AUTOMATIC CONTROL AND DATA ACQUISITION (SCADA) FOR GEOTHERMAL SYSTEMS

by Cornel Antal and Teodor Maghiar

1. INTRODUCTION

After general aspects of SCADA (Supervisory Control And Data Acquisition) this paper presents briefly the SCADA system used at the University of Oradea.

2. DEFINITION OF SCADA

SCADA is the technology that enables a user to collect data from one or more distant facilities and / or send control instructions to those facilities. SCADA makes it unnecessary for an operator to be assigned to stay at, or to visit, remote locations in the normal operation of that remote facility.

SCADA is an acronym that is formed from the first letters of Supervisory Control And Data Acquisition. A SCADA system allows an operator, in a location central to a widely distributed process such as an oil or gas field, pipeline system, or hydroelectric generating complex, to make set point changes on distant process controllers, to open or close valves or switches, to monitor alarms, and to gather measurement information. When the dimensions of the process become very large – hundreds or even thousands of kilometers from one end to the other – the benefits in terms of reduced cost of routine visits can be appreciated.

Typical signals gathered from remote locations include alarms, status indication, analog values, and totaled meter values. However, with this apparently limited menu of available signal types, a vast range of information can be gathered. Similarly, signals sent from the central location to the remote site are usually limited to discrete binary bit changes or analog values addressed to a device at the process. An example of a binary bit change would be an instruction ordering a motor to stop. An analog value example would be an instruction to change a valve controller set point to 70 percent. Given simple signal types like these and some imagination, many control changes can be effected (Boyer, 1993).

3. THE SCADA SYSTEM FROM THE UNIVERSITY OF ORADEA

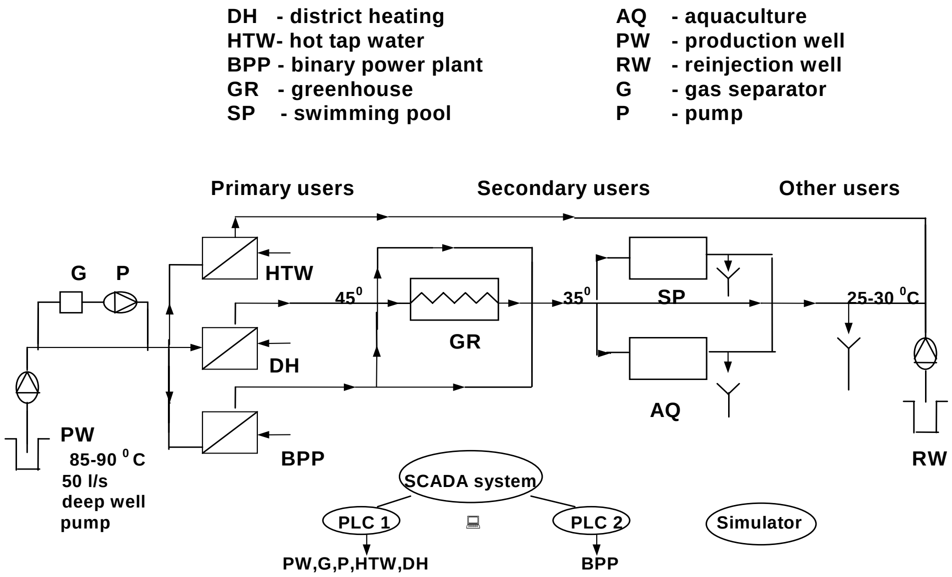

Figure 1: Cascaded use at the University of Oradea

The University of Oradea and the National Geothermal Research Centre, as part of the University, implemented a national demonstration and research geothermal power plant emphasising on geothermal energy utilisation. The geothermal system at the University of Oradea was improved considerably. Until 1995, the well potential was not utilised at maximum capacity, causing severe energy losses. Based on this situation, a project for modification of the existing system was already done and applied since 1996. The system is presented in Figure 1. A part of these modifications was to implement an automatic control system (SCADA) for the whole system, which ensures the optimum use of the energy of the geothermal water (Antal, 1995).

3.1 General considerations

The regulation of the heat supply for buildings was done manually by modifying the geothermal water flow rate through the plate heat exchangers in steps. Because there are many people involved in this process, it is very hard to control the operation of the system. Hence, for a system such as the one presented in this paper, it is necessary to implement an overall automatic control system for the whole geothermal system. This aim can be achieved by installing sensors and control devices and connecting them to a programmable logic controller (PLC).

The advantages which result from using a control system cannot be neglected. The main thing is that it ensures a more economical and safe operation of the process. Through the monitoring system, the state of the process can be monitored constantly, and therefore the reaction to failures or emergency situations is very fast. Also an important factor is that less manpower is necessary for controlling and monitoring the process.

Almost all-industrial processes need some form of control system if they are to run safely and economically. Very few industrial plants can be left to run themselves, and most need some form of control system to ensure safe and economical operation. The route towards increased productivity is through increased automation of processes and machines. This automation may be required to directly increase output quantities, or to improve product quality and precision. In any form, automation involves replacing some or all-human input and effort required both carrying out and controlling particular operations.

To achieve process automation, the operator must be replaced by a control system, that has the ability to start, regulate and stop a process in response to measured variables within the process, in order to obtain the desired output. These objectives are obtained using a control system based on PLC microcontroller and using SCADA man-machine interface.

Although PLCs are similar to conventional computers in terms of hardware technology, they have specific features suited for industrial control. One important characteristic is that they are designed to survive in an industrial environment with all that this implies for temperature, dirt and poor-quality mains supply. Also they have a modular plug-in construction, allowing easy replacement or addition of input and output units. Another important feature is that they are easy to program and reprogram in a constantly changing plant. Finally, but maybe the most important characteristic is that they are fast enough to operate in real time, as most of the industrial processes need.

Connecting a PLC to the plant is how we achieve the automatic control of the plant. But, a PLC also has to be connected to the human operators, accepting commands from them and displaying the status of the plant in a form that can readily and easily be understood. This is called the man-machine interface or MMI. Using SCADA MMI provides a very user-friendly graphical interface that is very suggestive to the human operator allowing him to perform his duty efficiently.

3.2 Fault monitoring and protection of system components

There are many advantages in using the facilities of programmable controllers to carry out, monitor and record operations on items of the plant. First, a PLC is usually required to bring operator’s attention to an alarm condition of the plant, or abnormal fault conditions. Second, most industrial equipment requires periodic routine maintenance, either after set lengths of operating time or after too many operations. Thus, PLC is required to produce an event/alarm log for historical maintenance analysis. Conventional recording methods can be expensive and difficult to operate.

Another problem is that all process that may, through failure of some part, cause injury to human beings or cause damage to the equipment or the environment should be equipped with a protective instrument system. Protective instruments are linked directly to the equipment, and are used only when the PLC fails. Protective instrument system is designed to override the normal control system. It could be manually or automatically initiated.

3.3 Data collection with SCADA MMI

SCADA is the technology that enables a user to collect data from one or more distant facilities and send control instructions to those facilities. That means that SCADA is a two-way system: it is possible not only to monitor a system but also possible to control the system.

The man-machine interface or MMI is the junction from which information travels from the SCADA system to the operator and from the operator to the SCADA system. There are several things that have to be monitored at the same time such as: alarms, status, graphics and trends. Because the picture on the screen can not be too complex, these are usually grouped into several screens, depending on functions.

The control change screens are usually very simple. The control functions can be affected by moving the screen cursor with the mouse to a spot next to the desired control function and pressing the enter button. In case of other kinds of adjustments (speed, level, flow) the cursor movement would be followed by entering the appropriate value.

The status screens are used to monitor the status changes associated with ongoing control commands and also measured values and the status of all controlled devices. Series of well designed status screens allows operator to do an electronic walkabout, and be well informed from information contained in a small number of screens.

SCADA MMI allows graphics and trends of the important parameters of the process to be obtained, which are more intuitive than other kinds of presentation. This can give a better image of the whole process, and also change the way processes are operated. Beside this, SCADA could provide several types of reports such as alarm logs, communication reports, etc. Some of these are printed automatically at a fixed time (daily communication reports, accounting related information, reports detailing the needs for process maintenance), but others are printed only when asked for or on demand (special alarm report, recent operation). For the alarm logs, there is usually a printer dedicated to that task.

Keeping the operation running and restoring it to operation quickly when it shuts down are two economic justifications for installing PLC and SCADA systems. To avoid accidental changes SCADA also provides some security measures such as passwords and restricted access in order to ensure that only those people who are authorized can effect changes.

3.4 SCADA - general overview and functional description

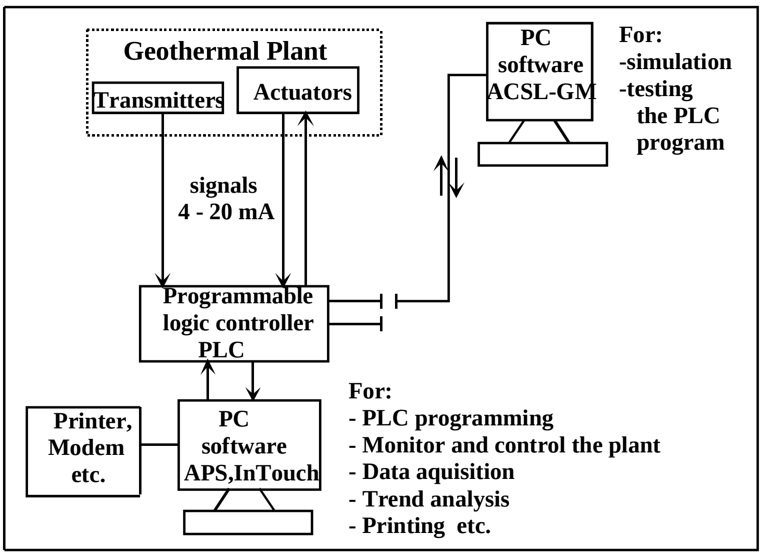

Figure 2: SCADA scheme

The SCADA system is configured using the InTouch SCADA package. InTouch is a software package used to create PC based man-machine interfaces. InTouch uses Microsoft Windows. It is the development environment, where object-oriented graphics are used to create touch-sensitive display windows.

These display windows can be connected to industrial I/O systems (such as programmable controllers) and other Microsoft applications. The SCADA pictures are linked with the Allen Bradley programmable logic controller using Dynamic Data Exchange (DDE) communication protocol in order to transfer data. The Wonderware Allen Bradley Serial Server is used like a DDE server that allows InTouch to access data in Allen Bradley PLC. The scheme of the SCADA system is presented in Figure 2.

3.5 Realisation of the system

The structure of the control system consists mainly of the following items: sensors, control devices, the programmable logic controller PLC and the SCADA user interface. The SCADA system is working based on the data stored into the PLC memory. Therefore, the first thing that was done in building the system was to prepare the data into the PLC, that means to allocate memory from the PLC memory for each data that is used by SCADA (Zmaranda, 1995).

Also, the SCADA has to communicate with the PLC so that it should be possible to read or write data to/from the PLC memory. This is achieved by installing the appropriate driver, the Wonderware Allen Bradley Serial Server, which ensures serial communication and takes care of the communication protocol.

Then the SCADA pictures were constructed, using the InTouch picture editor. The pictures show the schematic drawing of the system, containing reference to all inputs and outputs of interest. For the alarm picture, all the alarm texts were defined. Also, the definition of all trend curves and historical diagrams was done here.

The SCADA system is based of few main pictures: an overview picture of the well station (Figure 3), an overview picture of the pump station, an overview picture of the heat station (Figure 4), a picture showing the state (ON/OFF) of all alarms and warnings and two pictures showing trend curves for all analog values (Figure 5).

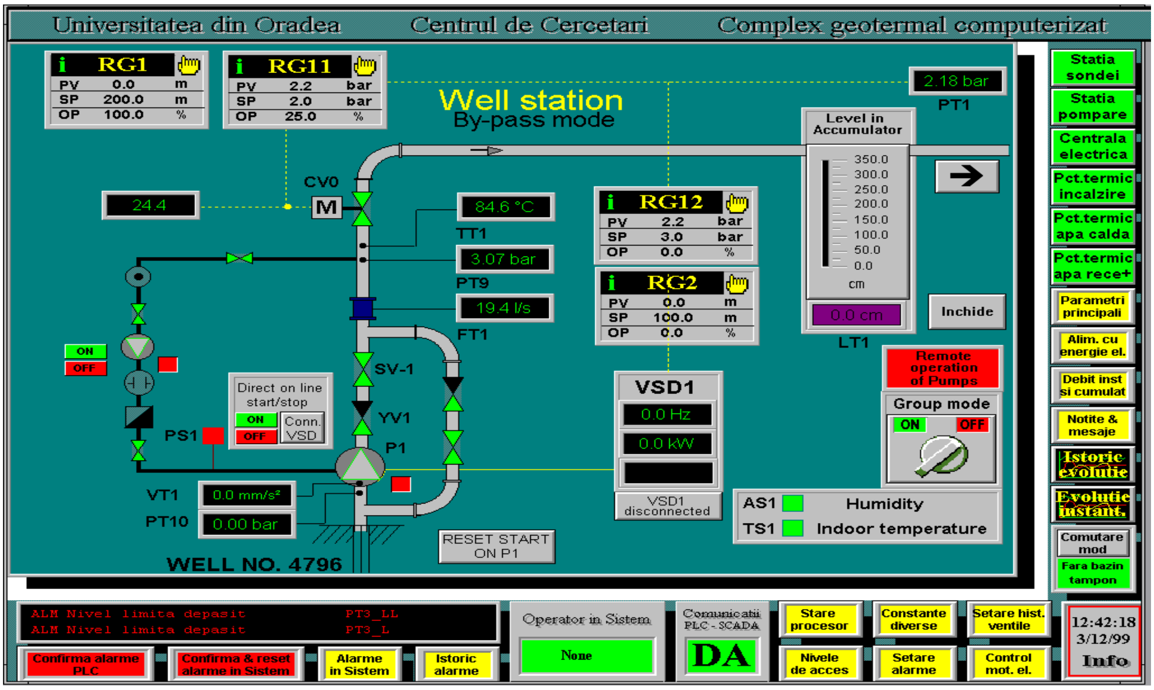

Figure 3: SCADA system – Well station

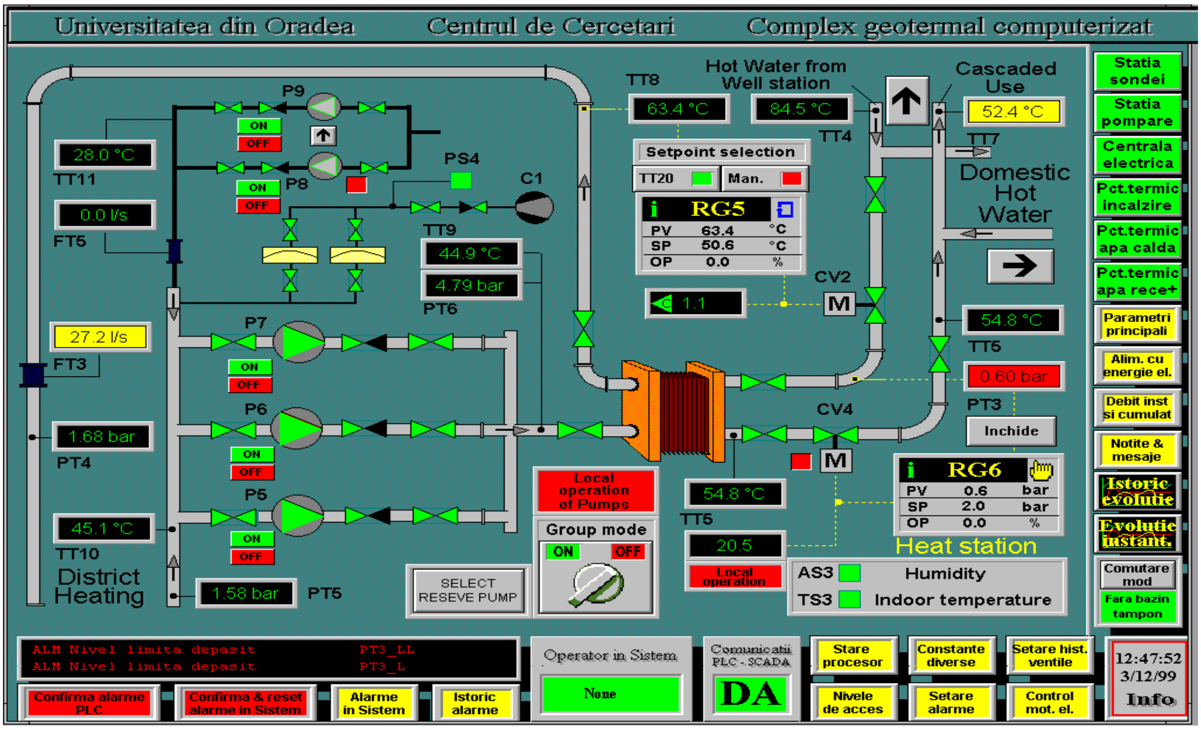

Figure 4: SCADA system – Heat station

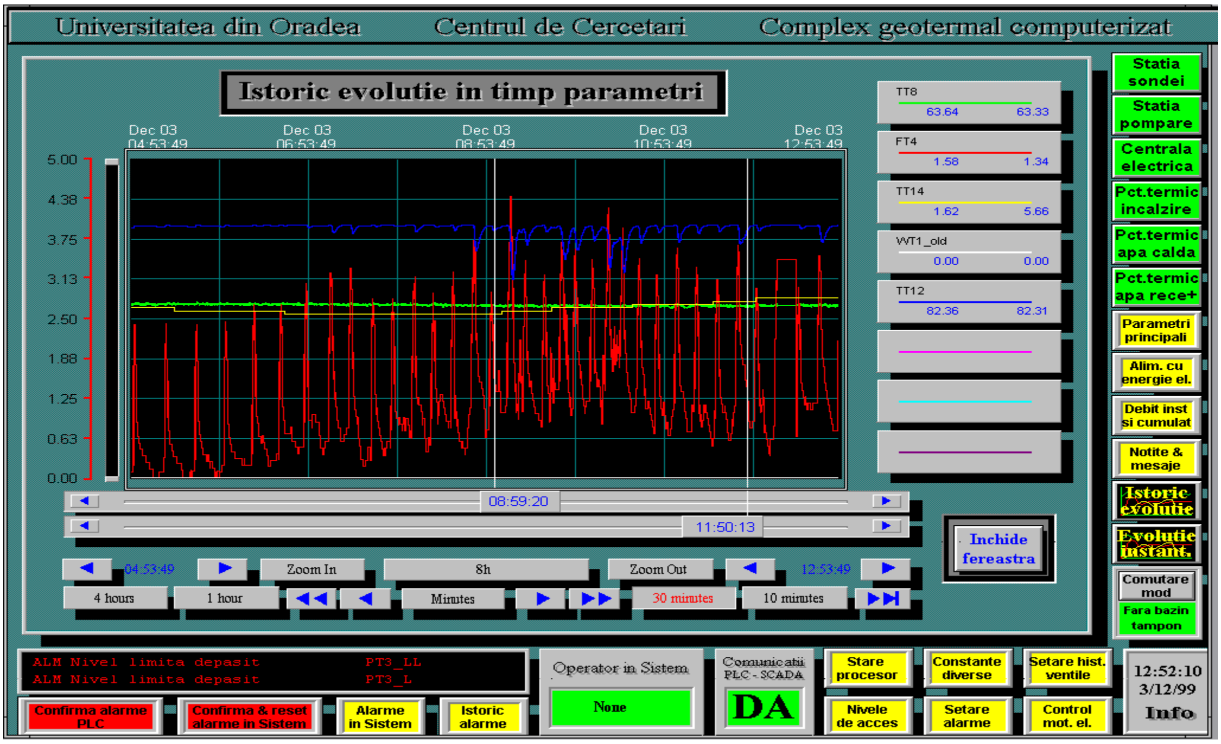

Figure 5: SCADA system – Historical diagram

3.6 Training simulator

A computer simulator for the geothermal system is under development. The simulator is a software program which allows the running of the whole geothermal system to be simulated, including the power plant, the PLC and SCADA system. Computer simulation is useful for engineers, plant operators and engineering students. It can be used as a tool in design and testing of control system hardware and software, and as an operator's training simulator.

The running of the geothermal power plant is simulated based on mathematical models of each part of the plant, for example production well, pipes, control valves, heat exchangers, pumps, etc. The user interacts with the simulator through a graphic display that shows all critical variables as well as control functions.

For a complex geothermal system, such as the system presented in this paper, the simulator can be used to find the optimal operation strategy. In this way, based on technical calculations, it is possible to create a mathematical model for the whole geothermal system. Further, by using the simulator, it is possible to analyze various process design alternatives, to develop and analyze different control strategies and to optimize the operational strategies.

4. CONCLUSIONS

A complex geothermal system can be improved by automation utilizing programmable logic controllers and specialized software system SCADA. This computer system is a powerful research tool in order to find the best strategy for geothermal utilization.

By introducing utilization of the geothermal water in cascade it is possible to save energy by increasing the thermal efficiency. For cascaded use, there are many possibilities to choose the type of users and their interconnections. In this paper, only one such alternative is presented.

Before deciding the cascaded users, it is recommended to study deeply the possibilities both from the point of view of technical and economical reasons. It is recommended to use SCADA system and the simulator in order to analyze various process design alternatives, to develop and analyze different control strategies and to optimize the operational strategies.

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