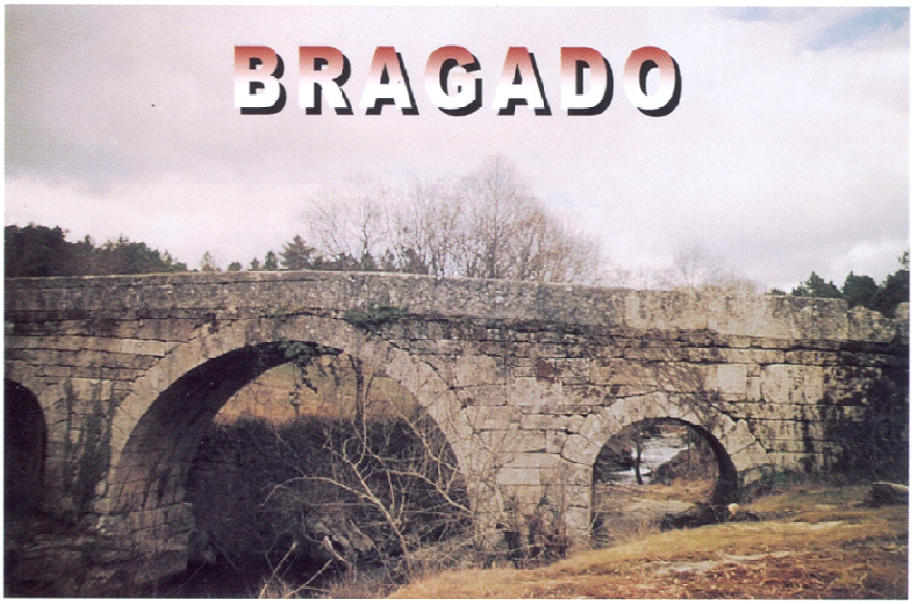
# HYDROPOWER SCHEME




Avelames River


Bragado small hydropower scheme (SHP) is located at the end stretch of the Avelames river, a left bank tributary of the Tâmega river, in the municipality of Vila Pouca de Aguiar, district of Vila Real, and it is exclusively designed for hydroelectricity production. The scheme's construction started in August 1997 and its first connection to the national electricity grid took place in December 1998.

The energetic worth of the Bragado Scheme is high, especially if viewed within an environmental sustainability framework. The scheme was designed and executed in such a way as to ensure its good integration in the water and land ecosystems and in the surrounding landscape, the improvement and enlargement of the existing road accesses, and the multifunctional use of the hydraulic infrastructures that were created.

This electricity producing facility is designed for a maximum discharge of 2,2 $m^3/s$ and for a maximum gross head of about 158,6 m, corresponding to an installed capacity of 2,8 MW. The energy produced, the mean annual value of which is 9,0 GWh, is fed into the national electricity grid at the Vidago switching station, through a 15-kV line, 12-km long.

The scheme includes a concrete weir, located on the Avelames river, with a height of 11,5 m above the river bed and a total developed length at crest of 45,8 m. The spillway chute was designed for the 100-year peak flow discharge (230 $m^3/s$). Its 13-m long crest comprehends two Creager-type contiguous cross-sections: one at the intake zone, close to the left bank of the river, where a hinged-type gate is installed for removal of floating objects, and the other at the longer span, the top of which is located at the full supply level (FSL - 495,1 m).

The reservoir created by the weir provides a storage, between the FSL and the minimum operation level (MOL - 492,9 m), of around 25 000 $m^3$, submerging an area of 1.4 ha at the FSL. This storage is intended to partially regulate the inflows, so that the daily energy production is mainly concentrated during the peak and full hours' periods. This operation mode is assured by the main programmable logical controller (PLC) installed in the powerhouse, which receives and processes the data from another PLC installed in the water intake, as well as from one water level gauge, in the forebay, and from one flow meter, in the penstock.

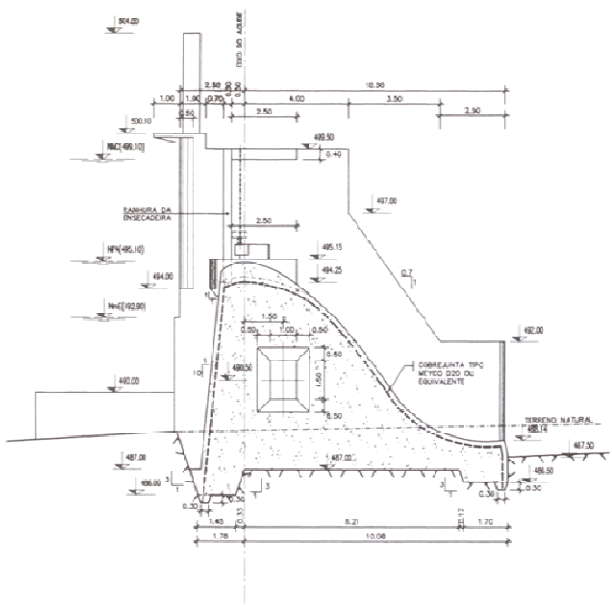
The water intake was designed for the above mentioned maximum discharge, plus the ecological and the reserved discharges, of 64 l/s and 60 l/s, respectively. This intake consists of a rectangular orifice at the left abutment of the weir, protected by a movable vertical grid. The diverted flow is regulated by a sluice gate Wagu-type, the opening of which is controlled by the PLC installed in the water intake. A small energy dissipation basin is located downstream of this gate, in order to prevent the propagation of turbulence phenomena into the diversion canal.

The bottom outlet, also located at the left abutment of the weir, below the water intake orifice, is composed of a 1,0 x 1,2 $m^2$ rectangular section gallery, the top of which is at the elevation 488,2 m. The control of such device is made by a roller gate that works automatically in case of flooding.

The hydraulic diversion runs along the left bank of the Avelames river. Its free surface reach, from the downstream end of the water intake energy dissipation basin to the forebay, is composed of a reinforced concrete diversion canal with a 1,08 ‰ bottom slope and a 1,5-m inner width rectangular section.

Approximately 200 meters of the canal are covered, including its cut-and-cover reaches. About 500 meters upstream of the forebay is a side spillway designed to limit the water level over-raising in result of the unsteady regimes caused by the stop of the turbine. The diversion canal is provided with three aqueducts over small streams, four passageways for pedestrians and vehicles, and with rescue ramps every ca. 350 meters.

Downstream of the diversion canal is the sedimentation chamber, followed by the forebay and by the valve chamber at the end. The sedimentation chamber is provided with a bottom outlet for removal of the debris dragged along the hydraulic diversion. In the valve chamber a 900-mm diameter butterfly valve is installed for protection and safety of the penstock, this valve being equipped with an automatic closing device that operates in cases of overspeed.



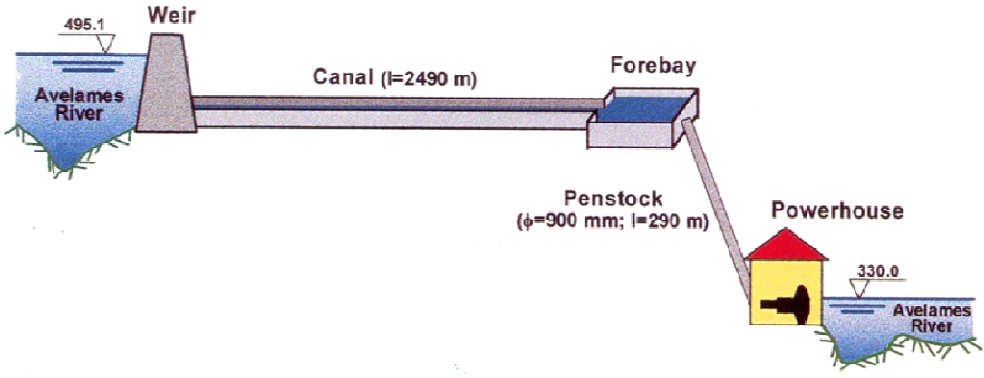
The penstock is a non-buried 900-mm diameter steel piping, supported on concrete blocks located every 12 meters in the straight reaches. There are three anchor blocks along the penstock to absorb the hydraulic impulses and the strains resulting from the penstock own weight and from the temperature variations.

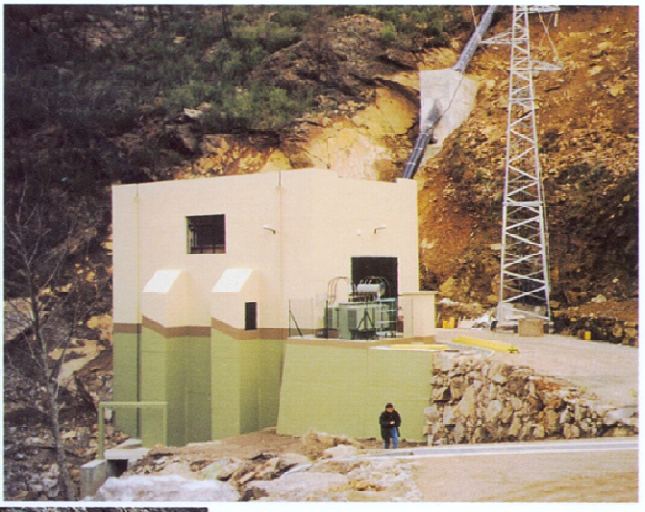
The powerhouse, located at the left bank of the Avelames river, has an horizontal area of 130 $m^2$. It has two floors, at the elevations 332,0 m and 338,0 m, and an intermediate floor, at the elevation 335,4 m, where the office and the operator's control room are located. In the lower floor, the horizontal Francis turbine, the synchronous generator, the turbine protection butterfly valve, the electro-hydraulic governor and the lubrication system are installed. The electrical installations, in particular the protection, signal, automation and electric/hydraulic control panels, the auxiliaries panel and the generation voltage metal switch-gear are installed in the upper floor.

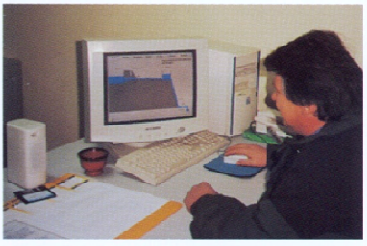
On the outside, in a platform adjacent to the powerhouse, is the transformer and, in a small contiguous building, the active and reactive energy metering board.

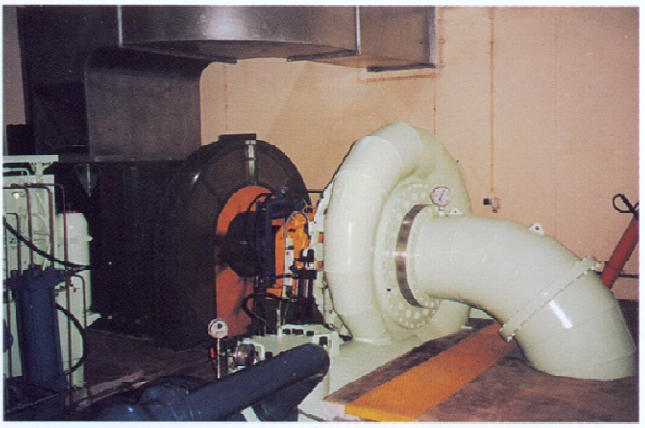
Under normal operation conditions, the power plant is unmanned, and it is automatically operated. The supervision and the control of the equipment, with the exception of the generator and turbine control excitation system, is made via the main PLC of the powerhouse. The distributor opening is controlled by the turbine PLC through the processing of the data relating to the water level in the forebay.

A data teletransmission system, via a switched telephone network and a modem, transmits to the operator the signals that allow him to be aware of any deficiencies that may occur while the powerhouse is operating, as well as to take the subsequent remote control procedures.









## GENERAL COORDINATION

HIDROERG - Projectos Energéticos, Lda.

## DESIGN

HIDROTÉCNICA PORTUGUESA - Consultores para Estudos e Projectos, Lda.

## CIVIL WORKS

| | |
|---|---|
| GENERAL CONTRACTOR | OBRECOL - Obras e Construções, S.A. |

## HYDROMECHANICAL, ELECTROMECHANICAL AND ELECTRICAL EQUIPMENT

| | |
|---|---|
| GENERAL CONTRACTOR | Mecánica de la Peña, S.A. |
| SUBCONTRACTORS | Cegelec AEG Instalações e Sistemas de Automação, Lda. |
| | INDAR - Construcciones Electro-mecánicas, S.A. |

## INTERCONNECTION TO THE NATIONAL ELECTRICITY GRID

Silva & Vinha, Lda.

## SUPERVISION OF THE CONTRACTS

HIDROERG - Projectos Energéticos, Lda.

EN - Electricidade do Norte, S.A.

# TECHNICAL DATA

| HYDROLOGICAL CHARACTERISTICS | | |
|---|---|---|
| WATERSHED AND WATERCOURSE | TÂMEGA RIVER | AVELAMES RIVER |
| WATERSHED AREA | 78,8 | $km^2$ |
| MEAN ANNUAL FLOW | 44,1 | $hm^3$ |
| 100-YEAR DESIGN FLOOD (WEIR SECTION) | 230 | $m^3 s^{-1}$ |

| HYDRAULIC DIVERSION | | |
|---|---|---|
| WEIR (TYPE AND HEIGHT) | GRAVITY CONCRETE | 11,5 m |
| RESERVOIR | DAILY REGULATION | 25 000 $m^3$ |
| WATER INTAKE | SUBMERGED | 2,2 $m^3 s^{-1}$ |
| DIVERSION CANAL | RECTANGULAR CROSS-SECTION | 2 490 m |
| VALVE CHAMBER AND FOREBAY | LONGITUDINAL | 90 $m^2$ |
| PENSTOCK | 900 mm | 290 m |

| POWERHOUSE | | |
|---|---|---|
| TURBINE | FRANCIS HORIZONTAL SHAFT | 1 000 rpm |
| GENERATOR | SYNCRONOUS | 3 725 kVA |
| DESIGN NET HEAD | 155,2 | m |
| INSTALLED CAPACITY | 3 100 | kW |
| MEAN ANNUAL PRODUCTION | 9,0 | GWh |

| INTERCONNECTION TO THE ELECTRICITY GRID | | |
|---|---|---|
| MAIN 6,6/15 kV TRANSFORMER | 3 600 | kVA |
| SUPPLY VOLTAGE | 15 | kV |
| CONNECTION LINE (15 kV) | 12 | km |
| SWITCHING STATION | VIDAGO | SUBSTATION |