TOWARDS AN UNIFORM MV SYSTEM EARTHING IN EDP DISTRIBUIÇÃO – PROJECT CHALLENGES AND QoS IMPROVEMENTS

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ABSTRACT

EDP Distribuição (EDP Group), is the mainland Portugal Distribution System Operator (DSO), with more than 6 million customers, over 400 HV/MV Substations, 60 thousand MV/LV Substations, 80 thousand km Network (HV/MV) and a LV Network about 140 thousand km.

At the end of 2010, most of the substations had low impedance earthing at the MV level, although there was a set of substations, mainly located in the centre of the country, which were operated in isolated neutral.

Between 2009 and 2010 several pilot projects were conducted by EDP Distribuição to evaluate the benefits of the MV impedance earthing vs. isolated neutral.

The outcome of those projects confirmed a reduction in the number of outages and a Quality of Service improvement, as presented in Cired 2011 paper 0853 [1].

So, EDP Distribuição decided to launch a nationwide program to achieve an uniform MV neutral earthing system.

The rollout of the Earthing Standardization Program was launched at the end of 2010, and was finished at the end of 2012.

The aim of this paper is to show how EDP Distribuição successfully achieved the purposes of the program, dealing with several constraints, and the resulting Quality of Service (QoS) improvement.

INTRODUCTION

At the end of 2010 EDP Distribuição decided to launch a large-scale program to reach an uniform MV neutral earthing system.

The main drivers of this program were:

- The QoS improvement;
- A reduction in the maintenance and operational costs, as an outcome of standardization.

This specific program, which involved 52 substations, had the following scope:

- Installing neutral impedances connected to MV busbars (15 kV and 30 kV);
- Replacement of the MV protection systems, where necessary, in order to assure the compliance with the new neutral system;
- Carry out, simultaneously, other works that were in pipeline, like: HV and MV extensions, protections and RTU's retrofits;
- Two year window for project implementation.

At the end of this project all EDP's substations will operate in neutral earthed system. However, in case of a neutral earthing reactor failure the substations will be able to operate in isolated neutral system. In this situation the IEDs will automatically switch settings, assuring network flexibility.

PROJECT CHALLENGES

Main Figures

The program has involved the following main figures: 14,5 M € budget; 52 contractor works; 57 new neutral earthing reactors; replacement of 564 MV and HV IEDs (in 12 substations it was also decided to replace the RTUs by new SAS); 143 modified or new MV bays; 700 planned outages.

Specifications and Planning

Retrofit projects are typically more challenging than projects in which everything is build from scratch. The old and the new parts must be compatible and the continuity of the substation operation must be assured during the process.

Managing different generations of substations, in terms of technologies and operating modes, required an extra effort mainly in the design and project phases.

Studying each substation project was the first step to overcome this challenge. It allowed EDP to prioritize the interventions and split the 52 substations in several groups, distributed in time.

Group distribution followed several criteria:

- Geographical proximity;
- Network operation limitations (existence of backups and seasonality limitations (weather and loads));

- Auxiliary equipment availability (ex: mobile substations, power cables, etc);
- HR availability.

Dispatch center validation of the project schedule was fundamental to optimize outages and network sustainability.

Exhaustive site-surveys were mandatory to identify all the necessary equipments (circuit breakers, current transformers, disconectors, neutral reactors, new bays, IEDs, ...), and confirm the exact scope of each project. Multi-disciplinary teams were involved in order to ensure that all technical aspects were covered. As a result, specifications were made for each substation, which also included other pipeline works, like: HV and MV extensions or retrofits, protections and RTU's upgrades, etc…

In order to reach a common operation philosophy for the substations, the standard technical requirements of EDP Distribuição substation project were applied, or slightly adapted for the oldest substations. This standardization enabled less design and execution costs and a better network knowledge.
Also relevant was the use of newer protection functionalities such as: MV fault location, cold load pick-up, inrush restraint, etc, and the implementation of remote switching of settings group to allow live line work, which has a direct impact on the network operation costs.

In partially retrofitted substations, the technology of IEDs installed allowed the establishment of IEC 61850 network that for now supports time synchronization services and remote access but leaves an open door for future functionalities. In totally retrofitted substations full IEC 61850 SAS were implemented.

As stated above, the retrofit and extensions of the 52 substations during two years was only possible by assuming that there would be simultaneous active work fronts, according with the established plan.

Execution

Most of the times an entire substation cannot be shut down for retrofit interventions. As a consequence, the common main challenges in this type of projects are:

- Assuring the continuity of the substation's operation during the works;
- Compatibility between the old and new parts during intervention;
- The planned outages must be as short as possible in order to minimize the distribution network's operation constraints;
- The continuity of service cannot be affected by the planned outages.

Due to this large scale program and limited time window, additional challenges were faced:

- Management of all the intervenients (electromechanical, civil and SAS contractors, EDP project managers, supervision, live line works and safety);
- Management of several simultaneous work fronts, from different contractors and suppliers;
- Large quantity of equipments and different supply dates;
- Planned outages restrictions, aggravated by the geographical proximity between substations which back up each other;
- Execution of the program simultaneously with the regular annual investment plans;
- Some substations, due to the deep intervention they were submitted, required the use of mobile substations and other auxiliary means, such as HV or MV shunt power cables.

One key factor for the success of this project was to establish good communication channels between all stakeholders. Information had to be available at all time, and, most important, it had to be up-to-date. A common network share was created to support all the relevant information, accessible to all project managers.

Progress report activities were held at many levels:

- Monthly official reports to the Board, ensuring the alignment of all the involved parts;
- Meetings with dispatch center in order to prioritize the outages sequence;
- EDP project management follow-up meetings (coordination, best practices, adjustments);
- Regular meetings with contractors and suppliers for progress report and milestones definition.

Close on site supervision was also crucial in order to control execution quality. The gained field experience enabled EDP to improve the efficiency of execution from site to site.

Finally, the flexibility and commitment was another key factor for success. Unexpected situations are common in this type of projects, and the ability of the intervenients to adapt was noteworthy, allowing to easily adjust the planning without compromising the goals.

The next image shows some of the works (reactor, new MV bays, and new IED's).

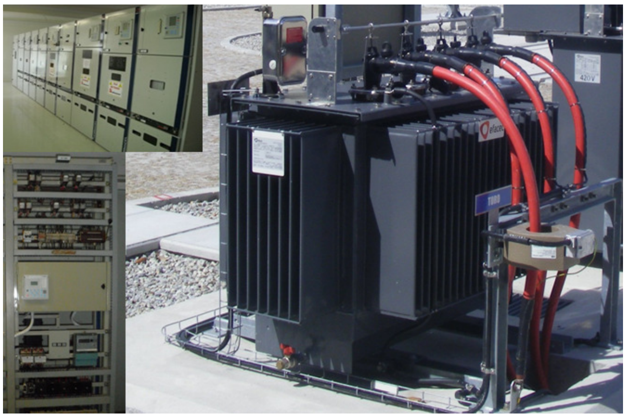

Fig.1 – Earthing Reactor, MV switch board and IED installed during the project

QUALITY OF SERVICE IMPROVEMENTS

One of the main purposes of changing the neutral earthing arrangement in Portugal was to improve the Quality of Service.
To assess if the neutral changes have produced an improvement in the Quality of Service, the interruption time and the number of interruptions were analyzed.
30 substations had their neutral earthing arrangement changed in 2011 and in the first 6 months of 2012. This analysis will center on this set of substations. There is enough observation time in this set to produce reliable data.
However, any analysis must take into account that there are other factors that contribute to the Quality of Service. The influence of external factors in the Quality of Service of the 30 substation set must be minimized. In fact the interruption time in Portugal has decreased significantly in the last 2 years (Fig. 2).

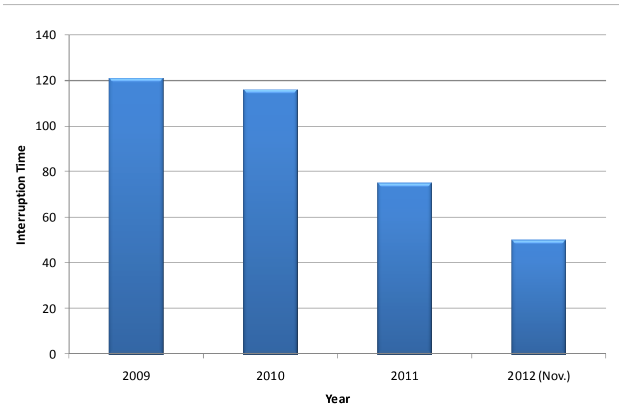

Fig.2 – Interruption time evolution in Portugal

A set of 312 substations, that have not suffered major changes, was established to serve as a control set for determining the improvement of Quality of Service for the 30 substation set.
The analysis will focus on increase, or decrease, of the QoS parameters in the 30 substations set with respect to the control set. A basis for comparison was obtained by dividing the sum of QoS indicator of the substation since 2009 up to the neutral change date and dividing by the interruption time of the control substations in the same time frame (red columns in figure 3 and 4). An identical procedure was performed between the neutral change date and the end of November 2012 (blue column in figures 3 and 4).
One of the parameters which were analyzed for this paper was the number of interruptions. Figure 3 depicts the percentage of trips with respect to the number of trips in the control substations for the periods in which the substations were in isolated neutral and equipped with a neutral reactance.

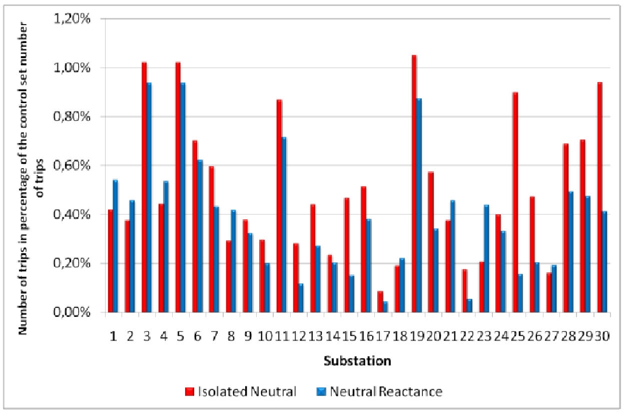

Fig.3 – Percentage of trips with respect to the overall number of trips of the control substations

22 of the substations (73%) experienced a decrease of the number of expected interruptions. This group of 22 includes all the worst performing substations with respect to number of interruptions. Substation 25, which was one of the worst performing substations, had a reduction of 83% in the number of interruptions.

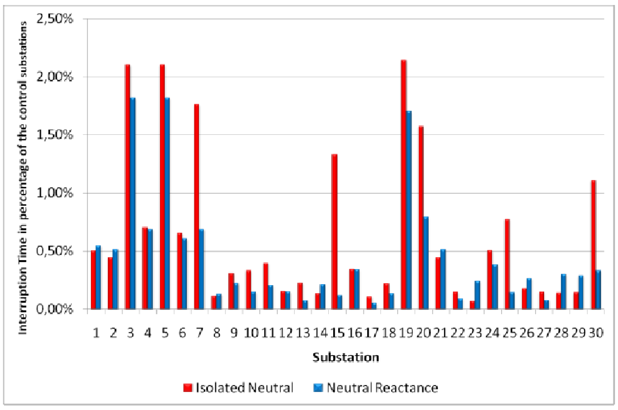

Fig.4 – Percentage of interruption time with respect to the overall interruption time of the control substations

Overall, the reduction of the expected number of interruptions in the 30 substation set was **22%**.
Interruption time was also assessed for determining the

improvement of QoS in the substations which were subjected to neutral earthing changes.
The number of substations which experienced a reduction of interruption time (Figure 4) was 21 (70%). Once again all of the worst performing substations experienced a reduction of expected interruption time. Substation 15 had a decrease of 91%.
Overall, the reduction of interruption time in the 30 substation set, with respect to the control substations, was **30%.**

CONCLUSION

The Earthing Standardization Program was successfully accomplished.
Thanks to close and constructive collaboration between all the intervenients, this complex project was completed with minimal inconvenience. Thorough planning was essential to ensure smooth and trouble free execution. Close site supervision, flexibility and commitment were essential to overcome difficulties and achieve success.
As a result of exemplary teamwork, the high quality project execution and proactive attitude, 52 substations were retrofitted in 2 years period.
An analysis of QoS on 30 substations before and after the neutral earthing changes evaluated a result of 22% reduction on the number of interruptions and 30% in reduction of interruption time.
This project fulfilled the expectations that had been created during the execution of the pilot projects, as foreseen in the paper 0853 presented in Cired 2011[1].

REFERENCES

[1] Miguel Louro et al., 2011, "Effects on the quality of service of changing the neutral grounding of MV networks ", *Cired 2011, paper 0853, Frankfurt.*