SERBIA

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1. OVERVIEW OF THE REGION

Characteristics of the Region

The region of research is the region of Belgrade. Boundaries of Belgrades region overlap with the boundaries of its metropolitan area. Belgrade is the capital and largest city of Serbia, the third largest city in South East Europe, after Istanbul and Athens, and among the largest in Danubian Europe. It is also one of the five regions in the Republic of Serbia, with more than 1.63 million inhabitants and covers an area of 3,974 km^2. It covers 3.6% of the territory of Serbia, and 24% of the country's population lives in the city. The city lies on two international waterways, at the confluence of the Sava and Danube rivers, where Central Europe's Pannonia Plain meets the Balkans. The city is placed along the pan-European corridors X and VII.

According the Law of Spatial plan of Republic of Serbia (Gazette RS 88/10) and Law of Regional Development, Belgrade's metropolitan area is a region (it belongs to NUTS 2 category). Belgrade also has a special administrative status within Serbia and it is one of five statistical regions of Serbia (*Figure 1*), with its own autonomous city government. Its metropolitan territory is divided into 17 municipalities, each having its own local council.

According the results from 2011, Belgrade region is one of the most developed in Serbia with GDP around €7,000 per capita, and an employment rate of 86.6%. More than 35% of Serbia's GDP is generated by the Belgrade region, which also has over 30% of Serbia's employed population.

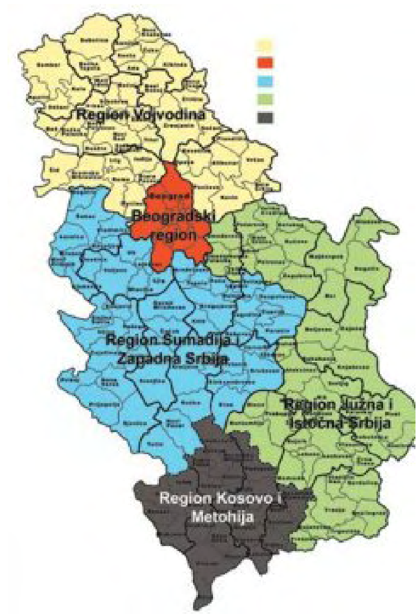


Figure 1 – Statistical (NUTS) regions of Serbia

Energy demand and supply of the Belgrade region

Energy balance of the Republic of Serbia assumes that all energy flows are observed in the three energy systems (Official Gazette of the Republic of Serbia, No. 122/2012):

- the system of primary (total) energy presents the structure of the available primary energy consumption. It is domestic production based on the use of its own resources of primary energy (coal, oil, natural gas, hydro and other renewable sources) and net imports of primary energy, including net imports of electricity. Showing the use of Renewable Energy Sources (RES) includes hydro usage statistics, production and use of geothermal and production of biomass and firewood.
- the system of transformation of primary energy presents the energy required for the

process of transformation of primary energy (including own consumption, losses in transformation, transmission and distribution of energy to the end users). The structure of this level consists of hydro power plants, thermal power plants – power plants, heating plants, industrial power plants, oil refineries, coal processing, and furnaces.
- the system of final energy integrates the final energy consumption for non-energy purposes and for energy purposes. Final energy consumption for energy purposes is expressed in two ways. The first method involves the structure of the sector, such as industry, transport and other (households, public and commercial activities and agriculture). Another method involves the structure of energy sources: solid fuels, liquid fuels, gaseous fuels, electricity, thermal energy, renewable energy. Since there is no reliable data on the structure of final energy consumption for energy purposes, this structure is mostly estimated.

The final energy consumption of Belgrade region added up to 95,346 TJ[1] (26,485 GWh) in the year 2012. It sub-divides into five sectors (*Figure 2*): the industrial sector with 19,620 TJ (5450 GWh), the housing sector with 29,340 TJ (8150 GWh), the commercial sector with 20,952 TJ (5820 GWh), the transport sector with 441,592 TJ (6310 GWh) and the agricultural sector with 2718 TJ (755 GWh), (Energoprojekt Entel, 2008b, p. 59).

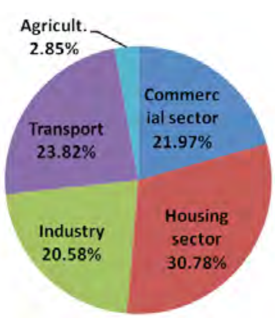


Figure 2 – Final energy consumption of Belgrade region according to sectors in 2012

The total (primary) energy consumption of Belgrade region added up to 153,252 TJ (42,570 GWh) in the year 2012. It subdivides into five sectors (*Figure 3*): The industrial sector with 32,450 TJ (9014 GWh), the housing sector with 57,916 TJ (16088 GWh), the commercial sector with 34,844 TJ (9679 GWh), the transport sector with 24602 TJ (6834 GWh) and the agricultural sector with 3438 TJ (955 GWh), (Energoprojekt Entel, 2008b, p. 65).

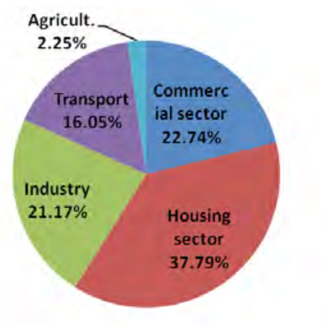


Figure 3 – Primary (Total) energy consumption of Belgrade region according to sectors in 2012

Total primary energy consumption in 2012 amounted to 16,247 Mtoe. Import dependence Serbia in 2012 amounted to 34%. In 2012, most imported crude oil 48%, natural gas 37%, coal 14% (Energy profile of Republic of Serbia for 2012, p.9).

The consumption structure of the transformation process, dominated by coal consumption with 67%, followed by crude oil and petroleum products 11%, natural gas 4%, hydro 8% and 9% of firewood, while geothermal energy less than 1% (Energy profile of Republic of Serbia for 2012, p. 9).
Total final energy consumption in Serbia in 2012 amounted to 10,404 Mtoe, of which the feedstock consumed 0,897 Mtoe, while final energy consumption for energy purposes was 9,507 Mtoe. By sector of final energy consumption is mostly consumed in the household sector 35%, followed by industry 30%, transport 24%, while other sectors accounted for 13%. On the other hand, the energy in final energy consumption was dominated by petroleum products by 29%

[1] Terajoule (TJ) equals 0,2778 Gigawatthours (GWh)

and electricity by 26%, followed by coal 12%, natural gas 13% and heat with 9% and renewable sources of energy (firewood and geothermal energy) accounted for 11% (Energy profile of Republic of Serbia for 2012, p. 10). Serbia's energy dependence has increased by 7% in 2012 compared to 2011 with 34% of primary energy being imported. Import dependence of Serbia is the largest when it comes to natural gas, following with oil. Serbia produces more than 98% of coal needed by the country. The structure of domestic coal is 98% lignite, while 2% were hard and brown coal and about 95% is consumed for power generation in thermal power plants.

Renewable energy sources in Serbia are hydroelectric, wind and solar energy, as well as the production and consumption of thermal energy from geothermal and solid biomass. The planned structure of primary energy from renewable sources for 2013 is 16%, while the defined goal is 27% in 2020; the share of biomass in renewable is 58%, hydroelectricity 41%, while wind, sun, etc. account for less than 1% (Energy balance of Republic of Serbia 2013, p. 10).

Biomass resources represent a significant potential energy source for Serbia. Serbia could replace 25% of their total energy produced with biomass facilities (Draft Energy Development Strategy of the Republic of Serbia by 2025. with projections to the 2030, 2013). The overall annual biomass potential in Serbia is approximately 28,000GWh. The predominant source of biomass in Serbia is agriculture (70%) with the rest coming from woody biomass. Serbia has some of the best solar resource in Europe. Its solar radiation average is around 40 percent higher than the European average. Annual solar irradiation for the country is approximately 1,400kWh/m^2. The lowest measured values of solar radiation in Serbia are comparable to the highest values in the leading countries in solar utilisation such as Germany and Austria.

Geothermal investigations in Serbia began in 1974, after the first world oil crisis. An assessment of geothermal resources has been made for all of Serbia. Detailed investigations in twenty localities are in progress. The territory of Serbia has favourable geothermal characteristics. Exploration to date has shown that geothermal energy use in Serbia for power generation can provide a significant component of the national energy balance. The prospective geothermal reserves in the reservoirs of the geothermal systems amount to 10 to the power of 6. The prospects for use of heat pumps on pumped ground water from alluvial deposits along major rivers are very good. Serbia has approximately 2,770 MW of hydroelectric capacity, which generates a third of their power. A majority of the capacity is from 11 large power plants. Only about 30 MW of capacity comes from small hydroelectric plants (less than 10 MW). Serbia is looking to double its hydroelectric capacity with about 2,800 MW of planned capacity (UDI, World Electric Power Plants Database, June 2009; Energy profile of Republic of Serbia).

As far as electricity is concerned, Serbia can meet the needs by own production, and produces more than 97%, while imports about 3% (Energy profile of Republic of Serbia).

Total energy consumption by fuel (%) in Belgrade region

The structure of final energy consumption in Belgrade region consists of the following fuel types (*Figure 2*; Energoprojekt Entel, 2008b, p.60):

- solid fuel – 6.44% (1705 GWh/a) in 2012; 7.9% (1927,74 GWh/a) in 2006;
- liquid fuel – 41.99% (11120 GWh/a) in 2012; 43.45% (10602 GWh/a) in 2006;
- natural gas – 7.74% (2050 GWh/a) in 2012; 3.68% (896,82 GWh/a) in 2006;
- electrical energy – 28.31% (7500 GWh/a) in 2012; 29.10% (7099,20 GWh/a) in 2006;
- thermal energy – 11.78% (3120 GWh/a) in 2012; 11.50% (2804,95 GWh/a) in 2006;
- renewable energy sources – 3.74% (990 GWh/a) in 2012; 4.37% (1064,88 GWh/a) in 2006.

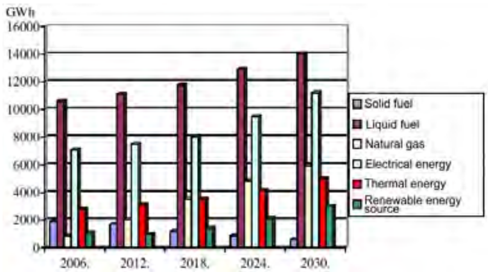


Figure 2 – Final energy consumption of Belgrade region according to type of fuel

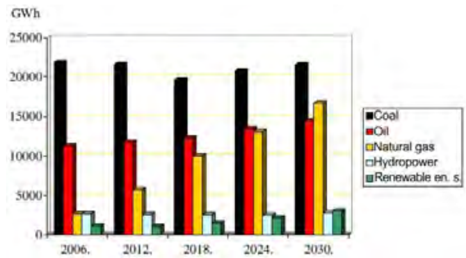


Figure 3 – Primary (Total) energy consumption of Belgrade region according to sources of energy

Primary (Total) energy consumption of Belgrade region according to sources of energy is (*Figure 3*; Energoprojekt Entel, 2008b, p.65):

- renewable energy sources – 2.34% (990 GWh/a) in 2012; 2.65% (1065 GWh/a) in 2006;
- coal – 50.71% (21587 GWh/a) in 2012; 54.31% (21860 GWh/a) in 2006;
- natural gas – 13.46% (5728 GWh/a) in 2012; 8.47% (3409 GWh/a) in 2006;
- oil and liquid gas – 27.56% (11733 GWh/a) in 2012; 28% (11270 GWh/a) in 2006;
- Hydropower – 5.93% (2522 GWh/a) in 2012; 6.57% (2645 GWh/a) in 2006.

Share of energy sources for electricity production

The thermal power plant in Belgrade region - Corporate Enterprise "Thermal Power Plants Nikola Tesla" produced and distributed to Electric Power System, 1,544,234.000 kWh of electricity in March 2012. The participation of the Corporal Enterprise "Thermal Power Plant Nikola Tesla" in the total production of EPS is 41.7%, and in the production of all power plants in the system 57.45%.

Serbia has significant potential for electricity generation and the structure of production is shown in *Table 3*.

Year	2006	2012
Thermal power plants (light fuel)	71.31	71.77
Hydro power plants	28.22	25.86
Cogeneration of natural gas	0.47	2.14
Renewable sources	0.00	0.23

Table 3 – Structure of electricity production in Serbia, %

Year	2006	2012
Final consumption GWh/a	7099.2	7500.0
Losses in distribution %	14.7	14.0
Amount of losses	1222.0	1221.0
Primary (total) energy GWh/a	8321.2	8721.0

Table 4 – Appraisal of electrical energy consumption and losses

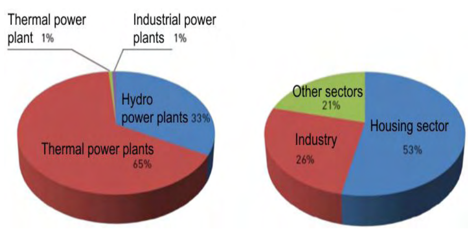


Figure 4 – Electricity production (left) and consumption (right) in Serbia in 2010 (Energy profile RS)

Appraisal of electrical energy production is shown in *Table 4* and *Figure 4*. The final electrical energy consumption of Belgrade region is shown in *Table 4*, in GWh/a, while consumption according to sectors is shown in *Figures 4*. A large amount of electricity is produced from carbon-intensive fuels – coal in power plants with low efficiency. Electricity consumption per capita in Serbia is shown in *Table 5*.

Republic of Serbia	2010	2011	2012
Efficiency of transformation (FE/PE)	0.57	0.57	0.59
Consumption of PE (kg en/capita)	2134	2224.5	2232.6
Electricity consumption (kWh/capita)	3789	3878	3898
Share of household electricity consumption%	53	52	53

Table 5 – Electricity consumption per capita in Serbia (Energy balance of RS, 2012)

GHG emission factor for electricity from grid

According to the regulations on energy efficiency in buildings, CO_2 emissions, which occur during the operation of the buildings, shall be determined on the basis of specific CO_2 emission data for individual energy sources. The annual primary energy required for the operation of the building by source of energy, must be multiplied by the specific data of CO_2 emissions, which is given in the Regulations and specific emissions for electricity is 0.53 kg/kWh. Data regarding carbon dioxide emissions in Serbia are presented in *Table 6*.

Carbon dioxide emissions							
Total		Carbon intensity		Per capita		Kg per 2005 PPP $ of GDP	
Thousand metric tons		Kg per kg of oil equivalent energy use		Metric tons			
1990	2009	1990	2009	1990	2009	1990	2009
	46.25		3.0		6.3		0.7

Table 6 – Carbon dioxide emissions, Serbia (World Development indicators, 2013)

Serbia is an energy intensive country, as well as Belgrade region – energy is not used efficiently. In addition, the electrical and thermal energy are produced in the most ancient plants that mainly use lignite as a fuel that has a relatively high level of emissions of greenhouse gases. Serbian energy sector has been hit hard by falling behind in maintenance and investments 90s, and suffered considerable damage during the war in 1999 year. Total emissions of greenhouse gases (*Figure 5*) measured per unit of gross domestic product (intensity of emission of gases with greenhouse effect Serbian economy) are among the highest in Europe (Energy profile of Republic of Serbia).

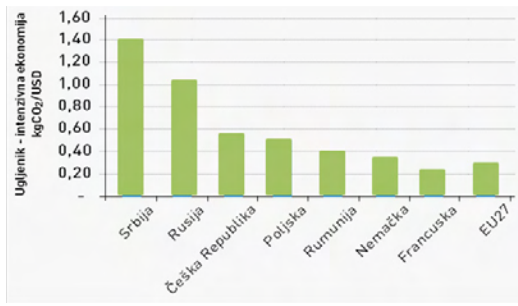


Figure 5 – Carbon dioxide emissions per unit of GDP/a measured by purchasing power parity in the 2009th (International Energy Agency, 2011)

Share of energy sources for thermal energy production (%)

For heat generation in the Belgrade district heating plants natural gas, liquid fuel, coal and municipality waste are used. Share of energy sources for thermal energy production is shown in *Table 7* and *Figure 6*.

Year	2006	2012
Natural gas	82.1	85.3
Liquid fuel	14.8	12.0
Coal	3.1	2.5
Municipal waste	0.0	0.2

Table 7 – Structure of fuel in district heating systems, %

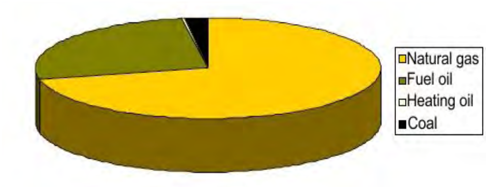


Figure 6 – The structure of heat power by fuels in Belgrade`s region

2. CURRENT SITUATION: TARGETS RELATED TO ENERGY POLICY

In order to reduce energy dependence of Serbia, it is necessary to fulfill three conditions (Energy profile of Republic of Serbia):

- to increase the production of energy from its own energy resources, primarily refers to hydro because Serbia has a dense river network, as well as to increase production of energy from renewable sources;
- to change the pricing policy that Serbia made only losses. Changing the pricing policy would mean higher prices and billing of electricity consumption according to actual consumption, rather than m^2 heating area. Both measures would certainly lead to a more rational use of electricity by households, and the decline in energy deficit RS, and indirectly reducing the import of electricity and energy;
- to set the legal and institutional framework to enable the production and sale of electricity to residents and companies.

Department of Energy, Secretariat of Housing and Municipal Affairs of the City of Belgrade, in cooperation with "Energoprojekt Entel" a. d. and the expert committee, formed by the City, created the Energy Development Strategy of the City of Belgrade. Energy Development Strategy of the City of Belgrade is in line with the objectives, concept and strategy to priority set out in the Strategy for Development of the City of Belgrade and the Strategy of Energy Development of the Republic of Serbia.
As part of the Energy Strategy of Belgrade, which covers the period up to 2030, the current situation in all aspects of production, transmission and consumption of all forms of energy is analysed and such strategic directions of the strategy are defined allowing the objectives to be achieved by ensuring sustainable development and efficient management of energy. When drafting this document modern statistical methods, Eurostat have been applied in order to achieve optimal effects while satisfying the energy needs of the City.

Calculation of final energy consumption by 2030, indicates that the following factors have a relatively large impact on energy consumption in Belgrade: assumed dynamics of growth of living standards and industrial production and dynamics of increasing energy efficiency, especially in the heating of buildings. The highest energy consumption is in households, and lowest in agriculture, and hence the fastest growing its percentage share of final energy consumption. In the case of achieving the projected growth of certain sectors, the total annual final energy consumption in Belgrade in 2030 would reach 39,860 KWh (Table 8), or 3,247,343 toe, so that consumption per capita increased from 1.31 toe (in 2006) to 2.14 toe by the year 2030.

Final energy consumption, GWh					
Year	2006	2012	2018	2024	2030
Industry	5037	5450	5800	6300	6920
Housing sector	7930	8150	8800	10560	12350
Commercial sector	5130	5820	6840	8000	9280
Transport	5807	6310	6950	8060	9450
Agriculture	491	755	1060	1495	1860
Total	24395	26485	29450	34415	39860

Share in percent, %					
Year	2006	2012	2018	2024	2030
Industry	20.65	20.58	19.69	18.31	17.36
Housing sector	32.51	30.78	29.88	30.68	30.98
Commercial sector	21.03	21.97	23.23	23.25	23.28
Transport	23.80	23.82	23.60	23.42	23.71
Agriculture	2.01	2.85	3.60	4.34	4.67
Total	100.00	100.00	100.00	100.00	100.00

Table 8 – Appraisal of final energy consumption of Belgrade region according to sectors with projections by 2030

Appraisal of final energy consumption of Belgrade region according to sectors and energy sources with projections by 2030 is shown in *Figure 7*.

Primary (Total) energy consumption, GWh					
Year	2006	2012	2018	2024	2030
Industry	8378	9014	9468	10443	10984
Housing sector	16429	16088	15663	17853	19960
Commercial sector	8812	9679	11006	12410	13779
Transport	6020	6834	7819	9492	11386
Agriculture	610	955	1369	1852	2344
Total	40249	42570	45326	52050	58453
Share in percent, %					
Year	2006	2012	2018	2024	2030
Industry	20.81	21.17	20.89	20.06	18.79
Housing sector	40.81	37.79	34.56	34.30	34.15
Commercial sector	21.91	22.74	24.28	23.84	23.57
Transport	14.95	16.05	17.25	18.24	19.48
Agriculture	1.52	2.25	3.02	3.56	4.01
Total	100.0	100.00	100.0	100.	100.0

Table 9 – Appraisal of Primary (Total) energy consumption of Belgrade region according to sectors with projections by 2030

The assumed structure of final energy consumption by type of fuel is given in *Table 10* and *Figure 8* (Energoprojekt Entel, 2008b, p.60 data). It can be concluded that the commitment to the reduction of the share of coal and liquid fuels in final energy consumption is present, due to environmental reasons and in order to increase the consumption of natural gas. However, liquid fuels remain the dominant fuel in the final energy consumption despite the partial substitution with natural gas. Share of electrical energy is maintained at almost the same level (by 2030 dropped by only 1%), similar to the share of thermal energy (by 2030, rising only by 1%). The strategic decision to increase the share of renewable energy is evident.

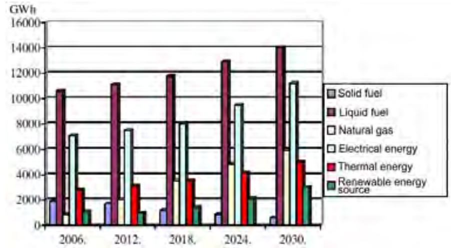
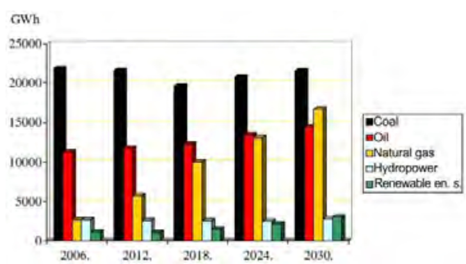


Figure 8 – Projections of the structure of total final energy consumption in Belgrade region according to types of fuel, until 2030

PRIMARY (TOTAL) ENERGY, GWH/A, (%)					
YEAR	2006	2012	2018	2024	2030
Renewable energy source	1065.0 (4.37)	990.0 (3.74)	1420.0 (4.82)	2130.0 (6.19)	3000.0 (7.53)
Solid fuel	1927.7 (7.90)	170.05 (6.44)	1190.0 (4.04)	885.0 (2.57)	620.0 (1.56)
Natural gas	896.8 (3.68)	2050.0 (7.74)	3550.0 (12.05)	4850.0 (14.09)	5940.0 (14.98)
Liquid gas	10602 (43.45)	11120 (41.99)	11780 (40.00)	12890 (37.45)	14050 (35.25)
Electrical energy	7099.0 (29.10)	7500.0 (28.31)	8010.0 (27.20)	9500.0 (27.61)	11220 (28.14)
Thermal energy	2805.0 (11.5)	3120.0 (11.8)	3500.0 (11.9)	4160.0 (12.1)	5000.0 (12.5)
Total	24395 (100)	26485 (100)	29450 (100)	34415 (100)	39860 (100)

Table 10 – Appraisal of final energy consumption of Belgrade region according to type of fuel with projections by 2030

Appraisal of primary (total) energy consumption of Belgrade region according to sources of energy sectors with projections by 2030.is shown in *Table 11* and *Figure 9* (Energoprojekt Entel, 2008b, p.65).



9 – Appraisal of Primary (Total) energy consumption of Belgrade region according to sources of energy with projections by 2030

PRIMARY (TOTAL) ENERGY, GWH/A, (%)					
YEAR	2006	2012	2018	2024	2030
Renewable energy source	1065 (2.65)	990 (2.34)	1420 (3.13)	2130 (4.09)	3000 (5.13)
Coal	21860 (54.31)	21587 (50.71)	19637 (43.32)	20959 (40.27)	21560 (36.88)
Natural gas	3409 (8.47)	5738 (13.46)	9501 (20.96)	13072 (25.11)	16682 (24.71)
Oil and liquid gas	11270 (28.00)	11733 (27.56)	12318 (27.18)	13416 (25.77)	14441 (24.71)
Hydro power	2645 (6.57)	2522 (5.93)	2449 (5.41)	2475 (4.75)	2770 (4.74)
Total	40249 (100.0)	42570 (100.0)	45336 (100.0)	52052 (100.0)	58353 (100.0)

Table 11 – Appraisal of Primary (Total) energy consumption of Belgrade region according to sources of energy with projections by 2030

Bearing in mind the level of efficiency of thermal power plants, with their improvements through rehabilitation of existing and construction of new facilities (*Table 12*), especially those with a combined gas-steam cycle, and the gradual reduction of losses (*Table 13*) in the distribution of electricity, amount of primary energy (coal, liquid fuels and gas) needed for the production of electricity required for the area of the City of Belgrade, is analysed. Use of hydropower and wind, as renewable energy sources, is taken into consideration in the assessment of electrical energy production.

Year	2006	2012	2018	2024	2030
Thermal power plants	71.31	71.77	65.15	61.92	56.27
Hydro power plants	28.22	25.86	22.14	24.30	22.07
Cogeneration of natural gas	0.47	2.14	11.82	11.23	18.42
Renewable sources	0.00	0.23	0.89	2.55	3.24

Table 12 – Structure of electricity production in Serbia (%) with projection by 2030

Year	2006	2012	2018	2024	2030
Final consumption GWh/a	7099.2	7500	8010	9500	11220
Losses in distribution %	14.7	14	13	12	11
Amount of losses GWh/a	1222	1221	1197	1295	1387
Primary (total) energy	8321.2	8721	9207	10795	12607

Table 13 – Appraisal of electrical energy consumption and losses

In the process of heat production priority is given to natural gas (*Table 14*), which contributes to reduction of environmental pollution.

Year	2006	2012	2018	2024	2030
Natural gas	82.1	85.3	89.1	92.7	94.5
Liquid fuel	14.8	12.0	7.8	3.9	1.4
Coal	3.1	2.5	2.3	2.2	2.1
Municipal waste	0.0	0.2	0.8	1.2	2.0

Table 14 – Structure of fuel in district heating system (%) with projection by 2030

According to a most recent study, entitled European Green City Index, Belgrade is in 27th place by the state of key environmental parameters (score 40.3/100) (Economist Intelligence Unit 2009). One of the included parameters is CO_2 emissions. According to those criteria, Belgrade is in 28th place, and according to transport criteria it is in 29th place. Cities were evaluated based on eight environmental categories. The categories include CO_2 emissions, energy, buildings, transport, water, land use, and air quality. The best ranking for Belgrade was for the energy parameter (17th place). The reason for this lies in the decline and reduction of heavy industry, as a consequence of the situation in the 1990s. The worst result for Belgrade was in the field of transport and water. In these categories Belgrade ranked 29th of 30 European cities (transport 3.98/8.81; water 3.90/9.21).

CO_2 emissions per capita are 3.9t compared to the average CO_2 emissions of 5.2t. Considering this sub-category Belgrade is ranked 7th in the overall ranking and 1st in the category of midsize cities. The reason for this is reflected in the fact that the majority of electricity production in Serbia comes from hydropower (Djukic, Vukmirovic, IJJTE, 2011).

Serbia has not yet conducted a full greenhouse gas inventory and is yet to submit its First National Communication under the UNFCCC. Based on vehicle inventories, fuel use and vehicle mode share, the estimated total GHG emissions in 2008 from Belgrade's passenger road transport is 449,490 tonnes. It is estimated that over 60% percent of the total air emissions in Belgrade come directly from automobile sources, with private cars constituting a growing fraction of these emissions (Support to Sustainable Transport in the City of Belgrade, 2010).

The transport sector, which accounted for 11% of total CO_2 emissions in Serbia already in 1999, represents the fastest growing source of CO_2 emissions in Serbia and Belgrade today. The main factors contributing to GHG emissions in the transport sector in Belgrade are: (1) the large number of vehicles registered and operating in Belgrade (more than 420,000 cars in 2007, or one third of all vehicles in the country); (2) a relatively high proportion of old cars, with an average car age of 13 years and corresponding high levels of gasoline consumption exceeding 10 liters/100 km (or about 0.23 kg CO_2 /km); (3) increasing road congestion, which results in stop-and-go maneuvering and therefore poor fuel economy and higher emissions of GHG; (4) high intensity of freight transport (11,000 lorries and trucks enter the city every day); (5) 8000 taxis are operating in the city (Support to Sustainable Transport in the City Of Belgrade Project Document).

The study shows that 40% of people go to work using public transport while the remaining 35% walk or use bikes. This is 75% which is more than the 63% of using a non-motor transport as the average value for European cities. This result was achieved thanks to the extensive public transport system. However, public transport vehicles (buses, trams and trolleys) are in very bad condition, so work is needed to modernise them. The traffic control and management system is outdated (Economist Intelligence Unit 2009).

Specific energy-related technology present in the region

The Electric Power Industry of Serbia (EPS) encompasses coal mines, electric power sources (hydroelectric power plants, thermal power plants, heating plants) and grid distribution systems (Environment in Serbia, 2007, SEEPA).

The 1990 – 2005 period was characterised by reduced energy consumption by 6% and a predominant use of fossil fuels (coal, oil and gas). However, a trend of slow reduction of fossil fuel consumption is perceptible as their share decreased from 97.9% to 93.6% and the energy consumption from renewable resources (hydroelectric power plants) increased from 4.7% to 6.9% (Environment in Serbia, 2007, SEEPA).

Over the 1990 – 2005 periods, the structure of energy consumption changed significantly. The highest increase in energy consumption was achieved in the transport sector – 29.5%, slightly lower in the sectors of households, agriculture, public and commerce – 10.4%, while a decline of 36.7% was recorded in the industrial sector (Environment in Serbia, 2007, SEEPA).

Current Situation

Initiatives and measures for improving the state of transport and CO_2 emissions

The strategic approach of Belgrade in this domain is defined in the General Plan of Belgrade 2021, Transportation Model of Belgrade 2007, Traffic Master Plan of Belgrade: Smart Plan 2021 and the Development Strategy for the City of Belgrade 2012. One of the targets for the Belgrade region is reduction of GHG emissions and increasing use of sustainable and non-motorised modes of travel, as well as reduction of 285 tons of CO_2 per year until 2014 in the transport sector.

In accordance with these documents, the Secretariat of Transport of the City of Belgrade and other institutions implement various initiatives and projects in order to resolve these problems. The aim is to increase the use of public transport to a level of 50%, and in addition to encourage other forms of sustainable transport, i.e. walking and cycling.

One of the projects of that kind, which showed good results, is the implementation of parking zones in the centre of the city. This project restricts the duration of parking to 1 hour, 2 hours and 3 hours depending on the zone. When the time expires, the driver is required to move the car to another location. This measure led to the reduction in the number of cars in the central city area (City of Belgrade, 2011).

In accordance with these goals pedestrian and bicycle transport should be significantly improved. The main tasks related to this are: freeing public space intended for pedestrians from parked vehicles and other barriers, increasing attractiveness of public transport, and creating conditions for realisation of attractive pedestrian and cycle spaces and routes.

Regional targets, barriers and drivers

Climate-friendly mobility

The City of Belgrade Development Strategy from 2009, in the topic area related to traffic, provides for the construction and development of the transport system of Belgrade. This will allow sustainable mobility of citizens, still supporting the rapid development of the city and its competitiveness in the region of Southern Europe (Stojkov, 2008). One of the operational goals is the implementation of a transport system that will contribute to the environmental optimisation of the city. This will be achieved by:

- construction of the first line of the high capacity public transport system in Belgrade;
- stimulating the use of Beovoz trains in commuter transport (shorter but more reliable intervals) in the public transport system of the City;
- reorganisation of public city transport in the vicinity of the Beovoz train corridor as well as within the whole network;
- introduction of river passenger transport;
- increasing the attractiveness of trolley buses and trams (which are powered by electricity);
- increased level of transport safety;
- development of new technologies (traffic management and control, ITS);
- development of bicycle transport;
- stimulating pedestrian transport;
- rehabilitation and modernisation of city streets in urban centre in line with transport demands and standards;
- Modernisation of local roads (Stojkov, 2008);
- Fuel shifting towards low-carbon fuels.

Reducing the average distance of trips (mode-shifting to higher capacity public transport options will improve the load factor; and better integration of land-use planning around transport corridors combined with improved parking management).

The Strategy envisages the retaining of the level of passenger car travel, amounting to 25 – 30%. The use of public transport must reach the level of 45 – 50% of daily trips and ensure a high level of service. Walking is planned at a level of 20 – 25% in intercity movement. Para transit (cycling, taxi and other types of collective transport) must reach the level of 5 – 10% of daily trips (City of Belgrade, 2005). As part of its Transportation Management Plan, the City of Belgrade has initiated various programs such as Park and Ride facilities and increased bus lines to reduce congestion into Central Belgrade.

3. CASE STUDY: REFURBISHMENT OF SUBURBAN APARTMENT BUILDINGS, KARABURMA

Karaburma is a residential area and one of the most populous neighbourhoods of Belgrade, with a combined population of 34,343.
The buildings were built in the late 1950s and early 1960s for workers who were employed in factories in the area. During the 1980s and 1990s most of the factories were closed.
The fact that buildings were designed without consideration to energy consumption, as well as the building deterioration, are the reasons of negative consequences in terms of the poor living conditions, health problems of the residents and greater wasting of energy.

The main technical problems can be summarised as follows: poor thermal and noise insulation of the envelope (facades, roofs, ground floors) and noise insulating efficiency of door and window frames; leaking of the roofs; lack of district heating. A technical problem that should also be indicated is accessibility for disabled, particularly caused by the lack of elevators.

The renovation has been funded by by private investors (building contractors). Through the improvement of the existing buildings investors gain the right to annex the attic or a few floors, which results in construction of new housing units. The investors gain profit by selling these additional flats. Although the main motivation of investors is profit, it can be concluded that the improvement of housing conditions is achieved which promotes the refurbishment of suburban districts affected by social, economic and architectural deterioration.

Objectives and methods

The refurbishment of about hundreds of similar detached buildings was carried out along the main streets around the settlement (see *Figure 10*).

Figure 10 – Buildings in Vojvode Micka Street, Karaburma, bird's eye view

The main objectives of the refurbishment are the compliance with new regulation in terms of accessibility and energy efficiency, the fulfillment of the real needs of the users as well as the improvement of the building's architectural and technical quality. The following main refurbishment strategies are foreseen: improvement of living comfort, especially thermal comfort and energy efficiency of buildings, as well as visual identity and appearance of buildings and settlement.

Figure 11a – View of the buildings type 2 (in the streets Vojvode Micka) before the refurbishment (source: Krstic-Furundzic A., 2012)

Figure 11b – View of the buildings type 2 (in the streets Vojvode Micka) after the refurbishment (source: Krstic-Furundzic A., 2012)

The improvement of living comfort and building appearance was achieved by annex of attics, addition of balconies as new structures and organised closing (glazing) of balconies, as well as by laying of thermal insulation on the facade surface and painting in different colors resulting in housing variation (see *Figures 11a, b*).
The refurbishment undertaken involves the building system and main roof load-bearing members being made of the same material as the building (masonry construction) while the roof structure is wooden. The addition of balconies is created as the new concrete structures (see *Figures 11a, b*). The balconies' slabs are supported partly by the building structure and partly by columns placed on the front. The same concept is applied in case of enlargement of existing balconies, which enabled better usability of the balcony, glazing options provided in advance and good appearance of the building.

These interventions resulted in:

- the recovery of lodgings with new typology of flats coming from attic annex;
- creation of improved dwelling typology by addition of new or enlargement of existing balconies;
- organised closing (glazing) of balconies or glazing options provided in advance creating new living spaces.

As masonry walls had no thermal insulation, their thermal performance was as follows: walls have high thermal transmittance, i.e.

U-value=1.06W/m2K; low inner surface temperature is obvious, thermal bridges are present, condensation is present; walls are wet and freezing is possible; mold growth is noticeable. Box type windows with float glass (4mm) are unfavourable, U-value=3.5W/m2K. Resulting high heat losses during the winter period, led to an increase of conventional fuels consumption and environmental pollution. Improvement of thermal performances of external walls included installing thermal insulation, breaking thermal bridges and replacing windows. All these measures were applied in case of refurbishment of existing buildings in Karaburma settlement.
The refurbishment of the envelopes of existing buildings included:

- laying of thermal insulation on the facade external surfaces – 5cm of expanded polystyrene is added to masonry 19cm tick walls which provided U-value=0,46W/m2K;
- replacement of existing wooden windows with double glazed windows made of three or five-chamber PVC profiles, U-value=2.3W/m^{2}K (subject to consent of the tenant);
- placing of thermal insulation of 10cm of expanded polystyrene (U=0,171W/m^{2}K) on the new roof structures.

Results

Installation of external wall insulation enables thermal bridges to be broken, as moisture is reduced, the temperature of inner wall surface is higher and provides existing external massive wall to be converted into energy rational structure consisting of three layers: existing solid wall as thermal storage layer, thermal insulation and external protective and final layer as re-cladding (Krstic-Furundzic), A.,1998). After improvement U-value=0,46W/m2K of external walls is litter higher than defined by actual regulations (0,40W/m^{2}K), that is due the refurbishment was done before new regulations on energy efficiency of buildings.

Since the refurbishment took place in the last three years, monitoring period has not long enough to provide conclusive evidence. However, by interviewing residents data on energy consumption for heating before and after refurbishment were provided (see *Table 15*).

	Heated floor area (m^2)	Primarly energy demands for heating			CO_2 emissions (kg/a)
		(kWh/month)	(kWh/a)	(kWh/m^2/a)	
Before refurbishment	64	4750	28500	445.30	15105
After refurbishment	69	2750	16500	239.12	8745
Savings/CO_2 reduction		2000	12000	206.18	6360

Table 16 – Primary energy demands for heating and CO_2 emissions before and after refurbishment (data for one standard flat)

In analysis of CO_2 emissions, as the apartments are heated with electrical energy, there were taken into account characteristics of electrical power network of Serbia (Regulations on Energy Efficiency of Buildings), indicating that the electrical power network for production of 1 kWh realises the emissions of 0.53 kgCO_2/kWh. CO_2 emissions before and after refurbishment are shown in *Table 16*.

Application of the described refurbishment measures enabled: improvement of spatial and thermal comfort, higher inner surface temperature, thermal bridges break, reduction in heat losses in winter and overheating in summer, thereby achieving energy savings and reduces consumption of conventional energy sources and environmental pollution. New appearance of buildings and blocks of flats is achieved by balconies and attic annex and variously painted facades.

Intervention is significant, but it is necessary that all buildings which were designed without consideration to energy consumption should be refurbished. Therefore, a transfer of the case study to the region—limited to the residential area of multi-family housing – seems appropriate.

Outcomes

In general terms, renovation of residential buildings in Karaburma could be recognised as a successful rehabilitation funded by private investors (building contractors).

It could be apply on the improvement of the existing privately owned multi-family residential buildings where investors gain profit by selling additional flats.

Apart from the resulting abatement of CO_2 emissions, and improvement of energy performances, the refurbishment also brought positive economic and social impacts, including a reduction in energy bills. Many interventions such as external wall insulation, glazing of balconies and replacement of windows have improved the thermal comfort of the properties together with their external appearance.
An important positive effect of the large-scale and regional approach is - recognising the affordable model due to the coast of intervention and investors.
Despite the positive overall outcomes, a set of issues have been identified as barriers to the achievement of better results:

- of investments, the improvement was just from energy class G to D;
- shortage of knowledge and skills on innovative measures among the professionals and the workers involved in the retrofits;
- private ownership of apartments in multi-family houses.

On the other hand, a series of conditions have been identified as active drivers:

- energy savings of about 40%:
- increase of the value of a property (apartments) for 30%.

4. CONCLUSIONS

As regards the Republic of Serbia, in conformity with Decision 2009/05 of the Ministerial Council of the Energy Community, the first Action Plan covers the period from 2010 to 2012 and sets the average indicative target for this period at 1.5% of domestic energy end use in 2008, and the end target at a minimum of 9% of energy end use in the ninth year of implementation (at the end of 2018). The energy end-use savings target of 1.5% will be attained by implementing measures towards increasing energy efficiency in household, public and commercial sectors (0.0235 Mtoe), industry (0.0566 Mtoe) and transportation (0.0453 Mtoe). During the APEE implementation period, the Republic of Serbia should continue introducing considerable legislative, fiscal, financial and organisational measures in the interest of full implementation of and adherence to the Directive.

In Belgrade, many of housing settlements dating from the late fifties and the sixties of the 20th century and represent a large percentage of the city's building stock. Most of them are consisted of a numerous of buildings with the same or similar layouts. Up to the seventies the buildings were designed without consideration of energy demands and consumption. Nowadays they are characterised by some social, architectural and technical problems, but building decay is the main problem. Old-age, lack of maintenance, poor quality of materials and improper design cause deterioration of buildings. Improvement of housing settlements is becoming increasingly inevitable. The same characteristics were feature of housing settlement Karaburma until the building refurbishment began in 2009. The improvement of living comfort and building appearance was achieved by annex of attics, addition of balconies as new structures and organised closing (glazing) of balconies, as well as by laying of thermal insulation on the facade surface and it's painting in different colours resulting in housing diversity as well as improvement of facade thermal performances. It is evident that heating demands are less for about 40 percent compared with heating demands before refurbishment, which means that the energy savings of about 40 percent are achieved and thus reduced environmental pollution. Achieved benefits contribute to other tenants opt for intervention.

Applied intervention for improving the energy performance of the multi-family housing sector can bring environmental, economic and social benefits, both on local and regional level.
It could be applied also in residential area in cities and towns throughout Serbia.

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