



GROUP
coba

E N G I N E E R I N G A N D E N V I R O N M E N T A L C O N S U L T A N T S



55 years
more than 300

Dams

AREAS OF ACTIVITY

DAMS AND HYDROPOWER PLANTS

WATER SUPPLY SYSTEMS AND WATER AND
WASTEWATER TREATMENT PLANTS

IRRIGATION AND DRAINAGE SYSTEMS

ROADS, MOTORWAYS, RAILWAYS AND AIRPORTS

BRIDGES, VIADUCTS AND TUNNELS

ENVIRONMENTAL STUDIES

CARTOGRAPHY AND GIS

400 employees in COBA Group
(250 in COBA PT)

Offices in
**Portugal, Angola, Brasil, Mozambique,
Algeria, Peru and Colombia**

Worked in
38 countries

55
1962-2017



Dams
> 300

Hydropower
> 9300 MW

Since COBA's foundation 1962





PORTUGUESE NATIONAL PROGRAM FOR DAMS WITH HIGH HYDROELECTRIC POTENTIAL (PNBEPH)

1 096 MW

DEFINITION OF PRIORITIES FOR
INVESTMENTS IN LARGE HYDROELECTRIC
DEVELOPMENTS (2007 - 2020)

10 SITES IDENTIFIED FOR DEVELOPMENT

Client/Owner: REN – Rede Eléctrica Nacional / INAG – Instituto da Água

Establishment of the program: 2007

COBA lead consultant



PORTUGUESE NATIONAL PROGRAM FOR DAMS WITH HIGH HYDROELECTRIC POTENTIAL (PNBEPH)

Client/Owner: REN – Rede Eléctrica Nacional / INAG – Instituto da Água
Establishment of the program: 2007
COBA lead consultant

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.

Development	Watershed	River	Type	Watershed area (km²)	Reservoir capacity (hm³)	Installed capacity (MW)	Power generated (GWh/ano)
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

DAMS

PORTUGAL



ODELOUCA II DAM AND ODELOUCA-FUNCHO WATER CONVEYANCE STRUCTURES

TYPE

ZONED EARTHFILL DAM WITH CLAYEY CORE

HEIGHT

76 M

CREST LENGTH

415 M

Client/Owner: Instituto da Água (INAG)

Design: 1999/2001

Technical Assistance to the Owner:

2001 / 2004 (Tunnel)

2002 / 2003 (Dam) (works interrupted)

2007 / 2010 reinstatement and completion works





ODELOUCA II DAM AND ODELOUCA-FUNCHO WATER CONVEYANCE STRUCTURES

Client/Owner: Instituto da Água (INAG)

Design: 1999/2001

Technical Assistance to the Owner:

2001 / 2004 (Tunnel)

2002 / 2003 (Dam) (works interrupted)

2007 / 2010 reinstatement and completion works

DAM

- **Type:** Zoned earthfill dam with clayey core
- **Height:** 76 m
- **Crest Length:** 415 m
- **Volume of Dam:** $2\,020 \times 10^3 \text{ m}^3$
- **Reservoir capacity:** 157 hm^3
- **Maximum flood flow:** $1\,513 \text{ m}^3/\text{s}$ ($t = 1000$ years)
- **Spillway:** $2\,205 \text{ m}^3/\text{s}$ – channel with frontal weir controlled by three gates
- **Bottom outlet:** gallery ($\varnothing 2,0 \text{ m}$) installed in the provisional diversion tunnel
- **Provisional diversion:** in tunnel, 435 m long, set up on right bank
- **Access roads:** 3,3 km long, with current engineering works to cross streams

HYDRAULIC CIRCUIT (TUNNEL)

- **Length:** 8 150 m
- **Diameter:** 2 130 mm
- **Volume of concrete:** 16.300 m^3
- **Design flood in tunnel:** $9 \text{ m}^3/\text{s}$



DAMS

PORTUGAL



FUNCHO DAM

TYPE

CONCRETE ARCH

HEIGHT

49 M

CREST LENGTH

210 M

Client/Owner: Instituto da Água (INAG), (Ministry of Environment and Water Resources)

General Layout: 1972

Design: 1983

Final Design and Technical Assistance: 1987/93

Purposes: The Funcho dam aims at the flows regulation of the Arade stream for irrigation and water supply to the “Barlavento Algarvio” (Western region of Algarve)





FUNCHO DAM

Client/Owner: Instituto da Água (INAG), (Ministry of Environment and Water Resources)

General Layout: 1972

Design: 1983

Final Design and Technical Assistance: 1987/93

Purposes: The Funcho dam aims at the flows regulation of the Arade stream for irrigation and water supply to the “Barlavento Algarvio” (Western region of Algarve)

- Type: Concrete arch
- Height: 49 m
- Crest length: 210 m
- Dam volume: 44,000 m³
- Reservoir capacity: 43 mio. m³
- Maximum flood flow: 800 m³/s
- Spillway: 75 m³/s - overflow with gates
- Bottom outlet: 2 x 162 m³/s - 2 orifices





SABUGAL DAM

TYPE

EARTHFILL DAM

HEIGHT

58,5 M

CREST LENGTH

1 005 M

SABUGAL-MEIMOA WATERWAY

POWER PLANT

Client/Owner: INAG (Instituto da Água) and IHERA (Instituto de Hidráulica, Engenharia Rural e Ambiente) for the construction phase

Feasibility Study/Design: 1972/1974

Design Review, Tender Documents and Procurement Processes: 1993/1994

Technical Assistance to Supervision

Dam: 1997/2000 **Waterway:** 1999/2001



DAMS

PORTUGAL



MEIMOA DAM

TYPE

ROCKFILL DAM

HEIGHT

56 M

CREST LENGTH

656 M

Client/Owner: DGRAH – Direcção Geral dos Recursos e Aproveitamentos Hidráulicos (Ministry of Environment and Natural Resources)

Design / Detailed Design / Technical Assistance: 1978 / 1984



DAMS

PORTUGAL



MEIMOA DAM

Client/Owner: DGRAH – Direcção Geral dos Recursos e Aproveitamentos Hidráulicos (Ministry of Environment and Natural Resources)

Design / Detailed Design / Technical Assistance: 1978 / 1984

Purpose: Irrigation area 14 200 ha

Location: Meimoa stream, Castelo Branco

Type: Rockfill dam

Height: 56 m

Crest length: 656 m

Volume of dam: $2\,500 \times 10^3 \text{ m}^3$

Gross capacity of reservoir: 41 hm³

Maximum flood flow: 228 m³/s

Spillway: 124 m³/s - gated spillway

Bottom outlet: 11 m³/s - tunnel



DAMS

PORTUGAL



APARTADURA DAM

TYPE

ROCKFILL

HEIGHT

47 M

CREST LENGTH

284 M

Client/Owner: Direcção Geral dos Recursos Naturais

Final Design: 1977 / 1983

Final Design, Tender Documents and Procurement Processes,
Technical Assistance to Supervision: 1987/1992





APARTADURA DAM

Client/Owner: Direcção Geral dos Recursos Naturais

Final Design: 1977 / 1983

**Final Design, Tender Documents and Procurement Processes,
Technical Assistance to Supervision:** 1987/1992

- Purpose: Irrigation and Water Supply
- Type: Rockfill
- Height: 47 m
- Crest length: 284 m
- Dam volume: 417,000 m³
- Reservoir capacity: 7,5 mio. m³
- Maximum flood flow: 63 m³/s
- Spillway: 45 m³/s - canal
- Bottom outlet: 15 m³/s - gallery



DAMS

PORTUGAL



RIBEIRADIO-ERMIDA HYDROELECTRIC DEVELOPMENT

83 MW

2 DAMS - RIBEIRADIO AND ERMIDA
HYDROPOWER PLANT
SUBSTATION

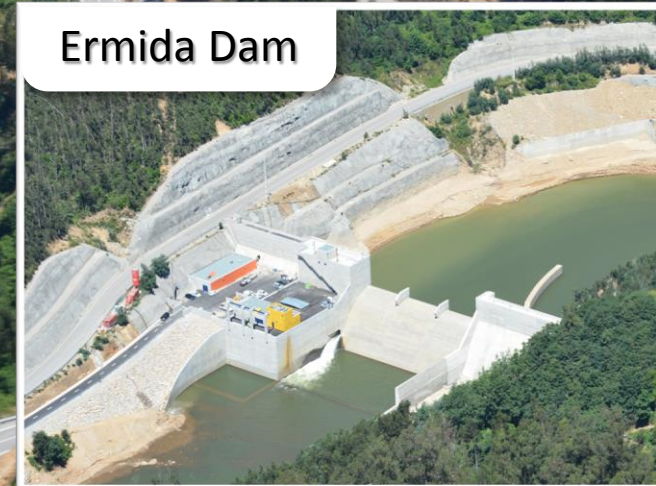
Client/Owner: EDP/Martifer JV

Planning, design and environmental studies: 2007/2015

Ribeiradio Dam



Ermida Dam



DAMS

PORTUGAL



83 MW

RIBEIRADIO-ERMIDA HYDROELECTRIC DEVELOPMENT

Client/Owner: EDP/Martifer JV

Planning, design and environmental studies: 2007/2015

2 DAMS – RIBEIRADIO AND ERMIDA

RIBEIRADIO

- Type: Concrete gravity dam
- Height: 83 m
- Crest length: 265 m
- Reservoir capacity: 136 million m³
- Concrete volume: 290 000 m³

ERMIDA

- Type: Concrete gravity dam
- Height: 35 m
- Crest length: 175 m
- Reservoir capacity: 4 million m³

HYDROPOWER PLANT

- Installed capacity: 74,5 MW / 8,0 MW

SUBSTATION

- Transformers: 82 MVA / 9 MVA
- 11/60 kV / 6/15 MVA

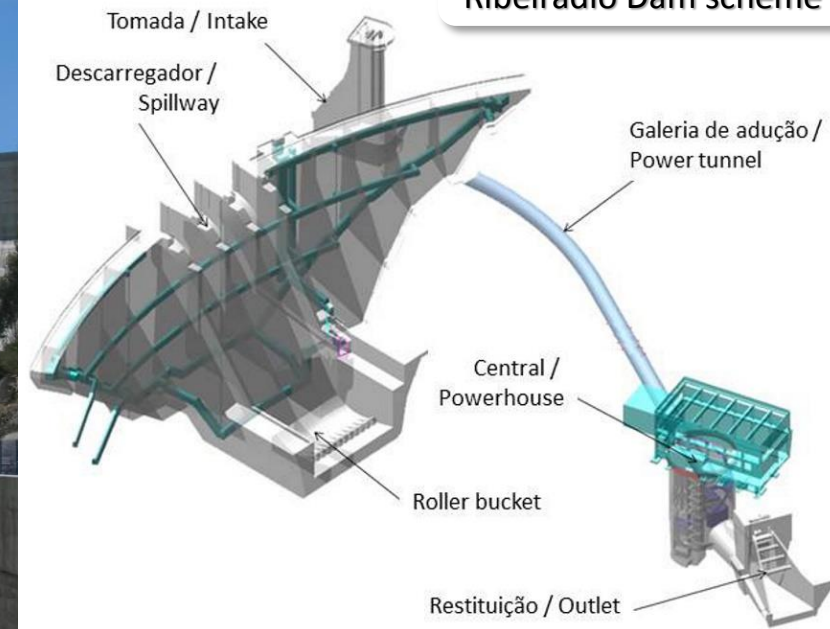
Ribeiradio Dam



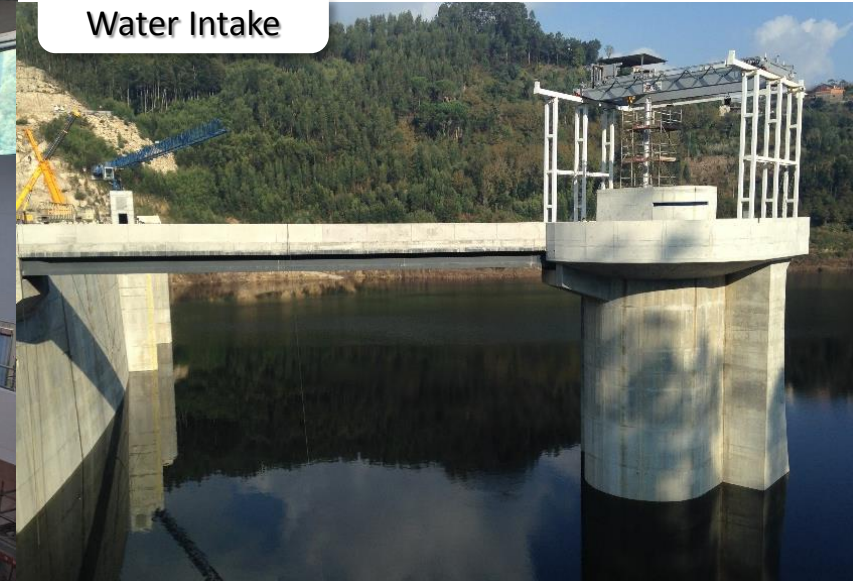
Power Plant



Ribeiradio Dam scheme



Water Intake



DAMS

PORTUGAL



83 MW

RIBEIRADIO-ERMIDA HYDROELECTRIC DEVELOPMENT

Client/Owner: EDP/Martifer JV

Planning, design and environmental studies: 2007/2015

2 DAMS – RIBEIRADIO AND ERMIDA

RIBEIRADIO

- Type: Concrete gravity dam
- Height: 83 m
- Crest length: 265 m
- Reservoir capacity: 136 million m³
- Concrete volume: 290 000 m³

ERMIDA

- Type: Concrete gravity dam
- Height: 35 m
- Crest length: 175 m
- Reservoir capacity: 4 million m³

HYDROPOWER PLANT

- Installed capacity: 74,5 MW / 8,0 MW

SUBSTATION

- Transformers: 82 MVA / 9 MVA
- 11/60 kV / 6/15 MVA

Ermida Dam



DAMS

PORTUGAL



ALQUEVA II HYDROELECTRIC DEVELOPMENT POWER PLANT II

260 MW

SECOND POWERHOUSE ALQUEVA II

Client/Owner: EDP - Electricidade de Portugal
Preliminary Design, Detailed Design, Final Design and
Environmental Impact Assessment: 2007/2012



DAMS

PORTUGAL



ALQUEVA II HYDROELECTRIC DEVELOPMENT POWER PLANT II

260 MW

Client/Owner: EDP - Electricidade de Portugal
**Preliminary Design, Detailed Design, Final Design and
Environmental Impact Assessment:** 2007/2012

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

Second Powerhouse Alqueva II

- 2 Francis units 260 MW
- 2 x 380 m long headrace tunnel (8,5 m Ø)

Water Intake



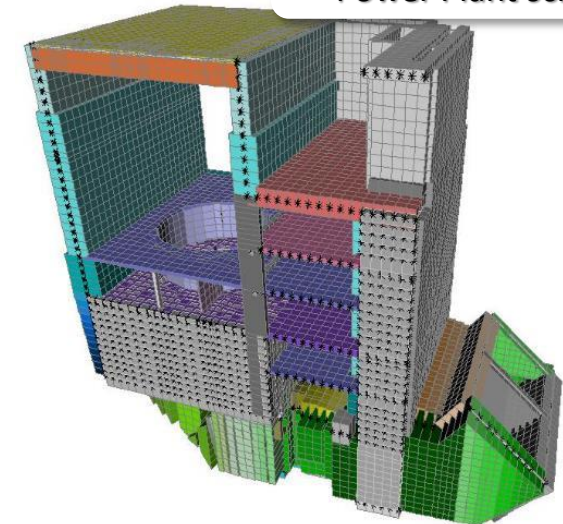
Power Plant



Restitution



Power Plant scheme



Detail

DAMS

PORTUGAL



PEDROGÃO STAGE HYDROPOWER DEVELOPMENT POWERPLANT II

13,3 MW

Client/Owner: EDP – Electricidade de Portugal

Licensing Design, Tender Design and Environmental Impact

Assessment: 2008 / 2009



DAMS

PORTUGAL



FOZ TUA HYDROELECTRIC DEVELOPMENT **262 MW**

CONCRETE ARCH DAM

POWER PLANT AND WATER CONVEYANCE
SYSTEM

WATER CONVEYANCE SYSTEM

Client/Owner: EDP - Gestão da Produção de Energia, S.A
Detailed Design and Tender Documents (Hydropower plant):
2009 / 2011
Final Design (Dam) and Technical Assistance: 2012 / 2016



DAMS

PORTUGAL



262 MW

FOZ TUA HYDROELECTRIC DEVELOPMENT

Client/Owner: EDP - Gestão da Produção de Energia, S.A
Detailed Design and Tender Documents (Hydropower plant):
2009 / 2011
Final Design (Dam) and Technical Assistance: 2012 / 2016

Dam

Type of dam: Concrete arch dam with double curvature
Height: 108 m
Crest length: 275 m
Concrete volume: 320 000 m³
Reservoir capacity: 106 million m³

Power Plant and Water Conveyance System

Nominal flow: 310 m³/s
Rated capacity: 262 MW
Number of units: 2 (reversible)

Water Conveyance System

2 x 750 m long headrace tunnels (7,5 m Ø)



HYDROPOWER

PORTUGAL



Hydroelectric Development

SALAMONDE HPP REPOWERING - POWER PLANT 2 **224 MW**

WATER INTAKE IN THE SALAMONDE
RESERVOIR
UPSTREAM WATER CONVEYANCE SYSTEM
POWER PLANT

Client/Owner: EDP - Gestão da Produção de Energia, S.A.

Tender Design and Tender Documents: 2009 / 2010

Final Design and Technical Assistance: 2010 / 2016



HYDROPOWER

PORTUGAL



224 MW

SALAMONDE HPP REPOWERING – POWER PLANT 2

Client/Owner: EDP - Gestão da Produção de Energia, S.A.

Tender Design and Tender Documents: 2009 / 2010

Final Design and Technical Assistance: 2010 / 2016

Main Works

Water Intake in the Salomonde 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

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 road

Length: 3.500 m; 70-m long bridge

Restitution



Power Plant



Power Plant



Water Intake



Detail

HYDROPOWER



PORTUGAL

BAIXO SABOR HYDROELECTRIC DEVELOPMENT

132 MW

WATER CONVEYANCE STRUCTURES
SHAFT POWER PLANT

Client/Owner: EDP - Gestão da Produção de Energia, S.A
Detailed Design and Technical Assistance: 2010 / 2015



HYDROPOWER

PORTUGAL



132 MW

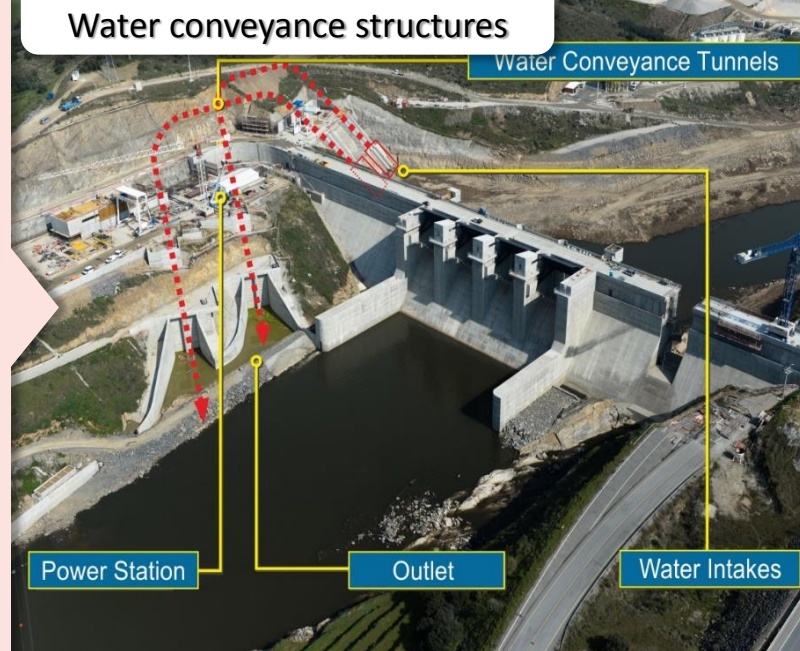
BAIXO SABOR HYDROELECTRIC DEVELOPMENT

Client/Owner: EDP - Gestão da Produção de Energia, S.A
Detailed Design and Technical Assistance: 2010 / 2015

Water conveyance structures composed of two independent tunnels for each generator with lengths of 590 m and 640 m and diameter of 6,90 m

Shaft power plant: head: 93,3 m; unit flow: 155 m³/s;
capacity: 131,7 MW

Water conveyance structures



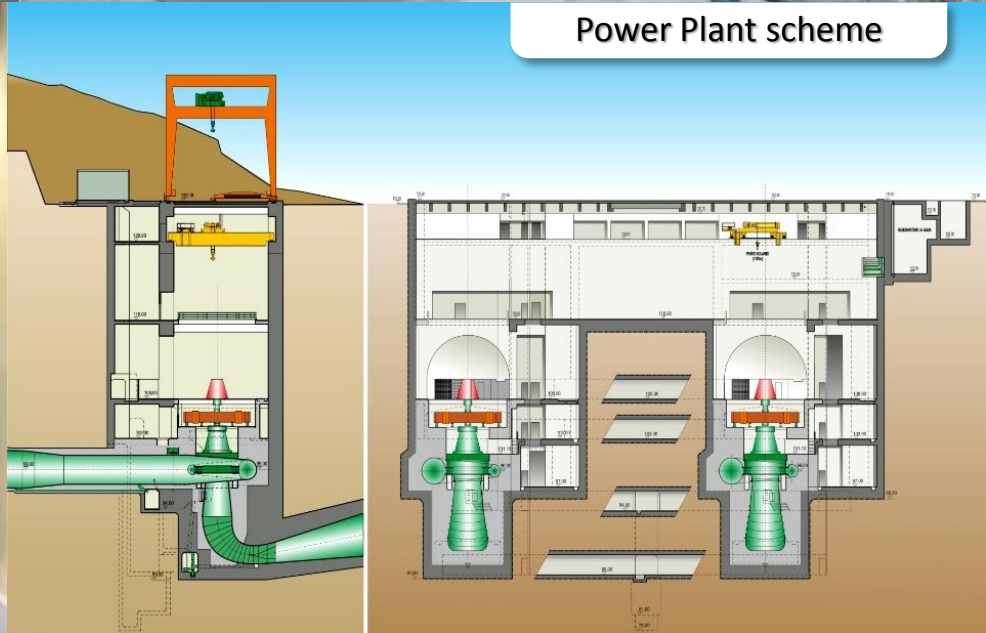
Water Intake



Power Plant



Power Plant scheme



DAMS

ANGOLA



CAMBAMBE HYDROELECTRIC DEVELOPMENT **714 MW**

DAM SAFETY ASSESSEMENT

Client/Owner: HSBC Bank and SRK Consulting
DAM SAFETY ASSESSEMENT : 2013 / 2015

HYDRO POWERPLANT 2

Client/Owner: ENE - Empresa Nacional de Electricidade
Design Review and Construction Supervision: 2011 / ongoing





ANGOLA

CAMBAMBE HYDROELECTRIC DEVELOPMENT DAM SAFETY ASSESSEMENT

Client/Owner: HSBC Bank and SRK Consulting
DAM SAFETY ASSESSEMENT : 2013 / 2015

This study concerns DAM SAFETY
ASSESSMENT of the Cambambe Dam
Heightening, as required by the financial
contract established between the
Government of Angola and the
consortium of banks led by HSBC-IB.





CAMBAMBE HYDROELECTRIC DEVELOPMENT DAM SAFETY ASSESSEMENT

Client/Owner: HSBC Bank and SRK Consulting
DAM SAFETY ASSESSEMENT : 2013 / 2015

This study concerns DAM SAFETY ASSESSMENT of the Cambambe Dam Heightening, as required by the financial contract established between the Government of Angola and the consortium of banks led by HSBC-IB.

The objective of the studies performed by COBA is to make an engineering assessment of the Cambambe dam safety, assuring that the project is designed and constructed using good international practices that guarantee the safety of structural elements and equipment, minimizing the risks and impacts arising from equipment accidents and structural failures during the project life cycle from both routine and non-routine circumstances.

The assignment is part of the Performance Standards Compliance Analysis on Social & Environmental Sustainability, as specified by the Multilateral Investment Guarantee Agency (MIGA) of the World Bank, developed by SRK Consulting (South Africa) Ltd as main Consultant.

The studies produced by COBA focused on the following:

Hydrological studies; Geological and engineering geological studies; Seismic hazard; Hydraulic design; Structural design; Geotechnical design; Hydromechanical equipment; Electrical installations; Monitoring systems; Emergency Management Plan





CAMBAMBE 2 CAMBAMBE HYDROELECTRIC DEVELOPMENT HYDRO POWERPLANT 2

714 MW

Client/Owner: ENE - Empresa Nacional de Electricidade
Design Review and Construction Supervision: 2011 / ongoing

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 714 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.
-
- Second hydro powerplant (Cambambe 2)
 - 4 Francis units 714 MW
 - 4 x 440 m long headrace tunnels (7,7 m Ø)



DAMS



ANGOLA

LAÚCA HYDROELECTRIC DEVELOPMENT

2 004 MW

RCC DAM

WATER CONVEYANCE SYSTEM

TOE-OF-DAM WATER CONVEYANCE
SYSTEM

MAIN UNDERGROUND POWERPLANT

Client/Owner: MINEA - Ministério da Energia e Águas / GAMEK

Design review, Project management and Construction

Supervision : 2013 / ongoing



HYDROPOWER



ANGOLA

2 004 MW

LAÚCA HYDROELECTRIC DEVELOPMENT

Client/Owner: MINEA - Ministério da Energia e Águas / GAMEK

Design review, Project management and Construction

Supervision : 2013 / ongoing

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 (2 004 MW), a toe-of-dam water conveyance system (ecologic flow (65,5 MW)) and a main underground powerplant.

- 6 Francis units 2 004 MW
- RCC Dam (132 m high, 1 075 m crest length)
- 6 x 1 900 m long headrace tunnels (9,0 x 12,0 m²)

Power Plant



**2 004 MW**

LAÚCA HYDROELECTRIC DEVELOPMENT

Client/Owner: MINEA - Ministério da Energia e Águas / GAMEK

Design review, Project management and Construction

Supervision : 2013 / ongoing

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 (2 004 MW), a toe-of-dam water conveyance system (ecologic flow (65,5 MW)) and a main underground powerplant.

- 6 Francis units 2 004 MW
- RCC Dam (132 m high, 1 075 m crest length)
- 6 x 1 900 m long headrace tunnels (9,0 x 12,0 m²)



DAMS

ANGOLA



GOVE HYDROELECTRIC DEVELOPMENT **60 MW**

GOVE DAM REHABILITATION AND CONSTRUCTION OF HYDROPOWER PLANT AND SUBSTATION

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

Project Management and Construction Supervision:
2007/2012

Dam Safety study: 2002/2005



DAMS

ANGOLA



60 MW

GOVE HYDROELECTRIC DEVELOPMENT

Gove Dam Rehabilitation and Construction of Hydropower Plant and Substation

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

Project Management and Construction Supervision:
2007/2012

DAM

Type: Earthfill
Height: 58 m
Crest length: 1,112 m
Reservoir volume: 2.5 bn m³

HYDROPOWER PLANT

Installed capacity: 60 MW
Average annual energy generation: 150 GWh

SUBSTATION

24 MVA transformers
11/220 kV

Dam Rehabilitation



Dam Rehabilitation



Power Plant



Power Plant



DAMS

ANGOLA

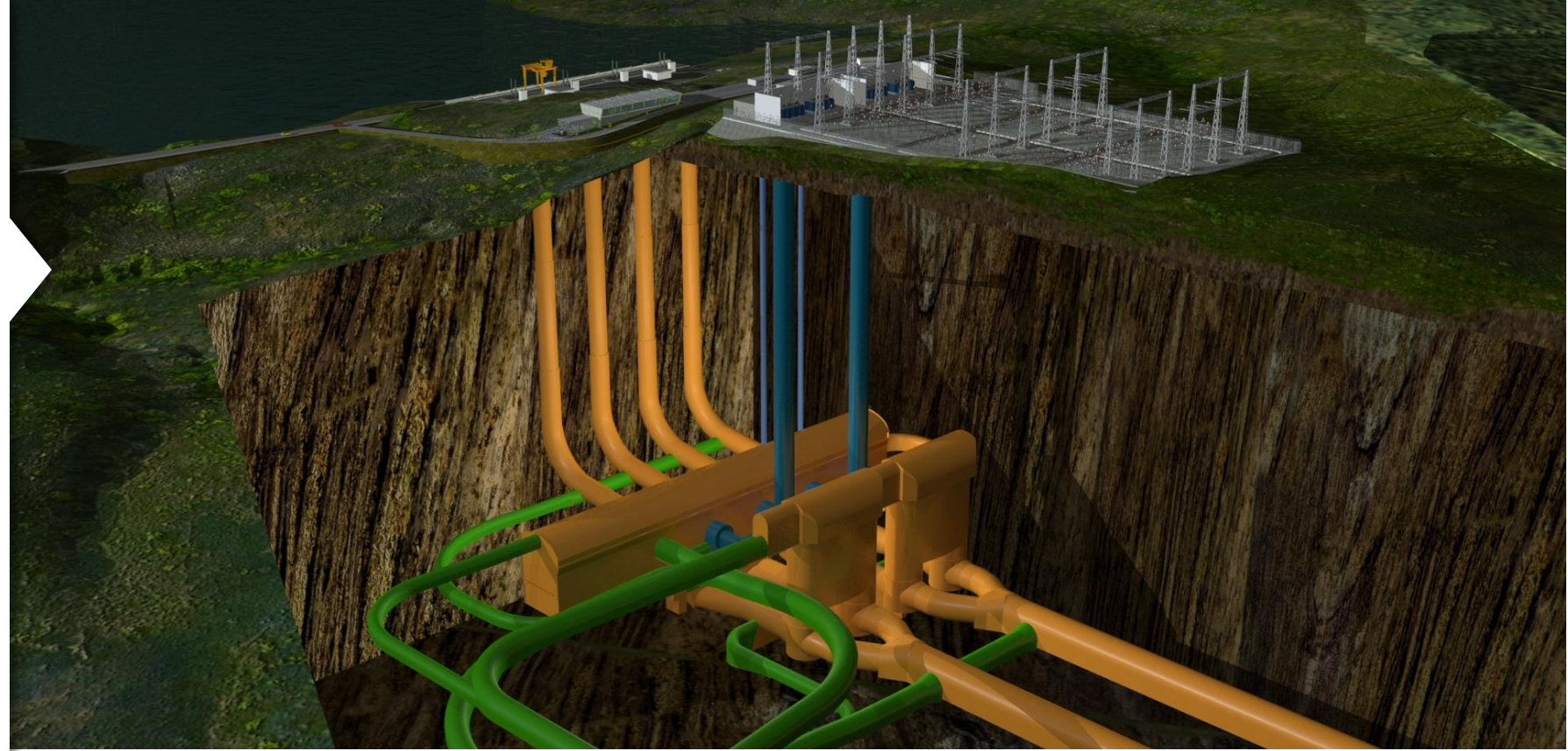


CACULO-CABAÇA HYDROELECTRIC DEVELOPMENT **2 040 MW**

**POWER PLANT
CONCRETE GRAVITY DAM
HEADRACE TUNNELS**

Client/Owner: GAMEK - Gabinete de Aproveitamento do Médio Kwanza

Detailed design and tender documents: 2013 / ongoing



HYDROPOWER

ANGOLA



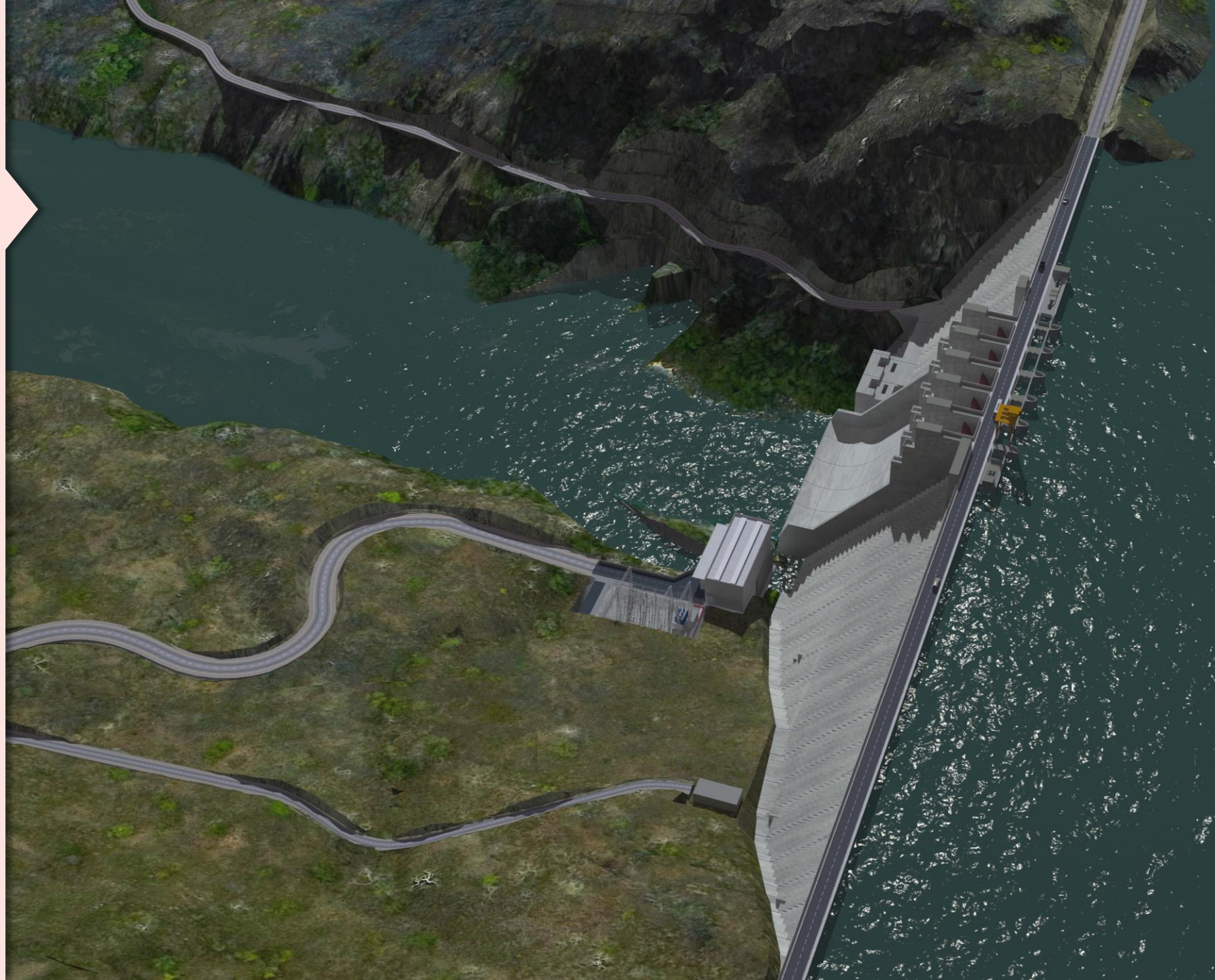
2 040 MW

CACULO-CABAÇA HYDROELECTRIC DEVELOPMENT

Client/Owner: GAMEK - Gabinete de Aproveitamento do Médio Kwanza

Detailed design and tender documents: 2013 / ongoing

- 4 Francis units 2 040 MW
- Concrete gravity dam (103 m height, 553 m crest length)
- 4 x 300 m long headrace tunnels
- 2 x 5 150 m long headrace tunnels (9,0 m Ø)



HYDROPOWER



ANGOLA

LUACHIMO HYDROELECTRIC DEVELOPMENT REHABILITATION AND REPOWERING

8,4 MW

Client/Owner: Direcção Nacional de Energia (Ministério de Energia e Águas (MINEA))

Tender Design and Environmental Impact Assessment: 2014/2015





ANGOLA

LUACHIMO HYDROELECTRIC DEVELOPMENT REHABILITATION AND REPOWERING

8,4 MW

Client/Owner: Direcção Nacional de Energia (Ministério de Energia e Águas (MINEA))

Tender Design and Environmental Impact Assessment: 2014/2015

The Luachimo Hydropower Development is located in the Luachimo River, close to the Dundo village, in the Lunda-North Province. This is a run-of-river hydropower Development, which resorts to the natural affluences of the Luachimo River and the gross head of about 18 m between the weir and the restitution location, in a short section of the river with about 750 m, where a series of successive rapids occur. It's construction dates back to the 50's and the plant began operating during 1957.

The undertaking 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 m³/s, including a water intake, conveyance canal, a forebay and penstocks and iii) a hydropower plant equipped with four turbine-alternator units with an installed capacity of 2,1 MW (total capacity of 8,4 MW).

In order the satisfactorily meet the current and future energy demands in the Lunda North province, and taking into account the available water resources in the Luachimo River, the Ministry of Energy and Water (MINEA) decided that the undertaking should be improved and thus enable to quadruple the total installed capacity.



DAMS

ANGOLA



JAMBA-IA-OMA HYDROELECTRIC DEVELOPMENT

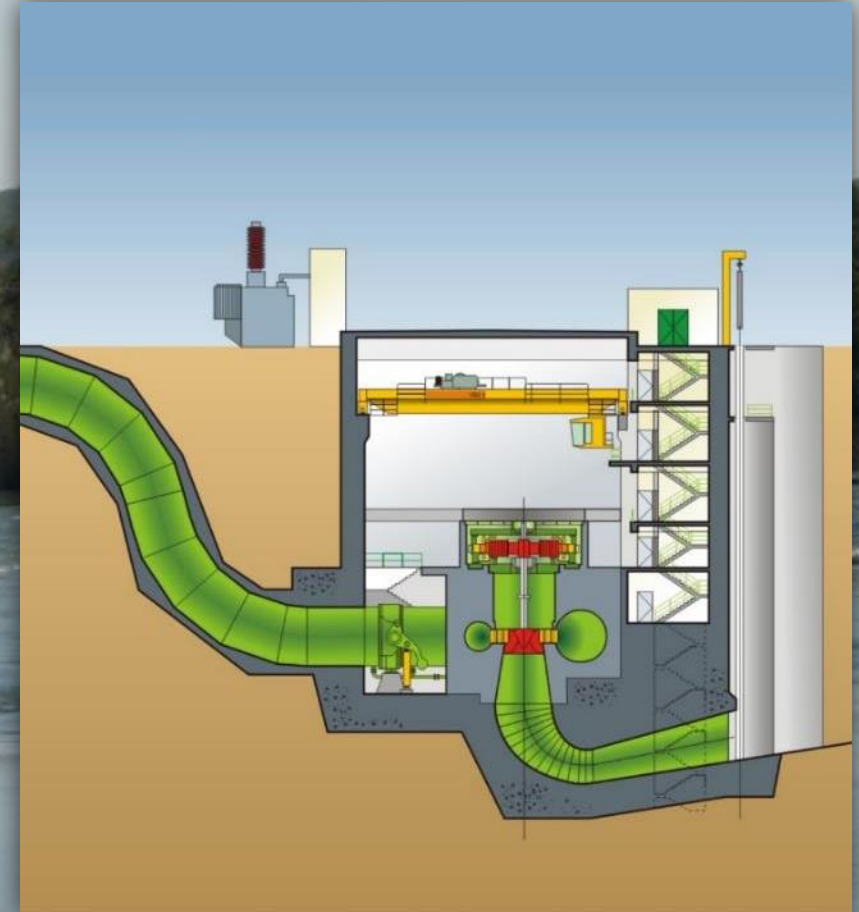
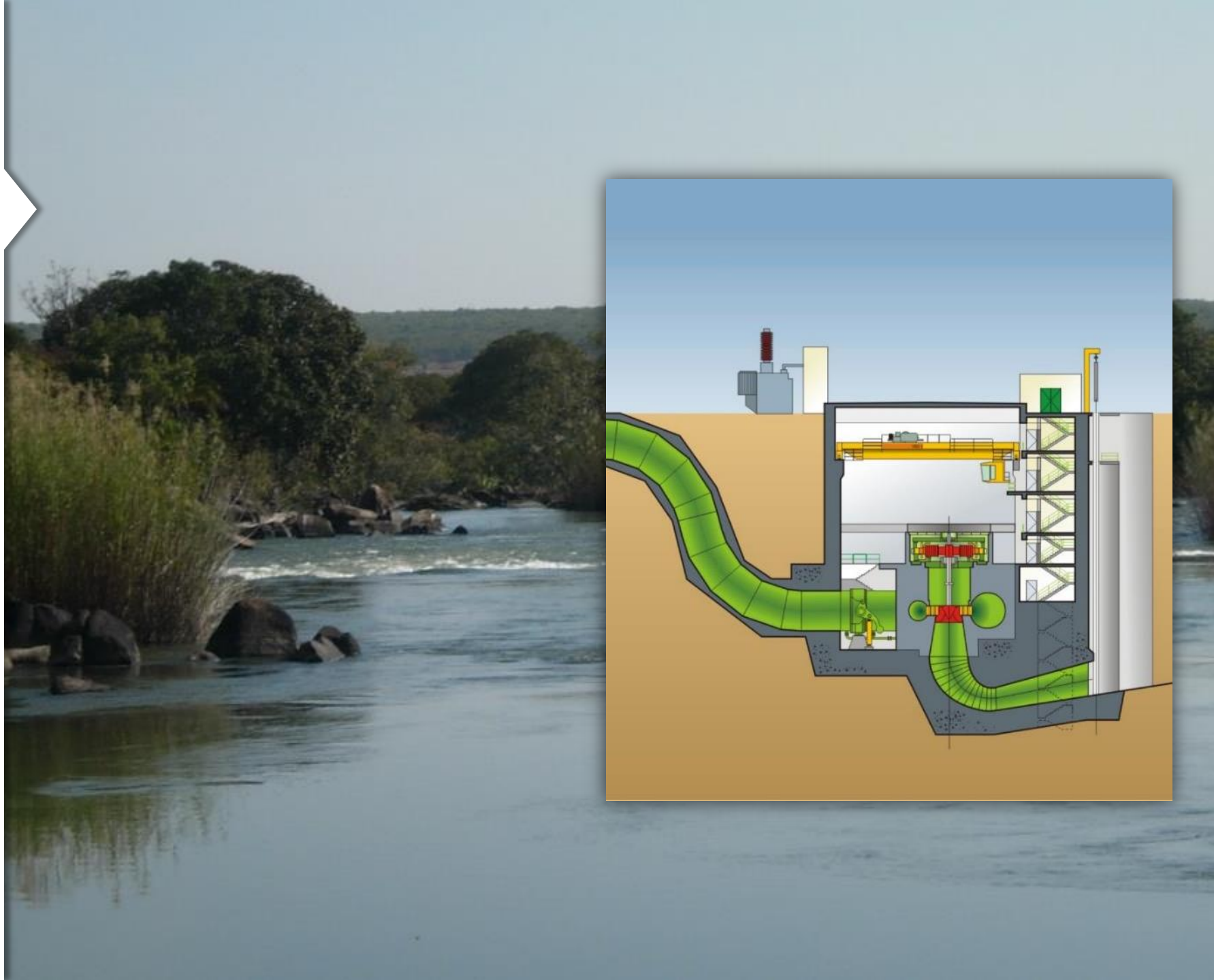
79 MW

GRAVITY CONCRETE AND EARTHFILL DAM
POWER PLANT
SUBSTATION

JAMBA-IA-OMA HIDROPOWER PLANT AND DAM (79 MW)

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

Feasibility Study: 2008 Tender Design: 2009/2011





79 MW

JAMBA-IA-OMA HYDROELECTRIC DEVELOPMENT

JAMBA-IA-OMA HIDROPOWER PLANT AND DAM (79 MW)

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

Feasibility Study: 2008 **Tender Design:** 2009/2011

DAM

Type: Gravity concrete and earthfill

Height: 47 m

Crest length: 2 803 m

Reservoir capacity: $1096,8 \times 10^6 \text{ m}^3$

Maximum flood flow: $4000 \text{ m}^3/\text{s}$

SPILLWAY

Type: frontal with six $14,0 \text{ m} \times 10,0 \text{ m}$ radial gates and ski jump

POWER PLANT

Number of Units: 3

Type: Francis, vertical

Nominal flow: $75 \text{ m}^3/\text{s}$

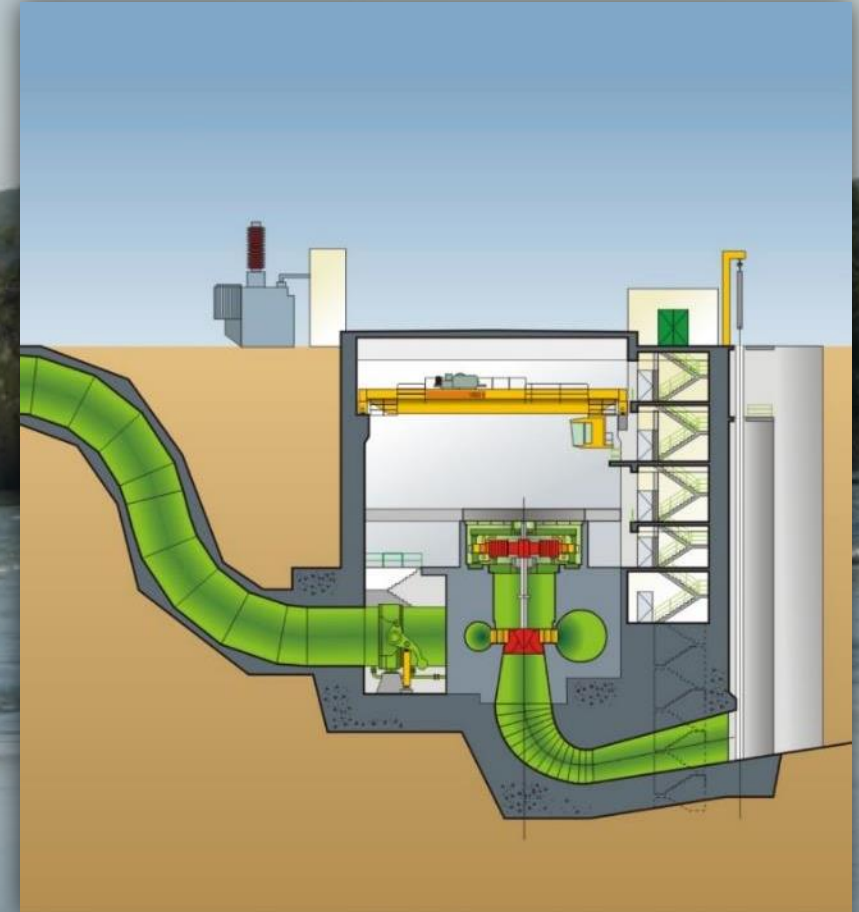
Net head: 38,8 m

Installed capacity : $3 \times 26,3 \text{ MW}$

SUBSTATION

Voltage of unit transformers: 29 MVA

Transformation ratio: 11 / 220 kV



DAMS

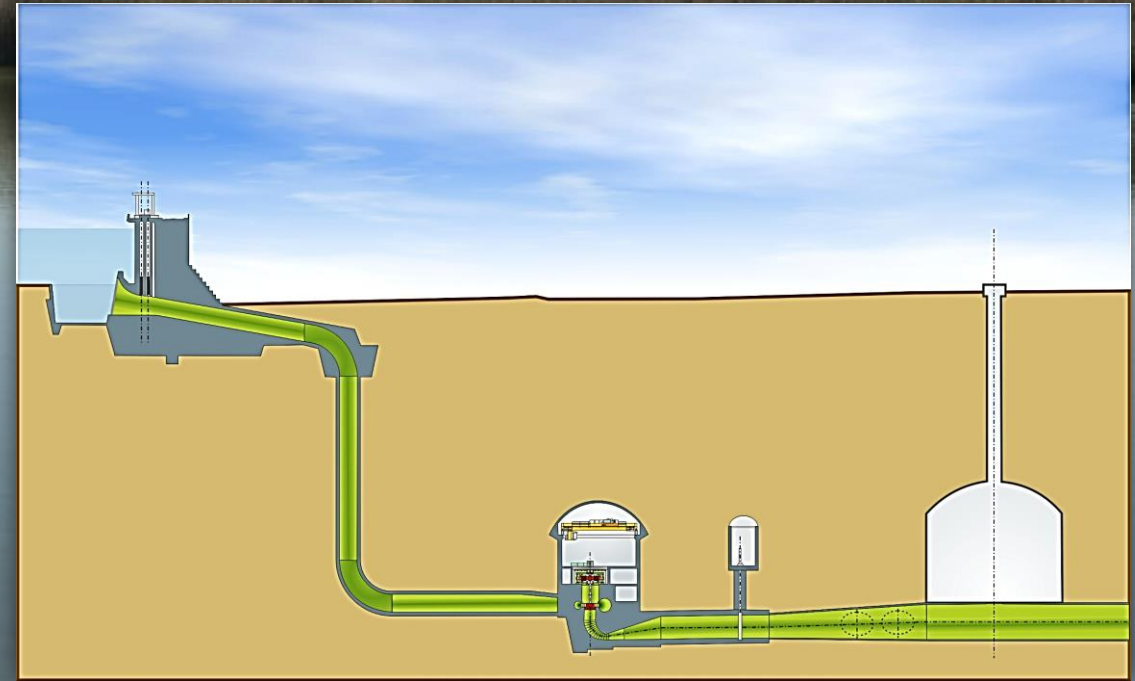
ANGOLA



JAMBA-IA-MINA HYDROELECTRIC DEVELOPMENT **224 MW**

GRAVITY CONCRETE DAM
POWER PLANT
SUBSTATION

JAMBA-IA-MINA HIDROPOWER PLANT AND DAM (224 MW)
Client/Owner: GABHIC - Gabinete para Administração da Bacia
Hidrográfica do Rio Cunene
Preliminary Design and Tender Design: 2010 / 2012





224 MW

JAMBA-IA-MINA HYDROELECTRIC DEVELOPMENT

JAMBA-IA-MINA HIDROPOWER PLANT AND DAM (224 MW)

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

Preliminary Design and Tender Design: 2010 / 2012

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; fourteen spans with 14 m widths, controlled by sector gates; restitution through ski jump.

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: 224 MW

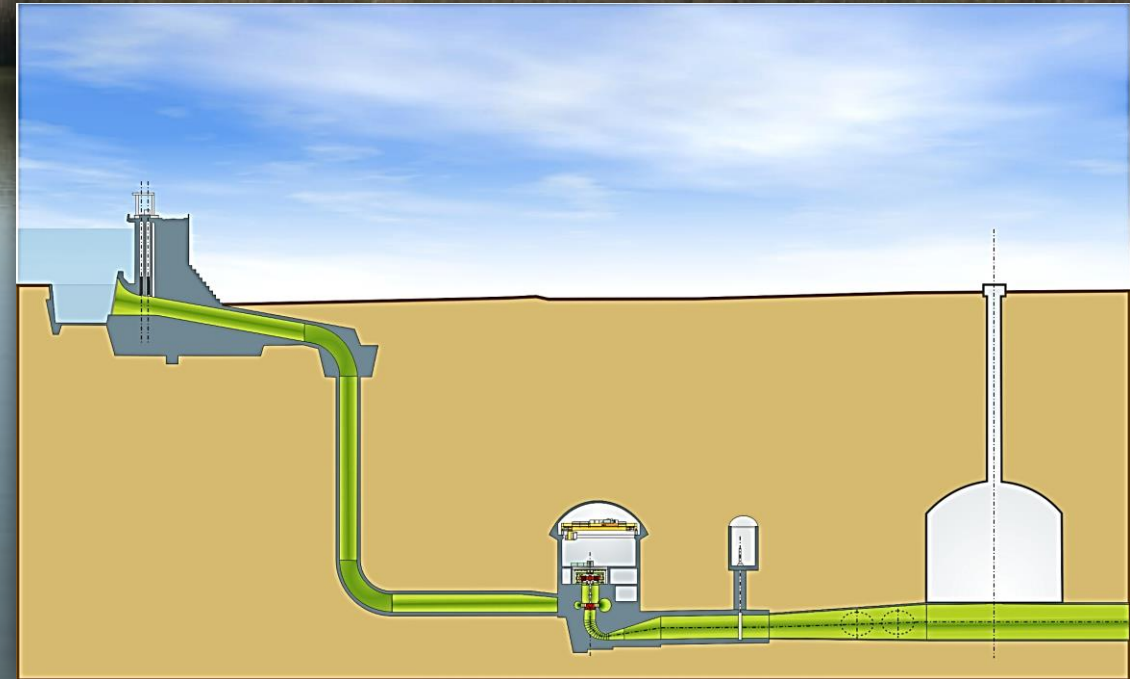
Rated flow: 300 m³/s

Head: 82,7 m

Number of units: 3 vertical axis Francis turbines

Annual mean generation: 535 GWh/year

220 kV Substation



Detail

DAMS

MOZAMBIQUE



CLIMATE RESILIENCE IN THE LIMPOPO BASIN (MAPAI DAM)

Client/Owner: ARA-SUL - Administração de Águas do Sul
Pre-Feasibility Assessment and Feasibility Studies: 2016 / 2018

TYPE

EARTHFILL DAM WITH ZONED PROFILE

HEIGHT

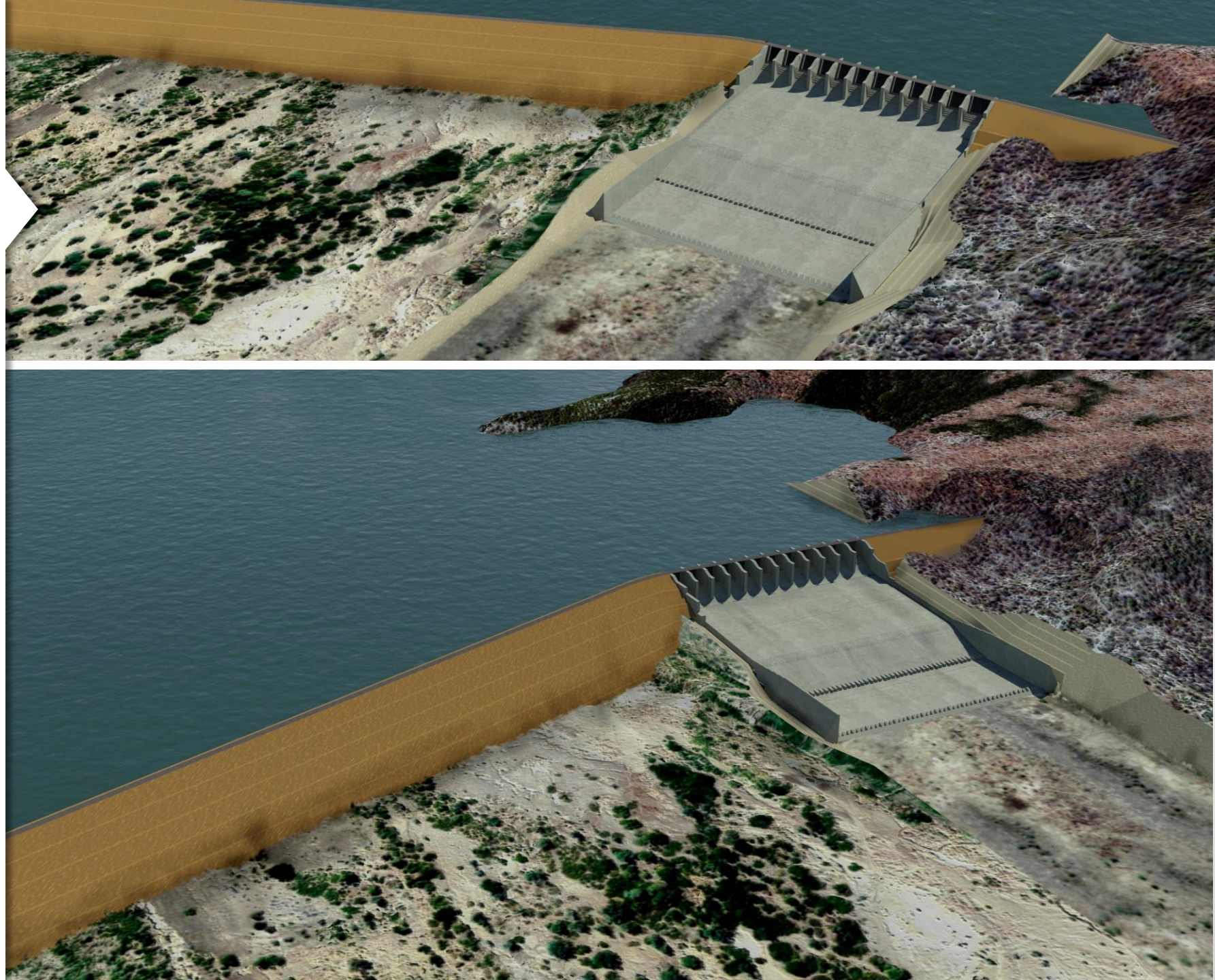
52 M

CREST LENGTH

3363 M

RESERVOIR CAPACITY

7288 hm³



DAMS

GREECE



315 MW

SFIKIA DAM

Client/Owner: PPC (Public Power Corporation)
Preliminary Studies : 1972

TYPE

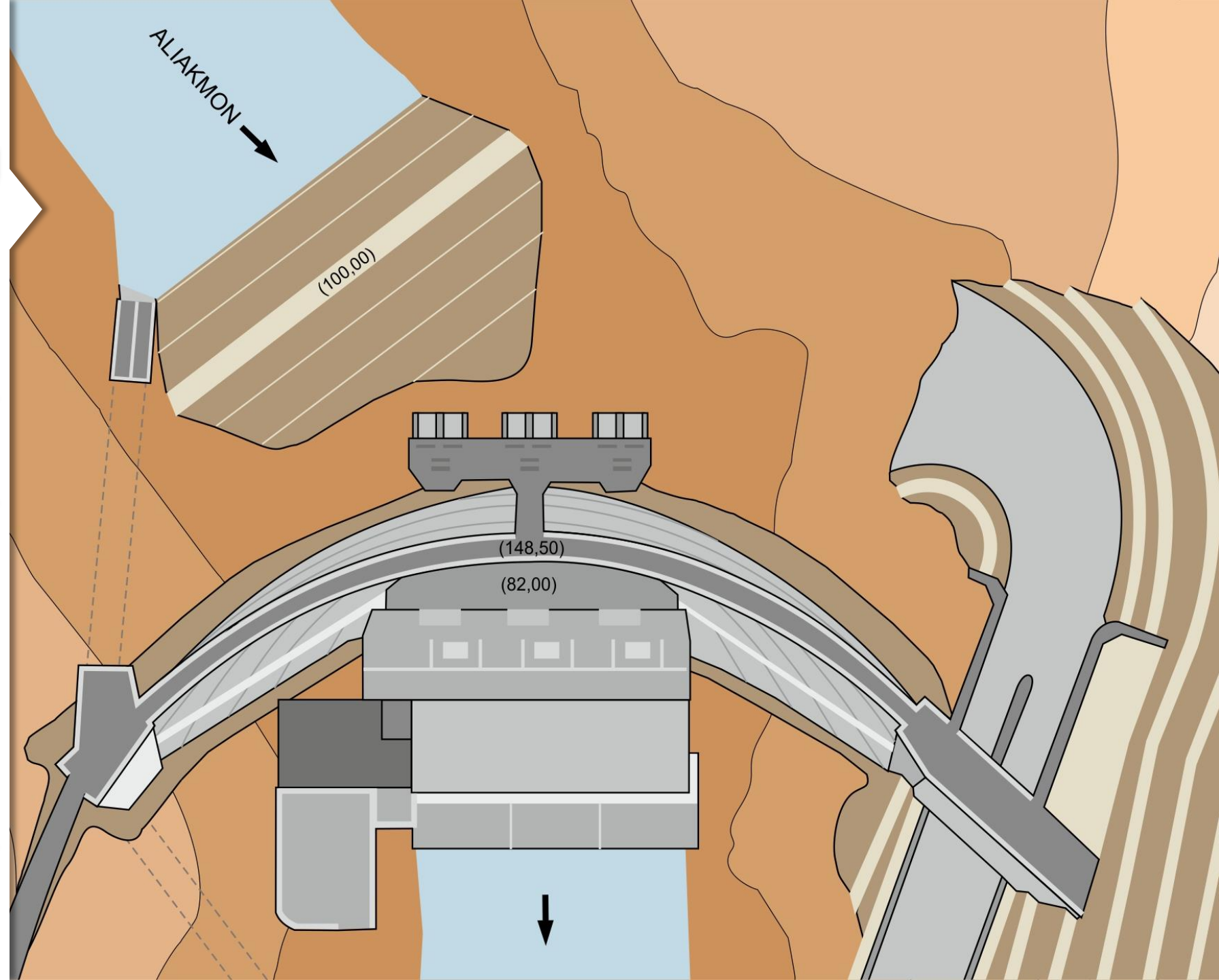
CONCRETE ARCH

HEIGHT

83 M

CREST LENGTH

310 M



DAMS

GREECE



108 MW

ASSOMATA DAM

Client/Owner: PPC (Public Power Corporation)
Preliminary Studies : 1972

TYPE

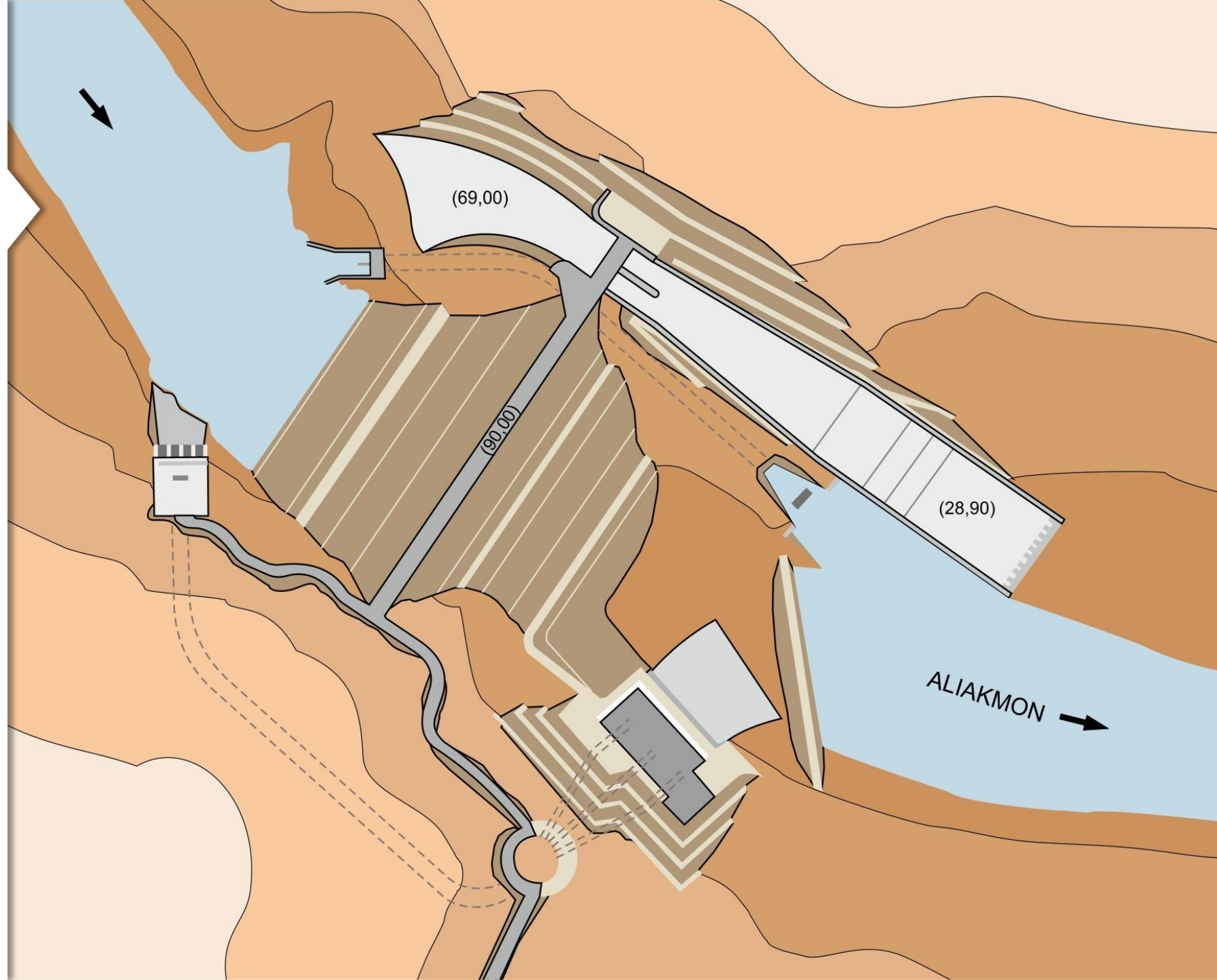
EARTHFILL DAM

HEIGHT

51 M

CREST LENGTH

205 M



DAMS

UGANDA



ORIAN HYDROELECTRIC DEVELOPMENT **437 MW**

**POWER PLANT
CONCRETE DAM
HEADRACE TUNNELS**

Client/Owner: Mota Engil África
Pre-feasibility studies: 2015/Ongoing



HYDROPOWER

UGANDA



437 MW

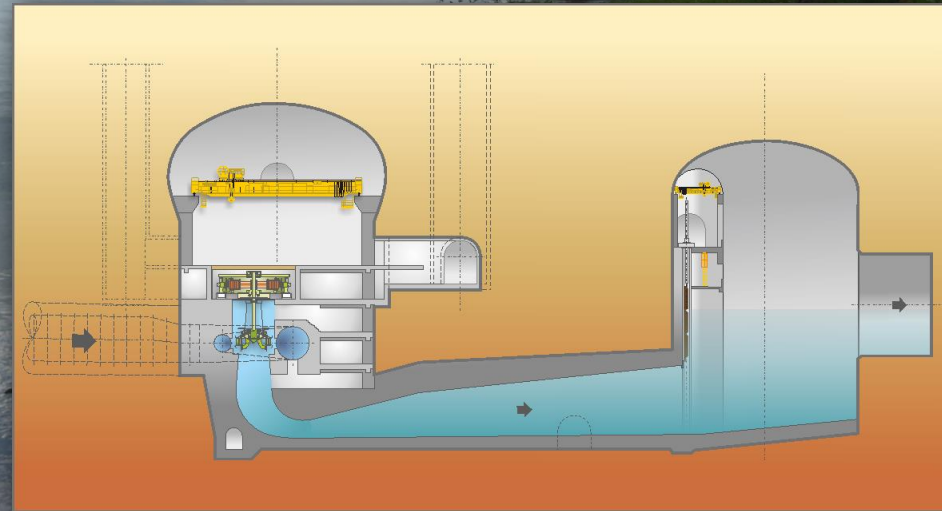
ORIAN HYDROELECTRIC DEVELOPMENT

Client/Owner: Mota Engil África

Pre-feasibility studies: 2015/Ongoing

Undertaking located in the Kyoga Nile river.

- 4 Francis units 437 MW
- Rockfill and concrete dam (37 m height, 1 620 m crest length)
- 4 x 326 m long headrace tunnels (9,0 m Ø)
- 2 x 8 250 m long headrace tunnels (15,4 x 15,4 m²)



Detail

DAMS

BRAZIL



DAM SAFETY INTERNATIONAL EXPERTS TEAM (DSIET) SUPPORT TO DAM SAFETY ANALYTICAL AND ADVISORY SERVICES TO THE NATIONAL WATER AUTHORITY (ANA) IN BRAZIL

Contract Date: 18 February 2013 - 30 June 2015

The contract envisaged support the World Bank in the preparation of all the necessary legislation, regulations and procedures that enable ANA to act, in the most appropriate manner, in the implementation of the Brazilian “National Policy on the Safety of Dams (PNSB)”, imposed under Law 12.334 of 20 September 2010





DAM SAFETY INTERNATIONAL EXPERTS TEAM (DSIET) SUPPORT TO DAM SAFETY ANALYTICAL AND ADVISORY SERVICES TO THE NATIONAL WATER AUTHORITY (ANA) IN BRAZIL

Contract Date: 18 February 2013 - 30 June 2015

The works consisted in the preparation of a set of Manuals and Guidebooks, containing proposals on best practice, to be used by the supervising authorities and by dam entrepreneurs, as well as documents pertaining to Classification of Dams as to Risk & Potential Associated Damage, as well as to the National Dam Safety Information System (SNISB).

The main deliverables produced were:

- Classification of Dams Regulated by the National Water Authority (ANA)
- Safety Policies and Operations Manual. Guidebook for ANA and Supervision Entities
- Safety Policies and Operations Manual. Guidebook for Entrepreneurs
 - Volume I – Emergency Action Plan Forms and Guidance Manual
 - Volume II – Dam Inspection Report Forms and Guidance Manual
 - Volume III – Periodic Dam Safety Review Guidance Manual
 - Volume IV – Terms of Reference for Contracting Services (Emergency Action Plan, Dam Safety Inspections and Periodic Dam Safety Review)
- Guidebook for Entrepreneurs
 - Volume I – Guidebook for Elaboration of Dam Designs
 - Volume II – Guidebook for Dam Construction
 - Volume III – Guidebook for Preparation of the Dam Operation, Maintenance and Instrumentation Plan.
- Assist in the Preparation of the Annual Report of Dam Safety
- Safety Manual for Small Dams
- National Information System on Dam Safety (SNISB)

Due to the complexity and range of the services consigned, COBA, Consultores de Engenharia e Ambiente, SA, established a partnership with COBA – Consultores para Obras, Barragens e Planejamento, Ltda (COBA Brazil), and subcontracted the services of the National Laboratory for Civil Engineering (LNEC), thus forming the COBA/LNEC Association.

The team included experts from the diverse areas of expertise in Dam Safety, who were responsible for the preparation of all documents delivered. These documents were regularly discussed with the World Bank specialists involved in the contract, and in several meetings held in Brasília, also attended by the ANA executives responsible for the Dam Safety activities.

The final presentation of the Consulting Services undertaken was done in a closing Workshop organized by ANA. To this event were invited approximately 150 directors of several Brazilian entities and companies, in an attempt to encourage reflection on the subject and on the documents produced.

DAMS

BRAZIL



IRAÍ DAM

TYPE

EMBANKMENT WITH ROCKFILL CORE

HEIGHT

19 M

CREST LENGTH

1 220 M

Client/Owner: SANEPAR, Companhia de Saneamento do Paraná

**Tender Design/Final Design, Tender Documents and
Procurement Processes:** 1996

Technical Assistance, Works Supervision and Management:
1996/1999

Behaviour and Safety Analysis: 1999/2002

Investment Cost: 10.4 M EUR

Located in the Curitiba Region, the Iraí dam envisages the reinforcement of water supply to Curitiba metropolitan area and downstream flood control.





IRAÍ DAM

Client/Owner: SANEPAR, Companhia de Saneamento do Paraná
Tender Design/Final Design, Tender Documents and Procurement Processes: 1996

Technical Assistance, Works Supervision and Management: 1996/1999

Behaviour and Safety Analysis: 1999/2002

Investment Cost: 10.4 M EUR

Located in the Curitiba Region, the Iraí dam envisages the reinforcement of water supply to Curitiba metropolitan area and downstream flood control.

- Type: Embankment with rockfill core
- Height: 19 m
- Crest length: 1 220 m
- Volume of Dam: 786,000 m³
- Reservoir capacity: 58 mio. M³
- Maximum flood flow: 1 005 m³
- Spillway: 80 m³/s, shaft with non-controlled weir
- Bottom outlet: 16,2 m³/s, gallery



DAMS

BRAZIL



FUNIL HYDROELECTRIC DEVELOPMENT

216 MW

TYPE

CONCRETE ARCH

HEIGHT

85 M

CREST LENGTH

360 M

Client/Owner: Companhia Hidroelétrica do Vale do Paraíba

Final Design and Technical Assistance: 1966/1969



DAMS

BRAZIL



216 MW

FUNIL HYDROELECTRIC DEVELOPMENT

DAM SAFETY

Dam seismic analysis (1998) and
strengthening of foundation curtain and
joints grouting (1991)

Client/Owner: Companhia Hidroelétrica do Vale do Paraíba
Final Design and Technical Assistance: 1966/1969



DAMS



ALGERIA

KEDDARA DAM

TYPE

EMBANKMENT WITH ROCKFILL

HEIGHT

108 M

CREST LENGTH

486 M

Client/Owner: National Dam Agency (ANB)

Final Design: 1980 / 1982

Technical Assistance: 1982 / 1986

Investment Cost: 60 M EUR

Dam located near Algiers on the Boudouaou river, with the purpose of water supply.





KEDDARA DAM

Client/Owner: National Dam Agency (ANB)

Final Design: 1980 / 1982

Technical Assistance: 1982 / 1986

Investment Cost: 60 M EUR

Dam located near Algiers on the Boudouaou river, with the purpose of water supply.

- Type: Embankment with rockfill
- Height: 108 m
- Crest length: 486 m
- Dam volume: 4.4 mio. m³
- Reservoir capacity: 146 mio. m³
- Maximum flood flow: 735 m³/s
- Spillway: 280 m³/s - canal
- Bottom outlet: 60 m³/s - tunnel



DAMS

MOROCCO



EL BORJ HYDROELECTRIC DEVELOPMENT **21,3 MW**

POWER PLANT
CONCRETE DAM
HEADRACE TUNNEL

Client/Owner: Office Nationale de Electricité - ONE
Feasibility Study: 1998/1999
Tender Design and Tender Documents: 2000/2003



HYDROPOWER

MOROCCO



21,3 MW

EL BORJ HYDROELECTRIC DEVELOPMENT

Client/Owner: Office Nationale de Electricité - ONE

Feasibility Study: 1998/1999

Tender Design and Tender Documents: 2000/2003

Undertaking located in the Oum Er-Rbia river.

- 2 Francis units 21,3 MW
- Earthfill and concrete Dam (25 m height, 270 m crest length)
- One 10 200 m long headrace tunnel (3,3 m Ø) and 200 m long penstock (2,8/3,0 m Ø)



DAMS

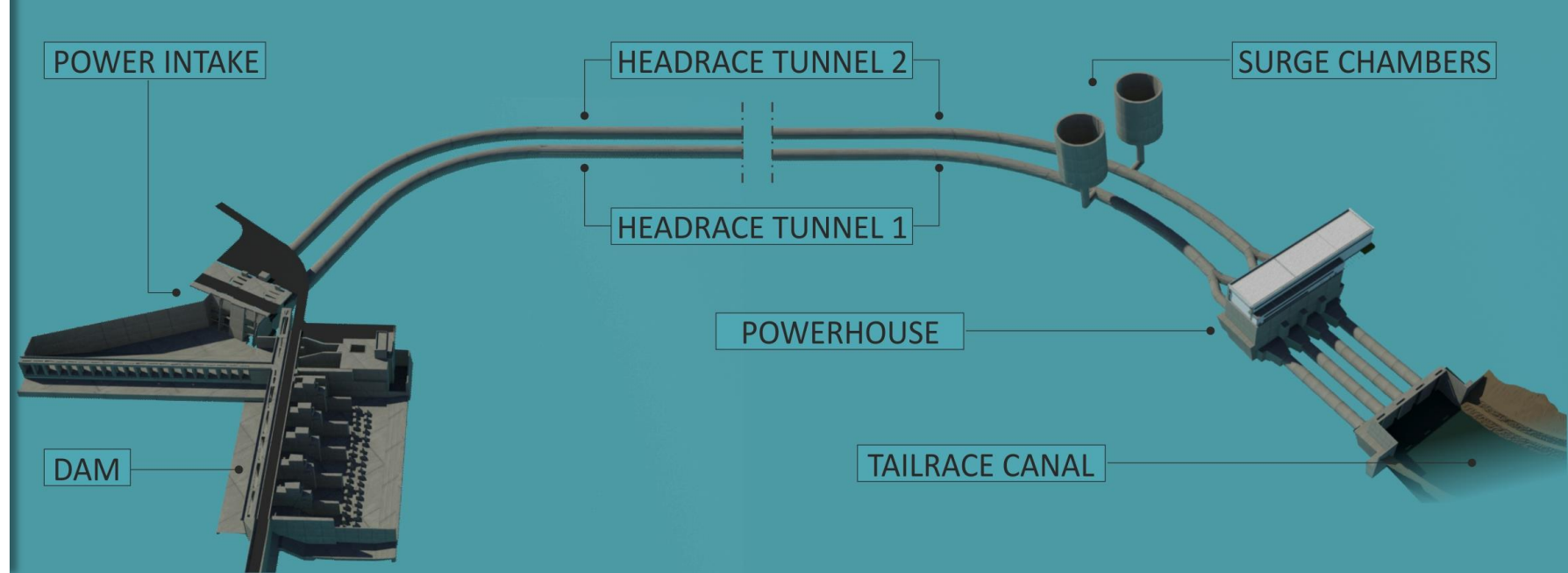
MALAWI



KHOLOMBIDZO HYDROELECTRIC DEVELOPMENT **212 MW**

CONCRETE GRAVITY DAM
HEADRACE TUNNELS
POWER PLANT

Client/Owner: Ministry of Natural Resources, Energy and Mining
Feasibility Study and Environmental and Social Impact
Assessment. Preliminary Engineering Design and Cost Estimate:
2015/ Ongoing





KHOLOMBIDZO HYDROELECTRIC DEVELOPMENT

212 MW

Client/Owner: Ministry of Natural Resources, Energy and Mining

Feasibility Study and Environmental and Social Impact Assessment. Preliminary Engineering Design and Cost Estimate: 2015/ Ongoing

The Kholombidzo Project is located in the middle of Shire River, upstream of Nkula Falls and the first falls downstream of Liwonde Barrage. The Site offers an advantage of a **potential electricity generation capacity ranging from 60 MW during dry season to 220 MW during rainy season.**

The feasibility studies have the purpose to construct a hydro power project of 212 MW at Kholombidzo.

- 4 Francis units 212 MW
- Concrete gravity dam (16,8 m height, 265 m crest length)
- 2 x 2 800 m long headrace tunnels (8,0 m Ø)





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