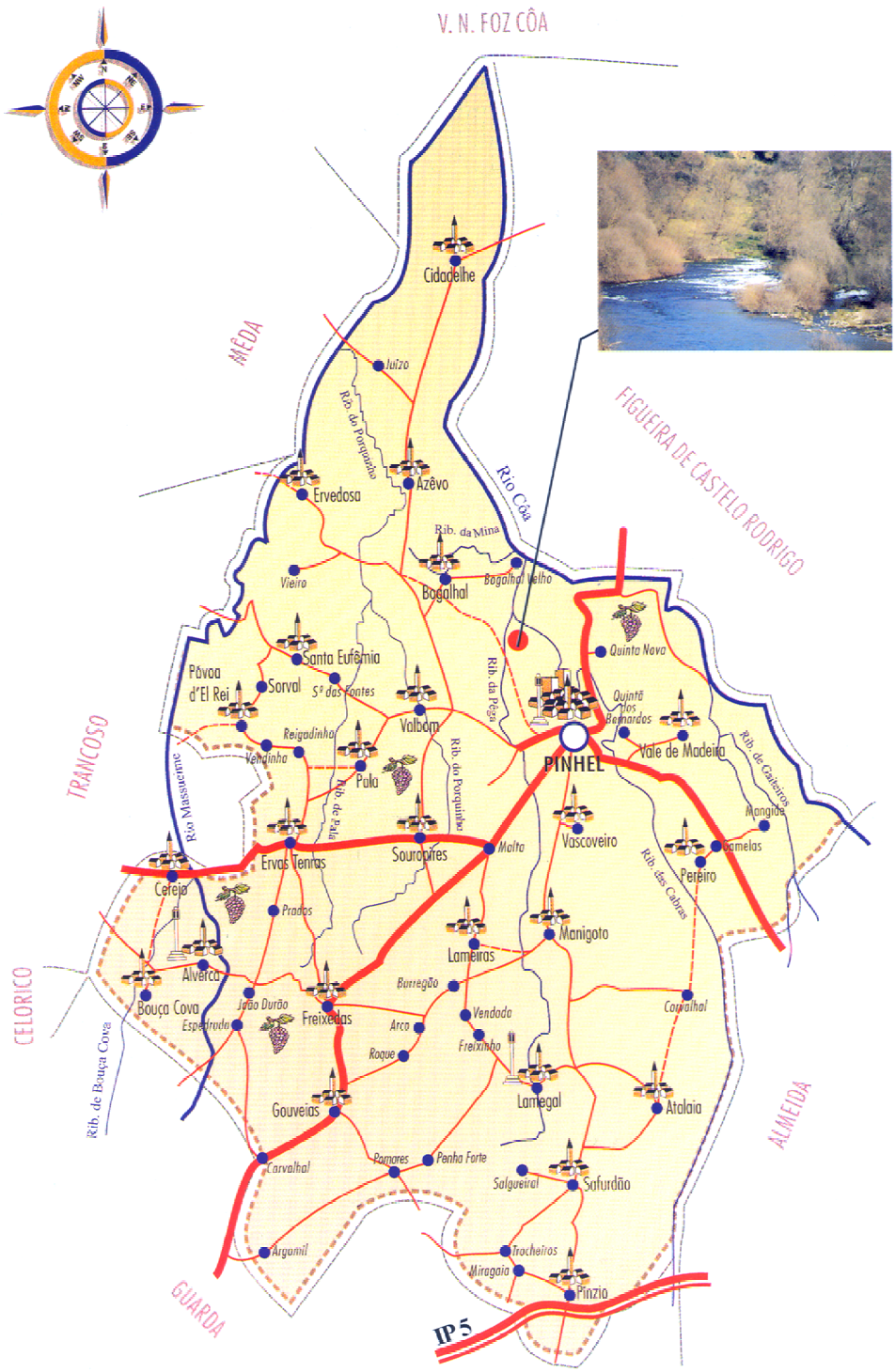
PINHEL HYDROPOWER SCHEME

CABRAS AND PÊGA RIVERS

PINHEL MUNICIPALITY



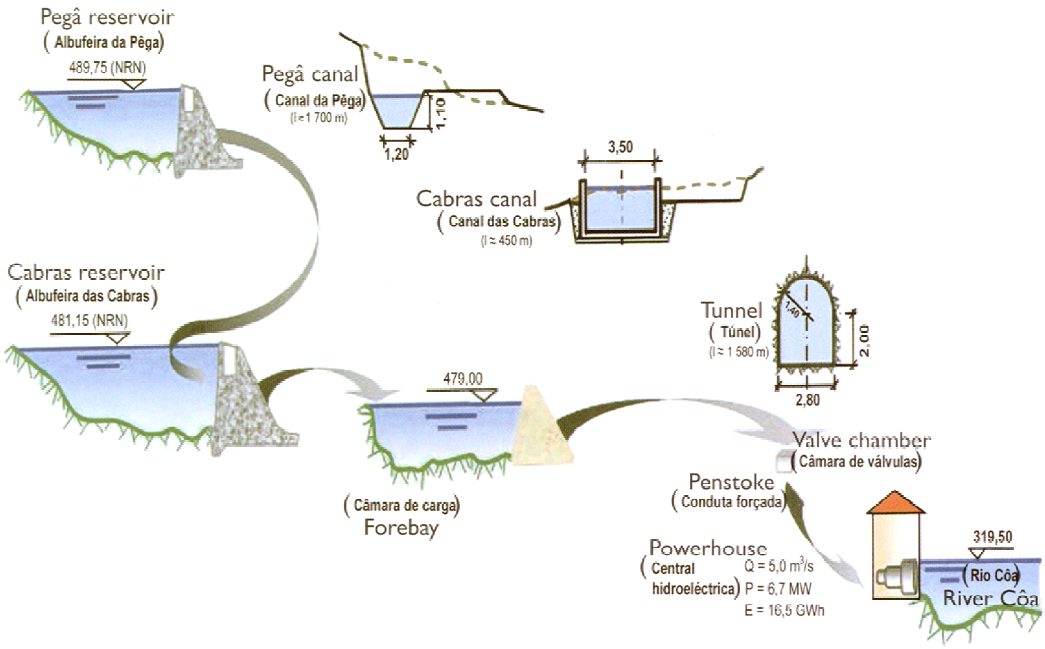
The Pinhel hydropower scheme, located in the Municipality of Pinhel and designed exclusively for the electrical energy production, is sited at the end stretches of the Pêga and Cabras rivers, the latter a left-bank tributary of the Côa river. The scheme is operated in a run-of-river mode, although with partial regulation of the daily flows. The construction of the scheme began in September 2002 and its first connection to the national electricity grid took place in April 2004.

Without jeopardizing its function and energetic worth, the scheme was designed and executed in such a way as to ensure its good harmonization with the local water and land ecosystems, as well as with the surrounding landscape. With the biophysical restoration and the landscape integration of the areas affected, which were carried out at the final stage of the construction works, this harmonization became even more evident.

The scheme was designed for a maximum discharge of 5,0 m^3/s, a maximum gross head of ca. 159,5 m, and an installed capacity of 6,76 MW. The energy produced, with a mean annual value of 16,5 GWh, is fed into the national electricity grid at the Pinhel substation, through a 60-kV electrical line, 6,3 km long.

In general lines, the Pinhel hydropower scheme includes two weirs, one on the Pêga river and the other on the Cabras river, a canal connecting the reservoirs formed by those weirs, and another canal between the Cabras weir and the forebay, downstream from which are the tunnel, the penstock, the powerhouse and the respective substation.

The general design of the two weirs is identical, being based on an overtopping gravity profile provided with Creager-type spillway chutes, with crests located at the corresponding normal retention levels and designed for the 500--year peak flood discharges. The weirs create small reservoirs, without regulation capacity and submerging, together, a total area of ca. 8,9 ha.



Pêga reservoir

The spillway chutes of the Pêga and Cabras weirs, each with a length of ca. 50 m, were designed for the peak flood discharges of 367 m^3/s and 518 m^3/s (500-year design floods). The weirs have maximum heights, above the foundations, of 7,75 m and 11,15 m.

Cabras weir

The weirs are provided with main water intakes, with bottom outlets and with water intakes for the ecological discharges. The main water intakes are Tyrolean-type, and are protected with grids with a 20% downstream slope. The bottom outlets consist of submerged circular intake orifices, equipped with flat sluice gates operated from the platforms located near the side abutments of the weirs. The water intakes for the ecological discharges consist of submerged, non-closable circular orifices designed to insure the prior discharge of the ecological flows, with values of 50 l/s and 102 l/s, in the Pêga and in the Cabras weirs, respectively.

Cabras weir and initial stretch of the Cabras-forebay canal

The diversion canal connecting the Pêga and the Cabras reservoirs has a total length of ca. 1 700 m and was designed for a maximum discharge of 2,6 m^3/s. It is a concrete-lined, excavated canal with a trapezoidal section with a bottom width of 1,2 m, nearly the same dimension in height and a side wall slope of 1:2 (W:H). A regulation gate was installed in its initial stretch, followed by a side spillway that returns to the river the flows exceeding the maximum design discharge.

Another diversion canal, designed for a maximum discharge of 5,0 m^3/s, having a length of ca. 450 m and a concrete rectangular section with a bottom width of 3,5 m and variable height, extends from the Cabras water intake to the forebay. This canal is provided with two side spillways, one immediately downstream from the regulation gate, and the other at its downstream end. This latter also functions as a surface spillway for the forebay, whenever an unexpected stop of the powerhouse occurs. The canal is still provided with rescue ramps with pedestrian passageways.

Cabras-forebay canal

Access road near Cabras weir

The forebay is located immediately upstream from the tunnel mouth. It consists of an embankment that closes a natural topographical depression at the right bank of the Cabras river. Between the normal retention level of 479,0 m and the minimum operation level of 475,0 m of the reservoir thus created, a net storage capacity of nearly 40 000 m^3, designed for partial regulation of the daily flows, is provided. The embankment has slopes of 1:1,3 (H:W), a maximum height of ca. 9,0 m and a length of 170 m, and it was mainly built with the tunnel excavation debris, duly compacted. Its upstream slope was made impervious by a concrete slab.

Forebay

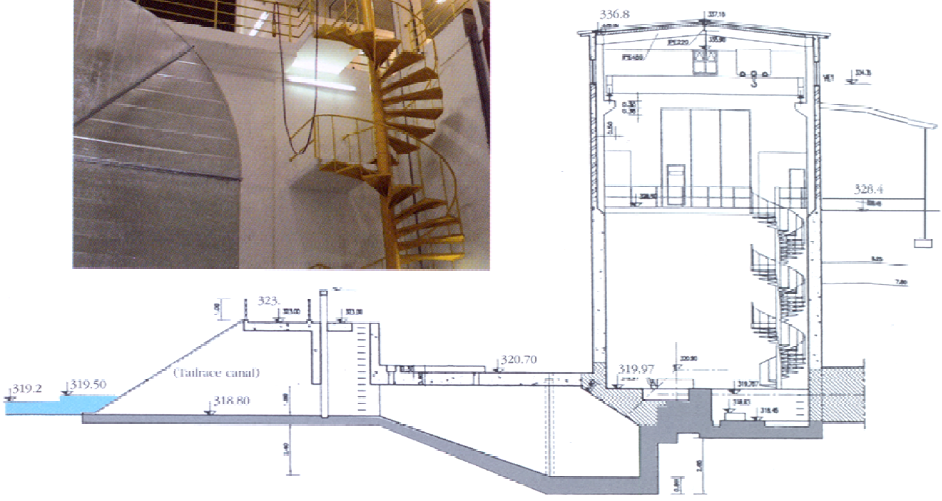
Right downstream from the forebay is the unlined tunnel, with the entrance protected by a grid. Near the tunnel entrance, the forebay water level control panel was installed. The tunnel has a ca. 1 600-m length, a slope of 0,16%, and a cross section with a 2,8-m bottom width, 2,0-m high side walls and a 1,4-m radius vault, its floor being concrete--lined. The tunnel and the forebay are emptied through the penstock and a complementary discharge circuit.

The valve chamber, embedded in the tunnel, near its downstream mouth, is provided with a ϕ 1 400 butterfly valve for protection of the penstock, and also with the respective control panel and electro-hydraulic governor.

The penstock extends between the elevations 468,5 m and 320,1 m a.s.l., in a length of ca. 380 m, and it consists of a 1 400-mm diameter welded steel piping, installed over the ground, with the exception of its end stretch, near the powerhouse building, where same is buried. It is supported on six anchor blocks, downstream from which expansion joints were installed. In the stretches between anchor blocks, the penstock lays on concrete saddle supports, spaced at intervals of ca. 11 m.

Penstock and powerhouse

The powerhouse building of the Pinhel scheme is located on the left bank of the Côa river, upstream from its confluence with the Cabras river. It comprises two floors with a total area of 212 m^2. The turbine, the generator and the remaining electromechanical equipment are installed in the largest of those floors, consisting on a basement that extends down to the elevation 320,0 m a.s.l., approximately. The ground floor elevation is 328,5 m a.s.l., that is, ca. 1,5 m above the 500-year flood level at the Côa river. This floor comprises an area reserved to the access and handling of the various equipment, the electrical installation and automation room, an office and the sanitary installations, as well as the telemetering equipment. The equipment displacement inside the powerhouse is made by a 32-t load capacity travelling crane.



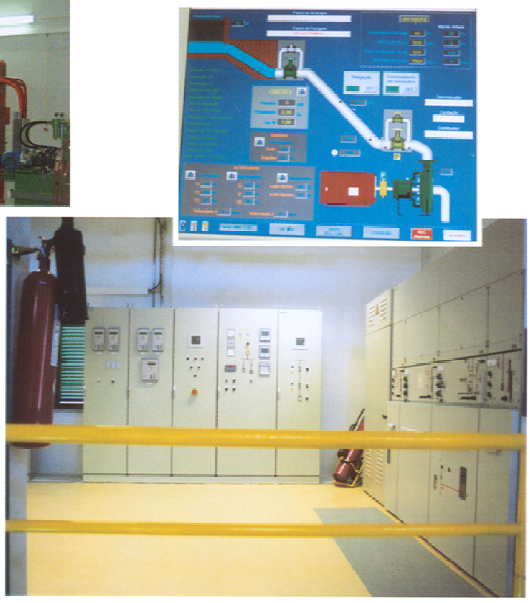
Powerhouse. Travelling crane and stairs

The turbine-generator unit includes one horizontal-shaft Francis turbine, with a 750-rpm speed and a 7,1-MW nominal power, at the shaft, and one horizontal-shaft synchronous generator with a 7,6-MW power, at the terminals, and a 6,6-kV generation voltage. The turbine protection is ensured by a ϕ 1 000 butterfly valve. The welded steel draft tube terminates submerged in an excavated gallery connected to the Côa river through a small and covered concrete tailrace canal.

Powerhouse and substation

The substation is located on a platform next to the powerhouse building, with its larger side parallel to the Côa river. It has an area of 180 m^2, and is fenced by a 2-m high metallic net. It is equipped with a main 6,6/60-kV transformer with a capacity of 7 600 kVA, and with a voltage and intensity transformer, overvoltage dischargers and a grid switch-disconnector.

Turbine-generator unit



Electrical board

The Pinhel hydropower scheme is interconnected with the national electricity grid at the Pinhel substation, at a supply voltage of 60 kV. For that purpose, an electrical line, with that same voltage, made of aluminium-steel conductors with a nominal section of 160 mm^2, and with a length of 6,3 km, approximately, was erected. As the initial stretch of the line is partially located in the Special Protection Zone (ZPE) of the Côa Valley, anti-perch and anti-nesting triangles were placed at the top of the line-supporting structures, and visual signs at the guard cables. This kind of signs was also provided for the air traffic.

Line interconnecting the grid

Under normal operation conditions, the power plant is unmanned and runs automatically. The equipment supervision and control, with the exception of the turbine distributor regulation and the generator excitation control systems, are performed via the main PLC installed in the powerhouse. The turbine distributor regulation and the start-up and shutdown sequences of the turbine-generator unit are controlled through the water level processing at the forebay. The status of the equipment installed inside the powerhouse is permanently monitored by a telecommunication system that transmits to the powerhouse operator, via a card *modem* connected to the PLC and via the local mobile phone network, the signals that will enable him to identify, from a long distance, any equipment malfunctions.

The environmental and landscaping integration of the Pinhel hydropower scheme stands out, not only by the design solutions and the construction methods adopted for the hydraulic structures and for the powerhouse building, but also by the methods used to open the road accesses, and to recover the riparian galleries, the excavation and landfill slopes (namely at the forebay) and all the other forested areas affected by the project. Such recovery is subject to the monitoring actions set forth in the Environmental Impact Declaration.

TECHNICAL DATA

HYDROLOGICAL CHARACTERISTICS	PÊGA RIVER	CABRAS RIVER
MAIN WATERSHED	Côa River	
WATERSHED AREA	136 km^2	274 km^2
NON-TURBINED MEAN ANNUAL FLOW	19,24 hm^3	51,63 hm^3
100-YEAR DESIGN FLOOD (weir section)	367 m^3/s	518 m^3/s

HYDRAULIC DIVERSION	PÊGA RIVER	CABRAS RIVER
WEIR	Gravity profile and Greager-type spillway chute	
NORMAL RETENTION LEVEL (NRL)	489,75	481,15
MAXIMUM HEIGHT OF THE SPILLWAY CHUTE CREST	7,75 m	11,15 m
WATER INTAKE	Tyrolean-type	
DESIGN DISCHARGE	2,6 m^3/s	5,0 m^3/s
CANAL - section / length	Trapezoidal / 1 700 m	Rectangular / 450 m
FOREBAY - maximum level / net storage capacity	479,0 / 40 000 m^3	
TUNNEL - cross section / length	12 m^2 / 1 600 m	
PENSTOCK - diameter / length	1 400 mm / 380 m	

POWERHOUSE	
OPERATION MODE	Partial regulation of daily flows; unmanned, automatic operation
TURBINE - type / speed	Horizontal-shaft Francis turbine / 750 rpm
GENERATOR - type / capacity	Syncronous / 7 600 kVA
TAILRACE WATER LEVEL (normal conditions)	319,5
MAXIMUM GROSS HEAD (downstream from the forebay)	479,0 - 319,5 = 159,5 m
INSTALLED CAPACITY	6 760 kW
MEAN ANNUAL ENERGY PRODUCTION	16,5 GWh

CONNECTION TO THE ELECTRICITY GRID	
MAIN 6,6/60-kV TRANSFORMER	7 600 kVA
SUPPLY VOLTAGE	60 kV
INTERCONNECTION LINE - section / length	Aluminium/steel - 160 mm^2 / 6,3 km
INTERCONNECTION POINT	Pinhel Substation

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