@ Изборот на противпритисна турбина во постројката за комбинирано производство на електрична и топлинска енергија е направен пред се од економски причини, се со цел да се намалат инвестиционите вложувања, но и од енергетски причини да се искористи што поголем дел од вложената енергија. При тоа се има во предвид дека постројката ќе работи само во текот на грејната сезона.

@ Дефинирањето и изборот на параметрите на постројката за когенерација е извршен врз основа на инсталираниот топлински капацитет на административните објекти во кои постојат инсталации за централно греење и нема потреба од дополнителни инвестиции за таа цел.

@ Проектираната енергана со вкупна инсталирана топлинска моќ од 20000 kWt овозможува приклучување кон системот за топлификација и на индивидуалните станбени објекти кои се предвидени во просторниот урбанистички план на Берово до 2020 година.

@ Во когенератината постројка во текот на годината ќе се произведат 35,76 GWht топлинска енергија и 5,6772 GWhe електрична енергија.

@ Со вкупна годишна потрошувачка на јаглен од 23 267,3 t/god, во облик на ситна фракција нема да се наруши нормалното работење на рудникот "БРИК"-Берово, бидејќи истиот при проектираниот капацитет на експлоатација годишно од оваа фракција произведува поголема количина од пресметаната.

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COMBINED GENERATION OF ELECTRIC AND HEATING ENERGY IN FUTURE DEVELOPMENT OF YUGOSLAV ENERGY SECTOR UNTIL 2000

MK0200035

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ABSTRACT

Development of the district heating system in the FR Yugoslavia, beside the combined generation of electric and heating energy presents a necessity for energy, economic and ecological reasons. Although the structure of energy reserves is rather unfavourable considering that the lignite is being predominantly used, available reserves of energy raw material are able to ensure the long-term development of Yugoslav energy sector, and to offer real possibilities for considerable substitution of foreign good quality fuels, especially in district heating systems. Their further development will depend, among other things: on the implementation of new technological solutions for the exploitation of local energy resources; need of reconstruction, revitalisation and transformation of old condensing thermal power plants into the cogeneration plants; installation of remote controlled transmission of heating energy as well as on development of heating plants and smaller co-generation plants based on local energy resources.

INTRODUCTION

Rapid rate of construction and development of towns has been and will continue to be the basic condition for faster development of district heating systems. Intensive construction of residential buildings which takes place in many towns in the FR Yugoslavia, based on long term planning of needs of towns, contributes to the development of the infrastructure of utilities, the main role of which is to supply the population with necessary energy. Advantages of the district heating systems over local supply of electric energy are more and more used in large number of towns where the district heating systems have already been installed or are planned to be built.

Taking in consideration anticipated combined generation of electric and heating energy in suburban cogeneration plants and remote transmission heating of energy, increased level of use of electricity for heating purposes, lack of good quality types of coal, ecological problems in urban areas and reduced economic power of the population, further synchronised development of centralised systems of electricity, heat and natural gas supply continues to gain in importance. This means that it is necessary to establish strategic goals to be achieved within the framework of the development of energy sector in towns, according to adopted "Strategy of Long Term Development of the Power Sector in Yugoslavia until 2020, with the Prospect until 2050", hereinafter referred to as the "Strategy" (1), based on which safe and rational supply of necessary energy will be ensured. The paper provides the analysis, based on the above mentioned "Strategy" (1), implementation of which only recently started (due to well known reasons of the aggression on our country, economic sanctions and consequences of the blockade), planned development of Yugoslav energy sector as well as needs and possibilities for the construction of combined facilities for district heating systems in towns of Yugoslavia.

SOME OF THE ELEMENTS OF PLANNED DEVELOPMENT OF ENERGY SECTOR IN YUGOSLAVIA UNTIL THE YEAR 2020

The "Strategy" (1) was conceived with the purpose to make the assessment of requirements and to systematise the inventory of resources and possibilities on which long-term sustainable development of the energy sector in the FR Yugoslavia should be based. The other purpose of this document was to examine the following:: development of energy consumption and generation with accompanying

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projections of energy results, possibilities for exploitation of locally available energy sources, participation of local electrical and mechanical engineering, most recent achievements and possibilities for engagement of local scientific potentials, ecological problems related to energy generation and consumption, as well as organisational and economic aspects of the development of the power sector. The following points had to be taken in consideration (1):

1. The structure of local energy resources is uniform to a great extent. The lignite of low calorific value is predominant in total energy reserves, supplemented eventually with available hydro power potential. According to current evaluations, geological reserves of coal account for nearly 88% in total energy reserves. The structure of reserves is unfavourable due to very small participation of good quality coals, considering that lignite reserves account for over 85% of total coal reserves.
2. The characteristics of former production of primary energy sources in the FR Yugoslavia are: very intensive development of lignite production, especially in open cast mine exploitation; increased use of hydro power potential; the increase, and then the maintenance of the level of crude oil and natural gas production; initially very slow growth followed by complete decline of production of good quality coal in underground mine exploitation.
3. Basic characteristics of secondary energy production in the FR Yugoslavia to present date are: very fast evolution of electricity generation in thermal power plants (over 80% of coal consumption), fast development of production of oil derivatives made from both foreign and local crude oil; development of production of dried lignite; starting and then suspension of production of synthetic gas: fast development of district heating systems.
4. If we take in consideration the final energy consumption, we may notice that the structure of energy consumption in Yugoslavia was subjected to significant changes, which are the consequence of: more frequent substitution of coal with the electric energy, oil derivatives and natural gas; increased consumption of coal for the purpose of electricity production; increased consumption of electric energy for heating purposes; development of gasification of industry and general consumption; improved standard and comfort of living; greater attention paid to environmental protection especially in urban areas, etc.
5. High dependency on imports, which participate with about 30 - 40 % in total energy consumption, is the result of full deficit (coal for coking) or considerable deficit of local production (crude oil, natural gas and better quality types of coal).

These options and evaluations of eventual changes of relevant factors of macro environment, based on which energy requirements are determined, also served to define in which direction Yugoslav power sector will be heading until 2020 (1). One of scenarios of demographic changes which were taken in consideration, started from the assumption that an efficient policy regarding the population will be introduced in order to revert old tendencies of negative birth rate, which existed nearly everywhere in the country, to the level of simple reproduction of the population, as soon as the beginning of next decade. Nevertheless, it has been neglected to take in account migrations resulting from the war in the former Yugoslavia, which contributed to a considerable increase of population in the FR Yugoslavia in this decade. Based on the evaluation of major important factors, the growth of industrial production has been quantified through three scenarios. According to the middle scenario, the level of gross domestic product (GDP) in 1999 would be reached in around 2006 whereas in 2020, it would mark an

increase of 87%. According to such an evaluation of industrial and population growth, total final energy consumption would reach the level of 1990 (11,8 mil toe) in 2006. Afterwards, during next fifteen years, the consumption would increase for nearly 6 mil. toe reaching 18 mil. toe in 2020, or over 50% more than in 1990. As far as the planned final consumption and its structure are concerned, total energy consumption in 2020 would amount to nearly 26,5 mil toe, or nearly 45% more than compared to 1990 (Table 1). In the structure of total consumption, the lignite remains predominant, whereas the participation of hydropotentials and natural gas marks an increase. Energy consumption per capita in 2020 will amount to nearly 2,3 toe, or around 75% of the average registered in 1990 in developed western European countries.

Table 1. General power balance of the FR Yugoslavia in 2020, Mtoe

	Coal & Coke	Crude oil	Gas	Hydro	New energy sources	Oil derivatives	Electric energy	Total
Generation	11.76	2.84	1.70	1.24	0.46			17.99.
- local	11.76	1.55	0.51	1.24	0.46			15.51
- concession								
- foreign		1.29	1.19					2.48
Net import	0.38	4.67	3.60					8.65
A Total consumption	12.14	7.50	5.30	1.24	0.46			26.64
B Transformation	-10.17	-7.50	-0.62	-1.24	-0.04	6.91	4.05	-8.62
HPPs				-1.24			1.24	0.00
TPPs	-10.09		-0.48			-0.13	3.70	-7.00
Refineries		-7.04				-7.04		0.00
Own consumption								
losses	-0.08	-0.46	-0.14		-0.04		-0.89	-1.61
C Final Consumption	1.97		4.69		0.42	6.91	4.05	18.03
Industry	1.05		2.72		0.14	0.91	1.68	6.50
Traffic			0.05			3.70	0.15	3.90
Households	0.74		1.19		0.10	0.45	1.43	3.90
Other	0.17		0.28		0.18	0.57	0.80	2.00
Non-en. consumption			0.45			1.28		1.73

Basic long term changes in final energy consumption should have moved towards: (1) reduction of participation of liquid fuels, almost exclusively due to reduction, and then suspension of absolute consumption of heating oil, (2) increase of participation of natural gas, (3) decrease of participation of solid fuels, but primarily those of foreign origin, (4) gradual reduction of, at present, excessive participation of electric energy and (5) gradual introduction of new energy sources. At the level of consumption categories, it may be expected that the participation of industry will be reduced and the

portion of households and the tertiary sector increased. Looking at the structure of consumption according to energy sources, the consumption of heat from community heating plants (due to the increased portion in urban populations) and of the natural gas marked an extreme increase. At present, the consumption of electric energy in this sector is excessive and far from rational, so it will mark slight growth, and the major part of consumption growth will be due to insubstantial use of electric energy (1).

According to such evaluation of social and industrial growth, final energy consumption would reach the level of 9,89 mil. toe in 1999, or 84% of 1990 (11,8 mil. toe) reaching in 2020 18 mil. toe or for 50% more than in 1990. For the planned final consumption and its structure, the total energy consumption in 1999 should amount to 15.4 mil toe, that is 85% of the consumption in 1990 (18.25 mil. toe), reaching in 2020 about 26.5 mil. toe or 45% more compared to 1990.

Although in the "Strategy" (1), the middle scenario of social and energy sector development was evaluated as the most probable one, we can say today that this scenario has not been realized and that we are far closer to (less optimistic) scenario, according to which we would reach the level of GDP and total production from 1990, only in 2010. Main reason for this is that basic assumptions related to social and economic development have not been proven right, which consequently led to the failure of plans related to the power industry development. From the point of view of external circumstances, we primarily refer to the extension of economic sanctions, imposed to the FR Yugoslavia, which impeded normal importation of energy resources as well as the access to international finances, necessary for more substantial investments in the energy sector. As for the internal plan, ownership transformation and privatization processes did not follow anticipated intensive dynamics, economic reforms and the introduction of market economy did not take place, neither changed the structure of final energy consumption especially of electric energy and real energy prices. Plans related to production, importation and consumption of energy, rational use of energy, investments and improvement of economic position of power utilities have not been realized either. All this, added to the aggression on Yugoslavia in 1999, destruction of infrastructure, industrial and energy installations and facilities, needs for their rehabilitation and revitalization, clearly show that the right time has come to update the "Strategy" in order to adapt it to new conditions. As far as the actual consumption of total energy is concerned, the table 2 represents its dynamics and the structure, whereas the figure 1. represents the diagram of changes according to the "Strategy" (1) and actual values for the period from 1995 to 1999 (2).

Table 2. - Total primary energy of FR Yugoslavia in Mtoe.

Year	Hydroenergy	Coal	Oil	Gas	Total
1995	1.06	7.556	2.2	1.452	12.268
1996	1.262	7.457	3.4	2.148	14.267
1997	1.106	8.308	4.05	3.334	15.798
1998	1.118	8.663	4.3	2.097	16.178
1999	1.179	6.59	3.0	1.486	12.255

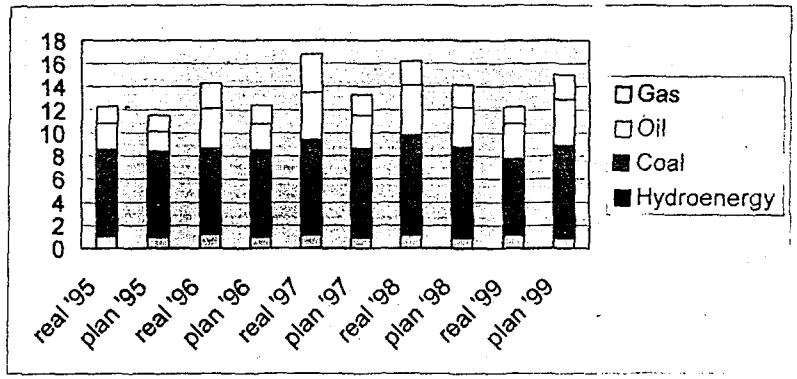

Figure 1.

It is clear that in 1999, due to the aggression and the destruction of energy and industrial installations, total consumption underwent terrible drop, equalling practically with the consumption in 1995. Similar situation happens to the final energy consumption which retained very unfavourable structure (Figure 2) compared to previsions set out in the "Strategy", especially regarding the electric energy.

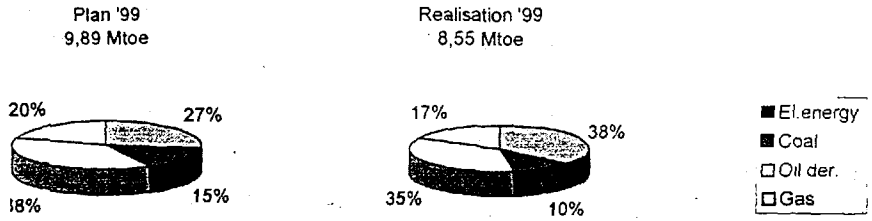

Figure 2. Level and structure of final energy consumption in 1999, according to plans set out in the "Strategy".

Electric energy has a growing role in meeting needs of heating purposes. Nevertheless, excessive increase of use of electricity for heating purposes caused numerous problems to the operation of the electric power system and led to extremely irrational use of electricity. Despite considerable decline of industrial activities and consumption, total annual demand in Serbia grew since 1990, for nearly 6.000 GWh (21%), reaching 33622 GWh. Even though the dynamics of growth of the annual electricity consumption in last two years is slower than planned, above all, thanks to warmer winters, peak load in 1998 reached 7189 MW, which is for over 2100 MW (42%) more than in 1990 (3).
Relative changes of some of most relevant indicators in past ten years, presented in the figure 3, showed how deep the gap is between the changes of general development components of society and the consumption of electric energy.

The fact that the heating with electric energy is still more favourable than many other possible, less comfortable and more expensive substitutes, is the key factor of such trend.

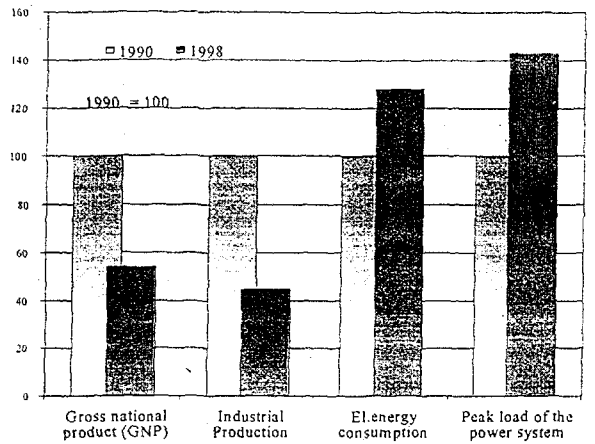

Figure 3. - Changes of general development components and consumption of electric energy

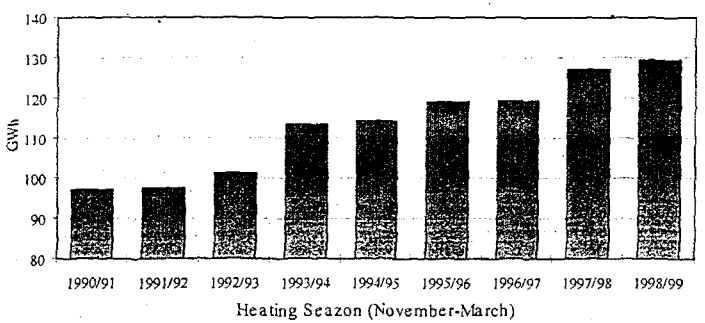

Figure 4. - Daily consumption of electric energy at average temperature of 0°C.

The fact that the heating based on electric energy is still more favourable than most of possible, less comfortable and less acceptable means (from the point of view of payment methods) is the key factor for such trend. Also, heating based on electric energy remains the best option and almost the only choice for a large number of new buildings with different purposes. The growth of daily electricity consumption at the average daily temperature of 0°C (figure 4) confirms that the consumption of electric energy for heating purposes rapidly keeps growing. The characteristics of electricity consumption (ratio between minimum and peak loads and the duration of the latter) are less and less corresponding to the structure of production. Loads over 5000 MW, which were practically non-existent in 1990, lasted for less than 1870 hours (about 2,5 months) in 1998, whereas nearly 2200 MW were necessary for their covering. In that part of the diagram, only 3.8% of total annual energy is being used. Minimum (summer) loads remained unchanged whereas maximum (winter) loads increased, as it has already been mentioned, for 42%. The conditions of unit commitment in electric power plants, actually thermal power plants are becoming more unfavourable from energy and economic point of view. In late 1980s, thermal power plants (at that time called ZEP) were in operation for more than 6000 hours per year, reduced to the nominal power (partly thanks to big exports) whereas today their commitment hardly reaches 4700 hours (3).

Bearing all these facts in mind, it is evident that speeding up of district heating system development, based on local coal exploitation is necessary, and which can be obtained primarily through combined generation of electric and heating energy.

DEVELOPMENT OF INSTALLATIONS WITH COMBINED GENERATION OF ELECTRIC AND THERMAL ENERGY ACCORDING TO THE "STRATEGY"

Fast development of district heating systems in Yugoslav towns was propped up by wish for rational use of energy potentials, environmental protection and improvement of living standards. The towns, as the point of concentration of people, production activities and industrial capacities, underwent a very fast and uneven development which caused the increased of energy needs, due to the population growth, industrial and traffic development and better living conditions. Introduction of district heating systems in FR Yugoslavia started in Belgrade and Novi Sad in 1961, in Subotica and Kragujevac in 1962, and continued later on in many other towns (4), so that 50 towns have district heating systems installed, whereas total installed capacity of heating plants amounts to 6500 MW. Today, for ecological and other reasons, we use in our country mainly imported liquid fuels and natural gas (over 80%) for meeting heating requirements in district heating system.

Basic orientation of development of Yugoslav energy sector should be based on intensification of production and rational use of local energy resources, making sure to achieve best economic results in the power system. This policy is based on available coal reserves, as the primary source for electric and thermal energy production. The coal, or more precisely the lignite, is undoubtedly our most important energy resource (nearly 80% of geological reserves) and it will surely be of the prime importance and will play the main role in the long term development of Yugoslav energy sector. The fact that main part of lignite reserves is concentrated in several sites is the advantage favourable for opening of large open cast fields, with relatively small specific investments and production costs,

which ensures very economical production of lignite, primarily used for the production of thermal energy. Beside the production of lignite in open cast exploitation, production of good quality coals (dark, brown and brown lignite) in underground exploitation is also important for FR Yugoslavia, because these coals are being used in the industry and for the general consumption.

According to the "Strategy", support to the implementation of new technological solutions for the use of coal, reconstruction and transformation of existing condensing thermal power plants into co-generation plants, implementation of remote transportation of heating energy, construction of heating plants and smaller co-generation plants on local sources, development of new technologies for burning of coal and biomass (fluidized beds), combined steam-gas cycles based on the use of natural gas and coordination with the development of gas pipeline system of Serbia, i.e. complex use of lignite for generation of electric and heating energy, synthetic gas and enriched solid fuels...have great importance for heat requirements in our country.

Rational construction of co-generation plants and district heating systems from suburban co-generation plants and coal fueled heating plants imply the possibility for more extensive use of coal in our towns. Combined generation of electric and thermal energy is well known since long time ago, but many countries only recently started to use it (some 20 years ago, when so-called "thermal crisis" took place) (4). But, taking in account energy, economic, ecological, security and technological effects, combined generation has been used more and more. Energy effects are due to the fact that combined generation leads to considerable savings of local fuels, because of higher level of energy efficiency, economic effects, expressed as lower cost of thermal energy production, are based on such energy results, and finally ecological effects - the benefit of which is that heating plants may be located out of towns (from consumption areas), keeping the price of delivered heating energy competitive to local plants on liquid fuels based in town.

For this reason, the activities related to transformation of thermal power plants Nikola TEsla A, Kostolac and Pljevlja into co-generation plants and the use of dryer installation in TPP Kosovo and heating plant in "SARTID 1913" for the construction of district heating system of Belgrade, Pozarevac, Pljevlja, Pristina and Smederevo will play important role not only in reduction of ecological problems in these towns, but for overall power balance of the country. One of disadvantages of transformation of condensing thermal power plants in co-generation plants, is the loss of certain percentage and reduced production of electric energy. Nevertheless, taking in account that 4 to 5 times more heating energy (expressed in MWh) is produced on the account of such loss of electric energy, it is clear that we are achieving important energy results. Even more since the major part of electric energy produced during the heating season is used not for heating purposes, but in a very irrational manner, so that 1 kWh (in TPP) corresponds to 0,9 kWh of consumption (due to usual transmission and transformation losses). This way, energy results of combined generation of electric and heating energy in our electric power system are indubitable, since they are contributing to the reduction of irrational use of electric energy (5).

Planned implementation of above mentioned projects would also imply an important involvement of mechanical, electrical and civil engineering operations. Here are some basic date related to district

heating system for Belgrade, Smederevo, Pristina and Pozarevac: total quantity of plates for pipes and constructions - 26.700 t, fittings - 175 pieces, 27 heat exchangers, 3380 t of thermal insulation, 1780 t of protection layers, 43 circulation pumps, over 20.000 t of cement, 5.580 t of concrete iron, near 6.500.000 hours of mechanical equipment assembly, over 800.000 standard hours of civil engineering assembly etc. In other words, the realisation of these projects give create the possibility to our industry to be more involved and obtain important references for future engagements abroad.
The dynamics of construction of district heating systems in above mentioned towns has been the topic of discussions for years. Today, only the district heating system of Kostolac and Pozarevac supplied from TPP Kostolac A is operating, whereas all other projects are delayed, primarily due to the lack of financial resources and the consequences of economic sanctions. Still, the implementation of these projects will ensure considerable savings of liquid or gas fuels of nearly 300.000 toe. This would enable further construction of co-generation plants in our country, even more that it can be carried out within the framework of planned rehabilitation of existing thermal power facilities, by use of natural gas and switching to new technologies of combined generation of electric and heating energy (combined process).

Possibilities and requirements of more intensive use of lignite calls for the application of new technologies which enable economic use of solid fuels also in urban areas, without major harmful effects on the environment. In that respect, technology of burning in fluidized bed could enable greater use of lignite in boiler rooms and industrial power plants in urban the areas (4). Development of small local, sometimes better quality coal mines, reserves of which are relatively limited and inadequate for mass production and transport, but which are suitable for use on the spot, could be important for development of district heating system. Construction of small co-generation plants and the supply of consumers with heating energy, through remote controlled transportation would contribute to the overall development of our power sector. The special advantage of these coal mines is that they are located near small towns (5), which often have not other possibilities for use of conventional types of fuel other than biomass or electric energy. Construction of district heating systems, together with the substitution of imported energy sources with locally available coal, would also includes the activities necessary for ensuring sufficient quantities of coal, considering that our coal mines are at such level that the substitution of imported energy sources with locally available coal may not take place immediately.

The evaluation of the "Strategy" (1) is that necessary investments in the forthcoming period regarding transformation of TPPs into co-generation plants will require around 250 mil. USD, whereas the investments in industrial generation plants will be the subject of development industrial projects and nearby municipal utilities.

Nevertheless, it is necessary that corresponding state bodies, with more active policy of heating energy prices, and by introducing corresponding system measures in construction of power installations, by adopting stimulating policy and favorable credits, ensure conditions for construction of district heating systems and the rational use and energy savings in towns. Due to inappropriate price of heating energy, all utilities for production and distribution of heating energy are today in extremely bad position, unable to make investments and proceed to further development without help

from towns. In the forthcoming period, special attention should be paid to the improvement of economic position of district heating system companies, in order to create at least the minimum of basic conditions for free development of district heating systems in our towns.

CONCLUSION

Further development of Yugoslav power sector is connected both to the development of district heating systems based on installations for combined generation of electric and heating energy. Their development in the forthcoming period is required so as to meet energy requirements in towns, namely: safer and more reliable supplies, coordinated development of electrification, district heating and gasification, more rational use of primary energy and environmental protection.

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