Integration of DSO control systems and TSO automatic Load Shedding system to improve the security of the National Grid

G. Di Lembo - ENEL Distribuzione Italy

giorgio.dilembo@enel.com
Introduction

TERNA is responsible for the transmission and dispatching of electric energy throughout the entire Italian territory, and therefore for the safe management of the balance between electricity supply and demand all the year round. The modern term used for this kind of company is: Transmission System Operator (TSO).

Usually some services are required to assure a good level of security of the National Grid, to face events where generation may be reduced or disconnected following a system fault, to relieve localized network overloads, to maintain system stability, to manage system voltages and to avoid the so called “Black outs”.

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The project

One of the classical method to manage critical situations is the “Load shedding”, a technique that today can be applied in a very modern way thanks to the new technologies.

In this direction, TERNA developed a modern Load shedding application (called BME) that, connected to remote control systems of Distribution System Operators (DSO) makes possible a very effective automatic procedure for emergency situations.

ENEL Distribuzione, that is the main DSO of the Country, played a consistent role in the project as far as system integration is concerned.
The old System

The old system, developed in the ’80, was managed by the operators in the TSO control centres: they could manually disconnect some loads in the network by special grouped remote commands, so as to reduce the power by a specific amount.

This system, apart from being technologically obsolete, has two main limits:

- when the opening is activated, the disconnected load is not known exactly because it is based on an average estimated value, updated only once a year;

- the action is performed manually by the operator therefore, in many situations, the response time is not as short to avoid the network collapse.
The new System

The new application overcomes the problems mentioned before and performs the load reduction with a new smart method.

Thanks to the communication between the TSO central intelligence (Centralized Computer for automatic Load reduction, called EDA) and DSO peripherals:

– the loads are monitored in real time to have the real value of the power available for disconnection;
– The reduction of the right amount of load is performed automatically by the System on the happening of the critical event.
How the System works

The central EDA:

- foresees any “Critical event” and calculates the amount of power to be disconnected to avoid network problems;
- sends appropriate messages to all the Loads to be disconnected for each critical event, in order to make them prompt to open (Arming messages);
- programs the “Sentinels” (Special RTUs installed in critical sections of the grid that sense each Critical event) to send a Multicast messages directly to the armed loads in case of each foreseen event.

In case a particular Critical Event happens, the Sentinel sends a multicast message over the network to reach the relevant loads. All and only the loads armed for that kind of event will disconnect in a while, avoiding major problems in the network.
Main constraints

In the case of line overloads, the delay time between the critical event and the disconnection of the loads must be as short as to avoid the trip of line protections (<800ms). This requirement was the main technical constraint in the development of the system architecture.

Of course the cost of the system in terms of CAPEX and OPEX must be viable (Economical constraints).
System architecture

The functional blocks are the following

- A central computer (EDA) to analyze the current network status, evaluate the possible “Critical events”, calculate the corrections and send “Arming messages” to all the relevant loads;
- Several “Sentinels” installed in correspondence of the critical sections of the network;
- Some peripherals in correspondence of the Loads that can be disconnected;
- A telecommunication systems to connect central system with all the peripherals.
Interfacing the systems

Taking into account that ENEL Distribuzione controls the Italian territory through 28 SCADA systems (called STM) connected to about 2000 RTUs installed in every Primary substation, the following communication links are needed:

- a logic connection between each ENEL STM system and central EDA server, based on standard application protocol IEC 60870-5-104;
- a logic connections between TERNA sentinels and ENEL RTUs, based on UDP transport protocol and IEC 60870-5-104 application protocol.

Of course all unicast and multicast messages in both direction must be encrypted to assure the requested level of system security.
Data exchange during everyday running is limited to:

- information regarding the instantaneous load values coming from the primary substations: these data are sent to EDA by STM continuously;
- arming/disarming commands towards the loads: they are sent by EDA to STMs that forward them to the RTUs using the existing communication links;

In case of a critical event, disconnection commands are sent by the sentinels directly to all the RTUs of the network, using a multicast message (UDP). Only the loads armed for that specific event will be disconnected.
System testing

The Test Plan has been arranged into several steps:

• Laboratory Test;
• Field test on the pilot in Naples.

Thanks to the positive results obtained in laboratory, the field test phase started quickly in Naples at the beginning of the year 2008. Seven Primary substations are connected in real operation and monitored for one year to check:

• real delay times;
• reliability of the overall system;
• real traffic on communication network.
Practical results

The application was a real success and the delay times measured all the time were better than the expected ones.

In fact, the total delay time between the event and the actuation on the RTUs in Primary substations did not exceed 400ms. Adding the average operation time of a circuit breaker, it is possible to say that 500ms is the total time needed by the application to react to a Critical event. This value is far away from the stated limit of 800ms.
Extension to all the Italian network

The positive results of the pilot project lead to an application plan to extend the application to all the Italian territory.

First of all 8 gateways have been activated to connect the 28 STM system to TERNA Network.

A rollout plan is in progress to connect the south of Italy first and then going up toward the central and the north regions.

In the current year the system should be extended to all the territory.

Fortunately, so far, there was no need this system and we hope the same will happen in the future.