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The Aspect of Supervising and Remote Control System Developing - SCADA Implementation

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1. ABSTRACT

Implementation and development of a Supervising and Remote Control System (SRCS) has become an imperative for all the companies taking care of their own progress in the field of gas production (transmission, distribution, etc.) automatization. Therefore, public enterprise SRBIJAGAS pais great attention to a system developing, especially considering its importance for natural gas transmission and distribution under conditions of reduced supply. SRBIJAGAS has been operating its SRCS for more than twenty years.

With introduction of very precise and accurate metering devices an automated invoicing to the consumers becomes a fact. Flow computer enables this option and much more, which will be detailed described in this paper. System is ready and used for invoicing.

Our Supervising and Remote Control System has become one of the most important tools, not only to our Dispatching Center, but also to the management responsible for natural gas transmission and distribution planning. A very detailed archive and a lot of tools for data monitoring and processing enable easier anticipation of consumption trends, particularly concerning demand swinging over the seasons. One of the most important tasks made possible by SRCS is a consumption planning.

The price of the system, together with maintaining and development costs, is fully justified by the advantages it provides.

Our SRCS is also designed to support tariff system, facilitating acceptance of this essential feature in our provider-customer relationship.

We find it very important to make these data available outside the LAN and the Dispatching Center through the secure Internet connection, making the web/wap server become one of the most important parts of our system. We also enable data viewing using mobile phone and GPRS/3G protocol over GSM network. The archives are also accessible over the Internet. This feature enables work from home or some other location as long as you are connected to our website.

Our system provides SMS and e-mail notification and alarm signal warning the specific employees of alarm state or some other preset malfunction. It is a very useful tool that provides fast notification and shorter response time.

This paper will also describe both software (our own design - application, database, network part, desktop parts) and hardware (acquisition, communication, network, servers and desktop) elements, including tools and packages used.

Since our efforts included also projects and settings for hardware equipment (routers, SHDSL modems, protocol converters, configurable Ethernet switches, GPRS/3G routers, GPRS/3G modems...), one chapter of the paper will be dedicated to it. A communication overview shows that we used digital links n x 64kbps to communicate with the station, under appropriate link speed. Video control on the station requires higher link speed. As the redundancy we use GPRS / 3G routers or modems and communicate via GSM network in case of broken wired link.

Flow computers are widely being used in our system and as a vital element of the tariff system they get more than one section in our paper.

The paper also includes the explanation of our Integrated Information System.

Short equipment description relates only to acquisition facility and RS232/RS485/Ethernet converter.

Key words: 1. Supervising 2. Control 3. Transport 4. Distribution 5. Flow Computer 6. Tariff System 7. Hardware, 8. Software, 9. Digital Links, 10. GPRS / 3G, 11. SCADA

C O N T E N T S

2. BODY OF PAPER

2.1. INTRODUCTION

Main function of the SRCS is to enable an easier and more efficient control of natural gas transmission and distribution process. Disposing of inlet data on a number of stations facilitates understanding how system is going to behave under various circumstances, especially during periods of uneven consumption, as well as reduction of supply, oscillating consumption and supply of the preferential consumers.

Beside the Dispatching centre, data and archive of the SCRS are available to the engineers in charge with transmission and distribution monitoring, experts responsible for transmission planning and, in some cases, maintenance and construction service, as well as managers in order to define actual consumption trends and supply quantities accordingly. A very detailed archive and a lot of tools for data monitoring and processing enable easier anticipation of consumption trends, particularly concerning demand swinging over the seasons. One of the most important tasks made possible by SRCS is the consumption planning.

The price of the system, together with maintaining and development costs, is fully justified by the advantages it provides. Lower prices of communication links and network equipment necessary to connect stations with the Dispatching Center, with decreasing prices of the acquisition equipment and PC technology confirm that fact. We are convinced that our Dispatching Center could not operate without the System presented in this paper.

2.2. HISTORICAL OVERVIEW-SCRS DEVELOPMENT THROUGH THE DECADES

SRBIJAGAS started to operate it's SRCS almost twenty years ago. Some of the equipment implemented then is still being used, performing its defined function efficiently. Due to a proper design and development of SRSC as a whole, it is possible to operate different generations of the equipment and consequently bridge a technical period of two decades without being forced to change the complete equipment every time we performed the reconstruction of our system. All we needed was to provide new stations with advanced equipment or eventually one technology level below that, according to investor's demands. We can conclude, without being pretentious, that the development of the equipment in this field – equipment for the data acquisition at the station as well as communication equipment and communication media-was regulated in line with the development of our supervision and remote control system. Achieved progress in server and network technology has enabled creation of sophisticated SCADA software modules as well as much easier and faster supervision and remote control database browsing. Our system is far (not so far) from the state-of-the-art technology, but we can freely point it out continuous efforts are continually being made, hopefully successful, to create the system able to meet all the requests and necessary improvements, within defined budget.

For the purpose of easier design and development of SRCS, we divided our system into subsystems - software and hardware in the first line. It might seam to be too common, but it enables an easier system operation monitoring and partially independent development under conditions of flexible approach in the construction of

these two systems. The SCADA software is written in such a way providing new station to be added easily, without changing of other modules and regardless of the station's hardware, communication equipment and medium for connecting data station with the Dispatching center.

2.3. SCRS SOFTWARE

SRCS software includes three basic subsystems: communication software (with acquisitive-controlling software), desktop and server software, normally comprising also a database with an archive for the last twelve years. [1]

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GMRS KRNJAČA	X	39.3	6.0		18	2061
GMRS ŠABAC	X	39.3	3.2		14	4180
GMRS LOZNICA	X	36.3	5.8		20	907
GMRS SMEDEREVO	X	12.0	P1 8.0		T1 19	Q1 15025
			P2 5.7		T2 21	Q2 16902
GMRS ZEMUN	X	27.5	4.7		4	6507
GMRS BATAJNICA	X	30.1	2.9		14	989
GRS BEŽANIJA	X	28.9	9.5	11	Tizl 26	
GMRS N.BEOGRAD	X	8.8	Pr2 6.3		T2 11	Q1 31829
GMRS UMKA	X	29.1	5.8		19	2152
GMRS ŽELEZNIK	X	29.0	3.9		9	2
GMRS CERAK	X	28.2	6.4		9	28789
GMRS AVALA	X	27.6	10.7	-15	10	49793
RS VOŽDOVAC	X	10.4	5.2			
GMRS MLADENOVAC	X	27.0	4.1		18	3521
GMRS ARANĐELOVAC	X	27.1	7.4		13	3664
GMRS KRAGUJEVAC	X	26.3	5.8		18	6146
GMRS KRALJEVO	X	24.1	5.6		17	3826
GMRS V.BANJA	X	26.0	3.9	5	19	
GMRS ČAČAK	X	25.9	5.3		16	7984
GMRS G.MILANOVAC	X	25.5	5.2		11	3176
GMRS UŽICE	X	25.2	5.7	6	21	2442
GMRS JAGODINA	X	27.5	5.9		20	5104
GMRS PARAĆIN	X	26.1	6.0		19	4808
GMRS KRUŠEVAC	X	20.0	6.2		18	6840
GMRS POPOVAC	X	25.1	5.0		21	18

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Figure 1: One of the stations listing

Communication software (with acquisitive-controlling software) requires a good knowledge of the communication protocol for the station equipment. Microprocessor module for data acquisition and supervision can perform various operations depending on use of the particular code. Microprocessor modules we use mostly support some of the serial communication protocols. Based on MODBUS commands and ACSII symbols, they recognize any request issued. Communication software takes also responsibility for request transmission to the relating device by proper addressing of the relating remote station. To design that software, it is necessary to get acquainted with the applied communication protocol, communication medium, as well as with the communication method between network devices as well as with the server and

microprocessor part of the equipment. It also requires design of proper routing tables, which are mostly part of a network equipment setting. Desktop or application software is an interface to the end user. For this part of SCADA software is especially important to be conceived right and provide to its users (the Dispatching Center and natural gas transmission and distribution managers) to recognise and use system performances easier.

Database or archive is part of the server software. It is suitable for browsing and various analysis provided by the software.
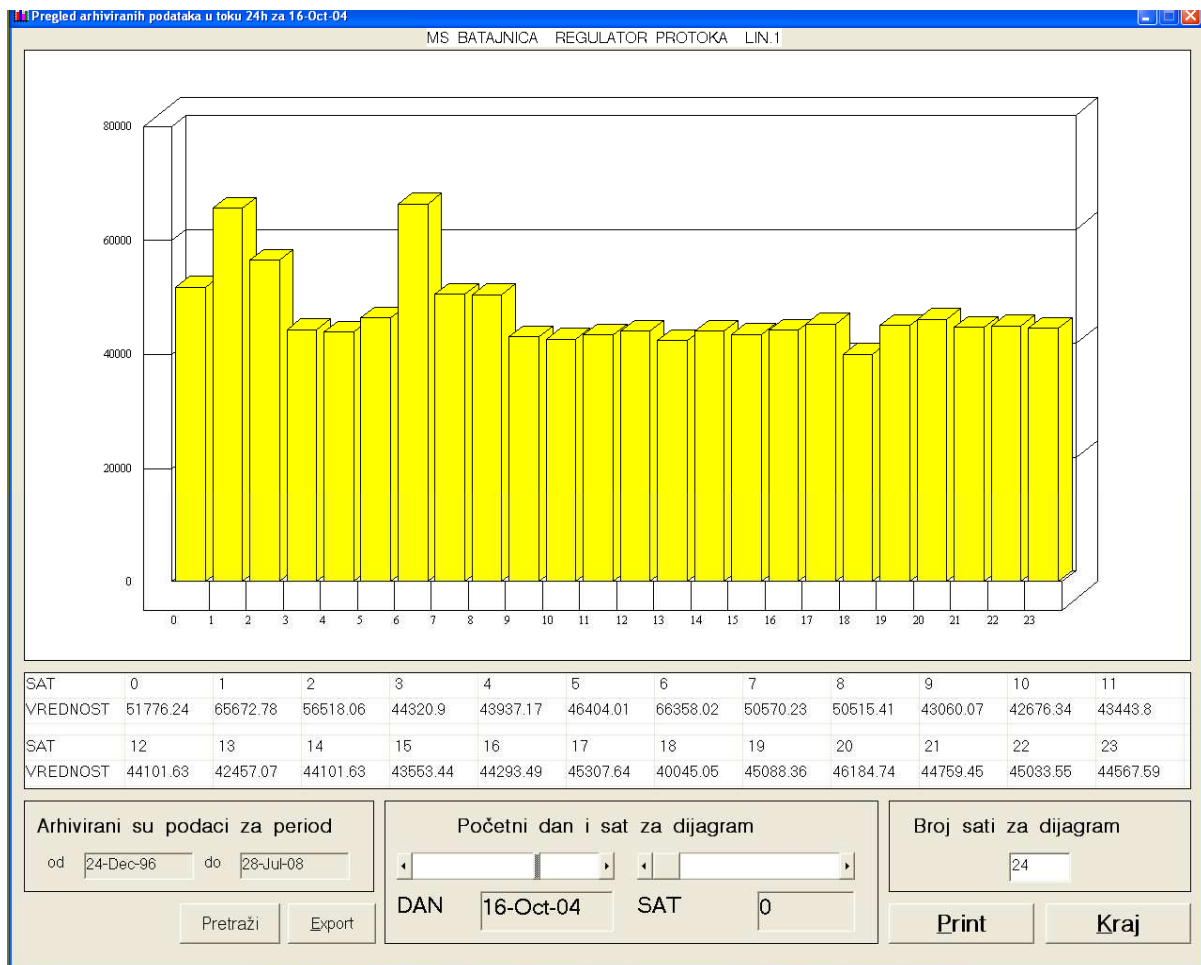

Figure 2 : Archived data for particular station

Essential for easier control of the system is simple control software. There is also the possibility of software networking and dispatch at all computers on the network having assigned privilege to use SCADA software. Issuing instructions and control are functions much more complex than supervision. Therefore, a strict user authorization system is needed.

2.4. SRCS HARDWARE

Hardware equipment can also be divided in three groups, which facilitates system design and assembling: Acquisitive-controlling, communication/network and server equipment. [1]

Acquisitive-controlling equipment is located within the station. Interface to the process equipment is designed to collect physical quantity equivalents (direct current, impulse sequence...) and micro switch state, as well as to issue instructions and specific control signals in accordance with requests the Dispatching center sent through the SCADA system software. This equipment is not designed to issue automatic commands or control the system, since each assembly is equipped (if necessary) with the appropriate module (fire protection valve, shut off valve).

Serial interface to the communications equipment enables communication with the rest of the system, i.e. receiving requests and sending the appropriate data, whether data acquisition, issuing requests or control. Mostly used protocol is MODBUS or some other serial producers proprietary protocol.
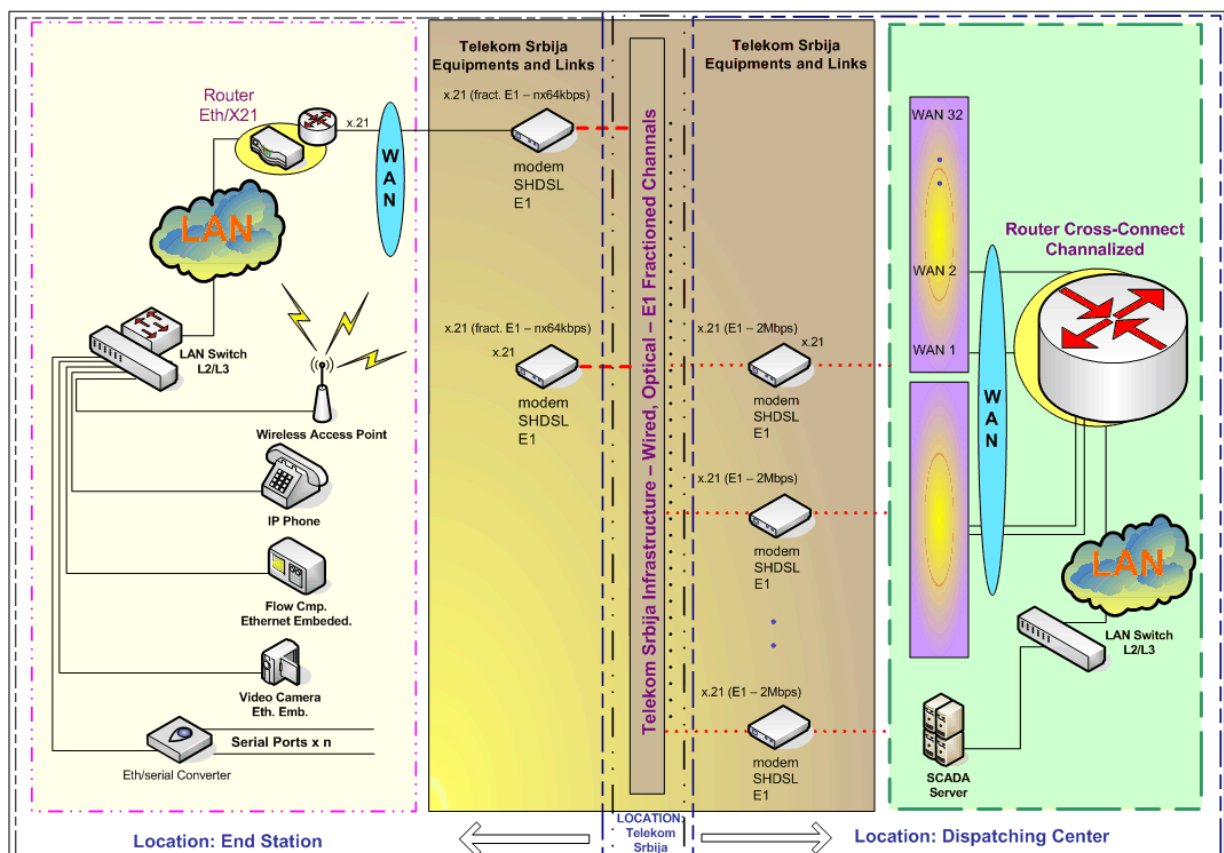

Figure 3: Digitalization-Equipment shown by the location-Block scheme

Regarding its placement, communication equipment is most dispersive, with elements placed in the Dispatching center, telecommunication centers along the communication path and at the remote station. This equipment has to comply with disposable communication medium. We use digital subscriber lines (most of them are 64kbps), as well as fiber-optics, Satellite link (just one for now-Jun 2008.) and, as the redundancy, GSM network with appropriate 3G/Eth.LAN routers. Communications equipment should provide communication and proper request routing to related stations within previously determined period or–in case communication cannot be provided–to indicate failure. Communication (and network) equipment includes Cross-Connect Channelized Routers, SHDSL modems, X21(V.35)/Eth.LAN routers,

optic/Eth.LAN converters, GSM-3G/Eth.LAN routers, satellite equipment and different kind of converters. [3][4]

Communication is established by digital links and four E1 links with 4 x 2Mbps channelized by 64Kbps. It is about 120 channels per one channelized router with 64Kbps. For SCADA communication 64Kbps is more than enough, one data sequence has less than 1KB of data per session and per station. Other services we implemented request more bandwidth. For example if some remote station is equipped with personnel we connect their PCs to our corporate network and have to assign more bandwidth, even more that 64Kbps - about 256Kbps and this is 4 basic channels. Video monitoring also needs about 256Kbps to have minimum capabilities, of course combined with local storage, but this is not the point of this paper. The biggest problem is to dedicate proper bandwidth according to local services SCRS provides. [3]

As it mentioned before each main communication link has it's own redundancy. We use GSM network and 3G/Eth.LAN routers. Main route is through digital channel but if it is dropped out the cellular route take it over and communication is established again in a few seconds. Link speed is the highest speed offered by 3G protocols. [3][4]
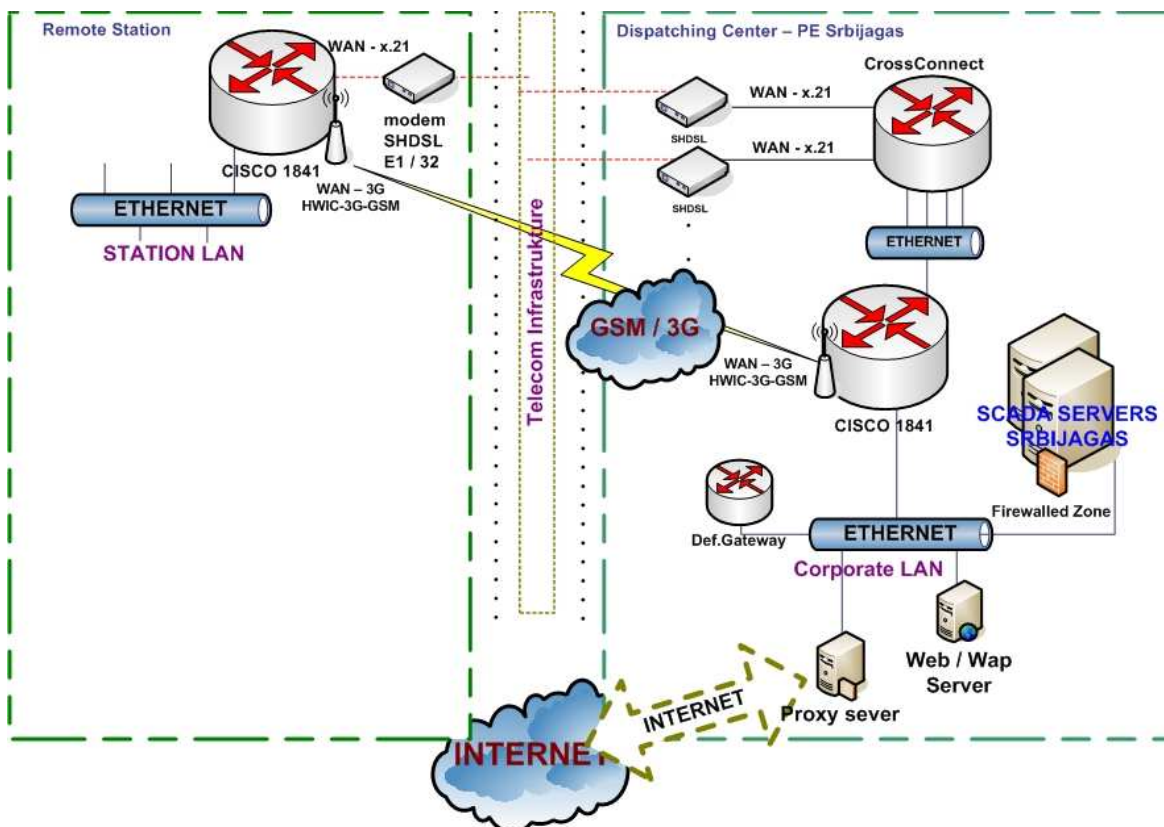

Figure 4: Data access through the GSM network using 3G protocol and routers

The servers in the Dispatching center run all the SCADA software applications, server operation system however provides connection of the authorized users. Server platform is MS Windows Server 2003 Ent. Ed. Based.

The system is constructed as a classic client-server system, which means that all the applications are being performed at the server side, in distinction of the client layer, which can only list results of application performed, whether they want to list actual data, brows the archive and make different analysis or issue commands and

control the system. The most important clients are PCs dedicated to Dispatching Centre.

2.5. ACQUISITION AND REGULATING EQUIPMENT

The most important parts of our field equipment are acquisition and regulating facility items. These parts are very standard and stayed almost unchanged through the years of SCRS developing. There are some improvements, on a few stations we have "smart" kind of the equipment, but the basic characteristics stayed the same.

All physical values are measured by the specific sensor and after that converted in reciprocal direct electrical current from 4 mA to 20 mA as the linear representative of the measured value. These devices we call transmitters. SCADA software shows it as the physical value, displayed in appropriate field on the Dispatching Center screen.

Regulating flow valve control signal is analog output signal from 0 mA to 20 mA, inverse estimated providing the regulator is maximum open for the current from 0 mA and closed for the current from 20 mA. Within this current range, allowed consumption rate, i.e. opening of the flow regulator and direct current, does not occur linear. SCADA software converts the specific flow values into described electrical direct current from 0 mA to 20 mA.

2.6. SYSTEM CAPABILITIES

An up-to-date SCADA system as an integral part of the gas pipeline system is vital for improvement of the security, safety i operation of the gas pipeline system. A direct link to the equipment enables instant alarm or operational malfunction alert and subsequently facilitates fast reaction time.

Depending on the cosumer location and the equipment used, there are multiple ways to access SCADA system data.

The most frequent way is from the corporation LAN, and the most important consumers are the Dispatching Center and the related servicis. The Dispatching Center and it's engineers are in charge of supervision and regulation of the pipeline facilities, equiped with appropriate devices. Thanks to the corporate LAN it is possible for our maintenance department to monitor the system, looking for the data that could give them a signal on possible failure somewhere on the pipeline. The values monitored are, among others, also pressure values, and an unexpected change in these values can inform us about a dangerous malfunction, e.g. outlet pressure drop may be coused by the gas leakage at the station, differential pressure increase informs about filter pollution, inlet pressure and outlet pressure drop can be dangerous for the consumer, ect.

Data base of our SCADA system stores the system data for the last 12 years or from the time particular station was added in SCRS. This data base is of enourmas importance giving us informations on system development as well as data required for the capacity management. Together with our experts engaged, we managed to develop dosens of tools for data base browsing. A number of various reports make the requested data disposable "on the screen" for our customers. Flexibility of the system lies in its capability to create any report from the data base, needed by the customer whenever he wants.

Corporate LAN is firewalled from the outside entrance. This is very important for data integrity. All of the SCADA servers are protected with antivirus software and firewalled from the inside entrance too. Only authorized users-administrator are in a

position to controll services started on SCADA servers. Common users can use only tools reviewing offeed by SCADA software. Regulating is available only from Dispatching Center and only after very strict authorization and user introduction to the SCADA software.

It is possible to access the SCADA system data also through the Internet, but only for the purposes of supervision and system data base. Regulation through the Internet is not allowed within the system. This option is especially appropriate for working "out of the office", for urgent functional checking as well as for giving instructions to the Dispatching Center in case of energency situations occuring after hours. SCADA system data presentation on the Internet is designed in such a way to enable data base browsing, report making and work in LAN environment. SSL protocole ensures safety of the connection, crypted by the digital certificates.

Access to the data using wap protocole was introduced more than five years ago. This part of the Internet presentation remained unchanged since mobile phones displaying pages designed only according to this standard are still in use. Mobile phones with 3G protocols and full Web Browser Tools can provide full web and data base browsing.
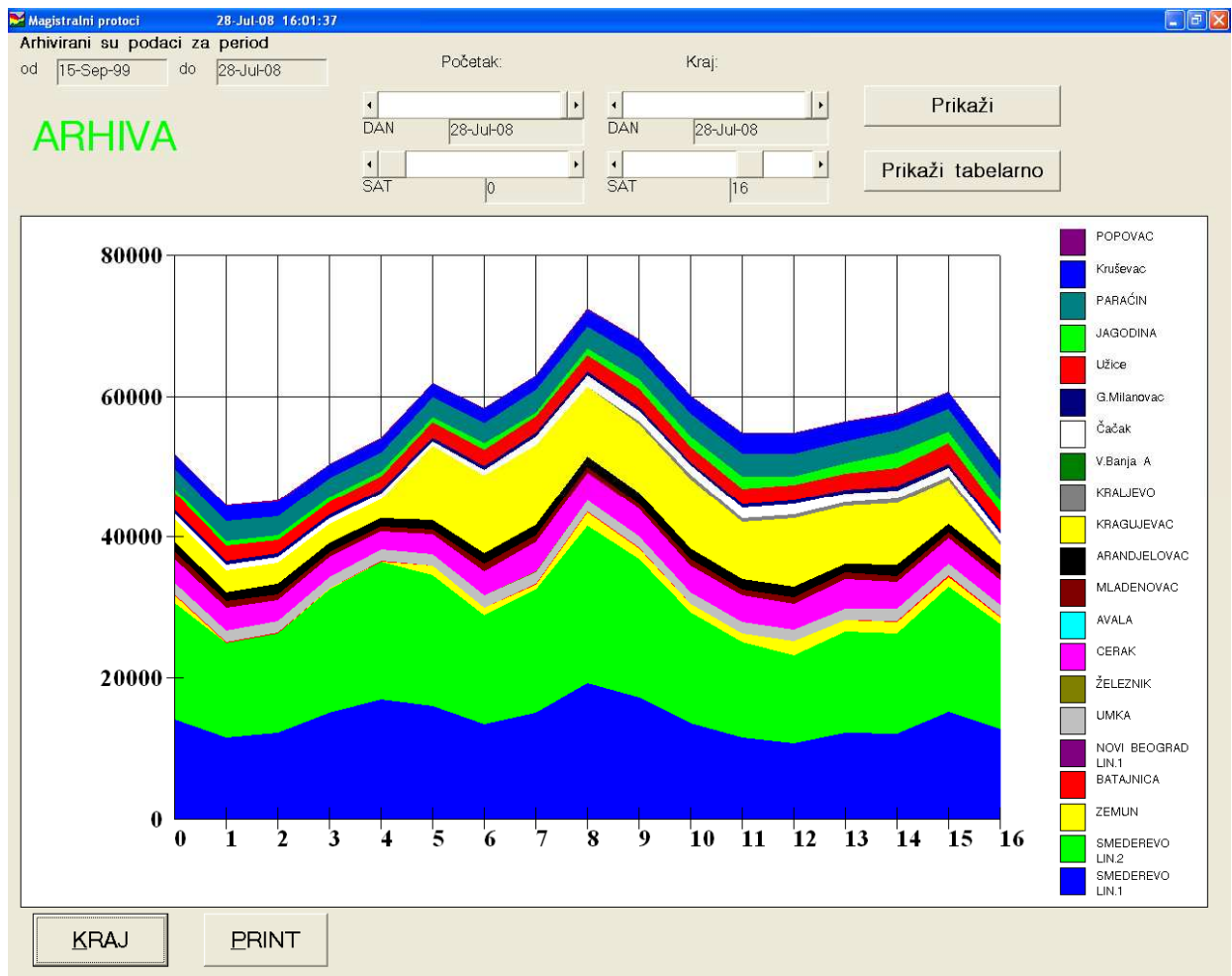

Figure 5: One of the dosens of SCADA software reports and calculations.

An additional feature of the SCADA system lies in the capability of the system to send an SMS through the GSM network after detecting a preset event, so that the operator in charge can act accordingly. For example, it may be a SMS sent to the maintenance operator on pressure drop somewhere in the system, on closing of the shutoff valve or failure in operation of some other device. Subsequently, the operator in charge can act faster, without additional communication with the Dispatching Center, there is no need to spend preciouss time making another phone call, which can be of enormas importance sometimes.

The SCRS equipment installed within the consumer's part of the network (mostly large consumers), the consumer have access via Internet to the SCADA data related to respective facility. From the data important to the consumers, our website showes active consumption data and a mini archive for the last 24 hours. A data parsing is available for the consumers with their own survailance system. The consumer is allowed to take over the related data and use them according to his needs. Upon authorizing, the consumer can access the data also via mobile phone with wap browser. Crypting by the digital certificates ensures safety of the data. A continuous monitoring of the consumprion by the consumer may contribute to overal energy efficiency, as one of the most important goals of our company, in line with the national and EU regulations.

2.7. FLOW COMPUTER - BASIC FEATURES

Flow Computer is a kind of specific microprocessor platform with all characteristics of industrial PC platform. The main parts of the flow computer are processor, memory (in most cases flash memory, hard disks are very rare), communication ports with interfaces to the communication equipment and media as well as to acquisition parts of the facility. Very important parts are also pressure and temperature meters (sensors and transmitters) and very high frequency impulse (HFI) integrator. HFI are emitted from a turbine. Power supply is arranged mostly by separated batteries with very long durability (more than three years) or using public network 230VAC with AD/DC conversion. Flow computer software is closed and only with proper interface could be arranged to change basic parameters for gas consumption metering (not energy, but gas flow!). It could be done using front panel of the flow computer or using PC with a proper interface. [2]

One of the most important characteristics is the appropriate device casing. In some circumstances devices have to be placed in the hazardous area and basic knowledge about using devices in that kind of process is necessary, following very strict rules on fire and explosion protection. The declaration on these features is provided by the producer.

The most important function of the flow computer is to correct gas consumption using the measured gas pressure and temperature and impulse from turbine meter HFI to get the corrected data. It has to use also some other data related to gas characteristics. Data could be displayed on front panel display or to be browsed using PC and flow computer interfaces. Display is also designed in battery saving manner.

Data on gas working pressure and temperature are inputted locally and there are two types.

First flow computer type gets pressure and temperature data directly from the turbine meter. Pressure data come from the impulse line and temperature data from

Pt100 or Pt1000 plugs. HFI impulse conductor is also connected to flow computer, directly from turbine meter.

Second type of flow computer collects the necessary data about pressure and temperature from it's transmitters. This type of flow computer could not be placed in hazardous area because it gets necessary data in form of electric current. It could be powered from public power supply network.

Flow computer, as mentioned before, has its own memory and can store data for some period depending on the memory type and size.

2.8. FLOW COMPUTER IN SCRS

Proper selection and good cooperation with the producers are essential for facilitating maximum performance of the equipment. The necessary precondition for proper SCADA system is to have all facts about communication protocol built in flow computer. In addition to the basic data (normalized volume, pressure and temperature), the most of the modern flow computers have more options with analog and digital inputs and outputs for reviewing data from other devices and also for regulating (flow regulating) or sending commands (block valve, fire protection valve...). This feature makes flow computers the most important (in some cases the only one) microprocessor device of the remote end station, with all the necessary features for gas facility control and regulation. Some of them has it's own communication facility. [2]

For proper flow computer activation it is necessary to take care of communication interface. Wide range of flow computers has RS-232 port or RS-485 port and some of them have both. USB interface is very rare and nowadays there are some types of devices with Ethernet interface, which is very interesting in combination with industrial Ethernet PC platforms. The most interesting port is Ethernet because of IP communication protocol and MODBUS TCP/IP preparation.

Devices we apply are have been equipped with serial interface (RS-232 or RS-485) and a special range of serial logical levels for battery consumption saving. Because of that, there is a special kind of active electronic device to adjust already mentioned logical levels for PC serial port.

Some of the flow computers provide more than one or two serial ports in one device. If there are several serial RS-485 ports they could be used for multidrop, so that one communication (DCE) device can connect all of them to the central location. The routing could be arranged with proper flow computer addressing or with routers configured for that purposes. In this case flow computer receives acquisition string or command string as ASCII symbols. This routed network is very important to avoid line collision (some of the flow computers can not have its own address-older version) in a case when more than one device attempts to take the line. Described situation is characteristic for network behind the communication device (modem) to gas facility. With Ethernet port and new flow computers implementation this problem could become history. We have to utilize older version of flow computers with new models. This is one of the described aspect of our SCRS.

We implemented flow computer with serial RS232 portsand also RS485 ports and use RS232/Ethernet converter to connect device to the LAN with proper IP adrress. All communication is TCP/IP and local data exchange is serial to serial port.

2.9. SCADA-PART OF THE PE SRBIJAGAS INTEGRATED INFORMATION SYSTEM

Our company has it's own developed Information System with different kind of modules used by certain departments and management, financial, law, bookkeeping modules and the most important for business are natural gas transport and natural gas distribution modules. [1]

We assume SCADA as the part of our Integrated Information System because certain part of listed modules use data provided by SCADA software. Some of the reports could be reached directly from SCADA tools and some modules use data SCADA provide. For example natural gas transport and natural gas distribution are essentially connected with SCADA data.

3.   REFERENCES

[1] E. KABILJO, S. CVETKOVIĆ, M. MILOJEVIĆ, D. JOVIČIĆ, "INFORMATION SYSTEM IN FUNCTION OF THE NATURAL GAS TRANSPORT AND DISTRIBUTION OF NIS ENERGOGAS", INTERGAS 2004, CAIRO, EGYPT

[2] E. KABILJO, S. CVETKOVIĆ, M. MILOJEVIĆ, V.MILOŠEVIĆ, "CONCEPT OF A MODERN SUPERVISING AND REMOTE CONTROL SYSTEMS", GAS2006, WORLD GAS CONFERENCE, AMSTERDAM, HOLLAND

[3] V. MILOŠEVIĆ, E. KABILJO, M. MILOJEVIĆ, "DATA TRANSFER DIGITALIZING IN PE SRBIJAGAS", GAS2008, SERBIAN GAS ASSOCIATION, VRNJAČKA BANJA 2008, SERBIA.

[4] E. KABILJO, S. CVETKOVIĆ, M. MILOJEVIĆ, V.MILOŠEVIĆ, "GSM/GPRS NETWORK FOR REMOTE SUPERVISING AND CONTROL SYSTEM DATA TRANSFER", YUNG2006, ASSOSIATION FOR OIL AND GAS, ZLATIBOR 2006, SERBIA

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