



GOVE HYDROELECTRIC DEVELOPMENT

ANGOLA

**GOVE HYDROELECTRIC 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

Studies executed in consortium with the local consulting engineers Progest

**Hydropower Station and substation.**

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 substations will be located nearby the power plant occupying an area of 10.000 m<sup>2</sup>.



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

In the former design a hydroelectric power station has been planned to be incorporated in the dam. Thus, this station 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 hydro power plant.

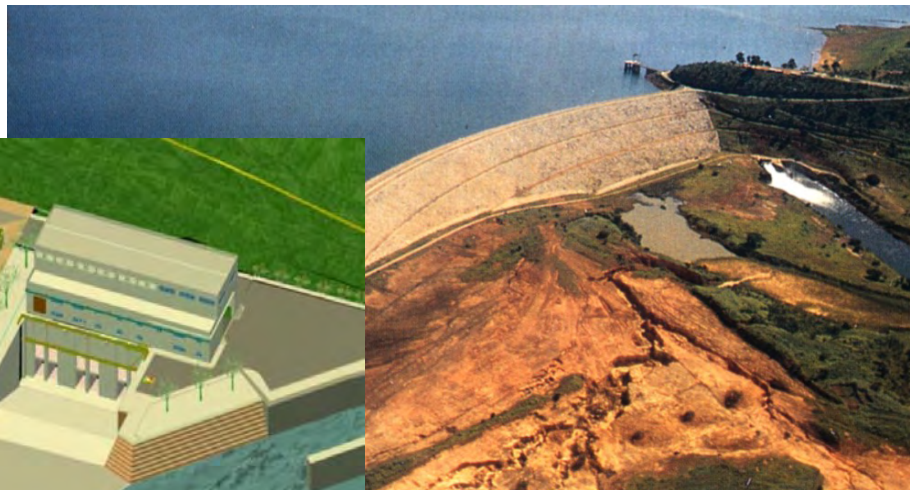
**Dam:**

The Gove dam site covers a basin area of 4 667 km<sup>2</sup> and the reservoir, with the NWL at (1590,00), has a storage capacity of 2547 x 10<sup>6</sup> m<sup>3</sup>.

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 10<sup>6</sup> m<sup>3</sup>.

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 minimise 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 gullying;
- 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.





## HYDROELECTRIC DEVELOPMENTS

### HYDROELECTRIC DEVELOPMENT OF THE RABAÇAL RIVER NEARBY BOUÇOAIS-SONIM

PORTUGAL

#### HYDROELECTRIC DEVELOPMENT OF THE RABAÇAL RIVER NEARBY THE REBORDELO VILLAGE

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

#### Final Design and Technical Assistance:

2003 / 05

#### Hydraulic Circuit

- The hydraulic circuit is installed between the reservoir and the power station, 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 m<sup>3</sup>/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.

#### DESCRIÇÃO

The Rabaçal Hydro Power Project is located nearby 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 organisations, 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 <sup>3</sup> m <sup>3</sup> |
| – Reservoir capacity: | 3,13 x 10 <sup>6</sup> m <sup>3</sup> |
| – Maximum flood flow: | 1480 m <sup>3</sup> /s                |
| – Spillway:           | overflow, without gates               |

#### Power Station

The power station 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 <sup>3</sup> /s |
| – Number of units:          | 1, Kaplan turbines     |
| – Design flow:              | 24,4 m <sup>3</sup> /s |
| – Annual energy generation: | 24 GWh/year            |







## HYDROELECTRIC DEVELOPMENTS

### EL BORJ HYDROELECTRIC DEVELOPMENT

MOROCCO

#### EI BORJ HYDROELECTRIC DEVELOPMENT

**Client:**  
ONE – Office National  
d'Electricité

**Feasibility Study:**  
1998/99

**Design and Contract  
Documents:**  
1999/2003

**Studies developed in  
association**

**Estimated costs of the  
project: 36 million Euros**



The El-Borj hydroelectric project is located at the oued Oum Er Rbia. It is composed of the following infrastructures:

#### Tanafnit Dam

- Purpose: Hydropower generation
- Type: Mixed dam (earthand rockfill)
- Purpose: Power generation
- Height: 25 m
- Crest length: 270 m
- Volume of dam:  $201 \times 10^3 \text{ m}^3$
- Reservoir capacity:  $2 \times 10^6 \text{ m}^3$
- Maximum flood flow:  $1\,100 \text{ m}^3/\text{s}$

#### Hydroelectric power plant

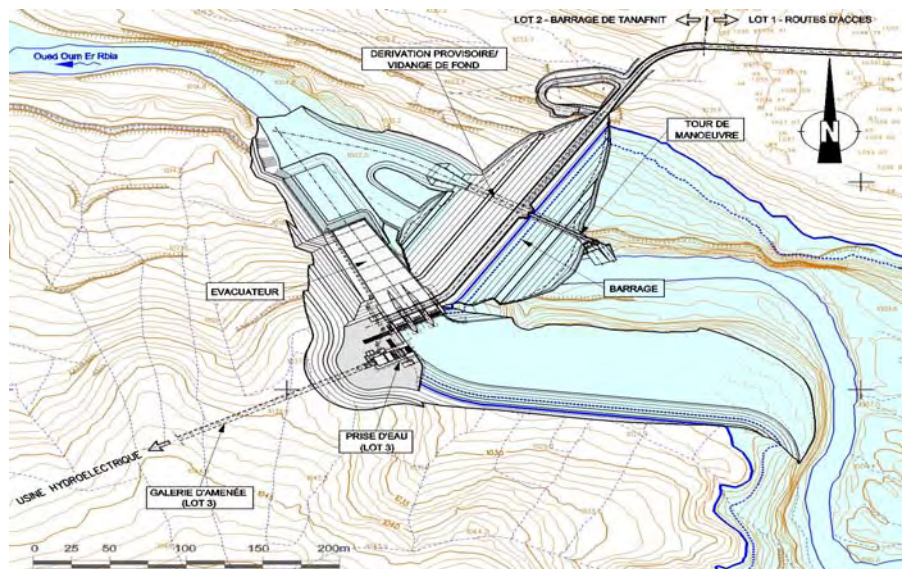
- Installed capacity: 21,3 MVA
- Units: 2, Francis turbines
- Head: 106,5 m
- Design flow:  $24 \text{ m}^3/\text{s}$  ( $2 \times 12 \text{ m}^3/\text{s}$ )

#### Hydraulic Circuit (10,7 km)

- Tunnel: 10,5 km
- Inside diameter: 3,30 m
- Design flow:  $24 \text{ m}^3/\text{s}$

#### Access roads

- Length: 6,2 km
- Bridge over the oued Oum er Rbia with 43 m





## APROVEITAMENTOS HIDROELÉTRICOS

### PORTUGUESE NATIONAL PROGRAM ON DAMS WITH HIGH HYDROELECTRIC POTENTIAL

PORTUGAL

#### PORTUGUESE NATIONAL PROGRAM ON DAMS WITH HIGH HYDROELECTRIC POTENTIAL

**Client:** REN – Rede Eléctrica Nacional / INAG

2007

Studies undertaken by the consortium COBA/PROCESL

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 CO<sub>2</sub> 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](http://www.inag.pt)) or on COBA site ([www.coba.pt/landpnba/](http://www.coba.pt/landpnba/)). Here the dam sites and the reservoirs areas can be visualised and all documents can be consulted.



## HYDROELECTRIC DEVELOPMENTS

### CHIUMBE-DALA HYDROELECTRIC DEVELOPMENT

ANGOLA

#### REHABILITATION OF CHIUMBE - DALA HYDROELECTRIC DEVELOPMENT

**Client:**

ENE – Empresa Nacional de  
Electricidade

**Tender Design:  
2002/03**

#### *Studies undertaken in association*

**... Cont.**

- Access roads, including:
  - Access road to the powerplant and substation (approximate length: 1 400 m);
  - Bridge over the Chiumbe river (14,40 m span).

Besides these works, the project will include a 60 kV line for energy transportation, approximately 80 km long, and a local 6 kV power line.

This hydroelectric development located in the Chiumbe River, near the town of Dala situated in the Lunda-Sul Province, essentially envisages hydropower supply to the city of Luena, in the Moxico Province.

Construction of this project was initiated in 1981 and subsequently interrupted, having been undertaken all civil works associated to the diversion weirs, water intake, conveyance canal, canal-pipeline transition structure and access bridge, and general earthworks associated to the remaining works. No equipment was installed, and the construction of the powerhouse was not initiated.

The studies now undertaken include Hydrological and Energy studies, Technical and Economic Feasibility Study and a Final Design that includes preparation of the Tender Documents for Works bid launching.

The general characteristics of the Chiumbe-Dala hydroelectric development are as follows:

- Diversion weir in the Chiumbe river, with a total length of 143,50 m and a height of 1,65 m.
- 342 m long hydraulic circuit, comprising:
  - 44,80 m wide water intake divided into nine sections,
  - Trapezoidal conveyance canal (which also acts as a forebay) with a length of about 109 m,
  - Canal-pipeline transition structure,
  - Penstocks, comprising two steel pipelines with  $\varnothing$  2 200 m and 213 length each.
- Hydropower plant, located on the west bank of the Chiumbe River and equipped with four units, one of which is to be installed in a second phase. Total installed capacity shall be 12,42 MW.
- The 60 kV substation shall be located close to the power plant, on the right bank. **(description continues at the left)**





## HYDROELECTRIC DEVELOPMENTS

### PEDROGÃO STAGE HYDRO POWER DEVELOPMENT. POWERPLANT II

PORTUGAL

#### ALQUEVA MULTIPURPOSE DEVELOPMENT. PEDRÓGAO STAGE HYDRO POWER PLANT. POWER PLANT II

**Client:** EDP – Electricidade de Portugal

**Licensing Design, Tender Design and Environmental Impact Assessment:**  
2008/..

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 m <sup>3</sup> /s
Number of units:.....	1, Kaplan
Hydraulic Circuit: 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.	





## HYDROELECTRIC DEVELOPMENTS

### ALQUEVA HYDROELECTRIC DEVELOPMENT. STRENGTHENING OF HYDROPOWER GENERATION

PORTUGAL

#### ALQUEVA HYDROELECTRIC DEVELOPMENT. STRENGTHENING OF ALQUEVA II POWER GENERATION

**Client:** EDP – Electricidade de Portugal

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

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.

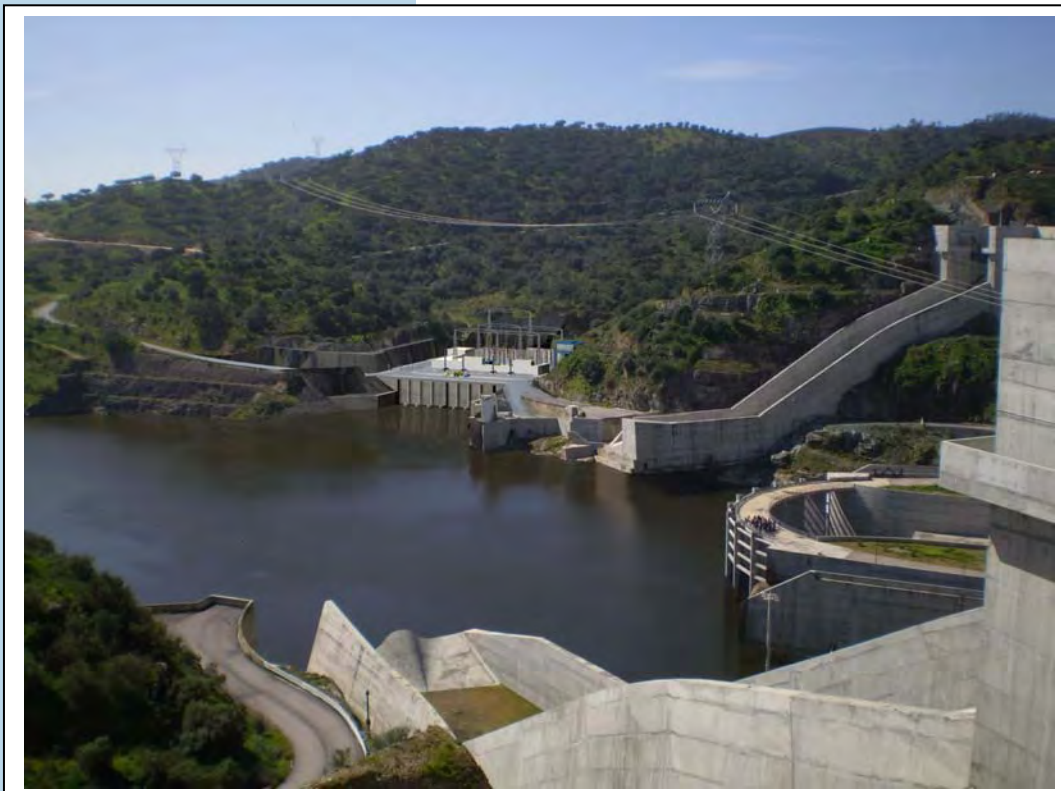
The Alqueva stage water power development includes the hydraulic tunnel hydraulic, the power plant, the outlet and the substation.

#### 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 <sup>3</sup> /s
Net head: .....	71 m
Capacity .....	129,6 MW



#### Outlet

Exit level ... (74 m)

#### Substation

Unit transformers:  
- Capacity 150 MVA

The cost estimation for the Alqueva II project is of 166,5 M Euros as at June 2007.



## HYDROELECTRIC DEVELOPMENTS

### HYDROELECTRIC DEVELOPMENT OF THE RABAÇAL RIVER NEARBY BOUÇOAIS AND SONIM

PORTUGAL

#### HYDROELECTRIC DEVELOPMENT OF THE RABAÇAL RIVER NEARBY THE BOUÇOAIS AND SONIM VILLAGES

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

**Final Design and Technical Assistance:  
2003 / 05**

#### Hydraulic Circuit

- The hydraulic circuit 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 m<sup>3</sup>/s.

#### Access roads

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

#### DESCRIÇÃO

The Rabaçal hydro-electric 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 <sup>3</sup> m <sup>3</sup> |
| – Reservoir capacity: | 1,4 x 10 <sup>6</sup> m <sup>3</sup>  |
| – Maximum flood flow: | 1500 m <sup>3</sup> /s                |
| – Spillway:           | overflow, without gates               |

#### Power Station

The power station 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 <sup>3</sup> /s |
| – Number of units:          | 2, Francis turbines  |
| – Design flow:              | 22 m <sup>3</sup> /s |
| – Annual energy generation: | 30 GWh/year          |





## HYDROELECTRIC DEVELOPMENTS

### LUACHIMO HYDROELECTRIC DEVELOPMENT

ANGOLA

#### LUACHIMO HYDROELECTRIC DEVELOPMENT. REHABILITATION AND STRENGTHENING OF THE POWER GENERATION CAPACITY

**Client:**

ENE – Empresa Nacional de  
Electricidade

**Technical and Economical  
Feasibility Study  
2006/07**

*Studies undertaken in  
Association with SOF and  
BDO*

The Hydroelectric Development is located in the Luachimo River, Province of Lunda-Norte in Angola, approximately 3 km to the northeast of the Dundo locality.

It's construction dates back to the 50's and the plant began operating during 1957.

In light of the overall poor condition of the undertaking, especially as far as the operation of equipments is concerned, these studies envisage the rehabilitation of the undertaking and the eventual strengthening of the power generation capacity, due to the increasing demand for electrical power in the region.

The Luachimo Hydroelectric Development is composed of:

- A concrete dam, 12 m wide at the base and 6,5 average height above the river bed
- Concrete-lined conveyance canal with a total extension of 660 m.
- 4 reinforced concrete penstocks with an inner diameter of 2,50 m. Each one of these supplies one of the plant's turbines.
- Power plant:

Gross/net Head:	17 m
Installed Capacity:	8,4 MW
Rated Flow:	15,4 m <sup>3</sup> /s
Turbine:	
Quantity:	4
Type:	Francis

Three alternative solutions were studied. At this stage, alternative 2 figures to be the one that most satisfactory responds to the present and future demands of a very poorly supplied region as far as electricity is concerned. Taking into account the available water resources, this solution considers the possibility of increasing the turbinated flow from the current 61,6 m<sup>3</sup>/s to 181,6 m<sup>3</sup>/s, and the total installed capacity from 8,4 MW to 26,6 MW. This can be achieved by rehabilitation of the existing undertaking accompanied by the construction of a new power plant and respective hydraulic circuit.





## HYDROELECTRIC DEVELOPMENTS

### RIBEIRADIO – ERMIDA HYDROELECTRIC DEVELOPMENT

PORTUGAL

#### RIBEIRADIO – ERMIDA HYDROELECTRIC DEVELOPMENT

**Client:** EDP / EVIVA

**Preliminary Study**  
2007

**Design and Tender  
Documents, Final Design,  
Environmental Impact  
Assessment, Technical  
Assistance:**

2008/..

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-EVIVA, for whom COBA prepared the preliminary design that founded their offer.

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

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

#### Ribeiradio Dam

- Type: Concrete gravity dam
- Height: 75 m
- Crest length: 295 m
- Reservoir capacity: 133 x 106 m<sup>3</sup>
- Maximum flood flow: 3 250 m<sup>3</sup>/s
- Spillway: gated spillway
- Bottom outlet: conduit with a 2 m diameter (100 m<sup>3</sup>/s)

#### Power plant

- Capacity: 72 MW
- Head: 66 m
- Nominal flow: 125 m<sup>3</sup>/s
- Number of units: 1, Kaplan turbine
- Yearly Power generation: 117 GWh
- Underground hydraulic water way formed of a gallery with a length of 210 m and 6 m inside diameter.

#### Ermida Dam

- Type: Concrete gravity dam
- Height: 29,5 m
- Crest length: 125 m
- Spillway: uncontrolled overflow  
64 m wide

#### Ermida power plant

- Capacity: 6,1 MW
- Head: 14 m
- Nominal flow: Unit 1: 15 m<sup>3</sup>/s;  
Unit 2: 35 m<sup>3</sup>/s
- Number of units: 2, Kaplan turbines
- Yearly power generation: 17,3 GWh

