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CHALLENGES IN THE IMPLEMENTATION OF A DISTRIBUTION AUTOMATION PROJECT IN A MODEL WITH DECENTRALIZED OPERATION CENTERS

Fernando H. MOLINA CELESC D – Brazil fernandohm@celesc.com.br

Rafael Z. HOMMA Renato B. ROLIM CELESC D – Brazil rafaelzh@celesc.com.br Felipe M. ENGELKES CELESC D – Brazil felipeme@celesc.com.br

Luiz H. C. de OLIVEIRA Antônio C. de MORAES CELESC D – Brazil luizhco@celesc.com.br Rodrigo C. de ANDRADE CELESC D – Brazil rcandrade@celesc.com.br

Zenildo F. da SILVA CELESC D – Brazil zenildofs@celesc.com.br

ABSTRACT

The main objective of this paper is to present the challenges and solutions encountered in the design of the automation distribution project from CELESC, a power utility in southern of Brazil. The main focus of the paper is to present the challenges of the implementation in a decentralized model of operation centers, regarding that CELESC has 16 Distribution Operation Centers, one in each region of the state.

INTRODUCTION

It stands out in recent years the significant performance of the regulator in the Brazilian electricity distribution, especially regarding the electrical energy quality provided to consumer units. The resolutions published and the current "Procedures for Distribution" and "Rate Review Procedures", have highlighted the reduction of collective continuity indicators and penalties on violation of individual continuity indicators, measured directly on each consumer unit.

To achieve the goals of the Brazilian regulator, one of the main projects being developed in CELESC D is the automation of distribution lines, with the use of reclosers and three-pole switches in these lines, in order to give greater protection and recursion to the system.

The utility has in its concession area a decentralized model of operation for medium voltage lines, with a structure of 16 **Distribution Operation Centers (DOC)**, managed by local operating bases and with a central supervision. The DOC has different numbers of operators and working scales, set in accordance with the size of the electrical system operated.

The DOC operates on a regional basis, centralizing and developing operational tasks relating to operational support, supervision, operation, programming and shutdowns maneuvers and coordination the services performed by emergency maintenance crew.

The decentralized model of operation has as its primary purpose to provide a faster response to outages and greater interaction between the field staff and system operators, which make them more knowledgeable about the local distribution lines that they operate. This knowledge brings benefits in a faster decision making and better energy continuity indicators to customers, mainly in the occurrence of extreme events, like thunderstorms and windstorms, when the number of occurrences is well above normal.

Among the disadvantages, it is necessary a greater amount of operators, increasing operating costs, and also makes it more difficult and costly to perform any change in procedure or to implement a new technology, as was the design automation of distribution lines, focus of this paper.

PROJECT CONCEPTION

The project aims to implement a control system for remote monitoring and operation of protective and maneuver equipments in the medium voltage distribution grids of Celesc.

In this context it should be noted that in substations supplied in 138 and 69 kV, protective equipment are already mostly remote controlled, and the benefits of automation have brought considerable operational efficiencies for the company. At this stage, the challenge is to bring this technology also for the distribution networks of medium voltage, included herein equipment operating in distribution substations fed at voltages of 23.1 kV and 34.5 kV.

The areas of knowledge of the initial phase of the project are divided into four main topics:

- Equipments;
- SCADA System;
- Communication system;
- IT Infrastructure.

<u>Equipments</u>

Of the existing equipments in the medium voltage distribution lines was chosen for telesupervision/remote control the following equipment:

- Reclosers (priority);
- Voltage regulators;
- Three-pole switches.

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Existing assets were analyzed in order to determine which equipments could be integrated into the automation system. The equipments that can be remotely controlled are those having digital control with the possibility of communication.

There are also equipments in the system that do not have digital control and therefore cannot be controlled remotely. For them, the solution is to replace them with more modern equipment or, in the case of regulators, performance of retrofit (technological upgrade of the command). For these equipments was defined a replacement plan within 3 years, with a budget of 7 million Euros.

SCADA System

The premise of the system is that the supervision and remote control of equipments in the medium voltage distribution grids should be centralized in a single system, called SCADA (Supervisory Control and Data Acquisition), in order to facilitate the access of information and decisions for the operators of Distribution Operation Centers.

The system installed is ELIPSE POWER, a solution developed by ELIPSE SOFTWARE, provided to integrate, into a single operation screen, the information needed to make the telesupervision and remote control of field equipment. It also allows viewing of alarms and load curves of equipment, besides having integration with GeoNet system - georeferenced representation system of Celesc distribution lines.

Communication System

The communication of the equipments with ELIPSE POWER system, installed on the Distribution Operations Center, will be through GPRS communication.[1]

Therefore it is necessary to install a GPRS modem in each equipment, as well as evaluating the availability of signal coverage offered by mobile operators. To increase the reliability of reporting, the modems are equipped with chips of two operators simultaneously, increased equipment availability in the system.

In points of great importance to the system where there is no GPRS signal availability, alternatives are evaluated, such as satellite communication or digital radio.

IT Infrastructure

The ELIPSE POWER system was installed on a server located in the headquarters of Celesc, whose access to operators in DOC will be through client server connection. The DOC should have a workstation (PC and monitor) dedicated to monitoring and control of distribution equipments at voltages up to 34.5 kV in its coverage area. The figure below illustrates the overall architecture of the solution:



Figure 1 - Overall architecture of the solution

SYSTEM DEPLOYMENT IN OPERATION BASES

To start the project implementation in the field, a pilot deployment was defined in a operation base, in this case, in the city of Blumenau, automating about 30 reclosers and one bank of voltage regulators. This pilot evaluation was carried out to support the team with information in order to build an enterprise solution to be extended to other operation bases.

In the first operation base deployment steps were closely monitored by the project team, working together to find points that need to be improved for the continuation of the project.

In this contact the major contributions and changes made to the system ELIPSE were: (i) adopting different colors for each voltage level, (ii) development and improvement of supervision reports, (iii) improved identification of equipments in the system and creating a user manual with direct access through the ELIPSE system.

Each class distribution feeder voltage is associated with a distinct color, green for 13,8kV feeders, blue for 23,1kV and gold for 34,5kV. In the system also are represented the connectivity with the equipment and those between feeders and/or substations.



Figure 2 - System screen – Electrical System

The concept of the solution and the Scada system used showed to be efficient during the implementation in the first operation base, with great reliability, easy training of the operators and use by them and the engineers responsible for the operation of distribution grids, with reports and information useful for decision making.

After validation of the initial phase, it was necessary to establish an action plan for each DOC, which involves:

- a) Listing equipments installed in distribution overhead lines, in order to check the amount of equipments that can be automated.
- b) Design the Scada system for each operation center, so it could be requested to the operation base to build a single line diagram of the operating region, in order to be implemented in the ELIPSE system.
- c) Testing and registration of modems for communication, to permit the perform functional tests on modems and register them in the system.
- d) Training of field teams for installation and commissioning. Perform 40 hours of training for teams of operation bases for system and equipment knowledge. With training, it is expected that teams can conduct evaluation of signal quality, installation of modems, supporting the commissioning of the equipments, conduct procedures for fault finding, among others.



Figure 3- Field installation

- e) Evaluation of signal quality at the point of installation. The analysis of the signal quality using GPRS chips of 4 different mobile operators, defining the two mobile operators, primary and secondary, which will be used at the point of installation.
- f) Commissioning of the equipments. For each equipment installed in the system was set up a commissioning plan and checking of their integration into the Scada system, ensuring that all functions are suitable for use and are reliable.
- g) Installation of software on servers and clients. Provide one computer to access the central server, with licenses required available.
- h) Operators training for the SCADA system. Four hours training for system operators, transferring the contents

of the guide, focusing on major commands and system features.

Decentralized model

The difficulty of dealing with decentralized operating model is reflected mainly in the post-pilot project, where time and human resources required are much higher when compared to the centralized system. While in a centralized system the final deployment would require only a few adjusts to become corporate, for the decentralized model was needed another 12 month project to bring the solution to the remaining 15 DOC.

The team, in these one year project, deals with huge challenges, that include the need to improve the structure of some operation centers, the need to improve the skills of professionals, with difficulties to teach all functionalities for operators, some of them with more than 30 years working with the old model, and reliability communication system, considering that in the countryside and in smaller cities is often a challenge to get a good signal coverage.

An action plan was built to monitor the work at each base of operation, with the definition of the activities to be performed, their deadlines and who were responsible for the implementation, in order to facilitate control, mainly because often the deployment was given in parallel in at least four bases of operation.



Figure 4 - System screen - Curves Menu



Figure 5 - System screen – Alarm list

BENEFITS

The distribution automation project implemented brings, among other benefits, reducing the cost associated with the operation of the electrical system, part of the operational costs of Celesc. The replacement form of manual operation of protective equipment and handling in distribution networks of medium voltage by remote operation from the remote DOC implies a significant optimization of the use of labor from electricians, contributing to:

- a) Reduction of the non distributed energy;
- b) Reduction of travel expenses of teams;
- c) Improving the quality of power supply.

Evaluating the results of the first phase of the project, in view of the number and types of commands performed in each operation center during the implementation and a few months after its ending, it is estimated that the project has already brought the following results:

Action	Benefits (~)
Teams availability	€ 240.000,00
Energy distributed	€ 225.000,00
SAIDI Avoided	48 minutes

Table 1 - Main benefits of equipment remote control at Celesc

These estimates considered average of consumers affected by the occurrence, value of kWh, average power consumption and kW interrupted by power failure, time required for manual operation and remote of the equipments, operating costs for the teams Celesc.

In addition to the estimated benefits, other benefits should be remembered, such as improving the company's image in front of their clients, the use of supervisory information for engineering studies and planning, increased security personnel in the electrical system, avoid configuration errors and adjustments to equipments that causes unnecessary interruptions and the possibility of monitoring the load on different parts of the feeder.

CONCLUSION

The automation project has brought significant benefits to the utility, mainly the reduction of operating costs.

A new phase of the project is being executed with the massive installation in the next four years of 3000 reclosers in overhead distribution lines. The new phase of the project focuses mainly in:

- a) Automation of the feeders of the metropolitan areas with the largest number of consumers / load and prioritizing those that have reliability issues;
- b) Automation of transfer (NO / NC) of smaller cities with double power supply;
- c) Automation of urban municipalities midsize multiple power supply.

This phase of the project should bring greater benefits such as a reduction of events in the system and reducing its impacts, as well as an improvement of up to 25% (240 minutes) in the continuity indicators currently calculated by Celesc.

The implementation of distribution automation in a decentralized system, with 16 operations centers, brings difficulties, especially regarding the uniformity of knowledge and use of the system. There are still significant differences between the bases, some with greater use and exploitation of system resources. To minimize this problem, it will be held another round of training for the supervisors and operators responsible for the operation of the region.

The decentralized model demands more time to implement the project, requiring a longer delay for full operation of the project and return of the investment.

In continuation of the project, addition to the work of integrating the new equipments will be made a pilot for automation of capacitor banks and voltage control. Improvements will also be made on SCADA screens to fit the amount of new equipment and to improve the navigability of the user.

Celesc is also running R&D projects for the development of algorithm for self-healing of distribution lines and state estimator, both to be integrated into the ELIPSE system.

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