SOFTWARE TOOL FOR PLANNING THE AUTOMATION OF MV FEEDERS IN ENEL DISTRIBUTION NETWORK

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ABSTRACT
This paper presents the software tool designed and used by Enel Distribuzione to assist the planners in the projects making of the network automation and to permit the management of all the involved processes. More activities are necessary and more people are engaged to build the network automation system; a good planning, coordination and control are essential for a uniform implementation of this system. That means: incisive actions in the part of the network with mediocre performance; because an electrical distributor is called to reduce the quality gaps in its network and because in these cases the benefits of automation are greater. The final purpose is to conform the maximum percentage of the MV network of Enel Distribuzione to the target levels established by Italian Regulator.

INTRODUCTION
Enel Distribuzione planned important investments to improve the continuity of service to face the target levels established Italian Regulator (AEEG). With reference to the reduction of the number and the time duration of interruptions, great improvement can be obtained by an optimal planning of the Network Automation System (NAS). This word in Enel jargon means a System capable to operate the fault location, its isolation and the service restoration, automatically without the intervention of man.

The benefits obtainable with the extension of this system to the entire distribution network are decisive in case of a perturbation involving a large area, because it makes possible the supply restoration on the healthy sections of the MV feeders affected by faults, without any delay due to the operator’s service time.

In order to implement the NAS some activities are necessary; the principal ones are the following:
- to install the resonant grounding system of MV neutral point (Petersen coil);
- to update of the setting of the lines protections;
- to place automation devices (ADs) along the feeders.

With reference to the AD, it is made of a motorized switch, a directional fault detector and a group of automatons resident in the memory of the RTU.

Therefore, in order to help the development of the automation program on all the Italian territory and to assist all the people involved in the project, a software tool has been developed.

Since the ENEL distribution network is organized in 28 Operative Areas (COs), the use of this tool in each area allows to define easily all the issues necessary for the program development and verify the work in progress. With reference to the plan, each activity is taken into account by assigning it a specific cost, to obtain the total cost of project and the costs/benefits analysis per each feeder, per primary substations and per CO.

In this paper, this tool is described in detail; the main steps to create a correct automation plan are listed.

NETWORK AUTOMATION PHILOSOPHY
The NAS philosophy (called FNC) works differently in dependence of the type of the fault that is detected by the fault detectors:
- a short circuit is isolated after several trips of the circuit breaker (the entire feeder suffers some supply interruptions);
- an earth fault is isolated without any tripping of the circuit breaker (only the healthy sections located downstream the faulty suffer a single supply interruption).

In case of short circuit the following procedure is applied:
- when the bay protection detects the fault, the circuit breaker isolate the feeder;
- the switches that have been crossed of the fault current are opened;
- the circuit breaker is closed;
- one at time all the switches are closed (with a specific time setting) until only the healthy sections located downstream the faulty are deenergized.

In case of earth fault, when the fault detector detects the fault on the line, the correspondent switch is opened if the fault persist for a programmed time.

More information about the Enel telecontrol and automation system can be found in [1].

SOFTWARE TOOL DESCRIPTION
The software tool is based on an client server architecture, that assure availability and fast updating, also in case of contemporary usage of several operator.

The tool shows the entire network of a CO, by giving for it and for each its part all the parameters necessary for the technical project. Moreover the tool assist in the decision making, taking into account all the issues:
- the activities into the Primary Substations;
- the activities into the nodes along each MV feeder;
– the benefits and the costs;
– the condition of the earthing systems in the entire network under automation;
– the scheduling of the investments.

For each issue, a special software application is available; between these softwares, the data are continuously aligned, after a work session in an application all the results are transferred in the other ones.

A data flow exchange provide to the software the followings data inputs:
– the physical structure and the characteristics of all the MV network;
– the characteristics of the customers (MV and LV) connected to the network;
– reliability data for all the network elements;
– the costs of all the activity and building materials necessary to perform the automation;
– historical data about faults and interruptions.

**Project overview**

The project overview page (Figure 1) is the start point in the tool using; it contains all the links to the other software and the most important project indexes.

![Figure 1: Project overview page](image)

This page illustrate the global state of the project for all the network, that is presented in hierarchical organization. All the data are available for all the levels of organization. The data are the following:
– structural data;
– data about the customers (type, number, location);
– foreseen data about quality of service (it are calculated starting from the input data and it are updated continuously during the progress of the project);
– historical data about quality of service;
– project progress indexes;
– cost/benefits indexes.

The levels of the organization are (in order of importance):
– CO;
– primary substation area (ACP);
– feeder area.

The highest organization level is the CO; according to the organization model of Enel Distribuzione, that assign at this level the management of the MV distribution network development.

The contribution of each part of the network to the quality of supply of the CO, is measured through a special index [2].

In order to plan an incisive works in those of the network with mediocre quality of service, the value of another special index indicates the parts of the network that require other investments. Since the project is made to the planner (that can change significantly the allocations suggest from the optimization algorithm) a cost/benefits index is available.

During the scheduling of the investments, these index permit to give priority to more critical areas.

**ADs placement**

By selecting a part of the network, from the project overview page, it is possible to open the application (Figure 2) for the optimal ADs placement.

![Figure 2: Application for the optimal ADs placement](image)

The application assists the planner, in order to explore a sufficient number of alternatives and to avoid non-optimal choices. For each line, an electric diagram is provided, the automation devices are positioned along the feeder through an optimization algorithm [2]. In order to take into account other factors (RTU already present, uncomfortable location of a substations, work already in progress, etc), the planner can modify the allocations; during this process he receives the results of the change in terms of pre-defined performances value.

The benefits are calculated starting from theoretical and the historical data, to ensure maximum coherence with the actual network status and therefore meet the need of a well-balanced and not redundant project.

The costs are calculated combining specific unitary costs;
each complex activity is made by elementary activities, each elementary activity has a cost. Each CO have a personal set of unitary costs, that are modifiable to take into account further specific differences.

**Primary substations activities**

The application (Figure 3) illustrates the state of the activities in all primary substations of the considered network, moreover it permits to plan the work needed to adjust the site not capable to perform the NAS.

In order to implement Enel network automation the primary substation is the minimum subset; in fact the adopted solution requires the presence a Petersen grounding system and a specific setting of the protection in the MV bay. For these reasons, it is necessary to make all the activities in the primary substation, before to automatize its feeders. In case of automation of few feeders, it is possible to set only theirs MV bays; in this case all the costs of the other activities (Petersen, protections of transformer etc.) have to be justified with the benefits foresee in the planned lines.

**Conditions of the earthing systems**

The application (Figure 5) illustrates the state of the earthing systems in all the nodes and it permits to plan the work needed to adjust the sites not capable to perform the NAS.

In case of earth fault into a substation, the fault current is dispersed through the earthing system for around twenty seconds (the breaker does not open); in order to avoid not acceptable step-voltage, before enabling the automation rules in a feeder, it is necessary to verify the ground resistance values for all its nodes. In case of bad ground resistance value, the adjustments will be planned thanks to this application.

**Investments scheduling**

The application (Figure 7) illustrates the global plan of the investments needed to perform the work fixed in the other applications.

After the closing of the project in the CO, all the activities, benefits and costs are well known; our software permit to
plan the subsequent investments in the year. The duration of automation program in Enel Distribuzione is 3 years, however it is possible to plan activities after this deadline, when:

- important structural changes are planned in selected part of the network;
- budget restrain;
- the critical works required the whole 3 years.

The critical works are:
- the automation for part of the network with the worst quality of service;
- the automation of part of the network with the best cost/benefits index;
- the automation of part of the network that require minor costs.

EXPERIENCE AND MAIN BENEFITS

The early experiences in the utilization of this software tool have been positive. One year has been enough to complete the projects for the entire distribution networks; in all the case, the planning activities have been faster than similar ones made in the past.

The main observed benefits are:
- completeness, all the necessary data and all the activities has been managed in a single tool;
- alignment with the field, all the network components and its connections are presents in the db, besides the utilization of this software package has been the initial step in the updating and completion of the capacities of the existing equipment;
- support to optimal choice, the value of the indexes, the cost/benefits analysis and the optimization algorithms are a complete and various set in order to avoid the not optimal choice;
- flexibility, the technical level of the planning engineers has been valued, because this software is theirs assistant and not a substitute;
- information interchange and team work, each project has been preview (or modified) for more people in different site and the same time, that has permitted an efficient sharing of experience and a profitable round table.

Additional benefits are predictable in the future. In case of great network reconfigurations (creation of new primary substation, creation of new feeders etc.), the software receives automatically the new network configuration and generate an allarm in all the involved projects. In case of the planner decides that the projects are good also in the new network schema, all the index are recalculated; the planner can change or confirm previous activities, moreover if some work have already been done, the relative cost are charged.

CONCLUSIONS

In this paper an integrated system of applications, using in Enel Distribuzione to planning the Network automation in the MV distribution network, has been presented. A rich set of functional possibilities was described, these are contained in five main software applications. Finally, through the results obtained in one year of utilization, the positive experiences and benefits of utilization of this integrated system were shown.

REFERENCES