SECONDARY SUBSTATIONS SMART METERING CAMPAIGN

Diogo TABORDA
EDP Distribuição – Portugal
diogo.taborda@edp.pt

António AIRES DE MATOS
EDP Distribuição – Portugal
antonio.airesmatos@edp.pt

José GERIA
EDP Distribuição – Portugal
jose.geria@edp.pt

Samuel FORTUNATO
EDP Distribuição – Portugal
samuel.fortunato@edp.pt

João SILVA
Canas, S.A. – Portugal
joao.silva@canas.pt

ABSTRACT

After implementing a smart metering commercial process for High and Medium Voltage customers, as well as high consumption Low Voltage customers, EDP Distribuição decided to extend the process to the segments of public lighting and secondary substations (MV/LV). The process, designed to smart meter almost 124,000 facilities, was designated “Secondary Substations Smart Metering Campaign”, and was to be carried out for a three years period. The expertise developed and acquired with the two previous Campaigns was vital to outline the process.

The purpose of this paper is to explain the three major areas of the process, namely, Implementation Control, Field Technical Work and IT Update. Through almost three years many adjustments were introduced in all these areas in order to keep the Project on schedule, guarantee high standard quality and enhance the process, leading to the correct implementation of the infrastructure.

INTRODUCTION

The Portuguese distribution electrical grid is made up of more than 400 HV/MV primary substations, 66,300 MV/LV secondary substations and 6 million customers. For EDP Distribuição, the main Distribution System Operator in Portugal, innovative matters are taken seriously and are faced as a key opportunity to improve efficiency, transparency and accuracy of Company’s operations. Thus, two different drivers for this Project stand out.

The first was an imposition by the Portuguese Energy Regulator (ERSE) to incorporate Real Time Data from all secondary substations in the Energy Balance. As of October 2013, the Energy Balance was calculated using Smart Metered Data from Extra High Voltage, High Voltage, Medium Voltage and high consumption Low Voltage customers, all producers connected to the grid, primary substations and Transmission Network substations. Data from secondary substations, Low Voltage residential customers and Public Lighting (PL) installations was used via sampling of some key non-smart-metered installations. Since this was not as accurate as it was intended to be, ERSE imposed that Data from all secondary substations should be Smart Metered.

Meanwhile, the 278 Municipalities of Continental Portugal were starting to demand a newer, and more accurate, billing process for their Public Lighting commercial contracts, instead of the process then in use based on periodic throughout the year readings which led to estimation of consumption.

EDP Distribuição’s Board, aware of the demands of the Stakeholders and watchful of the opportunities, decided that both subjects should be tackled in the same moment. It was time to seize the opportunity, design and execute a large scale process called “Secondary Substations Smart Metering Campaign”, with the three major areas of the process, namely, Implementation Control, Field Technical Work and IT Update, in mind.

The aim of this Campaign was, as the name says, to Smart Meter all 66,308 secondary substations, which could be equipped with one or more Power Transformers of MV levels ranging from 6 kV to 30 kV, and Smart Meter all the 57,566 Public Lighting commercial contracts. As the process design was being outlined it was clearly evident that articulation was needed in many fronts: determine the set of installations that would be tackled during a period of time, give the teams in the field the proper conditions, tools and equipment necessary to install everything correctly and that all the information needed to update IT was arriving according to what was on the field.

The Campaign National Coordination Team (CNCT) was responsible to guide, provide information, produce control reports and help all 6 Campaign Local Teams (CLT). Each of the 6 CLT guaranteed that the Technical Teams had all the conditions, both material and IT-wise, to do their work correctly, kept track of the progress and articulated all necessary topics with the CNCT.

In order to accomplish such an assignment it was designed a process based on SAP-PS (for technical assets) and on SAP-ISU (for the commercial contracts). In order to eliminate much of the paperwork and to make the flow of information smoother, a solution via SAP-PM/ Workforce Mobility System (WFM) was adopted.
IMPLEMENTATION CONTROL

Looking into detail on the Campaign process, it is extremely important to mention that despite the Project being under the “Secondary Substations Smart Metering Campaign” umbrella, the fact was that there were two independent “Campaigns” running simultaneously and taking advantage of the Field Technical Work being done in the same location. One Campaign to Smart Meter the secondary substation, by installing a C&I Meter in each Power Transformer (PTM), and another Campaign to Smart Meter the Public Lighting circuit via a, Company exclusive, EDP BOX Meter (EB IP).

Depending on the number of Power Transformers and Public Lighting commercial contracts, the following scenarios for a secondary substation are possible (Figure 1):

![Figure 1 - Meters to be installed in a secondary substation](image)

Although very similar from a conceptual point of view, in reality a PTM installation procedure differs from the one of an EB IP, the main difference between them being that the later assists a commercial contract with a marketer. Figure 2 schematically represents all the Campaign process stages.

![Figure 2 - Campaign process stages flowchart](image)

Given that the group of 66,308 secondary substations and 57,566 Public Lighting commercial contracts were known of both CNCT and 6 CLT, the formers periodically made a selection of the assets intended to be intervened each fortnight and informed the CNCT.

After CNCT got this information they generated and provided the CLT with critical IT information to order the work to be done. For the Secondary Substation Campaign was generated an Investment Order (SAP PS), because the secondary substation is a Company Technical Asset, and a Maintenance Order (SAP PM). For the Public Lighting Campaign was created a Commercial Order (SAP IS-U), which was the way to order a Technical-Commercial operation on a specific Public Lighting installation, and a Maintenance Order (SAP PM). Afterwards the CLT were prepared to program interventions with the independent service providers.

Due to the expected high number of daily nationwide field interventions, it would be extremely costly to set up a network operations centre with the capacity to perform all the required analysis online with the independent service provider’s teams in the field. Indeed, the solution, for not incurring in unnecessary costs, was to set up a way to assure the IT Update team would get the field information on the day after the work was done. The Maintenance Orders, created for both PTM installation and EB IP installation, were the vehicle for a IT Checklist, that was specific for each scenario, and was due to be filled in by the field technicians.

Basically, this Checklist was sent directly to the field technicians’ smartphones and comprised a series of enquiries regarding the type of work. For PTM installation, for example, information about secondary substation itself (e.g.: number of Power Transformers and current transformation ratio of the Current Transformers), the devices to be substituted (e.g.: Meter), the devices to be installed (e.g.: Modem and Meter) and some electrical measures (e.g.: currents, voltages and vector diagrams) was required. As for EB IP installation, besides filling in a slightly different Checklist, the Commercial Order was also sent directly to the field technicians’ smartphones (Figure 3).

![Figure 3 - Maintenance Order Checklist (left) and Commercial Order (right) update in WFM](image)
Despite addressing details on the Field Technical Work and the IT Update later on, it is worth to mention that Control Reports were generated weekly in order to keep work on track. On this report, CNCT informed all 6 CLT of the PTM and EB IP successfully installed and IT updated, so that the CLT could proceed with the task payment to the independent service providers. In case there was some implementation problem or malfunction, another order was created so that the asset was once again intervened by the field technicians, this time with a simultaneous call to the CNCT.

FIELD TECHNICAL WORK

The main mission of the Field Technical team was to install a C&I Meter for each Transformer, a PTM, inside the secondary substation and an EB IP for each Public Lighting commercial contract. As all the Smart Metered process is ran by a GSM/GPRS type of communication, it is necessary to connect these meters to a Modem. In this Secondary Substations Smart Metering Campaign an innovative approach was taken. Whenever possible, a shared Modem was connected to the PTM and the EB IP (Figure 4). Communications ran independently to each Meter in different moments in time.

Figure 4 – PTM and EB IP interconnection with a single Modem

Among the 66.308 secondary substations connected to the Portuguese MV electrical grid it is possible to identify two constructive types: overhead and cabin. Until recently, an overhead secondary substation could be characterized as A or AS type (with two LV power circuits and one PL circuit) and AI type (with four LV power circuits and three PL circuits). However, more recently a new generation of LV distribution boards has been installed and designated R100 (with one LV power circuit and one PL circuit) or R250 (with three LV power circuits and three PL circuits). Indeed, these last assets have been designed having in mind the smart metering equipment specifications, whereby they are separated into two different compartments: one being for hosting all the metering and communications equipment, and another for hosting the power equipment.

Standard cases

Figure 5 depicts two LV distribution boards of both an overhead and a cabin secondary substation, which may be considered standard cases for the Campaign under analysis.

Figure 5 – PTM and EB IP in a R250 type overhead (left) and in a cabin (right) secondary substations

In these facilities the PTM, EB IP and Modem may be implemented immediately since they can accommodate the new equipment without any further modifications. In order to improve working conditions and increase safety during future interventions, it was decided that all secondary substations should have a terminal block installed. Thereby, depending on the model, manufacturer and the aging of LV distribution boards, sometimes a new terminal block had to be installed.

Being the PTM responsible for measuring all the Power Flow through the Power Transformer, the installation of Current Transformers (C.T.) was required to allow indirect measurement. As for the EB IP, and due to the fact that it measures only Public Lighting energy consumption it was of direct measure, supporting up to 100A per phase.

Nonetheless, a Public Lighting circuit may be established from an electric cabinet connected to a secondary substation, instead of the secondary substation itself. In such situation, the EB IP must be installed in the cabinet (Figure 6).

Figure 6 – EB IP in an electric cabinet
Non-standard cases

The majority of the secondary substations aimed at this Campaign did not require complex modifications in order to install the smart meter equipment. However, some overhead A and AS type facilities had to be previously modified because it was impossible to perform this intervention conveniently, whether for safety or technical reasons. In such situation the independent service providers’ teams did not finish the SAP-PM order and, instead, described the reason for that impossibility. Afterwards the CLT technicians had to confirm the nonconformity in the field and make a proposal to solve it. Among the most common nonconformities and corresponding solutions faced upon this Campaign, it is worth mentioning:

- LV distribution board substitution
- Public Lighting equipment rearrangement
- Smart Metering cabinet installation
- Antenna reallocation

LV distribution board substitution

Sometimes it was better to substitute the LV distribution board itself rather than readjusting all the power circuits within and substituting certain devices. Figure 7 depicts such situation:

Figure 7 – LV distribution board in an AI type overhead secondary substation, before (left) and after (right) substitution

Public Lighting equipment rearrangement

Due to the equipment disposal in an A or AS type secondary substation, sometimes it was needed to rearrange the Public Lighting command circuit in order to have enough space to install the smart meters (Figure 8).

Figure 8 – Public Lighting command circuit before (left) and after (right) rearrangement

Smart Metering cabinet installation

Despite rearranging the Public Lighting command circuit, it still may not be possible to install all the smart metering equipment in an A or AS type secondary substation. In such situation a specific cabinet was installed side by side with the LV distribution board (Figure 9).

Figure 9 – Smart Metering cabinet installation in an AS type secondary substation

Antenna reallocation

When the Smart Metering Campaign began, standard antennas have been installed and no signal testing was performed. However, not rarely when the CNCT tried to establish a communication with the device, it noticed that the signal was too low. Thus other solutions had to be tested, namely: reallocation of the same antenna outside the LV distribution board or cabin, substitution for a high range antenna or usage of different SIM card operators (Figure 10).
Having in mind that this Campaign would be extremely demanding in terms of performance rate and that it was impossible to have a single procedure to work in any and all secondary substations, a lot of effort has been put into safety proceedings. The main objective was to accomplish zero working accidents.

Before the beginning of the Campaign a programme was implemented for all the field technicians, where both theoretical and practical aspects were analysed, as well as the formulation of a set of safety recommendations. Nevertheless, EDP Distribuição hired a safety company to oversee the field technicians and assure the proceedings were being followed.

**IT UPDATE**

During and after the Field Technical Work, essential measures were to be registered in the IT Checklist in order to feed the CNCT BackOffice IT Update team with all necessary Data. Every day two Microsoft Excel Report files arrived at the CNCT personnel’s e-mail inbox: one containing all the PTM works finished on the day before; the other filled with all the information regarding the EB IP installations Smart Metered the previous day.

The CNCT checked both these files to detect any incoherence or errors and, after a few validations, transferred the files to the BackOffice IT Update team in order to adapt all IT systems regarding the Smart Metered process. If any information was incomplete or incorrect on the Maintenance Order generated IT Checklist, or if any anomaly was detected while updating the IT systems, the CNCT articulated with the corresponding CLT in order to correctly update the installation.

EDP Distribuição uses 3 interconnected platforms to guarantee that all Data is sent from the Smart Meters to the Customer Relationship Management system (CRM). In reality, as PTM and EB IP serve, respectively, Company-Technical assets and Commercial assets, the IT platforms to be operated were different. For PTM was necessary to adapt the Meter itself to the right current transformation ratio, and to configure the Elster EIServer platform. In this platform, a Master-Slave communication protocol is applied daily and detailed 15-minute blocks of 6 channel \((A+, A-, Rc+, Rc-, Ri+, Ri-)\) information is collected and stored. For EB IP, as it is a Commercial asset, both Meter and Elster EIServer had to be configured as well. Complementary, a Data-Base called SGL, that gathers all Smart Metered and non-Smart Metered installations Data, and the Company’s CRM, SAP IS-U, had to be updated (Figure 11).

**CONCLUSIONS**

Work field confirmed that some facilities required specific electrical and telecommunication implementations. Among the 66,308 secondary substations some non-standard solutions had to be implemented due to the diversity of electrical installations connected to the grid and according to the particularities of each one of them. Along the three years of the Project, over 25M€ were invested in order to assure Company’s infrastructure asset, Service Providers’ asset and equipment to be installed.

A close partnership between the CNCT, the CLC and the independent service providers was crucial to overcome all these challenges. As intended since the beginning, all new secondary substations are being connected with a PTM and EB IP, properly Smart Metered. All Campaign targeted and new secondary substations, follow maintenance procedures, as all other Smart Metered facilities, to assure successful communication and equipment health.

**Figure 10 –** Outside high range antenna (left) and pole-mounted high range antenna (right)

**Figure 11 –** Outline of Smart Meter IT systems: PTM process involved only Meter and Elster EIServer as EB IP process involved Meter, Elster EIServer, SGL Data-Base and SAP IS-U CRM.