estimated cost (local and foreign) related to each function shown as the block diagram.

These cost estimates should be made for each national center, the regional dispatch facility and the telecommunication system.

The consultant's estimated cost of the dispatch center and telecommunication system should be included as a separate item.

C. Transmission planning criteria

For the planning of the transmission systems specified above the following criteria or others proposed by the consultant should be applied.

1. Voltage levels

1.1 Maximum operation voltage: Nominal voltage + 5%.

1.2 Minimum operation voltage: Nominal voltage - 5%.

1.3 Voltage under maximum load and all lines in service: the voltages should be maintained between the maximum and minimum voltage specified above.

1.4 Voltage under emergency conditions: under emergency conditions the voltages should be at least 95% of one-emergency voltage.

/2) Overloads

2. Overloads

2.1 Transformers

2.1.1 Under normal conditions the transformer loads should be maintained within their nominal capacity.

2.1.2 During emergencies it is admissible overloads of 20%.

2.2 Transmission lines

The loads on the transmission lines should not exceed the following limits:

i) Thermal capacity of the conductors
ii) Stability limits

3. Contingencies

Under any load condition the system should be able to maintain the voltage levels and overloads within the limits specified and for the following contingencies:

i) Fault on the largest generator or group of generators (one transformer with two generators).
ii) Single fault on any transmission lines.
iii) Single fault on any transformer

4. Dynamic stability

The studies should simulate the following contingencies, under any load conditions, to determine the dynamic stability of the system:

i) Fault on any substation equipment
ii) Disconnection of any generator group
iii) Disconnection of any line

/For the

For the dynamic stability studies single phase reclosure should be assumed with the following times:

T1 = 6 cycles (time to clear the fault)

T2 = T1 + T (to be determined) (reclosure time)

T3 = T2 + 6 cycles (time required to finally clear the fault)

For any of the above given conditions the dynamic stability of the system should be assured. In case of instability the application of corrective action should be investigated and a workable solution recommended.

5. Power factor

The power factor at the substation bus bars should be maintained between 0.95 and 1.0. Whenever necessary corrective actions should be indicated.

6. Short circuit studies

The short circuit levels at the substations should be determined to establish the substation equipment interrupting capabilities and to indicate whenever required the necessary corrective actions.

D. Methodology

The consultant in its proposal should indicate either its agreement to the given criteria or shall present a set of criteria which will ensure that the results will be as precise as the ones of the rest of the study.

The consultant may justify the need of detailed studies (as short-circuit or stability) when they could affect significantly the estimated costs of the transmission projects. In such cases global figures can be calculated so they include the cost of the corresponding corrective actions. In any event short-circuit and stability studies may at least be undertaken for the first typical year (1984).

/E. Information

E. Information to be given to consultants

1. Simplified schematic and geographic diagrams of the generating and high voltage transmission systems for the year 1980 or 1983 as available, including basic characteristics of existing transmission systems.

2. Generating additional programmes for each of the alternatives to be studied.

3. Generating capability, load demand (kW and kWh and power factor) actual generation (kWh) and monthly peak generation (kW) for each plant. The above data will be furnished by CEPAL, per month and per typical year. Besides, the generating capability and actual generation will be given by power plant.[9/]

4. Transient impedances of existing generating plants, impedance of transformers used to connect generators to transmission lines (for fault studies) and WR^2 of existing generators. (For stability studies.)

5. Previous studies applicable to this problem will be made available to the consultant if desired.

F. Results and information to be provided by the consultant in final report

1. Schematic and geographic diagrams showing lines and substations for each of the typical years;

2. Programme of additional transmission lines and substations including investment and operating costs involved;

3. Discussion of major aspects of each plan and justification of economic voltages utilized;

4. Basic flow diagrams for typical years for each plan;

5. Partial load flow diagrams to illustrate critical transmission problems;

6. All fault and stability analysis carried out;

9/ It must be noted that the monthly maximum generation for each plant does not necessarily represent the generation during the peak hour of all the plants of the system.

/7) Tabulations

7. Tabulations of all load, generation and line data used in the load flow studies;

8. Tabulations of additional data used in fault, stability studies.

G. Administration and procedures

1. The consultant will make a brief progress report, by teletype at least once a month;

2. Quarterly progress report will be presented by the consultant;

3. A draft of the final report (20 copies-Spanish) will be provided to the client 6 weeks before the final report is due;

4. The final report is due 9 months after the study is started. The consultant will provide 100 copies in Spanish, suitably bound, so the client may include it as a separate volume in the report he is making.

Schedule 1

REGIONAL ELECTRIC INTERCONNECTION PROJECT OF THE CENTRAL AMERICAN INSTHMUS.
SCHEDULE MANPOWER AND COST

PROJECT ACTIVITIES	SCHEDULE			MANPOWER				COSTS								
	Initiation Date	Completion Date	Duration Months	A	B	C	D	Total	Base Salaries A	B	C	D	Over-head	Fee	Direct	Miscel-laneous
Total																
Cost of Hyrdro Projects 1.1 1.2 1.3																
Technical Characte-ristics and Cost of Thermoelectric Plants 1.1 1.2 1.3																
Market Study 1.1 1.2 1.3																
Transmission Studies, Transmission 1.1 1.2 1.3																
Load Dispatching 1.1 1.2 1.3 Sub-total																

Schedule 2

REGIONAL ELECTRIC INTERCONNECTION PROJECT OF THE CENTRAL AMERICAN ISTHMUS

Other cost breakdown and resume

	Total	Sub-total	No.	Unit cost	Sub-total	Average travel time	Per diem
Total Direct Cost							
1. Travel Expenses							
1.1 Round Trip A							
1.2 Round Trip B							
1.3 Round Trip C							
2. Other expenses							
2.1 Cables, telex, telephone, etc.							
2.2 Passports, visas, etc.							
2.3 Progress reports							
2.4 Final report							
2.5							
2.6							
Resume							
Grand Total							
Salary Overhead and Fee							
Direct Cost							
Contingency							

/Annex

Annex

REGIONAL ELECTRIC INTERCONNECTION PROJECT OF THE CENTRAL AMERICAN ISTHMUS

Description of activities

(Second phase)

A. Activities

Enclosed herewith is a detailed description of the following activities:

1. Financial arrangements
2. Awarding of consultant's contracts
3. Revision of hydropower plant technical characteristics
4. Revision of hydropower project costs
5. Cost versus installed capacity curves
6. Technical characteristics and costs of thermoelectric plants
7. Electrical market study
8. Geothermal resources potential study
9. Formulation of long-term development programmes
10. Modifications to the WASP model
11. Medium-term studies on system operation
12. Study on energy transfers
13. Study on the international transmission network
14. Analysis and economic justification of interconnections
15. Sensibility analysis
16. Definition of development programmes
17. Final report

/B. Description

B. Description of activities

1. Financial arrangements

A precise definition of the contributions by each participating agency (CABEI, IDB, UNDP and CEPAL) will be agreed upon including their breakdown (into in-kind cash allotments, payments to consultants, etc.) Also parts of the study to be financed, periods and duration.

2. Awarding of consultant's contracts

In accordance with the previously stated financial arrangements, detailed terms of reference will be prepared for the study components to be carried out by consulting firms. Proposals are to be requested from qualified firms, so that they may be analyzed in detail and - after consultations with the financial agency involved - contracts negotiated and awarded.

3. Revision of hydropower plant technical characteristics

The activities included under this heading will provide the basis for the implementation of the MGI and WASP models.[1/] They refer to existing plants through 1983 as well as envisaged projects, and include:

i) Identification of technical and operational characteristics required to define energy output under different hydrological conditions. the most convenient operational policy and the possibility of eventually transferring energy from wet to dry seasons;

ii) Where needed, hydrological records are to be extended in order to provide a homogeneous base period.

iii) Taking into consideration the approximate characteristics of the electrical system and of the hydrological regime, a policy for plant operation should be defined to provide a basis for the subsequent long-term global optimization procedure;

iv) By means of a simulated operation model, the energy output for the already defined hydrological conditions will be determined,

---

1/ MGI: Global investment selection model.
WASP: Wien Automatic Planning System Pacjage (IAEA).

/taking into

taking into consideration the limitations, interference and interrelations among the projects available by 1983. Due consideration should be given to those cases where the installation of a new plant may effect the energy output of existing projects.

v) Energy output for typical (dry, average and wet) hydrological years is to be determined together with - in accordance with storage capacity estimates - the energy which could be transferred from the wet to the dry season. This should be carried out for several installed capacity alternatives so that for each set of hydrological conditions an energy output versus installed capacity curve can be prepared.

4. Revision of hydropower project costs

4.1 General. The overall objectives under this heading are:

i) To make a list of hydropower projects and preliminary schemes for each country to be utilized in the model of existing selection in order to formulate long-term electric power development programmes;

ii) To estimate construction costs of the project selected. Since the projects are to be matched against each other to determine the optimum development scheme, provisions should be adopted in order to ensure that the investment costs are estimated with the greatest possible accuracy and/or calculated on a similar basis, but taking into account existing unit cost differences among the countries;

iii) To calculate for each project its cost variation as a function of installed capacity, through the estimation of costs for three or four different project sizes in order to allow the model of investment selection to choose the optimum capacity to be included in the system.

4.2 Projects to be considered. The work is to be carried out on the basis of the projects included in CEPAL's report "Inventario de la información básica sobre centrales y proyectos hidroeléctricos en el Istmo Centroamericano". From such catalogue a selection is to be made of

those projects at feasibility, prefeasibility and inventory levels with acceptable data unless they are already under construction or under consideration for implementation in the near future.

4.3 Estimates of volumes and quantities in typical works. In order to adopt a common criteria for the estimation of project costs, these should be calculated on the basis of unitary quantities for each typical project component. These quantities could be obtained by detailed analysis or global estimates as required.

4.4 Unit costs. For each country a list of unit prices for the specific work components defined above is to be prepared. The unit prices should of course reflect the different conditions in each country as regards availability of construction materials, transportation and labor costs. Prices should be referred to late 1976, and a breakdown into local and foreign currency components should be made.

4.5 Project cost estimates. By combining the unit costs and the estimated work quantities the total project construction cost is to be determined for the installed capacity envisaged.

4.6 Project degree of definition. A method is to be devised in order to determine the degree of project definition, based on the quality and quantity of the information employed to formulate the project. The percentages of project contingency costs are to be established on the basis of such degree of definition. In this connection, special consideration should be given to available information on geology, hydrology and land topography. Whenever uncertainties and limitations on basic data exist, the project costs are to be penalized accordingly.

5. Cost versus installed capacity curves

A methodology is to be devised in order to be able to determine construction cost as a function of installed capacity, on the basis of the cost of basic works and their required modifications as the plant capacity varies. Whenever a project has been studied for several capacity alternatives, use should be made of such direct information.

/6. Technical

6. Technical characteristics and costs of thermoelectrical plants

6.1 General. The purpose of this study is to define the technical characteristics of alternate thermoelectrical plants to be included in the analysis and in accordance with the requirements of the mathematical models.

6.2 Types of plants. Consideration should be given to:

Oil (Bunker-C fired steam plants

Coal-fired steam plants

Combined cycle units

Gas turbines

6.3 Size of plants. A reasonable number ofunits - standard commercial sizes - should be selected among the following ranges:

50-1000 MW for steam plants

50-300 MW for combined cycle plants

25-100 MW for gas turbines

6.4 Technical operational data for thermoelectrical units. For each type and typical size of thermoelectrical plant as outlined above, operational technical data and annual cost figures are to be provided.

A survey is to be made to determine the basic characteristics of the oil and its derivates which are used throughout the region. This should include such information as specific weight, specific heat, etc. In addition, all available information on coal resources should be collected and analyzed.

6.5 Cost of thermoelectrical plants. For each type and size of thermoelectrical unit, as defined before, a breakdown of investment as well as fixed and variable operation and maintenance costs is to be provided.

Where required, a distinction is to be made between costs of units located near the sea and those located inland where cooling facilities may have a higher cost.

/Here again,

Here again, prices should be those of late 1976, subdivided in local and foreign currency components.

7. Electrical market study

The latest available information on demand projections for each country is to be collected. All major concentrated energy demands - such as for large industries, irrigation and mining operations - are to be identified.

A long-term overall capacity and energy demand forecast is to be prepared on a monthly basis for each country, and their typical demand curves are to be defined. Whenever required, sectorial demand forecasts are to be used in order to spot check on the overall demand projections.

A study of the peak load diversity and its projection among the isolated and integrated electrical systems is to be undertaken.

The demand forecasts are to be broken down in such a way that subregional nodes can be defined, for which typical monthly demands, maximum capacity and energy for the period 1977-2000 can be defined. The characteristics of each node consumption (apparent capacity and reactive base and peak demand) should be determined.

8 Geothermical resources potential study

A review is to be made of existing studies in order to assess the magnitude and quality of existing geothermal energy deposits; in addition, in-site reconnaissance and interviews with local and foreign experts on the field are to be undertaken if required.

An estimation of the geothermal potential which can be reasonably developed in each country, together with the dates on which each particular plant could be placed into operation and their suggested capacity, should be prepared.

In addition, estimates should be made of the costs involved in geothermal field exploration, plant construction and disposal of residues. The fixed and variable annual operational costs should also be calculated.

/9. Formulation

9. Formulation of long-term development programmes

The Global Investment Selection Model (MGI) is to be implemented on the basis of all existing information on market forecasts, existing systems and proposed projects, both for the case of individual national systems and for several alternatives of an integrated regional system. Adjustments will be made to ensure that the resulting programmes for each time interval are compatible with the available hydroprojects and with commercial-size thermoelectrical plants.

The MGI model is to be re-employed at a later date in case the results of the WASP model require a significative modification of the first programmes developed.

10. Modification to the WASP model

Several modifications are to be introduced in the WASP model in order to allow the determination of the energy output for each hydro-project included within the integrated systems, so that energy transfers from one country to another can be calculated. Such transfers are to be determined on a monthly basis and for different sets of hydrological conditions. In consultation with the IAEA[2/] a decision will be reached on whether to make major modifications to the model or whether an auxiliary subprogramme will suffice.

11. Medium-term studies on system operation

On the basis of the preliminary programmes for selected time intervals defined by means of the MGI model, the year in which each proposed project should be operating will be determined by means of the WASP model, both for the case of the independent national systems and the interconnected regional alternatives.

The WASP model should be provided with basic hydrological data for dry years (to determine reliability of supply), average years (to determine operational costs) and wet years (which case might allow the largest energy transfers and the definition of the transmission lines characteristics).

2/ International Atomic Energy Agency.

/The data

The data should be furnished in sucha a way that an analysis of the isolated national systems and of the regional integrated network can be made on a monthly basis. Such information refers to demand forecasts, generating characteristics of existing and proposed hydroprojects under diverse hydrological conditions, generation and availability of thermoelectrical units, and criteria loss of load probability.

12. Study on energy transfers

A computer model and program is to be formulated in order to - on the basis of the operational results obtained through the WASP model - allow the determination of energy transfers between the countries, on a monthly basis and for a given set of hydrological conditions.

By means of such model it should be possible to determine energy transfers for typical years and for different hydrological conditions.

On the basis of average hydrological conditions, the energy transfers to be made in the medium-term are to be calculated so that the benefits of interconnection can be estimated. The critical parameters are to be defined on the basis of extreme hydrological conditions so that the international transmission system can be designed.

13. Study on the international transmission network

The transmission study should include the analysis of the isolated national systems as well as that of several interconnection alternatives. Initially, national transmission systems are to be developed assuming an independent situation; then, a study will be made of the requirements to interconnec those isolated systems. In all instances, the operation of the systems is to be optimized and the transfers of energy should seek economies in operation.

These studies will aim to provide optimized developoent plans for the indicated situations, and for four typical years as defined during the previous operation study.

/For the

For the national systems, studies on power flow compatible with long-term optimum development programmes are to be undertaken. In addition, studies on loss of load, short circuit and stability as required will be made to determine the technical feasibility of the proposed scheme.

For the regional systems similar power flow studies will be made on the basis of energy transfers determined during the studies on operation. As in the case of the national systems, analysis will be made for loss of load short circuit and stability as required. The alternate routes to be followed by interconnection lines will be determined on the basis of topographical maps and in close consultation with the interested countries.

The philosophy characteristics and possible development of a Regional Load Dispatch Center as well as of the six national dispatch centers will be defined to allow the economic and coordinated operation of the systems. Specific development stages covering the control and dispatch needs for three to five years will be identified.

The programmes of transmission and dispatch center works will be formulated for those plants which will be placed under operation during the periods 1983-1986 and 1987-1990.

The works programme will be separated under national and international, as refers to lines pertaining to the isolated national systems and to those which will traverse existing international borders. The programmes will include preliminary definitions of the transmission line routes, substations and load dispatch centers. For such purpose use will be made of maps and other pertinent information to be provided by the countries.

14. Analysis and economic justification of interconnections

The economic and financial benefits which will be obtained through the joint operation of the electrical systems for several interconnection alternatives, are to be determined from a comparison with the operational costs of the isolated national systems.

/The economic

The economic justification of each interconnection line will be determined by comparing the cost of the international transmission system and the benefits to be obtained by each individual country.

Should not all international lines prove to be economically attractive, lower capacity and higher utilization standards for lines are to be considered. If these are still uneconomical, further analysis should be made to determine the economic feasibility of interconnecting only groups of countries instead of the whole region.

15. Sensibility analysis

The necessary sensibility analysis will be carried out to determine the influence on the study results of the variation of several key parameters such as rate of discount, fuel costs, etc.

16. Definition of development programmes

Based on the previous studies, construction programmes are to be developed for each of the alternative interconnection schemes, together with a calendar of investment requirements and estimates of annual operation and maintenance costs. A schedule of prefeasibility and feasibility studies to be carried out in order to ensure the timely execution of the construction programmes will be prepared.

17. Final report

A final report is to be prepared in sufficient detail to describe the basis, scope and results of the study. It should provide sufficient elements so that the countries may decide on all matters of interconnection, including the execution of feasibility studies of specific interconnection lines. The report will also provide a general framework for the construction of all generation and transmission works to be undertaken in the region.

/Table 1

Table 1

REGIONAL ELECTRIC INTERCONNECTION PROJECT OF THE CENTRAL AMERICAN ISTHMUS: SCHEDULE OF ACTIVITIES