SCADA/DMS SYSTEMS DEVELOPMENT IN A ROMANIAN UTILITY COMPANY

Daniel Craciun, Cezar Cristian, Constantin Costescu
Affiliation: ELECTRICA Muntenia Nord - Romania
Tel.: +40 0244 405 001 ; Fax number: +40 0244 405 004, Address: ELECTRICA MUNTENIA NORD
44 Marasesti Street, Ploiesti, code 100024, PRAHOVA, Romania,
danielc@electricaph.interplus.ro

Abstract:

The power substations' monitoring and control development from the remote control to SCADA/DMS systems is one of the main trends in a modern utility company. Strategic decisions, technology investments and multiple training sessions must be deployed to update the operational processes to the new requirements.

The paper overviews the most significant actions and achievements of ELECTRICA Muntenia Nord in the field of SCADA/DMS system development and DA and the prospective options, projects and local trends. Power system configuration and the dispatcher points structure are presented. Several power substations were modernized or are currently during retrofit actions and other projects are waiting their turn. The achieved system configurations and the control devices are briefly presented for the 110/MV substations and the control centres. In this stage, IEC 60870 series communication protocols were implemented. In the MV over-head lines, the company uses a local control package, hardware and software, for the control of reclosers and sectionalizers. The latest achievement in the company's MV network is a control system for the MV/LV substation allowing SCADA/DMS function implementation, presented in the paper.

Also, using inside firm technical solutions a gradual development process was initiated to replace the obsolete control panels with microprocessors based RTU and IED at the bay level, as a step forward to the existing remote control and monitoring system. The paper presents the system configuration and the software application and HMI.

The integration of different manufacturers devices in a interoperable system structure with the latest IEC 61850 standard protocol will be an essential requirement for the future investments. The company had gradually adjusted its policy, from simple and mostly local systems and integrators, towards state-of-the-art integrated systems compliant to the latest standard in the field. With pictures taken from power substations and control centers, and drawings in electronic form, the paper covers the topic both descriptively and graphically.

Keywords: SCADA/DMS, equipment, system configuration, communication protocol

1. OVERVIEW OF THE PRESENT STATE

ELECTRICA – Muntenia Nord S.A. provides the electricity distribution and supply in the center and east of Romania, on a geographical surface of 29,765 square kilometers, for approximately 1,300,000 distribution customers, from a total number of 3,300,000 inhabitants in the area. The 110 kV power distribution network of the company has 2300 km overhead lines and 121 substations of 110/MV.

Some of the most important industrial consumers also have 40 HV/MV substations of their own, coordinated by Muntenia Nord's dispatchers. Likewise, there is a number of 84 Medium Voltage substations (most of them being 20/6 kV) and 9500 Medium Voltage/Low Voltage substations or MV connection points.

The company's power network covers 6 Romanian counties with six relatively important towns and various industrial activities, agriculture and tourism. As operational coordination we have two area dispatchers for the high voltage network and substations, seven local dispatchers for the medium voltage network and MT/LT substations and one dispatcher coordination office (Figure 1).

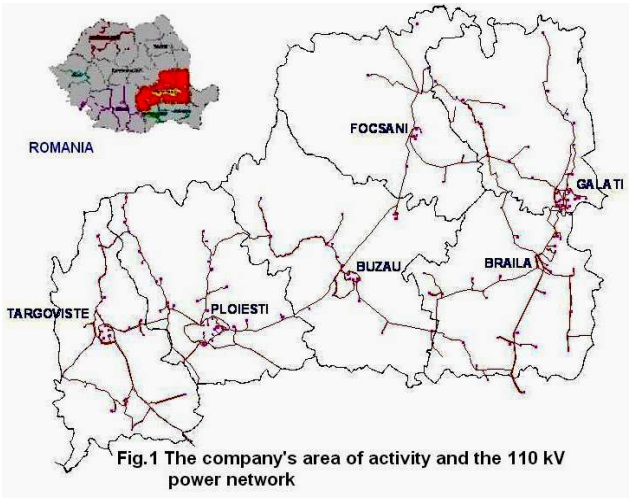


Fig.1 The company's area of activity and the 110 kV power network

We are still facing an important moral and physical ageing of the power installations, occurred especially in the eighties' and early nineties'. Consequently, a very important range of issues in the investments field is represented by the power substation retrofit and modernization, numerical protections, SCADA and DA projects and applications. The documents of the National Regulatory Authority (The independent Romanian system authority), like The Power Network Technical Code, and the present business environment requires a better control and monitoring level, simultaneously with the improvement of the power quality parameters in cost-effective conditions. The development of various SCADA solutions and the decisive steps towards a future integrated DMS it's definitely a task for the strategic thinking of the company.

Fig.2 Geographical map of the responsibility area

A SCADA/DMS concept cannot be created starting from the electromagnetic protections and automations, existing in most of the electric substations. Taking into account that the numeric equipments combine commands, data acquisition and communications, it is required a common strategy for the entire system of secondary circuits, part of the integrated IT and communication system within the company. Likewise, the switching equipment, circuit breakers, disconnectors, are obsolete, with a low reliability, therefore they must be replaced almost in every substation where retrofit works are being performed. An important number of 110 kV/MV substations (30) are driven by remote control panels with obsolete transistor equipments that allow commands or, in some cases, only measurements and signals. Now there are 4 High Voltage substations with complete numerical protections and modern SCADA solutions (from well-known manufacturers), and 12 HV substations with local SCADA solutions.

2. A SIMPLE SCADA SOLUTION CONCEIVED WITHIN THE COMPANY

Significant modernizing actions for a large number of substations were impossible to sustain, due to fund shortages, leading to the trend of achieving a simple SCADA system, with the help of our own specialists. Firstly, this was feasible for the substation with old remote control panels. A retrofit associated with an up-grade of the system was established both for reliability/availability reasons as for service operations cost. This development took several years, being fulfilled by the IT personnel and followed closely by the dispatching and safety specifications. The software application uses the Visual Basic language and the Windows XP operating system and allows managing a large amount of information, user-friendly graphical interface and the remote control of the substation. This approach offered the possibility to implement SCADA functions in several substations. Initially, the software allowed the disappearance of the control panels with transistors from the dispatching points and the computer management of the power substations. Later on, the software has been improved, up to the present variant. Likewise, adaptations of the drafts have been necessary, namely the achievement of some new montages for the equipment's time basis and a multiplexer in the control post.

This solution has solved a punctual problem, allowing the dismantling of the old panels, light bulbs, analogical gauges, command keys, etc.. Most of these elements generating faults have been eliminated. For the moment, some of the substations still use the initial execution panels. Subsequently, the same personnel made a step further conceiving an RTU and a IED bay terminal for the purpose of controlling other substations without previous remote control systems, but using the software they developed. This achievement, with limited funds, offered good return in term of results, as reliability, availability and operation cost. The main process-image of this software application is presented in figure 3. The window is of MDI type (Multi Development Interface) having the role of a container for the other secondary windows, including the buttons and menu bars of the program, the state and signaling bar.

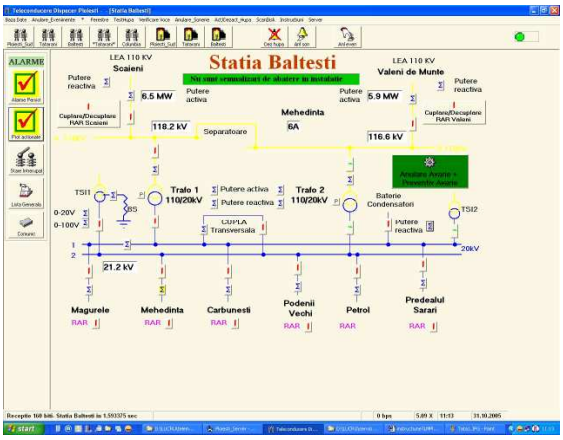


Fig. 3. Main process-image for a 110 kV substation

The achieved configuration is radial, using a server for all the substations managed through this system (Figure 4). Not only nominal and spontaneous flashing are supported, but also the display of various device and communication states. If the computer screen is busy with one substation, and we have an event in another substation, this will automatically become foreground. If several events occur simultaneously, they range in a waiting queue to be approached in the order of importance. The switching devices are controlled with a "select before operate" method. Each of the actions undertaken by the operator is registered in the database, chronologically, together with the events caused by the reception cycle.

There is a possibility to display the information referring to the data transmission mode and reception quality in other windows of the program. The application enables the event recording and processing. In case that it is useful to watch the parameters variation in a time interval, we can visualize power, voltage, current or the temperature variation for the chosen period, under the form of a graph or a table.

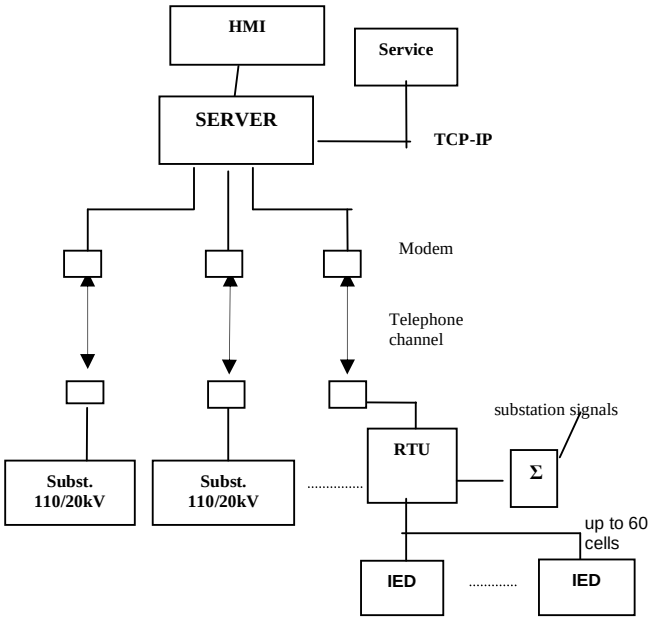


Figure 4. Local dispatcher at work and the configuration of the system conceived

However, the achievement of an almost hand-made SCADA system cannot represent a goal and this action has its own limitations. Whatever promising results this approach has given, especially in short-

time savings in operation and maintenance, it produced rapidly a so-called “legacy system” [4] that must be adapted to an integrated concept, using, as much as possible, standard protocols, according to the technical trends. ELECTRICA strategy stipulates, in SCADA and DA applications, the use of open standard protocols such as Modbus, DNP, IEC 870-5 series, IEC 61850, TCP/IP.

The use of the data support must provide reliable operation and a good performance/cost ratio, avoiding communication bottlenecks. The existing radio-trunking system must be integrated, but the optical fiber is preferred when possible, and telephone channels or radio 2.4 GHz remain as alternatives.

3. STATE-OF-THE-ART DISTRIBUTION CONTROL SYSTEMS

The company started to implement modern control systems in turn-key projects or in retrofit substations from well-known manufacturers. Definitely, we hope to reach towards new state-of-the-art control systems, but some of the first steps we made during the last years are presented further-on. At the first modern 110/20/6 kV substation of the company the designers adopted a control system with functionally decentralized structure. Two protection groups, each of them with basic and back-up protection, were adopted on the overhead lines and power transformers, as a new switching substation for a very important consumer (Figure 5).

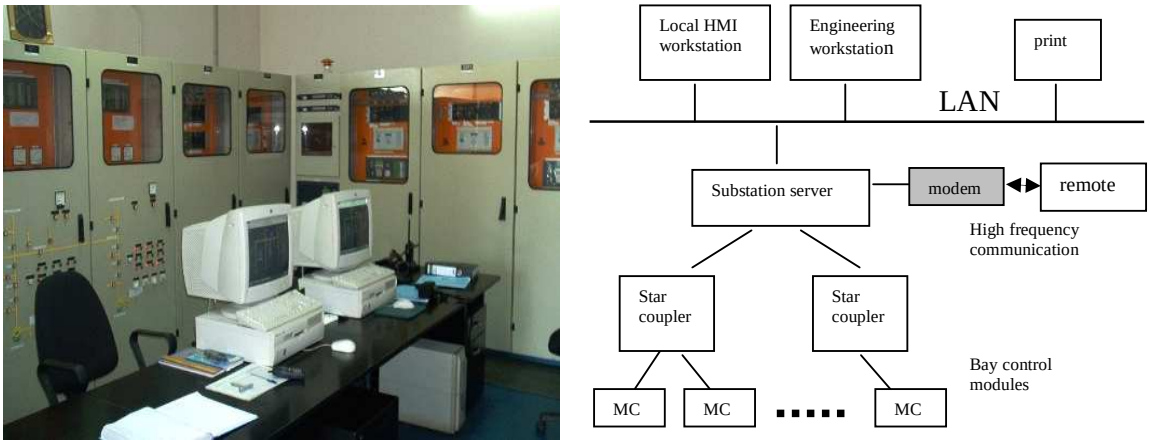


Figure 5. Control-room, protection panels, system configuration

There are three levels of control:

- Local level: emergency manoeuvres equipment. They allow the operator a rapid control without password;
- Control level: control panels from the control room for maintenance or back-up of the centralized level;
- Central level: the normally status for the substation control, allowing a complete configuration of the system and peripheral devices.

The control system is functionally decentralized but all the control equipment is in the control-room, having the usual SCADA and control functions on each level. The process data are gathered by the MC distributed modules in a real-time data base for calculation, archives, display purposes, printing, and/or remote transmission if necessary. All the components are mutually synchronized, after the server time-basis. The communication protocols are Modbus between MC modules and relays, and PROCOME from MC to the upper level.

Another example of turn-key project is from the eastern region of our company, with a 110/6 kV substation (Figure 6). The SCADA system was implemented with hardware and software structures based on IEC standards protocol. The system ensures the function of a range of « object » solutions (OBS - one box solutions), WIN32 applications. We distinguish between two levels of control (Figure 6), as follows:

A. The 6 kV bay level including numerical protections and the transformer differential protections to carry out function of protection and control. These IEDs are connected by optical fiber with the RTU, using IEC 60870-5-103 protocol. The control functions are :

- 3 switching devices control and monitoring ;
- signal acquisition ;
- analog values acquisition ;
- bay single-line diagram display ;
- status LEDs ;
- accessible event logging/fault logging ;
- measured value supervision ;
- timing resolution;
- serial port for local maintenance.

Substation protections and automations :

- 6 kV bus bars protections ;
- close command interlocking ;
- breaker failure protection (ANSI 50BF);
- under frequency protection (ANSI 81U) ;
- backup closing automation ;
- oscillographic fault recorder in the control room ;

Figure 6. 6 kV bays in a modernized substation

B. At the substation level, the following equipments and functions are implemented :

- the substation computer (RTU) ;
- connection monitoring of the FO with IEDs ;
- substation level interlocking ;
- GPS time synchronization ;
- signal monitoring and control ;
- communication with the IEDs via standard protocol ;
- communication with the HMI (human machine interface) ;
- serial communication and local maintenance via modem ;
- communication with the SCADA control center (local dispatcher) via IEC 60870-5-101 protocol ;

The software components of the HMI :

- Windows NT 4.0 platform;
- the on-line process software ;
- object oriented graphical user interface ;
- SQL data base ;
- events list, alarm list, filter capabilities after time or field.

For each voltage level, the system provides information, events-archives, buttons for control and setting menus, single-line diagrams.

For the moment there are 4 substations with numerical protection and a modern SCADA system, included in the technical trends, each of them being supplied by a different, well-known, manufacturer. Generally, we can speak of bay-oriented, distributed control systems, with a local HMI and communication with different control centers.

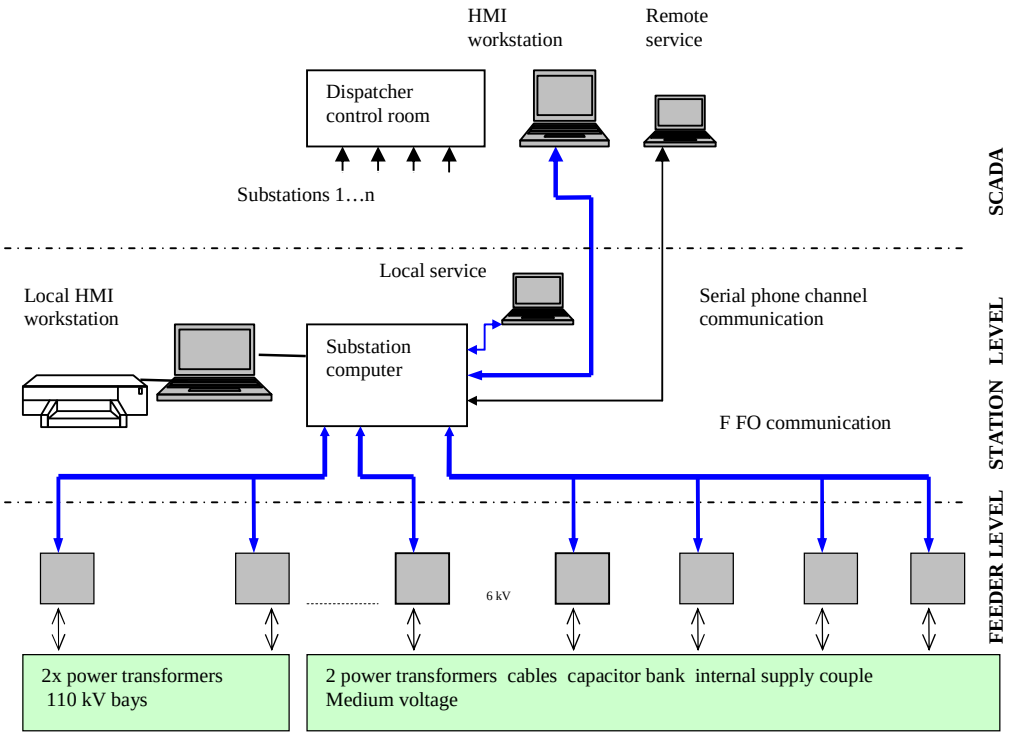


Figure 7. Configuration of the SCADA system achieved in a 110/6 kV substation

Still under implementation process it is the configuration shown in Figure 8 for a completely retrofit 110/20/6 kV substation in the Ploiesti region (Figure 8) with up-to-date numerical protections and IEC 60870-5 communication protocols. The RS 485 ring station bus will ensure a better availability and information redundancy for this configuration. The communication with the control center will be by the FO link (not yet operational). Other two substations have numerical protections and a control system with Modbus protocol supplied by a local manufacturer, and 10 substations are controlled by the solution conceived within the company, already presented.

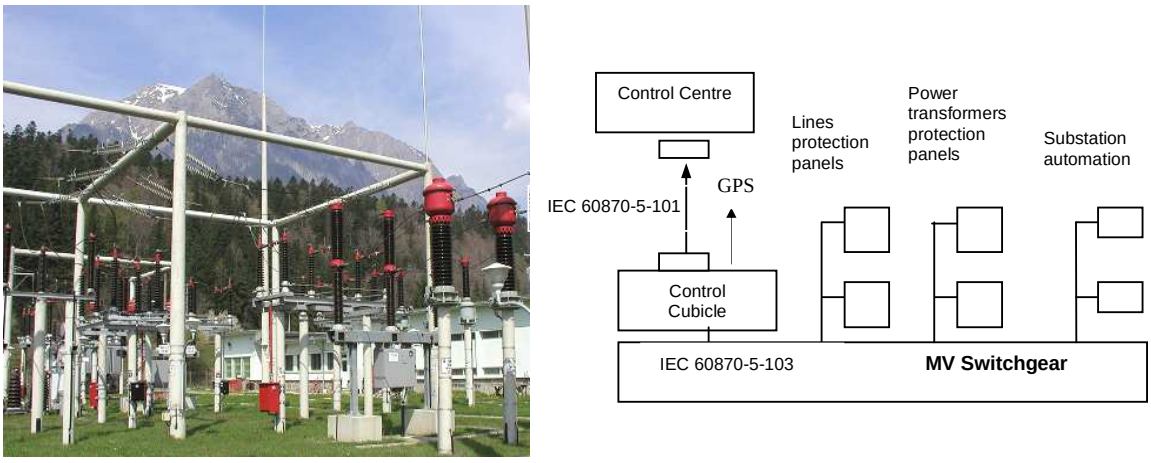


Figure 8. 110/20/6 kV in Ploiesti area and system configuration

Positively, this relatively wide range of solutions is not a good guarantee for the interoperability of an integrated system, so one of our concerns for the future will be to establish an optimal way to follow. In the years to come, other 4 substations are waiting their turn for retrofit and control systems implementation. As the IEC 61850 standard is now in trend and offers important benefits, we decided for the new projects to be compliant with this protocol.

4. SCADA/DMS APPLICATIONS IN THE MV NETWORK

In the MV network (20 kV) a number of 75 remote controlled reclosers and sectionalizers were placed in the most important medium voltage overhead lines in the last four years. The remote control package and software is provided by a local firm, on a Windows 2000SF platform, but remains the problem of integrating the application in a SCADA concept. In MV network, for reclosers and sectionalisers, the use of GSM signal was accepted. The latest achievement in the company's MV network is a control system for the MV/LV substation with the configuration presented bellow (Fig. 9).

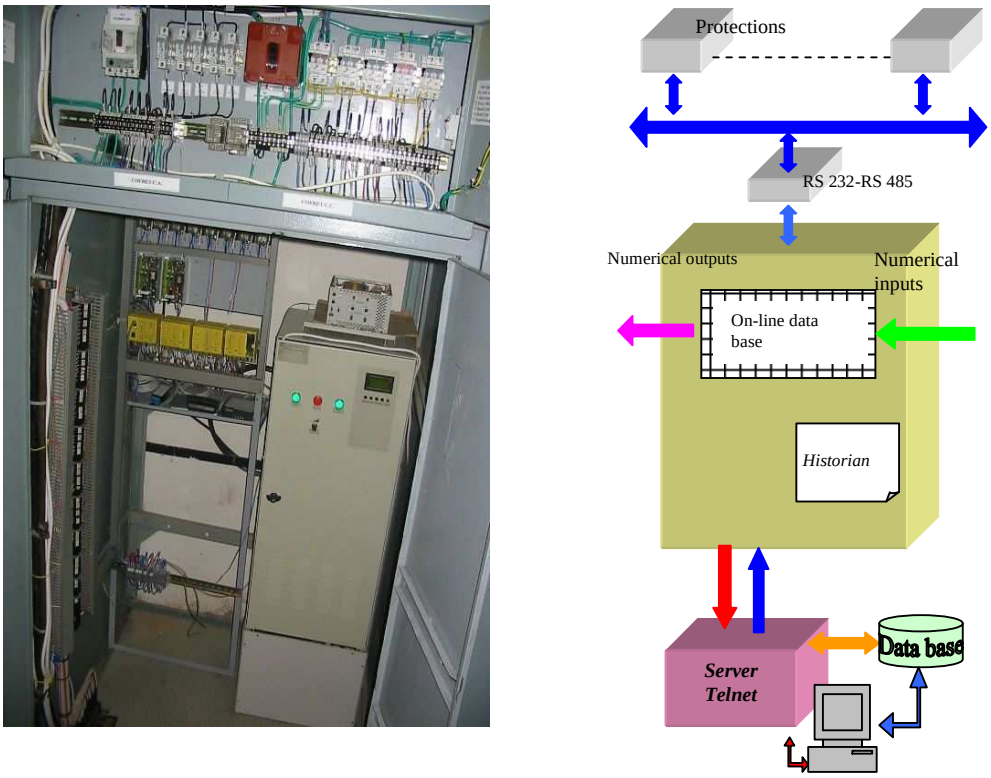


Fig. 9 System equipment in the MV/LV substation and control system configuration

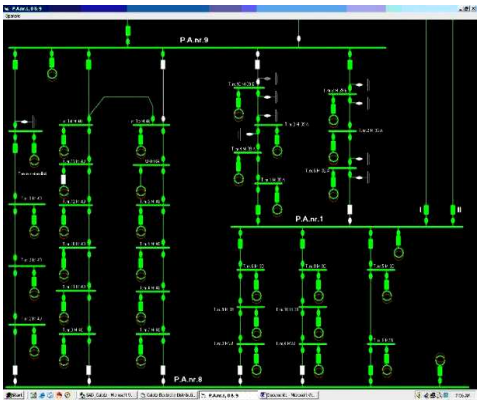
A controller in the MV/LV substation or the connection points creates the link with the process. As can be seen in the photo, the control equipment is in a small (yellow) box, where's placed the central module with microcontroller nearby a communication unit and two I/O modules. The link with the digital protections is made with RS 485-RS 232 interface connected to the bus. The system is conceived for multi-user and multi-tasking operation, on a OS 9 operating system, with an external ESRAM memory of 256 Mbytes. The power source from the automatically bridge rectifier is continuously monitored. The Telnet virtual server is a Java application for the management of the communication with the controllers and the process. It provides text-messages acknowledged by the OS 9 operating system, and, in the same time, provides start-up and monitoring sequences for the controllers. The relational data base is MS SQL 2000 type, on Windows XP, with tables modifiable on short, medium or long term, function of the specific sort of event, data, technological process or diagram. The equipment and the software are offered by the local provider, the task of configuration being fulfilled by our staff.

The on-line communication with the process platform and the controller is done through a virtual server, making possible the operation of a large number of controllers with a single virtual server. In the Control Center's server (computer) are implemented three essential components : the virtual server Telnet which adjust the commands-controls to the operating system (OS 9), the SQL

Table 1. System components

Application software	On-line communication between process and Control Centre
	Function applications
Operating system	Logger
	On-line data base
	I/O devices
	OS 9 kernel
Hardware	Controller
	Process interfaces

2000 relational database, and the HMI applications for DMS. As system components we distinguish the followings (Tab. 1):



Concerning the DMS functions only some features are of special interest. For e.g. the diagram loading and scanning is not done from pre-existing diagrams in *design time*, but from the data base in *run time*, allowing the operation with large diagrams. A zoom function wasalso implemented. The single-line diagram up-date is achieved in short and medium period, consequently the to the state of the switching devices. A dialog window will appear on screen for any switching operation, and security interlocking are operational. The Fault Restoration, Power Flows and Topology Management are functions under different degrees of implementation.

Fig.10 HMI of the DMS/SCADA system in MV network

5. CONCLUSIONS

In the DMS/SCADA selection and achievement, generally, it should be taken into consideration factors like the geographical coordinates of the dispatching centers, the communication infrastructure, the age and the importance of the substations. Modernization projects were achieved and commissioned mainly in the last ten years and, due to fund shortages, they included only a small part of the existing network. Both the technical solutions offered by manufacturers representing brand-names in the industry, as well as local solutions are put in work. Synthetically, we achieved a local solution for the remote control of the reclosers and sectionalizers. In other two substations and in the MV network, a local firm provided an integrated solution adapting acknowledged hardware and software components for industrial processes.

In four of the substations, modern equipments and system configurations were implemented, and other 4 projects are waiting their turn. The trend for the future SCADA extensions is the integration of the overall system from the bay level to the control center interface with fast data handling and reliable operations. However, the concepts and settings should support a direct exchange of data at the bay level, avoiding communication bottlenecks. The integration of different manufacturers devices in a interoperable system structure with, preferably, the latest IEC 61850 standard protocol is an essential requirement, and our short history in the field offered enough evidence to sustain the importance of a strong supplier for adaptable state-of-the-art systems. Our future options will be for:

1. The latest IEC 61850 protocol, also taking into account the compatibility with the systems already achieved;
2. Friendly graphical user HMI, up-dated to the present level of technology in the field;
3. Modern protections and control in one box solution;
4. The suitable engineering tools supplied with the devices;

New SCADA/DMS applications and options must be easily integrated when necessary, in a flexible manner, accordingly to the investments possibilities. The company had gradually adjusted its policy, from simple and mostly local systems and integrators, towards future state-of-the-art integrated systems.

6. REFERENCES

1. M. Lees, J. Thomson, R. Gibbons, The strategic technology program – a model for high value and collaborative technology development, CIRED, 2001, Amsterdam.
2. I. Paun, M. Contescu, D. Craciun, A Ionescu - A new approach in the substations remote control and monitoring based o a gradual development, Juko CIRED, Herceg Novi 2004.
3. C D'Adamo, F Tramonti, G. Mauri, M Sforna - Contribution of Distribution Network to the Security of The Italian Power Systems: Present Strategies and Future Innovations, CIRED, 2005, Turin.
4. D J P Ossenblock, R Derkinderen – How to integrate new technologies and legacy systems, CIRED, 2005, Turin.
5. L. Hossenlopp, Increasing substation automation standardization level, CIRED, Turin, 2005.
6. Newton-Evans Research Company, The World Market for Substation Automation and Integration Programs in Electric Utilities: 2002-2005.