ITAIPU BINACIONAL

Itaipú Hidroelectric Development

The Project of the Century

ASESORIA DE COMUNICACION SOCIAL
DIRECCION GENERAL PARAGUAY

2000

Index

Statical Summary

Parana River

Total length (including Paranaiba and Grande rivers)	4 000 km²
Total Basin area	3 000 000 km²
Project drainage area	820 000 km²
Discharges recorded at Guaira: 1921/1990 average	9 070 m³/s
maximum daily average	32 990 m³/s
minimum daily overage	2 900 m³/s
Potential maximum inflow to the Reservoir	72 000 m³/s

Itaipú Dam and Connected Works

Reservoir	
Maximum normal level	El. 220 m
Maximum filling level	El. 223 m
Minimum exceptional level	El. 1 97 m
Length at maximum normal level	170 km
Surface area at maximum normal level	1 350 km²
in Paraguay	580 km²
in Brazil	770 km²
Surface area at maximum filling level	1 460 km²
Total storage capacity	29 000 000 000 m³
Available storage capacity	l 9 000 000 000 m³

Tailwater level

Normal	El. 100 m
Maximum	El. 138 m
Minimum	El. 92 m

Gross head

Normal	120 m
Maximum	128 m
Minimum	85 m

Net head

Normal	118.4 m
Maximum	126.7 m
Minimum	83.7 m

River Diversion Channel

Length	2000 m
Width at bed	150 m
Maximum depth	90 m
Discharge capacity	35 000 m^3/s
Channel excavation	22 500 000 m^3
Cofferdams: maximum height	90 m
Volume	11 300 000 m^3

Diversion Structure

Type of Dam	solid gravity
Crest length	170 m
Crest elevation	225 m
Maximum height	162 m
Maximum discharge capacity	35 000 m^3/s
Concrete volume	2 100 000 m^3/s

Main Dam (Including Left Bank Connecting Dam)

Type of Dam hollow	gravity and buttress
Crest length	1 064 m
Crest elevation	225 m
Minimum foundation elevation	29 m
Maximum height	196 m
Earth and rock excavation	2 800 000 m^3
Concrete volume	5 200 000 m^3

Right Bank Lateral Dam

Type of Dam	massive head buttress
Crest length	986 m
Crest elevation	225 m
Maximum height	64.5 m
Earth and rock excavation	1 610 000 m^3
Concrete volume	800 000 m^3

Rockfill Dam

Crest length	1 984 m
Crest elevation	225 m
Maximum height	70 m
Earth and rock excavation	5 100 000 m^3
Volume	15 000 000 m^3

Earthfill Dams

Right bank

Crest length	872 m
Crest elevation	225 m
Maximum height	25 m
Volume	400 000 m^3

Left Bank

Crest length	2 294 m
Crest elevation	225 m
Maximum height	30 m
Volume	2 800 000 m^3

Spiltway

Maximum height	40 m
Maximum discharge capacity	62 200 m^3/s
Radial gates	14 of 20 m x 21.34 m
Total width	390 m
Total length (chute + crest)	483 m
Earth and rock excavation	13 000 000 m^3
Concrete volume	800 000 m^3

Water Intakes

Number of units	20
Penstocks: inside diometer	10.50 m
total length	142.2 m
Nominal discharge per turbine	690 m^3/s

Powerhouse

Number of generating units	18
in the river bed	15
in the Diversion Channel	3
Principal dimensions: length	968 m
width	99 m
height	112 m
Distance between unit axes	34 m
Earth and rock excavation	5 000 000 m^3
Concrete volume	3 300 000 m^3

Turbines

Type .... FRANCIS
Nominal head .... 112.9 m
Design unit rated power .... 715 MW
Maximum unit power (limited by generator) .... 740 MW
Design speed .... 91.6 rpm
Operahon speed (50/60 Hz) .... 90.9/92.3 rpm

Generators

Type .... modified umbrella (DIN W 42)
Number of units 18
Rated output (50 Hz units) .... 823.6 MVA
(60 Hz units) .... 737.0 MVA
Power factor (50 Hz units) 0.85
(60 Hz units) 0.95
Active rated power of unit .... 700 MW
Terminal voltage .... 18±5% kV
Operational speed (50 Hz units) .... 90.9 rpm
(60 Hz units) .... 92.3 rpm

Single-Phase Transformers

9 banks of 3 single-phase
transformers + 1 reserve
.... 50 Hz 18-525 kV, 825 MVA

9 banks of 3 single-phase
transformers + I reserve
.... 60 Hz 18-525 kV, 768 MVA

Emergency power diesel generators

Number of units
50 Hz 2
60 Hz 2

Nominal unit power .... 5 MVA

Main Quantities

Concrete .... 12 800 000 m^3
Earth excavation .... 23 700 000 m^3
Rock excavation .... 32 000 000 m^3
Rockfill .... 15 000 000 m^3
Other materials placed (transition, filter, clay, etc) .... 11 800 000 m^3
Removal of Cofferdams .... 4 100 000 m^3

General Features of the Itaipu Project

Background

The immense hydroelectric potential existing in the stretch of the Parana river that forms the border between Paraguay and Brazil held the attention over the years of engineers and specialists in both countries. General studies on the possibility of harnessing this power potential date back to the decade of the forties.

However, to carry out more complete and detailed studies the agreement of the governments of Paraguay and Brazil was required.

On June 22, 1966, the Ministers of Foreign Affairs of the two countries signed o joint statement known as the Act of Yguazu, by which they declared the determination of their respective governments to proceed by common agreement with the study and evaluation of the hydraulic resources of the Parana river, owned jointly by Paraguay and Brazil, from and including the Salto del Guaira to the mouth of the Yguazu river. They also established the principles that would guide the use of the energy developed in this stretcn of the river.

To carry out the agreement the two governments established the Paraguayan-Brazilian Joint Technical Commission, on February 12, 1967.

On April 10, 1970, a Cooperation Agreement was signed by the Joint Technical Commission, the Administracion Nacional de Electricidad (ANDE) for Paraguay and Centrais Eletricas Brasileiras S.A. (ELETROBRAS) for Brazil, calling for a joint study of the hydraulic potential of the stretch of the Parana river along the border between the two countries, and which was to include also a general appraisal of the multiple benefits of the water, such as navigation, human and industrial use, irrigation, and others.

On May 30, 1970, following a rigorous process of selection of the most prestigious international firms, the parties to the Cooperation Agreement invited several engineering consultant companies to submit proposals for a feasibility study. The consortium formed by International Engineering Company, Inc. (IECO), of San Francisco, CA, USA and Electroconsult SpA (ELC), of Milan, Italy, was selected.

The contract with this consortium was signed late in 1970, and went into effect on February 1st, 1971, at which time the studies effectively began. The Preliminary Feasibility Report was submitted by the consultants in October, 1972. It contained two alternatives which were the result of exhaustive comparative studies of a large number of possiblities for development. The first alternative consisted of a single dam at ITAIPU, developing the entire potential at a single power plant; the second alternative called for two smaller dams (one at ITAIPU and the other ot Santa Maria, 150 kilometers upstream) to develop the existing potential by means of two power plants.

Comparison between the alternatives clearly indicated the advantages of the first one. This was duly selected by the Paraguayan and Brazilian governments and served as the basis for the Treaty of ITAIPU.

The next stage was the development of the Feasibility Study proper. Studies at this point included, in addition to new geological and geotechnical field surveys, a number of vital small scale hydraulic tests. The consultants submitted fully detailed studies of the topography, geology and hydrology, and gave final form to the general scheme of the Project and other features, such as the installed capacity of the power plant.

The Itaipu Treaty and Creation of Itaipu Binacional

On April 26, 1973, Paraguay and Brazil signed the Treaty "for the development of the hydroelectric resources of fhe Parana river belonging to both countries in condominium, from and including the Salto del Guaira or Salto Grande das Sete Quedas, to the mouth of the Yguazu river".

The treaty was ratified by Paraguayan Law Nº 389 dated July 11, 1973 enacted by the National Congress and promulgated on July 13, 1973. The same procedure was applied in Brazil by Legislative Decree Nº 23, dated May 30, 1973, enacted by the National Congress and promulgated by Federal Decree Nº 72.707 on August 28, 1973.

To undertake the hydroelectric development project the Treaty created a binational entity known as ITAIPU Binacional, a corporation endowed with legal, administrative ond financial capacities, and technical responsibility, to study, design, direct and implement the works, place them in operation and manage them, with power to acquire rights and assume obligations.

ITAIPU is governed by rules set forth in the Treaty and its Annexes, by additional protocols and other acts signed pursuant to the Treaty, and by its internal regulations.

The Binational entity was formally constituted on May 17, 1974. The members of its first Administration Council and Executive Board of Directors took office on that date.

The Parana Basin and the Geology of the Region

The Parana river, which runs for a totol 4 000 kilometers, including the Paranaiba and Grande rivers, from the confluence of which it originates in Brazilian territory, has a basin covering on area of 3 million km². Becouse of its flow rate and its huge drainage area the Parana is one of the major rivers of the world.

From the Salto del Guaira, now submerged in the ITAIPU reservoir, to the mouth of the Yguazu river, 190 kilometers downstream, the Parana river had a slope of 120 meters, susceptible for economic development.

The drainage area of the river and its tributaries, upstream from the ITAIPU Dam, cover aproximately 820 000 km². Average rate of flow at the Salto del Guaira is 9 070 m³/s.

The geology of the area contains massive basalt flows, uniformly horizontal, with dense basalt interspersed with layers of vesicular - amygdaloid rock and brecchia, which in some areas presents lithological discontinuities and severely fractured strips. This geologic formation is known os the "Serra Geral", and also as the "Trapp do Parana".

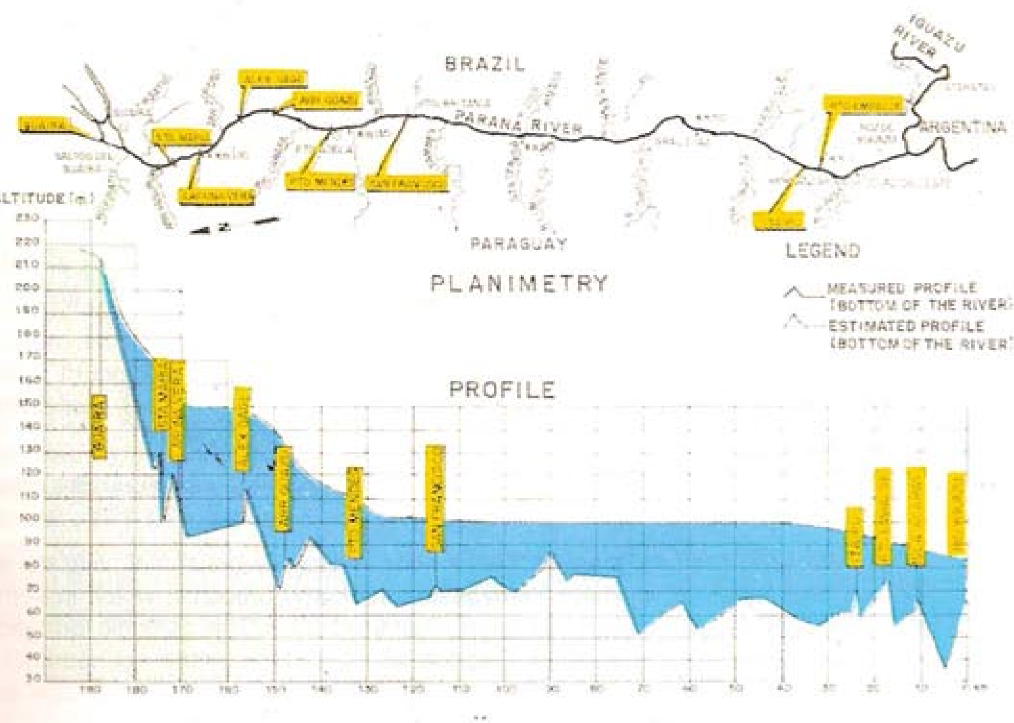
Residual clay soils cover the banks of the river and its tributaries.

Reservoir

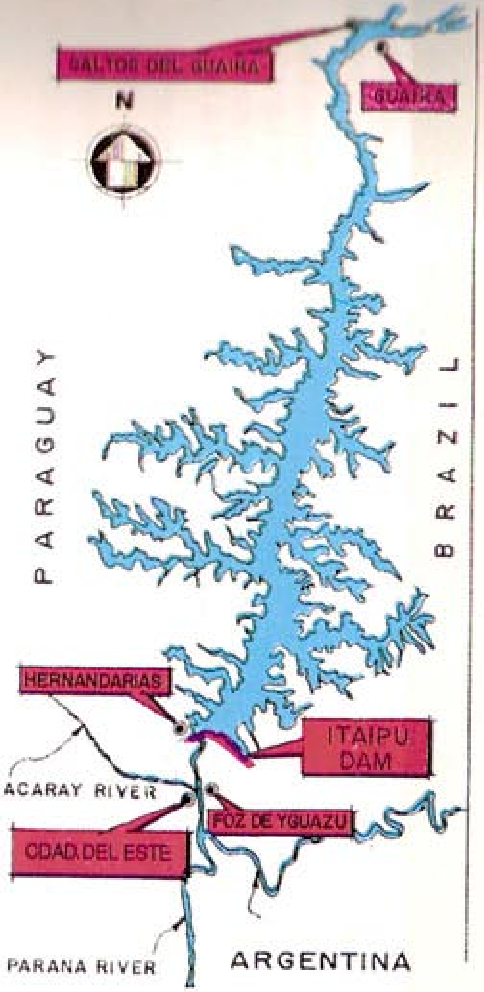
The ITAIPU Reservoir, at its maximum normal level of 220 meters above sea level, has an approximate length of 170 kilometers. The Reservoir extends over 1350 km², flooding 580 km² in Paraguay and 770 km² in Brazil. Gross volume of stored woter is 29 billion cubic meters. The maximum filling level in the reservoir is 223 m above sea level, and the lowest is 197 m. In view of the planned method of operation of ITAIPU, the reservoir is kept practicallv constant at 220 m above sea level.

Navigation

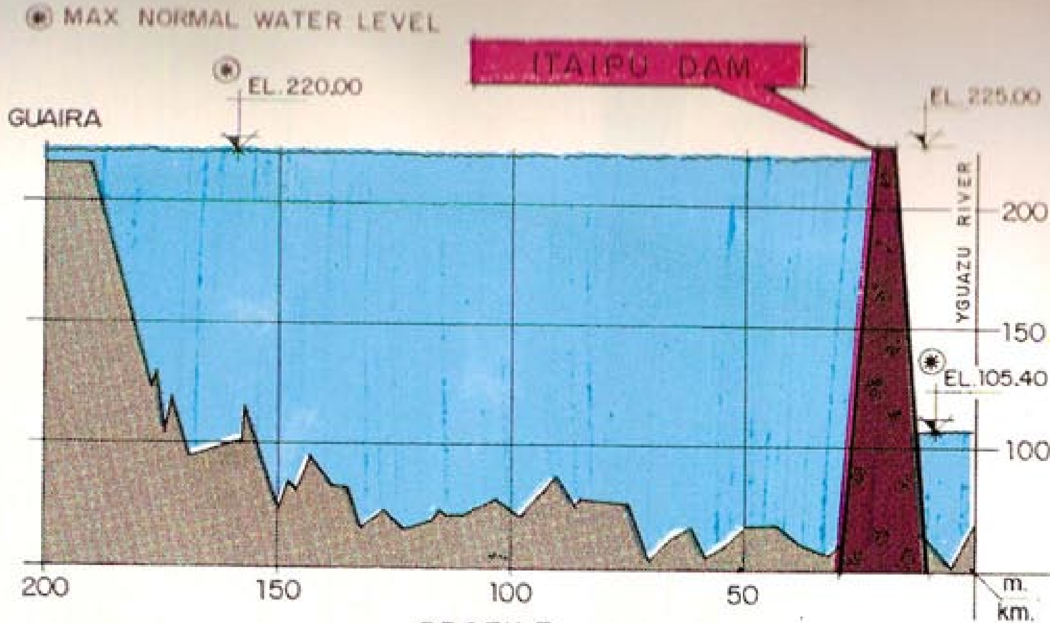
The ITAIPU Project included general studies on building altematives to allow for the requirements of river traffic, including terminals and land connections, locks, canals, elevators and similar works. This part of the Project has not yet been built.



PARANA RIVER FEASIBILITY STUDY - INITIAL STAGE



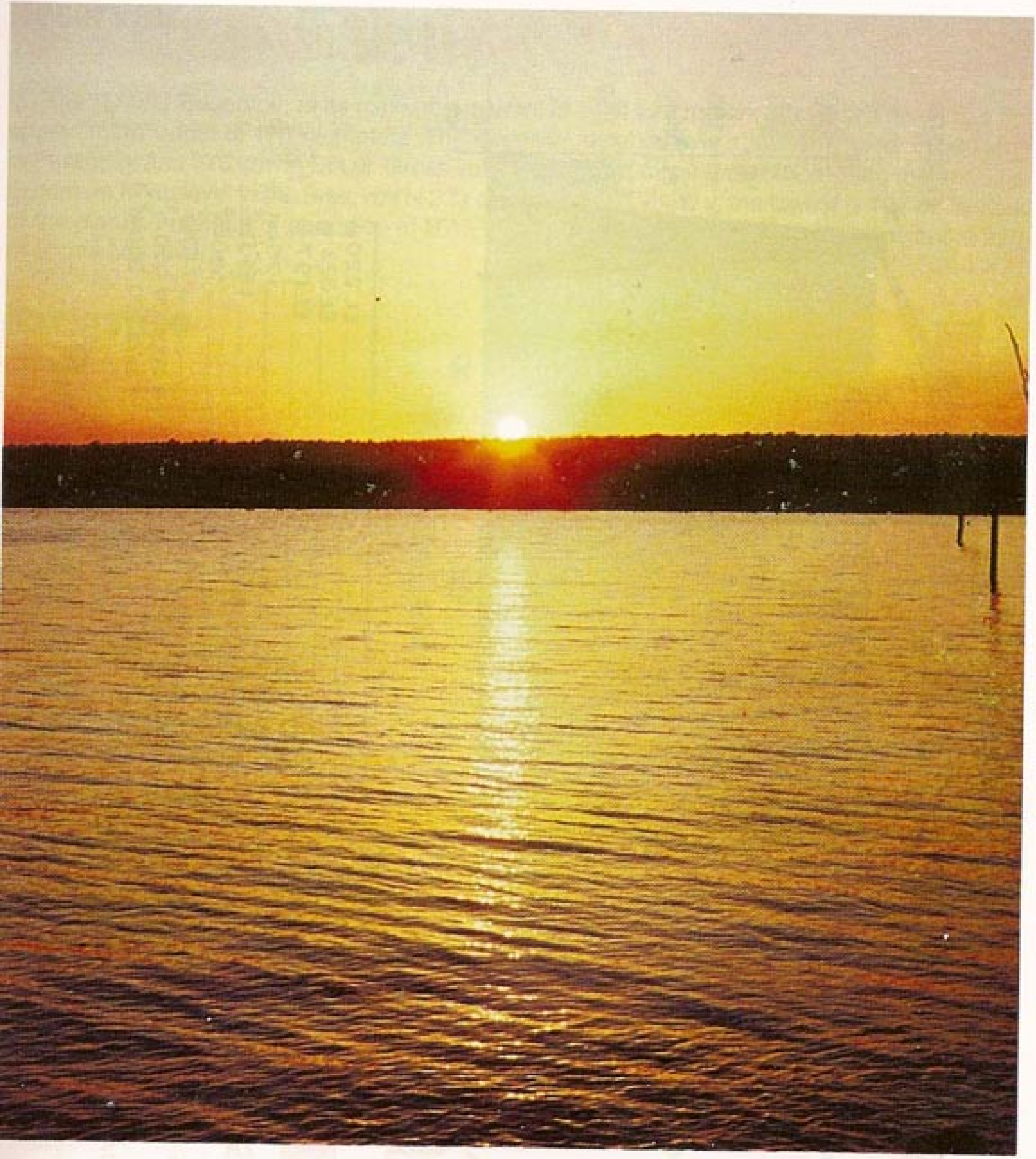
PLANIMETRY



PROFILE

RESERVOIR	
MAX NORMAL LEVEL	EL.220 m
MAX FILLING LEVEL	EL 223 m
MIN EXCEPTIONAL LEVEL	EL 197 m
LENGTH AT MAX NORMAL LEVEL	170 km
SURFACE AREA AT MAX NORMAL LEVEL	1 350 km^2
IN PARAGUAY	580 km^2
IN BRAZIL	770 km^2
TOTAL STORAGE CAPACITY	29 000 000 000 m^3
AVAILABLE STORAGE CAPACITY	19 000 000 000 m^3

ITAIPU RESERVOIR



Principal Companies tha Took Part in the Construction of the Project

Once established ITAIPU Binacional provided continuity to the work conducted by the Paraguayan-Brazilian Joint Technical Commission, by immediately proceeding with the organization and supervision of the executive engineering design and with the construction. From the beginning of the structuring process of ITAIPU, it became evident that since the Entity was to run a single undertaking, the establishment of o technical staff according to the organization of the other power companies would be an onerous solution. The decision adopted at this point was to create a small permanent technical staff in charge of general supervision over the Project, which would be carried out by engineering firms under constract.

The Paraguayan-Brazilian GCAP/ENGE-RIO/LOGOS Consortium drew up the construction plan for the engineering camp, including general planning and definition of the production standards required for the individual services, together with the dimensions of the support equipment for the industrial installations and production facilities to meet the gools set in advance.

Four Brazilian firms were retained to drow up the executive engineering design. Each of these companies was associated with Grupo Consultor Alto Parana (GCAP) in Paraguay to undertake the following jobs:

ENGEVIX - GCAP	Preparation of the design for the Spillway and the Right Bank Lateral Dam.
PROMON - GCAP	Preparation of the design for the Main Dam. Including the Water Intakes and Penstocks.
THE MAG - GCAP	Preparation of the design for the Powerhouse and the equipment Assembly Areas.
HIDROSERVICE - GCAP	Preparation of the design for the Earthfill Dams and the Navigation Facilities.

Coordination of the work conducted by the four engineering firms was entrusted to the consortium formed by International Engineering Company, Inc. (IECO) and Electroconsult SpA (ELC). This consortium was also assigned the following specific tasks: the design and specifications for the Diversion Works and the Rockfill Dam, and the specifications for Turbines, Generators and Extra High Voltage (EHV) equipment.

Tests on hydraulic models were performed in the CEHPAR (Centro de Estudos Hidraulicos Prof. Parigot de Souza) loboratories at the Parana Federal University. Research on structural models was conducted at ISMES (Instituto Sperimentale Modelli e Strutture SpA) at Bergamo, Italy, and at IPT (Instituto de Pesquisas Tecnologicas) in Sao Paulo, Brazil.

The Paraguayan-Brazilian CONEMPA/UNICON consortium was entrusted with building the civil works.

CONEMPA is made up by the following Paraguayan engineering firms: Barrail Hnos S.A. de Construcciones, Cia. General de Construcciones S.R.L., ECCA S.A., ECOMIPA- Empresa

Constructora Minera Paraguaya S.A., Ing. Civil Hermann Baumann Empresario de Obras, and Jimenez Gaona y Lima Ingenieros Civiles - Empresa de Construcciones.

UNICON is constituted by the Brazilian firms: Constructora Andrade Gutierrez S.A.; Construcoes e Comercio Comargo Correa S.A.; Companhia Brasileira de Projetos e Obras (CBPO); Cetenco S.A.; and Construtora Mendes Junior S.A.

The design, manufacture and supply of electromechanical equipment was contracted out to various engineering consortiums under a policy that favored the widest possible participation by Paraguayan and Brazilian manufacturers. As a result of this policy the percentage of domestic participation in equipment supply reached 80 per cent.

The turbines and generators were purchased from a consortium made up of the following firms: Consorcio de Ingenieria Electromecanica S.A.-CIE (Paraguay); Bardella S.A. Industrias Mecanicas S.A., BSI - Industrias Mecanicas S.A., Industria Eletrica Brown Boveri S.A., Mecanica Pesada S.A, Siemens S.A. and Voith S.A. Maquinas e Equipamentos (Brazil); Alsthom Atlantique and Neyrpic (France); A.G. Brown Boveri and Cie. (Germany and Switzerland); J.M. Voith GmbH and Siemens Aktiengesellschaft (Germany).

The rest of the permanent equipment in the Powerhouse was produced exclusively by Paraguayan and Brazilian manufacturers, except for the 500 kV gas insulated Switchgear (GIS-SF6), which was supplied by A.G. Brown Boveri and Cia.

A quality control program for the manufacturing of electromechanical equipment was organized by IECO-ELC. Factory inspections were conducted under the supervision of the above mentioned consortium, by the following companies:

Themag - Electromon

Promon - Electromon

Hidroservice - Electromon

Engevix - Electromon

Berenhauser - Electromon

Barbosa - Electromon

Mortara - Electromon

Assembly of the permanent equipment was performed by the ITAMON Ltda. (Brazil) and CIE (Paraguay) consortiums. The ITAMON consortium is mode up of the following companies: A. ARAUJO S.A. Engenharia e Montagens, Empresa Brasileira de Engenharia S.A. - EBE, Montreal Engenharia S.A., SADE Sul Americana de Engenharia S.A., SERTEP S.A. Engenharia e Montagens, TECHINT Companhia Tecnica Internacional, TENENGE Tecnica Nacional de Engenharia S.A. and Ultratec Engenharia S.A.

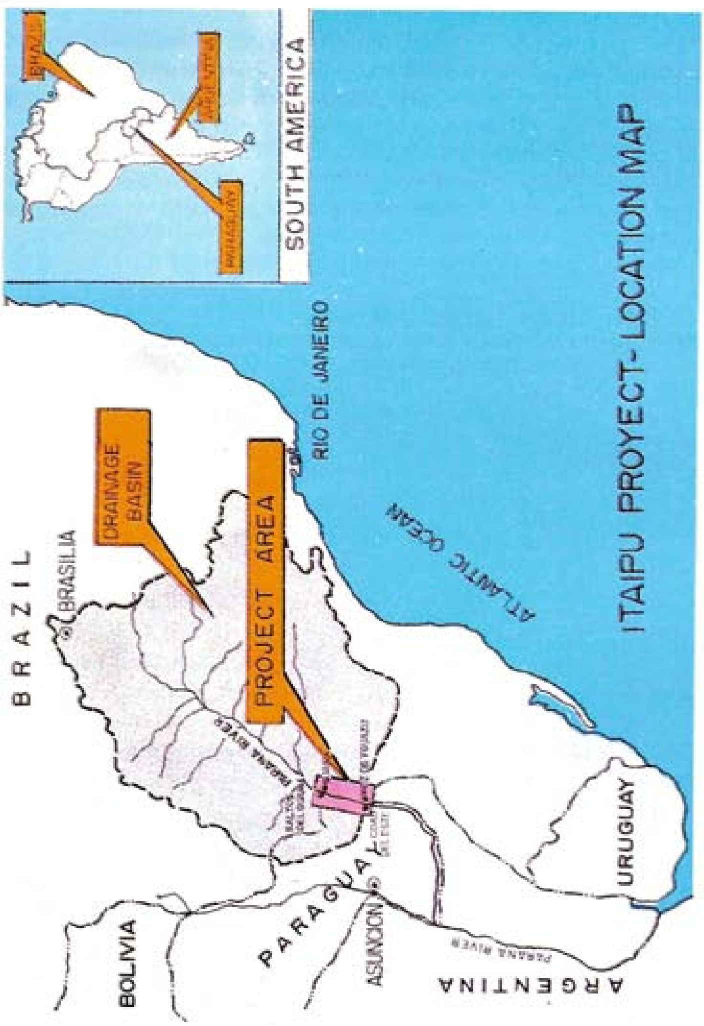
Due to the Project complexity and its peculiar characteristics, ITAIPU Binacional also contracted the services of many independent consultants to conduct studies on technical problems related to the civil works design and construction and to the design and manufacture of the permanent equipment. These consultants are named in the list below:

Consultonts	Country	Field of specializalion
Civil Works		
Flavio H. Lyra	Brazil	Chairmain of the Panel
Charles Blanchet	France	Hydraulics
Roy W. Carlson	USA	Concrete technology
Arthur Casagrande	USA	Soil mechanics
Don U. Deere	USA	Geology and rock Mechanics
Klaus W. John	Germany	Geology and rock Mechanics
Lyman D. Wilbur	USA	Project layout and construction aspects
Turbines		
John Parmakian	USA	Turbines
M. Braikevitch	Great Britain	Turbines
Gunther Wernicke	Germany	Turbines
Generators		
E.T. Metcalf	Great Britain	Generators
E.C. Whitney	USA	Generators

Physical Description of the Project

Location

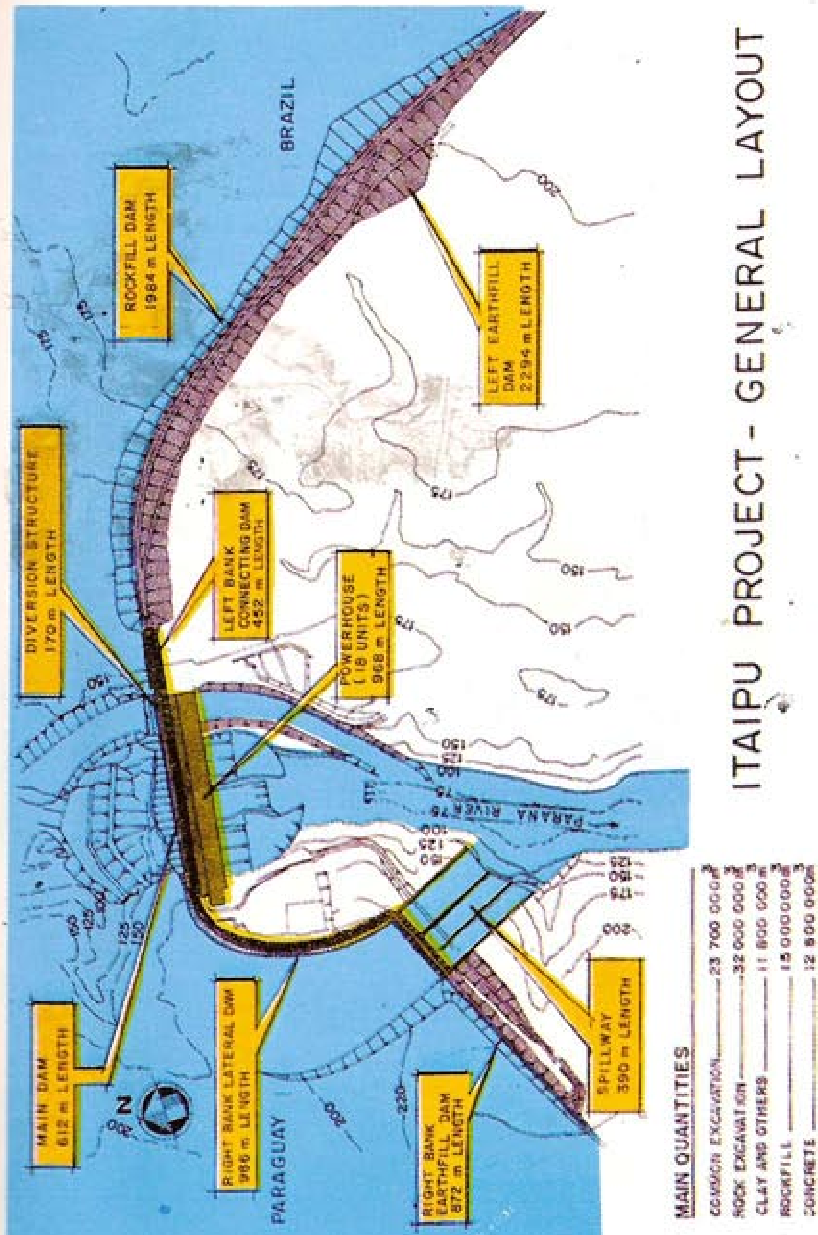
The main facilities of the ITAIPU Hydroelectric Project are located on the Parana river which runs along the border between Paraguay and Brazil, 14 kilometers upstream from the international bridge joining Ciudad del Este with Foz de Yguazu. The area of the Project extends all the way from the Salto del Guaira in the north, to Ciudad del Este and Foz de Yguazu to the south.



General Layout of the Project

The main civil works of the ITAIPU Project consist of o series of dams of various types built on an axis that crosses the Parana river. Beginning at the right margin these succesive structures are: Right Bank Earthfill Dam, Spillway, Right Bank Lateral Dam, Main Dam, Diversion Structure, Left Bank Connecting Dam, Rockfill Dam, Left Bank Earthfill Dam with a total length of 7 760 m. The Powerhouse is located at the foot of the Main Dam, perpendicular to the river.

The selection of the type of dams was made with due consideration to the most economical use of basic materials available of the site.



Diversion Channel and Diversion Structure

To allow for construction of the Main Dam and the Powerhouse, located on the river bed, the Parana river was diverted by means of a lateral Channel cut out of the left bank, which was 2000 m long, 150 m wide and 90 m in depth at its deepest point.

Opening this channel required removing 22 500 000 m³ of earth and rock. Part of the extracted rock was used in the construction of the Rockfill Dam, and the rest, after crushing, as aggregate in the concrete.

The subsequent closing of the Diversion Channel was achieved by means of a solid gravity

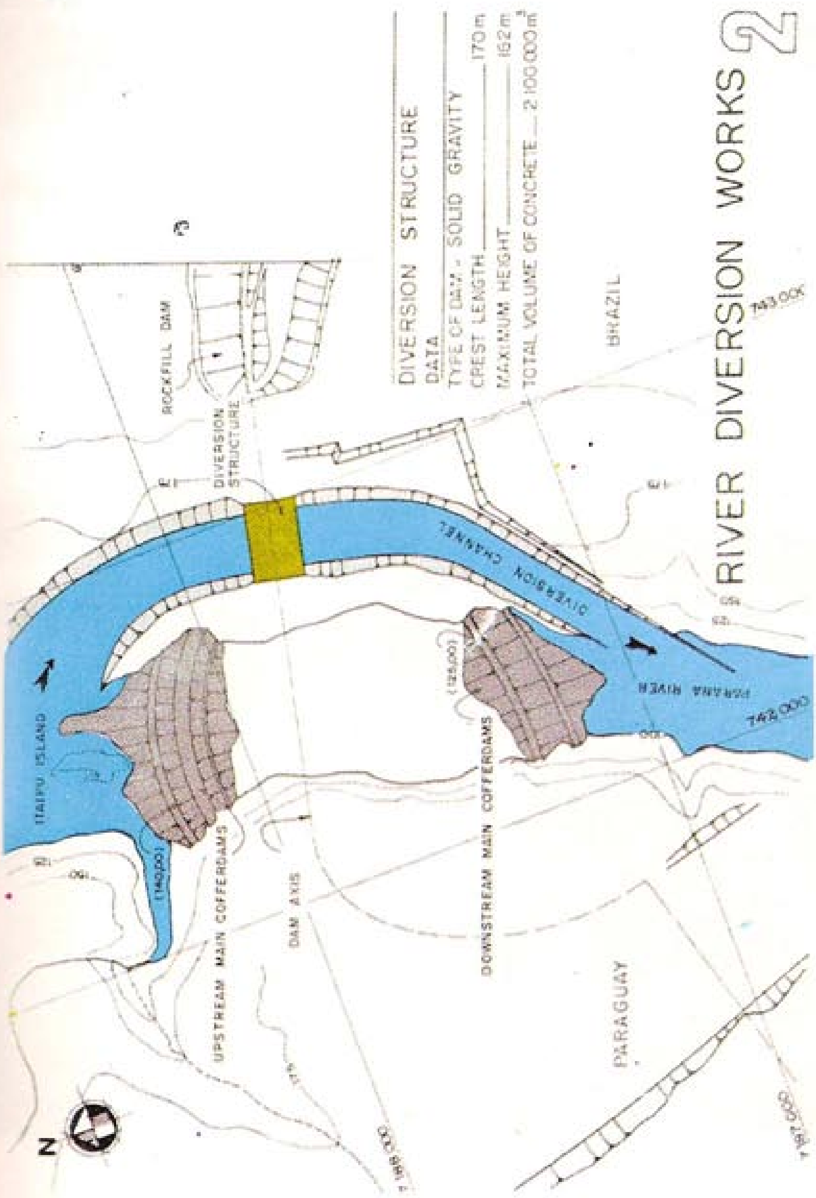

ITAIPU
BINACIONAL

concrete structure known as the Diversion Structure, equipped with 12 sluices and crest ot elevation 225 m. This structure is 170 m long, reaches a maximum height of 162 m and is designed for a maximum discharge capacity of 35 000 m³/s without overflowing the cofferdams located in the river bed.

The concrete volume required for its construction was 2 100 000 m³.

The Diversion Structure was used as such during four years, the construction period of the Main Dam, Powerhouse and other works in the river bed. At the moment of filling the Reservoir, the sluices were closed by gotes and then plugged with concrete.

Once the Diversion Structure was closed the second construction stage for the Powerhouse in the Diversion Channel begon, whereupon three Generating Units were installed.



Main Dam (Including the Left Bank Connecting Dam)

The Main Dam is a hollow gravity concrete structure, buttress type, founded on basalt. Total length is 1 064 m (the Main Dom proper measures 61,2 m and the Left Bank Connecting Dom measures 452 m). The crest is ot !evel 225 m, with a maximum height of 196 m measured from the lowest point of the foundation.

These structures required a volume of 5 200 000 m^3 of concrete, and excavation volumes in earth and rock of 600 000 m^3 and 2 200 000 m^3, respectively.

The rock foundations on which the Main Dam is supported received special attention by means of consolidating and waterproofing treatments and droinage systems.

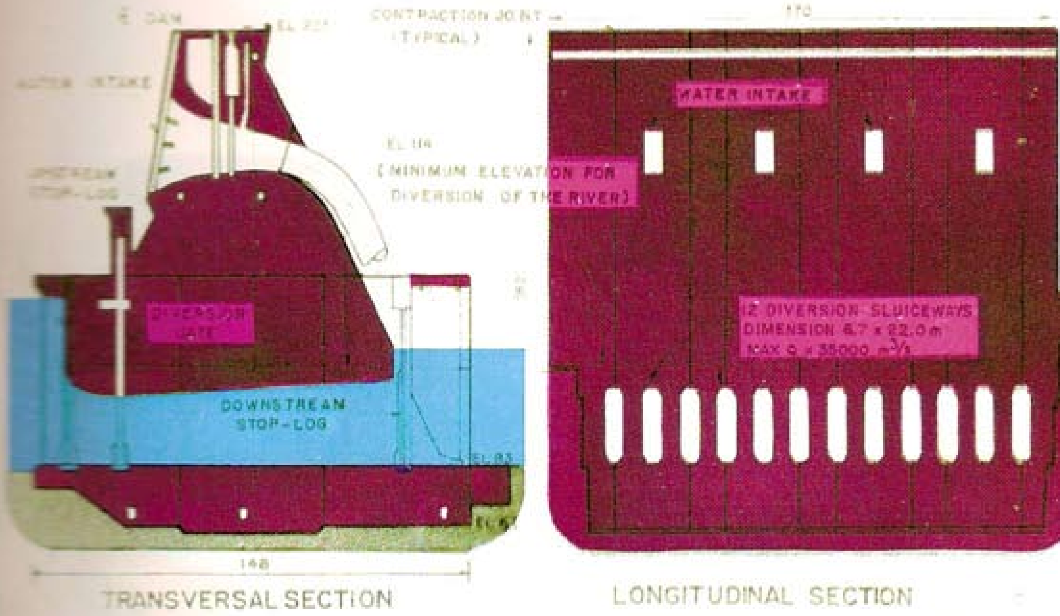
Right Bank Lateral Dam

The Main Dam is connected to the Spillway by a massive head buttress dam, located on the right bank, 986 m long, with its crest at elevation 225 m. Its maximum height is 64.50 m with a curve design to direct into the Spillway the water flow not utilized by the Turbines.

The Right Bank Lateral Dam required a volume of 800 000 m^3 of concrete and excavation volumes of earth and rock of 1 110 000 m^3 and 500 000 m^3, respectively.

The characteristics of the one typical block of the right lateral dam content 30% less concrete than one comparable block of compact gravity.

All the blocks of the right lateral press are founded in macise basalt wicht treatment was similar at the applicated in the foundations of the principal press.



DIVERSION STRUCTURE

Earthfill Dams

The use of Earthfill Dams was decided for those spots where more than 15 m of soil overlay the basalt and the necessary excavation for the construction of a Rockfill Dam was not considered economically convenient.

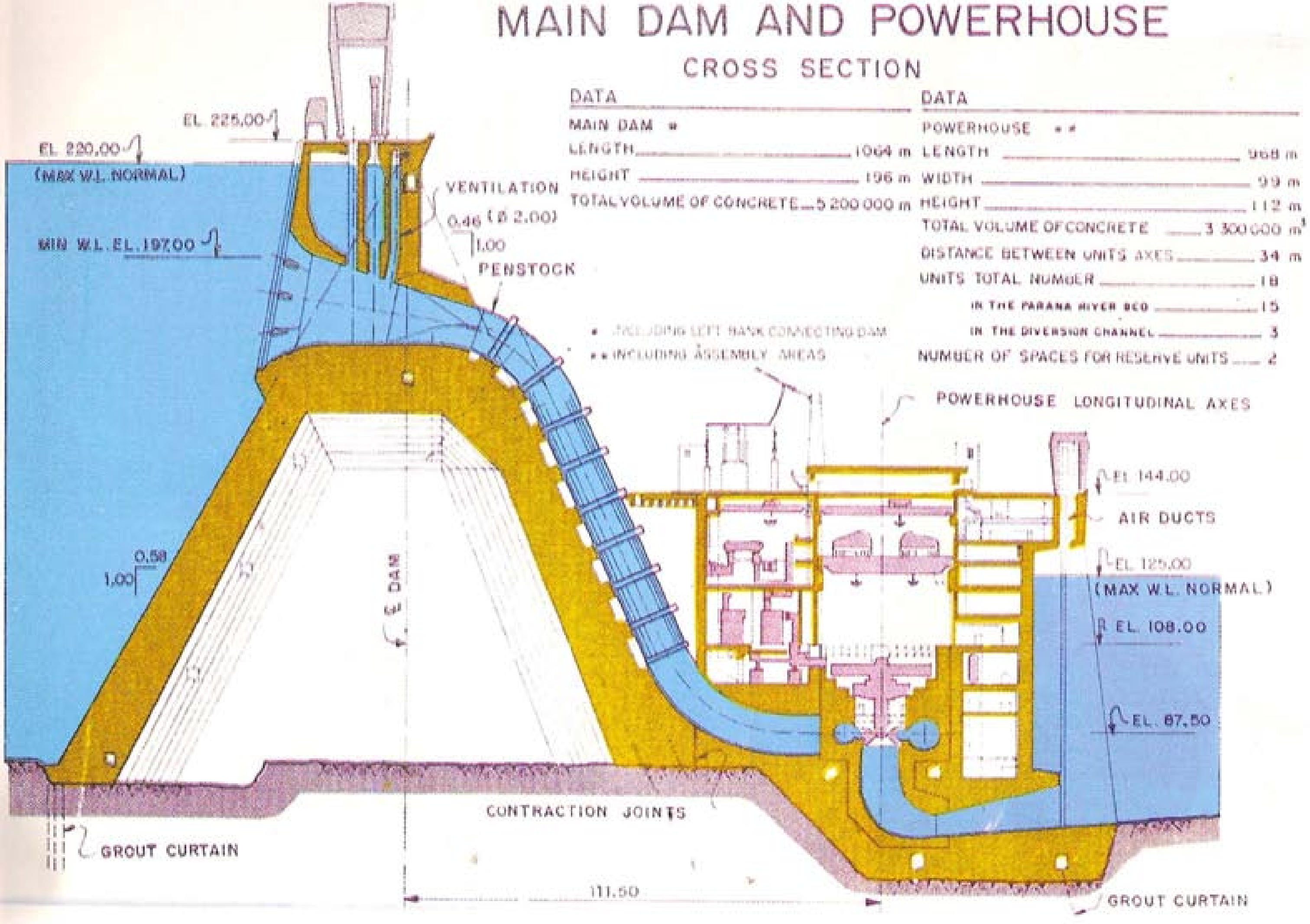
The Earthfill Dams on both banks of the river have their crest at elevation 225 m, a total length of 3 166 m, with 872 m on the right bank and 2 294 m on the left bank, and a maximum height of 25 m and 30 m, respectively.

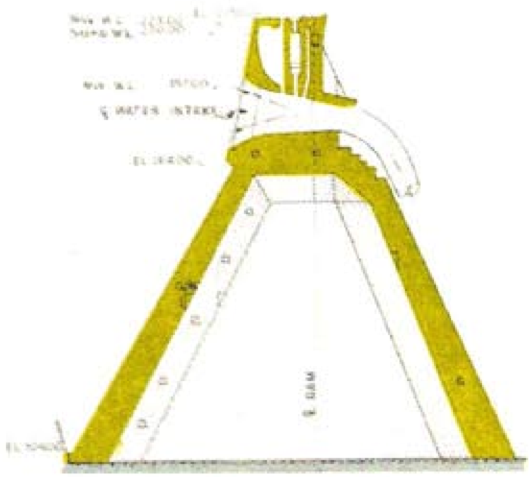
The volume of earth used in the construction was 400 000 m³ on the right bank and 2 800 000 m³ on the left bank.

A typical section of the dam has stabilizing berms for heights above 10 m.

MAIN DAM AND POWERHOUSE

CROSS SECTION





CROSS SECTION

PLANT

DATA

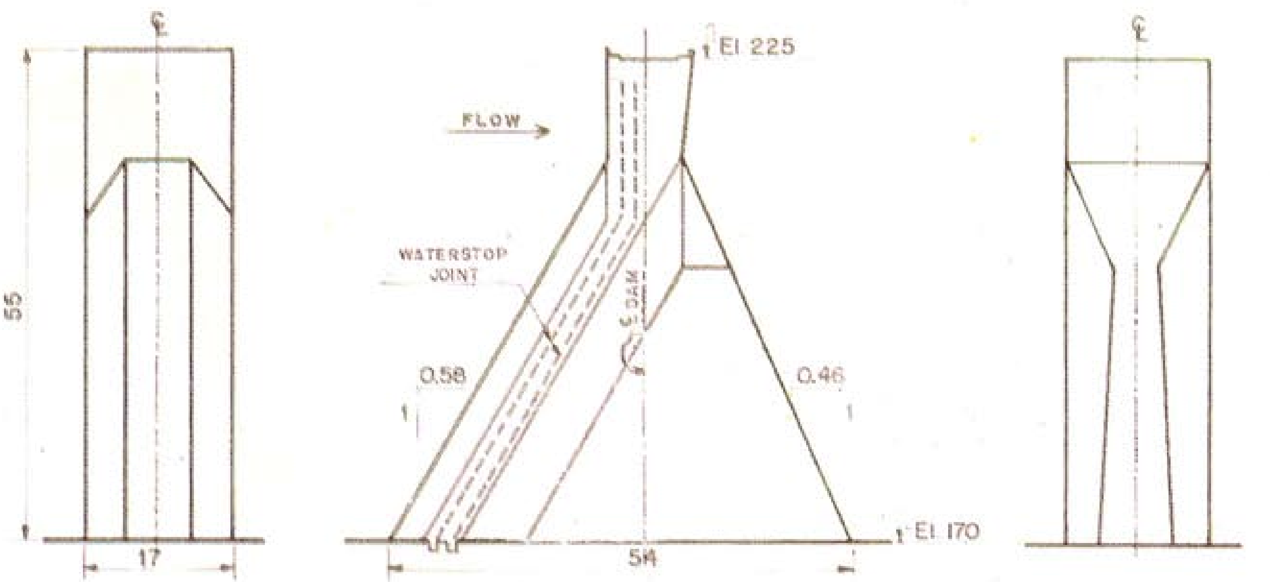
TYPE OF DAM: HOLLOW GRAVITY AND BUTTRESS

CREST LENGTH .... 612 m

MAXIMUM HEIGHT .... 196 m

MAIN DAM

Aerial view of the Main Dam showing Operations Building and Penstocks



UPSTREAM VIEW

LATERAL VIEW

DOWNSTREAM VIEW

DATA

TYPE OF DAM: MASSIVE HEAD BUTTRESS
CREST LENGTH .... 986 m
MAXIMUM HEIGHT .... 64.5 m
TOTAL VOLUME OF CONCRETE .... 800 000 m^3

PLAN ON THE FOUNDATION

RIGHT BANK LATERAL DAM

Rockfill Dam

The Rockfill Dam, located on the left bank, has its crest at elevation 225 m, a length of 1984 m, and a maximum height of 70 m. It is formed by an impervious nucleus of clay in the center and two lateral prisms of rocky material.

In its construction, 5 100 000 m^3 of earth were excavated and a volume of 15 000 000 m^3 of rockfilling was also required.

The use of rockfill material from the excavation of the Diversion Channel made the Rockfill Dam more economical than the other alternatives.

Spillway

The Spillway, located on the right bank due to its favorable morphological conditions, has the function of discharging excess water flows. It includes an approach channel, control structure, chutes and discharge buckets to dissipateenergy. Including the lateral walls, the Spillway has a length of 390 m, with its crest at elevation 225 m. It includes 14 gates with dimensions of 20 m x 21,34 m.

The maximurn height of the Spillway is 40 m, and the total length of the chutes and crest is 483 m. For maintenance purposes the Spillway is divided into three chutes, separated by dividing walls of a height of 14 m.

The Spillway required a volume of 800 000 m^3 of concrete, and excavations in earth and rock of 8 700 000 m^3 and 4 300 000 m^3, respectively.

The maximum discharge capacity of the Spillway is 62 200 m^3/s with the Reservoir at elevation 223 m, the maximum filling level, according to the tests performed on a scale model.

Water Intake and Penstocks

The Water Intake structures, located in the Main Dam and in the Diversion Structure, are designed to intake and control the water flow through the Penstocks into the Turbines of the generating units. The number of Intakes is 20, with their highest level at elevation 202,50 m. Eighteen Penstocks are now working, and the remaining two were installed, one in the Main Dam and one in the Diversion Structure, for the eventual installation of two reserve Generating Units.

The lower sections of the Intakes are connected to the Penstocks, made of metal plates with a thickness of 25 to 65 mm.

The Penstocks have a diameter of 10,50 m, a flow capacity of approximately 700 m^3/s, and a length of 142,2 m.

Powerhouse and Assembly Areas

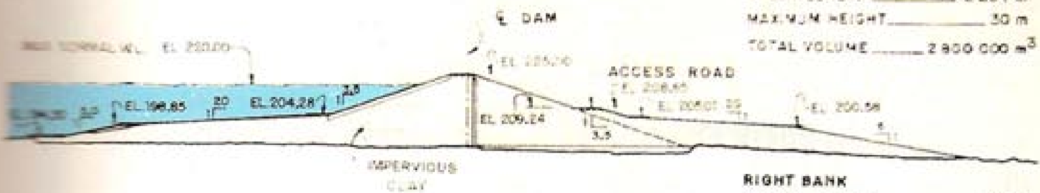
Located at the foot of the Main Dam, the Powerhouse contains 18 Generating Units, with spaces of 34 m between axes. The necessary space was provided to install two additionol units, one in the river bed and the other in the Diversion Channel.

The total dimensions of the Powerhouse are: length 968 m including two assembly areas, maximum height 112 m and width 99 m.

The Powerhouse required a volume of 3 300 000 m^3 of concrete, and excavation of 1 100 000 m^3 3 900 000 m^3 of earth and rock respectively.

To allow simultaneous assembly of Generating Units on both banks two equipment assembly areas were planned, one to the right of the Powerhouse and the other on the rock separating the river bed from the Diversion Channel, both equipped with the necessary infrastructure for handling heavy equipment.

EARTHFILL DAMS



DATA

LEFT BANK

CREST LENGTH ________ 2 294 m

MAXIMUM HEIGHT ________ 30 m

TOTAL VOLUME ________ 2 800 000 m^3

RIGHT BANK

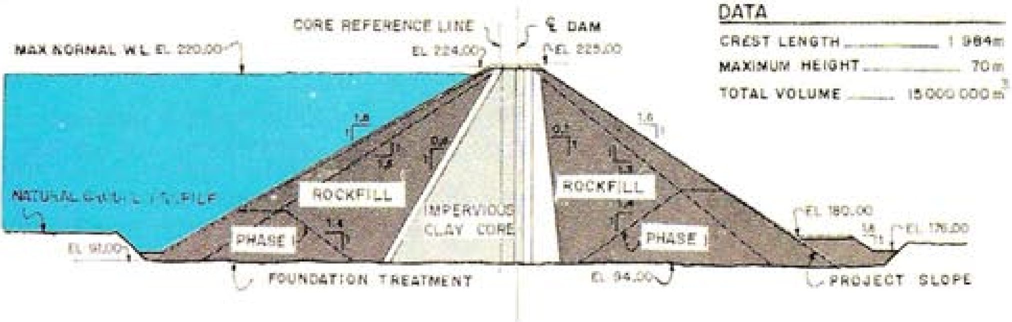
CREST LENGTH ________ 672m

MAXIMUM HEIGHT ________ 25m

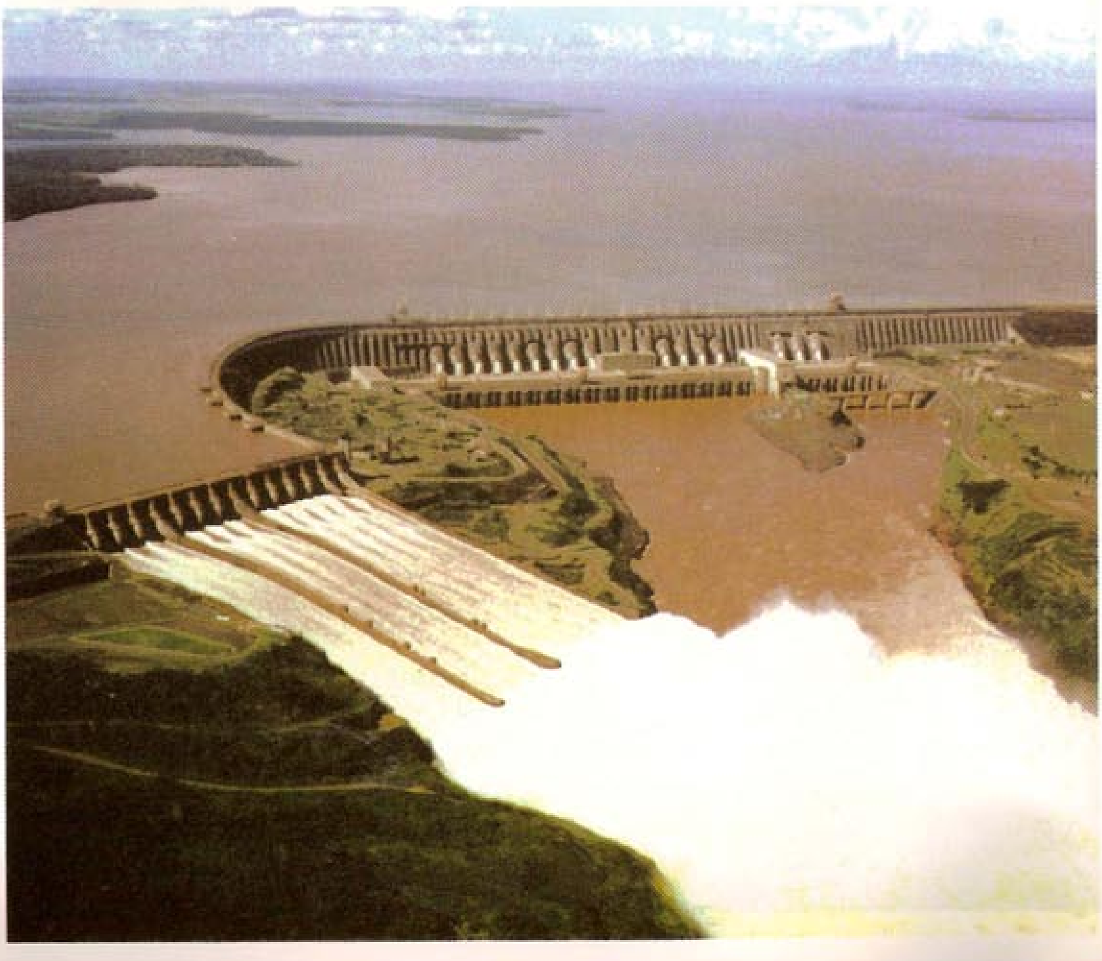
TOTAL VOLUME ________ 400 000 m^3

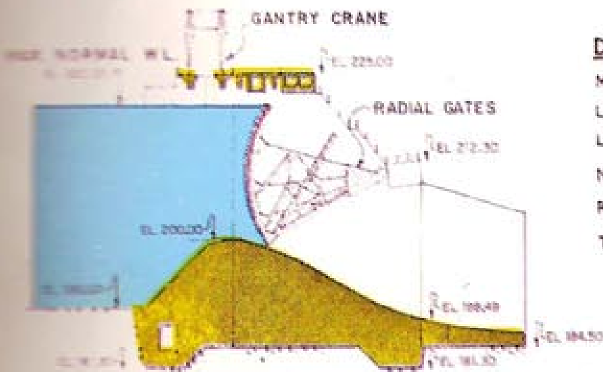
CROSS SECTION

ROCKFILL DAM



CROSS SECTION

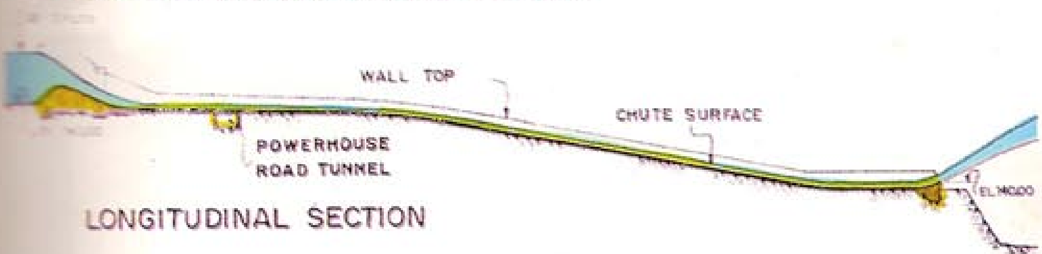




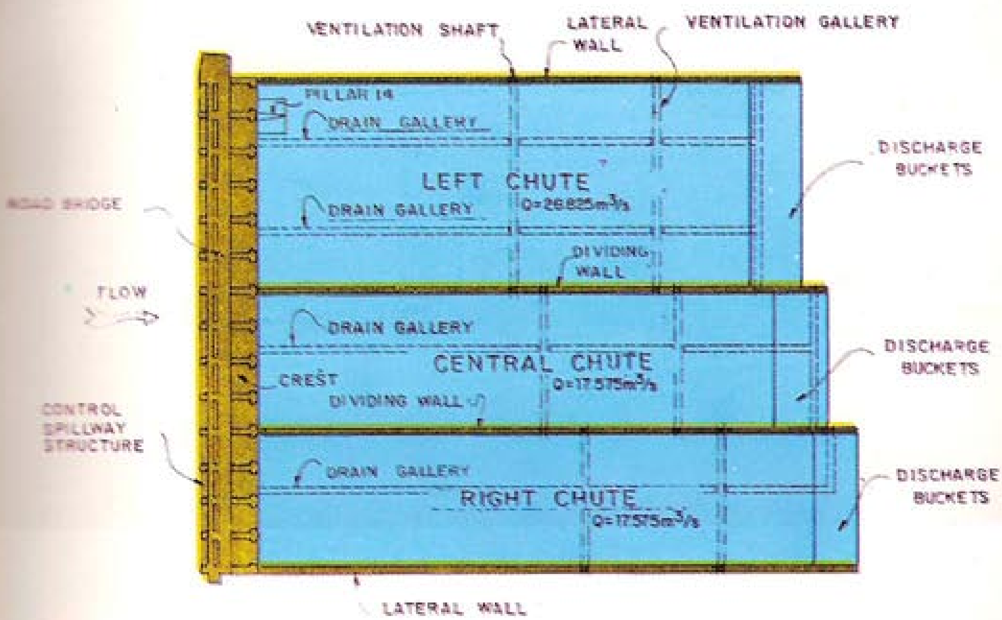
DATA

MAXIMUM DISCHARGE CAPACITY	62 200 m³/s
LENGTH OF CONTROL STRUCTURE	390 m
LENGTH OF CHUTES AND CREST	483 m
NUMBER OF RADIAL GATES	14 UNITS
RADIAL GATE DIMENSIONS	21.34 m x 20.00 m
TOTAL VOLUME OF CONCRETE	800 000 m³

CONTROL STRUCTURE - CROSS SECTION

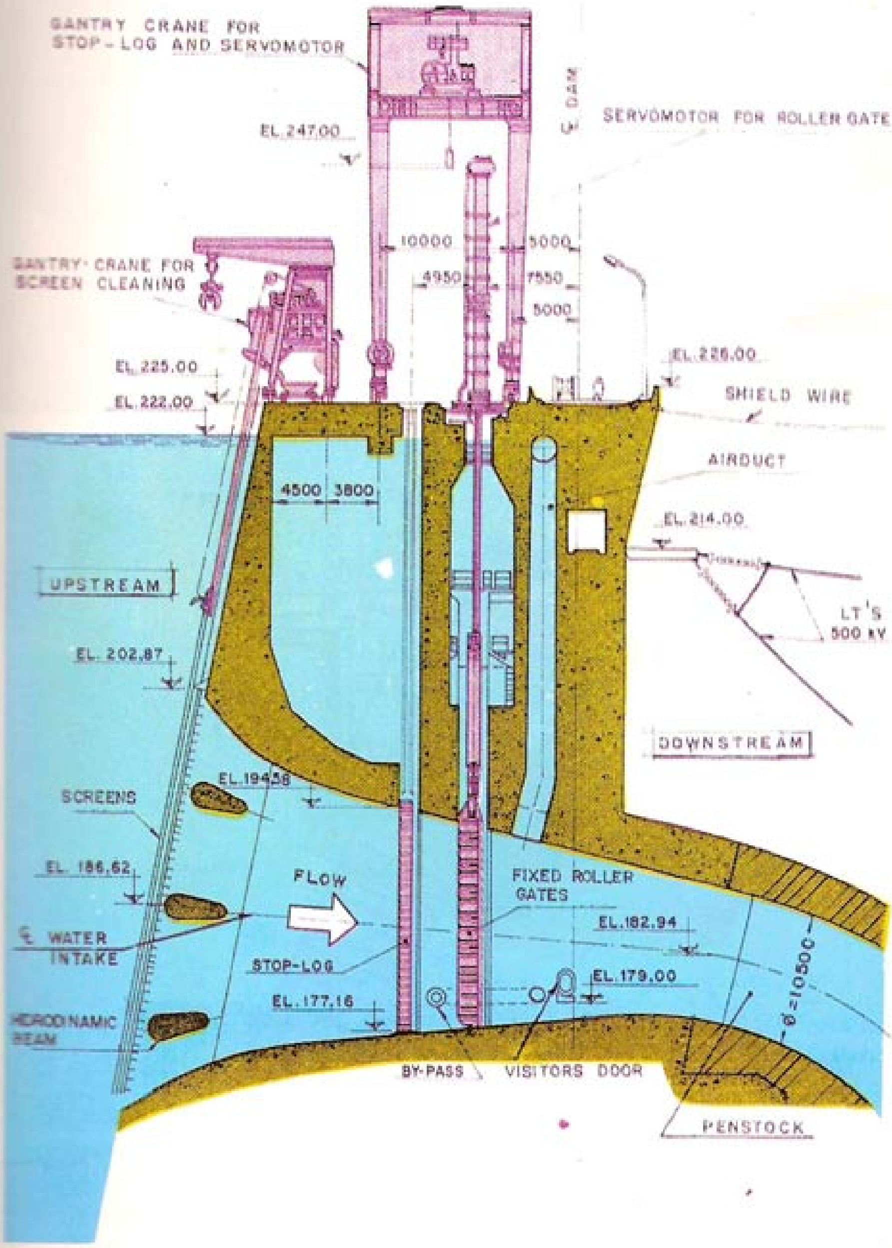


LONGITUDINAL SECTION



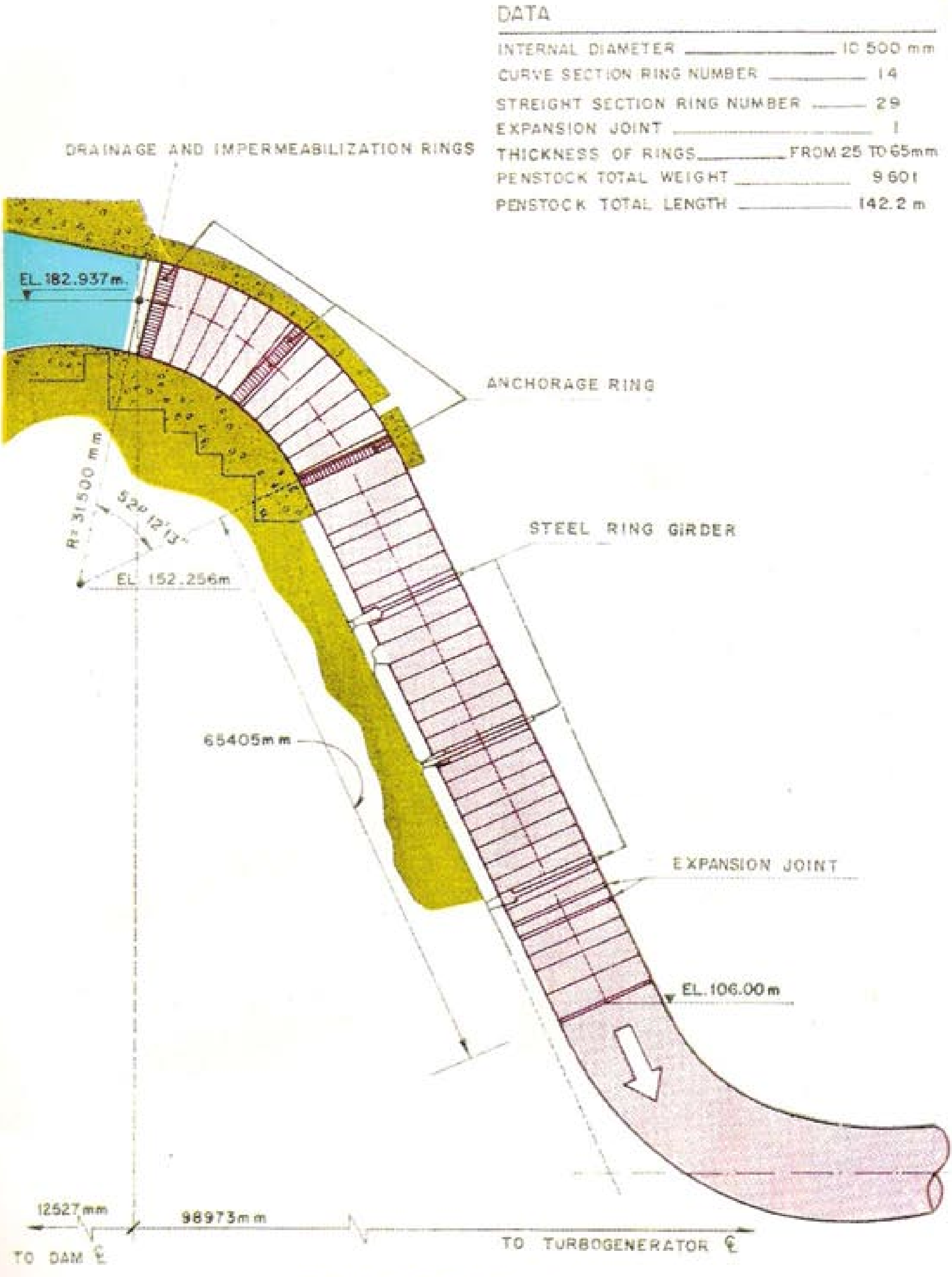
PLANT

SPILLWAY



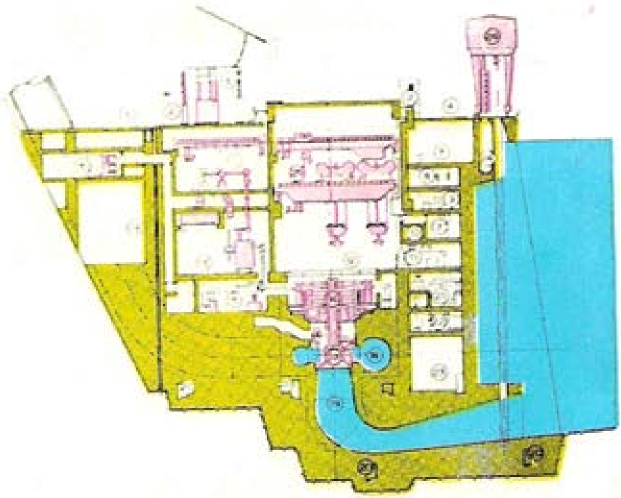
WATER INTAKE

CROSS SECTION



PENSTOCK

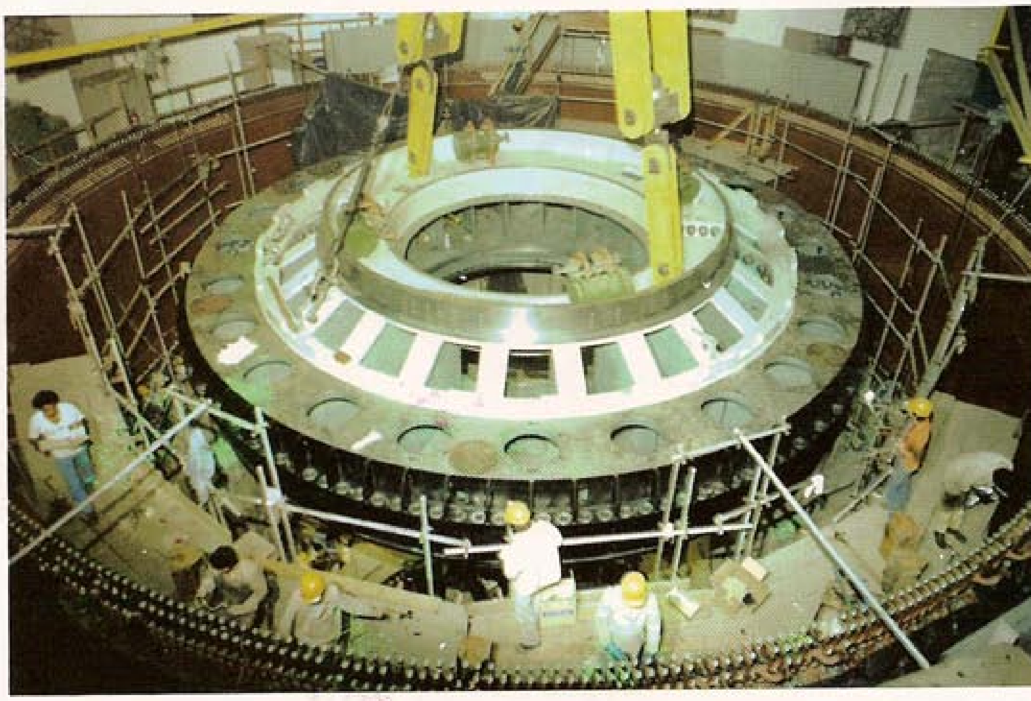
LONGITUDINAL SECTION

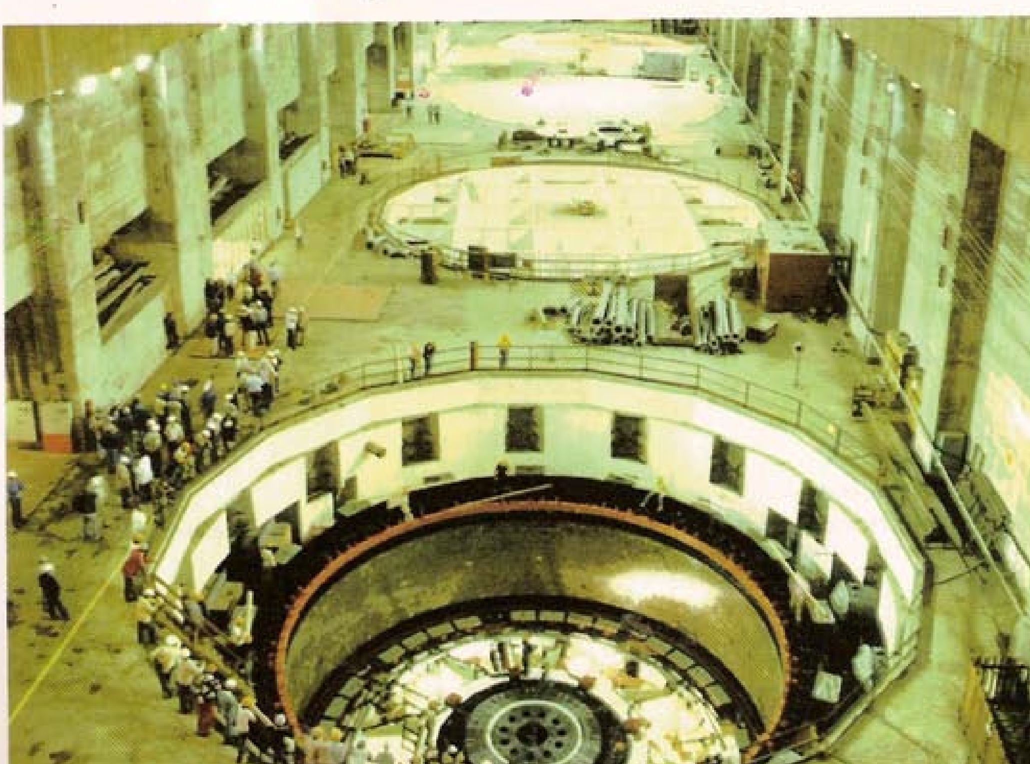


POWERHOUSE

CROSS SECTION

(1) UPSTREAM ROAD
(2) VERTICAL ACCESS
(3) TRANS. LINE TAKE OFFS
(4) DOWNSTREAM ROAD
(5) UPSTREAM VENTILATION
(6) SF6 SUBSTATION
(7) ELECTRICAL EQUIP. GALLERY
(8) CABLE GALLERY
(9) VENTILATION EQUIP. GALLERY
(10) BATTERY ROOM
(11) LOCAL UNIT CONTROL
(12) GENERATOR HALL
(13) TRANSFORMER GALLERY
(14) PENSTOKC
(15) UPSTREAM ELEC.- MECH. EQUIP. GALLERY
(16) GENERATOR
(17) TURBINE
(18) SPIRAL CASE
(19) DRAFT TUBE
(20) DRAINAGE GALLERY
(21) MECHANICAL EQUIP. GALLERY
(22) PUMPS
(23) ANTI-FLOODING GALLERY
(24) DRAFT TUBE GATE STORAGE
(25) MAIN POWERHOUSE CRANE
(26) GANTRY CRANE





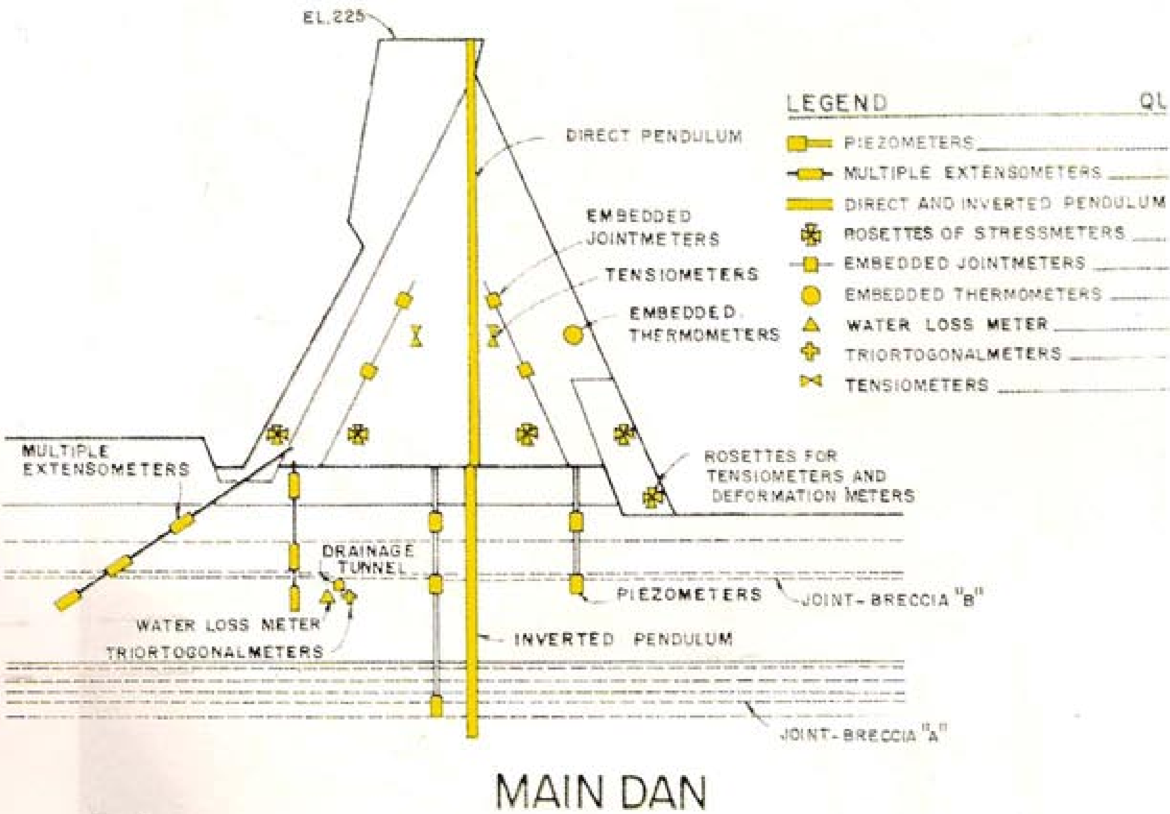
Operation Building

The Operations Building, now in its final construction phase, is located over the Power-house. The load dispatching center and other important facilities are located in this building. These premises are furnished with the most modem equipment and installations to be found in hydroelectric plants. Once completed, its facilities will allow for total automatization of the operoting systems, and will centralize all the technical elements for production, operation, coordination and electrical energy supply

Testing Instrument and Seismology

To verify the structural, thermal and hydrogeological safety of the dam structures ond their foundations during the filling of the Reservoir and the operation of the plant, 1830 special measuring instruments were installed in the Dam, with detailed monitoring of the structural behavior in some selected blocks that present particularities.

Though the Project area is located in a non-seismic zone, a teleseismology net was installed to observe eventual seismic activities. Until now, none were detected.



MAIN DAN

KEY BLOCK INSTRUMENTATION

Construction

Expropiations and Settlements

The expropriation at the necessary areas for construction totalized 3 381 hect. on the right bank, and 5 322 hect. on the left bank.

For construction of the residential areas, 413 hect. were expropriated on the right bank, and 581 hect. on the left bank. For auxiliary services, 771 hect. were expropriated on the right bank.

The Reservoir area required the expropriation of 120 376 hect. on the right bank, and 100 000 hect. on the left bank.

The adquisitions wass development since 1977 to 1982 and was conclude for specialist personnel was have careful to relocalize the original people in other productives areas without social order problems.

Physical and Social Insfraestructure

Before the start of the construction of ITAIPU the cities located near the dam site locked adequate infrastructures to meet the basic requirements of an undertaking of this magnitude. For this reason the Entity proceeded to install all the necessary facilities. Notable among them were the more than 9 500 houses built, half in each country, and all the basic services for residential areas, adopting for this purpose the highest urban planning standards. Recreation centers, parks, churches, supermarkets, water supply, drainage systems, paved roads, street lights, as well as administrative centers were built.

The school system established by ITAIPU was designed for approximately 15 700 students of different levels. The healt program was designed to give medical assistance to all the persons directly related to the works and their families.

In order to reestablish highway communications interrupted by the reservoir and to improve the transportation facilities in the region, ITAIPU Binacional built or graded 300 km of roads, gravelled 1 000 km and paved with asphalt more than 100 km.

Along these road 1 264 m of concrete and wood bridges were built, together with drainage and other special structures.

For the supply of electric power to the work site during construction, two Substation were installed, of 50 and 60 Hz respectively. The 50 Hz Substation, located on the right bank is connected to Administración Nacional de Electricidad (ANDE), while the 60 Hz Substation on the left bank is connected to the Companhia Paranaense de Energia (COPEL).

Telecommunications facilities (telephones, telex, facsimile and radio) were installed connecting the work site to the communication system of Paraguay and Brazil. An auxiliary airport for small aircraft was built and other basic services were also provided.

It should be noted, that after the completion of the ITAIPU proyect, the permanent infrastructure facilities built by ITAIPU Binacional in Paraguay and Brazil will continue serving the people in both countries, although under the responsability of other agencies.

Among the main goals of ITAIPU during the construction were the establishment of standard covering recruitment, selection, promotion, and relocation of Entity personnel as well as keeping complete personnel records.

Staff training in the various fields was also provided, together with studies on jobs ond salaries, labor market surveys and personnel welfare.

Entity personnel policies were executed according to the guidelines, standards and principles adopted by the top administration, following the directives of the two governments to achieve the highest working standards.

One of the guidelines followed emphasized control of the number of employees working for ITAIPU, both as Entity personnel and workers engaged by the contractors, setting hiring limits.

With respect to personnel training, the Entity developed instruction programs for employees at all levels. Emphasis was placed on providing highly trained personnel to handle operations and maintenance for the plant.

Actions aimed at guaranteeing safe working conditions in all fields were taken. The accident rates were among the lowest ever for undertakings of this kind.

To that end, Individual Protection Units were fumished to the workers. At the same time special emphasis was given by the Entity management to Internal Committees for the Prevention of Accidents (ICPA). The Internal Committees were established to monitor compliance with safety regulations and train workers in safety rules.

The high working standards of the ITAIPU Binacional workers were the result of rigorous control measures applied by the Entity and of the excellent working and welfare conditions created by management to obtain the best performance from its personnel.

Among these conditions the social assistance programs, personnel training and the establishement of harmonious social relationships are to be listed.

Activities in the cultural, social and recreational fields were organized and supervised by the Entity's specialized staff, as well as specialized personnel of the contractors and other organizations existing in the community including the Church.

Entity efforts in this field are basically oriented to children and youth.

Construction Planning

In 1975 ITAIPU Binacional set its goal of operating the first generating unit by 1983, according to the provisions of the Treaty. This meant a term of eight years within which to build the civil works and install the initial permanent equipment.

Careful planning became crucial in view of the time frame adopted for achievement of this goal and because of the exceptional magnitude and complexity of the project which imposed the necessity of setting ambitious productivity standards.

Planning included the construction program, general layout of the work site, setting time schedules and the selection of the principal building equipment in order to make the production programs compatible with the time available.

The construction of ITAIPU was divided into three stages:

The first stage included the excavation of the Diversion Channel, the construction of the Diversion Structure and proceeding to divert the river;

The second stage included construction of the different Concrete Structures, Earthfill and Rockfill Dams, as well as the assembly of the first Generators. It ended with the closing of the river, filling of the Reservoir and operation of the first generating unit;

The third stage included the construction of the Powerhouse in the Diversion Channel and completing the assembly of the remaining generator units.

Construction Equipment

The construction equipment for ITAIPU was conceived as two large machinery complexes almost equivalent in the conformation and capacity of their units. They were dimensioned to assure a monthly production of 300 000 m^3 of concrete, cooled down to 7° C, suitably distributed on both river banks close to the point of greatest demand.

For the production and casting of concrete the following equipment was used:

Two rock crushing plants, two cooling plants for aggregates, three ice producing plants six concrete mixing plants, two monorail units, seven mobile cableways connecting the river banks, and other equipment.

It became necessary to organize within relatively small areas an exceptionally heavy concrete flow, intense truck traffic, which not only had to transport forms and reinforcing steel but also parts and materials for the installation of permanent equipment.

It was also fundamental to ensure the continuity and regularity of the concrete supply, even under low visibility conditions due to the intense mist that covered the work site during the winter.

River Diversion Works

Construction began in October, 1975. According to the general timetable the first important goal to be achieved was the diversion of the river, which was to be completed by November, 1978.

The river closure was carried out by means of two rnain Cofferroams, which began to be constructed at the end of 1977. Their purpose was to dry the river bed where the foundations for the Main Dam and Powerhouse were to be laid.

The main Cofferdams were formed by two lateral rock dams and a central clay nucleus with a height of approximately 90 m, The bases of the clay nucleus of the Cofferdams were dredged to remove the existing loose materials, and to assure their imperviousness. The total volume of the cofferdams is 11 300 000 m³.

Compared to river diversion projects in earlier hydroelectric plants the Parana river diversion was the largest ever in view of the huge water flow.

Dam Works

The work of damming the river was accomplished in two stages:

- Work that did not depend on the river diversion and was not subject to time restrictions; - Work that depended on the river diversion and where time consequently was critical.

The first group included the construction of the Spiltway and the Right Bank Lateral Dam, and the Rockfill and Earthfill Dams, as well as part of the Left Bank Connecting Dam. These activities, though important, were not critical because they were located outside the river bed.

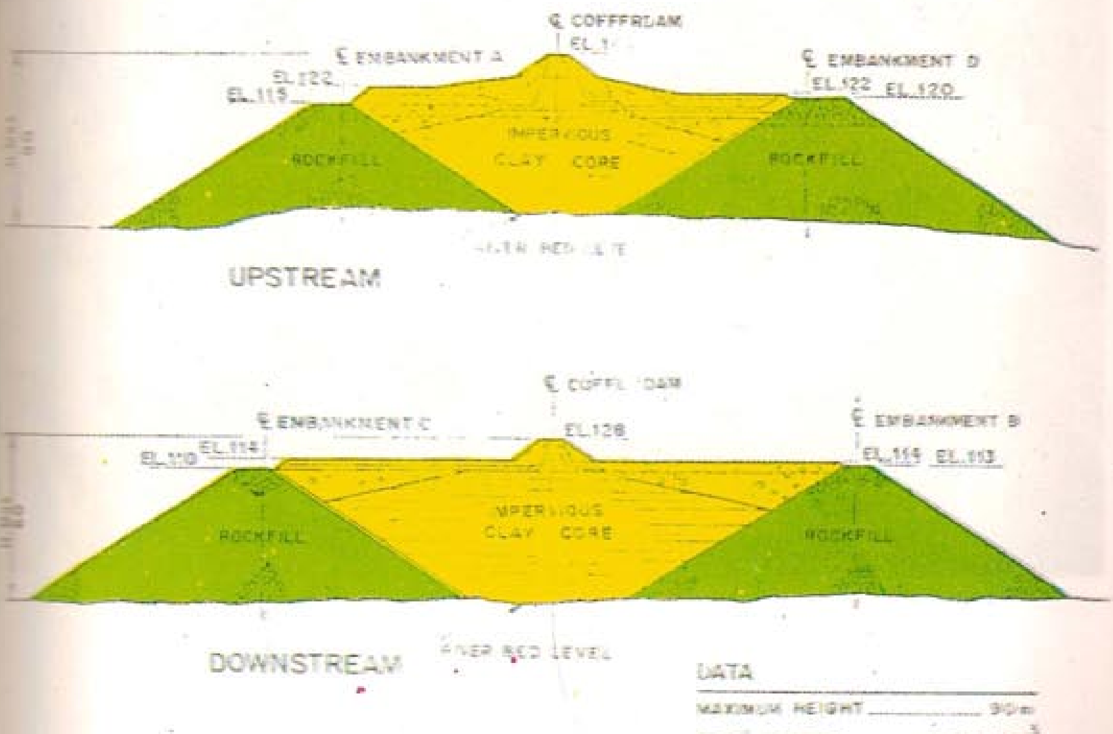
The second group included those structure which depended on the river diversion, and subsequent works. The second group includes the excavation in the river bed to lay the foundations for the concrete structure, construction and erection of the Powerhouse and Main Dam including the upper section of the Diversion Structure.

Diversion Closure and Reservoir Filling

The filling of the ITAIPU Reservoir, accomplished with total success in October, 1982, required very detailed planning and coordination to overcome possible difficulties, such as the failure to observe the Trilateral Agreement signed by Paraguay, Brazil and Argentina. Planning was conducted with the cooperotion of ANDE and ELETROBRAS, assisted by engineering groups from ELETROSUL and COPEL, from the State of Parana; also of CESP, from the State of Sao Paulo, and COMIP, the Paraguay-Argentina Commission for the Parana River.

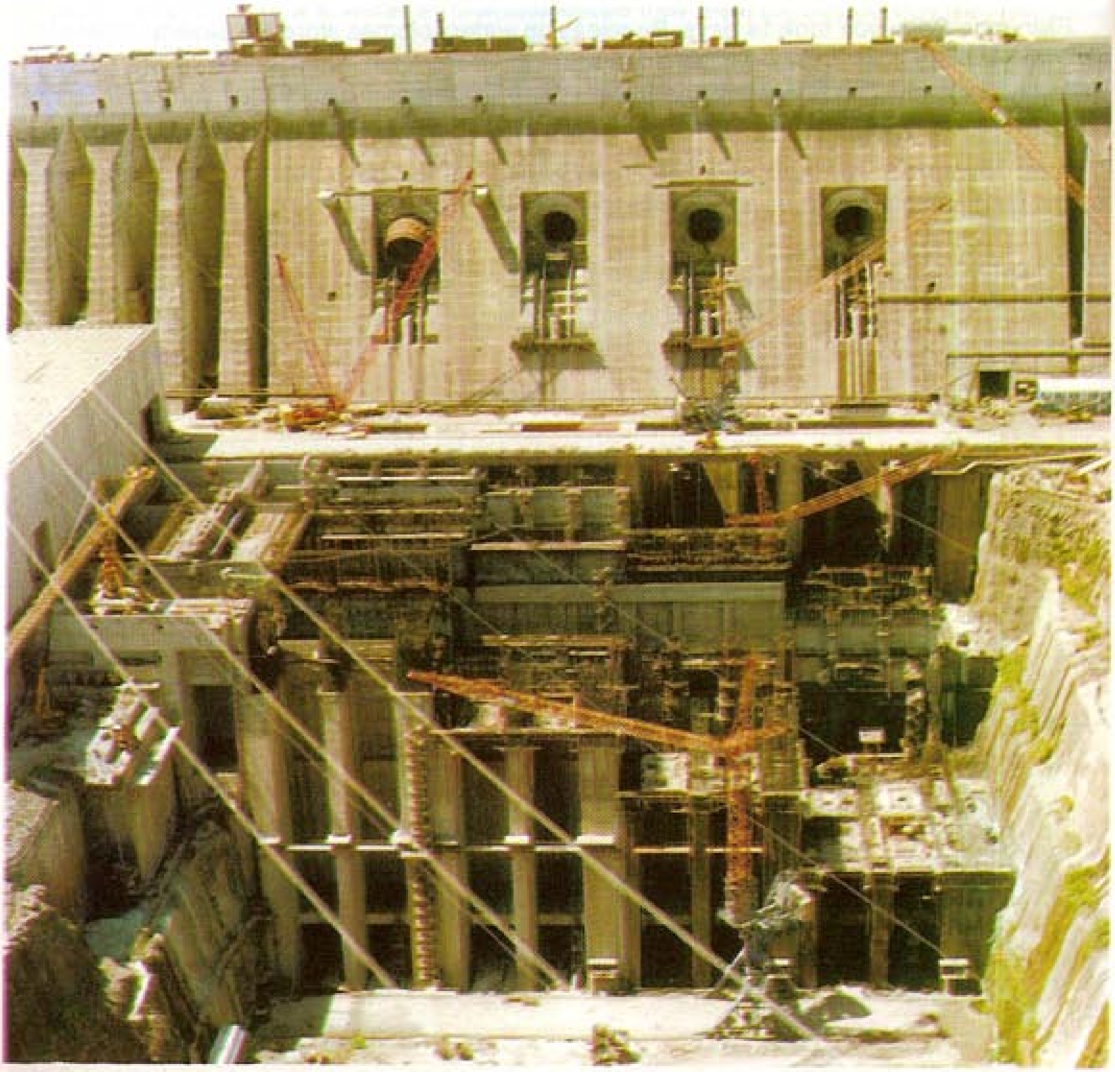
Filling the Reservoir took 14 days. By releasing water volumes stored in several reservoirs on the Yguazu River in Brazil it became possible to maintain water levels at the cities of Encarnacion and Posadas above the minimum of 5 000 m³/s, estoblished by the Trilateral Agreement.

After November 10, the water flow from ITAIPU started contributing to the water level downstream mointaining the same discharge as at Guaira.



COFFERDAMS

TRANSVERSAL SECTION



Concrete Production and Casting

The summary of concrete volumes includes oll the finished structures of ITAIPU:

- Main Dam (including the Left Bank	
- Connecting Dam)	5 200 000 m³
- Diversion Structure	2 100 000 m³
- Right Bank Lateral Dam	800 000 m³
- Spillway	800 000 m³
- Powerhouse	3 300 000 m³
- Others	600 000 m³
- Total	12 800 000 m³

To produce this volume of concrete, the following elements were used:

- Sound rock for aggregate production	8 300 000 m³
- Natural dredged sand	1 700 000 m³
- Cement	2 100 000 tn.
- Fly ash	300 000 tn.
- Additives	3 400 tn.

The world records for concrete production and casting were as follows:

- Daily	14 896 m³
- Monthly	339 772 m³
- Annual	3 051 184 m³

Permanent Equipment

Turbines and Generators

Simultaneously with the design of the Project and the performance of the civil works, studies related to the electromechanical equipment and the specifications for their manufacturing and purchase were prepared.

These studies mode it possible for supply contracts for the Generating Units to be drawn up in 1978, pursuant to the terms of the timetable, and to proceed with the purchase of the rest of the equipment.

The quality control applied by the Entity, based on the strictest international standards, guaranteed excellent levels of reliability of the electromechanical equipment. It should be mentioned that the purchase of raw materials, the fabrication and preassembly of the permanent equipment, and the transportation of the equipment to the work site were closely supervised by technicians of ITAIPU Binacional.

The Feasibility Study proved that the most economical option for the operation of ITAIPU would be as a base station, with very limited variation in the levels of the Reservoir.

In this study, joint operation of all the hydroelectric stations located on the basin of the Parana river were simulated, taking into consideration not only those existing at the time but also those that were in the planning stage.

The interaction of a series of factors, including the flow of water, heads, generator speeds and physical dimensions, resulted in the definition of the number and output of the Generating Units: 18 units of 700 MW each, with o total installed capacity of I 2 600 MW.

Due to the difference in the frequencies of the Paraguayan ond Brazilian electric systems, the station is divided into two independent sectors, of 50 ond 60 Hz.

The ITAIPU electromechanical project was drafted observing the following guidelines:

Reliability trough the employment of proven solutions, whenever possible;

Simplicity in order to expedite operation and maintenance;

Best equipment layout;

Sturdiness of the equipment, considering the safety factors of the project.

The height of the heads used in the specifications of the turbines was calculated from the hydroelectric data and the permanence curves downstream from the Dam.

CONDITIONS	WATER LEVEL (m)		(*) HEAD LOSS (m)	NET HEAD (m)	POWER (MW)	
	UP-STREAM	DOWN-STREAM			CONTRACTUAL	FINAL
Maximun Exceptional Level	220.0	92.0	1.3	126.7	740	800
Maximun Normal Level	220.0	96.6	1.6	121.8	740	800
Design	220.0	100.0	1.6	118.4	715	780
Minimum Normal Level	219.4	106.1	1.5	111.8	640	640
Minimun Exceptional Level	222.0	138.0	1.1	82.9	...	...

(*) Head loss between Intake gate to tail race tunnel

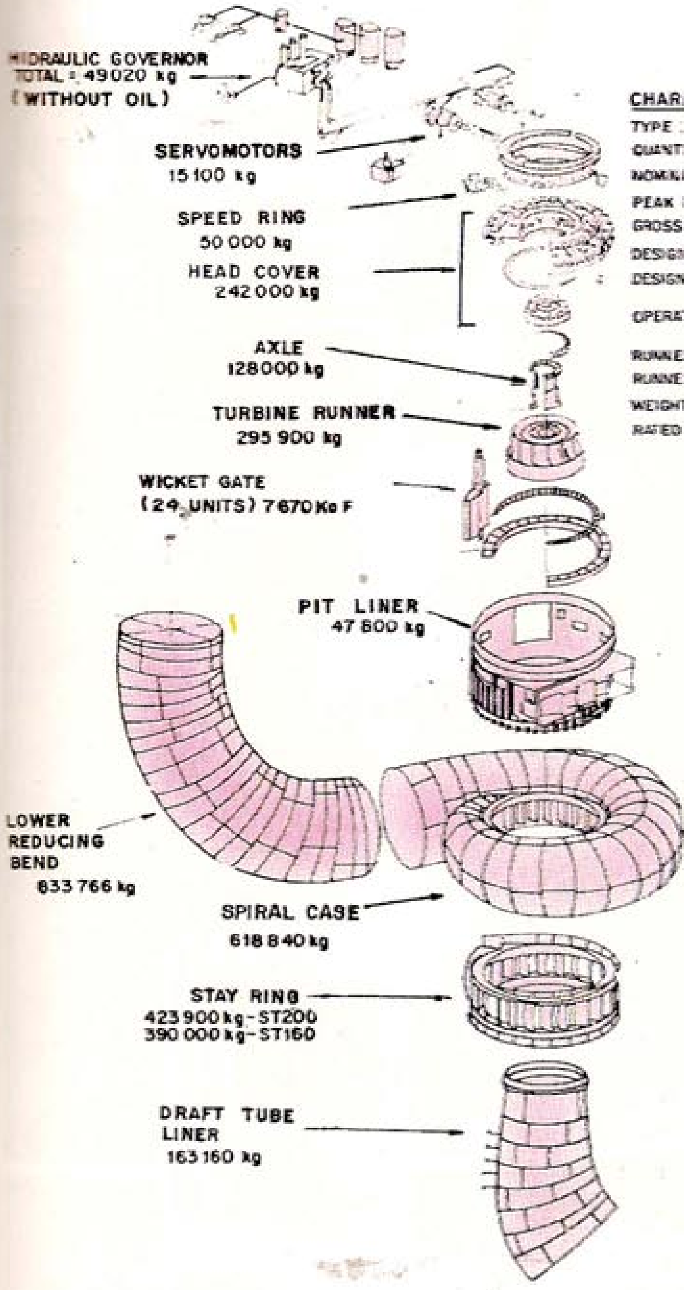
The application of strict quality control measures, and the adoption of safety coefficients made it possible for the consortium responsible for the supply of the Generating Units to guarantee an increase in the band of admissible overload as indicated in the last column of the above table.

The Turbines were given the following specifications:

Type .... FRANCIS
Rated Capacity..715 MW
Rated head .... 112.9 m
Design speed ....
for 50 Hz .... 90.9 rpm
for 60 Hz .... 92.3 rpm

Taking into consideration the planned method of operation of the ITAIPU Station, and using Hill curves of turbines with specific velocities similar to those of ITAIPU, the following specifications were established:

NET HEAD (m)	RATED OUTPUT (MW)	EFFICIENCY %
118.4	715	92.5
118.4	610	94.5



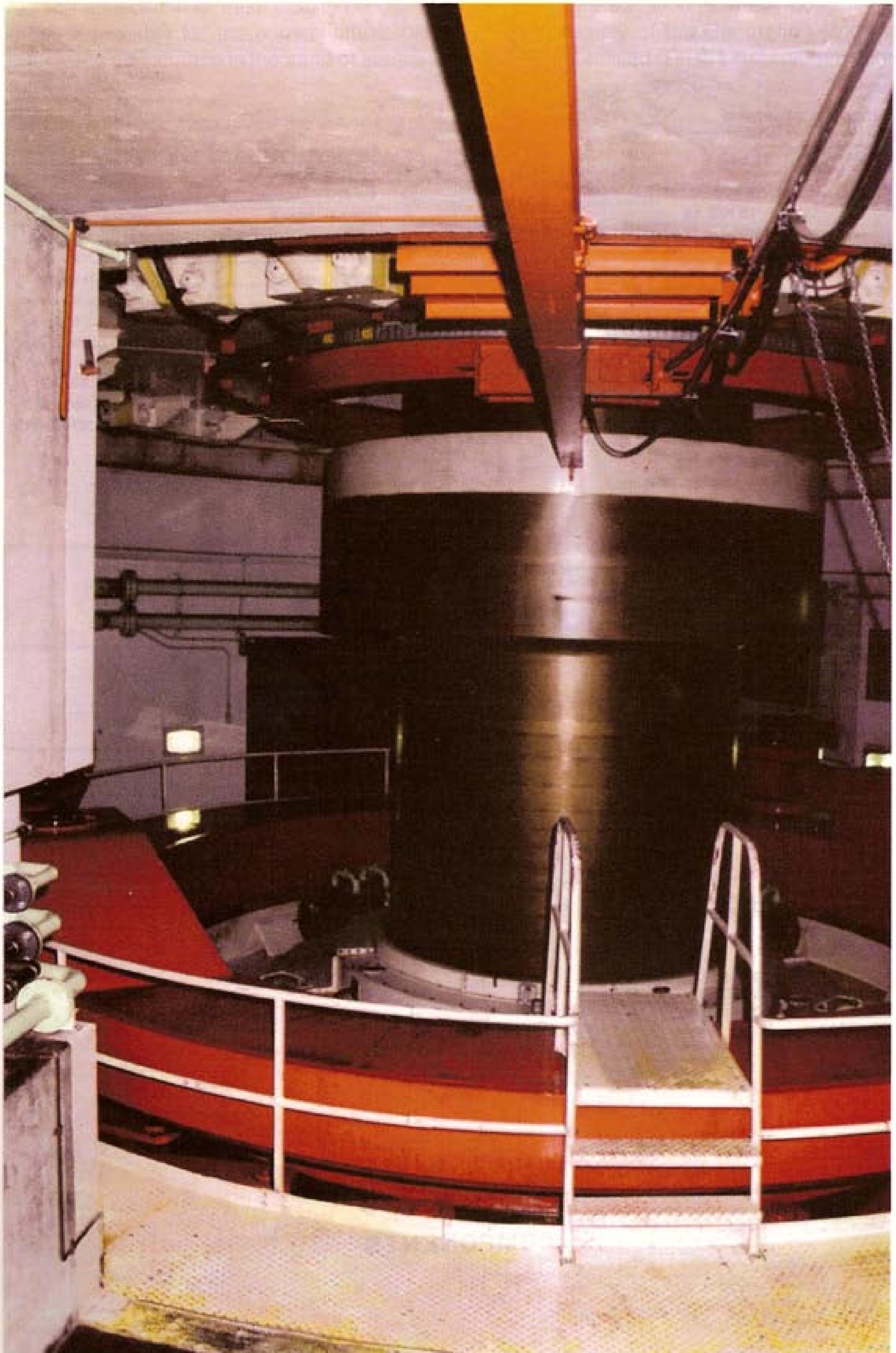
CHARACTERISTICS

TYPE : FRANCIS

QUANTITY	18
NOMINAL POWER	715 MW
PEAK POWER (Limited by Generator)	740 MW
GROSS HEAD	120 m
DESIGN HEAD	118,4 m
DESIGN SPEED	91,6 rpm
OPERATION SPEED: 50 Hz	90,9 rpm
OPERATION SPEED: 60 Hz	92,3 rpm
RUNNER DIAMETER	8,6 m
RUNNER WEIGHT	300 tn
WEIGHT OF EACH UNIT	3 300 tn
RATED UNIT FLOW	645 m^3/s

TURBINES

COMPONENTS



In addition, a weighted performance of no less than 93,8% was specified. The consortium charged with the supply of the Turbines guaranteed values over and above those set forth in the specifications.

The tests mode with the Turbine model were carried out in accordance with IEC standards 193/1965 and 193A/1972 during the period of April/May, 1979, at the Federal Institute of Technology at Lausanne, Switzerland.

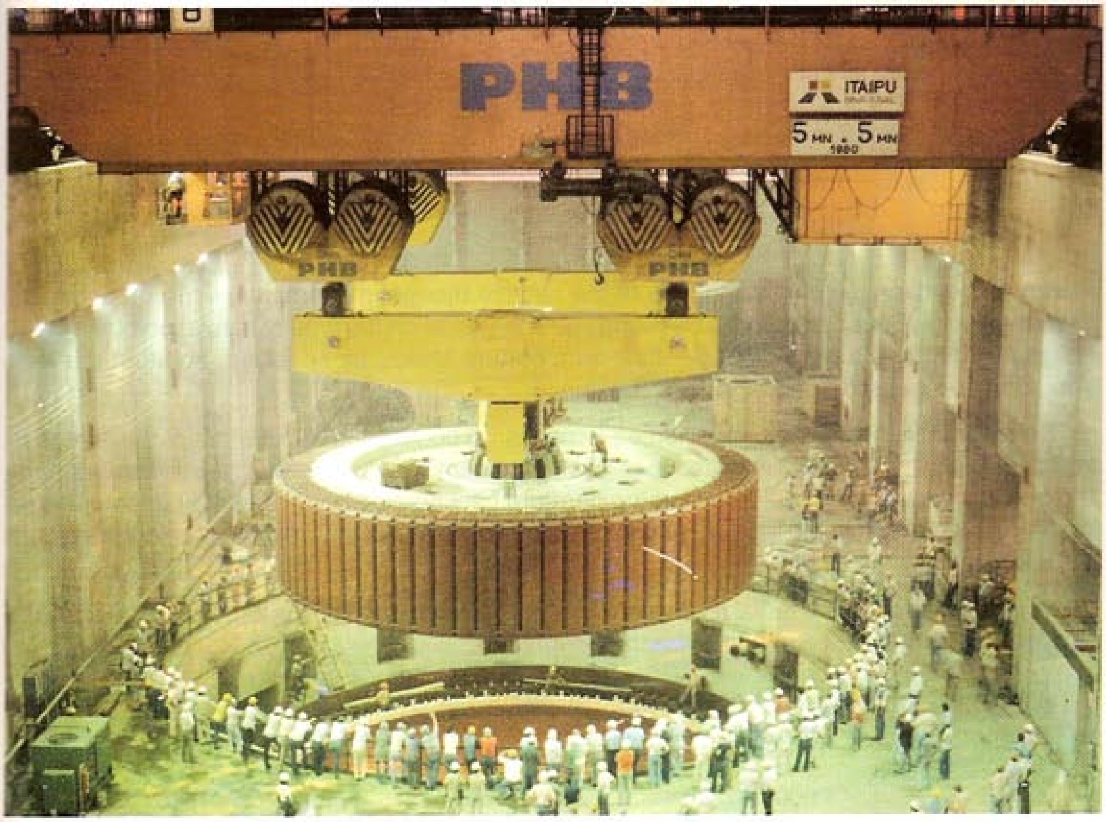
The Generator, the Turbine, the Shafts and Bearings were to be considered as an integrated system. In the case of ITAIPU, these units were included in a single bid in such a way that responsibility for the supply would not be divided.

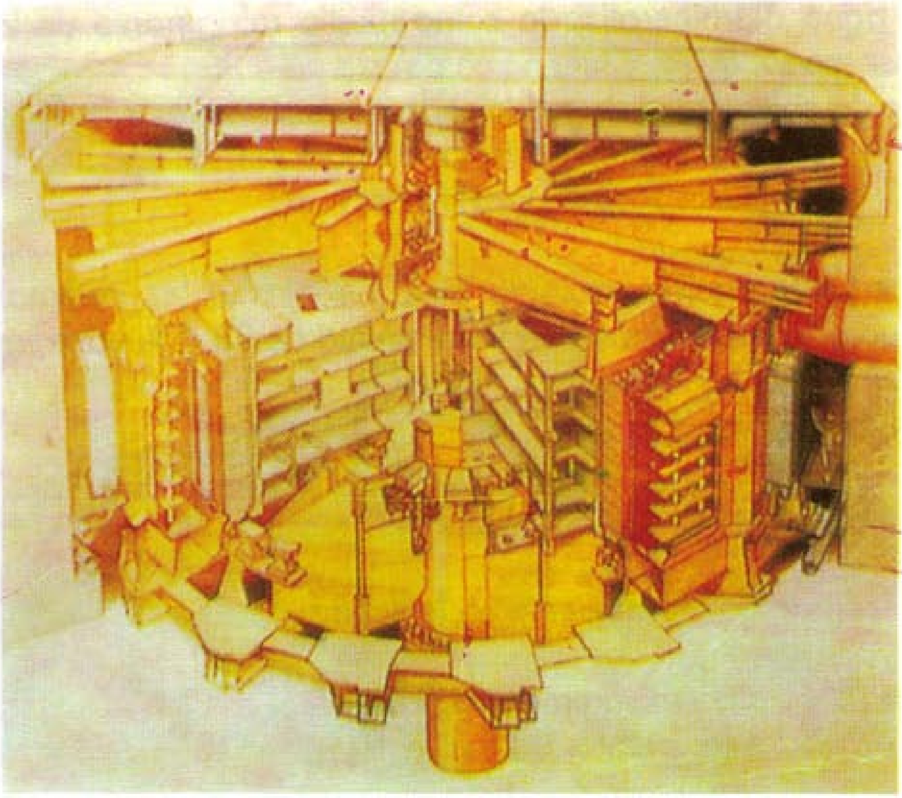
Severe restrictions with regard to the extent and frequency of the vibrations were established.

Considering that the frequency of the Generating Units is related to rotation speed and the number of poles, the studies determined that for the best performance 66 pules should correspond to the 50 Hz units, and 78 to the 60 Hz units.

The difference in the characteristics of the 50 Hz and 60 Hz units is due to the fact that they supply completely different transmission systems.

One of the factors for determining maximum unit capacity was temperature of operation as





in very large machines the magnitude of the relative thermal movements is the predominant limitative factor. For this reason, and taking into consideration the type of insulation of the coils, it was decided that a maximun operating temperature should be specified, and that this limit should not be exceeded under any circunstance.

Demineralized water was specified as a means for cooling the conductors of the Stator. In this manner, with the direct elimination of heat, the intention was to equalize the distribution of the heating, reducing the difference of temperature between the hottest point and temperature of the conductors, minimizing the relative displacement between conductors ond the yoke of the stator.

The rotor possesses a radial air cooling system. Thecooling system adopted mode it possible to specify a performance of 98.6% for the generators.

The temperatures of the project are:

- Stator coil .... 90° C
- Treated water for cooling, at discharge .... 75° C
- Stator nucleus, maximum at any point, including the teeth .... 100° C
- Crude water for cooling .... 30° C

ELECTRICAL CHARACTERISTICS

	50 Hz	60 HZ
Rated Output	823.6 MVA	737.0 MVA
Terminal Voltage	18 000 V±5%	18 000 V±5%
Current (Divided into six paralell circuits)	26 417 A	26 639 A
Operational speed	90.9 rpm	92.3 rpm
Cooling of windings		
Stator Winding	Purified Water	
Stator Core and Rotor	Air	
Excitation system	STATIC (with tiristors)	
Exciting current under load	4 000 A	3 237 A

MECHANICAL CHARACTERISTICS

	50 Hz	60 HZ
Stator		
Outer Diameter	18.65 m	18.65 m
Internal Diameter	16.00 m	16.00 m
Weight	734 t	633 t
Rotor		
Diameter	15.93 m	15.95 m
Height	3.82 m	3.53 m
Weight	1 760 t	1 760 t
Number of Poles	66	78
Bearings		
Upper	guide	guide
Lower	trust and guide	trust and guide
Air gap	37 mm	27 mm
Total weight of rotating mass	2 650 t	2 650 t

Total height of rotating mass	22.00 m	22.00 m
Trip speed	140%	140%
Runaway speed	185%	185%

TABLE AND PARAMETERS OF THE GENERATORS

Frecuency (Hz)	50	60
Rated Output (MVA)	823.6	737
Terminal Voltage (kV)	18±0.9	18±0.9
Powrr Factor	0.85	0.95
Design Speed (rpm)	90.9	92.3
Inertia Constant (kW x sec/kVA)	4.4	5.3
Exciter Maximum Voltage with positive Current (PU)	6	12
Exciter Maximum Voltage with negative Current (PU)	6	9
Direct-axis Reactance Xd (pu)	0.90	0.90
Quadrature-axis Reactance Xq (pu)	0.705	0.68
Direct-axis Transient Reactance X'd (pu)	0.32	0.30
Direct-axis Subtransient Reactance X'd (pu)	0.243	0.24
Number of poles	66	78
Rotor Diameter (m)	16	16
Rotor Weight (t) (without axle)	1 760	1 760
Stator Outer Diameter (m)	16.77	17.45
Arragement of the Turbine 2 guide bearings and Generator unit (standard DIN) I thrust bearing	W42	W42
Support bearing, Kingsbury type with injected high oil pressure for start/stop operafion	16 shoes	16 shoes
Speed Governor, electronic P.I.D type (proportional - integral - differential)	RAPID 77	RAPID 77

Transformers

To increase voltage of the generating units, Single-Phase Transformer groups with a nominal capacity, per group, of 825 MVA and 768 MVA, for 50 ond 60 Hz, respectively, were specified.

The nominal voltages of the Transformers are 18 kV for the primary and 525/√3 kV for the secondary, with 4 derivations (Taps) of± 2 x 2.5% kV, moneuverable without load.

The cooling process is carried out by means of oil-water heat interchangers, one for each Single-Phase Transformer.

Generators Step-Up Transformers

Location: El. 108.00 - Upstream

		50 Hz	60 Hz
Rated voltage	Low voltage	18 kv	
	High voltage	525/√ 3 kV	
Rated current	Low voltage	15 278 A	14 222 A
	High voltage	907.3 A	845 A
Rated Power		275 MVA	256 MVA
Approx. total weight		214 T	166 T
Insulating oil		Mineral oil	
Cooling Type		Pressurized oil-pressurized water	
Number of heat interchanges		4 (one spare)	
Arrangement		Bank of three single - phase units	
Number of Banks		9	9
Connections		Low voltage - Delta High voltage - Grounded wye	
Rated power per Bank		825 MVA	768 MVA

Auxiliary Services

Electrical

Due to the existence of two frequencies, 50 Hz and 60 Hz, two independent auxiliary service systems were installed.

The main feeding panels of 13.8 kV of the auxiliary services are supplied by the single - phase transformer groups of 45 MVA, with a voltage of 525/√3 kV for the primary, ond 13.8/√3 for the secondary.

The primary feeding sources of the auxiliary services are the Transformer groups, supplied directly from the busses of the SF6 Substation.

As a back-up for the primary feeding, there are two three-phase transformer: of 45 MVA, supplied by cables insulated in oil that proceed from the Right Bank Substation for the 50 Hz sector, and from the Fumas Substation in the Left Bonk for the 60 Hz sector.

Supply for the distribution panels of the auxiliary services is made from the main panels, which in turn supply the secondary distribution panels at 460 V.

Generally, the loads of the auxiliary services use voltages of 460 and 220 V, three-phase, both at 50 Hz and at 60 Hz.

In case of a breakdown of the main feeders, both systems have Emergency Diesel Generator groups and rotative frequency convertors at 50/60 Hz and 60/50 Hz, supplying the distribution panels of the Auxiliary Services.

Mechanics

Water Supply

The station possesses a water supply system in order to support the cooling systems of the equipment and facilities for fighting fires, sanitary services and drinking water.

Supply of compressed air

The compressed air system is made up of two compressed air stations located at the assembly areas, which supply a system of tubes for general distribution to the station. Each station has three compressors that operate of a pressure of approximately 7 kg/cm^2.

Oil System

Due to the size and number of the Generating Units, insulating oil and lubricating centralized systems are used.

Oil pipes for the transformers and for lubrication are distributed throughout the Pawerhouse, connecting the units to the two storage zones, located on the right and central Assembly Areas. Each storage zone is furnished with storage tanks for both pure and contaminated oil and also with the pertinent purification devices.

In addition, the machine room has auxiliary systems for drainage, flood prevention, ventilation, air-conditioning and a system for hoisting cargo.

Gas Insulated Substation - SF6

During the preparation of the Project several alternatives for the Substations and for the outlet lines of the Powerhouse were studied.

The restrictions imposed by the layout of the Project, including the proximity and concentration of the construction equipment, made it practically impossible to install the nine output lines, at extra high voltage, in 345 - 500 kV range, for each bank of the river, as was originally anticipated in the Feasibility Study.

Altemative plans, such as the coupling of two units in each output, and the use of a circuit breaker at the low voltage side were examined and discarded, as they implied diminished reliability and higher civil construction and equipment costs.

The use of SF6 gas insulated Substations, finally installed as an internal part of the Powerhouse, solved the problem. The plan selected for the Substation was easily set up as the space available in the Powerhouse, adjacent to the Main Dam, was sufficient to lodge all the equipment for this type of Substation.

Distribution of Electric Power

For the distribution of electric Power the hydroelectric station uses two conventional Substations of the air-insulated type:

-The Right Bank Substation, located in Paraguayan territory, and within the limits of ITAIPU;

-The Left Bank Substation, located in Brazilian territory, owned by FURNAS.

Eight transmission lines of 500 kV derive from the SF6 Substation located in the Powerhouse, four of which transport the energy generated by the 50 Hz units to the Right Bank Substation, and four transport the energy from the 60 hz units to the Left Bank Substation.

Currently two of the four 50 Hz lines connected to the Right Bank Substation are coupled to the 500 kV bus. The other two are carried directly to the left Bank Substation, for the time being.

The unused portion of the power generated that belongs to Paraguay is assigned to Brazil.

Right Bank Substation

It is located some 2.5 kms from the Powerhouse and constitutes the distribution center of the electric power generated ot 50 Hz. This Substation receives and delivers power to ANDE, the Paraguayan electric system, and to the converting station of FURNAS in Brazil. During the design phase the long term growth needs of the Paraguayan electric system were taken into consideration to establish the dimension of the Right Bank Substation.

The Right Bank Substation is divided into four sectors, connected by 500 kV busses, and is made up of 500 kV, 220 kV ond 66 kV yards.

The 500 kV and 220 kV yards are connected by autotransformers of 500/220 kV, 375 MVA, featuring o "breaker and a half" configuration to provide maximum flexibility and dependability.

On the other hand, the 66 kV yard is supplied by 220/66 kV, 25 MVA transformers, and feeds electric Power to the auxiliary services of the Substation, Powerhouse and Left Bank Substation.

Transmission System

Considering that during the first years of operation of ITAIPU Paraguay shall deliver to Brazil most of the power generated at 50 Hz to which it is entitled (for which it shall receive financial compensation), and that the frequencies in Brazil and Paraguay are different, it was decided to build o composite transmission system in EHV-AC (Extra High Voltage- Altemating Current) and in HV-DC (High Voltage-Direct Current) to allow the Brazilian purchasing entities to transmit the energy generated at both 50 Hz and 60 Hz.

The altenating current system of FURNAS, made up by two bipoles at a nominal voltage of ±600 kV, was structured to transport practically the entire production of the nine 50 Hz units (6 300 MW). These bipoles have independent transmission lines, connecting a substation in Foz de Yguazu (rectifier) to a substation in Ibiuna (inverter), Sao Paulo.

The electric power of ITAIPU generated by the 50 Hz units and used in Paraguay is inserted into fhe Paraguayan electric system through the Right Bank Substation. Currently, three lines of 220 kV each derive from this substation, two for the substation located at the Acoray hydroelectric station, and one recently connected to the Substation of Limpio, both awned by ANDE.

In its final configuration, the Right Bank Substation shall be supplied by the four 50 Hz transmission lines that currently leave the Powerhouse. From this Substation five other transmission lines of 500 kV, and seven of 220 kV shall supply the Paraguayan electric system.

As already mentioned, the connection of the Right Bank Substation to the FURNAS rectifier Substation, on the Left Bank, is accomplished by four lines of 500 kV. These lines are already in operation, requiring only that the two that presently bypass the Substation be connected to the 500 kV busses, once the 500 kV yard of Sector I of this Substation is normalized.

The electric power generated by the 60 Hz units will be transported by an 891 km transmission system, formed by three lines of 750 kV, with compensation in series, connecting the Elevating Substation of Foz do Yguazu with two Lowering Substations located in the São Paulo metropolitan area. Currently, two of the three mentioned tronsmission lines are in operation. The third line is under construction.

The Maintenance of Itaipu

With the introduction ot the operating structure for ITAIPU, the responsibility of which pertains to the Superintendence of Operations and Maintenance of the Technical Area, there arase o concern for the establishment of an active and reliable maintenance body.

Even before the initiation of equipment assembly, ITAIPU initiated the supply of resources to set up this activity.

To achieve high level performance for this technical staff, ITAIPU Odapted as a working policy that the commissioning constitutes the first maintenance operations activity. The commissioning is understood to be a combination of controls, adjustments and tests, the purpose of which is the outfitting of the installations for operation and generation within the levels of quality and continuity required by the electric services.

As a result of this policy, after a few years the Superintendence of Operations and Maintenance was properly structured with qualified personnel, adequate methods and even possessed a laboratory for instrumentation and tests to assist in the commissioning and maintenance tasks.

By means of an àdequate structure a strong and dynamic negotiation channel was established between those responsible for commissioning works, the remaining departments of ITAIPU and the manufacturers, creating practices and information flows.

The particular characteristics of ITAIPU, such as the enormous amount and variety of equipment, the supply through the syndication of numerous manufacturers, the need of o clear separation between the assembling stages (carried out by means of contracted services), and the commissioning (carried out with own resources), plus the heterogeneous character of the groups involved made up by elements from different origin and nationality has made it indispensable to adapt a detailed and comprehensive commissioning methodology.

The system odapted at the time fully attained its goals, making possible the commissioning of the main and auxiliary equipment within the anticipated terms without affecting the progression of the intense rhythm of assembly and, in addition, permitting that ITAIPU obtain several benefits, amongst which we may mention:

- The assimilation, on part of the personnel, of the necessary know-how for the commissioning and maintenance of the equipment;

- The review of drawings through reliable processes;

- Effective replacement of damaged components during the commissioning and guarantee phases;

- The programming of solutions for technical problems for which the manufacturers are liable, in a manner compatible with Power generation commitments;

- The use of a reliable process for the timely diagnosis of problems, seeking and finding solutions on the basis of diolog and agreements with the manufacturers.

From the initial phase af the maintenance program it become clear that as a resutt of the magnitude of a hydroelectric station of the size of ITAIPU, with an enormous amount af equipment, the planning, performance and control of maintenance would be a very complex task, and one which required systematization through computer resources.

In line with this thinking, as from 1 985, the necessary computer equipment was identified and purchased and, toking advantoge of the experience assimilated with the operation and maintenance of the first generator units, about mid year in 1986, the development of the Operations and Mointenance System was initiated and, at a later stage, received the abbreviated name of SOM.

SOM was divided into two systems: Operation and Maintenance.

In a first stoge all the permanent equipment was codified so as to facilitate identification and inventory control.

The maintenance system was divided into three sub-systems, as follows:

- An operiodic (corrective) mointenance sub-system, implemented as from 1987;
- A periodic (preventive) maintenance sub-system, implemented os from January, 1989;
- A property record subsystem using inventory cards, currently in the implementation stage.

The maintenance of the security of the civil woks merited a special approach. To this end ITAIPU uses a complex group of instruments for the control and security of the dam, including its own seismograph network.

The periodic maintenance operation uses documents known as inspection and control lists, where information is gathered. The information noted dawn during the periodic and aperiodic maintenance operations are recorded in compute files and form part of the history of the equipment. It is possible to have occess to them at any time in the form of reports and have become invaluable for the analysis of performance.

The correctness of the maintenance policies adopted has been confirmed by the excellent performance of the ITAIPU generating equipment, meeting the goals and commitmenh assumed by the Binational Entity.

Financial Summary

The ITAIPU Treaty establishes the financial system devised to supply the resources needed to carry out the binational hydroelectric development.

- This financial plan provides for three financing sources:
- The Entity's capital;
- Brazilion loans;
- Foreign loans

Capital was established in an amount equivalent to 100 million U.S. dollars, owned by ANDE and ELETROBRAS, in equal and untransferable shares.

The principal source of funds has been loans from Brazilian government entities including Centrais Eletricas Brasileiras (ELETROBRAS), Banco Nacional de Desenvolvimento Economico e Social (BNDES), Banco Nocional da Habitacao (BNH), Financiadora de Maquinas e Equipamento (FINAME), and others.

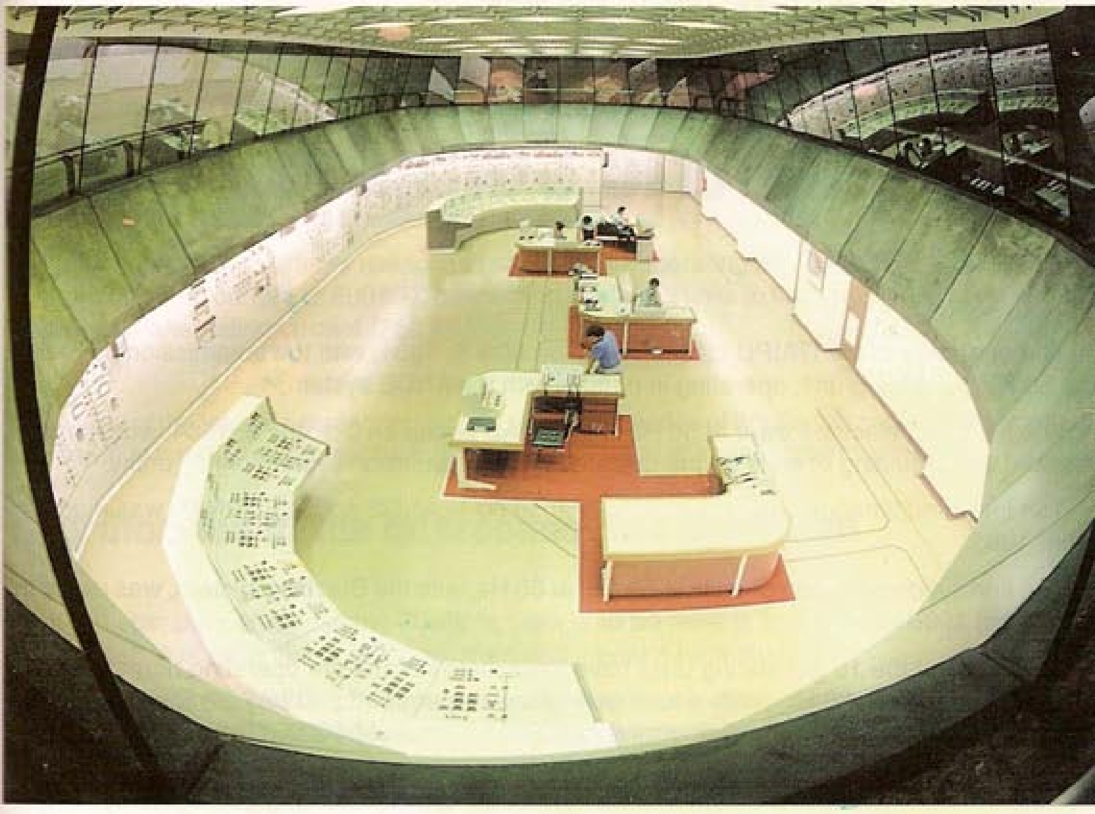
The financial requirements were completed by means of loans obtained from third country financial entities, essentially under the following forms:

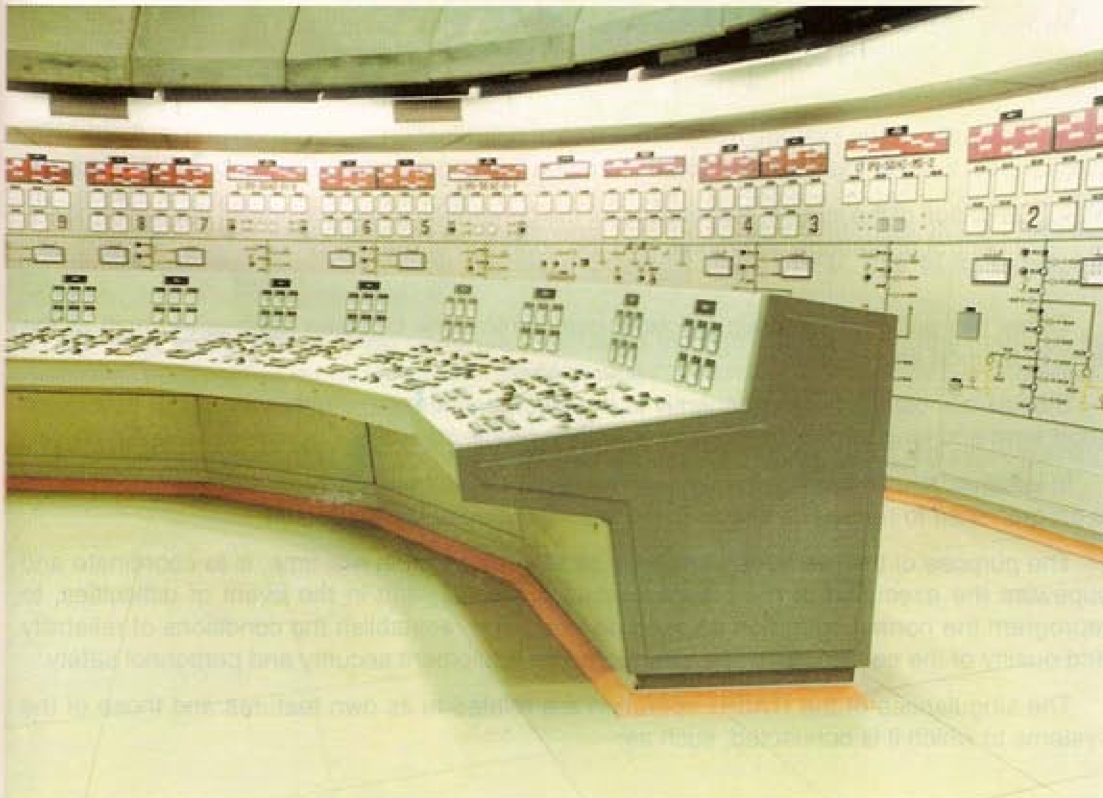
- Credits from entities with an official relation in the countries from which equipment has been imported (Buyer's Credits), and connected with such imports.

- Credits from private banks, both from the countries supplying the equipment and countries unrelated with the equipment supply.

The final cost of ITAIPU amounts to approximately US$ 20 billion, including exchange differences carried in the Entity General Balance Sheet and which shall be deducted upon completion of the Project.

Of this total cost about 50% represents direct investments and the bolance financial charges.





Operation of the Itaipu Hydroelectric Complex

General Aspects

The operation of the ITAIPU station began on May 5, 1984, with the commissioning of the first 50 Hz generating unit, operating in parallel with the ANDE system.

The supply of electric Power at 50 Hz to FURNAS began on October 8, 1984, which made possible the beginning of tests on the direct current transmission system of this entity.

The first simultaneous supply of electricity at 50 Hz to ANDE and to FURNAS was made in June, 1985.

The first synchronization of units I4 ond I5, at 60 Hz, with the Brazilian system, was made in December, 1986.

To date all of the 18 generating units have been installed and are operating normally (nine ot 50 Hz and nine at 60 Hz), with o total generating output of 12 600 MW, as foreseen in the Project, with an overage annual energy production of about 77 000 GWh/ año. The ratio of generating output/overage annual energy production is among the most fovorable in the world.

To assure a more reliable and effective management and to coordinate the Station operation, supervision and control activities are divided into two management levels:

> Operation of the system, responsible for the coordination, supervision and performance, in real time, of the interconnected operation in its energy, electric and hydraulic aspects.
>
> Operation of the station, responsible for the generation of electric power, the performance of control operations and monitoring the condition of the equipment.

These two activities maintain a flow of communications between each other, both at the level of support and operation.

Studies are conducted permanently in the electric, energy and hydraulic fields, to support short term and long term planning and operation programs.

In addition, shutdown of generating units, both at the station and the interconnected system, is programmed to reduce its effects in the management of the operation.

The purpose of the functions performed by the operation, in real time, is to coordinate and supewise the execution of the preestablished programs, and in the event of difficulties, to reprogram the normal operation so as to maintain and reestablish the conditions of reliability and quality of the service, as well as to guarantee equipment security and personnel safety.

The singularities of the ITAIPU operation are related to its own features and those of the systems to which it is connected, such as:

-Generation in two frequencies, fifly percent at 50 Hz and fifty at 60 Hz;

-Size of the station, with an installed capacity of 12 600 MW;

-Size of the generating units, each with a rated output of 700 MW;

-The location of the Station on the Parana, an international river shared by three countries. The Tripartite Treaty signed by Paraguay, Brazil and Argentina places restrictions on the use of the water resources for Power generation;

-Transmission systems associated with ITAIPU operating at Extra High Voltage, one of them on direct current (± 600 kV), connecting the 60 Hz units to the Brazilian system and the other for alternating current (750 kV).

In view of the features mentioned above, reliable operation of the Station requires the adoption of operative configurations, protection plans ond control of special interchanges.

Coordination of the Interconnected Operation

If the operation of an electric Power system is to be reliable and the quality of the supply guaranteed, it is essential to carry out short and medium term studies.

In addition to the studies performed internally in each one of the companies that make up an interconnected system, it is necesary to develop group studies where the principal companies of the system are represented.

In the case of ITAIPU, once the hydroelectric station interconnected the Paraguayan and Brazilian systems, it was necessary to create an agency which made it possible to perform operative studies at the ANDE-ITAIPU-ELETROBRAS systems.

On July 23, 1981, the Joint Commission for Operation and Coordination of the ANDE, ITAIPU and ELETROBRAS systems, known as CMO, was created and is currently in full operation.

In Brazil, the representatives of FURNAS and ELETROSUL, subsidiary entities of ELETROBRAS that purchase electric services from ITAIPU, also participate in the activities of this Commission in order to expedite the arrangements that the studies determine. In the CMO the companies are represented by their Technical Directors and ITAIPU, due to its binational condition, has double representation.

The technical activities of the CMO are channelled through four study groups made up by specialists from each of the companies. In these groups ITAIPU is represented by two engineers, one Paraguayan and one Brazilian.

In almost nine years of activity the CMO has prepared hundreds of technical reports containing recommendations to the companies and instructions to be implemented by the systems.

Supervision and Control

The supervision and control of the system is to be performed through anolog and digital (SCADA-Supervisory Control and Data Acquisition) systems, especially developed for this purpose.

The analog system, already in operation, supplies fundamental information for the operation of the Station and the digital system, currently of the implementation stage, will support, with detailed information, the two management levels.

Once the digital system starts operating the analog system will be placed on stand-by.

The SCADA system permits the centralized control and supervision of the generation and transmission of electric power using the data supplied automatically by the operation process.

In addition to the basic functions (gathering of data and supervision control), the system is supplemented by functions of energy management, better known as EMS (Energy Management System) functions that support the operation in the programming, supervision in real time and post-operative analyses (such as the programming of generation, automatic control of generation, etc.)

It also monitors and diagnoses the generating units (MONDIG).

The purpose of MONDIG is to increase the operative availability and dependability of the equipment to minimize preventive maintenance and inspection stoppages, as well as making it possible to program repairs before any problem becomes critical.

The monitored parameters include vibrations, air gaps, partial discharges and temperatures. The diagnosis of deficiencies shall be initially performed by the engineer in charge of maintenance. A higher level of automation in the performance of this work should by reached in the future by implementation of programs using Artificial Intelligence (AI) tools.

Taking into account the special characteristics of the Project, the SCADA Work Group, known as GTS, was created. It is made up, mainly, by personnel of the Superintendence of Operations and Maintenance of the ITAIPU station.

The GTS, together with an integrated group formed by one Paraguayan and four Brazilian consultant firms is responsible for the design, management and implementation of SCADA and participates at all stages of this project to attain the transfer of know-how required to secure autonomy in the operation and maintenance of the system by ITAIPU personnel. The basic goals of the supervision and control of the operation are:

The supply of information, in real time, to those in charge of the dispatching of load and to the operators regarding actual conditions of the electric and hydraulic systems, organized to allow the taking of operative decisions and the executions of adequate and timely control actions.

-Provide software programs to those in charge of dispatching load and to the operators thot will permit the optimization of the generation and delivery of electric power and will support operation and maintenance activities;

-Interconnect, in real time, the ITAIPU Station to the ELETROBRAS (through FURNAS and ELETROSUL) and ANDE systems, for the interchange of operative messages and data related to the automatic control of the generation;

-Interconnect, in real time, the following systems: operation and mointenance, hydraulic operation and security of the Station.

Marketing the Power from Itaipu

The Treaty and Terms for Power Supply

The basic terms for marketing the electric power from ITAIPU are defined in the Treaty and Annex "C" thereto.

The Treaty provides that the energy produced by the hydroelectrical station is to be divided equally between Paraguay and Brazil, recognizing in favor of each of the parties the right to acquire any energy not utilized by the other for its own consumption.

Under the same international treaty the Governments of Paraguay and Brazil agree to purchase, either jointly or separately, under the terms to which they shall agree, the entire installed capacity.

The terms of supply established in Annex "C" are the following:

- Division of the energy into equal shares shall be effected by dividing the output of the Station;

- Each entity, in the exercise of its right to utilize the installed capacity shall enter into contracts with ITAIPU for periods of twenty years (such periods to be divided if need be into two ten -year periods), for fractions of installed capacity, within an utilization timetable covering the aforesaid term, and shall indicate, on an annual basis, the capacity to be utilized;

- Each of the entities shall deliver to ITAIPU the aforementioned timetable two years in advance of the date projected for the beginning of commercial operation of the first generating unit of the Station, and two years before the completion of the first and each following twenty-year contract;

- Each entity shall be entitled to use any energy that may be produced by the installed capacity contracted by the entity, up to a limit to be established by ITAIPU;

- The installed capacity contracted is defined as the output in kilowatts that ITAIPU shall make available on a permanent basis to the purchasing entity during the periods of time and under the terms of the respective contracts;

- In the event an entity shall decide not to utilize part of the installed capacity contracted, or any part of the energy produced by that capacity, the entity may authorize ITAIPU to sell to other entities the part that thus becomes available, both of capacity and of energy, during the billing and operation period. Under these circunstances, billing shall be based on the output effectively utilized by each entity.

- Energy produced by ITAIPU shall be delivered to the entities through the busses system in the Powerhouse, pursuant to the terms prescribed by the relevant purchase contracts.

Annex "C" defines the methodology to be employed in computing the Cost of Provision of Electrical Services, and establishes that the annual component parts shall be the following:

- The amount required to pay returns to ANDE and ELETROBRAS at an annual rate of twelve per cent on their respective shares of paid-in capital;
- The amount required for payment of financial services arising from loans received;
- The amount necessary to poy royalties to the governments of Paraguay and Brazil;
- The amount necessary to pay ANDE and ELETROBRAS in equal shores, for reimbursement of expenses of administration and supevision related to ITAIPU;
- The amount necessary to cover operating costs;
- The amount of any difference, positive or negative, between income and expenses in the previous fiscal year;
- The amount necessary to pay compensation to one of the countries for Power assigned to the other. This compensation is charged exclusively to the country receiving the assigned power.

The amount of royalties, compensation for assigned power and reimbursement of operating and supervising expenses are computed in U.S. Dollars per gigawatt-hour generated and measured at the Powerhouse, and payment thereof shall be effected monthly.

Annex "C" provides that yearly income from the provision of electrical services shall be equal, every year, to the cost of such services. It further provides that such cost is to be distributed in proportion to the installed capacity contracted by the entities receiving the supply.

ANDE is the Paraguayan utility authorized to buy electric power services from ITAIPU.

On the Brazilian side, Law Nº 85 889 dated July 5, 1973, regulates the purchase of electric power services from ITAIPU, and provides that the ELETROBRAS subsidiaries authorized to purchase the electric power services available to Brazil, are FURNAS and ELETROSUL.

The Administration Council of ITAIPU has responsibility for deciding the terms of supply of electric power, pursuant to the provisions of the Treaty and its Annexes.

Administration and Operation of Agreements

The Commitee for Administration and Operation of the Purchase Agreements for ITAIPU Power services (CADOP) composed by the Technical Directors of ANDE, ELETROBRAS, FURNAS, ELETROSUL and ITAIPU is the board responsible for the administration and operation of the instruments of agreement that regulate the supply of power by the Binational Entity.

This authority includes the task of analizing and setting policy that permits correct programming, bookkeeping and billing for power supplied by ITAIPU to ANDE, FURNAS and ELETROSUL.

CADOP technical activities are closely connected with those of the commission to study bookkeeping policy for ITAIPU electric supply (CECOI), a committee of experts appointed by the companies listed obove.

The formal activities of CADOP are performed by two secretariats, one Paraguayan and one Brazilian, whose principal duties are the issue of Committee documents, keeping files, keeping minutes of meetings, preparing reports and proposals to be discussed by the Committee, to print and distribute its Resolutions, and perform other administrative duties.

Established on October 25, 1985, CADOP has since then approved 37 technical reports in connection with scheduling supply, bookkeeping, and billing ITAIPU power. The main issues discussed to date are the following:

- Policy guiding scheduling, accounting and billing of electric power supplied by ITAIPU to ANDE, FURNAS and ELETROSUL;
- Keeping records of power supplied as a basis for computing royalties, payable to the governments of Paraguay and Brazil, reimbursement of operating and supervising costs to ANDE and ELETROBRAS, and compensation payable to the government of Paraguay for power assigned to Brazil;
- Policy on bookkeeping, transfer and use of operational power reserve;
- Procedures related to the flow of information on agreements between the purchaser entities and ITAIPU;
- Methodology and policy for monthly scheduling of ITAIPU Power to the purchasing entities.
- Quarterly bookkeeping and billing reports;
- Annual scheduling of electric power supply to purchasing utilities;

Application of the policies established in the reports has facilitated programming, bookkeeping and billing of the ITAIPU power supply. Policies are constantly being reviewed and brought up to date in view of new operational situations that have come up with the evolution of Power transmission systems in Paraguay and Brazil, and increases in installed capacity as construction of the station developed.

Bookkeeping and Billing

The bookkeeping and billing processes for ITAIPU power supply begin at the stage of monthly scheduling.

The purchasing utilities schedule their Power demand according to their particular markets, on the basis of the quantities established in their agreements, the availability of energy at the Station, and the scheduling policies adopted by CADOP.

Original scheduling, occasional rescheduling, the recording of hourly exchanges at the delivery points, and the description of contingencies arising in the system, are assessed daily for application of the policies adopted by CADOP, for bookkeeping purposes.

At the end of each calendar month (the billing period established in the ITAIPU Treaty), annexes to the bills for ANDE, FURNAS and ELETROSUL are prepared and issued. These documents in turn are the basis for billing the entities. They also serve as the basis for credit reports for payment of royalties to Paraguay and Brazil, reimbursements for operation and supervising costs to ANDE and ELETROBRAS and compensation to Paraguay for power assigned to Brazil.

Energy Delivered by Itaipu to Paraguay and Brazil

YEAR	PARAGUAY (MWh)	BRAZIL (MWh)
1985	314 753.535	5 796 726.871
1986	584 077.721	21 185 883.039
1987	1 004 145.282	34 630 702.127
1988	1 270 682.000	37 084 639.882
1989	1 508 903.000	45 523 075.694
1990	1 740 748.768	51 060 223.845

Evolution of Power Demand Billed to Entities

	PARAGUAY		BRAZIL					
	ANDE		FURNAS		ELETROSUL			
	INVOICED		INVOICED		INVOICED			
YEAR	POWER DEMAND (kW)	AMOUNT (US$)	POWER DEMAND (kW)	AMOUNT (US$)	POWER DEMAND (kW)	AMOUNT (US$)	TOTAL (US$)	TOTAL REVENUE (US$)
1985	229 362	2 293 620	8 496 901	84 969 010	1 692 410	16 924 100	101 893 110	104 186 730
1986	607 299	6 072 990	22 328 045	223 280 450	4 402 664	44 026 640	267 307 090	273 380 080
1987	1 132 525	12 784 785	41 928 861	474 309 280	8 447 221	95 557 654	569 866 934	582 651 719
1988	1 296 581	17 370 505	52 154 132	699 644 204	10 027 068	134 513 745	834 157 949	851 528 454
1989	1 781 445	24 536 004	67 039 284	923 701 297	14 084 538	194 063 664	1 117 764 961	1 142 300 965
1990	1 960 585	30 788 000	84 481 767	1 330 870 400	17 682 951	278 563 900	1 609 434 300	1 640 222 300

Benefits and Ecological Issues

The Changes Produced by the Reservoir

From the very beginning of the ITAIPU Project, concern over ecological and enviromental issues has been a fundamental objective of the hydroelectric development. This goal aims not only to neutralize any possible negative impact of the reservoir on the environment, and on the almost unexplored natural resources of the region, but concentrates on the positive features and benefits that could derive from rational use of the reservoir as a factor in the economic development of the region.

To implement the objectives outlined above, a "Basic Plan for Conservation of the Environment" was drawn up in 1975. This was later supplemented by the "Master Plan for the Utilization of the Reservoir Area".

The principles that guide the environmental management of ITAIPU are the following:

- Compatibility of the alternative uses of natural resources, to guarantee that the employment of such resources, especially water in its different aspects (electric power generation, human and industrial use, navigation, irrigation, etc.) shall not alter the balance of the environment as a whole;

- Special attention to the social consequences of the use of natural resources so as to ensure that the greatest possible number of users participate on a sustainable basis in the benefits offered by these resources;

- Protection and preservation of essential ecological processes, including the nutritional chains in the lake environment and along the reservoir coastline, and the conservation of the natural elements that make up the ecosystems;

- Preservation of ecological diversity through the establishment of properly protected environments, either in the form of botanical gardens or biological refuges and reserves, or by means of the protective belt organized on both banks of the reservoir;

- Promotion of regional integration with the understanding that some undertakings within the area can affect the entire Reservoir.

The application of these principles would be impossible if no additional measures had been taken, such as the acquisition of lands beyond the limit of the the maximum elevation of reservoir filling level, and actions designed to counteract the effects of flooding, some of which date back to seven years before the reservoir was filled, and suported by subsequent works of social and environmental infrastructure.

This confirms an evident truth: the preventive environmental steps adopted in the early stages of a hydroelectrical project implementation have the most positive results. Actions based on foresight, applied through judicious planning, work effectively to prevent unforeseen and negative environmental consequences.

Environmental Projects

The ITAIPU Reservoir area is the site of 20 environmental projects currently under way, designed to achieve the following goals:

- Study of the limnology, which includes monitoring water quality and understanding the physical, chemical and biological phenomena connected with the Reservoir, and the relationship between these and the normal flow of the Parana river and its tributaries, within the area of influence of ITAIPU;

- Studies of sedimentation, including determination of the origin and trasportation of suspended materials and bottom sediment transport, anticipating future obstacles to navigation, the problem of the useful life of the reservoir, and its effect on water-based species;

- Monitoring the effect of the Reservoir an meteorological conditions in the area;

- Recovery of the coastal areas of the Reservoir by planting approximately 20 million trees;

- Developing new areas of interest for tourism within the Reservoir, and in the residential areas.

- Protection for vital life forms and processes in biological refuges and extensive special reserves provided for the purpose. Determining the influence exerted by the new lake on those life processes;

- Reconnaissance of aquatic biology and monitoring the processes of fish repopulation;

- Control of undesirable species, especially aquotic plants that could affect the use of water or create health hazards;

- Monitoring and providing support for repopulation of animal wild life in the resevoir area and in the refuges, through the Fauna Management Project;

-Control of aquatic species, with special attention to human needs, through managements of fish resources;

- Implementation and monitoring of basic health measures;

- Monitoring and control of the incidence of human diseases, animal diseases, and rural endemic sickness, through epidemiological vigilance;

- Environmental education on human uses and habits, with particular attention to the influence of the population on the Reservoir. Keeping a historical record and assembling information on the relationship between man and the environment;

- Recovery and improvement of the systems of information exchange and social communication, through the Documentation and Information Project;

- Improvement in the systems of economic development available under the new circumstances, by means of Reservoir management;

- Identification of and support for recreational and touristic needs and opportunities created by the Reservoir;

- Development of new transport systems and navigation in the region by means of the waterway created by the Reservoir, which offers vast new opportunities for trade with the upstream markets;

- Increased use of the Reservoir waters for new purposes, by providing greater access of the population to its huge coastal areas;

- Support for new economic systems designed to improve the life style of the economically disadvantaged through fishing and fruit production along the coostland areas;

- An effective support of the regional development process, to which the Resorvoir is making a significant contribution. It should be kept in mind that the Reservoir must in no way be subjected to irreversible consequences that may be the result of industrial, urban or rural activities in its proximity.

Management of the Reservoir area where the lake, the expropriated coostlands, and the islands are located, is possible because the Binational Entity, as owner, can place restrictions on unadvisable uses of water. This jurisdiction is not opposed to regulations imposed by government agencies, but rather serves to help these agencies in the performance of their duties.

In carrying out its technical and scientific initiatives, project priorities are established with due consideration to the importance and interest of each discipline.

These policies point to the influence certain subjects, or groups of subjects, exert an hydroelectric Power generation, the ecology, economics and society in terms of disadvantages and benefits arising directly or indirectly from the project.

Finally, the need to assess the unending search for indicators that may efficiently represent the real environmental impact of this hydroelectric undertaking, with special attention to its biological, physical, chemical, social, economic and cultural consequences.

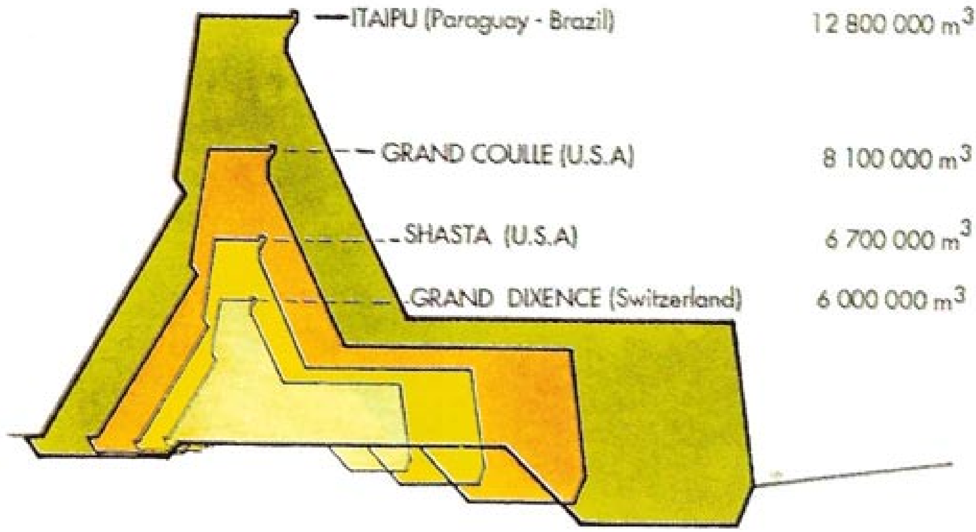
Landscaping

Over and above the ecological, enviromental and landscaping initiatives outlined earlier, special attention was given to large scale beautification projects developed in the ITAIPU area to improve the urban and naturalment environments.

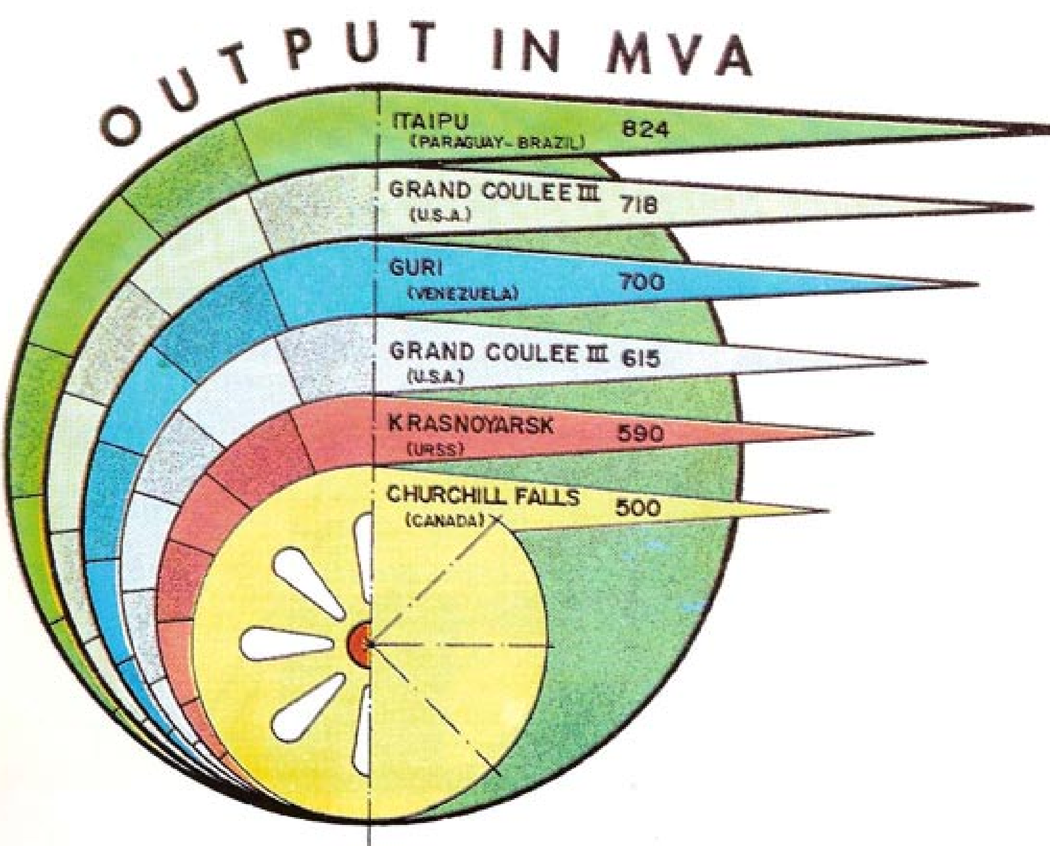
Comparative Graphics

Major Hydroelectric Plant of the World
Installed Capacity vs. Annual Energy Production

Volume of Concrete



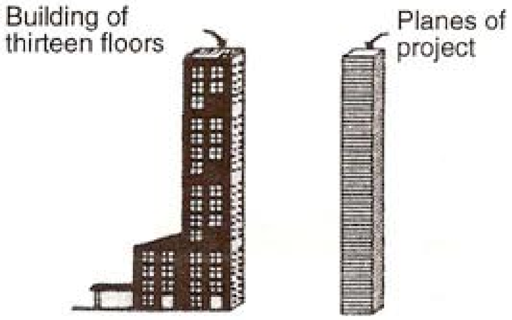
Major Hydrogenerators of the World
Output in MVA



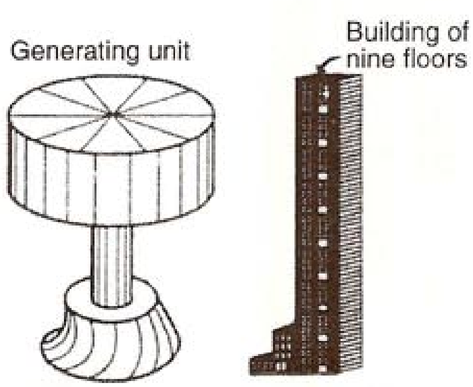
Comparisons and other Information

The ITAIPU project is notable for its vast scale which bears some comparisons:

If the more than 400 000 drawings drafted for use during the construction and assembly stages were laid one on top of the other they would form o pile as high as a thirteen story building.

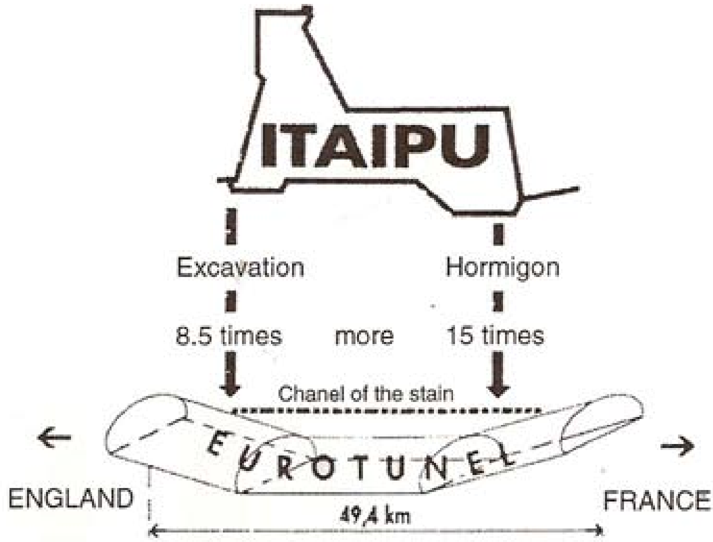


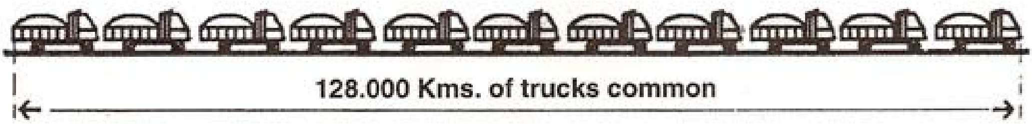
The 18 Generating Units are the largest in operation anywhere in the world, each generating 700 000 kilowatts (although they can reach 780 000 kilowatts). Each of the giant machines is 27 meters high, as tall as a nine-story building, and weighs 6 600 tons, the equivalent of a line of Volkswagen automobiles stretching 50 kilometers. One of the these Generating Units alone could supply enough power for a city four times the size of Asuncion.



The total volume of rock and earth excavated at ITAIPU is eight and a half times the excavation for the Eurotunnel joining England and France, another large engineering projects of this century.

The 60 million cubic meters would fill a line of dump trucks 128 000 kilometers long, which is equivalent to 92 times the distance between Rio de Janeiro and Foz do Iguazu, more than 400 times the distance from Asuncion to Itaipu, or three times around the planet Earth.

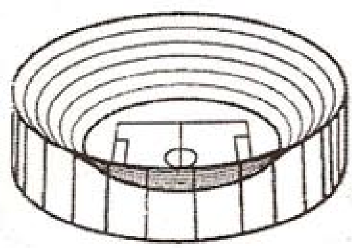




The total volume of concrete laid for Itaipu is fifteen times greater than that used in the Eurotunnel. The 12 800000 cubic meters of concrete would be enough to rebuild every building in a city like Rio de Janeiro or 210 football stadiums like Maracana.

The number of people who worked at Itaipu worksite was over 30 000. During construction the dining rooms served 1 400000 meals every month, and cooked, just as an example, three tons of rice for a single lunch.

A city like Rio of Janeiro



210 Same Stadiums as Maracana