



HYDROPOWER DEVELOPMENTS

CAMBAMBE 2 HYDROPOWER PLANT

ANGOLA

CAMBAMBE HYDROPOWER DEVELOPMENT - POWER STRENGTHENING

POWER PLANT 2

Client:

Empresa Nacional de
Electricidade

**Design Review and
Construction Supervision:**
2011 / ongoing

DESCRIPTION:

The Cambambe Hydropower Development is located in the Kwanza River, approximately 180 km southwest from the city of Luanda and about 15 km from the city of Dondo. It was initially designed and built for a phased construction.

Phase II of the project is currently ongoing and includes the construction of the Cambambe 2 Power Plant. The Phase II works are divided into two lots: civil construction works (power plant 2) and electrical and mechanical equipment (supply and erection).

Power plant 2 is an underground plant with an installed capacity of 700 MW. It includes the following main components:

- a new water intake and water conveyance tunnel;
- a power plant, the respective units, transformers, substation and ancillary systems: access tunnel and control building;
- A feeder canal and discharge tunnel located downstream.

The works provided by COBA within the scope of this project are as follows:

- Project management;
- Review of studies, design and tender documents pertaining to the civil construction works and to the electrical and mechanical equipment, as well as the review of the model test results;
- Approval of the design of the civil construction works and of the electrical and mechanical equipment;
- Construction supervision;
- Start-up and initial operation;
- Assistance during the warranty period.





HYDROPOWER DEVELOPMENTS

LAÚCA HYDROPOWER DEVELOPMENT

ANGOLA

LAÚCA HYDROPOWER DEVELOPMENT

Client:

GAMEK – Gabinete de Aproveitamento do Médio Kwanza

Review of the Basic and Detailed Designs
2012/...

Construction Management and Supervision
2012/...

*Undertaken in association with
Lahmeyer International*

The Laúca Hydropower Development is located in the Kwanza River, about 47 km downstream from the Capanda Hydropower Undertaking, currently under operation, and principally envisages energy generation.

The undertaking is composed of a RCC dam, an underground water conveyance system (energy generation (2004 MW), a toe-of-dam water conveyance system (ecologic flow (65,5 MW)) and a main underground powerplant.

Laúca Dam:

- Type: RCC
- Height: 132 m
- Crest length: 1 075 m
- Total amount of concrete: 2 750 000 m³
- Reservoir capacity: 5 482 x 10⁶ m³
- Spillway design flow: 10 020 m³/s

Water Conveyance System (energy generation):

- Underground, composed of 6 water intakes, 6 wells with inner diameter of 7,0 m and depths ranging from 110 m to 115 m; 6 conveyance galleries with 9,0 x 12, m and average length of 1900 m each and slope of 4%.

Main Laúca Powerplant:

- Underground: 21 m wide and 273 m long
- Underground excavation: 302 000 m³
- Capacity: 6 x 334 MW = 2004 MW
- Net head: 200 m
- Nominal flow: 182 m³/s
- Units: 6 vertical axis Francis Units
- Energy produced: 8 640 GWh/year

Ancillary Laúca Powerplant (ecological flow)

- Surface toe-of-dam power plant
- Open air excavation: 6 200 m³
- Capacity: 65,5 MW
- Net head: 128 m
- Nominal flow: 60 m³/s
- Units: 1 vertical axis Francis

Substations:

- Main Substation: 400 kV
- Ancillary Substation: 220 kV



Dam location, upstream view (03.10.2012)

40140LAUC_AH Lauca



HYDROPOWER DEVELOPMENTS

GOVE HYDROPOWER DEVELOPMENT

ANGOLA

GOVE HYDROPOWER DEVELOPMENT. Gove Dam Rehabilitation and Construction of Hydropower Plant and respective Substation

Client: GABHIC - Gabinete para
Administração da Bacia
Hidrográfica do Rio Cunene

Detailed Design:
2003 / 2005

Tendering Assistance:
2006 / 2007

**Final Design, Technical
Assistance and Construction
Supervision:**
2008/12

*Studies executed in consortium
with the local consulting engineers
Progest*

**Hydropower Plant and sub-
station.** Its purpose is to generate
electrical power to supply, in the
short term, the town of Huambo. It
has an installed capacity of 60 MW
and generates in average some
150 GWh/year. The substation will
be located nearby the power plant
occupying an area of 10.000 m².



5050 gove_AH Gove

The GOVE dam is located in the Province of Huambo, some 120 km South of the town of Huambo. It was built with the main purpose of flood control of the Cunene river flows and was completed in 1975. The dam was subject to sabotage actions (in 1986 and 1990) that endangered its exploitation.

In the former design a hydroelectric power plant was planned to be incorporated in the dam. Thus, this part is now part of the works to be executed

The consortium COBA/PROGEST was in charge of the detailed design and tender documents for the dam rehabilitation as well as the associated infrastructures and the design of the new hydropower plant.

Dam:

The Gove dam site covers a basin area of 4 667 km² and the reservoir, with the NWL at (1590,00), has a storage capacity of 2547 x 10⁹ m³.

The Gove dam has a homogeneous embankment cross-section and a rockfill toe. The maximum height above the foundation is 58 m and the crest length is 1 112 m. The dam volume is 4 x 10⁶ m³.

Given the sabotage damages, the dam and existing infrastructures were object of rehabilitation studies that comprised:

- Rehabilitation of the dam nearby the left abutment; foundation treatment for reinforcement of the cut-off structure; treatment of longitudinal and drainage galleries to minimize the seepage and to improve the consistency of the interface fills of the gallery; protection of downstream rockfill face to prevent the serious evolution of erosion and the migration of fill fines; dam external drainage; drainage pumping system and drainage at the toe of dam; dam heightening in 1 m; dam monitoring plan; remedial actions in the water intake and in the bottom outlet; repair and strengthening of the initial protection of the outlet channel affected by erosion; repair and improvement of lighting and electrical power supply to several dam infrastructures; control and prevention of the serious evolution of gully; improvement of the dam left abutment ring road and the Operators building area; rehabilitation and improvement of lodging-house and operators building area; rehabilitation of the airfield pavement and upgrade the movement area according to the ICAO' standards applicable to an Airfield code 2C.





JAMBA-IA-OMA HYDROPOWER DEVELOPMENT

Client:

GABHIC – Gabinete para a
Administração da Bacia
Hidrográfica do Cunene

Preliminary Design and Tender Design:

October 2008 / May 2011

Client:

Gabinete do Plano do Cunene

Design and Tender Documents: 1974

Investment Cost: 500.000.000 USD

Powerplant:

- Type: incorporated in the dam, totally buried with access from the roof, with dimensions of 78,5 x 33,6 m and maximum height of 34 m.
- Installed capacity: 79 MW
- Rated flow: 225 m³/s
- Head: 38,8 m
- Number of units: 3 vertical axis Francis turbines
- Annual mean generation: 180 GWh/year

220 kV Substation

Power of the Group Transformers:
Transformer Ratio:

Access Roads:

The access roads associated to the undertaking contemplate the connection to existing roads (5,7 km), access roads to the power plant and substation (2,2 km), besides the road above the crest.

Operators' Village:

The residential area for the operators of the Jamba-Ia-Oma Undertaking is endowed with infra-structures, includes seven dwelling for resident personnel, a lodge for displaced staff and administrative building.

HYDROPOWER DEVELOPMENTS

JAMBA-IA-OMA HYDROPOWER DEVELOPMENT

ANGOLA

DESCRIPTION:

The Jamba-Ia-Oma Hydropower Development is located on the Cunene River, approximately 50 km downstream from the Gove Undertaking and 110 km to the south of the city of Huambo.

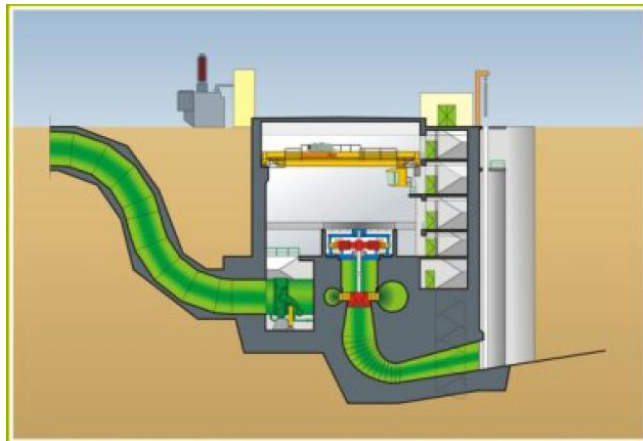
Dam:

- Type: Gravity concrete (dam body) and earthfill (buttresses)
- Max. height of the concrete part: 47 m
- Max. height of the earthfill part: 24 m
- Crest length: 2800 m
- Reservoir capacity: 1100 hm³
- Spillway: included in the dam's concrete body. Maximum flow = 4000 m³/s; six spans with 14 m widths, controlled by sector gates; restitution through ski jump.
- Bottom outlet: included in the dam's concrete body. Maximum flow: 194 m³/s (2 x 97 m³/s).

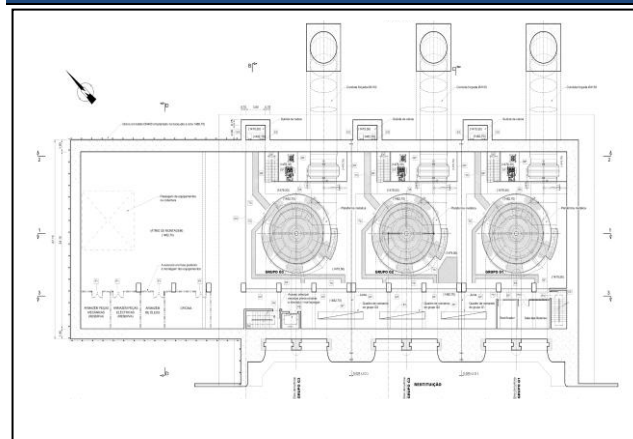
Water Conveyance System:

The water conveyance system is designed for a flow of 225 m³/s (3 x 75 m³/s) and includes:

- 3 independent water intakes embodied in the dam's concrete part;
- 3 penstocks with a Ø 4,15 and 80 m length;
- Tailrace tunnel, with a length of 430 m and width ranging from 40 to 100 m.



Cross-section of the power plant



Layout of the power plant's main floor



JAMBA-IA-MINA HYDROPOWER DEVELOPMENT

Client:

GABHIC – Gabinete para a
Administração da Bacia
Hidrográfica do Cunene

Preliminary Design and Tender Design:

January 2010 / January 2012

Client:

Gabinete do Plano do Cunene

Design and Tender Documents: 1974

Investment Cost:

710.000.000 USD

Operators' Village:

The residential area for the operators of the Jamba-la-Mina Undertaking is endowed with infrastructures, includes seven dwelling for resident personnel, a lodge for displaced staff and administrative building.

HYDROPOWER DEVELOPMENTS

JAMBA-IA-MINA HYDROPOWER DEVELOPMENT

ANGOLA

DESCRIPTION:

The Jamba-la-Mina Hydropower Development is located on the upper Cunene, downstream from the confluence with the Cuando River and at a distance of approximately 160 km to the south of the city of Huambo, in the province with the same name. It is situated about 110 km downstream from the existing Gove Hydropower Development and 60 km upstream from the, also existing, Matala Undertaking. It is likewise located approximately 60 km downstream from the planned Jamba-la-Oma Hydropower Development.

Dam:

- Type: Gravity concrete (dam body) and earthfill (buttresses) on the left bank
- Maximum height of the concrete part: 38,5 m
- Maximum height of the earthfill part: 24,5 m
- Crest length: 1270 m
- Reservoir capacity: 522 hm³
- Spillway: included in the dam's concrete body. Maximum flow = 7000 m³/s; fourteen spans with 14 m widths, controlled by sector gates; restitution through ski jump.
- Bottom outlet: included in the dam's concrete body. Maximum flow: 204 m³/s (2 x 102 m³/s).

Water Conveyance System:

The water conveyance system is designed for a flow of 300 m³/s (3 x 100 m³/s) and includes:

- 3 independent water intakes embodied in the dam's concrete part;
- 3 conveyance galleries (Ø 5,00 m; length: 180 m);
- Tailrace tunnel (Ø 10,00 m; length: 6,6 km), protected by a surge chamber.
- Restitution in the Cuengué River (Cunene River tributary)

Power Plant:

- Type: underground (cavern), with dimensions of 96,1 x 23,4 m and maximum height of 34 m. The control building is located at the surface, with connection to the power plant through a vertical shaft.
- Installed capacity: 205 MW
- Rated flow: 300 m³/s
- Head: 82,7 m
- Number of units: 3 vertical axis Francis turbines
- Annual mean generation: 535 GWh/year

220 kV Substation

Access Roads:

The access roads associated to the undertaking contemplate the connection to existing roads (10,1 km), access roads to the power plant (1,6 km, of which 1,2 km are in tunnel), to the substation and control building (1,0 km) and to restitution (1,3 km), besides the road above the crest.



HYDROPOWER DEVELOPMENTS

CHIUMBE-DALA HYDROPOWER DEVELOPMENT

ANGOLA

Project Phases / Dates:

Feasibility Study
2002
Tender Design
2003

Client:

ENE - Empresa Nacional de
Electricidade

DESCRIPTION:

The Chiumbe-Dala Hydropower Undertaking is located in the Chiumbe (Tchihumbwe) River, close to the town of Dala situated in the Luanda-Sul Province, and essentially envisages electric energy supply to the city of Luena in the Moxico Province.

The undertaking is partially built and rehabilitation of existing structures is required (diversion weir, water intake, conveyance canal and power plant excavations), in conjunction with the installation of equipment and construction of the structures' designs (penstock and power plant)

The studies undertaken by the SOAPRO/COBA Joint-Venture were developed at a Tender Design level.

Environmental Studies were also carried out.

The undertaking includes the following main infrastructures:

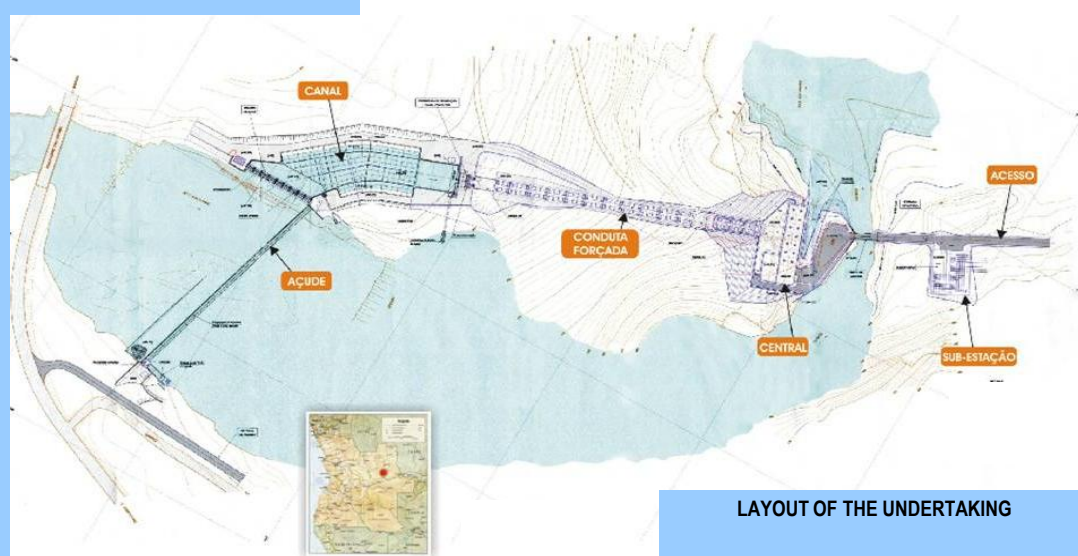
Rehabilitation of Existing Structures

- Diversion weir: concrete free-flowing weir and bottom outlet on the right bank, NWL (496,50), length of 143,5 m;
- Water intake of the left bank;
- Conveyance canal with a total length of 109 m;
- Canal-pipeline concrete transition structure;
- Access road and bridge.

New Structures

- Penstocks: diameter of 2 x 2,2 m and length of 2 x 213 m;
- Power Plant:
- | | |
|--|---------------|
| Maximum capacity (2x4,14 + 2x2,07 MW)..... | 12,42 MW |
| Maximum flow (2x8,0 + 2x4,0 m³/s)..... | 24 m³/s |
| Gross/net head..... | 58,0 / 56,8 m |
- 4 horizontal Francis units
- 6/60 kV Substation: 2 x 10 MVA Transformers

The two 2,07 MW units and one of the 4,14 MW units shall be installed during the first phase of the works.



LAYOUT OF THE UNDERTAKING



PRELIMINARY VIEW OF THE
POWER PLANT

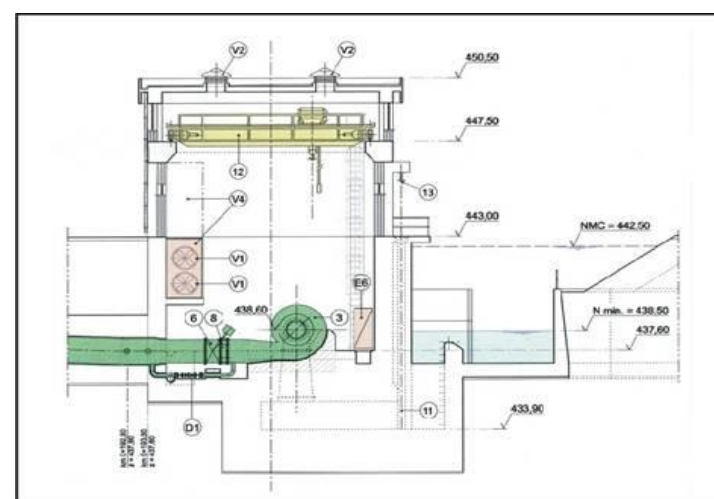
Joint-Venture
SOAPRO / COBA
(26% / 74%)

Contract Amount:
173.375 €

Cost of Works:
38.000.000 €



DIVERSION WEIR (EXISTING)



CROSS-SECTION OF THE POWER PLANT



HYDROPOWER DEVELOPMENTS

M'BRIDGE HYDROPOWER DEVELOPMENT

ANGOLA

Project Phases / Dates:

Basic Studies
2003
Feasibility Study
2003
Final Design
2004

Client:

ENE - Empresa Nacional de
Electricidade

DESCRIPTION:

The M'Bridge Hydropower Development is located in the M'Bridge River, close to the town of Cuimba, in the Zaire Province, and essentially envisages electric energy supply to the city of M'Banza Congo.

The hydropower development comprises two diversion weirs located in the M'Bridge and Passassa Rivers, the respective water intakes and sand traps, the pipelines that connect both dams and a surge chamber, the power plant and the access roads to the undertaking.

The studies undertaken by the SOAPRO/COBA Joint-Venture were developed at a Final Design level. Environmental Studies were also carried out.

The undertaking includes the following main infrastructures:

Diversion Weir

- M'Bridge Weir, with RWL at (933.00), maximum height of 8.5 m and 36 m concrete free-flowing weir. The water intake and the bottom outlet are located next to the dam abutment.
- Passassa weir, with a similar layout, RWL at (943.50), maximum height of 8.5 m and length of 24 m.

Water Conveyance System

The two sections of the water conveyance system originate at the water intake structures, integrated in the body of each one of the weirs, and include sand traps and HDPE pipelines with diameters of 1200 mm and length of 600 m for the pipeline with origin at the M'Bridge Weir and 2900 mm for the pipeline with origin at the Passassa Weir.

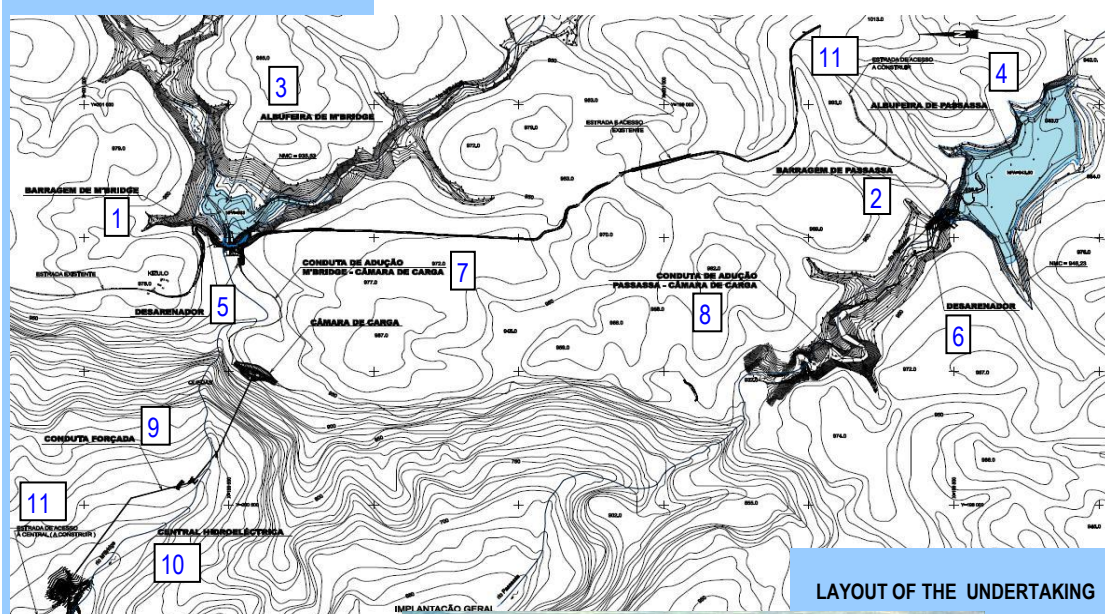
A surge chamber with a length of approximately 80,0 m and 14,0 m maximum width gathers all flows incoming from both weirs. From this point departs a steel pestock with 1200 m and Ø 1000 mm.

Power Plant

- Rated capacity (3x2,275 MW).....6,825 MW
- Maximum flow.....2,4 m³/s
- Net head324,0 m
- 3 horizontal axis Pelton units.
- 6/60 kV Substation

Access Roads

- Access roads to the undertaking with a length of approximately 5,1 km.



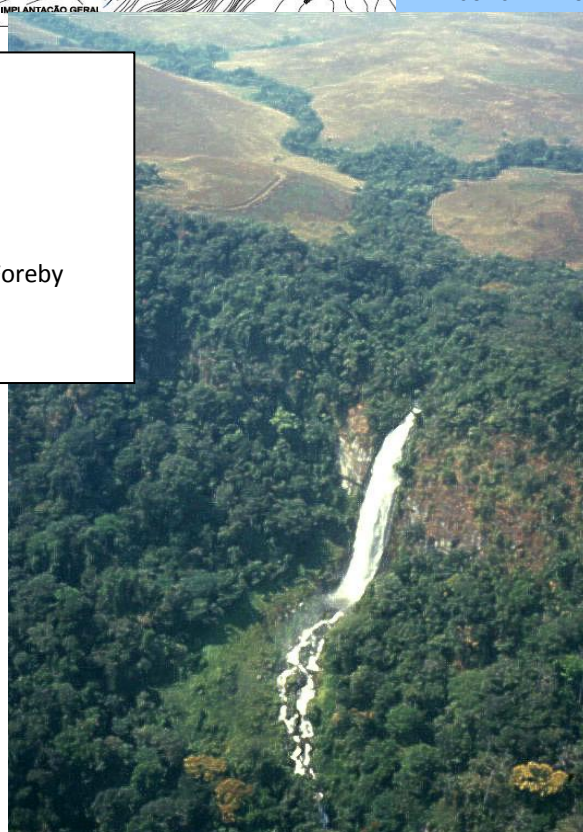
LAYOUT OF THE UNDERTAKING

- 1 - M'Bridge Dam
- 2 - Passassa Dam
- 3 - M'Bridge Reservoir
- 4 - Passassa Reservoir
- 5 - M'Bridge Sand trap
- 6 - Passassa Sand Trap
- 7 - M'Bridge water supply pipeline - Foreby
- 8 - Passassa water supply pipeline - Foreby
- 9 - Penstock
- 10 - Power plant
- 11 - Access Road to be built

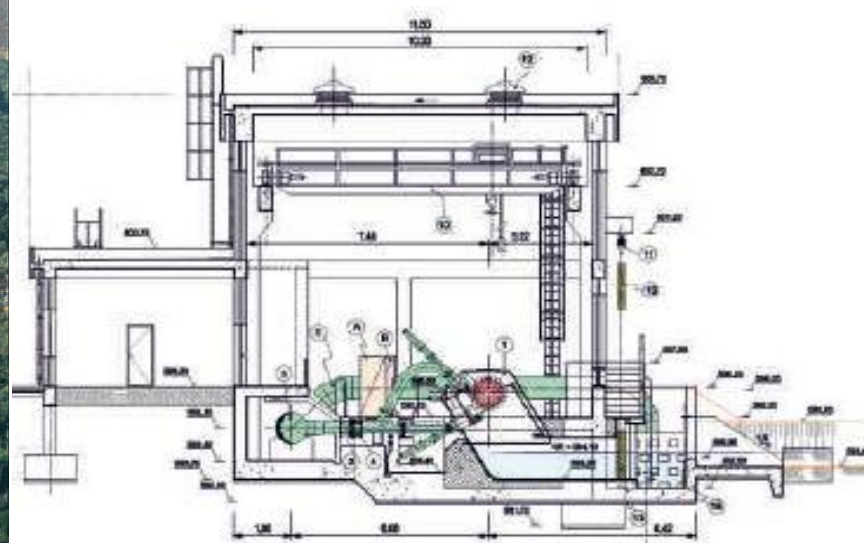
Joint-Venture
SOAPRO / COBA
(21% / 79%)

Contract Value:
610.350 €

Cost of Works:
61.000.000 €



M'BRIDGE WATER FALLS



POWER PLANT CROSS-SECTION



HYDROELECTRIC DEVELOPMENTS

SAMUELA HYDROPOWER DEVELOPMENT

ANGOLA

SAMUELA HYDROPOWER DEVELOPMENT

Client:
ESCOM Mining Energy, Ltd

Preliminary Study:
2006/07

DESCRIPTION:

The Samuela Hydropower Development is located on the Tchicapa River, in the Luanda North Province, about 60 km to the south of the Lucapa city, close to the Luó mining complex.

The objective of the undertaking is to increase the electric energy generation in order to satisfy the requirements of the ESCOM mining complexes that exist in the region and that are currently supplied through thermal units, which present high operation costs, namely regarding fuel transportation.

MAIN CHARACTERISTICS:

Dam:

Type: mixed (concrete in the central zone and earthfill at the abutments)

Maximum Height:	20,5 m
Crest Length:	575 m
Normal Water Level:	856 m
Maximum Water Level:	857 m
Spillway design flow:	717 m ³ /s

Water Conveyance System (connection between the water intake and the power plant)

Diameter:	5,0 m
Length:	92,5 m

Power Plant:

It is located about 115 m downstream of the dam, on the right bank, and occupies a building with an area of 37 m length x 23 m width.

Head:	17,5 m
Installed capacity:	15 100 kW
Energy generated:	78,9 GWh/year
Turbine:	
Number:	2
Type:	Kaplan



1258 samu_AH Samuela EP



HYDROPOWER DEVELOPMENTS

RIBEIRADIO – ERMIDA HYDROPOWER DEVELOPMENT

PORTUGAL

RIBEIRADIO – ERMIDA HYDROPOWER DEVELOPMENT

Client:

EDP / Martifer Renewables

Preliminary Study: 2007

Client:

GREENVOUGA, S.A.

Licensing Process, Tender Documents for the Overall Construction Works and Equipment Supply: 2008 / 2009

Final Design and Technical Assistance: 2009 / 2015

DESCRIPTION:

The Ribeiradio – Ermida development is situated in the Vouga River and its purpose is the water supply and power generation. The integrated development of the Vouga water resources has been analysed over the last three decades, within various studies, most of them elaborated by COBA. The Ribeiradio dam has also been object of many studies made by COBA, essentially during the last ten years.

In 2007, the Instituto da Água (INAG) launched a call for tenders for the **Construction and Exploitation of the Ribeiradio-Ermida Development**. One of the bidders was the consortium EDP-Martifer Renewables, for whom COBA prepared the preliminary design that founded their offer. 0

This consortium was the winner of the project and then COBA was committed to the execution of the Tender Design, Final Design and Technical Assistance.

The project involves the Ribeiradio dam, the Ribeiradio powerplant, the afterbay Ermida dam to control the flows released by the Ribeiradio powerplant and the Ermida powerplant.

Ribeiradio Dam:

- Type: Concrete gravity dam
- Height: 83 m
- Crest length: 265 m
- Reservoir capacity: $136 \times 10^6 \text{ m}^3$
- Maximum flood flow: $2\,750 \text{ m}^3/\text{s}$
- Spillway: gated spillway divided in three bays, equipped with $13 \times 13 \text{ m}^2$ radial gates
- Bottom outlet: pipeline with a 2,5 m diameter ($125 \text{ m}^3/\text{s}$)

Ribeiradio Powerplant:

- Capacity: 74,5 MW
- Head: 72 m
- Nominal flow: $125 \text{ m}^3/\text{s}$
- Number of units: 1, Francis turbine
- Yearly Power generation: 117 GWh
- Underground hydraulic conveyance system composed of 200 m long and 5,5 m diameter concrete lined tunnel.

Ermida Dam:

- Type: Concrete gravity dam
- Height: 35 m
- Crest length: 175 m
- Spillway: uncontrolled overflow with a West-type weir profile 55 m wide

Ermida Powerplant:

- Capacity: 8 MW
- Head: 16,8 m
- Nominal flow: $50 \text{ m}^3/\text{s}$
- Number of units: 2 horizontal axis Kaplan turbines
- Yearly power generation: 17,3 GWh

Ribeiradio dam





HYDROPOWER DEVELOPMENTS

ALQUEVA HYDROPOWER DEVELOPMENT. STRENGTHENING OF HYDROPOWER GENERATION

PORTUGAL

ALQUEVA HYDROPOWER DEVELOPMENT. STRENGTHENING OF ALQUEVA II POWER GENERATION

Client:
EDP – Electricidade de
Portugal

**Tender Design, Final Design
and Environmental Impact
Assessment:**
2007/12

The Alqueva stage water power development has been equipped with two 130 MW reversible units in the first phase. The strengthening has the purpose of duplicating the reversible installed capacity in order to take advantage of the conditions created by the combination of the Alqueva large reservoir and the Pedrógão afterbay dam allowing pumping-turbining weekly cycles.

The units for the strengthening are to be installed in a new hydropower plant (power plant II), to be open and cut built at the right bank of the Guadiana River, downstream the dam right abutment, taking advantage of the existing platform.

The conception of the adopted solutions is the result of the feasibility studies prepared by COBA to EDIA – Empresa de Desenvolvimento e Infra-Estruturas do Alqueva (Company for the Alqueva Project), together with the option of equipping the power plant with units similar to the existing ones.

The Alqueva stage water power development includes the hydraulic tunnel hydraulic, the power plant, the outlet and the substation.

Hydraulic tunnel:

Unit 1:	361 m
Unit 2:	387 m
Diameter:	8,50 m

Power Plant:

Number of units:	2, Francis
Nominal flow:	200 m ³ /s
Net head:	71 m
Capacity/unit	130 MW

Outlet

Exit level ...(74 m)

Substation

Unit transformers:
- Capacity 150 MVA





HYDROPOWER DEVELOPMENTS

FRIDÃO HYDROPOWER DEVELOPMENT

PORTUGAL

Project Phases / Dates:

Preliminary Design
2009

Client:

EDP Produção

DESCRIPTION:

The Fridão Hydropower Development, located on the Tâmega River, is composed of a Main Stage that includes the Fridão Dam and the power plant, as well as a second dam located downstream, destined for regulation of turbinated flows.

This undertaking is integrated in the framework of the "National Programme of Dams with High Hydroelectric Potential (PNBEPH)" undertaken in 2007.

The studies undertaken by COBA included the power plant, the water conveyance system and the access roads to the undertaking. These studies were undertaken at a Preliminary Design level.

The undertaking includes the following infrastructures designed by COBA:

Water Conveyance System

The 330 m long water conveyance system includes a water intake tower with a maximum height of 53,3 m, a conveyance tunnel with a diameter of 11,0 m and a short restitution tunnel with an outlet mouth.

Power Plant

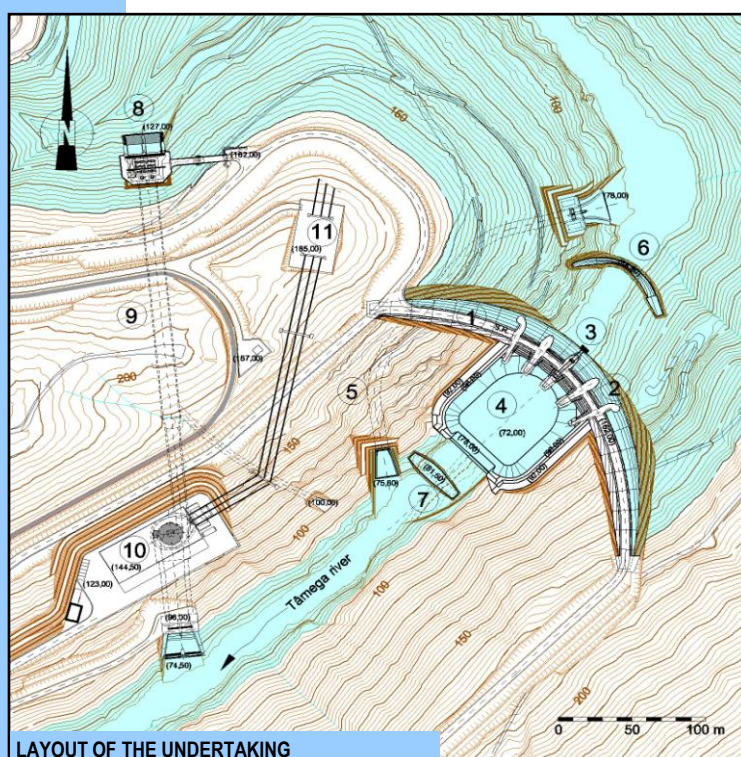
- Installed capacity.....241 MW
- Nominal flow.....350 m³/s
- Net head75.6 m
- 1 vertical axis Francis unit, installed inside a pit, with an erection hall and surface operation building.
- 400 kV substation, including a 283 MVA, 15/400 kV transformer.

The power plant is composed of a pit and a surface operation building, with a maximum height of 94 m, including the underground structures.

The expected annual average energy generation amounts to 300 GWh/year.

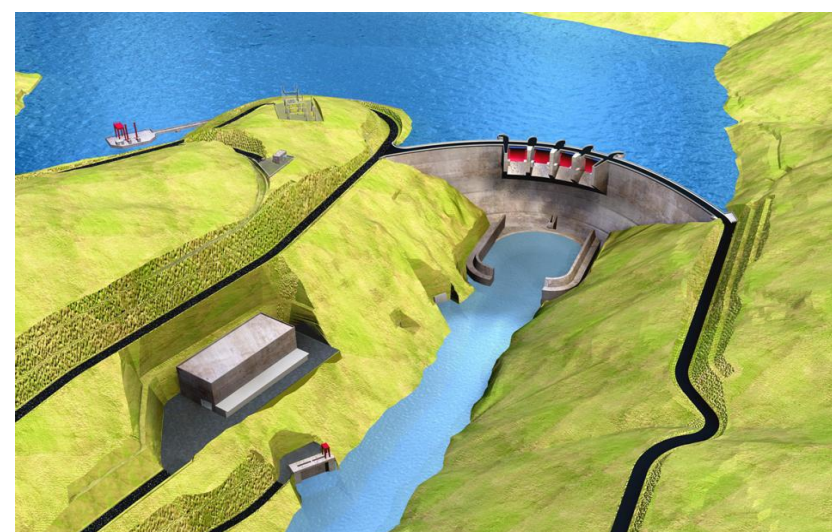
Access Roads and Relocation of Road Infrastructures

- 3,3 km long access roads.
- Relocation of existing roads over an extent of 0,6 km, including 6 bridges across the Tâmega River and its tributaries.



LAYOUT OF THE UNDERTAKING

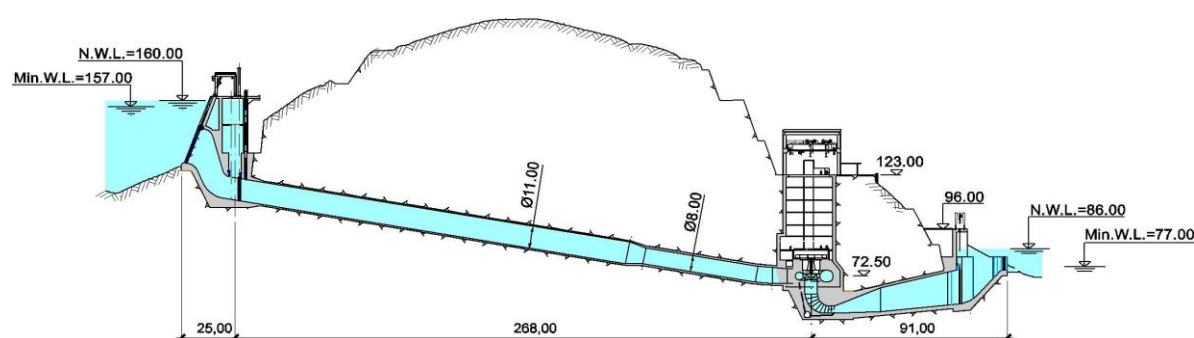
- 1 - Dam
- 2 - Spillway
- 3 - Bottom Outlet
- 4 - Stilling Basin
- 5 - Diversion Tunnel
- 6 - Upstream cofferdam
- 7 - Downstream cofferdam
- 8 - Water Intake
- 9 - Water Conveyance Sytem
- 10 - Powerplant
- 11 - Substation



PRELIMINARY VIEW OF THE FRIDÃO DAM AND POWER PLANT

Contract Value:
475.410 €

Cost of Works:
120.000.000 €



LONGITUDINAL PROFILE OF THE POWER PLANT AND WATER CONVEYANCE SYSTEM



HYDROELECTRIC DEVELOPMENTS

PEDRÓGÃO STAGE HYDROPOWER DEVELOPMENT. POWERPLANT II

PORTUGAL

ALQUEVA MULTIPURPOSE DEVELOPMENT. PEDRÓGÃO STAGE HYDROPOWER PLANT. POWER PLANT II

Client:
EDP – Electricidade de Portugal

Licensing Design, Tender Design and Environmental Impact Assessment:
2008 / 2010

The present study pertains to Power Plant II of the Pedrógão Stage Water Power Plant integrated in the Alqueva Multipurpose Development. It envisages the construction of a new hydraulic circuit and a power plant equipped with a Kaplan turbine and alternator.

The Pedrógão Power Plant II shall be built on the left bank of the Guadiana River upon a platform that also serves the EDIA pumping station at level (79,10), approximately 160 m downstream from the Pedrógão Dam.

Characteristics:

Capacity 13,34 MW
Net head: 21 m
Nominal flow: 70 m³/s
Number of units: 1, Kaplan
Water Conveyance System: 192 m long: initial section (18 m and Ø 4,40 m; pipeline for connection to the pumping station (98 m and Ø 4,0 m);
Penstock (76 m and Ø between 3,85 and 4,30 m).
Exterior substation with a 60 kV capacity.



1427 rped_AH Pedrogao



Project Phases / Dates:

Licensing Project
2010

Tender Design
2010 - 2011

Client:
EDP Produção

DESCRIPTION:

The Foz Tua Hydropower Development, located on the Tua River at the confluence with the Douro River, is composed of an arch dam and an underground water conveyance pipeline situated on the right bank, as well as by an underground reversible power plant, with a surface operation building.

This undertaking is integrated within the framework of the "National Programme of Dams with High Hydroelectric Potential (PNBEPH)" undertaken in 2007.

COBA undertook the studies pertaining to the power plant and the water conveyance system. These studies consisted in a first Licensing Project, followed by a Tender Design.

The undertaking is composed of the following infrastructures designed by COBA:

Water Conveyance System

The water conveyance system includes two systems with total lengths of 700 and 770m respectively, and includes a water intake, a conveyance tunnel and an outlet tunnel, with the following characteristics:

- Two water intake towers, 40,3 m high, connected by a causeway at the same level as the dam crest.
- Two outlet tunnels with lengths of 83 m and 103 m, respectively, that include a pit for installation of the downstream shut-off equipment.

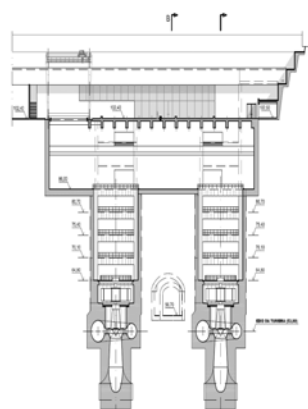
Power Plant

- Installed capacity.....262 MW
- Nominal flow.....310 m³/s
- Net head.....93.6 m
- 2 reversible vertical axis Francis units, with 131 MW, installed underground, with an erection hall and surface operation building. The maximum height amounts to 98,6 m, including the underground structures.

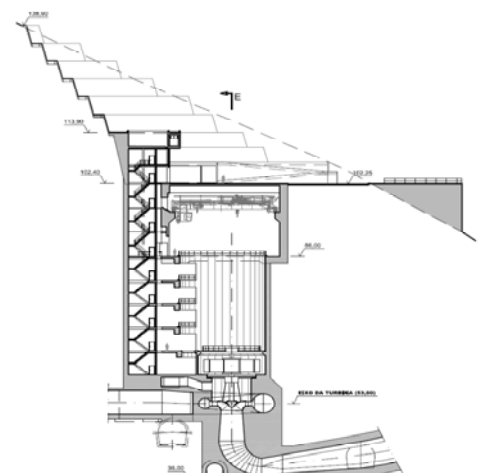
The expected energy generation amounts to 349 GWh/year, of which 44 GWh/year corresponds to reversible energy.



PREVIEW OF THE FOZ TUA POWER PLANT



LONGITUDINAL PROFILE



CROSS-SECTION

Contract Value:
1.040.000 €

Cost of Works:
140.000.000 €



HYDROPOWER DEVELOPMENTS

SALAMONDE HYDROPOWER DEVELOPMENT – POWER STRENGTHENING – SALAMONDE II

PORTUGAL

SALAMONDE HYDROPOWER PROJECT – POWER STRENGTHENING – SALAMONDE II

Client:

EDP - Gestão da Produção de
Energia, S.A.

Licensing Design and Tender Documents 2009 / 2010

Final Design and Technical Assistance: 2010 / ongoing

Ancillary Works

- Cofferdam

Type: concrete arch dam
Height: 27 m
Crest length: 130 m

- Access Tunnel to the Powerplant

1170 m long and Ø 8,0 m

- Access Roads:

Length: 3.500 m; 70 m-long bridge

The Salamonde Hydropower Development is located in the Cávado River between the Salamonde and Caniçada reservoirs.

The Undertaking includes the following infrastructures:

Main Works

- Water Intake in the Salamonde Reservoir

- Upstream Water Conveyance System

Design flow: 200 m³/s
Length: 300 m
Diameter of the lined section: 8,4 m

- Power Plant

Units: 1 (reversible vertical Francis unit)
Capacity: 206 MW
Nominal flow: 200 m³/s (turbine); 163 m³/s (pump)
Net head (turbine): 115 m
Net head (pump): 120 m
Cavern: height - 57 m; length - 67 m

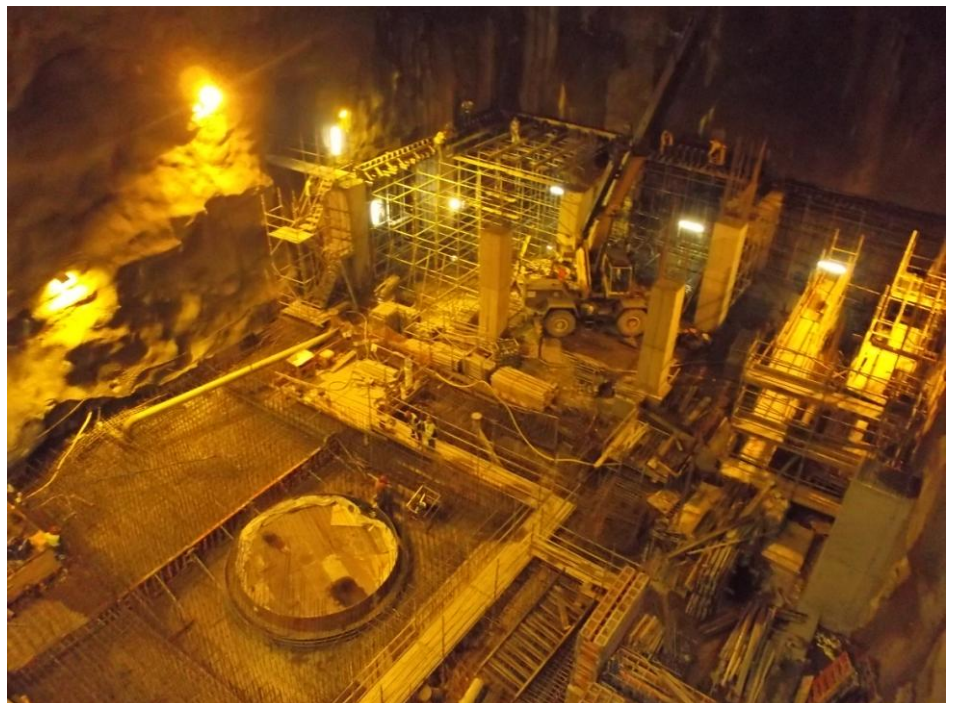
- Surge chamber downstream from the power plant

Inner diameter: 27,5 m
Height: 60 m

- Downstream water conveyance system up to the Caniçada Reservoir

Design flow: 200 m³/s
Length: 2.000 m
Diameter of the lined section: 8,4 m

- Restitution in the Caniçada Reservoir



HYDROPOWER DEVELOPMENTS

ALVITO HYDROPOWER DEVELOPMENT

PORTUGAL

Project Phases / Dates:

Preliminary Design
2009

Client:

EDP Produção

DESCRIÇÃO:

The Alvito Hydropower Development, located on the Ocreza River immediately upstream from the confluence with the Alvito River, is composed of a gravity concrete dam (RCC), a cavern power plant and an underground water conveyance system.

The undertaking is reversible, and is used as a reservoir downstream from the existing Pracana Dam reservoir, also located on the Ocreza River.

This undertaking is integrated within the framework of the "National Programme of Dams with High Hydroelectric Potential (PNBEPH)" undertaken in 2007.

The Preliminary Design was undertaken in association, being COBA the leader of the joint-venture and responsible for the dam and access studies.

The undertaking is composed of the following infrastructures:

Dam

Type.....	concrete gravity (RCC)
Storage capacity.....	425 hm ³
Maximum height.....	88 m
Crest length.....	425 m

Water Conveyance System

The underground water conveyance system is 3,8 km long and comprises an intake, a conveyance tunnel, a restitution tunnel, a surge chamber and a restitution structure.

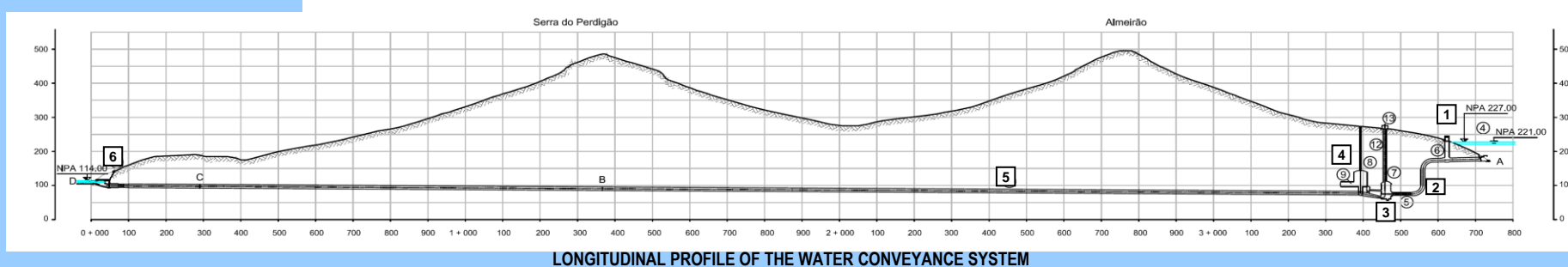
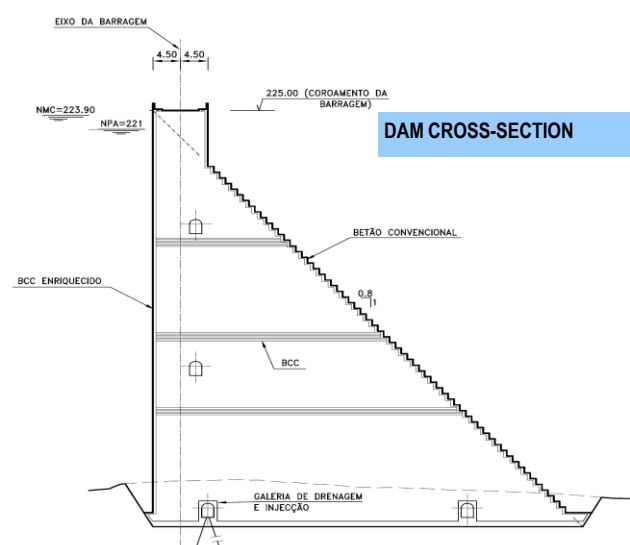
Power Plant

- Installed capacity.....214 MW
- Nominal flow.....250 m³/s
- Net head.....101.2 m
- 1 underground reversible vertical axis Francis unit.
- 400 kV substation, including a 262 MVA, 18/400 kV transformer.

The expected energy generation amounts to 66 GWh/year.

Access Roads and Relocation of Road Infrastructures

- Access roads over an extent of 2.7 km.
- Relocation of existing roads along 7,5 km, including 4 bridges across the Ocreza River and its tributaries.

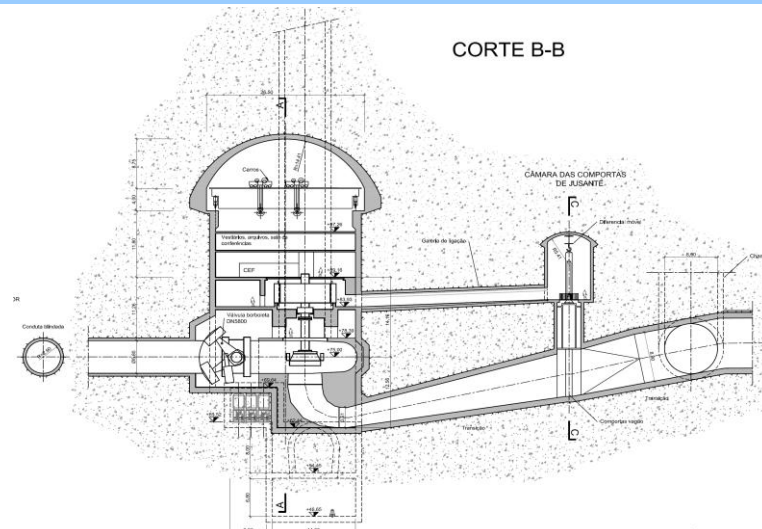


Joint-Venture:
COBA / STUCKY
(45% / 55%)

Contract Value:
900.000 €

Cost of Works:
356.000.000 €

CORTE B-B



- 1 -Water intake
- 2 -Water conveyance tunnel
- 3 -Power plant
- 4 -Surge chamber
- 5 -Restitution tunnel
- 6 -Restitution outlet

POWER PLANT



HYDROPOWER DEVELOPMENT OF THE RABAÇAL RIVER NEAR THE BOUÇOAIS AND SONIM VILLAGES

Client:
ENGIL – Sociedade de
Construção Civil, S.A.

**Final Design and Technical
Assistance:**
2003 / 2005

Water Conveyance System

- The water conveyance system is installed between the reservoir and the power station, being formed of a tunnel with some 1350 m excavated in the granite formation of the right bank of the river and of a penstock with a length of 65 m. The tunnel excavation diameter is 4,20 m, being concrete lined in the sections whose conditions so require, a thickness of 0,30 m, defining a hydraulic with an internal diameter of 3,60 m.

Fish facilities

- Fish lift following a fish ladder of successive basins designed for 0,450 m³/s.

Access roads

- Access road to the dam (linking to the NR 103) and to the powerhouse with a length of some 2650 m.

988 soni_AH Boucoais Sonim

HYDROPOWER DEVELOPMENTS

HYDROPOWER DEVELOPMENT OF THE RABAÇAL RIVER NEAR BOUÇOAIS AND SONIM

PORTUGAL

DESCRIÇÃO

The Rabaçal hydropower development, tributary of the Tua river (tributary of the international Douro river), is located near the Bouçoais and Sonim villages.

The project purpose is the electric power generation, within the legislation in force applicable to independent generating companies, i.e., the installed capacity shall be up to 10 MW.

The site relief is very hilly, with steep slopes cut in the granite formations and with a very steep river (average slope of 1%), creating good conditions for the project construction.

It involves the following structures:

Dam

– Type:	Concrete, gravity
– Height:	43 m
– Crest length:	87 m
– Dam volume:	19,5 x 10 ³ m ³
– Reservoir capacity:	1,4 x 10 ⁶ m ³
– Maximum flood flow:	1500 m ³ /s
– Spillway:	overflow, without gates

Power Plant

The power plant is located on the right bank of the Rabaçal river, about 1,3 km downstream the dam, taking advantage of the difference in height of about 28 m between the two sites, and has the following characteristics:

– Installed capacity:	10 000 kW
– Head:	53 m
– Nominal flow:	22 m ³ /s
– Number of units:	2, Francis turbines
– Design flow:	22 m ³ /s
– Annual energy generation:	30 GWh/year





HYDROPOWER DEVELOPMENT OF THE RABAÇAL RIVER NEAR THE REBORDELO VILLAGE

Client:
ENGIL – Sociedade de
Construção Civil, S.A.

Final Design and Technical Assistance:

2003 / 2005

Water Conveyance System

- The water conveyance system is installed between the reservoir and the power plant, has a length of some 1700 m excavated in the granite formation of the right bank of the river. The excavation diameter is of 4,20 m, being concrete lined in the sections whose conditions so require, a thickness of 0,30 m, defining a hydraulic with an internal diameter of 3,60 m.

Fish facilities

- Fish lift following a fish ladder with successive basins designed for 0,450 m³/s.

Access roads

- Access road to the dam (linking to the NR 103) with some 2650 m.
- Access road to the power plant (linking to the NR 103) with 650 m.
- Re-establishment of the CM 511 between Vale do Arneiro and S. Jomil over a length of 360 m.

989 rebo_AH Rebordelo

HYDROPOWER DEVELOPMENTS

HYDROPOWER DEVELOPMENT OF THE RABAÇAL RIVER NEAR REBORDELO

PORTUGAL

DESCRIPTION:

The Rabaçal HydroPower Project is located near the Rebordelo village, in the Rabaçal river, a sub-affluent of the international Douro river.

The project purpose is the electric power generation, within the legislation in force applicable to independent organizations, i.e., the installed capacity shall be up to 10 MW.

The project site is extremely hilly, with steep slopes cut in the granite formations and with a very steep river (average slope of 1%), creating good conditions for the project construction.

It involves the following structures:

Dam

– Type:	Concrete arch-gravity dam
– Height:	35 m
– Crest length:	127 m
– Dam volume:	21,4 x 10 ³ m ³
– Reservoir capacity:	3,13 x 10 ⁶ m ³
– Maximum flood flow:	1480 m ³ /s
– Spillway:	overflow, without gates

Power Station

The power plant is located on the right bank of the Rabaçal river, about 1,7 km downstream the dam, taking advantage of the difference in height of about 20 m between the two sites, and has the following characteristics:

– Installed capacity:	8 750 kW
– Head:	42,5 m
– Nominal flow:	24,4 m ³ /s
– Number of units:	1, Kaplan turbines
– Design flow:	24,4 m ³ /s
– Annual energy generation:	24 GWh/year





HYDROPOWER DEVELOPMENTS

SELA SMALL HYDROPOWER PLANT

PORTUGAL / SPAIN

SELA HYDROPOWER DEVELOPMENT. SELA POWER PLANT

Client:

EDP – Electricidade de
Portugal / FENOSA – Fuerzas
Eléctricas del Noroeste

Design:

1981/83

MAIN CHARACTERISTICS:

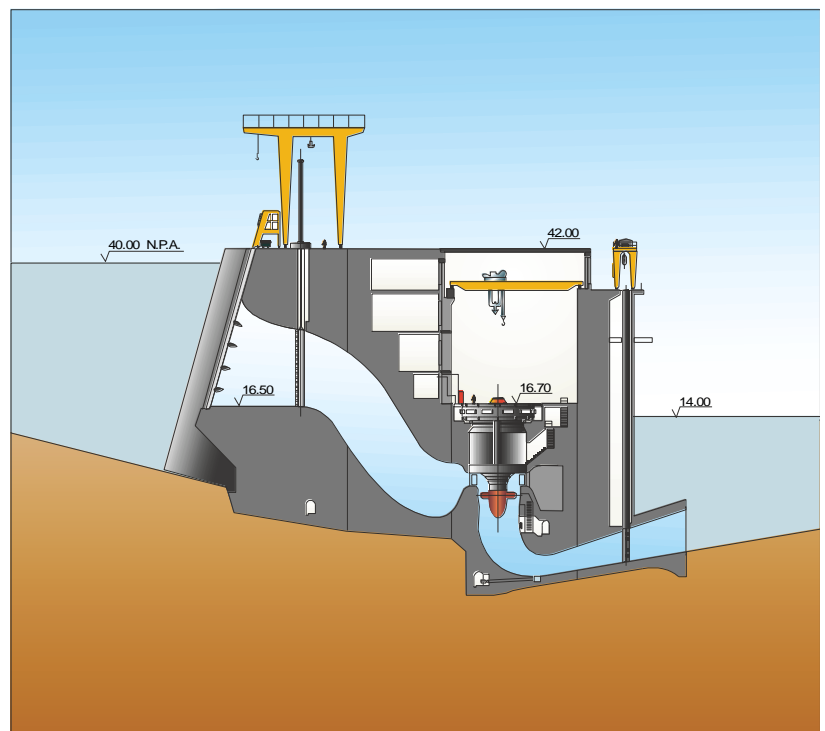
- River: Minho
- Type: Foot of the dam
- Head: 26 m
- Number of units: 2 (Kaplan turbines)
- Rated capacity: 152 MW
- Annual mean energy generation: 527 GWh

DESCRIPTION:

The Sela Hydropower Plant is to be located in the international section of the Minho River, its energy output being distributed between Spain and Portugal.

The Sela run-of-river development is constrained by the projects that have already been built upstream the Minho river and exploited by FENOSA.

High voltage transmission lines start in the switchyard towards Spain and Portugal.



Schematic Cross Section



PORTUGUESE NATIONAL PROGRAM ON DAMS WITH HIGH HYDROELECTRIC POTENTIAL

Client:

REN – Rede Eléctrica Nacional
/ INAG – Instituto da Água

Date:

2007

Studies undertaken by the
consortium COBA/PROCESL

1363 pnba_AH PNBEPH

HYDROPOWER DEVELOPMENTS

PORTUGUESE NATIONAL PROGRAM ON DAMS WITH HIGH HYDROELECTRIC POTENTIAL

PORTUGAL

The **National Program of High Hydroelectric Potential Dams** (PNBEPH) has the purpose of identifying and defining priorities for investments in large hydroelectric developments in the project horizon 2007-2020.

The PNBEPH intends to reach a national hydro rated capacity above 7 000 MW in 2020 (70% of the national hydro potential), of which the hydropower projects to implement shall generate an additional capacity of 2 000 MW, contributing, this way, to accomplish the goals established by the Portuguese Government as to power generated by renewable energies for 2020, reduction of national energy dependency and reduction of CO₂ emissions

An assessment was made of a comprehensive set of 25 hydroelectric sites, previously identified at national level. The selection of the hydroelectric sites to develop to accomplish the defined objectives was based on the definition of strategic options, which evaluates the hydro value of each development and takes into account the associated technical, economic, environmental and social aspects.

The studies were undertaken in two phases:

Phase A : Elaboration of a “**Programme Project**”, as well as the corresponding “Environmental Report”.

Phase B : Process for public participation and elaboration of a “Program” and respective “Environmental Declaration”.

The programme project includes four key activities:

- Identification and characterisation of all potential sites for the developments location.
- Elaboration of a “Report of Critical Factors” of the environmental assessment, to be submitted to public consultation.
- Elaboration of a strategic environmental assessment (“Environmental Report”).
- Classification of different developments, bearing in mind the technical, economic, social and environmental characteristics.

The **Programme**, carried out in Phase B, included the following activities:

- Participation in the public participation process within the Program and the Environmental Impact Assessment, including the preparation of disclosure information and elaboration of the respective Consultation Report.
- Inclusion of the public consultation results in the Programme Project and in the Environmental Report (“Programme” and the “Environmental Declaration”)

The strategic options defined for the Program were subject to an Environmental Strategic Evaluation, which allowed the definition of 10 hydro developments that will integrate the PNBEPH: **Almourol, Alvito, Daivões, Foz Tua, Fridão, Girabolhos, Gouvães, Padroselos, Pinhosão, Vidago.**

To support the “Public Consultation” process, LandCOBA (COBA Group) has developed a Geographic Information System based on the Internet, that can be accessed on the INAG’s site (www.inag.pt) or on COBA site (www.coba.pt/landpnba/). Here the dam sites and the reservoirs areas can be visualised and all documents can be consulted.



HYDROPOWER DEVELOPMENTS

EL BORJ HYDROPOWER DEVELOPMENT

MOROCCO

Project Phases / Dates:

Feasibility Study
1998 - 1999

Tender Design
2000 - 2003

Construction Date
2007

Client:
Office Nationale de Electricité -
ONE

DESCRIPTION:

The El Borj Hydropower Development is located on the Oum Er Rbia, one of Morocco's main rivers, and comprises the second Stage of the cascade foreseen for its upper course. The undertaking is situated in the middle Atlas, near the city of Kénifra.

This is a run-of-river undertaking that resorts to a fall of approximately 130 m available in a section of about 15 km between the villages of Tanafnit and El Borj.

The studies were undertaken in the following phases: Feasibility Study and Preliminary Design. The Tender Documents were divided into 5 Lots and the works were concluded in 2008.

The hydraulic structures of the dam were tested in a reduced model and the results were duly taken into account in the project.

The project also included training sessions for ONE's staff, pertaining to hydrological studies and hydraulic dimensioning.

The undertaking includes the following main infrastructures:

Tanafnit Dam:

Mixed dam, with an earthfill body and lateral concrete spillway:

- Maximum height.....25 m
- Crest length.....270 m
- Reservoir capacity.....2.1 hm³

The spillway is equipped with sluice gates and includes a canal that ends in a ski jump.

The bottom outlet is composed of a water tower and gallery beneath the embankment.

Water Conveyance System

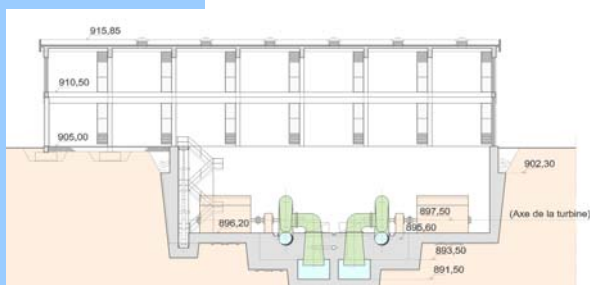
- 10,2 km long and Ø 3,3 m tunnel.
- Surge chamber with a diameter of 5,5 m.
- ND 2600 mm safety valve chamber .
- ND 2800 and 3000 mm penstock with a length of 200 m.

Power Plant

- Installed capacity.....21,3 MW
- Nominal flow.....24 m³/s
- Net head.....106,5 m
- 2 horizontal axis Francis units, with 10,65 MW, installed inside a specific building .
- Exterior 60 kV substation, including two 15 MVA, 6/60 kV transformers.

Access Roads

- Access roads to the undertaking with a length of 6,2 km.
- Bridge with a total span of 43 m.



LONGITUDINAL PROFILE OF THE POWER PLANT

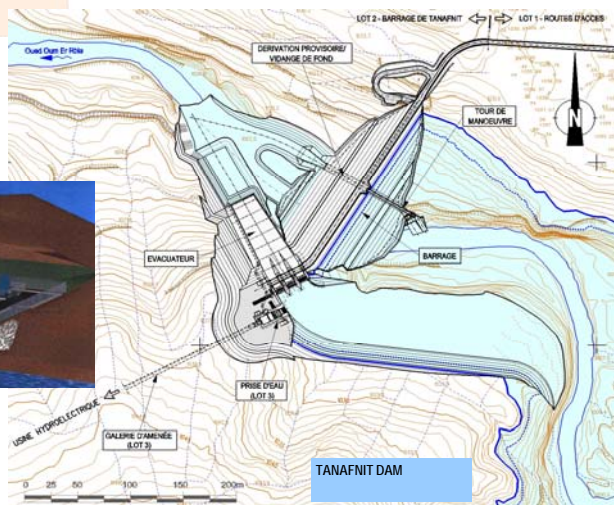
Joint-Venture
COBA / PROJEMA
(90% / 10%)

Contract Value:
766.568 €

Cost of Works:
36.000.000 €



PRELIMINARY VIEW OF THE
POWER PLANT



COBA - ENGINEERING AND ENVIRONMENTAL CONSULTANTS



HYDROPOWER DEVELOPMENTS

SAMBANGALOU HYDROPOWER DEVELOPMENT

SENEGAL

SAMBANGALOU AND KALETA HYDROPOWER DEVELOPMENTS AND POWER TRANSMISSION LINE

Client:

Organisation pour la Mise en
Valeur du Fleuve Gambie
(OMVG)

Technical and Economical Feasibility Study, Detailed Design and Tender Documents: 2005/07

*Studies undertaken by the
COTECO Joint-Venture (Coyne et
Bellier - Tecstult - COBA)*

DESCRIPTION

The study concerning the "Electrical Power Generation and Transmission" of the OMVG's member countries includes the regional analysis of power development, environment impact studies and the preliminary design of the following structures:

Sambangalou Dam

Type:	RCC
Height:	94 m
Crest length:	560 m
Volume of concrete:	1 200 000 m ³
Volume of excavations:	1 100 000 m ³

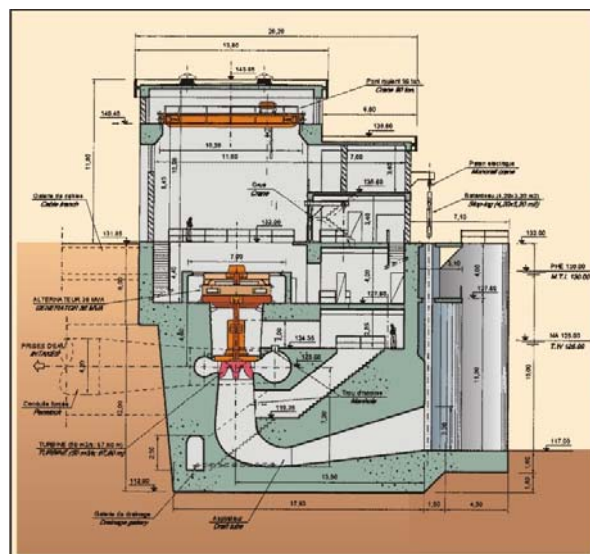
Power Plant

Location:	adjacent to the dam
Number of units:	4, Francis
Installed capacity:	120 MW (4x30 MW)
Maximum capacity:	133 MW
Nominal flow:	200 m ³ /s
Head:	61,9 to 73,7 m
Estimated power generation:	400 GWh/year
Penstocks:	4 x 4000 mm

Power transmission line

Capacity:	225 kV
Number of stations:	15
Length:	1 723 km

COBA was responsible for the hydropower station, including intake, penstocks and switchyard, and for the geological and geotechnical studies of the dam.





SMALL HYDROPOWER PLANTS IN THE STATE OF CEARÁ

ASSESSMENT OF AVAILABLE WATER RESOURCES AND TECHNICAL AND ECONOMIC FEASIBILITY STUDIES

Client:
Secretaria dos Recursos
Hídricos do Estado do Ceará
(SRH-CE)

Date:
2005/06

HYDROPOWER DEVELOPMENTS

SMALL HYDROPOWER PLANTS IN THE CEARÁ STATE

BRASIL

OBJECTIVE:

The principal objective of the studies undertaken was to define the characteristics for six Small Hydropower Plants associated to large weirs or other hydraulic undertakings in the State of Ceará.

The Small Hydropower Plants have capacities from 0,6 MW to 5 MW.

The studies undertaken included the definition of the flow regulating capacities made possible by the several weirs and the estimation of power generation capacity of the future Small Hydropower Plant. The operation of the reservoirs was constrained by the primary requirement of water supply for human consumption and irrigation purposes.

The main characteristics of each Small Hydropower Plant, namely the flow, respective installed capacity and number of units were established based on a technical and economic assessment.

SMALL HYDROPOWER PLANT	Nominal Characteristics (total)			Number of Units
	Flow (m ³ /s)	Head (m)	Capacity (MW)	
1 Castanhão	15	39	4,87	2
2 Orós	3	45	1,12	2
3 Banabuiú	11	38	3,48	2
4 Aracoiaba	2,0	25	0,42	1
5 Jaburú I	1,6	46	0,61	1
6 Queda do Trecho 1	7	11	0,64	1
	14		1,28	2

A technical and economic comparison between alternative solutions for implementation of Small Hydropower Plants or installation of turbine pumps was carried out. This comparison led to the conclusion that the implementation of Small Hydropower Plants in the six cases comprises the most advantageous scenario from an economical point of view.

The studies also included the preparation of Terms of Reference for further phases of the studies, namely the Final Design phase, including the identification of ancillary works, such as topographic and geotechnical field surveys.

