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THE POSSIBILITIES OF INCREASING THE ENERGY EFFICIENCY IN THE CITY OF TUZLA

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Preliminary notes

The paper analyzes the consumption of all forms of energy in the city of Tuzla as well as the total energy consumption. The first aspect of the analysis is a major problem of irrational consumption of energy in the city of Tuzla. There is an urgent need to reduce consumption of all forms of energy in the city of Tuzla in this way. Other aspects of all forms of energy consumption in the city of Tuzla are the huge energy intensity, environmental pollution, increasing the energy efficiency of new investments through affordable credit lines based on energy savings.

Keywords: *energy efficiency, energy consumption per capita, heating system, electric energy, public transport*

Mogućnost povećanja energetske učinkovitosti u gradu Tuzli

Prethodno priopćenje

U radu se analizira potrošnja svih oblika energije u gradu Tuzli kao i ukupna potrošnja energije. Prvi aspekt analize je veliki problem neracionalne potrošnje energije u gradu Tuzli. Zbog toga postoji hitna potreba smanjenja potrošnje svih oblika energije u gradu Tuzli. Ostali aspekti potrošnje svih oblika energije u gradu Tuzli su veliki energetski intenzitet, zagađenje okoliša, povećanje energetske efikasnosti novim investicijama kroz povoljne kreditne linije na temelju uštede energije.

Ključne riječi: *energetska učinkovitost, potrošnja energije po glavi stanovnika, sustav grijanja, električna energija, javni prijevoz*

1 Introduction

As a result of rapid development due to the rapid influx of population into cities, the problems occur with housing, transport, supply, satisfying cultural and other needs of increased living standards. The problems and difficulties in their solving are even more acute in the cities built tissue and to a lesser extent in the cities of underdeveloped economy, the peripheral parts of the cities and suburbs. In their own way those problems are reflected on the partially built or not built up territory within these settlements [1].

Solving urban problems started when there was a need to expand the settlements for residential and industrial construction. Such interventions have adversely affected the economy of narrower and wider areas. The city becomes a complex and dynamic organism which turns into an organized system composed of many subsystems. The progress and activities of urban units and the wider area depend on the development of municipal infrastructure and the level of planning. If the utility infrastructure elements are correctly overviewed social relations and living standards rise to a higher level.

2 Energy

From an energy point of view, all forms of energy use, electricity sector, the sector of heating (space heating fuels) and the transport sector are interesting in the city. Today the EU and the world are based on synergy and cooperation of at least two networked systems - electricity and gas. It is important to allow all the consumers access to at least two networked systems. Possible systems are gas, electricity, heat and steam. Studies are carried out as the separate analysis of non-renewable (all minerals) and renewable (hydropower, biomass, particularly density, wind, solar) energy sources [2]. In this way, related to the knowledge on possible introduction of new energy sources in use, assessments and conclusions on the possible terms of securing the balance needs and on the course and scope of installing energy capacities are made. All the reflections on this subject indicate that the consideration of long-term energy development as a field of economic infrastructure, the predecessor and conditions of general social development, should be allocated to a much longer period than it has been the practice in the world so far. This is confirmed not only by the rapid growth in consumption but also by the results of the era of scientific-technical revolution, of which we are participants and which should be assessed at such longer periods, their timely implementation monitored and ensured.

2.1. City and energy

In the early stages of their organized life men satisfied all their energy needs from biomass, mainly from timber. At the same time mankind began to use wind and water energy and later on organized exploitation of coal, oil, gas, bituminous shale and nuclear materials, in order to warm the living space and to get the energy from them. At present, mankind has started a significant use of non-conventional energy sources, wind energy, solar, tidal and geothermal energy.

Non-conventional sources are already quite significant in meeting energy needs, particularly in some regions of the world. Today the world is permanently oriented to obtain energy from non-conventional (non-classical) sources caused by many reasons, including:

- A real opportunity to get cheap energy from these sources,
- Significantly less environmental pollution,
- Depletion of resources of fossil and nuclear materials,
- Population growth accompanied by a constant increase in the need and faster development of the so-called third world countries (China, India, etc.).

The increase of energy consumption and production, with minor fluctuations in times of economic crises and

wars, was constant in the past, and in particular during the 20th century. In the world from 1945 to 2000 energy needs were growing exponentially. Today, in the 21th century special attention is devoted to the energy consumption in the developed world. This is a first-rate issue in each country.

Most of the energy is consumed in cities and their immediate surroundings. Therefore, we will observe the two inseparable concepts: "City and Energy".

Cities are a specific spatial unit, as a result of the dynamic social, technical and technologic development, with increasing demands for energy to meet their essential needs, primarily the development of industry, transportation and utilities in order to increase their inhabitants' comfort of living and quality of life. Special attention is paid to energy development in cities, because all elements of energy development carry long-term characteristics, require long-term expensive investments and highly reliable operation. It is therefore necessary to determine and establish long-term energy balance, especially for larger cities, in order to ensure safe and efficient supply of energy, based primarily on domestic energy sources, providing the optimal composition of spending, saving and rational use of energy.

In the past it was very difficult to ensure investment funding, dependent more on a series of political factors than on the economic strength of the city and its people. The problem is that solving energy needs of each city is an extremely complex issue aimed at resolving utility issues and it should be addressed as such. However, energy problems of cities are approached casually, so nowadays they do not meet the energy infrastructure needs and lag behind the needs. Implementing the measures and rational use of energy saving and decentralized supply of fuel to the consumers in some parts of the city, particularly in suburban areas along with synchronized development of three centralized supplies it is possible to achieve optimal supply of energy needs.

Today, economic power of the majority of citizens is very low on the average and the question is whether the citizens are able to pay all utilities services, especially heating. The budgets of municipalities and cities are modest and so are the investments in municipal infrastructure of the counties and municipalities. The quality of central heating systems, drinking water, traffic, using domestic energy sources and electrical supply is far from what it should be and how we would all like it to be. At present, further development of centralized supply is doubtful, decentralized supply is required especially because of the non-economic electricity prices, not justified in the long-term development of the city.

Cities as separate urban areas, with concentration of population, cultural, historical and other characteristics, have a tremendously fast and uncoordinated development. As factors of urbanization, cities have contributed to the development of industries of the country and changes in agriculture. With the development of services their operation has become more complex and rational, with all the social consequences. In the cities there is a concentration of most of the (energy) production capacities and the overall economic development depends on their rational operation. Therefore increasing attention is devoted to the problems of their development in terms of economic stabilization, traffic, gross revenues increase and the similar. Share of urban population grew in the overall population of Bosnia and Herzegovina (B&H) and in 1991 the percentage of the population was 43 %.

2.2. The indicators in B&H

Although in Bosnia and Herzegovina the energy needs and energy related data are not followed statistically precisely and there are very limited data on the municipalities, cities, etc., the cities, particularly the largest industrial centres are spending increasing amounts of energy. As seen in Tabs. 1 and 2, energy consumption and electric energy consumption per capita in Bosnia and Herzegovina in year 2000 were considerably lower than the world average.

Table 1 Energy consumption per capita in the world in 2000

	Year	
	1991	2000
World	69 GJ/capita	70 GJ/capita
Developed countries	–	230 GJ/capita
B&H	73 GJ /capita	45 GJ/capita

Table 2 Consumption of electricity per capita in 2000

World	2 343 kWh/capita
OECD countries	8 089 kWh/capita
B&H	1 915 kWh/capita

In 2001 there were approximately 3.9 million inhabitants in Bosnia and Herzegovina, GDP per capita was approximately 1.270 USD and the urban population in total population was approximately 43 %. One indicator of the efficiency of energy use is the country's energy intensity defined as a ratio of energy consumption and GDP.

Table 3 Energy Intensity Indicators 2000

World	10,14 GJ insurance 1.000 $ US GDP-a
Developing countries	22,57 GJ
B&H	30,1 GJ

The main sources of primary energy in Bosnia and Herzegovina are coal and hydropower. Annual production of energy from these sources in B&H in 2001 amounted to 62 % of total primary energy consumption, which is a clear indication that Bosnia and Herzegovina depends on energy import, because it is impossible to replace some domestic energy. Demand for gas today is significantly lower than in 1991, because of the situation in the industrial sector. It is also important to point out the bad structure of gas consumption. Most consumption is achieved in the households. Gas supply is from only one direction, which is a problem in terms of the security of supply. Storage of oil and gas reserves in our country does not exist. The EU made the preparations for the increase in reserves above the required 90-day reserves.

Households in B&H have connections to the electricity grid, but they are rare for gas and central heating. The most vulnerable population categories spend significant revenues on securing the basic energy needs (mainly coal and wood), and wood heating is very frequent in poor families.

The main consumers of the final forms of energy are households, commercial sector, industry and transport. In the EU countries with similar climate, these shares are:

Table 4 General Indicators for Tuzla 2005

Municipality of Tuzla	Population	Density	Area km2	GDP ×1000 KM	GDP per capita KM	Derivatives ×1000 l	Number of motor vehicles
	135 785	461,9	294	664 574	4 894,3	38 569	20 894

Municipality of Tuzla	Number of employees and rate	Unemployment and rate	Number of companies	Number of enterprises per 1000 inhabitants	Investment in technology, per capita
	28 938 21,9 %	16 360 36,1 %	1963	14,5	80 KM

- 40,7 % for households and commercial sector
- 31,0 % for transport
- 28,3 % for industry.

In Bosnia and Herzegovina in 2000 there share are:
- 50 % for households and commercial sector
- 25 % for transport
- 25 % for industry.

The share of households and commercial sector is the largest. The energy consumed in households and commercial sector is used for space heating (mostly), obtaining hot and sanitary water, cooking, lighting, appliances and equipment operation. Reduction of energy consumption can be achieved by using a central heating system. There is no measurement of heat consumption individually for each consumer.

In road transport oil should be replaced by gas; there is a need to turn to railway transport, passenger motor vehicles should be more focused on the use of gas, a trend in EU countries and the region. The traffic in the city has to be partly substituted with domestic forms of energy (introduction of trams and trolley buses in phases). Specific energy consumption and total consumption per capita in the city is much higher than the average of Bosnia and Herzegovina. As an example, the municipality of Tuzla was taken into consideration and the data are presented in Tab. 4 [3].

2.3.
Energy policy in town

In the earlier period of cheap and available energy, most cities in the world, as well as our cities, were not giving necessary attention to the issue of energy security. This lasted until the famous "oil crisis" 1973/74 (really an energy crisis). Cities were the sole consumers that appeared on the demand side, leaving to the state or someone else to solve the problem of production or import of energy. Today the situation has changed, because the cities, like all consumers, understand that the conventional fuel sources are exhausted and that "the most expensive energy is the non-exiting one", that our energy resources are currently small and insufficient to meet all the needs, especially in high-quality forms of energy, and that it is necessary to substitute the imported energy in all areas of consumption. The situation is particularly pronounced in large cities, because in previous periods they practically abandoned coal, they used better fuels, mostly imported, and of course electricity to meet the low-temperature needs. The galloping increase of oil and gas prices and the decrease of possibility to import, due to our poor economic situation, especially affected the cities. Thus, in Tuzla, in the last years there have been tremendous changes in the consumption structure of the customers' energy supply, but that is not enough for sufficient use of domestic energy and potential.

3.
Analysis of energy consumption in Tuzla
3.1.
Heat energy/district heating system in Tuzla

Warming up more housing units (apartments or other areas) from a central place in the city of Tuzla started in 1955 by the construction of local and domestic heating plants. Since 1965 to 1978, due to increasing demands and needs, it moved on to the concept of heating by the block or regional heating plants with higher energy efficiency, i.e. better utilization of the fuel [4]. Increased standard of living and increased demand for environmental protection and increased need for a more rational use of energy and energy resources created the idea of remote heating of Tuzla.

The first study was made in 1967. Due to the electric utility plans, solution was found in reconstruction of the existing 100 MW blocks. According to the planned connection to the district heating system, the capacity of the main heat pipeline of 145/75 °C (220 MW) regime was reached in 1983, and in 2000 the capacity of 175/75 °C (280 MW) regime was used. According to the projects of long-ago, before the war, heat production in the Tuzla thermal power plant and transmission capacity of thermal energy from producers to consumers should have been increased. The work started before 1991, while the reconstruction of the Block IV in the thermal power plant Tuzla was performed after 1991, which provided possible production of additional 260 MW of thermal energy. This satisfied basic requirement that, after the reduction of the need for thermal energy of Lukavac (approximately 60 MW) and Zivinice (approx 40 MW), additional 160 MW of thermal energy be redirected together with existing 174 MW to the city of Tuzla. The dynamics of connection to the remote heating system did not follow the planned connection projects. Till 1985 the plan amounted to 131,2 MW while 76 MW was connected and in 1992 212,8 MW was planned with achievement of 145 MW. At the end of 2004 the remote heating system in the city of Tuzla was connected to the thermal power consumption with engaged capacity of 173,17 MW as listed in the data and documentation, "Centralno grijanje d.d." Tuzla. From the standpoint of engaged capacity there was still the possibility of increasing the heat consumption to 45 or 50 MW. Due to the technical inability of manufacturers of hot water (thermal power Tuzla) to achieve 175/75 °C operation regime, and to the age of heat pipeline - deterioration of its technical characteristics, hot water capacity of 280 MW could be objectively achieved. This given, heating capacity will practically very quickly become a bottleneck of development of heating the city of Tuzla.

By introducing the district heating system from 1983 to present time approximately 67 regional and local boilers

Table 5 Overview of the heated area in m^2 per year

Categories of users	Year					
	1999	2000	2001	2002	2003	2004
Institution	98 410	108 696	108 696	107 068	124 787	124 915
Economy	193 974	198 084	199 869	203 471	184 257	175 293
Legal entities	292 384	306 780	308 565	310 539	309 044	300 208
Household	656 915	661 733	661 789	705 315	714 634	734 482
Toiral	949 299	968 513	970 354	1 015 854	1 023 676	1 034 690
Index	100	102	102	107	107	109

Table 6 Volume taken heat generation from Tuzla by year

Description	Year					
	1999	2000	2001	2002	2003	2004
MWh	197 533	186 900	181 070	194 038	238 541	219 918
Index 1999=100	100	95	97	107	123	111
Number of days of heating/-	189	172	179	178	192	168
Daily consumption/ MWh	1 045,15	1 086,63	1 011,56	1 090,10	1 242,40	1 309,04

Table 7 Daily energy consumption per m^2

Description	Year					
	1999	2000	2001	2002	2003	2004
MWh	197 533	186 900	181 070	194 038	238 541	219 918
Average temperature / °C	4,30	6,10	5,30	7,00	3,80	5,78
Number of days of heating/-	189	172	179	178	192	168
Heating surface / m^2	949 299	968 513	970 354	1 015 854	1 023 678	1 034 690
Consumption kWh/m^2/day	1,10	1,12	1,04	1,07	1,21	1,27

with installed capacity of about 105,28 MW have been closed, although there are still in use about 50 small local boilers. Hot water is distributed from the main hot water pipeline through a thermal network to 366 thermal stations, through which the heating is performed. According to data from the end of 2004 there are 13 936 households (and small number of individual objects), 101 objects in category "institutions" and 1491 commercial spaces in category "economy" including parts of industry users connected to the remote heating system.

Tab. 5 indicates that between 1999 and 2004 there was an evident constant increase of the heating area. The biggest impact was from the household category, but it is important to note that constant heat supply was suspended to some consumers from the economic sector due to the lack of payment or cancellation of the use of heating services (TTU, Hotel Tuzla, Auto Center, Veleteks and others). Part of the cultural and educational institutions went from accounting systems through the heating calorimeter to calculating per sq chto that caused a fall in heating the area of "economy" and an increase in heating the area of "institution".

The total amount of energy consumption should be directly proportional to the changes in the heated area and the number of days, and inversely proportional to temperature changes. From Tab. 5 such a conclusion cannot be fully performed. In 2000, compared to 1999 there were fewer days of heating with increased average temperature, which should have affected reduction of energy consumption per square meter per day. But the data is reversed. The same thing happened in 2002 compared to 2001, and 2004 by 2003. The explanation is in increased losses and low effective expenditure of thermal energy. Of the total number of substations (366) meters of thermal energy consumption were set at 92 substations. Since heat measurement equipment (calorimeters) were not built in at all substations, it is not possible to determine this relationship in an exact way. In order to consider energy efficiency of district heating it is therefore necessary to have 100 % coverage of the final measurement of energy consumption.

In conclusion: district heating system of the city of Tuzla has not achieved the planned volume. The maximum of hot water pipeline capacity will soon be reached. All this proves that the new transport capacity of the thermal media is necessary. Summing all the elements the room heating in Tuzla is carried out on one of the following:

- District heating system of the city of Tuzla and the distribution of that energy to the consumers connected to the district heating system.
- Production and distribution of thermal energy to the heating body in the households and economy objects from local home-boiler.
- Heating of individual household units and apartment stoves (or other heating equipment) with solid fuel-coal, wood, el. energy, oil and gas.

Because of the need for reducing environmental pollution in Tuzla, conservation of energy resources, reducing heating costs and improving living conditions of those who have no heating from district heating systems (keeping in mind that the system of heating is not installed at approximately 50 % of the initially planned capacities), accelerated building of district heating system has become a top priority issue in the city of Tuzla and the neighbouring municipalities.

3.2. Electrical energy

According to the data from the electricity distribution utility of Tuzla (ED Tuzla) average increase in electricity consumption between 1999 and the end of 2005 was by about 4,5 %. This increase in consumption of electricity was followed by a decline in the production of electrical energy sources. In 1999 generator G1 at the power plant Tuzla with 32 MW of rated power was taken out of operation, followed by the G2 generator connected to the 110 kV bus. Generator G1 was tied to a 35 kV bus and there has been a reduced availability of energy at this voltage level since. The Tuzla town is fully powered only from the Tuzla-Centar power station 110/35/10 kV and the supply does not meet the security of supply ($n-1$) criteria of secure supply in case of a single power system component failure [5].

Table 8 Overview of electricity consumption in Tuzla (LV- customers/households)

Year	NN customers (household) / kWh	Growth / %
1997	91 418 090	–
1998	121 228 720	32,60
1999	118 958 380	–1,87
2000	116 630 460	–1,95
2001	120 726 510	3,51
2002	123 060 250	1,93
2003	123 241 050	0,14
2004	127 516 515	3,46
2005	139 235 127	9,19

Table 9 Specific consumption per customer/household

Year	No of customers	Electric energy consumption/ kWh	Specific consumption kWh/customer	Specific consumption/ kWh per capita
2003	40 003	123 241 050	3 080,79	1 026,93
2004	40 528	127 516 515	3 146,38	1 048,79
2005	40 818	139 235 127	3 411,12	1 137,04

Table 10 Indicators of consumption Electricity in Germany

Number persons per household	Consumption per year	
	Household /kWh	Capita /kWh
1 person	1 798	1 790
2 persons	3 030	1 515
3 persons	3 880	1 290
4 persons	4 430	1 110

Source: Electric power association (VDEW) of Germany, for 2000

There has been a constant increase in electricity consumption at households in Tuzla in the last three years. Electricity is still irrationally used for regular supply of electric power in winter. It can be argued that electricity consumption is higher per household and per capita in the urban metropolitan area than in suburban local communities.

3.3. Public transport

In B&H, the price of oil increased by 79 % in the period of January 2003 to September 2005. Unlike other municipalities in B&H, thanks to its position in the municipality of Tuzla and its wider environment, Tuzla has a standard daily migration in the territory of the municipality, which is conditioned by the need for communications with certain services, daily supply, or other motives.

In order to meet the needs of citizens in the Tuzla area urban and suburban traffic is organized. There are several companies engaged in this activity. All companies, except GSP Tuzla, perform line long-distance traffic. According to the number of registered passenger seats and the number of passengers transported the GSP Tuzla is dominant with a share of 41 % and 51 %. The GSP Tuzla is the only one to have representative indicators, because it is of optimal size with exclusive participation of urban and suburban traffic. Therefore approximate parameters for the necessary transportation in the city of Tuzla are taken from the indicators of GSP Tuzla.

Table 11 Fuel consumption and number of passengers in GSP in Tuzla

Year	Spent fuel diesel, l	Number of passengers transported
2001	2 228 492	14 524 054
2002	2 335 504	15 184 084
2003	2 511 416	15 338 975
2004	2 529 860	15 004 493
2005	2 386 805	14 748 077

Considering the tradition, the performed privatization process, expected trends in the energy market, it is necessary for the GSP Tuzla, the municipality of Tuzla, the Tuzla Canton and B&H to find a solution for introducing of trolleys or electric driven buses in the first phase. This will contribute to even better and greater financial and in particular environmental effects while in the future it will not be possible to include classic buses in traffic of the city of Tuzla. The transport in Tuzla has become a significant environmental pollutant so that in the future it should be reduced to the smallest possible measure. Effects would be reflected in better energy efficiency achieving better (lower) energy intensity: higher GDP per capita with lower energy utilization.

3.4. Energy indicators in Tuzla

Long-term energy balances allow the substitution of expensive strategic planning and unsafe imported fuels with local domestic energy sources and demand immediate development plans and environment protection, with the optimization of necessary investments.

Even if the ratio of energy prices does not provide immediate economic effects it is necessary to prove the benefits by a qualitative techno-economic analysis. It is also important to consider both the conventional and the alternative energy sources. There are a small number of cities and municipalities in B&H that have made their energy balances. Assessing energy balances enables monitoring of expenditures and structuring of consumption

Table 12 Consumption of all forms of energy in the city of Tuzla

Year	Electricity Household/ MWh	Heat/ "CG" d.d./ MWh	Traffic/ GPSTuzla/ MWh	Heating individual houses/ MWh	Own transport/ m/v MWh	Total/ MWh	Consumption per household/ MWh	Consumption per capita/ MWh
2001	120 726	181 070	27 931	130 000	120 000	579 727	14,49	4,83
2002	123 060	194 038	27 896	130 000	120 000	594 994	14,87	4,95
2003	123 241	238 541	29 997	130 000	120 000	641 779	16,04	5,34
2004	127 516	219 918	30 217	130 000	120 000	627 651	15,69	5,23
2005	139 235	220 000	28 509	130 000	120 000	637 744	15,94	5,31

in available terms, with the least impact on normal operation of all functions in the city and the municipality, and safer planning and provision of necessary quantities of fuel and energy by type.

Personal and general consumption exert the strongest influence on the structure of the estimated energy consumption in cities, as it can use all types of fuels and energy. Type and volume of fuel are pre-designated in industry.

Centralized electricity supply is still largely present in B&H. Virtually 100 % of households are covered by electrification. Space heating problems now lead to irrational use of electricity or to a very poor performance of the complete power system. Load curve of the cities, major municipal centres, is a classic load curve of the household, with all indicators of a large deviation of variable loads.

Electricity should mainly be used for heating and hot water when it is not possible to build a system of centralized supply of hot water or gas. Frequent use of large number of heaters can lead to the overload of low-voltage installations, increasing the peak load and thus the unavailability of distribution system because it does not tolerate such an imbalance.

The energy should be used rationally only for the low-temperature requirements as stated above, but this is not the case today in Bosnia, with the share of household consumption from 50 % to 70 %. Electric energy in B&H is the only wide-spread local form of energy. It is produced in thermal and hydropower plants. Using electricity in heating contributes to a large load in power system during the heating season and the total irrationality of using primary energy. It is therefore necessary to coordinate electric power systems with the centralized heat energy supply. The problem is that the centralized heat system is insufficiently developed and does not meet the long-term function.

Systems of centralized heat and gas energy supply allow for the rational use of energy in the heating, domestic hot water and cooking, and substitute the electricity, which is now indispensable in the world. Today the dilemma regarding the use of gas or heating system of energy supply is finally removed. After the winter of 2005/2006 and problems with unavailability of gas supply from Russia (Russia – Ukraine dispute), the best option for district heating system is in energy supply based on domestic coal, wherever it is realistic and economically viable. This system has the advantage over the other taking into account the availability of fuels, phase construction, culture, housing and many social and community aspects of using a certain type of energy. The main problem in the use of domestic coal is the pollution of environment, but today these impacts are reduced to the technically acceptable amounts.

If we want to achieve that every consumer uses energy rationally we must be more agile in Tuzla to start with the reconstruction of the existing system and give each individual consumer the possibility of individual measurement. There is no justification in the 21st century for avoiding such activities by the "Centralno grijanje d.d." Tuzla. We must offer consumers such a possibility and ask from them to take part in financing such projects as in the long run this investment will pay off and bring profit in the end. The consumers will certainly reduce energy consumption which will in turn reduce the pollution of environment.

This will justify the wise German saying that "the best energy is an unspent energy". The fact is that such interventions require considerable investment, but in fact the majority of end users are willing to finance such projects. Several pilot projects (2-3) at several entrances to the city are in the course. With small interventions the existing heating systems could be adapted to allow the installation of individual heating meters in each apartment.

There is also the problem of passing legislation delay in this area by local communities, municipalities, cities. The mere privatization of public enterprises involved in this issue, which was completed in the past, will not contribute to the same starting conditions in economic savings and rational use of energy for each individual consumer. The standard of living falling trend adds to the worsening situation of the issue. Residential buildings of the pre-war period do not meet the standards in construction, i.e. thermal performance of buildings. Consumers are not encouraged to perform interventions on objects. Local councils of municipalities and cities must initiate the most urgent issue of legal regulation of this field. Failure to solve these problems will cause certain adverse economic, social, political and technical consequences.

In the city of Tuzla and all municipalities, main problem is the development of municipal energy infrastructure. This is a limiting factor for harmonious economic energy and environment development with adverse consequences for the living standards and of course for economic conditions. The situation in the municipal infrastructure of any municipality is not satisfying. Existing financial sources in municipal budgets for this purpose cannot provide even a normal maintenance. Bank funding for this purpose is approved with unfavourable interest rates, which is unacceptable for all utility companies involved in supplying heat. Their activities in this area are therefore mostly reduced to some kind of putting the system into operation. The system in the city of Tuzla is burdened with war debt and uncertainty for each of the heating seasons. But we must find a way to engage experts in teams to solve the problem of energy in the Tuzla area. A positive example might be the experience of neighbours, primarily the Republic of Croatia, which has made substantial progress in this field.

4
Possibility of saving and rational using of energy

In the future the development of our cities and all urban centres will depend on their ways to solve problems in energy, and of course in all sectors of consumption. More efficient use of energy will be a key part in solving energy problems. Given the complexity of the energy situation, all factors in this area must initiate more frequent conferences and consultations devoted to these topics (County, Tuzla University, Municipality, etc.). This will properly direct all activities concerning the problems in this area, in a time of the weak economic power of each municipality separately. But these meetings will contribute to policies directed towards the efficient use of domestic energy sources. Today, in Bosnia, in county and in each municipality it is difficult to follow the annual energy use so to talk about the rational use of energy is almost impossible. It turns out that the rationalization of energy consumption can be substantially achieved in the larger urban centres and in Tuzla. Energy can save money by improving insulation characteristics of existing facilities, construction of new buildings with modern materials and installation of quality thermal insulation, taking into account the orientation of buildings (insulation). By using any known scientific method we can save energy up to about 30 % compared to the existing facilities. All entities engaged in the delivery of heat have to be pioneers in the "promoting" of the interventions that contribute to a rational use of all forms of energy.

Our economic condition, design, approval for building, construction, supervision and other weaknesses that follow us contribute to the irrational use of all forms of energy. Important improvements are made regarding the installation of thermal insulation of houses. It is understandable because the individual is the one funding it and will have long-term financial savings and it is safe for a society with less environmental pollution. In Bosnia, still effective Standards are from 1980, enacted after the energy crisis in 1973/74. We must overcome weaknesses regarding the implementation of the Building Act and the Law on Physical Planning TK. While presenting the possible saving and rational use, we should keep in mind that the economic situation affects all activities in terms of use and efficiency of use of all forms of energy in our area.

4.1
The centralized heating system

The centralized heating system functions in the majority of the city of Tuzla, partly in Lukavac by using the energy from thermal power plant Tuzla. In other municipalities, counties have a modest capacity for a centralized heating system of urban centres. The heating system in the city of Tuzla in this form has been in operation for 22 years while some parts of the heating networks are older than 35 years. Deterioration in this part of the network is the largest problem in the system exploitation because failures that require large resources for the partial rehabilitation are very frequent. The problem is with 26 deteriorated sub-stations installed in the settlements "Slatina" and "Irac" of the "mixing" type of age of about 30 years causing inability for rational regulation of the entire system which in turns prevents a significant reduction in energy consumption. The past war period accelerated ageing of the system, because in that period and the last 6÷7 years no work has been performed on capital maintenance of the system due to lack of funds from the sale.

Currently the main problem of heating is the lack of productive resources in reserve in thermal power plant Tuzla. War events interrupted the completion of the reconstruction of four blocks of 200 MW in Tuzla, which would be the main source of thermal energy and the current block 2 of 100 MW would be a 100 % reserve in case of failure or major fault in the fourth block.

"Centralno grijanje d.d." has permanently implemented the project of remote monitoring and control system. Data analysis gives guidance to improve energy efficiency and energy savings. The programme for measuring heat consumption must be actualized because it is in accordance with the White Paper of the EU directives and the Law on Consumer Protection in Bosnia and Herzegovina. "Centralno grijanje d.d." is working on implementing the measurements of actual heat consumption. The project includes installation of cumulative heat consumption meters at the buildings and entrances. Heating costs will be charged according to actual consumption in the facility and will enable significant savings and direct each tenant to directly affect the amount of heating bills. In the near future it is necessary to:

a) replace worn-out hot water and hot water pipeline network in the settlements of Novi Grad, Boulevard and Slatina,
b) build 40 new "convertible" type heating substations Slatina in settlements and in Irac,
c) complete work on the information system of remote control,
d) increase the utilization of the current consumption of 174 MW connection of the remaining buildings in the old city centre and resort Pašabunar,
e) move to a new payment method for heat based on actual consumption,
f) ensure financial ability for investments in network expansion and rehabilitation of heating,
g) increase the level of debt collection by heating,
h) adjust staff employment in accordance to the planned development of the company,
i) adopt a strategy for solving problems in the district heating sector in B&H,
j) establish a system of regulating prices of central heating at the state level,
k) regulate energy prices, with the specificity of each system.

In conclusion: central heating systems in general and in Bosnia and Tuzla are deteriorated, due to very little investment in maintenance, so their costs and energy losses in the system are high. Responsibility of the municipality through the public company for central heating in Tuzla affects the maintenance with unrealistic low cost of heating. The tariff and collection rates are insufficient to maintain the system, which makes this sector economically unsustainable.

4.2
Industry/raising energy efficiency

In Tuzla, the industry can significantly contribute to reducing the consumption of all forms of energy. Most industrial plants have been privatized, all these systems are at a very low technological level. It is necessary that the new owners make a qualitative analysis of the situation in plants and methods of quality procedures at these facilities, which are known in the world and will certainly contribute to

energy efficiency and of course reduce energy consumption. This project should be implemented with expert persons. But generally the situation with private businesses is in implementation of "a policy of maximum profit with minimal investment in equipment and payment of labour". The problem is that in such companies even highly educated work force is paid very low, and therefore we do not have significant results in this field.

4.3
Energy audits for public buildings

It is necessary to perform energy audits for all public buildings in the Tuzla county and B&H, such is the practice in e.g. the neighbouring Republic of Croatia [8].

Characteristic of the fund of public buildings in Bosnia and Herzegovina (other than newly constructed residential and commercial buildings) is irrationally high energy consumption. Experience shows that the use of various energy efficiency measures can achieve energy savings up to even 80 %. An energy audit of buildings is a document on the energy performance of buildings that is based on collecting and processing data collected by a precise form, which will result in the proposed energy efficiency measures and energy-optimal economic order of their implementation to reduce consumption of all types of energy in a reference building.

Form of energy audit of the building is divided into three main sections:
- Data collection;
- Data processing;
- Measures to improve energy performance of buildings.

The main objective of the energy audit is the collecting and processing of clearly defined parameters of the building to get an accurate insight into the situation at the building as to its construction characteristics, quality systems for heating, cooling, ventilation, lighting, frequency and quality of power devices, building management structure and enabling access to employees on energy issues. Energy audit is therefore a basis for specific and economically optimal energy efficiency measures for the observed building whose implementation will result in significant savings of various types of energy, on one hand, and financial savings on the other side. The last stage in the implementation of energy audit of public buildings is a concrete proposal of the order of energy efficiency measures for the reference building for public purposes, whose implementation will depend on the decisions of the building owner management.

It is necessary for Tuzla to start with energy audits for public establishments (schools, hospitals, clinics, kindergartens, universities, etc.), and the owners of the funds and collective residential buildings (apartment buildings). To carry out these activities it is essential to ensure highly educated staff which is certainly present in the county. In particular the largest achieved savings of this project are in thermal energy (heating).

Municipality of Tuzla performed a complete study of the needs and possibilities of introducing trolleybus traffic in Tuzla. The 1991 investment program was prepared in the GSP and the Municipality of Tuzla made concrete preparations for the construction of the contact network and supply trolley. The Autobaza Transportation Company, the "aerated concrete" whose construction is already partially realized, is based on the introduction of trolleybus transport in Tuzla. As part of the restoration of transport capacity in 1996 and post-war development JGSP and by the year 2000 the TPK in Tuzla also, actualized the introduction of trolleybus transport in Tuzla [6]. According to the indicated study actualized needs, trolleybus transport in Tuzla would be introduced on two lines:

1. Autobaza (Siporeks) - Solana - Slatina - Brčanska
2. Malta-Simin Han (The north road) ,
3. Autobaza (Siporeks)-N. From crack-BKC Tuzla - Sjenjak - Brčanska Malta - Solina (The south roads).

Because of a single departure from current autobaze GSP Tuzla and their intersections in Brčanska Malta, these two lines give the possibility of the roundabout at the narrow and wider metropolitan area. Also there is a possibility of extension of trolleybus traffic - the line to the east of Gornja Tuzla, west to Lukavac, and south to Živinice and Banovići, as phase II or project to be done in phases II and III as a regional-county project.

For introducing trolleybus traffic in the city of Tuzla it takes about 30 km contact network with 15 km of cables and 4 power supply rectifier stations, 32 trolley buses, an additional building space for servicing and maintenance of approximately 2 000 m^2 and 4 480 m^2 parking - garage space.

Table 13 Investment in trolley lines in the city of Tuzla

	×1000 KM
Contact network	
Power cords	3 473
Rectifier station 1 MW/24 pcs	2,544
Contact line /30 km	12 500
Vehicles and Other	
Trolleybuses 32 pcs	7 360
Workshop building 2000 m^2	2 400
Garage parking space 4480 m^2	672
Equipment servicing and maintenance	360
Total	**29 309**

Electric traction of 1 kWh replaces on average 0,28 kg of diesel or 2,5 kg of coal in steam traction. This is the proof that electric traction in the drive is cheaper than diesel and steam power plant [7].

The typical ratio of specific energy consumption for electric (E), diesel (D) and steam traction (S) is as follows:

E : D : S = 26 kWh/1000 gt/km (gross ton, kilometre)
6,8 to 8 kg of diesel/1000 gt/km
62÷71 kg coal/1000 gt/km.

It may be proven as technical and economic advantage to use electricity in transportation, with all indicators that are of interest to town and wider area. It is necessary to re-actualize this project - to increase energy efficiency in Tuzla and to reduce energy dependence on oil and its derivatives, to increase the use of domestic electricity generation, employment of local companies and personnel, and to reduce the environmental pollution.

In the second phase we could introduce vehicles that are used as a fuel and electricity ACCU battery (bus EDF, which is already used in the cities of France, Italy and Spain). In order to substitute the imported fuel it is necessary to maximize the use of rail transport, which would result in much better energy efficiency and traffic safety, having in

perspective that the roads in Bosnia do not meet the necessary safety requirements.

4.5
Media

It is necessary to promote energy conservation on a daily basis, organize competitions for drivers of foreign energy suppliers, which will result in reducing energy consumption. It remains to pay attention to the energy efficiency issue in the educational system of Bosnia and Herzegovina, too.

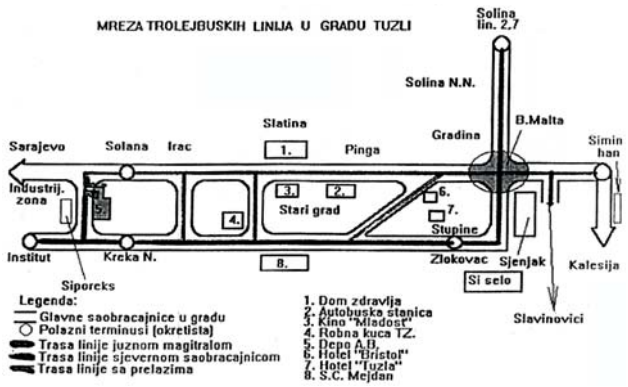

Figure 1 Simplified network view trolley lines in the city of Tuzla

5
Conclusion

Can cities and municipalities in B&H today effectively solve prominent problems in the area of energy policy? Certainly not. In Tuzla, as well as in surrounding communities, primarily in Zivinice and Lukavac we must use the maximum available heat energy from thermal power plant Tuzla. Individual citizen with his/her family in the suburban area, rural and most municipal areas of the Tuzla county is left on his/her own in terms of heat usage. The dominant way of heating living space is by solid fuel, the classic way to warm rooms or central heating system with the use of brown coal. A large number of households that previously used oil have transferred to the use of solid fuels.

The problems are reflected in the following:

- Lack of energy strategy,
- The technological backwardness.
- Administrative pricing of electricity,
- Postponing the restructuring of mines,
- Lack of transparency in the PE (EP companies)
- Irrational use of energy,
- High transport costs,
- Lack of reliable statistics, etc.

Due to the lack of energy strategy at the state level, the municipality must pay special attention to issues of energy efficiency and rational use of all forms of energy in the future. In an era of instability of oil and gas prices and supply in B&H the pioneering steps in understanding this problem and first results could be expected very soon.

And what we will need are the experts that could reflect themselves in the following:

"We are opening vacancy for the position of graduate engineers, who have the ability to work on the construction of modern furnaces of cast iron and who will assist in training for mass production. These furnaces must produce enough electricity and heat and in doing so must not threaten the environment. In addition to experience in the areas of technology, engineers are expected to economise, and this means that the technology used in these furnaces should not be too expensive, so it might be available to developing countries". Such should be a text for the competition for a position that would accommodate today's needs. The competition should primarily refer to engineers and technicians specialized in the field of thermal power plants whose operation is based on fossil energy carriers.

The necessity of working hard for the realization of one's vision can be exemplified by the words of Jules Verne, who in the novel "Mysterious Island" written in 1870 said: *"I believe that one day the water will be used as fuel, that hydrogen and oxygen, from which it is made, together or separately used, will become inexhaustible sources of heat and light, and to a far greater extent than coal. Water is the coal of the future.*

6
References

[1] Mirković, B. Osnovi urbanizma, Građevinska knjiga Beograd, 1983.
[2] Energija i razvoj, Jugoslovenska naučna tribina, Beograd, 1986.
[3] Socioekonomski pokazatelji FBiH, FZZPR, Sarajevo, 2005.
[4] Prostorni plan opštine Tuzla, Opštinski zavod za urbanizam Tuzla, maja 1985.
[5] Analiza trenda kretanja isporučene el.energije kupcima po PJ distribucije, naponskim nivoima i kategorijama za period 1997.-2005., ED Tuzla, Tuzla, marta 2006.
[6] Program obnove transportnih kapaciteta i poslijeratnog razvoja gradskog i prigradskog saobraćaja na području TPK-Transservis Tuzla, Tuzla, maja 1996.
[7] Tehnička enciklopedija 4, Jugoslavenski leksikografski zavod, Zagreb, 1968.
[8] Master plan energetske učinkovitosti za Republiku Hrvatsku, www.energetska-efikasnost.unpd.hr

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