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Scada Systems – Control, Supervision and Data Acquisition for the Power Plants Settled on a Stream (Part 2)

Scada (supervisory control and data acquisition) is a complex system that supervises and controls an industrial process and performs several functions. A human machine interface will also be presented and how the process in a power plant is controlled and supervised through it by the operator. The main screen will be described (which is a global view of the hydro unit) and what the operator can see and what he can press to control the power plants process also a few more screens will be presented for auxiliary installations and it will be described what the operator can see and what he can do to control the installation.

Keywords: *Scada Systems, Power Plants, energy*

1. Introduction

As discussed in a hydropower facility comprises the main storage reservoir, with a large capacity of water storage, which collects the running and rain waters flowing waters on the slopes of the mountains. It supplies the main hydro power plant built in the area with a configuration that provides a maximum head and minimal energy losses on the water conduit. Downstream of this main power plant is built a cascade of hydro power plants of low output that uses the water flow of the downstream plant to which is added the water of the secondary catchments between the two power plants. These plants, called run-of-the-river power plants, have a reservoir with low storage capacity, a gross head that is usually small, where the delivered output depends on the flow received from the downstream power plant.

In this case, it is clear that there is a need of implementing a SCADA system to correlate operation the assembly of hydro power plants built in cascade on the streamline, in order to maximize the use of the hydraulic energy available at any time.

Such a system must be organized in a structure hierarchical distributed on three functional levels, namely: [ICFelix]

- Level 1 - includes the SCADA systems in each power plant separately, that monitors the control, protection and remote control systems at each group separately.
- Level 2 - includes the SCADA systems in the control room of the load dispatcher from the run-of-the-river power plants.
- Level 3 - includes the SCADA systems in the control room of the load dispatcher from the power area (off-Site).

Usually, Level 2 and Level 3 form an integrated structure of computer equipment grouped in the same building.

Hereinafter follows a presentation of the structure and functions of a SCADA system for an assembly of run-of-the-river power plants. The charts and screens in this application had as source the "System of control, supervision and data acquisition (SCADA) of run-of-the-river power plants built on middle Olt" conducted by ICE Felix - Factory of computers S.A. Bucharest (documentary material used with the consent of the company ICE-Felix).

1. SCADA system at the level of the load dispatcher

The structure of SCADA system at the level of the load dispatcher of a hydo power plant assembly constructed on a stream is shown in Fig. 1 [10].

2. Structure of SCADA system

The SCADA system shown in Fig. 1 covers the monitoring tasks from Level 2 - Load dispatcher for the hydropower assembly and Level 3 - Load dispatcher for the energy area (electricity supply and transmission) covered by the hydropower assembly. The load dispatcher consists of a number of servers and consoles that are coupled to each other via a local area network (LAN) of Ethernet type.

The components of the dispatcher are:

- Primary communications servers (ordered by telephone) and secondary (connected via radio) that are designed to read data acquired in the hydro power plants with a maximum of 8 channels per server for wired communication. Keeping the number of communication channels at 8 is made for reasons of scalability and availability of the communication system. The operating system used is UNIX (QNX) and the communication protocol with the SCADA server is TCP/IP. The communication protocol with a HPP is compatible with IEC 870-5-101 protocol;
- The primary server SCADA is the server that maintains the database in real time of the dispatcher level. It is accompanied by a secondary server SCADA working as a backup mode for increased system reliability. The operating system used is Windows 2000 and for the development of the application the package iFIX

SCADA is used. The data from the power plants are read by the communication servers through the drivers OPC type (OLE for Process Control). The SCADA system used allows the users to develop their own application screens, to define variables in real-time database, to issue reports, to define and to modify the access rights to information, to memorize the history of certain values;

- The database server serves to store historical data and uses as operating system Windows 2000 uses the SQL Server 2000 system;

- The operator consoles are of two kinds: consoles that allow to perform commands and consoles that allow only visualization of process data. These consoles use the operating system Windows 2000 and as database management system iFIX SCADA package is provided;

- The engineering console from which the user can develop his application depending on subsequent additional requirements or in case of system extension;

- The simulator for a HPP, which consists of an operator console and an automation computer whose inputs are connected to a panel of switches and potentiometers and the outputs are connected to the luminescent indicators. It has the same features as HPP level and aims to simulate various situations in HPP with the purpose of training the operators from the dispatcher or power plants;

- Wall-display type screens that are coupled to a display server that are designed to enable viewing of synoptic diagrams that can be seen by dispatchers. The server is connected to the local network, runs an application of SCADA console using the operating system Windows 2000, allowing the operators from the dispatcher to determine the images that are displayed [10], [1].

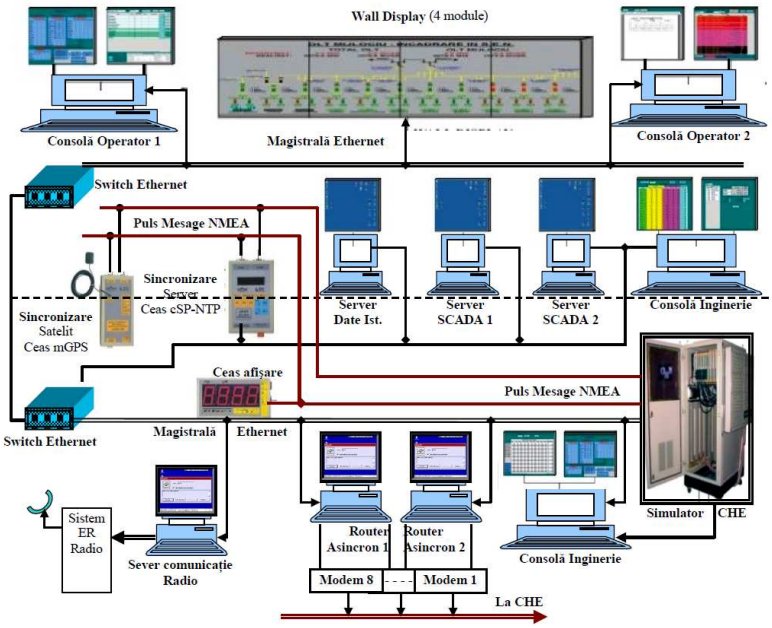


Figure 1. Structure of SCADA system at the level of a hydro power plant

3. The features and functions of SCADA system - dispatcher

* Safety system:

The safety system allows the following operations:

- Allows to start-up/shut-down the safety system;
- Allows creating, modifying and deleting of user accounts;
- Restricts access of users to certain programs or operator screens;
- Provides protection for writing for the real-time database;
- Allows classification of users in group accounts;
- Allows allocation of rights at the level of the application function (eg. leaving a screen, drawing an object, etc.);
- Allows to define safety areas at functional or physical level, which can restrict access to SCADA system resources;
- Allows to create a secure environment in which the user can be prevented to make the following operations: to start other tasks, to switch between unauthorized tasks, to leave the current screen, to open unauthorized screens, to restart the computer;
- Allows import and export of safety accounts.

* Long-term data acquisition (data history)

The system of long-term data acquisition has the following characteristics:

- Provides an automatic mode, comprehensive and for long-term acquisition, to store and display the process data;
- Allows an analysis of the trends monitored process;
- Archives the process variables to meet current standards;
- Allows a post-failure analysis;
- Allows setting of a strategy for data acquisition (organizing the variables in collections, setting the file length by the hours and time that they will be kept on hard-disk site);
- Allows creating of graphs based on the data acquired, also printing and exporting of the data acquired as ASCII files.

* Generating of reports

The generator of predefined reports is designed to allow the operator making reports based on historical data. The report is generated at intervals of time determined at the level of day an hour of the week, and it is repeated at fixed intervals of time. When generating, the report can be sent to a default file or directly to the printer. The system allows the operator to issue reports by recording the moment when editing was done together with the identity of the operator.

* Working with external databases

The SCADA system allows writing and reading of data from an external database implemented as a database management system SQL Server 2000, using commands written in SQL language. These operations take place at a set time or are triggered by a certain event that took place in the hydropower system.

* The system of alarms and messages

The system signalizes exceeding of a limit set by the value of the process by triggering an alarm. The system displays the alarm until the condition that triggered it disappears and the operator confirms it. Also, can be generated messages about the system activity, the operator and the database, messages that can be subsequently inspected.

The alarms and messages can be of several types: alarms generated by the database, messages generated by the occurrence of an event, messages generated by the system and messages generated by the application. To each alarm can be assigned a specific property, the program generates a summary of all alarms received from a SCADA point and can generate acoustic messages to the emergence of a new alarm. The SCADA system provides support to the local distribution network in distribution of alarms and messages to all points in the system. It also provides support for printing of the alarms as soon as they arrive on a SCADA point. The alarms and messages that come from the process are stored in the historical database. The system provides a service with the alarm history that allows to display on the screen a list of alarms and messages on a point, as soon as the point receives the information [9], [2].

* Real-time database

The real-time database consists of blocks that meet one of the following functions:

- Receiving of inputs from the driver OPC;
- Processing of data according to user instructions (according to the control strategy);
- Compare the values read with the preset alarm limits;
- Transmission of output values that change to the OPC driver;
- Sending alarm signals to operator screens for printing, files or alarm devices on the network, in accordance with the SCADA application.

The database blocks have names that are defined as tags and may be linked together forming interconnected functional structures. The system provides periodic scanning of these structures, performing reading of the data from the input blocks, comparing them with the preset limits, triggering of alarms and data processing in accordance with the control strategy. To prevent the operator to make unauthorized changes, the SCADA system provides a safety system that allows the administrator of the system to give access only to those blocks in the database to which it is entitled. In order to have access to certain data, the operator must enter the system using the appropriate username and password [4], [5].

4. Communication system

The communication system meets the following requirements:

- Provides real-time data traffic between hydro power plants and dispatcher, providing detection and correction of errors;
- Provides a secondary means of communication between hydro power plants and dispatcher;
- Supports a protocol based on transmission of events in order to minimize the necessary communication band;
- Possess self-testing capabilities;
- Uses data compression from the transmission of large amounts of data (eg. transmission of the entire database located at the level of the automation computer to the hydro power plant).

5. The application SCADA from the load dispatcher

The application SCADA from the load dispatcher allows the operator to visualize hydropower and hydrographic situations at the level of the hydro, to visualize data at each HPP separately, to edit, to view and print the reports issued during a shift, to view and confirm the alarm messages.

The following is a description of the main features of this application:

6. Control bar of the application

It is present all the time at the top of the screen and displays general information about the application:

- Date, time and frequency of the network;
- Name of the current user, the area and power plant;
- Name of the screen opened at a certain time and the last alarm occurred in the system.

The control bar of the application allows also to control the application: selection of current screen, changing of the current user and closing of the application

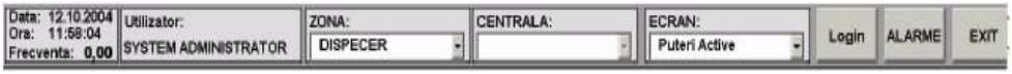


Figure 2. Control bar of the application

7. The screen for real and reactive powers

It is shown in Fig. 2 and allows real-time visualization of real/reactive powers from all power plants and on all groups. It is allowed to alter the sizes displayed where, for various reasons, they are not correct. Sizes whose values have been edited will be displayed with different colors. Also, will be displayed the total powers on different areas or groups of power plants. In the event that a size was changed, in calculating the total will be considered the input value and not the acquired one.

8. Screen for editing reports

It is shown in Figure 4 and allows to view and modify the values of all sizes that appear in reports. The columns of the table have the following meanings: size name, value of the size acquired from the system, the value proposed by the operator for the size, date and time it was proposed the value of the size and the name of the person that proposed the value, the value proposed by the dispatcher also the date and time at which it has been proposed. It is allowed to change only the value proposed for the size, not the value acquired. When the change is made, the name of the person that made this change and the date and time at which it was made are saved in the database. Changing the proposed value result in the change of the final value of the size, because the value proposed has priority over the value acquired. At the bottom of the screen there is a table that displays the history of the size selected in the main table in the last 2 weeks. The report selected for editing can be printed directly to the printer from this screen, or can be viewed in the display of the screen "Printing Reports" [6]; [7], [8].

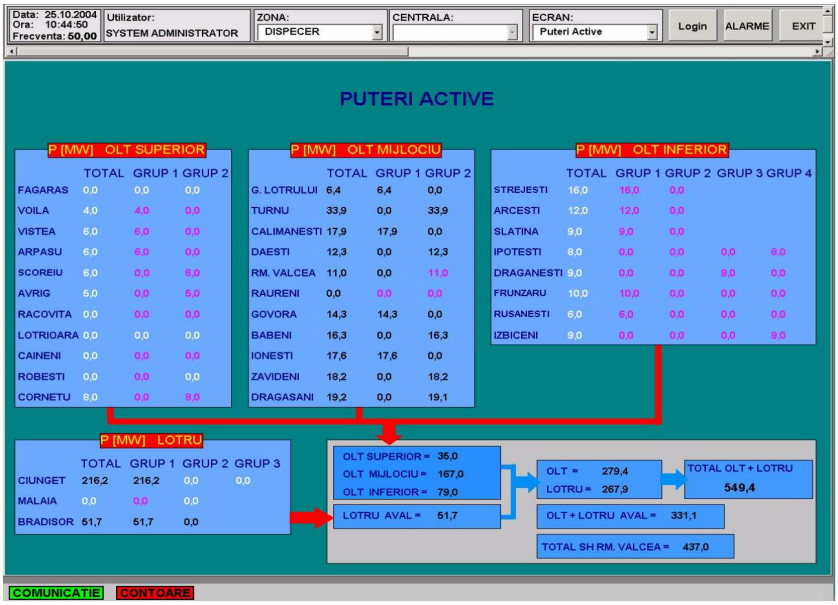


Figure 3. Screen for powers

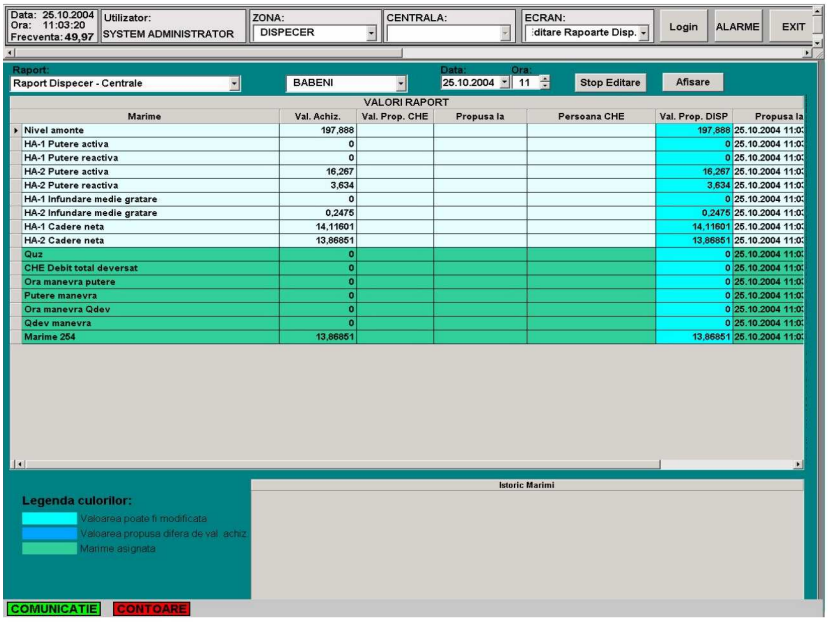


Figure 4. Screen for editing

9. Screen for printing reports

Allows selection of a report for viewing and printing at the printer. The screen uses a report type "Crystal Reports" which also allows the export of information from the report in various formats (XLS, PDF, HTML, etc.)[2]

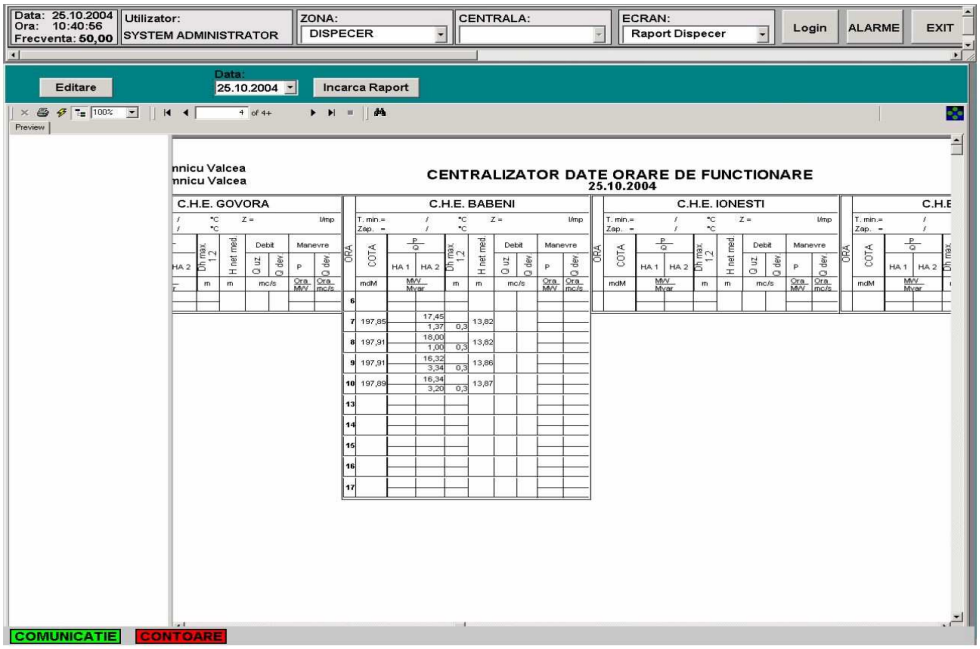


Figure 5. Screen for printing reports

10. Screen for alarms

Paper It contains a table of the latest alarms in the system, ordered by date and time, in descending order. Each line in the table represents an alarm and contains the name of the power plant from which it came, the date and time it occurred, the alarm message and its type. The background color of each alarm indicates if the alarm is confirmed or not, or if it is was canceled or not, according to the legend at the bottom of the screen. If you click the plus sign ("+" additional information) next to an alarm, other information related to that alarm will appear: if it was canceled, the time when it was canceled, if it was confirmed, the time when it was confirmed, the name of the person who confirmed it.

It is also possible to perform a filtering of alarms displayed based on several criteria: the power plant from which they came, the type of alarms, their state

(canceled, confirmed), the name of the person who confirmed or the alarms that occurred over a period of time.[10]

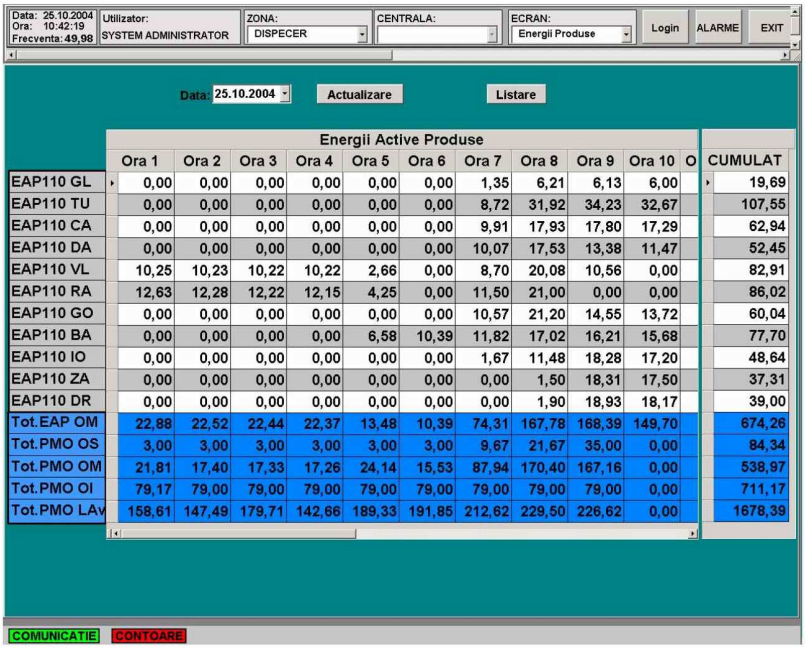
The screen allows printing of alarms to the printer under the form of a report.

Figure 6. Screen for alarms

11. Screen for energy output

Allows viewing of energy produced and supplied by each power plant in the system, every hour throughout the day.The equation is part of the text so it must have normal text ending - comma or full-stop, like

The selected day may be the current one or another previous day. It is allowed to modify the values of sizes that are incorrect, these changed values being displayed with different color. There are also displayed: the total energy for each power plant for the selected day, the total energy of all power plants at each time and the total of average power at each hour. The information displayed can be printed at the printer under the form of a report.



	Ora 1	Ora 2	Ora 3	Ora 4	Ora 5	Ora 6	Ora 7	Ora 8	Ora 9	Ora 10	O	CUMULAT
EAP110 GL	0,00	0,00	0,00	0,00	0,00	0,00	1,35	6,21	6,13	6,00		19,69
EAP110 TU	0,00	0,00	0,00	0,00	0,00	0,00	8,72	31,92	34,23	32,67		107,55
EAP110 CA	0,00	0,00	0,00	0,00	0,00	0,00	9,91	17,93	17,80	17,29		62,94
EAP110 DA	0,00	0,00	0,00	0,00	0,00	0,00	10,07	17,53	13,38	11,47		52,45
EAP110 VL	10,25	10,23	10,22	10,22	2,66	0,00	8,70	20,08	10,56	0,00		82,91
EAP110 RA	12,63	12,28	12,22	12,15	4,25	0,00	11,50	21,00	0,00	0,00		86,02
EAP110 GO	0,00	0,00	0,00	0,00	0,00	0,00	10,57	21,20	14,55	13,72		60,04
EAP110 BA	0,00	0,00	0,00	0,00	6,58	10,39	11,82	17,02	16,21	15,68		77,70
EAP110 IO	0,00	0,00	0,00	0,00	0,00	0,00	1,67	11,48	18,28	17,20		48,64
EAP110 ZA	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,50	18,31	17,50		37,31
EAP110 DR	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,90	18,93	18,17		39,00
Tot.EAP OM	22,88	22,52	22,44	22,37	13,48	10,39	74,31	167,78	168,39	149,70		674,26
Tot.PMO OS	3,00	3,00	3,00	3,00	3,00	3,00	9,67	21,67	35,00	0,00		84,34
Tot.PMO OM	21,81	17,40	17,33	17,26	24,14	15,53	87,94	170,40	167,16	0,00		538,97
Tot.PMO OI	79,17	79,00	79,00	79,00	79,00	79,00	79,00	79,00	79,00	0,00		711,17
Tot.PMO LAv	158,61	147,49	179,71	142,66	189,33	191,85	212,62	229,50	226,62	0,00		1678,39

Figure 7. Screen for energy output

12. Screen for volumes - Capacity curves

Allows viewing and editing of dimensions and volumes appropriate for each power plant. You can define and modify both the reference dimensions (maximum operating, maximum restrictive, normal level of reference and minimum operating), also other intermediate levels and their corresponding volumes that will be useful in calculating the volume corresponding to the current dimension at a time. For each power plant it is possible to print at the printer all defined dimensions and their corresponding volumes.

13. Screen for volumes – Cases

Allows viewing of information about the dimensions and volumes of the lakes, also to modify the values if they are not correct. The modified values will be displayed with different color.

Viewing can be done in several ways:

- For a certain time, in a given day, for all power plants it is displayed the required dimension and the corresponding useful and gross volume, the dimen-

sions NNR together with the useful and gross volume also the storage reserve. You can change the value of the dimension, which determine recalculating of values for the useful and gross volume and for the storage reserve;

- For a certain power plant it is displayed, for all hours in a given day, the required dimension and the corresponding useful and gross volume, the dimensions NNR together with the useful and gross volume also the storage reserve. You can change the value of the dimension, which determine recalculating of values for the useful and gross volume and for the storage reserve;

- For a certain time, in a given day, are displayed the totals on groups of power plants for the useful and gross volume (both the momentary value and the corresponding value NNR) and for the storage reserve.

- The sizes in real-time for the required dimension and the corresponding useful and gross volume, the dimension NNR together with useful and gross volume and the storage reserve.

The information displayed can be printed at the printer under the form of a report. [10], [9].

Figure 8. Screen for volumes - Cases

14. Hydrographic chart

Shows a graphical simulation at the level of the storage reservoir using the real-time data for each power plant. There are displayed also other sizes from each power plant: flow of the tributary stream, machined, overflowed and discharged, flow variation, current level, maximum and minimum, the powers on each generating group and clogging of grids on each group. It is allowed to change the sizes displayed if they are not correct. The sizes whose values have been edited will be displayed with different color [10].

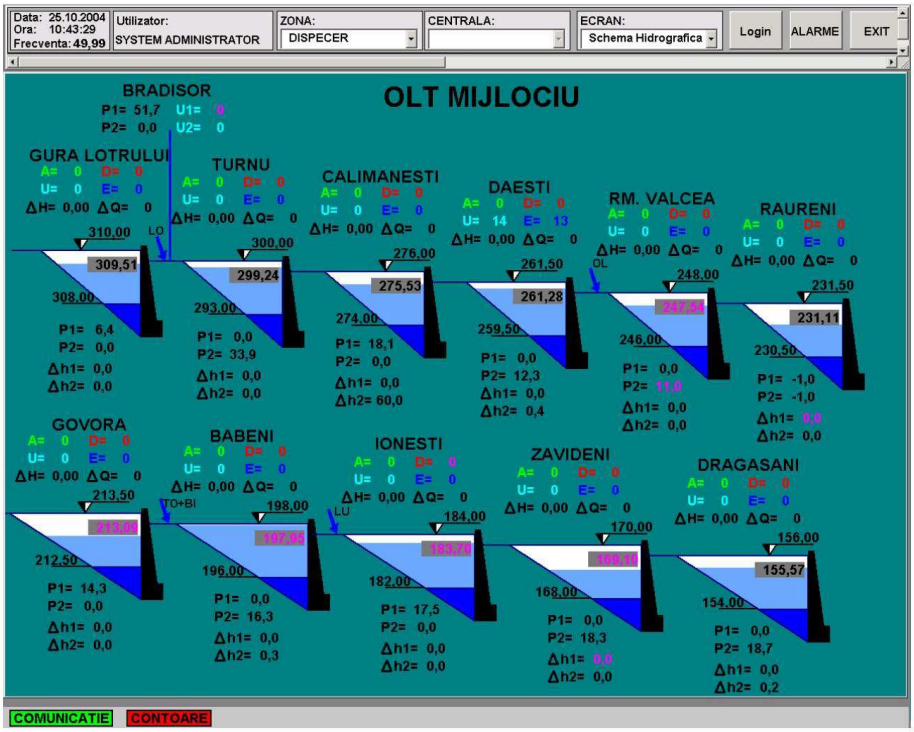


Figure 9. Hydrographic chart

15. Circuit diagram

Shows the circuit diagram of the area including all power plants and connections between them also the transformer stations.

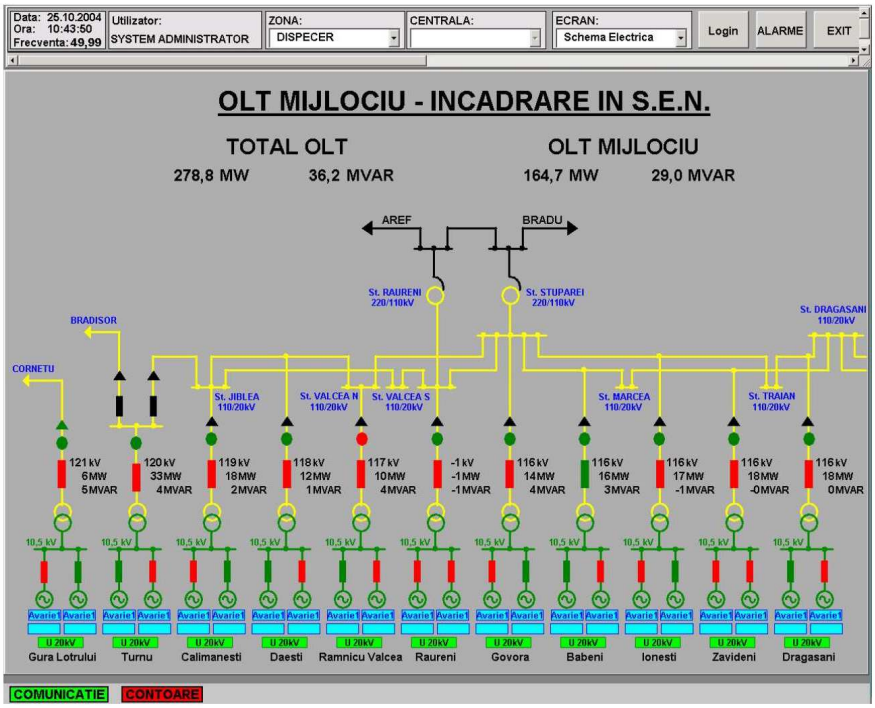


Figure 10. Circuit diagram

Text For each power plant are displayed the switches for each group, the circuit breaker and the arrester on the line of 110kV also the indicators for the presence or absence of voltage on the line of 110kV and 20kV. The positions of circuit breakers and arresters can be changed if they are not correct. On the circuit diagram also appear the real and reactive powers for each group, which can also be edited if they are not correct.

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