A NEW DISTRIBUTION MANAGEMENT SYSTEM FOR ANDORRA'S GRID

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ABSTRACT

Forces Electriques d'Andorra (FEDA) is the state owned company in charge of the production, import and distribution of electrical power for the entire state of Andorra. Today, Andorra's total energy consumption is around 583 GWh annually, out of which its own hydroelectric production represents 15%.
Following its strategy to invest and modernize its installation, FEDA commissioned in 2006 its new Distribution Management System, delivered and installed by AREVA T&D. This new control center system combines in the same SCADA/DMS system the monitoring and control facilities for the entire network, from high voltage 110kV substations to medium voltage distribution feeders.
This paper aims to share this collaborative experience and present key features of this successful project implementation:

- *Replacement of two legacy systems by a standard and compact solution*
- *Implementation of mixed telecommunication network solutions (GSM and PSTN) and protocols (HNZ, IEC 101) for dial-up RTU connections*
- *Large functional SCADA and DMS scope, including distribution load flow, network reconfiguration algorithms, dispatcher training simulator*
- *Graphical modelling tools for the maintenance of database and displays*
- *Aggressive schedule, including the system commissioning within 18 months*

Finally the paper discusses the benefits envisioned by FEDA when operating their network with this new system and the short-term network and system evolutions perspectives.

INTRODUCTION

The Principality of Andorra is in southwest Europe on the Mediterranean slope of the eastern Pyrenees between two European Union member states, France and Spain. Andorra, has 81 000 permanent Andorran habitants with a capacity of 220 000 habitants during the tourist season.

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Hydraulic production is ensured thanks to 5 lakes of 6 million m^3, directed to a hydraulic power plant with two 14 MW turbines.
Four 110 kV substation are the feeding points for the 110kV 35 km overhead lines and 3.7 km underground cable network. The overall feeding capacity sums up to 150.000 KW.
20 kV distribution network is fed out of these four feeding stations. Distribution network comprises 262 km of cables (mainly underground) connecting about 500 MV/LV distribution stations.

PROJECT SCOPE AND SCHEDULE

FEDA was operating with a SEVME SCADA since 1996 for the Feeder equipments and a Sainco (Telvent) SCADA installed in 2000 for the primary substations.

After 2 to 3 years of use, FEDA was not really satisfied to manage two different systems, firstly, because of remaining technical difficulties to merge properly and economically the two systems and their applications in order to operate easily all the networks, and secondly because of a double cost of maintenance.

Consequently, FEDA, after some tentative to evaluate the cost of a migration and evolution decided to replace the 2 SCADA with an integrated SCADA/DMS system for their complete network.

After an accurate technical and price evaluation, the project, was awarded and signed with AREVA T&D in January 2005. The scope was covering replacement of both existing SCADA systems by a completely integrated SCADA and DMS, preserving existing telecommunication networks for 5 substations and integrating more than 60 feeder RTUs. .
The scope of this project was including :

- A redundant SCADA DMS system with network colouring, management of temporary modifications (cuts/jumpers), real-time load flow and study mode, FDIR, training simulator.
- Integration with 5 x 110KV/20 KV substations with Protocol HNZ (French EDF protocol) via redundant links on PLC and leased lines.
- Telecommunication system connecting with 60 distribution substations with protocol HNZ and via PSTN/GSM communication medium.

An aggressive schedule was set up, achieving the following milestones:

- February 2005 : start of project implementation
- April 2005 : End of design phase
- December 2005 [T0+10] : Factory Acceptance Tests
- July 2006 [T0+18] : End of Site Acceptance Tests

AREVA T&D successfully delivered the system on time and on budget.

PROJECT DELIVERY

System hardware configuration

The SCADA/DMS hardware configuration is based on a redundant high speed Ethernet LAN, where all servers, workstations and other peripheral equipment (printers, video-projector…) are connected.

A full Windows configuration was chosen, using Windows operating systems on all the servers and work stations , in order to reduce the cost of ownership

This hardware configuration includes the following building blocks:

- Two SCADA/DMS servers running in hot-standby mode, dedicated to the SCADA/DMS functions and to the server part of the User Interface subsystem
- One Historical server dedicated to the long term archiving. This includes a total capacity of around 300 GB, in a RAID-5 configuration.
- One Development server, being the repository for the whole system (Database, Displays, source code). From this server the system can be 100% re-built and delivered.
- Two Front-end computers, running in load-sharing mode, in charge of the management of the communication links with he RTUs.
- Workstations (Operator and Engineer consoles)

In addition, the following LAN/WAN and Peripheral equipment is used:

- Printing equipment (B&W and color laser printers)
- Two LAN switching equipment, allowing up to 24 Ethernet connections each
- One Firewall Router allowing a secure connection with FEDA corporate LAN
- One VPN router for remote maintenance purpose.
- One GPS clock distributing accurate time to all Servers & Workstations
- A complete video-projection system allowing to call-up SCADA/DMS displays from any workstation on the wallboard.

The following picture provides a graphical summary of this Hardware configuration.

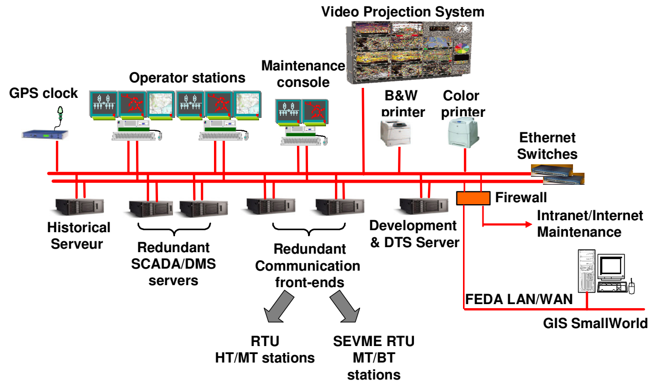

Figure 1; Hardware configuration

Telecommunication and protocols

Data acquisition system is composed of a set of hardware and software connected together and supporting the transfer of information from the field equipment to the control center:

- Two SCADA/DMS servers (master and standby), supporting the real-time database and data exchange with operators consoles.
- Two communication front end servers (FEP), connected on the same LAN. These front-ends are responsible for the data polling of the various RTUs
- Telecommunication lines :
  - Specialized lines (LS)
  - Public Telecommunication network (PSTN)
  - Mobile telephone network (GSM)
- RTUs of various types (ECP80, PCCN, ELECTRE) already installed in primary stations, and small feeder RTUs (SEVME) used as pole mounted RTUs or in MV/LV kiosks.

In this architecture, main SCADA/DMS servers are managed independently from the communication servers. RTU polling task is downloaded to the communication front-end equipments. The core application within front end processors is a powerful server whose main purpose is to distribute communication processing and to allow management of RTU specific communications and protocol independently from the main SCADA/DMS servers.

PSTN/GSM communication
About 50 RTUs are polled through a series of 11 available communication ports:

- 45 feeder RTUs equipped with PSTN modems (SEVME)
- 5 feeder RTUs equipped with GSM modems (Wavecom Fastrack M1206).

Depending on the « Dialout » property of the port, the communication lines are defined as « incoming» (i.e. used by RTUs when reporting changes) or « outgoing» (used for standard polling).

The eleven 11 ports have been allocated with 8 « Incoming» Modems and 3 « Outgoing »Modems.

Protocole HNZ80M
A common HNZ / Transport protocol is used to communicate with ECP80, PCCN, ELECTRE and PAS692 RTUs.

Protocol HNZ-45-S-53
Protocol master-Master HN45S53 is used to connect with feeder RTU equipment.

This protocol was implemented by AREVA in its communication front-end in order to support PSTN, GSM and Fiber Optic implementation.

IEC 60870-5-101 Protocol
IEC 101 was implemented for future evolution of the system and connection of new RTUs.

DMS System functions

In addition to standard SCADA capabilities, the Distribution Management System (DMS) installed at the DCC consists of the following functions:

- Display navigation utility
- Network Topology processing
- Real-time Load Flow
- Management of Temporary Modifications (Cuts/Jumpers) dynamically placed by operators
- Study Load Flow
- Fault Detection Isolation and Restoration
- DTS: Dispatching training Simulator
- Graphical Modeler tool for modelling of the data base and displays

The major breakthrough for FEDA is that the entire Distribution network is modelled, including the 500 ML/LV loads and switching devices.

User Interface

Graphical User Interface (GUI) software running on the workstation is designed to leverage the latest Web technologies and provide the best integration with the Windows environment. It provides all the features expected from a modern GUI software, like multiple viewports management, easy configuration and call-up of pre-defined display arrangements (rooms), pop-up pictures, pull-down menus, multiple fonts, efficient panning and zooming, support for scripting, etc…
The same user interface is used for SCADA and DMS functions.
The SCADA/DMS system, provides in the same user interface the capabilities to annotate the network with tags, to follow up work which is done in the field, and to issue remote control operations.

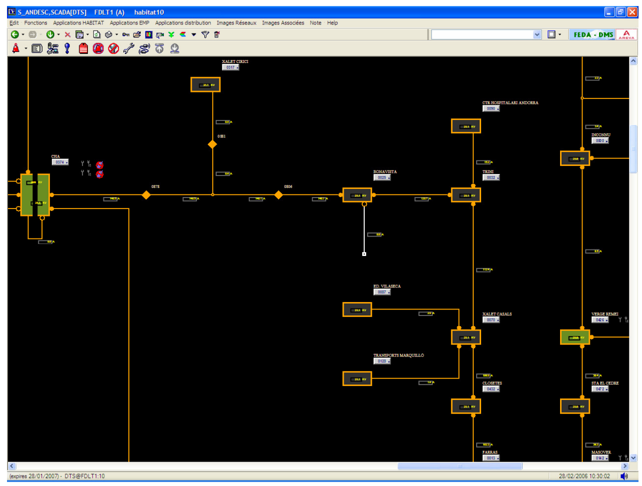

Figure 2; User Interface sample

FDIR

The Fault Detection Isolation and Restoration (FDIR) proposes switching plans to assist the DMS operator in the reconfiguration of the distribution network for maintenance purposes, and in the restoration of the network in case of fault.
The FDIR software is based on a powerful distribution network reconfiguration engine: Restoration and Transfer Plan.
On operator's request, FDIR computes and presents to the control engineer lists of switching actions, called switching plans, which describe the way to go from the current situation to a final network configuration recommended by FDIR.

All switching plans elaborated are checked against the operating limits. A powerflow solution is calculated in order to check that current flow values stay within limits defined for every feeder section. This powerflow solution uses the latest load values coming from the real-time state estimator.

User can review the solutions proposed by FDIR, check the details of the switching plans, and select one of the solutions for direct execution through the SCADA/DMS.

Dispatcher Training Simulator (DTS)

The simulator provides a realistic environment for system dispatchers to practice operating tasks and experience emergency as well as normal operating situations.

Activities such as use of supervisory control, voltage control, corrective action for loss of network element, and procedures for system restoration can be safely and conveniently practiced with the simulator responding in real-time as would an actual power system.

Graphical Modeling tool

After initial database conversion a Graphical Modeler was installed and used as central modeling tool for distribution network portions. This graphical tool allows editing and maintaining at the same time SCADA data, network data, and graphical diagrams representing the network.
The network is divided into pieces called subnetworks. Each subnetwork is covered by one eterraGraphicalModeler source file. Each source file can be edited separately allowing multiple Operators to work in parallel.

The graphical modeling environment uses a library of predefined symbols used by the Operator to build the diagrams.
Operators maintain database and displays by update drawings of the network, using drag/drop to create new components, and edit the connectivity graphically, thus avoiding errors.
Connectivity is maintained while objects are moved around in the graphical environment. Automatic routing facilities with various options are available for these connectors.

Once the model is complete, appropriate tools are available to populate the on-line environments with updated data and displays.

PROJECT PERSPECTIVES

Transition period

After a smooth transition phase, DCC operators accepted well the new DCC system. An efficient and intuitive user interface helped them to quickly get familiar with the system's functionality. The use of dynamic network coloring functions, of temporary modifications and tags has stimulated their interest in the system, bringing them a clear operation view of their network.
The easy-to-use configuration tools helped them to quickly get into real ownership of their system, and operators are now in a position to prepare themselves their network database and displays updates. Two people are in charge of the overall system maintenance activity.

In addition, the Training Simulator, provided as part of the main contract, leverages the capabilities of a full-featured simulation environment, and will help new operators to train themselves on a system with the same user interface as for the real-time one.

Benefits with the new system

FEDA derives several gains from this new unified system:

- Improved operation as it covers both transmission and distribution network
- Simplified configuration and extension

In addition, FEDA takes benefits from the load flow calculation which allows to operate safely and closer to the limits.
This will help to solve a situation where network extensions of 4% to 5 % per year are scheduled.

Finally, FEDA benefits from the Dispatching Training simulator, which is used to train operators but also for network model updates preparation and analysis..

Perspectives

The system has now been used for several months to FEDA satisfaction, and a number of further evolutions are being discussed.
One function which is particularly of interest to FEDA may be to complement the system with a Work Management function.
The Work Management application would provide a flexible way to automate the management of job forms describing the construction and maintenance works on the electrical network. It would support the step-by-step description of the work to be done, the life-cycle of the job forms - from creation, and approval to execution- and the necessary links with the SCADA when operations fall under DMS responsibility.