ENERGY EFFICIENCY IN SERBIA
– Research and development activity –

by

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Review paper
UDC: 620.92
BIBLID: 0354-9836, *10* (2006), 2, 5-32

Energy system in Serbia, from exploitation of primary energy sources, transformations in electric power plants and district heating plants, energy (electric and heat) transmission and distribution to final users, is faced with a number of irrational and inefficient behaviors and processes. Those are consequences of the old technologies in use, old equipment at the end of their life time, bad exploitation of the equipment in use, wrong energy strategy in the past, unsuitable energy price policy, as well as delayed refurbishment of the equipment and delayed implementation of the modern technologies. Structure of the industry, developed after the World War II, also contributed to a high specific use of energy per unit of production.

Paper gives a short review of the present status of energy system in Serbia, with special emphasis on the energy efficiency, renewable energy sources use and import energy dependence. Main part of the paper is devoted to the activity of the National Energy Efficiency Program (NEEP), founded by Ministry of Science and Environmental Protection. A program started in 2002, and in the period up to 2005, 140 R&D&D projects and 25 feasibility studies have been financed. The main aim of the NEEP is to combine research and engineering activities in order to research, demonstrate, and implement modern efficient technologies and equipment, engineering and management methods, as a tool for increasing energy efficiency and promotion of renewable energy sources. The intention was also to coordinate all activities, from the choice of the priorities, selection of the best projects proposed, up to the control of the realization of the projects financed. Review of the priorities chosen in the period 2002-2005 is also presented.

NEEP engaged the most experienced researchers from scientific institutes and faculties, and engineers from industry, but implementation of the results was not successful. Main reasons can be identified as: industry and agriculture, municipal and local authorities presently are not in an economic situation to invest money in new equipment and modern technologies in order to increase energy efficiency; energy and fuel prices do not stimulate rational and efficient use of energy; favorable environment for rational and efficient behavior of the people and companies was not created by governmental policy.

Key words: *energy, energy efficiency, renewable energy sources, energy policy, R&D&D projects in energy efficiency*

Introduction

Energy system in Serbia, from exploitation of primary energy sources, transformations in electric power plants and heat power plants, energy (electric and heat) transmission and distribution to final users, is faced with a number of irrational and inefficient behaviors and processes. Those are consequence of the old technologies in use, old equipment at the end of their life time, bad exploitation of the equipment in use, wrong energy strategy in the past, unsuitable energy price policy, as well as delayed refurbishment of the equipment and delayed implementation of the modern technologies. Structure of the industry, developed after the World War II, also contributed to a high specific use of energy per unit of production.

Inadequate operation of the energy system in Serbia and poor efficiency of transformation in energy production, transmission and end use, are so large that improvement of energy efficiency is the best, quickest and most powerful method to increase the primary and final energy supply, as well as for an increase of efficiency of industrial production, lowering prices of industrial products and for reduction of dependence of Serbian economy on imported energy and fuels.

With very small investments, better choice of energy and fuel mix and implementation of better organization and quality of equipment operation, it is possible to achieve significant energy savings and to improve economic effects, leading to the better competitiveness of industry on a world market.

Present status of energy sectors in Serbia

Short review of some characteristic data can illustrate present status of energy system in Serbia:

gross a national product (GDP) per capita fell 2.5 times in the period 1989 till 2000,
electric energy consumption per capita reached 3400 kWh/year, which is approximately on the level of medium developed countries in Europe, but electric energy consumption of 1700 kWh/1000 $ of GDP is greatest in Europe,
total primary energy consumption per 1000 $ of the GDP is also the greatest in Europe – 1100 ten, but total primary energy consumption per capita is the smallest in Europe – 1500 ten,
energy losses in electric energy transmission and distribution networks are the greatest in Europe – 14%,
price of electric energy in 2001 was about 0.7 c$/kWh, several times lower than in European countries (today is about 4 c$/kWh), and
electric energy consumption in households increased in the period 1990 till 2000, from 35% to more than 60% of total consumption (indicating use of electric energy for heating), at the same time energy consumption in industry decreases from 37% to 31% of total consumption (due to the drastic reduced activity).

Structure of the conventional energy resources

According to present geological investigations, greatest geological energy resource in Serbia is coal (about 80%), in particular low rank lignite (about 65%). Share of hydro energy in large rivers, enabling economical electric energy production, is less that 10%. Share of other reserves which are not in exploitation (small coal mines, oil shale, and small rivers) which can be activated in short time is about 15%. A similar situation is regarding exploitable energy reserves. The share of coal is about 88% in total, and possible energy production using remaining available reserves (small rivers, small coal mines, and oil shale), can be about 10% most.

In tab.1 fossil energy resources and hydro potential are compared [1].

Table 1. Energy reserves in Serbia*

	Geological reserves		Exploitable reserves	
	Mten	%	Mten	%
Coal – total	**1270**	**77.57**	**772.25**	**87.94**
– Possible new mines	82	5.01	41.6	4.74
– Coal mine Aleksinac	12	0.73	5.4	0.61
– Small mines exploitation	105	6.41	65.25	7.42
– Lignite (open pits)	1071	65.42	660.00	75.17
Oil shale	**140**	**8.55**	**84****	**9.57**
Oil and natural gas	**60**	**3.67**	**20**	**2.28**
Hydro potential***	**167**	**10.21**	**1.67**	**0.21**
>10 MW	152	9.29	1.52	0.19
<10 MW	15	0.92	0.15	0.02
Total	**1637**	**100.00**	**877.92**	**100.00**

* Not including reserves in Kosovo and Metohija
** Estimated as 60% of geological reserves
*** Hydro potential was estimated as 100 years for geological reserves and 1 year for balance reserves

Lignite is the largest natural energy source in Serbia. However, lignite resources in Kosovo and Metohija are under authority of United Nations Security Council, and it is not possible to count on them in the near future. Lignite in open pit mines Kolubara and Kostolac are already engaged for the existing power plants or for power plants planned to be built in the near future. Power production using lignite in large power plants presently enables Serbia not to import electric energy, but it is questionable if this will be possible in the next period of 10 years, considering the increase of economic activity and indus-

trial production (according to the recent predictions that growth of GDP of 7% per year is possible up to 2012). Nevertheless, it is not possible to count that lignite, as largest energy resource, can contribute in the near future to the reduction of dependence on imported fuels in energy production in industry and district heating. Considering those facts, it is interesting to indicate the existence of reserves of the bituminous and sub-bituminous coal and lignite in small deposits, since this energy resource, in spite the fact that those are small amounts compared to reserves of lignite in open pit mines, can highly contribute to the reduction of oil and natural gas presently used in district heating and energy production in industry, *I. e.* for so called distributed energy production, which (according to new Energy law) is declared as privileged power producer, and will be stimulated in the next period.

Comparison of the geological reserves of coal in different deposits is given in tab. 2.

Table 2. Different coal deposits – comparison of energy value

Deposit	Geological reserves			Average lower heat value
	Mt	Mten	%	MJ/kg
Lignite – open pit mines in exploitation	5980	1071	85.1	7.5
Sub-bituminous and bituminous coal – small mines, underground mining	275	105	8.5	16.0
Possible future new small mines	297	82	6.4	10-13
Total	**6552**	**1258**	**100**	

According to recent estimates made in the Serbia's economic development strategy up to the 2010, prepared in 2001 for Government of Serbia [2, 3], total geological reserves in 23 small coal deposits are about 230 Mten, and about 150 Mten of the exploitable reserves. Opening of mines in those coal deposits needs a significant investments, and can yield total coal production (mainly high rank coal) of about 5 million tons/year. Crude oil and natural gas reserves are significantly smaller, being main reason of the high dependence of Serbia on imported fuels.

Hydro potential in Serbia, ready for technical use, is estimated to about 20000 GWh per year, and makes 62% of the theoretical potential. Available for small hydro power plants (10 MW) is about 10% (approximately 1900 GWh/year, with possible installed capacity of about 600 MW). As can be seen from tab. 3, total usable technical hydro potential in Serbia presently is activated about 50% (*I. e.* about 10000 GWh/year).

More than 25% of technically usable potential is in small rivers, suitable for power plants with installed capacity <10 MW.

Table 3. Technically usable hydro potential in Serbia

Technically usable potential [GWh/year]				Presently used	Not in use >10 MW
>10 MW	<10 MW	Total	Shared with other countries		
17597	1770	19447	6393	10133	7515

Renewable energy sources

Consideration of domestic energy resources ready to be used for substitution of imported fuels in short time, in order to reduce dependence of district heating and industry on imported fuels and energy, cannot be complete if we do not turn to the energy potential of biomass and geothermal energy. Both energy sources need only conventional and cheap technologies, and short construction period. Wind energy potential may also be used in specific regions.

Available energy potential of biomass waste ready for energy production in Serbia is given in tab. 4, according to the data that has been given in the study made in the frame of a National energy efficiency program (NEEP) [4]. It is very conservative estimation, as only 1/3 of the available amount of waste biomass per year is accounted for, and data are given only for woods (wood in dolts, forestry waste wood, waste from wood processing in cellulose, paper and pulp, and furniture industries), and agricultural wastes (white straw, corn cobs and corn stems, waste from orchards and vineyards and liquid wastes from livestock).

Table 4. Energy potential of waste biomass in Serbia

Type	Energy potential	
	TJ/year	Mten/year
Wood in dolts	17000	0.4
Wood waste	26000	0.6
Wood – total	43000	1.0
Agriculture wastes – total	65000	1.56
Biomass – total	**108000**	**2.56**

Available energy potential of geothermal energy in hot waters in Serbia is estimated to about 0.185 Mten, which is comparable with hydro potential in small rivers, but much smaller than energy potential in waste biomass. Possible energy production from solar energy cannot change the general picture of available energy sources in Serbia.

Dependence on imported fuel and energy

Import of fuel and energy in Serbia in several past years has increased, and presently reaches more than 40% of the total primary energy consumption, with a trend of a further increase [1, 5].

Today, Serbia can produce, and will be able to produce in next short period, enough electric energy from domestic lignite and hydro potential. However, with a further increase of industrial activity and living standard of people, it can be concluded that available domestic resources will not be enough to satisfy the needs in electric energy. In the longer terms, increase of natural gas import for electric energy production, or import of electric energy itself, can be expected, if rigorous measures will not be undertaken to increase energy efficiency and use of renewable energy sources.

Serbia dependents more then 80% on imported oil and natural gas, since domestic production of those high quality fuels cannot satisfy even the fifth of the domestic consumption. Import of oil is about 3.5 Mt, and makes 4/5 of the consumption. Import of natural gas is $2.2 \cdot 10^9$ m^3 (1.9 Mten), which is approximately 90% of the amount needed. Capacity of domestic refineries is more than enough for production of oil derivatives used for traffic, agriculture, industry, and for other purposes. Liquid fuels are mainly used for public transportation and private cars, and this part of import cannot be substituted by available alternative domestic sources. Import of coal is about 0.37 Mten, mainly (about 4/5) coke, which also cannot be substituted. Import of sub-bituminous coal is only about 0.07 Mten.

To give a realistic picture of the possibility to decrease dependence on imported liquid and gaseous fuels, structure of gas and liquid fuel consumption in last three years is given in tab. 5 [1]. More then half of the final energy obtained from oil derivates is used in traffic and to drive machines in agriculture, and this part cannot be substituted with other energy resources. Dependence on imported fuels used in industry and public activity in local communities for district heating have to be reduced for economical, energy, and strategic reasons.

In energy production in industry, the share of coal is 33% and natural gas and liquid fuels 67%, central and district heating plants mainly burn natural gas (about 70%), liquid fuels about 16%, and coal about 18%, making import dependence of this energy consumption subsector higher than 80%. If we suppose that by using domestic energy sources it is possible to substitute light oil used in households for heating, and light and heavy oil burned in district and central heating plants and for energy production in industry, for starts up and flame supports in large utility boilers, we can reach the total amount of 0.9 Mten of the imported fuels that can be substituted.

Final energy consumption in traffic and agriculture is about 2.0-2.5 Mten. This part of final energy consumption can be substituted by domestic energy sources (not counting domestic production of oil and natural gas) only by mixing of fossil fuels with biodiesel and bioethanol. Following energy policy of the European Union, member states are obliged to substitute 5.75% of fossil liquid fuels by biodiesel and bioethanol until 2010. To reach such a goal, production of biodiesel and bioethanol in Serbia should be about 0.15 Mten. According to analysis in a study financed in the frame of NEEP [6], Ser-

Table 5. Structure of oil derivates consumption

	2003		2004		2005	
	Mt	Mten	Mt	Mten	Mt	Mten
Final consumption of oil derivates	**3.430**	**3.509**	**3.698**	**3.790**	**3.901**	**4.001**
– Non energy consumption	0.519	0.532	0.701	0.719	0.764	0.786
– Energy consumption	2.911	2.977	2.997	3.071	3.137	3.215
For final use	**2.611**	**2.683**	**2.767**	**2.847**	**2.875**	**2.958**
– Industry	0.491	0.495	0.488	0.496	0.483	0.492
– Traffic	1.906	1.979	2.021	2.099	2.142	2.223
– Other	0.214	0.209	0.258	0.252	0.250	0.243

bia has enough natural resources, and enough production capacity in chemical industry, to reach production of 150000 to 200000 tons of biofuel, reaching the share of biofuel in fossil fuels consumption of 5-6%.

For possible reduction of import dependence (mainly oil and natural gas) in some of its energy subsectors, Serbia can rely on some available, but presently not used, domestic energy sources. For energy used in industry and for district and central heating it is possible to substitute about 0.9 Mten. In traffic and agriculture substitution of about 0.15 Mten is possible (by mixing of 5.75% bio fuel with fossil fuel). About 0.07 Mten of imported bituminous and subbituminous coal can be substituted also (by an increase of coal production in small mines, or by renewable sources). In total, substitution of about 1.12 Mten of imported liquid and gaseous fuels is possible, making about 30% of the import for those energy subsectors.

Depending on the quality and temperature level of the energy needs (electric energy, heat at low and high temperature, *etc.*) for energy production, the following energy sources are at the disposal: biomass, wind, small rivers, waste coal (small size classes) of the underground coal production in small mines, and other. For electric energy production and high temperature heat waste biomass can be used with heat capacity of about 2.56 Mten/year, about 0.119 Mten/year of coal waste from presently active small mines (small size classes – 15 + 0 mm) and about 0.250-1.250 Mten/year, from increased coal production in active and new small mines, depending on the available investments and time for opening new mines. For low temperature heat geothermal energy is available at about 0.185-0.360 Mten/year, and small rivers and wind for electricity production of about 0.150 Mten. In total for reduction of import dependence today, and in the future, domestic energy potential of about 3-4 Mten/year is available, which is presently unused. Depending on the type of the source and final energy needed it is possible to reach about 1.0-1.5 Mten/year of the final energy production. In short and long term analysis this fact cannot be overlooked. However, activation of this presently unused energy potential depends on available investments and governmental support, set of laws and governmental directives in the field of concessions for investment in energy production plants, mines

etc., on energy prices, ecological taxes, implementation of modern, efficient and environmentally acceptable technologies as well as time necessary to activate a specific energy source.

Having in mind the lack of investments for new power plants, and necessity to have effects in near future, the only significant results in reduction of import dependence can be achieved by a wide activity in improvement of energy efficiency. Experience of some countries in transition, and some estimates made in Serbia's economic development strategy up to the 2010 [2], show, that it is possible, in short time (5-10 years) and with a small amount of investments, to increase the energy efficiency by about 20%.

Specific contribution to the reduction of dependence on import energy and fuels, and to the saving of domestic primary energy resources can be achieved by introduction of combined heat and electric energy production. By introduction of the combined heat and energy production in the thermal coal burning power plants in operation, it is possible to save the large amount of imported natural gas intended to be used for district heating plants. Cogeneration will also have a significant effect on emission control and sustainable energy development.

Serbia has the possibility and needs to organize fast activity in introduction of cogeneration in order to save its own primary energy resources, since share of cogeneration in Serbian energy system amounts to only 1%, of the electric energy production, compared with 82% heat energy produced in Germany in cogeneration plants, in the EU countries average 10%, 40% in Holland, and 50% in Denmark. EU countries are obliged, by the new directive, to double the share of cogeneration until 2010. By the new Serbian Energy law, cogeneration units obtained the status of privileged energy producers, which will stimulate construction of cogeneration plants, and even micro cogeneration in households.

Figure 1 shows that Serbian dependence on imported fuels and energy permanently increases since 2000, and in 2004 exceeded 40% of total primary energy consumption, in spite of the prediction made in Strategy of Serbian Energy Development up to 2015 [5], that share of imported energy will be 40% in 2015.

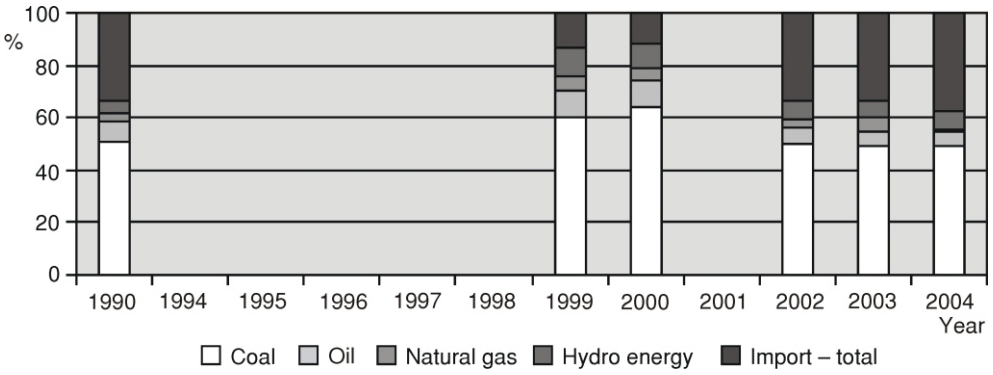

Figure 1. Share of import in primary energy consumption in Serbia

According to projected energy balance for the year 2006, dependence on energy import might be as high as 46.6%, making Serbia highly energy dependent country. Increase of natural gas import will be the highest, about 13.17%. Structure of the import is approximately: oil 47.5%, natural gas 27.9%, and high rank coal 22.9%. According to those figures, the highest national priority in energy policy of Serbia has to be the reduction of import energy dependence, by all possible measures in: rational energy use, increase of energy efficiency, substitution of imported fuels by domestic fuels, including cogeneration, increases of use of renewable energy sources, as well as use of wastes.

Energy efficiency – specific energy consumption in Serbia

Energy efficiency

According to the data on Serbian energy system presented in previous section, two facts have to be pointed out:

(1) Serbia has modest, limited, and practically exhausted energy potentials.

(2) Dependence on energy import is high, and will drastically increase in the future if some systematic measures will not be not undertaken. But, the most significant characteristic of Serbian energy system cannot be seen from the presented facts – *I.e,* inefficiency of the whole energy system.

In spite of the significant efforts in past 5 years in reconstruction and rehabilitation of the power plants, in the whole energy transformation chain, from coal, oil, and natural gas production, through energy transformations in heat and electric power plants, in energy transmission and distribution till final end use of energy, irrational behavior and operation are the consequence of: (a) old technologies used, (b) unprofessional and badly done exploitation of the equipment in use, (c) wrong energy strategy in the past, (d) unsuitable energy price policy, (e) late revitalization of the equipment, (f) lack of standards and regulations or their neglecting, *etc*.

Production in industry and GDP per capita have been reduced 2.5 times in the period from 1989 till 2000. Starting from 2001, until 2004 GDP in Serbia increased in average at a rate 5.1%/year, and in 2004 at 8.6%/year. In the first quarter of the 2005 increase of GDP was 5.2%/year. Mentioned increase of GDP indicates a possibility that energy intensity in Serbia will start to decrease, *i. e.* specific energy consumption per unit of GDP will be reduced in the future, contributing to energy efficiency. Compared to other countries, Serbia is lagging behind greatly. In order to achieve results in short time, an accent has to be put to the short term measures. Next figures illustrate energy inefficiency and irrational use of energy in Serbia, compared to some European countries. In spite of its low industrial activity, consumption of electric energy in 2002 in Serbia was 3400 kWh/capita, *i. e*. at the level of medium developed European countries (fig. 2).

However, electric energy consumption per 1000 $USA of the GDP, is the highest in Europe (1900 kWh/1000 $USA), due to the specific structure of industry and en-

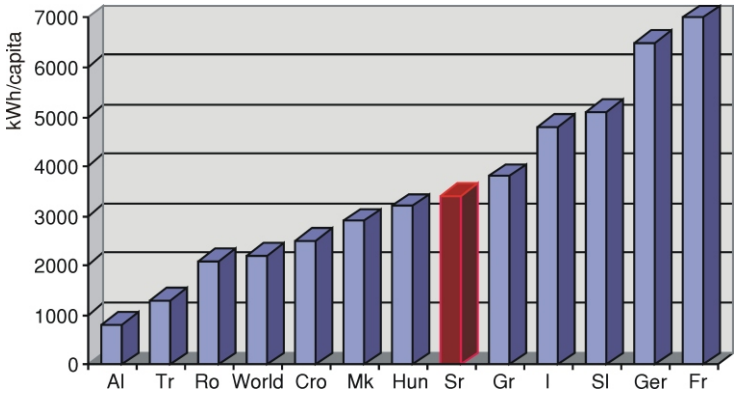

Figure 2. Electric energy consumption per capita

ergy sectors, as well as to low energy prices and decreased industrial activity since 1990 (fig. 3).

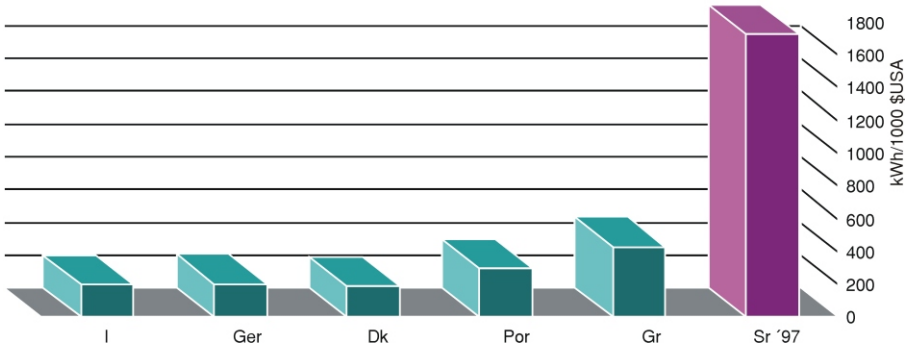

Figure 3. Specific electric energy consumption per unit GDP

High electric energy consumption per capita, compared to the low level of living standard of people and reduced industrial activity, means a nonrational use of electric energy for heating in households. That means, irreversible and nonrational spending of modest natural energy resources in Serbia, coal and hydro energy.

Nonrational use of natural energy resources and inefficiency of the Serbian energy system can also be presented with reference to the primary energy consumption. Figure 4 shows that primary energy consumption per capita is 2.5 times smaller then in developed countries.

On the contrary, primary energy consumption per unit of GDP is very small, fig. 5.

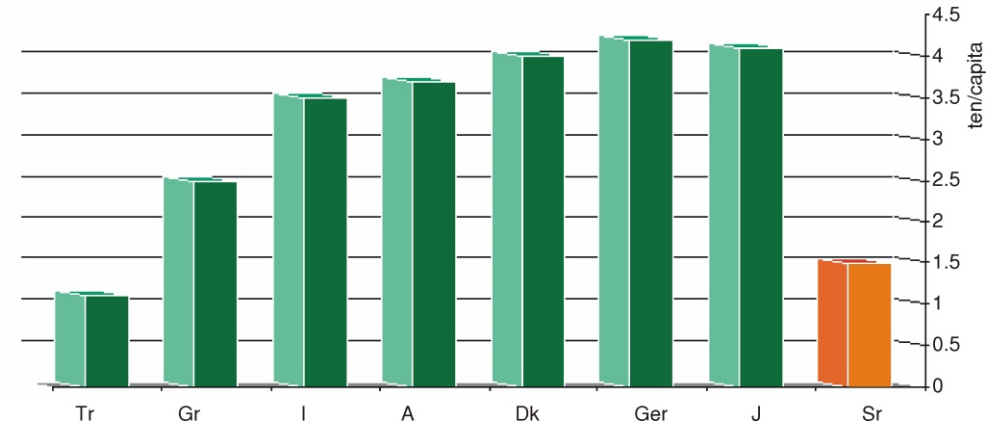

Figure 4. Primary energy consumption in Serbia

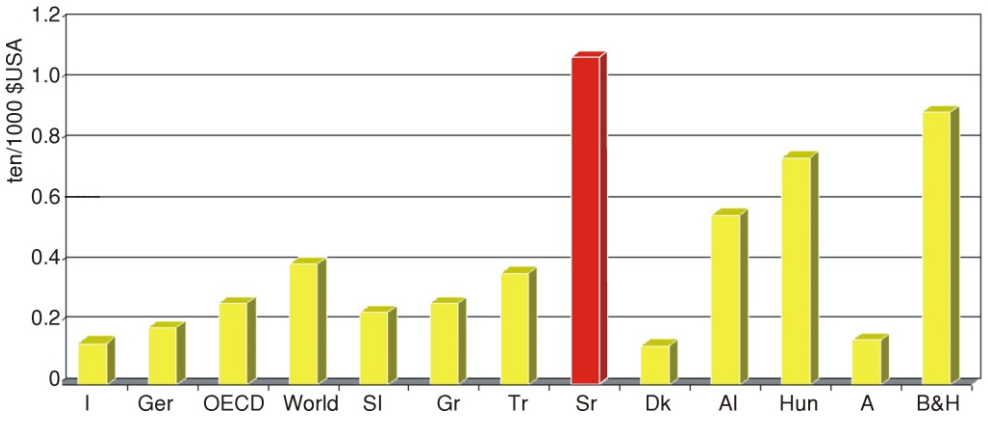

Figure 5. Primary energy consumption in Serbia, per 1000 $ of GDP

Another subsector, in which the inefficient energy consumption is evident, is energy needed for heating of houses and buildings. In buildings constructed before 1945 installed capacities of heating systems was on average 200 W/m^2, in those constructed after 1960 about 145 W/m^2, which means that average heat energy consumption in buildings is 200-300 kWh/m^2 in an average cold year, with an ideal maintenance of buildings and heating systems. In reality, having in mind the real statuses of buildings, maintenance, insulation, and sealing of buildings, average consumption in buildings connected to district heating systems is as high as 420 kWh/m^2, and in buildings with central heating system even up to 600 kWh/m^2. In the European countries with similar climate conditions, buildings are today constructed with annual consumption of energy for heating, hot water, air

conditioning, and lighting lower then 100 kWh/m^2. It is easy to calculate that specific energy consumption in buildings in Serbia is larger 3-4 times, and that in this subsector exists a large possibility for increase of energy efficiency.

Activities for increasing energy efficiency in Serbia

Regarding the status of the energy system of Serbia, presumably in the field of energy efficiency and lack of natural energy resources, leading to the high dependence on import energy and fuel, Government of Serbia undertook two parallel activities.

High attention was paid to the importance of oriented fundamental research, applied research, development and demonstration activities as avant-garde in the efforts to increase energy efficiency and implement the renewable energy sources, NEEP was founded on March 1st, 2001, and is financed by the Ministry of Science and Environmental Protection, in order to engage most prominent experts and researchers in this field. About 2 million €/year were allocated for those purposes.

Considering, also, the importance of the favorable environment for all activities in the field of energy efficiency (technical standards, regulations and appropriate laws for stimulation and control of energy efficiency and in the same time education of a large number of engineers, energy managers and other professionals in industry, public organizations and local authorities), and for rational behavior of people, enterprises and business organizations, Serbian Energy Efficiency Agency (SEEA) was founded at the beginning of 2002. SEEA was at the beginning financed by the European Agency for Reconstruction (EAR), but afterwards its activity was defined by the Serbian Energy law in 2004. A special Fund for energy efficiency should be established soon by the law.

The main objective of NEEP is to unite research, engineering and legislative activities in order to study, develop and implement new technologies and methods, and also to transfer already proven technologies and methods from developed countries, as well as demonstration of their effects in case studies under conditions of a specific Serbian natural and energy situation, including feasibility studies, energy and economic analysis in really industrial applications.

Also, this Program has an aim to overcome lack of money in industry, and to financially support the application of the research, implementation of already proven new energy efficient technologies, methods and equipment, available at the world's market, in order to promote their wide dissemination in industry and economy.

Responsibilities of the SEEA were defined as: determination of the potentials of energy efficiency in industry, traffic, buildings and other end use subsectors, improvement of the environment for energy efficient and rational behavior, economic and financial instruments for support and stimulation of energy efficiency and use of renewable energy sources, developing technical standards, pricing policy, taxes and tolls, *etc*. Also, educations of people, professionals, experts and engineers, transfer of knowledge and practice from developed countries, and using donations for realization of demonstration

projects (case studies) in buildings, industry, municipal systems, traffic, and households, as well using of renewable energy sources and implementation of cogeneration.

Up to now SEEA received about 5 million € for project realization from EAR, 21 million $USA from the World Bank, and about 300000 €/year from Norwegian Government. There have been realized 16 projects for saving energy in public buildings, 4 district heating projects, 5 projects dealing with public lighting, 4 projects for implementation of renewable energy sources (biomass, geothermal energy, small rivers). In education of professionals and engineers 5 courses have been organized: realization of energy balance in industry (30 persons, 18 companies), energy management in industry (80 persons), and energy business plans (24 persons, 10 companies), energy management in food industry (24 persons, 6 companies), and energy management in local authorities (46 persons, 46 communities). Activity of the SEEA in the future depends on the foundation of Fund for energy efficiency (in preparation), and partly on the money from the Fund for environmental protection, renewable energy sources, and energy efficiency founded by the Law for environmental protection.

Main characteristic of the activities in the fields of energy efficiency and use of renewable energy sources are lack of coordination of different ministries, unfavorable ambient for rational behavior and lack of stimulation and support from the Government. The only ministries taking care of energy efficiency and use of renewable energy sources are Ministry for Science and Environmental Protection and Ministry of Mining and Energy.

National energy efficiency program

Foundation of NEEP – motivation

In the Strategy of the Development of Energy Sector in Serbia up to the 2010, formulated in the frame of the Serbia's Economic Development Strategy up to the 2010 [2], and later in Strategy of Energy Development in Serbia [5], as one of the main objectives is an increase of energy efficiency by 20% up to the 2010 was postulated, in order to contribute at the same time to the emission control according to international standards, avoiding large investments in new technologies and equipment. Foundation of the NEEP has been considered also as a specific care to the importance of energy efficiency in development and reanimation of Serbian economy, and most significant activity in implementation of the new technologies.

Experience of many countries in the world shows that energy inefficiency should be attacked along the whole energy transformation chain – from primary energy production (supply side) to the consumption of final energy (end-use efficiency). At the same time, targeting of the energy efficiency increase requires whole set of different measures and activities, from oriented fundamental investigations of the physical and chemical processes involved, up to different engineering activities, management and organization followed by appropriate legislation.

Those are the reasons why it was necessary to join all mentioned activities in one united National energy efficiency program. The intention was to coordinate all activities, from definition of objectives and priorities, choice of the best projects proposed, up to the control and following up of the realization of the projects financed. Also, NEEP should be realized in the close cooperation with the Ministry of Science and Environmental Protection and Ministry of Mining and Energy, as well as in the cooperation with other relevant ministries, *I. e*. Ministry for Agriculture, Forestry and Water Management, Ministry of Capital Investments, and Ministry of Finances.

In spite of the fact that all existing strategies of energy development in former Yugoslavia and Serbia paid much attention to the increase of energy efficiency, the results have not fulfilled the expectations. Main reasons were: activities did not cover all energy system, research activities were not coordinated with engineering activities and implementation of demonstration programs, in general, there was no favorable ambient for rational behavior, there were no governmental support and stimulations for an increase of energy efficiency or for use of renewable energy sources, *etc*. This National program has also an objective to help the companies and local authorities to find and obtain financial support for implementation of the scientific results in practice, to demonstrate the best technologies, or to implement proven, commercially available technologies, methods or equipment as well as to disseminate best practice in industry, municipal system and communities.

Strategy of the Development of Energy Sector in Serbia up to the 2010 setting a mentioned objective in 2001 to increase energy efficiency for 20% up to the 2010, was based on the assumption that Serbian Government will, in short time, adopt a set of laws and legislative measures, technical standards, as well as financial and economical incentives in order to stimulate implementation of the more efficient technologies, equipment and methods, making favorable environment for energy saving and rational use of natural resources.

Basic principles of NEEP

The adopted strategy of the NEEP was based on the following principles [7]: (a) NEEP has to cover all sectors and subsectors of the energy system, from heat and electric energy production to end use in industry, traffic, buildings, municipal systems, and households, taking care of specific characteristics of each subsector and formulating specific Development programs for each of them; (b) NEEP has to include also, rational use of domestic natural energy resources, rational use of the potential of environment, use of alternative and renewable energy sources, efficiency in energy transformations, transmission, and distribution of energy till end users, rational energy management with domestic sources, as well as with imported energy and fuels, in a word sustainable development; and (c) energy efficiency is not only energy saving, but also security of supply, and quality of energy supplied to the end users.

In order to achieve energy efficiency in most general sense, it is necessary, besides implementation of the modern technologies, to invest in and stimulate research and

development, and demonstration of the modern technologies and to fit them to the specific characteristics of domestic energy sources.

Structure of the NEEP

NEEP is subdivided in nine *Development programs*, devoted to the nine subsectors of the energy system. In each Development program specific priorities have been formulated for the sub sector in question, according to the criterion obtain maximum possible increase of energy efficiency and satisfaction of the total energy needs. Priorities were formulated based on the results of previously done strategic and feasibility studies of the available potential of energy efficiency or of the potentials of domestic energy sources, fossil and renewable [4, 8-13]. Feasibility and strategic studies gave also basis for formulation of the measures for support and stimulation of the energy efficient behavior of people and firms, and also for energy efficiency control of the plants and equipment.

A Board of directors appointed by the Ministry of Science and Environmental Protection takes care about the activity and realization of the objectives of NEEP. Board of directors of the NEEP consists of directors and deputy directors of the Development programs. Board of directors is responsible for management and directing all activities of the NEEP including: formulation of the Energy Efficiency Strategy, choice of priorities, announcement of the Open invitations for financing R&D&D projects, evaluation and choice of projects for financing, control and follow up of the realization of projects, evaluation of the results of projects, and all other questions connected with realization of the objectives of NEEP. Director of the NEEP and deputy director chair and lead Board of directors of the NEEP, but final decisions and approval are with the Minister of Science and Environmental Protection.

NEEP consists of the following Development programs managed by directors and deputy directors of the specific program:

1. Energy efficiency in electric power generation,
2. Energy efficiency in electric power transmission and distribution,
3. Energy efficiency in industry,
4. Energy efficiency in municipal systems,
5. Energy efficiency in households,
6. Development of domestic ovens and boilers burning solid fuels,
7. Use of alternative and renewable energy resources,
8. Energy efficiency in buildings, and
9. Energy efficiency in traffic engineering.

General objectives of the NEEP

Board of directors of the NEEP formulated Strategy and priority topics of the NEEP, at the beginning of 2002, as a basis for future activity of the NEEP [7]. Strategy

and priorities of the NEEP were the results of an expert analysis done by the members of Board of directors, first of all analysis of the present status of energy system in Serbia based on Strategy of Energy Development in Serbia up to 2010 [1]. Results and analysis done in the R&D projects and feasibility studies financed in past 15 years have been also used, as well as knowledge and experience gained in the developed countries. In the execution of the projects financed in the frame of NEEP, the best available experts and researcher in Serbia were engaged.

Activity and realization of the general objectives and priorities of the NEEP are expected to contribute to more safe and continuous energy supply to consumers (industry, district heating and individuals), reduction of use of imported oil and gas, decrease of the specific energy consumption per unit of GDP and increase of competitiveness of domestic industry on the world market. Also, objectives of the NEEP are: rational and efficient use of domestic energy resources, rational and efficient use of energy in general, reducing of production costs, reducing of environmental impact of power generation equipment by implementing the European standards in energy efficiency and environmental protection, and smaller share of energy costs in the prices of industrial products making more favorably ambient for small, medium, and large enterprises.

Specific objectives and priorities of the NEEP

Realization of the NEEP projects has to achieve the following specific goals:

- Increased, but rational use of domestic energy resources, local energy resources and in particular renewable energy sources,
- Reduced use of the imported oil and gas in power and heat production in industry and in district heating,
- Reduced use of electric energy for heating households,
- Increased, efficient and economical use of waste biomass,
- Increased use of alternative energy resources, as municipal and industrial wastes,
- Higher efficiency of power production in utility plants,
- Higher efficiency of industrial and district heating plants,
- Reduced technical and commercial losses in energy transmission and distribution,
- Reduced heat and energy consumption in buildings,
- Higher efficiency in end-use of energy in industry, municipal systems, and households,
- Research, development, demonstration, promotion, and implementation of efficient and clean energy technologies for heat and electric energy production in utilities, industry, district heating and municipal systems, and in households,
- Increase of the energy efficiency of domestic appliances and energy labeling,
- Decrease of fuel consumption and increase of energy efficiency in traffic, and
- Control of environmental impact of energy plants and equipment.

One of the activities in the frame of NEEP relates to proposals of new regulations, standards and laws in energy sector, and support to the authorized laboratories for audit and control of the energy balances and control of energy efficiency.

In each Development program specific general and particular objectives for the energy subsector in question have been formulated. To achieve formulated priorities, general and specific goals open invitations for research, development, and demonstration projects have been announced.

Conditions necessary for favorable ambient for energy efficiency and rational use of energy sources

Achievement of the objectives formulated by the NEEP as well as implementation of the results of projects financed in the frame of NEEP is not possible if favorable ambient is not created by the government policy, legislative, and other economic and financial measures. Those governmental decisions are necessary in order to create a favorable ambient for rational behavior of people and enterprises, and for implementation of so called "sustainable development" in energy sector and in general. Therefore, special attention was paid in NEEP to the analysis and proposal of regulations, technical standards, economic and financial measures and stimulations in order to promote and support energy efficiency projects and implementation of renewable energy sources. Preparation and adoption of the mentioned measures for stimulation and support of the implementation of new, modern, energy efficient and environmentally acceptable technologies, use of alternative and renewable energy sources, as well as adoption of regulations and technical standards, are the responsibilities of the Ministry of mining and energy, and other responsible ministries. NEEP in its activity tried to create data basis and foundation for decisions of other responsible governmental bodies, agencies, and organizations. Successful realization of the objectives formulated by NEEP depends greatly on coordination of the activities of NEEP with the activities of different ministries, agencies in energy field and other governmental bodies. It was also the intention of the NEEP to provide modern experimental and measuring equipment to the research organizations, in order to make them qualified for control of the energy efficiency of power plants and other energy equipment in operation, and to control quality of the products in agreement with the European standards and regulations.

In a number of feasibility studies financed in the frame of NEEP adoption of new laws in energy field, technical standards, regulations, and other measures were proposed:

- Regulations and measures for control of quality and energy efficiency of the equipment using different fuels (ovens, combustion chambers and boilers for industry and households), industrial equipment and domestic appliances),
- Equipment for the authorized research laboratories for making energy efficiency control,
- Regulations and economical and financial measures and support for supporting use of renewable energy sources,
- Criteria for obtaining status of privileged energy producer for small energy generators and use of renewable energy sources,
- Regulation and control measurements for optimal exploitation of energy equipment,
- Standards and regulations in the field of energy transmission and distribution, and

- Regulations and standards for energy consumption in buildings, for insulation materials and for heat insulation of buildings.

In order to reduce use of electric energy for heating in households, stimulative measures were proposed for production of ovens and boilers burning solid fuels and biomass, waste, and liquid and gaseous biofuels:

- Economic and financial support for production and use of equipment using solid fuels and biomass for heating, cooking, and other purposes in households,
- Subsidies for solid fuels (coal, briquettes from coal and biomass) for consumption in households and favorable condition for loans for solid fuels and equipment,
- Tax reduction for the producers of equipment using solid fuels, and financial support for starting mass production,
- Long-term "soft" loans with a low interest rate for starting mass production of the equipment using solid fuels and biomass,
- Tax reduction for starting production of briquettes made from coal wastes and biomass, and for development of the appropriate equipment,
- Long-term loans for starting production of briquettes and pellets from coal and biomass,
- Financial support and tax reduction for enterprises using renewable energy sources or waste from their own production for satisfying process energy needs,
- "Soft" Long-term loans with a low interest rate for investors constructing small power plants using local and renewable energy sources (coal, biomass, small river potentials, municipal waste, wind, geothermal and solar energy), and
- Tax reduction, loans and financial support for better heat insulation of buildings, *etc*.

Projects financed in the frame of the NEEP

For realization of the projects financed in the frame of NEEP, majority of the available researchers and experts have been engaged. NEEP has an intention to make optimal harmony between short-term and long-term objectives, so three types of projects are financed:

- *Research, development, and demonstration projects (R&D&D)* with the aim to join and to coordinate: result oriented fundamental research, applied research and development in order to create new knowledge of the basic processes necessary for development new processes, new technologies and equipment, new products and services contributing to the increase of energy efficiency and decrease of specific energy consumption. Results of those projects are databases and conceptual designs for construction of pilot or demonstration units. Final results of the projects of this type are construction and testing of the pilot and demonstration units, new prototype and production activities for starting mass production of new equipment, and demonstration of their energy efficiency. R&D&D projects are planned for 3 years as a maximum.
- *Demonstration projects (D)* with the aim to use existing knowledge and experience gained in developed countries, or domestic knowledge accumulated in the past years,

have the main objective to demonstrate advantages of the modern, energy efficient and environmentally acceptable technologies or equipment, or to implement modern standard industrial technologies or equipment and/or engineering procedures and methods. A main goal of the demonstration projects is to increase energy efficiency in short time by demonstrating usefulness of the mass application of the technologies and equipment available on the world's market. Realization of the demonstration projects must include construction of pilot or demonstration plants and theirs testing in real exploitation conditions, design and construction of prototypes and starting of the production of new products, already proven or available on the world's market. D projects have to verify the validity of technologies, equipment, or start-up of the new production, followed by the analysis of the optimal conditions and fields for mass application. Duration of D projects is 12 months as a maximum.

- *Strategic and feasibility studies (S)* have an aim to prepare databases for planning and choice of priorities, to prepare the foundations for new strategies in the fields of energy efficiency, renewable energy sources, or energy system in general. Results of the strategic and/or feasibility studies are databases of the different energy potentials, potentials of renewable energy sources, regional distribution of renewable and other energy sources, characteristics, optimal conditions and fields of application of energy sources, in particular renewable energy sources, validation and optimal fields of application of different modern technologies, in particular technologies for use of renewable energy sources, potentials of energy efficiency in different industrial sectors and public sectors, *etc*. Duration of Studies is limited to 3-12 months.

Harmonization of the short term and long term objectives of the NEEP is intended to be achieved by the following:

(1) R&D&D projects comprise necessary oriented fundamental research, followed by applied research and development, and finished with construction of pilot or demonstration units or starting of the production of new product, know-how, technical and economic analysis, and feasibility study of implementation of new technology or equipment or new product. Fundamental and applied research have to be oriented to the topics connected with the characteristics of domestic energy sources – coal, biomass industrial and municipal wastes, and to take into account local natural or social conditions. Also, R&D&D projects are aimed at solving technical problems influencing economical or environmental advantages of the technologies, equipment or new product, and have to encounter all scientific fields important for energetic. Besides research part, R&D&D projects comprise all engineering activities, design, construction and testing of the new technologies and equipment, quality of new products, and to integrate activities of the research and engineering organizations and professional stuff in industry. Also, in financing the projects, governmental funds aimed to support R&D activities are integrated with the money from industry and

(2) D projects have to integrate activity of the research organizations, industry or local authorities and governmental funds in construction and testing of pilot and/or demonstration units, and in validation of the feasibility of mass implementation of modern technologies and equipment, methods or procedures.

Financing

Projects accepted for financing in the frame of NEEP have to be financed jointly by scientific funds and funds given by the users of the results – industry, public organizations, local authorities, and other possible users.

Financial support of the Ministry of Science and Environmental Protection

- Objective oriented fundamental and applied research and realization of strategic and feasibility studies – up to 100%,
- Research and development activities – 50-100%,
- Conceptual designs – up to 50%,
- Conceptual, basic, final and construction projects – up to 50%,
- Design, construction and manufacturing of the prototypes and laboratory apparatus – up to 50%,
- Technical and economic analyzes and feasibility analyzes – up to 50%,
- Testing of pilot and/or demonstration units, and starting of new production – up to 80%,
- Energy and material balances, energy audits and measures for an increase of energy efficiency – up to 50%, and
- Determination of environmental impact of the implemented methods, technologies, and equipment – 50-100%.

Financial support of the users

Since funds obtained from the Ministry of Science and Environmental Protection are not sufficient for realization of the projects accepted by NEEP, particularly if pilot and/or demonstration units have to be constructed and tested, users of the results of the projects must give financial support, and have to be engaged by delivering necessary materials, and/or to engage their engineers and workers. Practically all activities in the projects (except fundamental and applied research) have to be supported by the users: research and development, conceptual designs, construction of the pilot and demonstration units, testing them, preparation of the new production and prototypes, organization, technical and economical analysis and all other activities necessary for implementation of new technologies or equipment, methods or procedures.

Activity of the NEEP in the period 2002-2005

In the period from 2002 to 2005, there were announced 5 open invitations for submission of the project proposals for all 9 Development programs: 1st Open invitation (in the year 2002) – 49 projects and 4 studies (Development program 3, 4, and 6), 2nd Open invitation (in the year 2003) – 34 projects and 7 studies (Development programs 1, 2, and 8), 3rd Open invitation (in the year 2003) – 25 projects and 7 studies (only Development program 7), 4th Open invitation (in the year 2004) – 23 projects (only D projects in the Development programs 3, 4, and 6), and 5th Open invitation (in the year 2005) – 9 pro-

jects and 7 studies (Development programs 5 and 9). In total 140 projects and 25 studies have been selected for financing.

According to the new Strategy and priorities of the NEEP for the next period 2006-2008, two open invitations have been announced in 2006 for all 9 Development programs: 6th Open invitation – 31 projects and 5 studies and 7th Open invitation – 60 projects and 14 studies.

Up to now in the frame of NEEP 231 projects (both R&D&D and D) and 44 strategic and/or feasibility studies have been accepted for financing. 120 projects and 30 studies have been successfully finished by the end of 2005.

In order to inform scientific, engineering, professional and public community about results of the projects, three Presentations of the results of NEEP have been organized in the Chamber of commerce of Serbia in 2004 and 2005. Results of the projects presented have been made available on the special compact disc. Compact discs with the all finished studies are in preparation. Also, all scientific and professional Symposia were used for presentation of the results (7 symposia in total). Priorities for open invitations in 2005 were chosen in close cooperation with the Ministry for Mining and Energy, Ministry for Agriculture, Forestry and Waterworks, Serbian Energy Efficiency Agency, and Standing Conference of Towns and Municipalities.

Priorities in the different Development programs

Considering general and particular objectives defined in the Strategy of the NEEP, in the past five open invitations during the period 2002-2005, the following priorities were announced in each of the Development programs.

Development program 1: Energy efficiency in electric power generation

Priorities were defined in coal mining, thermal and hydro power plants:

- Implementation of the: (a) selective mining and homogenization of the lignite on open cast mines, (b) advanced procedures for water draining at open cast lignite mines, and (c) measurement methods, procedures and control systems for energy efficiency control;
- Increase of energy efficiency in: (a) mining, preparation, and transport of lignite from open cast mines to thermal power plants and ash and slag transport, (b) boilers, including ash and slag transport to damp, and (c) turbines and generators, including cooling system;
- Energy efficiency, availability and power level increase: (a) of the hydro power plant in operation, (b) by electricity production optimization at serial hydro units and pump accumulations, (c) by introduction of cogeneration in thermal power plants in operation, and (d) by coping electricity and heat production with the consumption demand;
- Study of the: (a) possibilities to increase energy conversion efficiency using cogeneration of heat and electricity, or combined a gas-steam cycle in electricity generation, (b) optimization of the hydro power plants in operation built on multipurpose

accumulations, and (c) implementation of advanced planning and control of the joint operation of hydro and thermal power plants in order to increase energy efficiency of the whole system.

Development program 2: Energy efficiency in electric power transmission and distribution

Priorities were defined both in transmission and distribution networks:

- Analysis of the amount and structure of losses in: (a) transmission, (b) distribution and (c) industrial networks;
- Increase of energy efficiency: (a) in transmission and distribution systems by compensation of the reactive power, (b) of the distribution and industrial networks by using existing high capacitance condensers in industry, and (c) by evaluation of the influence of electric energy transit on energy losses in transmission networks;
- Improvement of the methodology and application software for: (a) load and consumption management in distributive and industrial networks, (b) rehabilitation of the transmission network, (c) analysis of static stability of the electric transmission network, (d) dynamic stability of the electric transmission network, (e) calculation of the limiting transmission capabilities of the network's interconnections, and (f) determination of technical and economical aspects of deregulated electric energy market;
- Implementation of the: (a) measuring equipment in order to follow-up and control energy efficiency in transmission and distribution of electric energy, (b) internet technologies for acquisition, saving of data, and diagnostic, (c) temperature measurements of the high voltage equipment, (d) measurements and analysis of the electric energy quality due to the higher harmonics, (e) standards for electric energy quality, and (f) equipment for improvement of electric energy quality.

Development program 3: Energy efficiency in industry

Priorities were defined as:

- Energy management and control in industry and revitalization of energy systems;
- Integration of combined heat and power generation technology in existing power plants in industry;
- Development of the: (a) equipment for measurement and control, (b) industrial control systems, and (c) energy efficient equipment and technologies.

Development program 4: Energy efficiency in municipal systems

Priorities were defined in district heating systems, gas distribution and use, and water supply systems:

- Use of local fuels for district heating systems;
- Implementation of the: (a) distant control in district heating systems and (b) control of effects of the heat flow meters in pilot-buildings;
- Study of the: (a) use of gas engines in existing district heating plants for combined electricity and heat production, (b) decreasing of the return water temperature in order

to improve efficiency of district heating systems, and (c) optimal complementary development of district heating and gas distribution systems in towns;
- Efficient use of the: (a) natural gas in households, (b) domestic boilers by use of higher heating value of natural gas, (c) natural gas in autonomous total energy systems in large buildings, hospitals, sport centers *etc*., (d) gas engines in main control stations of the gas pipe lines, (e) small natural gas fields for local energy consumption in towns, and (f) natural gas for infrared heating in large halls;
- Improvement of the efficiency of the: (a) water pumping systems in towns, and (b) optimization and reengineering of existing water supply systems, and (c) by implementation of small hydro power plants in water supplying systems.

Development program 5: Energy efficiency in households

Priorities defined in this development program were:
- Study of the: (a) development and application of the method for evaluation of energy efficiency indicators in households and (b) economic aspects of energy efficiency in households;
- Increase of energy efficiency: (a) by improvement of the thermal isolation of existing houses, (b) by buildings designed according to modern climatic principles, (c) substitution of electric heating in households by other energy sources, (d) measurements and management of energy consumption for heating in flats connected to district heating systems, and (e) rational use of natural gas in households;
- Development and implementation of the: (a) more efficient system for hot water supply, (b) use of renewable energy sources for heating, and (c) use of heat pumps for heating and cooling in households;
- Increase of energy efficiency by: (a) efficient air cooling systems in buildings, (b) improvement of lighting, lighting control and development and application of more efficient light sources;
- Improvement of energy efficiency of the: (a) electric appliances in households, (b) thermal appliances for cooking, (c) washing machines, (d) cleaning equipment, (e) electronic equipment, (f) reducing of stand-by consumption of electronic equipment, and (g) implementation of electronic apparatuses with improved energy efficiency;
- Saving of energy by implementation of the: (a) legislation for stimulation and support of energy saving in households, (b) methods for management with energy consumption in households, (c) promotion of energy efficiency in households, and (d) improvement of standards for energy efficiency in households.

Development program 6: Development of domestic ovens and boilers burning solid fuels

Priorities were oriented to the solid fuels, particularly biomass:
- Development of the technology and equipment for production of: (a) briquettes from waste biomass (from agriculture, wood processing industry, forestry waste, fruit production, coal and biomass, coal mixed with limestone), (b) pellets from waste biomass (from agriculture, wood processing industry, forestry, fruit production), and (c) for distribution and transportation of the briquettes and pellets.

- Development of: (a) ovens with natural convection suitable for high volatile content fuels, with overall efficiency 55-65%, (b) ovens with forced convection suitable for high volatile content fuels, with overall efficiency 70-80%, (c) the combined oven-boiler designs for combustion of different fuels – wood, coal, different kinds of briquettes and pellets, (d) small boilers for households for briquette and pellets combustion, and (e) small boilers for combustion of coal without pretreatment.
- Feasibility studies of the: (a) available technologies and equipment for briquetting and pelleting, oriented to the biomass and low quality coals and (b) available energy potential and characteristics of the waste biomass of different kind.

Development program 7: Use of alternative and renewable energy sources

Priorities were defined in all types of renewable energy sources – biomass, geothermal, wind, solar, and potential in small rivers:

- Feasibility studies for: (a) implementation of system of authorized laboratories for testing equipment using renewable energy sources, (b) creating of network for transfer of information and knowledge in renewable energy sources, (c) fuel cells technologies and applications; (d) energy potentials of the gheothermal, solar and wind energy, and (e) production and application of biodiesel and bioethanol;
- Development, design and testing of the: (a) plane solar panels, (b) hybrid plane solar panels for heat and electric energy production, (c) heating and conditioning systems using hybrid active and passive solar energy systems, and (d) photovoltaic systems for supplying electric energy for lighting;
- Development, design and testing of the: (a) mini wind generators for insulated households, (b) wind generator farms for supplying energy to large regions, and (c) wind generator plant for water supply in agriculture;
- Development, design and testing of the: (a) heating and conditioning systems using geothermal hot water and heat pumps, (b) geothermal energy in agriculture and industry, and (c) systems with heat pumps for use of low temperature heat of earth for heating and conditioning;
- Development, design and construction of the: (a) mini/micro hydro power plants in multipurpose water reservoirs in mountain regions and (b) mini/micro hydro power plants for melioration in agriculture;
- Development and design and construction of the: (a) heating plants and cogeneration plants using solid biomass or solid wastes in municipal systems, agriculture, paper and pulp industry, wood processing *etc*., (b) equipment for biodiesel and bioethanol production, and (c) sustainable, energy efficient and ecologically clean farms.

Development program 8: Energy efficiency in buildings

Priorities were defined as follows:

- Determination of the: (a) actual outdoors design temperatures and other climatic data for designing effective and rational energy systems in buildings, based on recent period data and (b) a meteorological year for calculations and modeling of dynamical behavior of building energy systems;

- Development, design, and testing of the: (a) systems divided to individual apartments in apartment buildings or in office buildings with various offices owners and (b) use of the return water from heating systems before final return to district heating system;
- Application, intensification, and prediction methods of the: (a) passive/natural night cooling with natural airflow in high buildings in domestic climatic conditions, (b) implementation of the "thermal mass" in cooling and heating conditions, and (c) implementation of the double facades as a building element as method for heat losses and cooling loads reduction, in domestic climatic conditions;
- Development of the: (a) energy optimal integral control technology and programs of functioning building systems for heating and air conditioning – concept of intelligent buildings, (b) modern day lighting technology for decreasing electrical energy consumption, (c) technology and technique for revitalization of integral energy systems in existing buildings, (d) methods of revitalization of existing buildings, which belong to high-energy consumers with detailed projects, solutions, and description with all elements of investment costs, (e) measuring technique for testing building energy efficiency – windows, walls, lighting *etc*., (f) dynamic modeling of thermal behavior of buildings, and (g) multi modal simulation and optimization of buildings;
- Development of the: (a) windows with heat transfer coefficient less then 2 W/m^2K, (b) special glasses with increased reflection and selective/absorption and emission abilities, (c) design methods of a new, energy efficient settlements, with utilization of renewable energy sources and annual energy consumption <100 kWh/m^2a, and (d) methods of conservation of old monumental and historic buildings, using all methods for reducing annual energy consumption and use of renewable energy sources;
- Application of already confirmed patents: (a) resulting in energy consumption decrease in buildings – primary construction materials, insulation, heating systems and (b) apparatuses and installations, which are produced in a small series but should be improved and produced in multi series and placed on a market.

Development program 9: Energy efficiency in traffic engineering

Priorities were defined in all types of transport of people and goods:

- Feasibility studies of the: (a) European legislation, regulation, and technical standards in energy efficiency in traffic, (b) system for following of energy efficiency in traffic, (c) use of alternative fuels for internal combustion engines, (d) use of liquid gas for municipal motor vehicles, (e) use of natural gas for buses in towns, (f) use of bio-diesel for motor vehicles in city traffic and agriculture, and (g) present state of motor vehicles in Serbia and quality of maintenance;
- Implementation of the: (a) modern methods for control and maintenance of vehicles, (b) improved management in using motor vehicles, (c) modern methods in following and managements of the processes in traffic, (d) modern methods for management in traffic, (e) modern technologies in traffic, (f) integrated transport systems, and (g) new concepts in transport of people;

- Implementation of the: (a) information technologies in traffic, (b) modern technologies in transport of dangerous materials, and (c) European legislation in the field of fuel consumption, environmental protection and transport of dangerous materials;
- Study of the: (a) trends in development of engines with internal combustion, vehicles, and equipment, (b) modernization of vehicles and engines from domestic production, (c) harmonization of domestic motors with European standards of fuel consumption and emission, and (d) application of new driving engines in vehicles from domestic production.

Conclusions

NEEP engaged most experienced researchers from scientific institutes and faculties, and engineers from industry, but it cannot be said that results are satisfactory. Most of the projects realized gave very applicable results, but implementation of the results was not successful. Main reasons can be numbered as:

- Users of the results, enterprises from industry and agriculture, municipal and local authorities, were not, and presently still are not in an economic situation to invest money in equipment and technologies in order to increase energy efficiency. Most of the industrial firms are in transition of property, production is several times smaller then at the end of 90-ties,
- Prices of energy and fuels are not yet stimulative for rational and efficient use of energy,
- Government of Serbia, and responsible ministries have not yet made favorable environment for rational and efficient behavior of the people and firms, and
- Serbian Energy law and Strategy of Energy Development have been accepted by the Parliament of Serbia, but necessary regulations for realization of the objectives of those documents are not yet accepted.

In spite of such, may be too strong qualification, NEEP achieved many results that are a good base for further activities in the field of energy efficiency and use of renewable energy sources:

- Large number of experienced researchers, and large number of young researchers and engineers have gained experience and knowledge in new modern technologies, equipment, and methods, aiming to increase energy efficiency and use of renewable energy sources,
- New approach in preparing research projects has been implemented – starting with the definition of priorities closely oriented to the most important objectives, and with following verification of the projects proposed using different criteria,
- New approach in supervision and follow-up of the realization of the projects and validation of the results has been proposed and used, based mainly on the control of satisfying initial Terms of reference, and finally
- Many of the very valuable research and engineering results have been obtained, that would be applied in the future when an economical situation of the industry and local

authorities will be better, and when general environment for rational behavior will be created by the responsible ministries.

Special attention has to be paid to the results of many very detailed and successful strategic and feasibility studies, which gave significant databases for decisions in the future activities for planning, definition of strategies in different fields, and for implementation of new more efficient and environmentally acceptable technologies, equipment, and methods in energy system, agriculture, industry, and municipal systems, and for approach to the sustainable development.

Most interesting results of the R&D&D projects and feasibility studies financed in the frame of NEEP will be presented in special issue of the journal *Thermal Science*.

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Paper submitted: May 24, 2006
Paper revised: June 28, 2006
Paper accepted: July 4, 2006