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POSSIBILITIES AND DIRECTIONS FOR FURTHER DISTRICT HEATING OF NIŠ DEVELOPMENT

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Abstract. *This paper is actually abstract from "The Technoeconomical study of District Heating of Niš Development Exculpatorness". In this paper analysis of the current state of the city of Niš DHS is given and possibilities and directions of its further development in the period 2003 – 2008. are presented. Analysis of the existing state is given and necesarity of involving of the latest attainments in this field concerning the entire system energetical efficiency increase possibilities is pointed. The effects of heat energy saving which are in the range of 10 – 40%, concerning the observed subsystem, are verifying our efforts for as quick as possible reconstruction and enabling of this very important comunal systems.*
Efekti uštede toplotne energije, mereno u procentima, kreću se u granicama od u zavisnosti od posmatranog podsistema, nesumnjivo idu u prilog našem zalaganju za što bržu rekonstrukciju i osposobljavanje ovih, vrlo važnih, komunalnih sistema.

Key words: *District Heating System (DHS), Existing State, Further Development Directions, Reconstruction*

THE DISTRICT HEATING OF NIŠ HISTORY

First district heating plants for single objects in Niš were built in 1930, in the buildings of Health Center, Theatre, Business Academy, Employment Office. The systems usually worked with the low pressure steam.

After the World War II, the tendency was on building new apartments, because of the great migration, so the district heating was not in the center of interest. In the period from 1945 to 1960, only 12 boiler rooms were built in Niš. After 1960, district heating becomes, an important factor of comfort, so in the period from 1960 to 1973, 94 boiler rooms for hot water heating were built. In 1973, the complete amount of heat sources was 22,62 MW. It was used for heating of 104951 m^2 of apartments and 9327 m^2 of business offices, with 2600 m of hot water pipeline is over.

Concerning that single and block boiler houses are not profitable solutions for a constantly growing city, it became clear that there existed need for unique District heating system, because it ensures:

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- The most economical solution;
- Secure providing
- Energy efficiency
- Low lewel of CO_2 and pollutant emision;
- Low lewel of enviromental pollution;
- Adequate thermal comfort.

Considering all of this, a specialized organization "District Heating Plant" was founded in 1970. The same year six block boiler houses with individual capacities from 1 to 6 MW were made. In the period from 1975 to 1996, considering the District Heating programme, two District Heating Plants were build: "Krivi vir" i "Jug".

The first phase of District Heating Plant "Krivi vir" bilding was finished in 1975 with capacity of 35 MW. The second phase was finished in 1978 with building of another 35 MW of capacity. The third phase began in 1986, with enabling of the plant for producing of another 58 MW.

District Heating Plant "Jug" was also built in phases. In 1975 its capacity was 15,68MW, in 1980 another 16,96 MW and after 1986, in two occasions capacities of 33,92 MW were outhoused.

One can notice from Table 1, that from the whole number of the appartments only 31% are with District Heating. From this number 87% are connected to the District Heating System through two heat sources. From the rest, about 42,618 appartments which are heated individually, about 50% are using electrical energy, and other usually solid fuel (coal and wood).

The district Heating Plant capacities in 1995 were 237000 kW with 18 heat sources. In Table 2 a review of the heat sources condition in the municipate of Niš is given.

It can be noticed from Table 2 that out of 132 heat sources with capacity of 621.330 kW, more than a half is realized from the District Heating System, with two sources in the residental and business area and two in the industrial area. This table did not includ many of the individual heat sources, considering housing and business objects, which are heated with classic furnaces on liquid or solid fuel, and some objects which are using electrical energy.

In the period of dynamical development of the city, efforts were made for district heating of new, as well as old parts of the city. The accent was on the downtown, where is the biggest concentration of small boiler houses. Many of them were closed (from 1986 to 2000 38 individual and 4 block boiler houses). This leads us to the situation that in the year of 2000, only nine individual boiler houses remaind in the downtown, which was followed with significant reducing of air pollution. For example, concentration of SO_2 and soot was reduced for about 70%.

The specialized company "District Heating Plant", according to the decision of Niš municipality from 1980, considering the Law of Companies and the Law of Communal Activities, was transformed into JKP "Toplana" (Public Communal Company "City District Heating Plant").

Today "City District Heating Plant" has 15 heat sources with 37 boilers and installed power of **241,9 MW** and active power of **229,8 MW**, which are used for heating of **1.192710 m^2** of residental and **336.564 m^2** business space.

Increase of heat source capacity and number of consumers was followed with increase of the hot water pipeline is over. From 2600m in 1973, over 12800m in 1980, 35000m in 1990, we are reaching up to **42000m** of hot water pipeline today.

Table 1. District Heating of appartments after data from 1992

	Connected to DHS	Connect. to block and ind. B.H.	Individual heating	All
NUMBER OF APPARTMENTS	16.507	2.327	42.618	61.452
Number of appartments (city)	47.210	6.921	121.887	176.018
Area of appartments m^2	981.005	130.284	2.470.667	3.581.956
Average area of appartm. m^2	59,43	55,58	57,97	58,30
	27%	4%	69%	100%

Table 2. Heat source condition in 1995

Heat source	№ of heat sources	Fuel		Kapacity kW
		Solid	Liquid	
1. CITY DISTR. HEAT. PLANT				
• District heating plants	2		2	194.560
• Block boiler houses	3		3	25.720
• Individual boiler houses	13	1	12	16.720
	18	**1**	**17**	**237.000**
2. MEDICAL ORGANIZATIONS				
• Block boiler houses	1		1	13.960
• Individual boiler houses	5	2		12.340
	6	**2**	**4**	**26.300**
3. SCHOOLS				
• Block boiler houses	1		1	15.820
• Individual boiler houses	27	6	21	22.480
	28	**6**	**22**	**38.300**
4. INDUSTRY				
• District heating plants	2		2	145.000
• Block boiler houses	8		8	91.970
• Individual boiler houses	11	2	9	27.430
	21	**2**	**19**	**264.400**
5. RESIDENTAL OBJECTS				
• Individual boiler houses	5	3	2	3.800
	5	**3**	**2**	**3.800**
6. BUSINESS OBJECTS				
• Block boiler houses	1		1	5.820
• Individual boiler houses	53	9	44	45.610
	54	**9**	**45**	**51.430**
SUMMARY				
• District heating plants	**4**		**4**	**339.560**
• Block boiler houses	**14**		**14**	**153.290**
• Individual boiler houses	**114**	**23**	**91**	**128.380**
SUM:	**132**	**23**	**109**	**621.330**

Today, with **241,9MW** of heat sources, **42 km** of main hot water pipeline and **400** heating substations Public Communal Company "City District Heating Plant" became a respectable company in this area.

FURTHER DEVELOPMENT OF THE CITY OF NIŠ DISTRICT HEATING

Constantly changing exploitation conditions, as well as the significant expansion of the District Heating System, were solved technically mostly by compromises between existing equipment (pipeline diameter, armature) and theoretical obtaining of new project parameters.

In the case of building new heating substations, the use of pressure reducers and flow regulators in the primary circle was desisted (which are usually appointed for using in the joining technical conditions).

It is also fact that average age of the main hot water pipeline is over 25 years and that not much attention was dedicated to the District Heating System balancing

All this has an unfavorable effect upon many aspects of the city of Niš District Heating System.

Generally, further development of the city of Niš District Heating System depends on the available infrastructure and instalations, with limiting economical factor. Some of the possible technical solutions for improving and optimization of the DHS of Niš will be mentioned later.

Reconstruction and modernization of the existing District Heating System

Improving systems hydraulical stability

Following problems can be assorted here:

- Local automatics inefficiency in the thermal substations
- Abuse of by pass duct
- Impossibily primary hot water flow regulation in the substations with existing armature and automatics

The problems can be solved with:

- – implanting flow regulators in the primary return duct in thermal substations
  - (or) by replacement of three – way with pass – through regulation valves
  - (or) by blinding of existing functional valves splitting duct (three–way valves are working the same as pass-through)
- completing and fixing all the parts of local automatics
- canceling or forbiding longer use of by pass duct.
- JKP "Toplana" just finished embedding of compact substations with flow regulators at home substations.

Getting all heat energy consumers into equal position

Following problems can be noted:

- Lower exchanger capacity in some substations due to temperature regime change from 150/75°C to 135/75°C;

- Nonobjective heat remunerating through consumers heating area.

Solution of this problem is obtained with embedding of heat exchangers of adequate capacity in the most thermal substations. Solution of the second and the third problem could be obtained with:

a) Embedding and getting calorimeters into function in all trermal substations and with passing to more objective charging system after really consumed amount of heat.
b) Delay in heating of some consumers can be avoided in two ways:

- By using local regulator with function after a clock in real time with simultaneous start of heating all consumers.
- By passing to continuous District Heating System work without stopping in heating at night.

Maintain the nonreduced project parameters in thermal ducts

In order to overcome this problem, JKP "Toplana" changed a big part of frazzle pipeline with preinsulated pipes.

Reconstruction and modernization of existing heat sources

Efficiency increase of existing hot water boilers fired with heavy oil

Efficiency increase can be obtained with following activities:

a) Reducing exhaust gases temperature with maintaining below 180°C by embedding convective heater (economizer) of primary air for combustion in the flue channels.
b) Obtaining optimal excess air coefficient
c) Providing modern measuring and regulation equipment with adequate elements (as sensors in flue channels for burners control and motors frequent regulation after optimal amount of O_2 etc.).
d) Maintaining insulation of boilers in proper condition, by constant control and undertaking adequate protection measures.
e) Adding adequate liquid or powder additives (organic, metal-organic, nonorganic and combined) to the heavy oil.

Gasification of all District Heating Plants and involving gas as primary fuel

With finishing of main gas pipeline MG-9 from Pojate to Niš, the main measuring-regulation station (GMRS Niš 1), and building I section of city of Niš gas pipeline network, along with gas pipeline connexion to District Heating Plant "Krivi Vir" and MRS, the biggest Niš District Heating Plant will start the following heating season 2003/04. with gas as fuel.

Gasification of District Heating Plant "Jug" is expected in the following few years.

Improving water quality in the system by reconstruction
or replacing of existing water preparation system

At this moment, water is undergoing adequate chemical preparation of decarbonization, and hydrazine (levoxine) is added through a dosing device.

Considering international explirience, this problem can be overcome by using atmospherical (p=1,05-1,5 bar) degazator driven by hot water or steam. Technological steam for work of thermical degazator would be produced from new evaporator, which would be connected on the adequate position in the hot water transmition system.

Building new District Heating Plant "Apelovac" with closing and reducing in capacity of few block and individual boiler houses

District Heating System amplification

Satisfying new residental setlement and consumers wit new built or reconstructed existing District Heating Network

One of worldwide tendences is embedding of former completed prefabricated (compact) substations into planned tract and connecting them to District Heating System. In 2003, JKP "Toplana" embedded, some new and some to replace old ones – 161 compact substations.

Capacity enlargement of existing heat sources – primary District Heating Plant "Krivi vir"
Involving "alien" heat sources – District Heating Plant of the Electronic Industry for satisfying increased need for heating

Possible Inovations in the City of Niš hot water system

Centralized consumers supply with sanitary hot water
Building of cogenerative heat sources – combined production of thermal and electrical energy
Usage of renovable heat sources

The most inportant renovable heat sources are:
a) Geothermal water
b) Biomass
c) Solar energy
d) Wind Energy
e) Wasted materials and trash energy
f) Heat pumps

Concerning all this, it is realistic to eke District Heating System of Niš primarily by using geothermal water and solar energy.

BASICS OF DISTRICT HEATING SYSTEM MODERNIZATION (REMOTE CONTROL AND MONITORING)

Regulation of distant heat energy supply system

District Heating System supplies different consumers with heat energy, considering heat load size and character. Heat consumment are different for different consumers. Heating plants heat load changes after changes in enviromental air temperature, so adequate regulation, in the aim of heat energy rationalization, has to be done.

There are various regulation systems, but all of them could be assorted into following systems:

1. Centralized regulation – Done in DHP, TEP-DHP and Boiler Houses.
2. Group regulation in central stations for a group of same type consumers, by ensuring the needed heat carrier flow and temperature.

3. Local regulation is done in house station for additional correction of heat carriers parameters, after local conditions.

4. Individual regulation directlg on the heat exchanger (e.g. on radiators).

Due to heat load of various consumers in modern District Heating Systems, different in the heat carrier parameters as well as in character of heat consuming, central regulation is added group, local and individual, i.e., combined regulation.

When water is used, the following central regulation methods can be generally used:

a) Quality regulation, by changing heat carrier temperature;

b) Quantity regulation, by changing heat carrier flow;

c) Quality - quantity regulation, i.e. combination of preceding 2 cases.

d) Pause regulation by disconnecting of the system, i.e. by periodical pausing.

Regulation can be by hand, semiautomatic and automatic.

Regulation device consists of following parts, needed for influence on regulation system:

1. sensor – on the measuring point
2. comparator of real and inflicted values
3. executive device on the adjusting point – regulation valve.

Improved regulation devices have additional parts, as following:

- convertor of measured values into electrical or pneumatical values,
- amplifier of alternation signal,
- transducer of given values.

Also, automatic devices for temperature regulation in the rooms should be provided.

A very important element in heat substations regulation system is an executive device –a regulation valve. There are many types, but three are basic:

First group are pass through regulation valves EM driven.

Second group – three pass regulation valves with 3 taps for 2 streams. They can be used as splitting or as mixing valves.

Third group consists of so called regulators with convertors. They are valves which can be with or without additional energy.

Distant heating system of Niš is a very complex system. In some way, four basic wholes can be divided:

- Heat energy production system – boiler houses and District Heating Plants
- Distribution system heat energy – hot water to the consumers – hot water pipeline
- System of substations for heat exchange
- Hot water distribution system to the final consumers – radiator heating

There is very close interrelation of these parts, so work parameters change of one part influences work of the other.

There are many parameters in the work of the whole which should be monitored, and, if there is a need, corrected.

Boiler houses modernization (central regulation)

Most of the parameters that should be monitored and whose work should be affected are in the boiler houses, of which the most important are:

- Discharging and return water temperature
- Boiler installation pressure
- Pressure, i.e. hot water pipeline available head

Except this, following parameters should be monitored:
- System discharging water quality
- Water flow
- Heavy oil temperature and pressure
- Heavy oil consumption
- Exhaust gases constitution
- Amount of heat distributed to the consumers.

Today, monitoring of those parameters is mostly done in the boiler houses, local regulation systems or by hand, when it is done by the boiler operators.

Hot water pipeline equiping by armature with distant parameter reading (central regulation)

Hot water pipeline in the Distant Heating System of Niš consists of a very complex and branchy netvork. Many parameters should be monitored in the hot water pipeline, but before all:
- Superheated water flow through the system
- System pressure
- System's available head
- Boiler house's discharging water temperature
- Boiler house's return water temperature
- Possible system's leaking detection.

Those parameters monitoring should be done not only in the boiler houses, but also along the hot water pipeline itself.

Hot water pipeline system in the District Heating of Niš nowdays has got no possibilities for data monitoring and acquisition along the pipeline, even considering that replaced parts of hot water pipeline with embedded foreinsulated pipes, in the insulation contain a wire for detecting a leakage.

Boiler houses modernization (local regulation)

Distant Heating System of Niš is an indirect system, which means that substation has elements both from primary and from secondary part of the network.

Distant Heating System of Niš has qualitative regulation, which is basically done centrally, from the Distant Heating Plant.

In ideal conditions, this regulation would be adequate.

There are different deviations in the real conditions: incompletness of the calculation, deviations during the building of the installation, changes on the installation during exploatation, etc. That is the reason why regulation has to be done on the local level, too.

For regulation of substation's capacity three-point secondary fluid discharging water temperature regulation after enviromental air temperature by primary fluid flow change.

That is the reason for embedding a microprocessor regulator, with adequate parameters and possibilities, specified in the Technical requirements. One of the more important requirements is that the regulator posesses interface for communication with a distant dispatcher center.

This enables work monitoring, and also commands the executive apparatuses in the substation (opening and closing of valves, connecting and disconnecting of pumps) just as it performs additional correction in the system of local and central regulation.

RADIATORS ARMATURE MODERNIZATION (LOCAL REGULATION)

Radiator heating system consists of a distribution network and radiators in the consumer's objects.

By connecting microprocessor regulators from several substations with one central unit, we can monitor a system as whole, as well as mutual influences of some parameters change to entire system or to individual parts. This is the way to optimize the Distant Heating System work and to obtain maximal system work steadiness and stability, with minimal expenses.

Besides, by alarm function activation (pipeline leaking, pump malfunction, etc.) loses which appeared in practice because of lack or system information delay can be prevented. Besides, intervention would be much faster and simplier, so eventual stops in heating would be shorter.

On the basis of this, it can be concluded that there is necesarity to plan further system and all of its parts automatization, while District Heating System in Niš is still being reconstructed, in the aim of connecting the whole system into one central system for built or control and monitoring.

REFERENCES

1. Stefanović V., Petrović D. i dr., (2003) *Tehno-ekonomska studija opravdanosti toplifikacije grada Niša*, Mašinski fakultet Niš, Niš.
2. Sokolov J.J., (1985) *Toplifikacija i toplotne mreže*, Gradjevinska knjiga Beograd.
3. Stefanović V., (2001) *Problemi i pravci daljeg razvoja savremenih sistema daljinskog grejanja (SDG)*, Savetovanje udruženja "Toplane Srbije", Tara.

MOGUĆNOSTI I PRAVCI DALJEG RAZVOJA DALJINSKOG GREJANJA GRADA NIŠA

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Ovaj rad predstavlja izvod iz "Tehnoekonomske studije opravdanosti razvoja toplifikacije grada Niša". U ovom radu data je analiza postojećeg stanja SDG grada Niša i prezentovane su mogućnosti i pravci njegovog daljeg razvoja u periodu 2003. – 2008. godine. Data je analiza postojećeg stanja i ukazano na neophodnost uvođenja najsavremenijih dostignuća u ovoj oblasti u smislu povećanja energetske efikasnosti celog sistema. Efekti uštede toplotne energije, mereno u procentima, kreću se u granicama od 10 – 40%, u zavisnosti od posmatranog podsistema, nesumnjivo idu u prilog našem zalaganju za što bržu rekonstrukciju i osposobljavanje ovih, vrlo važnih, komunalnih sistema.

Ključne reči: *Sistem daljinskog grejanja (SDG), postojeće stanje, dalji pravci razvoja, rekonstrukcija.*