

DYNAMIC OPTIMIZATION OF THE FUNCTIONING OF THE DISTRICT HEATING SYSTEMS

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Summary:

This article introduces a modern approach to rational planning and building, as well as optimal functioning and maintenance of the district heating systems.

The system here described is a module system. The planning module enables the optimal design of the pipe networks, the Supervisory Control and Data Acquisition system (SCADA) makes it possible to effectively govern and maintain the executive elements of the system along with the data collecting. The Technical-Information System (TEHIS) enables the user to put in all needed geoinformation together with technical and business data, whereas the extended System for Hydraulic Analysis of the Pipe Networks (HACM) analyses the state of the energy supplying system in real time. Optimization modules that determine in advance the optimal regimes of the functioning of the executive elements and make the functioning of the controlling system more effective, using SCADA module, are in the testing phase.

Key words: System for Hydraulic Analysis of the Pipe Networks, HACM, Technical-Information system, TEHIS, GIS, remote control and operation, SCADA, optimization and rationalization of the functioning of the district heating systems.

1. INTRODUCTION

Hydraulic calculations connected to the task of determining sizes of district heating systems have a long tradition. Along with the fast development of the computer technology, the programme tools aimed for hydraulic calculations became more and more effective. Approximately at the same time the SCADA (Supervisory Control and Data Acquisition) systems of controlling and governing the processes in the district heating systems began to develop. This technologic advancement combined with ever bigger emphasis on the optimization of energy supplying devices, creates appropriate technologic base and indicate the need of the distributors of heating to integrate the systems of hydraulic analysis into the SCADA systems.

Along with what was mentioned, the quality of available information about the pipe networks, users, geometric characteristics etc. is quite high. Often the data are not collected in a fitting form, used in the right place and at the right time. This means that much of the information gathered doesn't prove useful for the managing of the process. Assembling of the data from various sources and their proper distribution in the enterprise that follows the data are converted into useful information and in this way attain the desired aim.

Modern and technologically perfected programmes for stimulation of the functioning of the district heating systems offer new, advanced solutions for the integration of the models of hydraulic analysis of the pipe networks into the systems for the district control and government of the systems (SCADA) and into the business system of a firm. The following are some of the existing business systems: the TEHIS (Technical Information System), the GIS (Geographical Information System), the CIS (Customer Information System), the MIS (Management Information System) and the ERP (Enterprise Resource Planning). The integration of the systems makes it easier to gather data, enables you to follow the functioning of your system of the district heating in real time, and also accelerates the processes of the decision making. In addition, it makes it possible to control and govern more wholly the pipe networks and processes in the system of the district heating, offers all the opportunities for optimization of the system of the district heating and building of the savings, which means that competitiveness of the service providers will be increased.

2. DEVELOPMENT OF THE SYSTEM OF THE DYNAMIC OPTIMIZATION OF DISTRICT HEATING SYSTEMS FUNCTIONING

Today's management of district heating systems is usually founded on the philosophy »follow/watch and react.« Only when something goes wrong and a customer sends information about the difficulty, maintenance personnel starts to investigate the possible causes of the problem at the spot. The structure of the maintenance is therefore often ineffective, because in the system of district heating too many interrelated events influencing its functioning can occur.

The system of dynamic optimization of the operation of district heating systems is not merely a programme package, used only at times, namely when we need some information about the functioning of the district heating system. The data from the district heating system are refreshed in real time, the updated information about the system functioning are always at hand. This is why the model of governing is more balanced. A controlling, governing and optimization system of this kind is an effective tool in the hands of the enterprise leadership. It enables efficient management and

control of their district heating system as well as timely servicing and successful maintenance of system elements.

The programme package can be used also to operative planning and analyses of the building of a new network or reconstruction, or expansion of the existing one. It is here where we can save very much by choosing the most appropriate option and excluding economically bad solutions before they are realized.

With the introduction of energy reckoning by the actual consumption and using other measures aimed to effective use of energy, the need of heat production in many district heating systems in Central and Eastern Europe was considerably decreased. Hydraulic analyses are used to ascertain the pressure and flow conditions in the pipe network, whereas by settings of the flow at the crucial points of the network the optimal function of the network pumps is reached. In certain cases, if the frequency regulators of the pump engines have not yet been installed, the result could even be the exclusion of individual network pumps from the operation. With these measures considerable economic effects are attained related to the decrease of energy loss and lower expenses for electricity. But not only that. By controlling the secondary systems of the heat consumers, the needed heat power of the energy producing sources can be determined in advance. Likewise in case of the expansion of the existing capacities by including new users, it becomes evident whether interventions into the district heating networks e. g. increase of the producing capacities are needed at all. It is often realized that there is no need of these interventions, which is how we spare lot of means spent on unnecessary investments into extending of the capacities of a district heating network. Practice shows that certain investments in the past were not necessary, planning of the pipe systems essentially more difficult and yet less effective.

3. DEVELOPMENTAL LINES OF THE ELTEC MULEJ SYSTEM OF OPTIMIZATION

Designing the system of dynamic optimization of the district heating networks, we have put together knowledge and years of experience of EL-TEC Mulej Bled, ASD&S Maribor, University of Maribor, JEKO-IN Jesenice and TOM Maribor. The main goals of the introduction of the system are the increase of efficiency, improvement of quality of services and attaining the lowest possible costs of production and distribution of heat. If introduced, the system of dynamic optimization of district heating systems will bring to the distributors of heat the following advantages:

- Operational savings are reached by the pump optimization programme module and heating needs expectation module. The pump optimization module determines optimal functioning points of a pump every few minutes and works on the principle of the lowest possible costs. Module aimed to anticipate the heating needs determines the heating needs of the district heating network 2-5 hours in advance based on the data collected from controllers of the heating stations and weather conditions. With these information we can optimally and in time decrease or increase the production of heat.
- The system measures the flow, pressures and temperatures on the most important spots of the district heating system and, if needed, warns the manager, when the functioning of the system deviates from the anticipated limitations. Because the system as well foretells conditions in the district heating system, some warnings could be communicated several hours before the actual fulfilment of those conditions. This is the way for the maintenance service of the distributor to attain significantly more reliable functioning of the system and considerable savings by taking care of the reasons for alarms even before they become a serious problem or disturbance in the operation of the system.

- With better planning and optimization of the problem solving measures aimed to attaining more economic functioning of the district heating network, considerable investment savings are realized also. It is particularly important here to determine net pump stations and peak boiler rooms, and the most important points in the district heating network, where there are reasons for building in of the regulators of the flow and pressure.

The system offers users still other possibilities:

- Selective approachability to all the collected information to everyone in the enterprise, which is the first condition of accomplishing of good business results.
- The system converts the acquired data and the results of the calculations of the optimizational programme modules into usable informations, which can give benefits of more economical managing of the functioning of your district heating network planning, maintenance and effective repairs done for your customers. Information, which would otherwise take days or weeks to be prepared, will be available without interruption.
- If desired, the distribution of data in the enterprise can blur previously experienced, often stiff organizational boundaries.
- With the gradual introduction of the new modular system parallel to the systems already in function in firms, the change of the technology can be done simultaneously (while the used way of managing the district heating system is in operation). This approach is very important because we want to avoid the leadership of enterprises to be reserved in view of the possible risks connected with the introduction of new, more recent technologies and working methods.
- Analyses of the benefits attained with the introduction of the new system and comparisons to the possibilities that the earlier system and organizational structure could offer yield new informations, which are of extraordinary importance to obtaining even better business/working (chosed one) results, and at the same time give the opportunity of proper directing the developmental activities.

The district heating system for the dynamic optimization of the functioning of the district heating network can be installed as an independent system, or can operate in a server manner. The server can be approached through the Internet. In this way, lesser heat providers can get to the optimization modules on their own, remotely, or can accept the offer of bigger enterprises to control, manage and maintain their system for optimization for them. This is how bigger firms can offer governing and servicing of the district heating systems and their optimization 24 hours a day in real time.

4. SYSTEM FOR DYNAMIC OPTIMIZATION OF THE OPERATION OF THE DISTRICT HEATING SYSTEMS ELTEC MULEJ

The programme package ELTEC MULEJ makes it easier to the heat providers to manage the district heating system, offers them new possibilities for improving the efficiency of its functioning and with that the increase of competitiveness on the market. The programme package is put together in a modular way and is introduced into the firm step by step. The framework of the system consists of three main modules:

1. NCM Module for the optimal planning of the pipe networks.
2. ELTEC SCADA System for the district control and management of the heating stations and distributional network.
3. ASD&S TEHIS Technical informational system, which enables the inputs and

manipulating of needed geoinformatical, technical and business data.

Control and management in real time mean much better understanding of the functioning of the pipe network. The presented system is auto-adaptive. It operates using SCADA module to get information and do the measurements in the district heating system which it sends through database to the informatic system (TEHIS). The heat provider uses TEHIS as a »window« to get into various applications of the enterprise built into the system, and simultaneously can communicate the input information to other, for the system itself outward applications in the firm, which, therefore, are not necessarily directly linked into the structure of the system. In itself it unites the programme modules for extended hydraulic analysis of the pipe networks (HACM), complexes of the geoinformatical system (GIS), module for producing reports and analyses of the functioning, optimization modules, module for maintenance of the project and other needed documentation, module for following the data about users, module for informing the users (via the Internet also) etc. The extended HACM module forecasts the events and makes the calculations in advance, optimization modules on the basis of calculated optimal functioning conditions of the system elements through SCADA module influences in return the efficiency of the management of the process.

If to all this we add effective alerting and selective reporting to the responsible leaders in the enterprise about events we get the powerful, user friendly tool, that makes it easier to govern the district heating network, accelerates the taking care of errors and in this way enhances the contentment of the customers, and enables attaining the business goals of the enterprise.

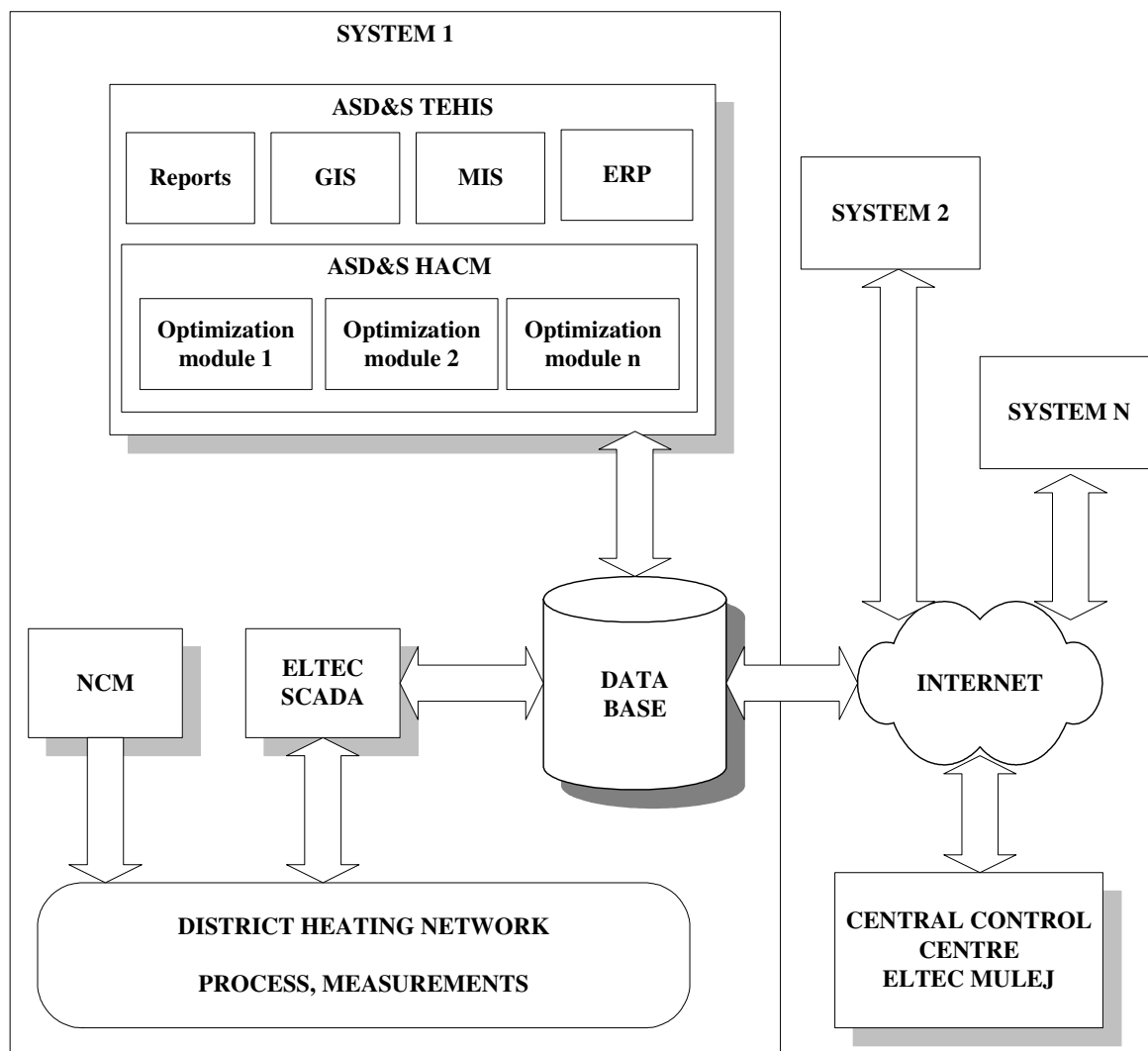


Figure 1: Outline of the system of the dynamic optimization of the functioning of the district heating systems

4.1. Programme module for planning pipe networks, NCM

Programme module NCM is designed for projectors or those investing into systems of district heating. It is intended to properly planning the course and size determining of district heating networks. With this module one can do static hydraulic analyses of one's pipe network, detect the limits of the existing production capacities...

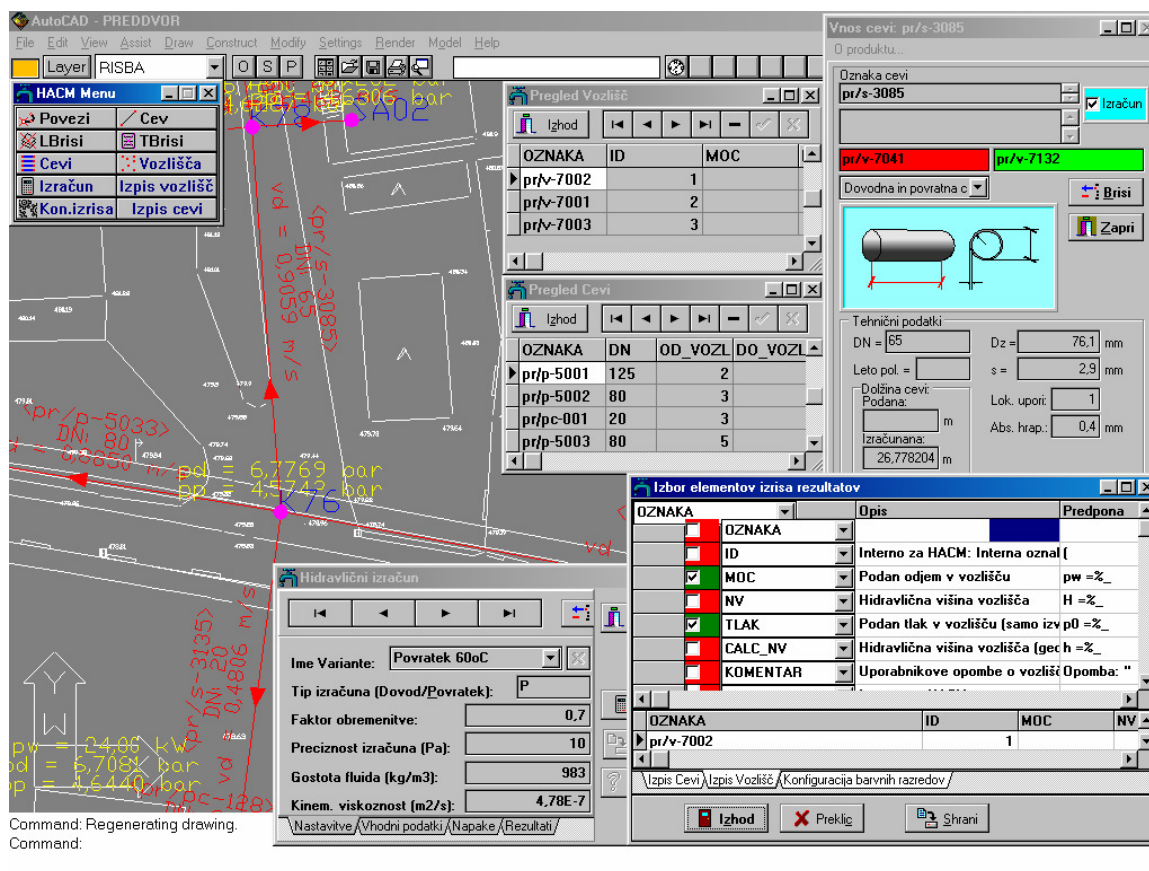


Figure 2: Example of data input about a pipe network, needed for the calculation of flow and pressure conditions of the network

4.2. Module for district control and management of systems, ELTEC SCADA

Module for district control and governing district heating systems ELTEC SCADA enables:

- gaining the information needed for governing the processes (measuring of temperatures, conditions of regulation valves, circulation pumps, actual, maximal and minimal power, actual, maximal and minimal flow, measuring of pressures...)
- limiting supplies of heat in the frame of rented connection power of the object or equalizing the peaks,
- integration of separated systems for management of circulation pumps,
- observing the heat losses along the district heating line,
- simultaneous sending of information about abnormalities and irregular functioning of the elements in the heating stations and district heating network in form of alarm messages to the control centre,
- remote programming of the electronic regulators from the control centre,
- possibility of technical aid to all controlling centres from the development centre and a short reaction time,
- complete service of all components of the system on a single telephone number.

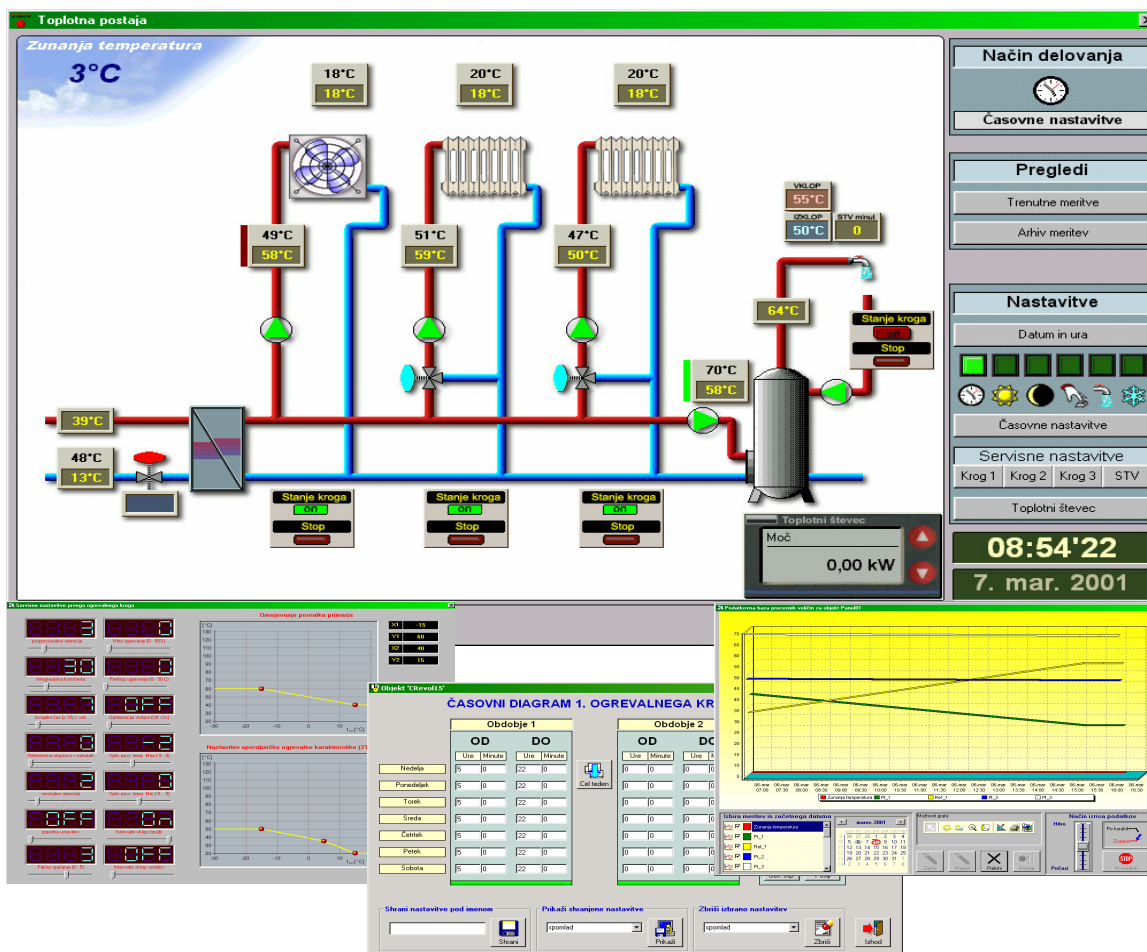


Figure 3: Example of control and management of the heating stations through the ELTEC SCADA module

The data acquired from the process through SCADA module are successively communicated via database to the technical information system.

4.3. Technical information system, ASD&S TEHIS

Heat providers use TEHIS as a »window« to access to various applications integrated into the system, at the same time the module sends the input information to other user applications in the enterprise, which might or might not be integrated into the system.

Various optimization modules can be added to the system. For example: optimization of the functioning of circulation pumps, anticipation of heating peaks in the system, including of the peak boiler rooms into the system and others. With the help of these modules we can considerably increase the effectiveness of managing of the district heating network. The heating suppliers can attain economic savings largely with simply leaving to the programme package to exercise simulations of the processes in the pipe system for four or more hours in advance and on the basis of an analysis of this simulations and a comparison with the actual measurement data determine feedback corrective instruction for SCADA module. For example: perhaps it will not be necessary to

start the peak boiler room for covering the start peaks, because the accumulated heat capacity of the network of district heating can be used. In the case of some bigger consumers the function of the reference step might be used. The latter is a time period in which the temperature of the inlet is raised gradually to prevent overloading. The overload peaks can be avoided with gradually raising the reference temperature in the inlet before the end of the period of reduction. In a similar manner, the number of simultaneously operating boilers in the boiling room can be decreased, if all the needed conditions are fulfilled. In case of any irregularities in the district heating system, alarms warn the operator that there is a need to do away with the errors and supply all the necessary information for enabling him to act quickly (e. g. non-attainment of the reference temperature, deviation from the allowed pressure in the system, disturbances in the functioning of the circulation pumps...).

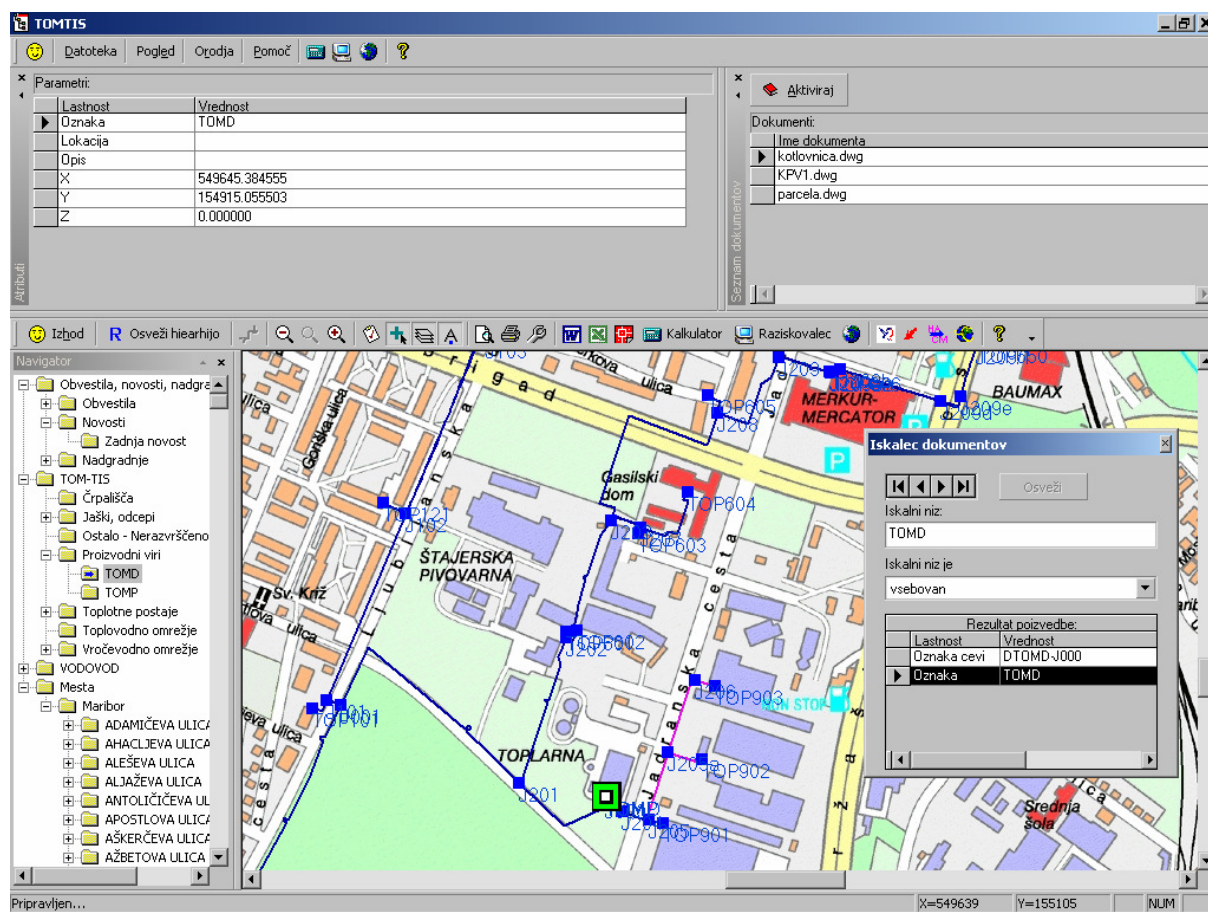


Figure 4: Display of the »window« for the access into the module ASD&S TEHIS

Indirect benefits of the system are shown in cases, when changes in the distribution system or the extensions of the district heating system were not sent to the operator (e. g.: exchange of the sequences of the district heating, functioning of the regulation valves, adding of the heating stations to the pipe network...) In case of the older, in practice more widespread, off-line model, the operator must completely trust the information got from other units of the enterprise. The presented system, on the other hand notes the deviations between the simulated conditions and the true data at that moment provided through SCADA system and warns the operator, what and where is to

be checked, changed or completed, or in the automatic mode - automatically via SCADA module (in the frame of the security limitations) reactively influences the ongoing exercise of corrections in the functioning of the system, and in this way performs the »economic regulation« of the system.

5. CONCLUSION

During the last several years in the Western and Northern Europe the trend of uniting the producers and distributors of heat can be observed. Due to ever bigger desire of the market to get better and cheaper services, and to more and more strict regulations, the distributors of heat must be ever more effective and adaptable. One can also note that the trend to make this sector private owned is more and more present. The consequence is that the enterprises wish to unite and make the operational costs as low as possible, with one purpose - to meet the needs of their customers and requirements of the authorities. These trends slowly but steadily move into Slovenia too.

With the increasing number of enterprises and augmentation of the producing capacities, concentration of knowledge and experiences also become greater. It is very likely that the enterprises equipped with complex and powerful programme tools and »armed« with appropriate personnel, will offer their services and take the responsibility of managing district heating networks of other producers and heat distributors in their near and far neighbourhood.

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