ECO-DESIGN AND LIMITATION OF VISUAL IMPACT – DESIGN AND CONSTRUCTION OF AN ELECTRICAL INSTALATION

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ABSTRACT

External HV/MV substations always have a big visual impact, which can be diminished if particular measures and actions are taken into consideration during the design phase.
This article presents the adopted solution by EDP Distribuição (EDP Group), Portugal, in a case where the substation was built in the vicinity of the only National Park in Portugal.

INTRODUCTION

EDP Distribuição

EDP Distribuição (EDP Group), Portugal, is the Distribution System Operator (DSO) in mainland Portugal. With more than 6 million customers, over 400 HV/MV Substations, 60 thousand MV/LV Substations, 80 thousand km of HV/MV Network and a LV Network of about 140 thousand km , is one of the major European operators of the energy sector. To achieve high quality levels, in accordance to customer expectations, these infrastructures are fundamental for the activity of electric energy distribution. For the second year running, Dow Jones Sustainability Indexes (New York stock exchange) considered EDP the world leader in the Electric Sector. This recognition describes the company commitment to sustainable development and environmental best practices according to EDP Principles of Sustainable Development, where EDP undertakes to adopt management measures designed to minimize and control environmental impacts. Furthermore, the activity of Project and Construction in EDP Distribuição is certified by Lloyd's Register Quality Assurance as having an Environmental Management System (ISO 14001:2004).

Technical need for this substation

As a result of the appearance of a new injector point of REN (National Transmission Grid) in Frades in 2009, EDP Distribuição studied the advantages of this new connection point to the HV network and hence to the MV network.

After some alternative studies, EDP's decision consisted in the implementation of a new substation, south of Rio Caldo. This would eliminate the problems of overloads and voltage drops in MV lines and increase the number of MV feeds, reducing the load from neighbor substations, allowing the disconnection of the existing 15/15kV autotransformer in Rio Caldo substation. This new substation should also create a HV backup to the 60/15kV Amares substation using the 2 new power lines: Frades (REN)-Caniçada and Caniçada-Amares.

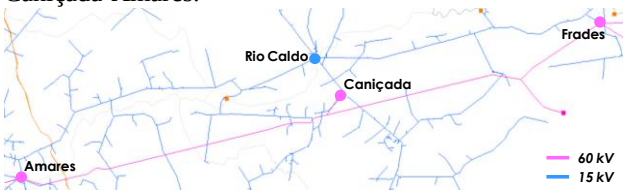

Fig. 1 - 60 and 15kV Network near Caniçada

As described, this new substation – Caniçada – near by the National Park of Peneda Gerês was needed to increase the continuity and the quality of service of this area.
This new substation connects to 60kV grid using 2 HV power lines and feeds 5 15kV power lines with a 20 MVA power transformer.

Environmental Performance Promoting Plan

Within the framework of the Environmental Performance Promoting Plan (PPDA) 2009-2011, approved and funded by the Regulatory Authority of Energy Services (ERSE), EDP Distribuição decided to use the design and the construction of Caniçada Substation as a Pilot Project of Landscape Integration of Electrical Infrastructures, in the scope of one of the approved measures in this plan. The design and the construction of this substation was developed by the Project and Construction Direction with the support of a research team of Oporto University (CIBIO), and followed by the Department of Environment and Sustainability of EDP Distribuição, as coordinator of PPDA.

Peneda-Gerês National Park

The Caniçada substation is located near the Peneda-Gerês National Park, the only National Park in Portugal and the

first protected area established in 1971. This park has a unique relevance for the conservation of flora nationally and a high importance worldwide, being equivalent to the National Park (Level II) classification of the International Union for Conservation of Nature (IUCN).
It is also one of the most attractive Natural Regions of Portugal, considered by UNESCO as a World Biosphere Reserve.
The Peneda-Gerês National Park is part of the ecological network Natura 2000 as Special Area of Conservation (SAC) designated by Member States under the Habitats Directive, and also incorporates Special Protection Area (SPA) which they designate under the 1979 Birds Directive. Since 2008, the National Park Peneda-Gerês is also considered a PAN Park, by Pan Parks Foundation the European organization for the protection of wildlife, among the 13 European parks with this status.

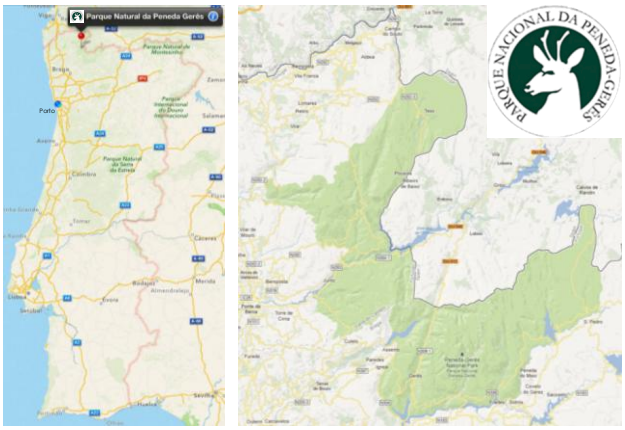

Fig. 2 - Peneda-Gerês National Park location

SUBSTATION'S ECO-DESIGN AND LIMITATION OF VISUAL IMPACT

Taking into consideration what was said in the previous paragraphs, EDP Distribuição decided to give a special attention to the construction of this new substation, namely into the landscape integration and environmental care.

Landscape integration

Methodology and guidelines for landscape integration

The methodology applied in the process of landscape integration of an electrical infrastructure is based both on the analysis of its formal characteristics and on the study of the biophysical attributes of the landscape and its visual component, particularly in the analysis of its character, its visual quality and its ability to absorb changes. The guiding principle is based on the general idea that the visual impact of the infrastructure should be minimal, which is obtained by finding solutions, at the stages of planning and design, that allows that the integration into the landscape is achieved through its inclusion in spaces with reduced visibility, i.e. with less visual sensitivity, while preserving the sections with higher visual quality and integrity levels and less infrastructures.
When the subject is a HV/MV substation, the principles of landscape integration start by choosing the most appropriate location, after knowing the functional and technical requirements of the infrastructure. This evaluation must consider the ecological sensitivity of the landscape as well as its ability to visually absorb the infrastructure that, due to its size and shape characteristics (particularly in the case of open substation), generally has a very significant impact, especially in non urban areas.

The landscape in the area of Caniçada substation

The study area is located in a valley. It is a land of about 5700 m^2 inserted in a mountainous landscape, with large variation of altitude and where steep slopes predominate. It is surrounded by cultivated fields and woods of oak and pine. It is a landscape of mountain traditional agriculture, organized in terraces supported by granite dry stone walls. These elements, alongside the hanged vineyard system, are the main elements of partitioning of crop fields. Due to its hillside location illuminated by predominant south sunlight, the area of implantation has high levels of visibility which is an extra difficulty for the integration of infrastructures.

Landscape integration of Caniçada substation

The study was carried out in two levels: definition of preventive measures and minimization measures. In the first case it was given a particular relevance to the impact evaluation that the substation would cause to the landscape. This impact depends on the visual absorption capacity of the landscape and how its physiographical characteristics and ecological value would be affected. The slope factor has assumed a primordial importance and it was given particular attention to the implantation dimensions and to the concordance with the surrounding topography.

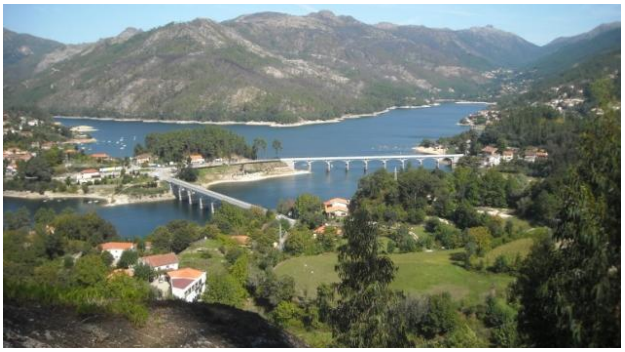

Fig. 3 - Surrounding landscape

The small size and rugged orography of the terrain conditioned the standard implementation of EDP's HV/MV substation type project. So a different solution has been proposed to minimize the footprint of the substation area.
Thus, it was decided to install hybrid compact HV

switchgears (SF6 encapsulated). These devices integrate in a single module almost all the functions of a conventional bay, replacing the disconnectors, the earthing switch, the circuit breaker and the current transformers.

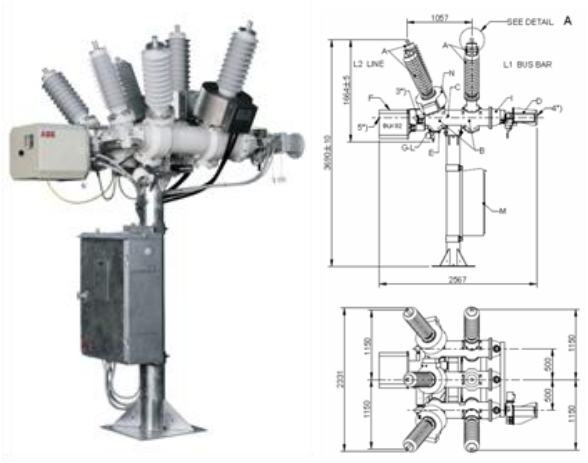

Fig. 4 - Hybrid compact HV switchgear

This solution allows a reduction of almost 40% area needed to install the HV equipment. The layout of the HV and MV equipments, main building and other infrastructures were also changed in order to optimize and reduce the overall area of the installation.

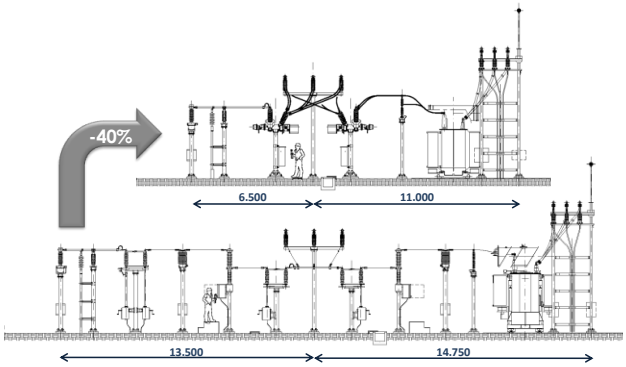

Fig. 5 - Compact hybrid equipment vs. conventional equipment

This decrease of the area needed for the HV equipment permitted the construction of a smaller platform, which allowed to reach the substation platform quota in a gradual manner. It was studied a system of terraces in similar proportions to the existing ones avoiding the creation of an extensive and significantly steep slope, completely anomalous to the existing landscape. The retaining walls were made in yellow dry granite stone from the region, following the contours, causing minor visual impact and promoting harmonization with the landscape type and character.

The outside pavements were executed in cubes of the same type of granite as well as the gravel placed in the HV equipment area.

The main building was painted in gray slate, to reduce reflection of light and help visual absorption, and was provided with a decorative stone panel from the region.

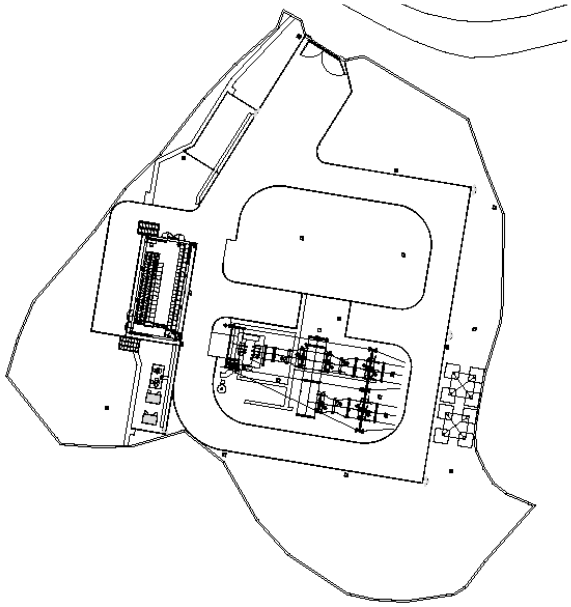

Fig. 6 - Conventional equipment and standard layout

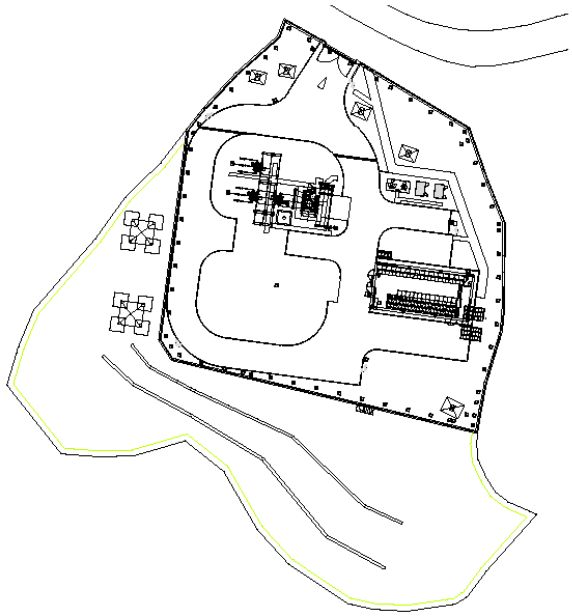

Fig. 7 - Compact hybrid equipment and optimized layout

In terms of vegetation, planting schemes were organized in clumps which are distributed over the various terraces assuming most extreme expression in the edges of the terrain, particularly for the connection with the existing woods or vegetation clumps. The groups of higher vegetation density intend to minimize the visual impact of the various power structures. The proposed vegetation belongs to the floristic association of the region, which ensures a more effective landscape integration and greater

adaptability of plants to the site. For the list of the various species two selection criteria were used: (1) safety requirements for equipments and power lines (larger trees outside the zone of influence of structures and smaller for the areas along the lines) and (2) aesthetic and visual aspects. The herbaceous cover is composed of meadow species adapted to both local soil and climate conditions and to a low level of maintenance, particularly regarding water and manpower factors.

Fig. 8 - Terraces and vegetation project

ENVIRONMENTAL ASPECTS

In addition to landscape integration, several environmental considerations were taken into account in the design phase, as it is usual in every new substation.

The power transformer platform is provided with an oil sink receiver, connected to an oil receiver bin, so that in case of an accident the oil is housed in these places avoiding spills and contamination of soil and water resources. The neutral reactor and the auxiliary services transformer's platform is also connected to this oil receiver bin.

Not being able to make the connection of sanitary wastewater from the plant to the public collector, it was decided to do its routing into a sealed pit.

The greenhouse gases (GHG) present in the HV equipments with SF6 and in the cooling equipments of the main building are inventoried and controlled according to Regulation No. 842/2006/CE – 17th May. These devices are clearly identified and contain the indication of the amount and pressure of the gases used, being operated only by qualified personnel for this purpose.

Electromagnetic fields were measured before and after the construction of the substation. It was confirmed that inside of the plant and in its immediate vicinity, the values comply with the reference levels for public exposure, defined by Decree 1421/2004, which essentially adopts the recommendations made in 1998 by ICNIRP - International Committee for Non-Ionizing Radiation Protection.

The batteries that are part of the DC power supply are protected with trays for retaining any spillages.

After the commissioning it was also carried out the measurement of the environmental noise emitted by the plant, confirming that it lies within legal limits.

CONCLUSIONS

The construction of the Caniçada substation took about 10 months. During this period an audit was conducted to this work in the framework of the certification renewal (by Lloyds) on Environmental Management of EDP Distribuição Project and Construction activities, obtaining a positive evaluation on the works.

Taking into account the good results achieved in the implementation of this project, it was integrated into the EDP Distribuição's Good Practices Manual for Electrical Infrastructure Integration in the Landscape. (http://www.edpdistribuicao.pt/pt/ambiente/desempenhoambiental/Pages/ integracaopaisagistica.aspx)

In the case of HV/MV substations some minimization measures should be considered in the design phase, including the use of materials identical to the ones existing in the region and planting must integrate in the character of the landscape, both in terms of plant species and of planting schemes. This question is particularly important in the establishment of this kind of infrastructures in non-urban landscapes. Shapes, volumes, materials, colors, shades of built elements (walls, fences and substation's buildings among others) must also be considered in the design phase to minimize the impact of the plant and facilitate its integration.

Reducing the number of components allowed the minimization of the visual impact of the HV equipment. Moreover all HV switchgear equipments are encapsulated, which, besides from having a lower maintenance and being safer, have also a smaller visual impact.

Fig. 9 - Terraces

Fig. 10 - Caniçada substation - general view