
Hydropower
GROUP
coba
ENGINEERING AND ENVIRONMENTAL CONSULTANTS

PRESENTATION

COBA is a multinational and multidisciplinary group of Engineering and Environmental Consultants, founded in 1962.

The Group provides engineering consultancy services ranging from basic and planning studies, technical, environmental and economic feasibility studies, design and construction design as well as project management and works supervision, to operation follow-up and behaviour monitoring.

The Group has offices/subsidiaries in three continents and experience in sixty countries and encompasses several companies in accordance with functional specializations or geographical areas.

The competences acquired along the last six decades, together with the state-of-the-art employee expertise, the stability of its permanent staff and the comprehensive international experience allow to find out the best solutions for the full satisfaction of public and private Clients' needs and expectations.

During its existence, the Group has participated together with public authorities or private developers, in the feasibility of multidimensional projects, some of them being structuring projects and with major impacts on the improvement of peoples' life conditions in the several countries where it worked.

At present, the Group has a wide number of competences and technical areas that allow the composition of multidisciplinary teams who share knowledge and experiences in the execution of projects.

BEGINNING AND EVOLUTION

Since its foundation, hydroelectric power is one of the major areas of expertise of COBA given its involvement in the study of hydraulic developments, namely dams for power generation.

The first major achievement in the 60's was the design of the Funil Hydroelectric Power Development, on the Paraíba river in Brazil, with an installed capacity of 216 MW and operating since 1969.

Until the early 80's, several hydroelectric power plants were designed in Angola, Mozambique, Greece, Brazil, Costa Rica and Portugal, with installed capacities ranging between 40 MW and 520 MW. Special reference is made to the Sela Hydropower plant in Portugal (152 MW) and Sfikia (315 MW) and Assomata (108 MW) Hydropower plants in Greece. COBA's intervention was from Feasibility Studies and Design to Technical Assistance to Construction, including the approval of as-built plans for the civil works and equipment.

From the 80's, COBA started its activity in small hydropower plants in Continental Portugal and Azores Autonomous Region and in Guinea-Bissau. This activity has continued until now with the execution of several studies and designs in Portugal and abroad, some of which are under construction or in operation. In Portugal, this increase was mainly due to the new legislation that favoured the independent power generation through small power plants with a maximum capacity of 10 MW.

During this period, COBA also started activities in the rehabilitation, refurbishment and uprating of power plants built in the first half of the XX century, improving outputs and allowing for remote control operation, with special emphasis on the power plants of the Serra da Estrela Hydroelectric Development in Portugal.

Courtesy of ODEBRECHT

CURRENT SITUATION AND PERSPECTIVES

In Portugal, after a long period of inactivity in this field, the Government recognized the importance of hydroelectric energy for the economic and social development of the country, since it enables the use of not yet exploited water resources. Besides being a national, clean and renewable resource, its conversion into hydroelectric energy will allow the increase of other intermittent renewable energy sources (wind and solar), and the energy transition to a system based on renewable sources, reducing the dependence on imported fossil fuels and lowering greenhouse gas emissions.

This new cycle started with the 2007 National Program for Dams with High Hydroelectric Potential, for which COBA was the leading Consultant, which defined 10 large hydroelectric dam sites to be developed in the near future. In the meantime, numerous hydropower projects were granted to EDP Produção as Concessions and COBA intensified its collaboration with EDP, executing studies and designs with emphasis on the following projects: , Alqueva II (260 MW), Pedrogão II (13 MW), Alvito (214 MW), Fridão (241 MW), Foz Tua (262 MW), Feiticeiro (30 MW), Ribeiradio-Ermida (75 MW and 8 MW) and Salamonde II (209 MW).

Abroad, recent years were marked by the strong growth of this activity in Angola, Morocco, Senegal, Brazil, Mozambique, Malawi, Guinea-Bissau and Pakistan. Special reference must be made to the large hydroelectric projects undertaken in Angola namely: Caculo Cabaça (2 172 MW), Laúca (2 070 MW) and Cambambe II (714 MW) on the Kwanza river and Gove (62 MW), Jamba-ia-Mina (224 MW), Jamba-ia-Oma (79 MW) and Matala (42 MW) on the Cunene river and many other smaller projects located all over the country, including the rehabilitation of several existing hydropower plants in other watersheds. In the other geographies, Saltinho (27 MW) in Guinea-Bissau and the multipurpose Mapai (18 MW) in Mozambique are also landmark projects.

Pumped-Storage Projects have gained relevance in recent years. Most of the projects developed in Portugal are equipped with reversible pump-turbine units and COBA is developing the Master Plan for Pumped-Storage Projects in Morocco and the Feasibility Study for a Pumped-Storage Project in Santiago Island (20 MW) in Cape Verde.

It is expected that the expansion of this activity will continue in the coming years both in Portugal and worldwide with new assignments guaranteeing the future of COBA's team in several scientific fields associated with these multidisciplinary projects, maintaining the international reputation gained throughout decades.

FIELDS OF ACTIVITY

HYDRAULIC UNDERTAKINGS
Concrete, Earth-fill and Rock-fill Dams. Weirs and Reservoirs Water Conveyance Systems. Hydraulic Structures.

POWER GENERATION AND TRANSMISSION
Hydroelectric Power Plants. Photovoltaic power plants and wind farms. Small Hydropower Plants. Power Plants Rehabilitation and Modernization. Substations High Voltage Transmission Lines. Cooling Water Systems for Thermoelectric Plants.

WATER SUPPLY AND WASTEWATER SYSTEMS
Catchment, Transport and Distribution of Potable Water. Water Treatment Plants. Drainage Systems. Wastewater Treatment Stations. Pumping Stations.

AGRICULTURES AND RURAL DEVELOPMENT
Irrigation and Drainage Systems. Rural Roads. Production Systems. Mapping and Basic Information.

TRANSPORTATION INFRASTRUCTURES
Roads and highways. Railways. Passenger and Freight Railway Stations. Metro and Light Rail. Airports. Bridges and other engineering structures.

ENVIRONMENT
Environmental Impact Assessment. Environmental Management, Monitoring and Auditing. Pollution Control. Landscaping. Land Management. Recovery of Degraded Areas. Waste Landfills.

GEOTECHNICAL STRUCTURES
Tunnels and Caverns. Slopes in Fill and Cut Section. Special Foundations Breakwaters. Embankment Works.

MARITIME AND FLUVIAL WORKS
Wharfs. River Training. Quay Rehabilitation. Flood and Flow Control.

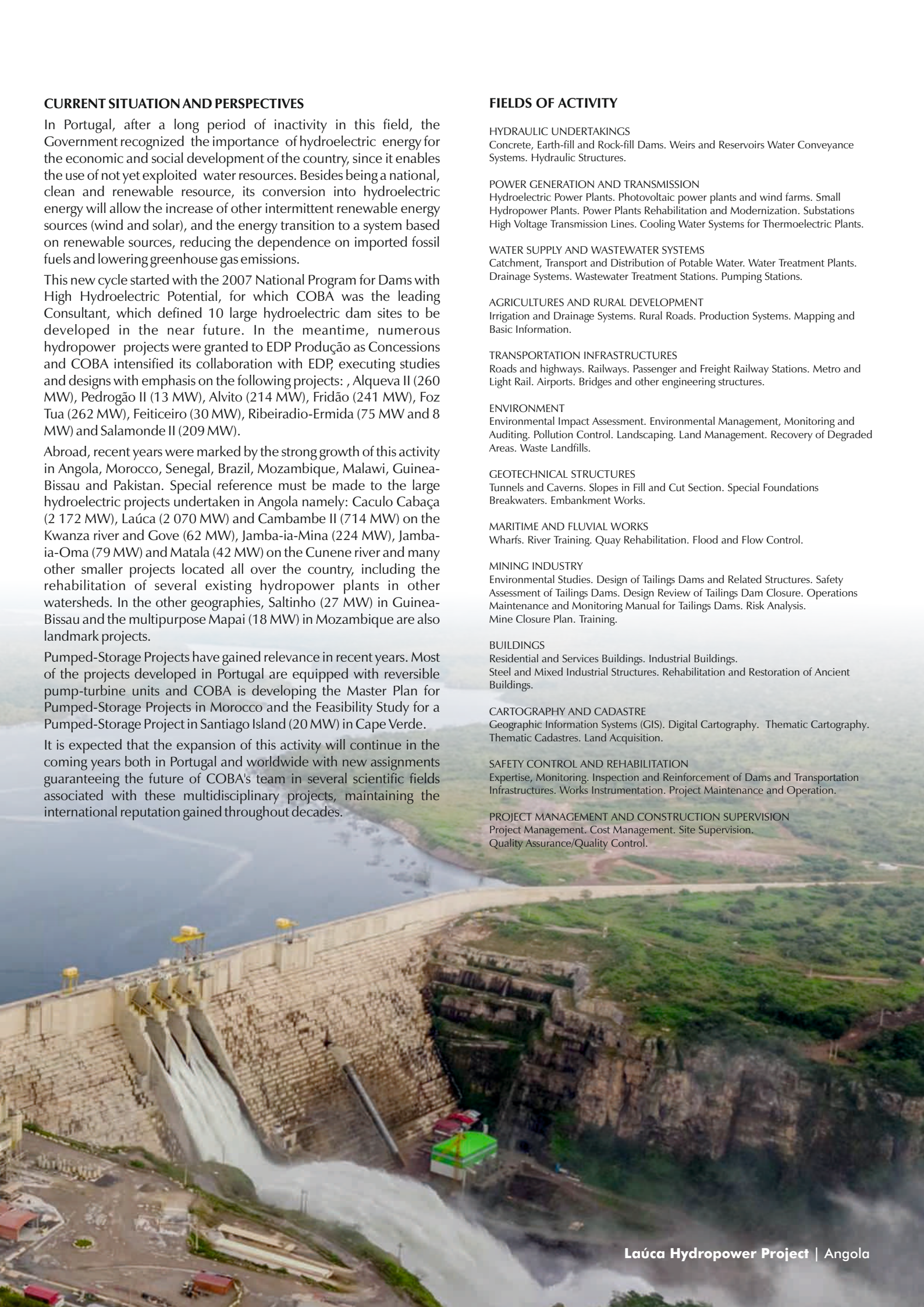
MINING INDUSTRY
Environmental Studies. Design of Tailings Dams and Related Structures. Safety Assessment of Tailings Dams. Design Review of Tailings Dam Closure. Operations Maintenance and Monitoring Manual for Tailings Dams. Risk Analysis.
Mine Closure Plan. Training.

BUILDINGS
Residential and Services Buildings. Industrial Buildings.
Steel and Mixed Industrial Structures. Rehabilitation and Restoration of Ancient Buildings.

CARTOGRAPHY AND CADASTRE
Geographic Information Systems (GIS). Digital Cartography. Thematic Cartography. Thematic Cadastres. Land Acquisition.

SAFETY CONTROL AND REHABILITATION
Expertise, Monitoring. Inspection and Reinforcement of Dams and Transportation Infrastructures. Works Instrumentation. Project Maintenance and Operation.

PROJECT MANAGEMENT AND CONSTRUCTION SUPERVISION
Project Management. Cost Management. Site Supervision.
Quality Assurance/Quality Control.



Laúca Hydropower Project | Angola

HYDROELECTRIC DEVELOPMENT

CACULO CABAÇA 2 172 MW

KWANZA RIVER - ANGOLA

The Caculo Cabaça Hydropower Project (HPP) is located on the middle Kwanza river, upstream from the Caculo Cabaça Falls, in the border of the Kwanza North and Kwanza South provinces, about 270 km away from the city of Luanda.

This hydropower project is the fourth step of the cascade development to be built on the river, upstream of Cambambe HPP and downstream of Capanda and Laúca HPPs.

The hydropower scheme is designed to be operated in an integrated manner with the Capanda and Laúca hydropower schemes.


3D Preview


River Diversion

DAM	
Type	Gravity, roller compacted concrete
Height	103 m
Crest length	553 m
Total amount of concrete	1 450 000 m^3
Reservoir capacity	436 x 10^6 m^3
Spillway	Located on the dam's central blocks, discharge 10 020 m^3/s via an overflow crest controlled by five radial gates
Bottom outlet	Located in the dam's blocks 8 and 9, steel lined tunnels with Ø 6.0 m
MAIN POWER PLANT	
Underground (cavern)	221 x 26.5 m^2
Capacity	4 x 530 MW = 2 120 MW
Gross head	217.30 m
Rated net head	209.20 m
Rated flow	275 m^3/s
Number of units / Type	4 / Francis vertical axis
Energy generation	8 123 GWh/year
ANCILLARY POWER PLANT (ENVIRONMENTAL FLOW)	
Area	42.1 x 18 m^2
Capacity	52 MW
Gross head	96.1 m
Rated net head	94.6 m
Rated flow	60 m^3/s
Number of units / Type	1 / Francis vertical axis
Energy generation	443 GWh/year
WATER CONVEYANCE SYSTEM	
Headrace waterway system	4 x 299 m (pressure shaft – 171 m; sloping concrete lined tunnel – 69 m and steel lined tunnel – 59 m)
Diameter	9 m (concrete lined section); 6.5 m (steel lined section); 6 m (spiral case inlet section)
Total rated flow	4 x 275 m^3/s
Surge chambers	2, in underground cavern, 63.8 m high, 1 049 m^2 area
Tailrace tunnels	
Tunnel 1	5 133 m
Tunnel 2	5 162 m
Cross section	arch-rectangle, 16 x 16 m^2
Rated flow per tunnel	550 m^3/s

The Caculo Cabaça dam consists of a 103 m high RCC gravity dam with a total crest length of 553 m. The spillway is located on the central blocks of the dam and will discharge up to 10 020 m^3/s via an overflow crest controlled by five radial gates.

The water conveyance system is totally underground and designed for a water discharge of 1100 m^3/s. The water intake, located 2.4 km upstream of the dam's left abutment, convey the flow directly to four concrete lined vertical pressure shafts, four steel lined tunnels, leading to the underground hydropower plant.

The power plant is equipped with four 530 MW Francis turbine, operating at a head from 202 m to 215 m.

Downstream of the power plant two pressurized tailrace tunnels, about 5 200 m long and up sloping at 0.4%, convey the turbined water to the Kwanza river. The cross section of the unlined tailrace tunnels is an arch-rectangle, 16 m wide and 16 m high.

POWER PLANT

HYDROELECTRIC DEVELOPMENT

LAÚCA 2 070 MW

KWANZA RIVER - ANGOLA

The Laúca Hydropower Project is located on the Kwanza river, about 47 km downstream from the Capanda Hydropower Undertaking, currently under operation, and with the main purpose of energy generation.

The HPP is composed of a RCC dam, an underground water conveyance system associated to the underground power plant with an installed capacity of 2004 MW and an environmental flow waterway system that includes an ancillary power plant with an installed capacity of 65.5 MW.

DAM

Type	RCC
Height	132 m
Crest length	1 075 m
Total amount of concrete	2 750 000 m^3
Reservoir capacity	5 482 x $10^6 m^3$
Spillway	Equipped with three 15 m-wide radial gates
Spillway design flow	10 020 m^3/s
Bottom outlet	Rectangular pipeline, 5.6 m wide and variable height between 6.7 and 8.0 m, 117.8 m long, steel lined (800 m^3/s)

MAIN POWER PLANT

Underground	21 m wide and 294 m long
Underground excavation	320 000 m^3
Capacity	6 x 334 MW = 2004 MW
Net head	200 m
Rated flow	182 m^3/s
Units	6 vertical axis Francis units equipped with ring gates
Energy generation	8 640 GWh/year

ANCILLARY POWER PLANT (ENVIRONMENTAL FLOW)

Surface toe-of-dam power plant	
Open air excavation	6 200 m^3
Capacity	65.5 MW
Net head	128 m
Rated flow	60 m^3/s
Units	1 vertical axis Francis unit

SUBSTATIONS

Main Substation	400 kV
Ancillary Substation	220 kV

WATER CONVEYANCE SYSTEM (ENERGY GENERATION):

Underground system composed of 6 water intakes, 6 pressure shafts with inner diameter of 7.0 m and depths ranging from 110 m to 115 m and 6 galleries with 9.0 m x 12.0 m (w x h), average length of 1 900 m each and slope of 4%.

Courtesy of ODEBRECHT

HYDROELECTRIC DEVELOPMENT

CAMBAMBE II 714 MW

KWANZA RIVER - ANGOLA

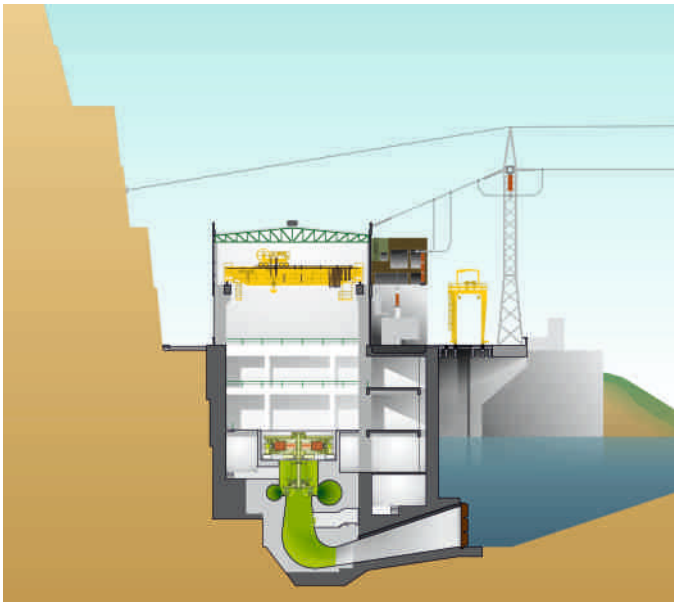
The Cambambe Hydropower Project is located in the Kwanza river, approximately 180 km southwest from the city of Luanda and 15 km from the city of Dondo. It was initially designed and built for a phased construction.

The Phase II of the Project is divided in two lots: civil construction works (Cambambe power plant II) and electrical and mechanical equipment (supply and assembly).

Cambambe power plant II has an installed capacity of 714 MW.

It includes the construction of the following main components:

- a new water intake and water conveyance tunnels.
- a power plant with 4 generating units , transformers, substation and ancillary systems and control building.



The activities conducted by COBA within the scope of the project were:

- 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.

TURBINES

Units/Type	4 / Vertical axis Francis
Rated capacity (per unit)	178.6 MW
Installed capacity	714.4 MW
Energy generation	4 400 GWh/year
Rated flow rate (per unit)	~180 m^3/s
Rated net head	111.50 m
Guaranteed net head	109.30 m
Maximum gross head	116.84 m
Minimum gross head	107.77 m

GENERATOR

Rated capacity	195.47 MVA
Rated voltage	15 kV

TRANSFORMERS

Units	4+1
Transformation ratio	15 kV/220 kV

SUBSTATION

400 kV
220 kV
60 kV

WATER CONVEYANCE SYSTEM

Water intake

Ground level	+109.60
Platform level	+132.00
Fixed wheel gates	4 with 6.5×8.5 m^2
Stoplogs	2 with 6.5×8.5 m^2
Trashracks	4 with13.8×13.8 m^2

Pressure shafts

Units	4
Average height	47 m
Outer Ø	8.5 m
Inner Ø	7.7 m
Lining	reinforced concrete

Sub horizontal tunnels

Units	4
Average length	440 m
High-pressure section	100 m
Slope	3% to 10%
Excavation Ø	8.5 m
Hydraulic Ø	7.7 m
Hydraulic Ø of high-pressure section	6.9 m
Lining	reinforced concrete/steel

Tailrace structure

Stoplogs	4 x 5.9 x 6.7 m^2
Gantry crane capacity	250 kN

HYDROELECTRIC DEVELOPMENT

KHOLOMBIDZO 219 MW

SHIRE RIVER - MALAWI

The hydropower scheme uses a natural head of 55 m and can provide 218.8 MW (212.8 MW + 6 MW) of power generation capacity.

The run-of-river development involves the construction of a diversion dam and appurtenant structures, the left bank waterway, the main hydropower plant and the environmental flow hydropower plant.

The dam with central gated spillway is located 160 m downstream of the existent Matope bridge and consists of a 16.8 m high concrete gravity dam founded on a gneiss rock mass outcropping in the river bed. The total crest length is 265 m at elevation 470 m.a.s.l. The dam with full supply water level at 468 m.a.s.l. impounds a reservoir of 26.7 million m^3 capacity and an inundated area of 21.7 km^2.

DAM

Type	Concrete gravity
Maximum height	16.8 m
Crest length	265 m

Spillway

Type	Gated, open surface
Type and number of gates, dim. (w x h)	Radial gates, 5 x (14.0 x 10.5) m^2
Energy dissipation structure	Stilling basin

WATER CONVEYANCE SYSTEM

Intake structure

Type and no. of safety gates, dim. (w x h)	Fixed-wheel, 2 x (6.3 x 8.0) m^2

Headrace tunnels

Number	2
Length	2 775 m (tunnel 1) and 2 828 m (tunnel 2) (~131 m steel lined)
Diameter	8.0 m
Surge chamber diameter	32 m

Tailrace canal

Length	1100 m
Discharge capacity	400 m^3/s

POWER PLANT

Type	Surface
Number of units	4 Francis turbines
Total rated flow	400 m^3/s
Unit rated flow	100 m^3/s
Rated head	58.8 m
Installed capacity	4 x 53.2 MW = 212.8 MW
Energy generation	1212 GWh/year

SWITCHYARD

Type	Indoor GIS

Transformers

Number	4
Power	66 MVA
Transmission line voltage	132 kV

ENVIRONMENTAL FLOW POWER PLANT

Type	Surface
Number of units	1 Kaplan Bulb type turbine
Rated flow	58 m^3/s
Rated head	11.4 m
Installed capacity	6 MW
Energy generation	46.8 GWh/year

The power waterway, designed for a flow rate of 400 m^3/s, comprises the following major components:

- Intake at tunnels portal near the dam left abutment;
- Two headrace tunnels, circular section (inner diameter 8.0 m), concrete lined and constant slope. Each tunnel supplying water to two of the four generating units;
- Two cylindrical surge chambers, one per tunnel, with 32.0 m of internal diameter and 38 m high, to provide protection against transient events and ensure stability of operation;
- The headrace tunnels end with steel lined sections that bifurcate into four tunnels upstream the four generating units installed at the power plant;
- Four tailrace tunnels, circular section (inner diameter 7.4 m), concrete lined, that connect the draft tubes of the powerhouse to the outlet portal near Mkundi river;
- Unlined tailrace canal, trapezoidal section with bottom width of 40 m and constant slope, conveying water back to Shire river.

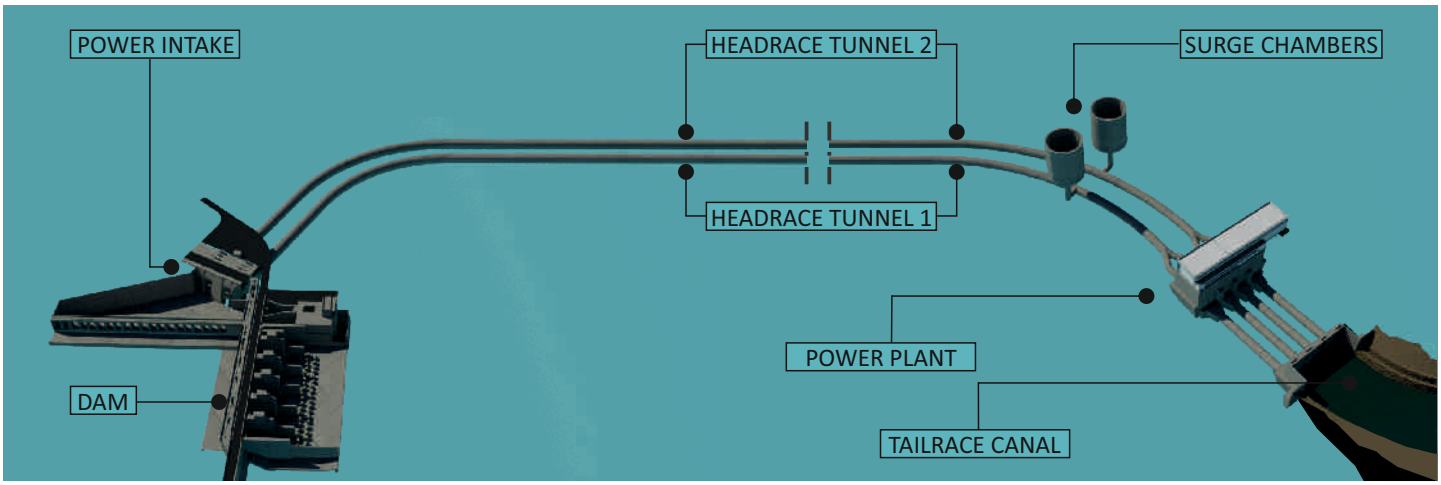
The total length of the power waterway is 4.2 km.

The surface power plant is equipped with four 53.2 MW Francis type turbine coupled to a 63 MVA generator, operating at a rated net head of 58.8 m. The rated flow is 100 m^3/s per unit, totalling 400 m^3/s. The transformers are located on the access platform to the power plant. The switchyard for a voltage level of 132 kV is located in an excavated platform between the power plant and the surge chambers.

The river diversion for the main power plant, implies the maintenance of an environmental flow regime in the Shire river reach between diversion dam and tailrace of the power waterway. It was found interesting the construction of a small hydropower plant to turbine these flows. The environmental flow power plant is equipped with one 6 MW Kaplan Bulb, horizontal axis type turbine, operating at a rated flow of 58 m^3/s and net head of 11.4 m.

The electrical network connection is assured by two 132 kV Overhead Transmission Lines with approximately 16 km long between HPP and Phombeya substation.

OVERALL LAYOUT



HYDROELECTRIC DEVELOPMENT

ORIANG 435 MW

KYOGA NILE RIVER - UGANDA

The Oriang hydropower scheme is located in the Republic of Uganda, on the Kyoga Nile river that flows from Lake Kyoga to the Albert Lake, approximately 90 km upstream of the latter. The HPP is also located about 30 km downstream from the Karuma HPP, under construction, and 14 km upstream from the planned Ayago hydroelectric development.

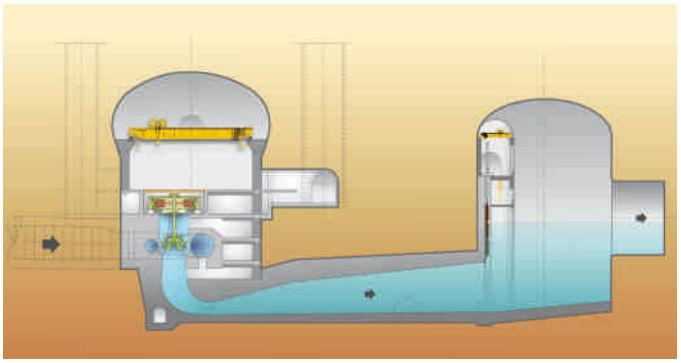
The design of the HPP includes a diversion dam, a water conveyance system, an underground power plant, a substation, an energy transmission line and access roads.

The dam is a mixed solution of rockfill and concrete and will have a spillway equipped with flood gates, a bottom outlet and a fish ladder. The design of the bottom outlet promotes the cleaning of sediments at the entry of the water intake structure.

The water conveyance system is composed by a water intake channel, four water intakes, short individual headrace tunnels, a power plant, two surge chambers and two free surface tailrace tunnels ending at an outlet structure.

The power plant will be equipped with four generating units of 435 MW total capacity and will consist of a cavern and a surface support building. The transformers will be located at the surface and the substation will be of the GIS type.

A double circuit overhead 400 kV energy transmission line shall ensure the connection with the Karuma Substation.

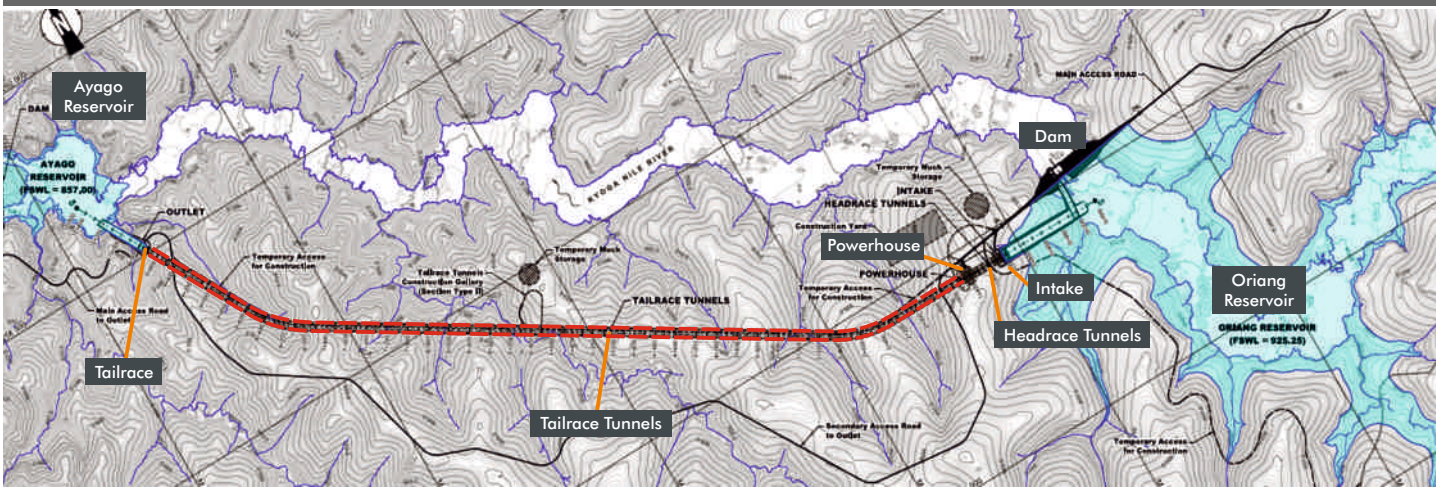


RESERVOIR	
FSWL (Full Supply Water Level)	925.25 m
Flooded area	9.98 km^2
Storage capacity	88.64 hm^3
DAM	
Type	Concrete and rockfill
Height	39 m
Crest length	1 620 m
WATER CONVEYANCE SYSTEM	
Total length	8.6 km
Length of headrace tunnels	326 m
Surge chambers dimension	2 x (40 x 28 x 44) m^3
Length of tailrace tunnels	8.25 km
POWER PLANT	
Number of units / Type	4 / vertical axis Francis
Rated flow	800 m^3/s
Net head	61.1 m
Installed capacity	435 MW
Energy generation	2 610 GWh/year

The studies undertaken by COBA included preliminary and pre-feasibility studies, having been subdivided into several milestones to analyze the technical and economic feasibility of the project, including: field visits, hydrologic studies, energy production simulations, alternative solutions studies, optimization and preliminary design of the main structures.

Furthermore, the studies scope also encompassed the specifications for the field works, namely topographical and bathymetric surveys, geotechnical survey campaign and tests, as well as a monitoring program of flows, water levels and sediments.

OVERALL LAYOUT



HYDROELECTRIC DEVELOPMENT

LUACHIMO 34 MW

Rehabilitation and Upgrade

The Luachimo hydropower development is located on the Luachimo river, close to the Dundo village, in the North Lunda province.

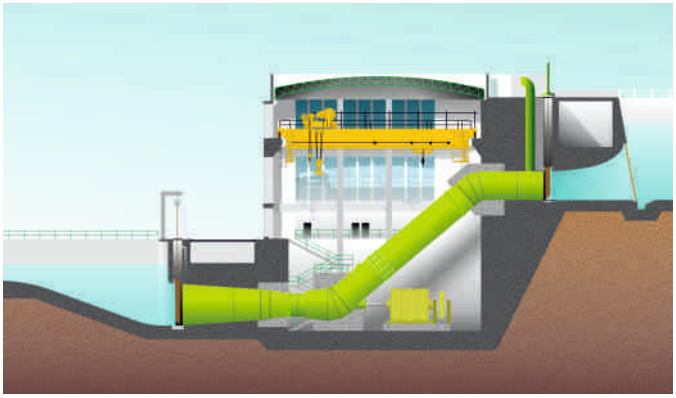
This is a run-of-river hydropower development, that uses a gross head of about 18 m between the weir and the tailrace outlet, in a short section of the river with about 750 m, where a series of successive rapids occurs.

Its construction dates to the 50's and the plant began operating in 1957. The HPP is composed of: i) a 6.5 m high dam with a 305 m long spillway; ii) a water conveyance canal designed for a flow of 61.6 m^3/s, including intake, conveyance canal, forebay and penstocks; iii) a hydropower plant equipped with four turbine-generator units with an installed capacity of 2.1 MW (total capacity of 8.4 MW).

In order to meet the current and future energy demands in the North Lunda province, and taking into account the available water resources in the Luachimo river, the Ministry of Energy and Water (MINEA) decided that the HPP should be refurbished and expanded, which led to an increase of four times the total installed capacity.

DAM	
Height	6.5 m
Crest length	305 m
WATER CONVEYANCE SYSTEM	
Flow Capacity	240m^3/s
Water intake	
Intake width	76.8 m
Trashrack	movable, 10 x (6.00 x 4.00) m^2
Stoplog type	slide gate, 10 x (6.00 x 1.50) m^2
Safety gate type	roller gate, 2 x (6.50 x 8.20) m^2
Headrace canal	
Total length	649 m
Cross section	trapezoidal
Bottom slope	0.13%
Canal invert width	4.35 m
Side slopes	1V:1.25H
Maximum height	9.0 m – 9.86 m
Forebay	
Length	116.0 m
Width near trashracks	8.0 m
Maximum height	13.3 m
Trashrack	fixed, 4 x (8.80 x 6.90) m^2
Safety gate	roller gate, 4 x (3.75 x 3.75) m^2
POWER PLANT	
Number of units	4
Area (including control building)	80.0 x 28.5 m^2
Maximum height above erection bay	21.4 m
Turbines	
Type	Kaplan, horizontal
Nominal flow	4 x 60 m^3/s
Gross head / Net head	18.2 m / 16.0 m
Rated capacity	4 x 8.5 MW
Energy Generation	262 GWh/year
Generators	
Rated capacity	4x 8.2 MW
Voltage	10 kV
Transformers	
Power	2 x 20 MVA
Voltage ratio	10 kV/60kV
Overhead crane	
Capacity	125 ton.
Span	25.4 m
SUBSTATION	
Type	exterior
Area	80.0 x 70.0 m^2
Interconnection voltage	60 kV

LUACHIMO RIVER - ANGOLA



Rehabilitation and expansion of the power generation capacity including: i) rehabilitation of the dam body and existing hydromechanical equipment; ii) construction of a new water conveyance system, composed of a water intake, conveyance canal, forebay and tailrace canal; iii) construction of a new power plant, located next to the existing plant, equipped with four turbine-generator units with a capacity of 8.5 MW each (total capacity of 34.0 MW) and construction of a new 60 kV substation.

HYDROELECTRIC DEVELOPMENT

FOZ TUA

262 MW
(Reversible)

TUA RIVER - PORTUGAL

The Foz Tua Hydropower Development, located on the Tua river close to the confluence with the Douro river , is composed of a double-curvature arch dam, an underground water conveyance system on the right bank and an underground reversible power plant, with a surface operation building.

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

COBA developed the Detailed Design, Licensing Project and the Tender Design of the power plant and water conveyance system. COBA was also responsible for the Construction Design and Technical Assistance of the dam and the river diversion.

DAM	
Type	Concrete, double-curvature arch dam
Height	108 m
Crest length	275 m
Reservoir capacity	106 x $10^6 m^3$
Maximum flood flow	5 500 m^3/s
Spillway	WES gated spillway, 4 radial gates with 15.7x11.5 m^2 and plunge pool stilling basin
WATER CONVEYANCE SYSTEM	
Total length	2 circuits, 700 and 770 m
Intake towers	2 x 40.3 m high
Headrace tunnels	580 and 620 m long, 7.5 m diameter
Tailrace tunnels	83 and 103 m long.
POWER PLANT	
Installed capacity	262 MW
Rated flow	2 x 155 m^3/s
Net head	93.6 m
Number/Type of units	2/reversible vertical axis Francis units
Unit capacity	131 MW
Energy generation	349 GWh/year
SUBSTATION	400 kV
Type	GIS
Transformers	2 x 150 MVA
Transformation ratio	15/415 kV

The water conveyance system has two independent circuits, each with total length of 700 m and 770 m, and includes a water intake, a pressure tunnel and a tailrace tunnel, with the following characteristics:

- Two water intake towers, 40.3 m high, with common access road at the dam crest level.
- Two pressure tunnels 580 m and 620 m long and 7.5 m diameter.
- Two tailrace tunnels 83 m and 103 m long, including a shaft for installation of the downstream stoplogs.

HYDROELECTRIC DEVELOPMENT

RIBEIRADIO - ERMIDA 75 MW - 8 MW

VOUGA RIVER - PORTUGAL

The Ribeiradio studies date back to 1975. In 2007, EDP/MARTIFER was awarded the concession to use water from the Vouga river, in the Ribeiradio-Ermida location. The Joint Venture contracted COBA to prepare the studies, design, and environmental impact studies of the development.

The Ribeiradio-Ermida Hydroelectric Project includes two stages, both equipped with a power plant.

The construction started in 2010 and the commercial operation began in 2015.

RIBEIRADIO 75 MW

DAM

Type	Concrete gravity dam
Height	83 m
Crest length	265 m
Reservoir capacity	136.4 x 10^6 m^3
Maximum flood flow	2 750 m^3/s

Spillway

Type	Central Overflow Spillway (ogee type) equipped with three radial gates of 13.0 x 13.6 m^2, with a Roller Bucket type energy dissipator (slotted bucket)

WATER CONVEYANCE SYSTEM

Total length	205 m
Diameter	5.5 m
Length of lined tunnel section	45 m
Diameter of lined tunnel diameter	4.8 m

POWER PLANT

Number of units/Type	1 / Francis, vertical
Rated flow	125 m^3/s
Net head	64 m
Capacity	75.4 MW
Energy generation	117 GWh/year

Generator

Apparent capacity	83 MVA
Voltage	15 kV

SUBSTATION

Transformer	86 MVA
Transformation ratio	15 / 67 kV

The Ribeiradio power plant is equipped with a Francis turbine with a capacity of 75.4 MW and annual power generation of 117 GWh.

The Ermida power plant is equipped with two horizontal axis Kaplan turbines.

The Ermida stage will enable the modulation of turbinated flows from the Ribeiradio power plant (125 m^3/s), releasing 6-50 m^3/s flows downstream.

ERMIDA 8 MW

DAM

Type	Concrete gravity dam
Height	35 m
Crest length	175 m
Reservoir capacity	3.9 x 10^6 m^3
Maximum flood flow	2 750 m^3/s

Spillway

Type	Uncontrolled overflow spillway (ogee type)

POWER PLANT

Number of units/Type	2/Horiz. axis S Kaplan turbine
Nominal flow	2 x 25 m^3/s
Net head	17.3 m
Capacity	2 x 3.9 MW
Energy generation	20.5 GWh/year

Generators

Apparent capacity	4.2 MVA
Voltage	6 kV

TRANSFORMER

Capacity	9 MVA
Transformation ratio	6 / 15 kV

HYDROELECTRIC DEVELOPMENT

SALAMONDE II

209 MW
(Reversible)

Integrated in the Cávado-Rabagão system, the Salamonde development takes advantage of 120 m available head between Salamonde and Caniçada reservoirs, immediately downstream.

The Salamonde power plant I is equipped with two Francis units with a rated capacity of 21 MW (25 MVA) per unit and a nominal flow of approximately 22 m^3/s per unit under a 115 m head. The annual power generation is around 220 GWh.

Considering an average net head of 115 m and an overall yield of 85%, the theoretical productivity of the site will be in the range of 280 GWh / year: under these conditions, the current average production amounts to about 80% of the theoretical productivity.

The equipped flow in the power plant of the first phase is slightly superior to the average inflow (equipment factor 1.33), which implies very high annual operation periods and a very low generation modulation capacity. This feature was compatible with the characteristics of the national power grid in the 50's and 60's, when most of the country's energy generation was hydroelectric and when essentially base load demand was provided by reservoir power plants.

Presently, the purpose of hydroelectric developments is mainly to supply energy during peak periods, as well as to balance the generation fluctuations that result from the variability of renewable sources as wind and solar, whose total capacity is increasing significantly.

EDP - Produção implemented a program for re-equipping the older developments, both run-of-river power plants (power plants of the International Douro river) and reservoir power plants (developments of the Cávado-Rabagão system). The Salamonde power plant II was within this program.

RESERVOIRS	
Salamonde	
Normal top water level	(270.36)
Minimum operating level	(259.00)
Caniçada	
Normal top water level	(152.50)
Minimum operating level	(144.00)
WATER INTAKE	
Racks	3 with 7.00 x 9.86 m^2
Stoplog	1 with 6.50 x 8.40 m^2
Service gate	1 with 6.50 x 8.34 m^2
WATER CONVEYANCE SYSTEM	
Headrace tunnel	
Total length	280 m
Diameter	8.3 m
Length of lined tunnel section	46 m
Diameter of lined tunnel section	5.8 m
Tailrace tunnel	
Length	2 017 m
Diameter	11.5 m
Downstream structure	
Racks	3 with 6.00 x 12.00 m^2
Stoplogs	3 with 6.00 x 12.00 m^2
POWER PLANT	
Number of units/Type	1 / Francis vertical pump reversible
Turbine	turbine generator-motor
Nominal flow	200 m^3/s
Net head	115.0 m
Rated capacity	209.1 MW
Energy generation	386 GWh/year
Pump	
Nominal flow	163.2 m^3/s
Net head	120.1 m
Maximum capacity	202.3 MW
Generator-Motor	
Capacity as generator	246 MVA
Capacity as motor	206 MVA
Voltage	15 kV

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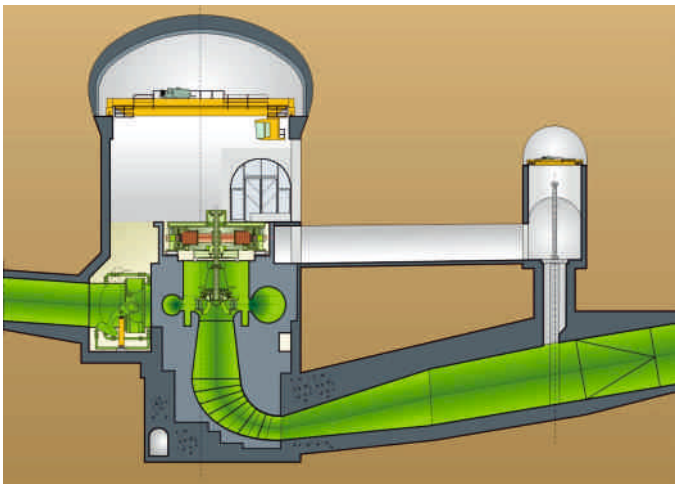
CÁVADO - RABAGÃO SYSTEM
PORTUGAL



The studies were awarded to COBA by EDP on 2009.

The increase of installed capacity of the new Salamonde power plant II does not correspond to a significant increase of the development capacity. On the other hand, the increased capacity will enable to modulate the generation according to demand, thus increasing significantly the flexibility of the development and the energy generated.

Particularly during very windy days, the increased wind energy in the national power grid will lead to potential surplus energy, especially during the night periods. In these conditions, the availability of reversible units will enable to absorb the surplus energy by pumping and storing it under the form of potential energy that may later be turbinated to meet the needs during the most demanding hours.

The Salamonde power plant II includes a new water intake in the Salamonde reservoir, an underground water conveyance system with a total length of 2 297 m , a cavern power plant and a downstream structure in the Caniçada reservoir. A substation and a support building was built at the surface.

The power plant is equipped with a Francis vertical turbine – pump unit, with a capacity of 209 MW and nominal flow of 200 m^3/s under a 115 m head.

HYDROELECTRIC DEVELOPMENT

ALQUEVA II

260 MW
(Reversible)

GUADIANA RIVER - ALQUEVA SYSTEM
PORTUGAL

In the first phase, the Alqueva power plant development was equipped with two 130 MW reversible units. The Alqueva power plant II has the purpose of duplicating the reversible installed capacity taking advantage of the conditions created by the combination of the Alqueva large reservoir and the Pedrógão downstream reservoir allowing weekly pumping-turbination cycles.

The Alqueva II units are installed in the new hydropower plant, open and cut on the right bank of the Guadiana river, downstream of the dam right abutment, taking advantage of the existing platform.

The adopted solutions resulted from the feasibility studies (2007) together with the option of equipping the power plant with units similar to the existing ones.

RESERVOIRS	
Alqueva	
Normal top water level	(152.00)
Minimum operating level	(139.50)
Pedrógão	
Normal top water level	(84.80)
Minimum operating level	(79.00)
WATER INTAKE	
Mobile racks	4 x (8.00 x 16.50) m^2
Stoplogs	1 x (7.40 x 8.60) m^2
Service gates	2 x (7.00 x 8.60) m^2
WATER CONVEYANCE STRUCTURE	
Unit 1	361 m
Unit 2	387 m
Current section	
Diameter	8.5 m
Lined tunnel section	
Diameter	7.5 m
Unit 1	80 m
Unit 2	106 m
DOWNSTREAM STRUCTURE	
Mobile racks	16 x (4.25 x 14.00) m^2
Stoplogs	4 x (6.50 m x 6.50) m^2
POWER PLANT	
Number of units/Type	2 / Vertical axis Francis, with generator - motor
Turbines (characteristics during turbine operation)	
Nominal flow	203.5 m^3/s
Net head	70.8 m
Installed capacity	2 x 130 MW
Pumps (characteristics during pumping operation)	
Nominal flow	169 m^3/s
Net head	64.7 m
Maximum capacity	2 x 115.3 MW
Generator-Motors	
Capacity as generator	143 MVA
Capacity as motor	127 MW
Voltage	15 kV
Energy generation	470 GWh/year
SUBSTATION	
Unit transformers	
Capacity	150 MVA
Transforming ratio	15/400 kV

The studies, design and environmental impact studies were awarded to COBA by EDP on 2007.

The new Alqueva power plant II aims to operate essentially as a network regulator, by pumping the water from Pedrógão onto Alqueva during the off-peak hours, when energy surplus is at low cost, and turbinating the water pumped during the peak period.

The Alqueva power plant I shall operate in the same manner when it does not have to turbinate its own inflows, which will occur frequently during the dry season.

MULTIPURPOSE DEVELOPMENTS

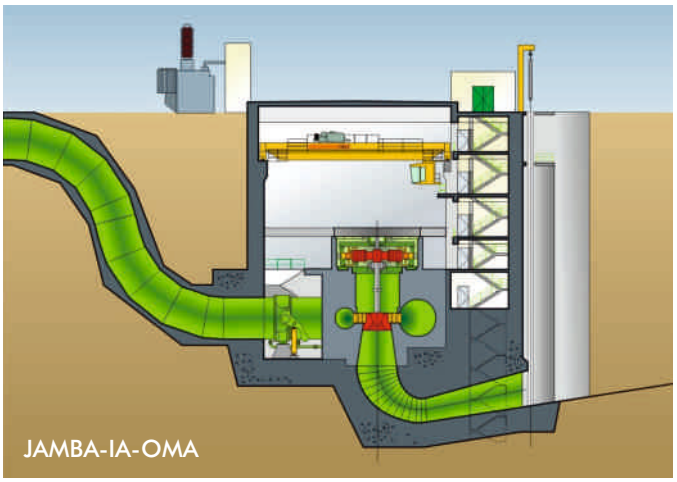
JAMBA - IA - OMA 79 MW

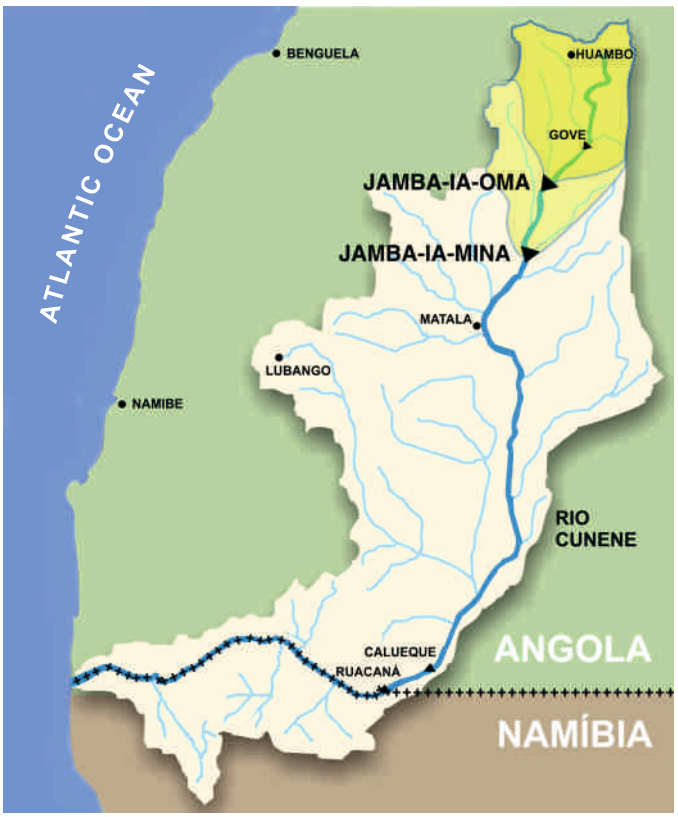
The Jamba-Ia-Oma Hydropower Development is located on the Cunene river, approximately 50 km downstream of Gove dam and 130 km to the south of the city of Huambo.

The main objectives of this multipurpose hydraulic scheme are to regulate the river flows downstream and the energy generation in a power plant included in the project.

The energy produced supplies the city of Huambo and a subsequent connection to the national grid. It is expected to operate in conjunction with the Jamba-Ia-Mina hydropower plant (design concluded) and with the Gove hydropower plant (under operation).

DAM	
Type	Concrete gravity and earthfill
Height	47 m
Crest length	2 800 m
Reservoir capacity	1100 x 10^6 m^3
Maximum flood flow	4 000 m^3/s
Spillway	Frontal with six 14.0 x 10.0 m^2 radial gates and ski jump
WATER CONVEYANCE SYSTEM	
Penstock	3 x 200 m long with 4.15 m diam.
POWER PLANT	
Number of units/Type	3 / vertical axis Francis
Total design flow	225 m^3/s
Nominal net head	38.8 m
Total nominal capacity	78.75 MW
Energy generation	180 GWh/year
Turbines	
Nominal flow	3 x 75 m^3/s
Installed capacity	3 x 26.25 MW
Generators	
Apparent capacity	3 x 29 MVA
Voltage	11 kV
SUBSTATION	
Capacity	3 x 30 MVA
Transformation ratio	11 / 220 kV





MULTIPURPOSE DEVELOPMENTS

JAMBA - IA - MINA 224 MW

The Jamba-Ia-Mina Hydropower Development is located on the Cunene river, approximately 110 km downstream of the Gove dam and 190 km south of the city of Huambo.

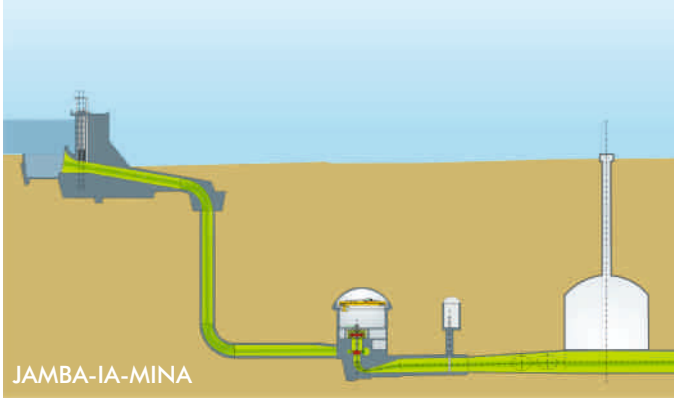
The main objectives of this multipurpose hydraulic scheme are to regulate river flows downstream and the energy generation in a power plant included in the project.

The energy produced supplies the city of Huambo and a subsequent connection to the national grid. It is expected to operate in conjunction with the Jamba-Ia-Oma hydropower plant (design concluded) and with the Gove hydropower plant (under operation).

DAM	
Type	Concrete gravity and earthfill
Height	38.5 m
Crest length	1 270 m
Reservoir capacity	522 x 10^6 m^3
Maximum flood flow	7 250 m^3/s
Spillway	
Type	Frontal with fourteen 14.0 x 7.0 m^2 radial gates and ski jump
WATER CONVEYANCE SYSTEM	
Headrace tunnels	3 x 183 m long and 5 m diameter
Tailrace tunnels	6 600 m long and 12 m diameter
POWER PLANT	
Number of units/Type	3 / Vertical axis Francis
Total design flow	300 m^3/s
Nominal net head	82.7 m
Total nominal capacity	224 MW
Energy generation	535 GWh/year
Turbines	
Nominal flow	3 x 100 m^3/s
Installed capacity	3 x 74.6 MW
Generators	
Apparent capacity	3 x 85 MVA
Voltage	15 kV
SUBSTATION	
Capacity	3 x 89 MVA
Transformation ratio	15 / 220 kV

The initial studies and design carried out by COBA date back to 1976. In 2006 the "Gabinete para a Administração da Bacia Hidrográfica do rio Cunene (GABHIC)" contracted COBA for the execution of design, tender documents and environmental impact study of the hydroelectric development.

The studies included the preparation of a Feasibility Study, a Basic Design, an Environmental Impact Assessment and Tender Documents.



MULTIPURPOSE DEVELOPMENT

GOVE

62 MW

CUNENE RIVER - ANGOLA

The Gove dam is located on the Cunene river, some 80 km south of the city of Huambo. It was constructed with the main purpose of river flood control and was completed in 1975. Between 1986 and 1990, the dam was subject to sabotage actions that put its operation at risk. For safety reasons, it was necessary to lower the level of exploitation.

The former project considered the inclusion of a power plant at the dam toe. With the dam rehabilitation, the power plant was built, equipped with three 20.6 MW vertical axis Francis turbine-generators.

DAM	
Type	Homogeneous embankment with rockfill toe
Height	58 m
Crest length	1 112 m
Reservoir total capacity	2 547 x 10^6 m^3
POWER PLANT	
Number of units/Type	3 / Vertical axis Francis
Units	
Nominal flow	3 x 51 m^3/s
Net head	45 m
Installed capacity	3 x 20.6 MW
Energy generation	150 GWh/year
Generators	
Apparent capacity	24 MVA
Voltage	11 kV
SUBSTATION	
Capacity	3 x 24 MVA
Transformation ratio	11 / 220 kV

Studies, design, and construction drawings for the dam rehabilitation and construction of the power plant and substation were carried out by COBA, in association, who is also responsible for the project management and construction supervision.

HYDROELECTRIC DEVELOPMENT

EL BORJ 21 MW

OUM ER RBIA RIVER - MOROCCO

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

This is a run-of-river power plant that uses a natural head of approximately 130 m available in a river section of about 15 km between the villages of Tanafnit and El Borj.

The studies and interventions carried out involved the following phases: i) Feasibility Study and Preliminary Design; ii) Tender Documents, divided in 5 lots; iii) Technical Assistance to the Works, concluded in 2008.

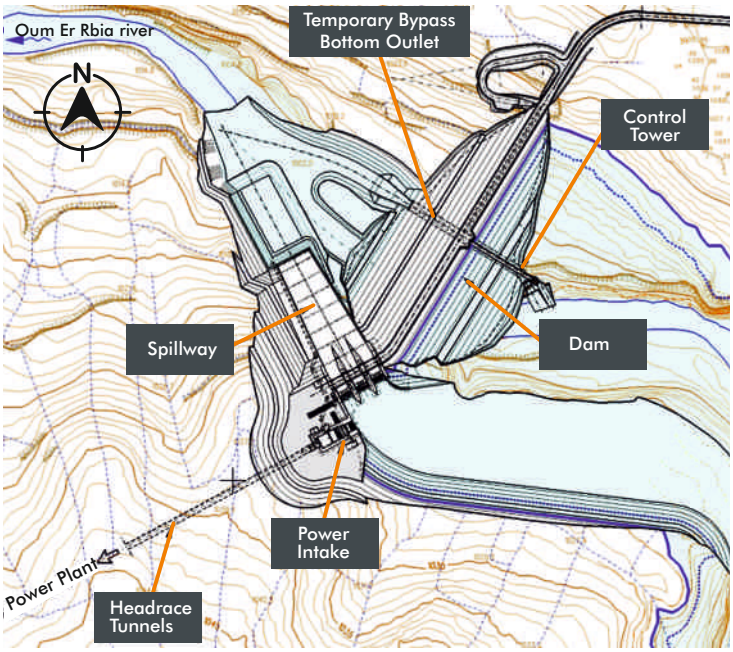
The hydraulic structures of the dam were tested in a reduced model.

The assignment also included training sessions for ONE's staff, related to hydrological studies and hydraulic design.

TANAFNIT - EL BORJ DAM

Earthfill dam with a concrete spillway on the left bank.

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.



DAM	
Maximum height	25 m
Crest length	270 m
Reservoir capacity	2.1 hm^3
WATER CONVEYANCE SYSTEM	
Tunnel	10.2 km long, 3.3 m diam.
Surge chamber	5.5 m diameter
Safety valve chamber	DN 2 600 mm
Penstock	200 m long, DN 2 800 /3 000 mm
POWER PLANT	
Number of units/Type	2 / Francis with horizontal axis
Turbines	
Installed capacity	2 x 10.65 MW
Nominal flow	24 m^3/s
Net head	106.5 m
Energy generation	108.6 GWh/year
SUBSTATION	60 kV
Capacity	2 X 15 MVA
Transformers ratio	6/60 kV

HYDROPOWER PLANNING

PORTUGUESE NATIONAL PROGRAM OF DAMS WITH HIGH HYDROELECTRIC POTENTIAL

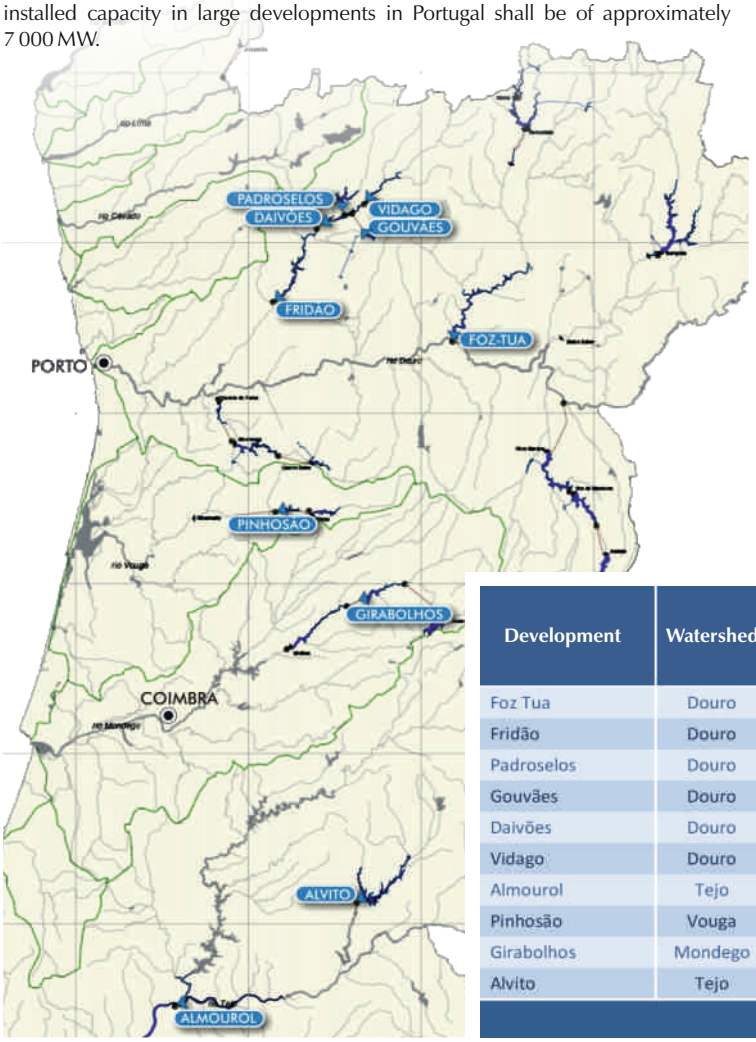
The purpose of the Portuguese National Program of Dams with High Hydroelectric Potential (PNBEPH) was to identify and define investment priorities for large hydroelectric developments in the 2007-2020 project horizon.

The studies carried out analysed 25 hydroelectric developments with installed capacities above 30 MW.

The selected developments are of great interest regarding power generation, optimization of the watershed resources and their potential to meet with other uses, as well as their better technical, economic, social and environmental conditions that enable them to be implemented in the short to medium term.

The 10 selected developments able to meet the installed capacity established for the 2020 horizon are: Almourol, Alvito, Daivões, Foz Tua, Fridão, Girabolhos, Gouvães, Padroselos, Pinhosão and Vidago, which are expected to generate a total installed capacity of approximately 1100 MW, generating 1630 GWh/year on an average hydrologic year.

At the end of the PNBEPH implementation, in 2020, the total hydroelectric installed capacity in large developments in Portugal shall be of approximately 7 000 MW.



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DAMS WITH HIGH HYDROELECTRIC POTENTIAL PORTUGAL

The proposal regarding the developments to be implemented resulted from the Strategic Environmental Assessment of 4 large strategic options established within the scope of the PNBEPH (National Program of Dams with High Hydroeletric Potential).

The Environmental Assessment Studies were developed according to critical factors identified in the environmental and sustainability factors, as well as to strategic reference framework relevant to the program: climate changes, biodiversity, natural and cultural resources, natural and technological resources, human development and competitiveness.

The Environmental Assessment enabled to conclude that Option D Energy, Socio-economic and Environmental points of view is the one that, in global terms, mostly contributes to achieving the strategic goals regarding the critical factors and that less conflict with them.

Development	Watershed	River	Type	Watershed area (km²)	Reservoir capacity (hm³)	Installed capacity (MW)	Power generated (GWh/year)
Foz Tua	Douro	Tua	Reversible	3 822	310	234	340
Fridão	Douro	Tâmega	-	2 630	195	163	299
Padroselos	Douro	Beça/Tâmega	Reversible	315	147	113	102
Gouvães	Douro	Torno/Tâmega	Reversible	100	13	112	153
Daivões	Douro	Tâmega	Reversible	1 984	66	109	148
Vidago	Douro	Tâmega	Reversible	1 557	96	90	114
Almourol	Tejo	Tejo	-	67 323	20	78	209
Pinhosão	Vouga	Vouga	Reversible	401	68	77	106
Girabolhos	Mondego	Mondego	Reversible	980	143	72	99
Alvito	Tejo	Ocreza	-	968	209	48	62
				TOTAL	1 266	1 096	1 632

HYDROPOWER PLANNING

INVENTORY AND PRE-FEASIBILITY STUDIES OF PUMPED HYDRO STORAGE PROJECTS IN MOROCCO

MOROCCO

The overall objective of this project is to assess the potential of Morocco for hydro energy storage, by developing new pumped-storage installations and, with the purpose of complementing, optimizing and increasing the penetration of other intermittent renewable energy sources in the national grid – solar and wind – guaranteeing the daily variation of energy and power demand.

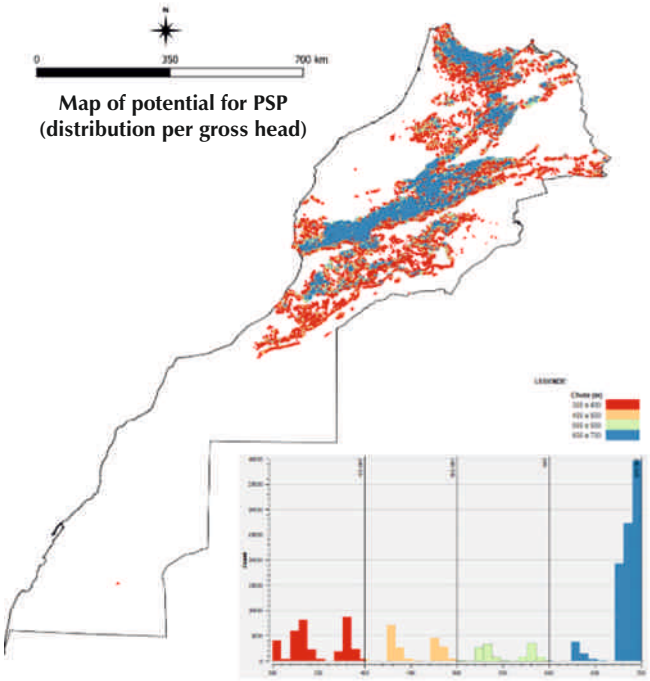
The specific objective of the studies is to develop the Inventory of the Pumped Hydro Storage Projects (PSP) in Morocco, including inland, near water courses and dams/reservoirs, and seawater schemes, using saltwater and the sea as the lower reservoir.

The studies aim at the Moroccan territory as a whole, with a particular interest in the mountain and coastal areas, where are found the larger heads and shorter hydraulic circuits, consequently the most favourable from an economic point of view.

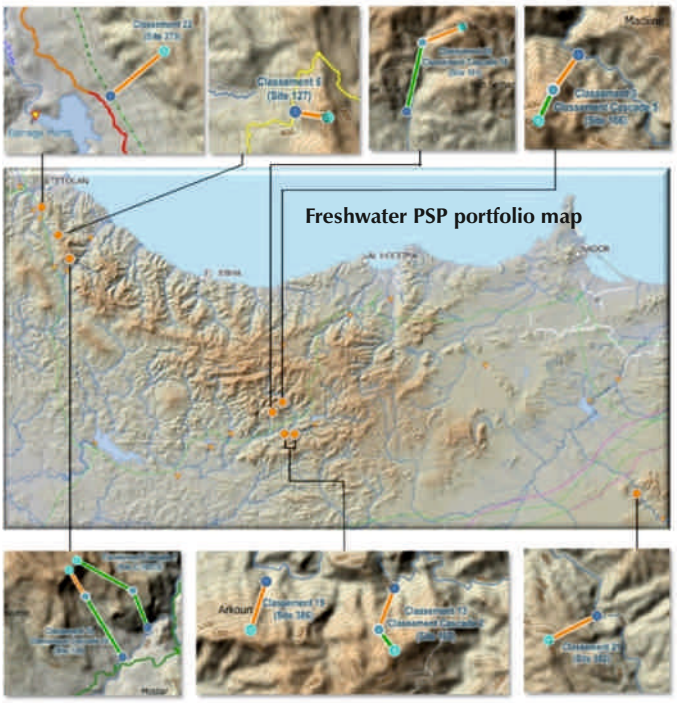
The Project includes also technical and economic feasibility studies of the 25 most favourable identified sites, with capacities of around 400-600 MW each, and the creation of a GIS database with the results of the studies.

The studies include the two following missions:

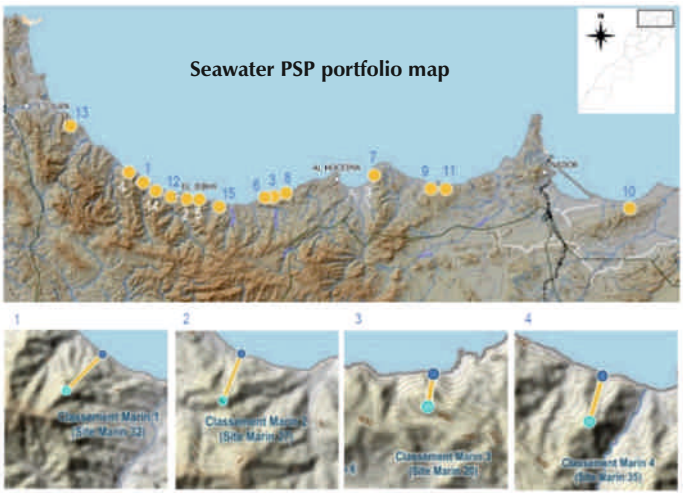
- Mission 1: Systematic prospection, identification, and classification of the potential sites.
- Mission 2: Pre-feasibility studies of the selected sites.



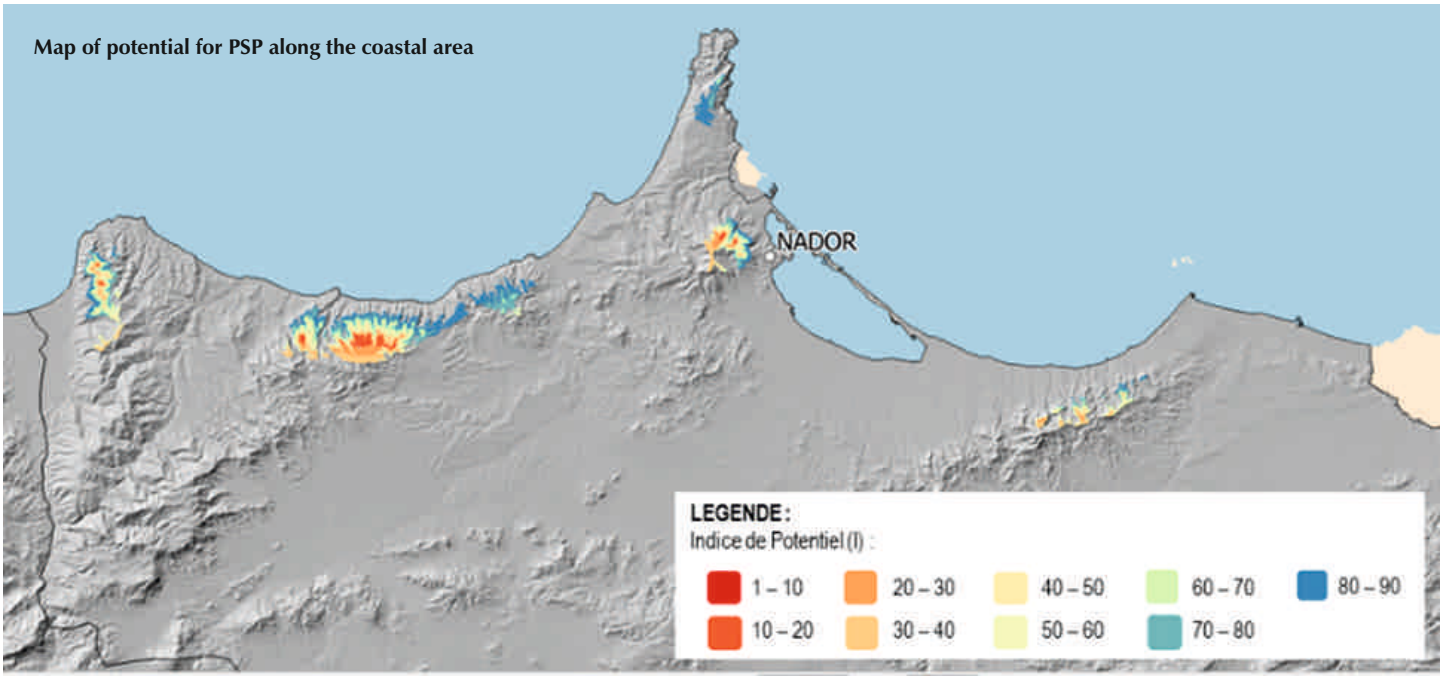
Map of potential for PSP (distribution per gross head)



Freshwater PSP portfolio map



Seawater PSP portfolio map



Map of potential for PSP along the coastal area

HYDROPOWER PROJECTS AT COBA

MAJOR PROJECTS IN PORTUGAL

PROJECT NAME	HYDROPOWER SCHEMES		COUNTRY	CLIENT	DATE
	POWER PLANT Rated Capacity	DAM / WATER CONVEYANCE SYSTEM			
Foz Tua	262 MW (Reversible)	Concrete arch dam (108 m high) Tunnels 1 470 m long, Ø 7.5 m	Portugal	EDP Gestão da Produção de Energia, S.A.	2010/11
Salamonde II	209 MW (Reversible)	Tunnels 2 297 m long, Ø 5.8/8.3/11.5 m	Portugal	EDP Gestão da Produção de Energia, S.A.	2009/16
Alqueva II	260 MW (Reversible)	Tunnels 750 m long, Ø 8.5 m	Portugal	EDP Electricidade de Portugal, S.A.	2007/12
Feiticeiro (Downstream Baixo Sabor)	30 MW (Reversible)	Tunnels 590 m / 640 m long, Ø 6.9 m	Portugal	EDP Gestão da Produção de Energia, S.A.	2009/12
Fridão	241 MW (Reversible)	Tunnel 380 m long, Ø 7.3/11.0 m	Portugal	EDP Gestão da Produção de Energia, S.A.	2009/10
Ribeiradio - Ermida	75 MW (Ribeiradio) 8 MW (Ermida)	Ribeiradio: Concrete dam (83 m high) Ermida: Concrete dam (35 m high) Tunnel 205 m long, Ø 5.5 m	Portugal	EDP Gestão da Produção de Energia, S.A.	2008/15
Pedrogão	13 MW	Penstock 117 m long, Ø 4.0 m	Portugal	EDP Gestão da Produção de Energia, S.A.	2008/09
Alvito	214 MW (Reversible)	RCC dam (88 m high)	Portugal	EDP Gestão da Produção de Energia, S.A.	2008/11

MAJOR RECENT INTERNATIONAL PROJECTS

PROJECT NAME	HYDROPOWER SCHEMES		COUNTRY	CLIENT	DATE
	POWER PLANT Rated Capacity	DAM / WATER CONVEYANCE SYSTEM			
Santiago	20 MW (Reversible)	2 x 400 000 m^3 reservoirs Penstock 1.2 km long, Ø 2.0 m	Cape Verde (Santiago Island)	LuxDev Luxembourg Development Agency	2021
Saltinho	27 MW	Concrete diversion dam (16.0 m high)	Guinea Bissau	OMVG Organisation de Mise en Valeur du Fleuve Gambie	1983/88 1991/93 2019/ongoing
Luachimo (Dam Rehabilitation and new Hydropower Plant)	34 MW	Concrete diversion dam (6.5 m high) Headrace canal 649 m long	Angola	MINEA Ministério da Energia e Águas	2018/ 2024
Biópio (Hydropower Plant Rehabilitation)	15 MW		Angola	AFD – Agence Française de Développement Owner: Governo da República de Angola	2018
Mapai	18 MW	Earthfill dam (53m high) Penstock 210 m long, Ø 5.0 m	Mozambique	ARA-Sul	2018
Warsak (Hydropower Plant Rehabilitation)	243 MW	———	Pakistan	WAPDA Water and Power Development Authority	2017/ ongoing
Kholombidzo	213 MW (Main) 6 MW (Ancillary)	Concrete gravity dam (16.8 m high) Tunnels 2 x 2.8 km long, Ø 8.0 m	Malawi	Ministry of Natural Resources, Energy and Mining	2017
Oriang	435 MW	Concrete and rockfill dam (39 m high) Tunnels 8.6 km long	Uganda	Mota-Engil Africa	2016
Kalungwishi (**Kabwelume** and **kundabwika** stages)	100/160 MW	Mixed dam / Gravity dam Tunnels 1 610 m / 2 487 m long	Zambia	Mota-Engil Africa	2014
Caculo-Cabaça	2 120 MW (Main) 52 MW (Ancillary)	RCC dam (103 m high) Tunnels 4 x 299 m long, Ø 6.0/6.5/9.0 m; 2 x 5 200 m, 16 x 16 m^2	Angola	GAMEK Gabinete de Aproveitamento do Médio Kwanza	2013/ under construction
Laúca	2 004 MW (Main) 65.5 MW (Ancillary)	RCC dam (132 m high) Tunnels 6 x 1.9 km long, 9 x 12 m^2	Angola	GAMEK Gabinete de Aproveitamento do Médio Kwanza	2013/15 2017/23
Cambambe II	714 MW	Tunnels 4 x 440 m long, Ø 7.7 m; 4 x 100 m long, Ø 6.9 m	Angola	GAMEK Gabinete de Aproveitamento do Médio Kwanza	2012/17
Matala (Hydropower Plant Rehabilitation)	42 MW	———	Angola	ENE Empresa Nacional de Eletricidade	2012/14
Marañon	90 MW	Concrete and embankment dam (21.5 m high) Concrete lined trapezoidal canal, 1 445 m long, 5.0 m trail width, 6.5 m high	Peru	Mota-Engil Perú	2012/14
Juale	87 MW	Earth and RCC dam (40 m high) Design flow spillway: 7000 m^3/s Power plant with capacity of 87 MW	Ghana	Andrade Gutierrez / Odebrecht Joint-Venture	2010
Jamba-Ia-Mina	224 MW	Concrete gravity dam (38.5 m high) Tunnels 3 x 183 m long, Ø 5 m; 6 600 m long, Ø 12 m	Angola	GABHIC Gabinete para Administração da Bacia Hidrográfica do Rio Cunene	2010/12
Jamba-Ia-Oma	79 MW	Concrete gravity and earthfill dam (47 m high) Penstock 3 x 200 m long, Ø 4.15 m	Angola	GABHIC Gabinete para Administração da Bacia Hidrográfica do Rio Cunene	2008/11
Lomaum (Rehabilitation and Extension)	76 MW	———	Angola	EDP Gestão da Produção de Energia, S.A.	2009/10
Gove (Dam Rehabilitation and new Hydropower Plant)	62 MW	Embankment dam (58 m high)	Angola	GABHIC Gabinete para Administração da Bacia Hidrográfica do Rio Cunene	2002 2007/12
Sambangalou and **Kaleta**	120 MW	RCC dam (94 m high), GG studies	Senegal	OMVG Organisation de Mise en Valeur du Fleuve Gambie	2005/07
El Borj	21 MW	Tunnel 10.4 km long, Ø 3.3 m Penstock 200 m long, Ø 2.8/3.0 m	Morocco	ONE Office Nationale de l'Electricité	1998/00

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