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Energy-efficient refurbishment of public buildings in Serbia

In order to contribute to global initiatives for reducing energy consumption through energy efficiency increase, Serbia has adopted a set of related national regulations and invested in several large energy-efficient projects targeting the sector of public buildings. Since inefficient or inappropriate energy use in public buildings was often found to be coupled with compromised indoor comfort conditions, national energy efficiency projects have been particularly designed to target facilities providing services to the most vulnerable population, such as schools, health care and social care institutions. Implementation of high technical norms related to building elements and equipment to be installed when conducting energy efficient refurbishments has proven to be highly beneficial with respect to both energy savings and improved comfort conditions. Reduced emissions and use of renewable energy sources were found to be of high importance as well.

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Inefficiency in the use of energy

Energy shortage, energy conservation, energy efficiency – the terms we hear more and more often when discussing somewhat grim predictions about the future of global energy supply, energy security and environmental problems associated with energy generation. Together with increased reliance on renewable energy sources, energy efficiency increase was recognized as one of the measures that can lead to somewhat better energy future if implemented systematically and methodically.

Inefficient use of energy represents a major concern in Serbia. Consumption of primary energy per every unit of GDP is significantly higher than in the EU (13 times higher than in Germany, 10 times higher than in France) [1]. Many studies have pointed out that Serbia has a large energy efficiency improvement potential in the building sector, primarily resulting from the fact that largest portion of Serbian building stock are buildings built during the '70s and the '80s, with brick walls and no thermal insulation, deteriorated wood/metal fenestration and worn-out metalwork. In case of individual boilers (usually burning coal or fuel oil), heating installations are often in very poor condition, without properly insulated distribution lines, non-operating control equipment and out of order radiator valves. As a result, efficiency of the systems is low, which coupled with poor building envelope features causes valuable energy to be wasted. Having in mind financial hardships Serbia is facing today, any effort to reduce excessive energy consumption is considered largely beneficial.

In line with global attempts, Serbia has adopted a series of regulations that are intended to contribute to national energy efficiency increase, including National Energy Efficiency Action Plan adopted in 2010, as well as Decree on Energy Efficiency in Buildings and Decree on Modalities of Issuing and Content of Building Energy Performance Certificates, that came in force in late 2012. In addition, the new Law on Rational Energy Use is expected to be adopted in early 2013. As specified in the National Energy Efficiency Action Plan, building sector is expected to contribute largely to national energy efficiency increase, with 9% reduction in the final energy consumption planned to be achieved until 2018 [2].

Serbia Energy Efficiency Project (SEEP)

Public sector has been identified as a sector that needs to set an exemplary role in the implementation of energy efficiency measures [3], [4]. In line with such intention, Serbia has implemented several projects aimed at energy-efficient refurbishment of public buildings, particularly schools, health care and social care institutions. The largest energy efficiency project is *Serbia Energy Efficiency Project (SEEP)*, funded through IDA credit and IBRD loan and with foreseen total investment value of 49 million USD [1]. The project was planned to be implemented in phases, carried out from 2004 through 2013. The project objective is to improve energy efficiency in public buildings in Serbia and to provide more affordable space heating services, as well as more functional and healthy environment for the end-users. **Table 1** summarizes the number of public facilities included in the first and the second project phase, while **Figure 1** illustrates location-wise distribution of associated buildings [5].

Energy Saving Opportunities Identified

Measures implemented in public buildings included in the scope of SEEP project have been selected so as to provide the best cost-effective building refurbishment i.e. to result in the largest energy savings in the shortest span of time. Individual measures included intervention on building envelope, boiler room modernization, fuel switch (natural gas as an alternative to coal or fuel oil), installation of thermostatic radiator and balancing valves, installation of variable flow pumps and automatic control systems. Although energy audit of each build-

Table 1. The scope of **S**erbia **E**nergy **E**fficiency **P**roject.

Facility type	Project Phase	
	Phase 1 (SEEP1) 2004-2008	Phase 2 (SEEP2) 2009-2012
Schools (elementary and secondary education level)	16	28
Health care institutions	12	29
Social care institutions	–	5
TOTAL	**28**	**62**

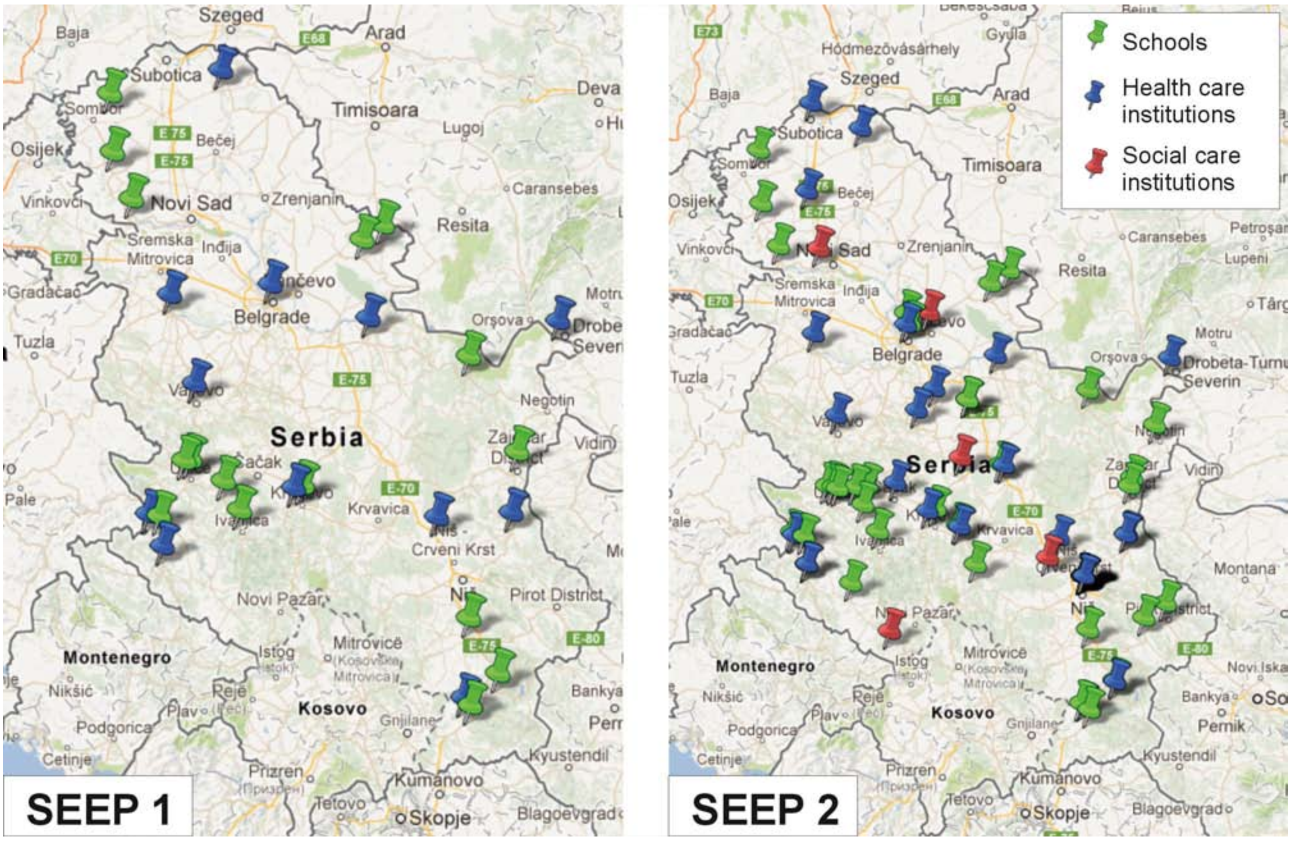

Figure 1. Locations of public buildings included in the scope of SEEP project.

ing enabled identification of all feasible refurbishment measures, only the cost-optimal combination of energy efficient improvements was implemented.

Table 2. Individual measures applied in the buildings included in the scope of SEEP2 project.

Type of measure	Share of buildings where measure was applied
Façade joinery replacement	79%
Façade insulation	37%
Attic/sloped roof/flat roof insulation	69%
Installation of thermostatic radiator valves	69%
Installation of balancing valves	21%
Installation of variable flow pumps	6%
Modernization of boiler room	24%
Fuel switch	2%
Lighting system upgrade	13%

It should be mentioned that replacement of worn out façade joinery and installation of thermostatic valves have found their way into the most of implemented energy efficiency packages, as seen in **Table 2**. This demonstrates particularly poor condition of fenestration systems prior to refurbishments, whose replacement, apart from resulting in significant energy savings, considerably improved end-user comfort by reducing infiltration. Installation of thermostatic radiator valves enabled heating regulation and prevented potential overheating in buildings whose heat loses were considerably reduced. On the other hand, fuel switch, as financially, administratively and technically more complex and demanding, was implemented only in one social care institution in the town of Pančevo, located near the capital city of Belgrade, where new gas-fired boiler was installed to replace light fuel oil fired boiler utilized previously. This was deemed largely beneficial for local population, having in mind that Pančevo inhabitants frequently struggle with elevated pollution levels due to large industrial complexes, including oil refinery, petrochemical plant and fertilizer factory, located and operating in the very town of Pančevo.

Energy savings achieved in each group of buildings are depicted in **Figure 2**. Clinical Centre of the City of Niš is presented as an individual building group since it represents a 19-building complex. As seen in **Figure 2**,

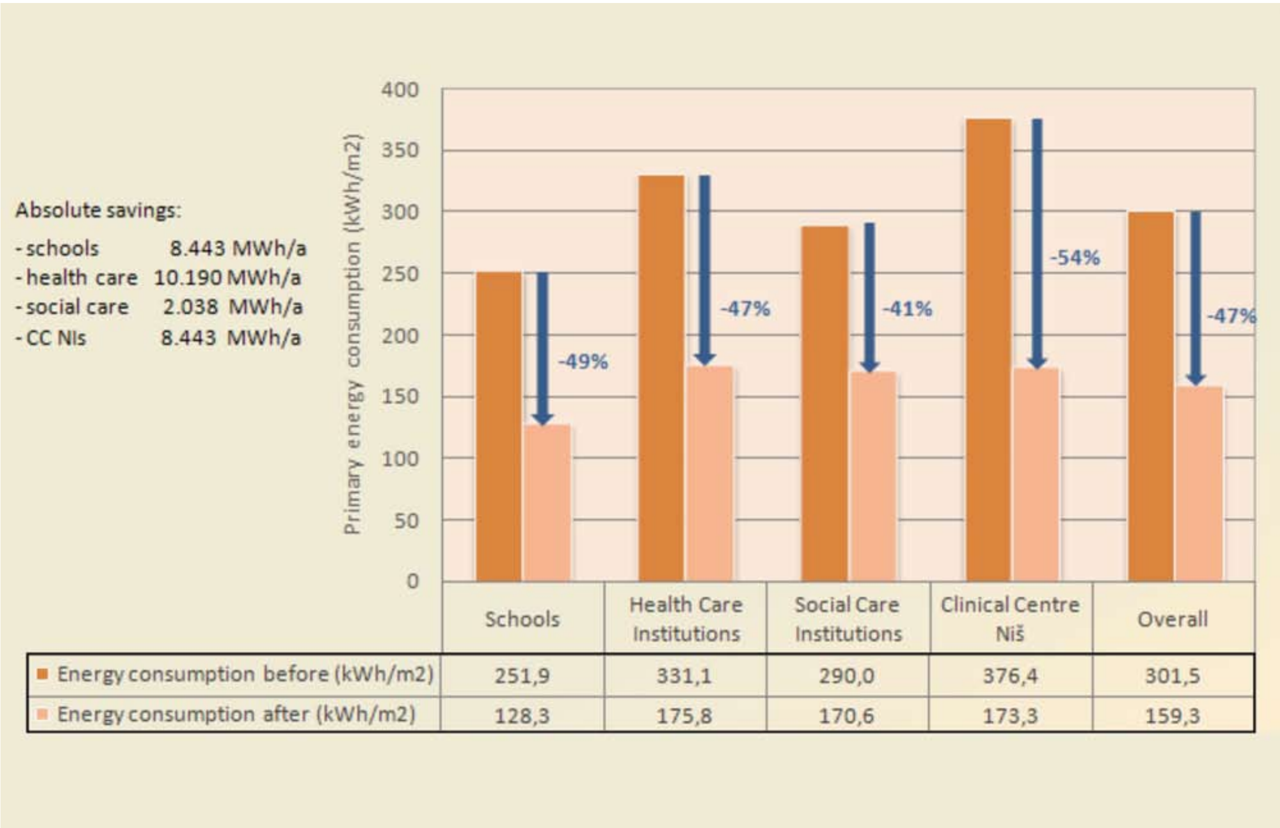

Figure 2. Annual energy savings achieved in public buildings included in the scope of SEEP2 project.

in average, 47% energy consumption reduction has been achieved in 62 refurbished public buildings. Although the consumption values presented surely leave room for additional improvements, it is important to mention that only a small handful of buildings have been fitted with full set of energy efficiency measures, while majority were only fitted with a couple of improvements selected as the cost-effective refurbishment solution. This was mainly due to budgetary constraints as well as situations when end-users failed to conduct prerequisite repair works that were deemed necessary in order to implement certain energy efficiency improvement. In addition, facilities were required to remain fully operational during the entire work execution, which significantly slowed down the works and was particularly challenging in case of health care and social care institutions.

It is also worth mentioning that measurements conducted in some of the refurbished schools prior to improvements have indicated that indoor temperatures in the classrooms were only 15…16°C. The fact that proper indoor temperatures were measured following the refurbishments points out to the conclusion that energy savings achieved have been reduced by the fact that portion of potentially "saved" energy needed to be used to provide required indoor conditions and necessary end-user comfort.

Savings achieved in health care facilities are particularly important when considering the overall annual energy consumption, since hospital heating systems are designed to operate continuously i.e. 24/7 and achieve higher indoor temperatures when compared to social care institutions and particularly when compared to schools whose heating systems are usually completely shut-down (or operate at reduced capacity) during overnight/ weekend and holiday periods. This is more evident when specifying that absolute annual energy consumption of 62 considered buildings have been reduced by 29.114 MWh in total, where 64% of this annual value is attributed to savings achieved in 29 health care institutions, while 29% comes from the savings achieved in 28 schools. The remaining 7% results from refurbishments carried out in 5 social care institutions.

Economics of energy savings

Investment costs associated with execution of energy efficiency improvements amounted to 11.6 million EUR, where 47% of the funds was used to increase energy efficiency in schools, while 6% to improve situation in social care institutions, as seen in **Figure 3**. Interestingly enough, the identical 47% of the funds enabled improvements of health care institutions (individual hospitals and the complex of Clinical Centre of Niš) although significantly larger area was services (total

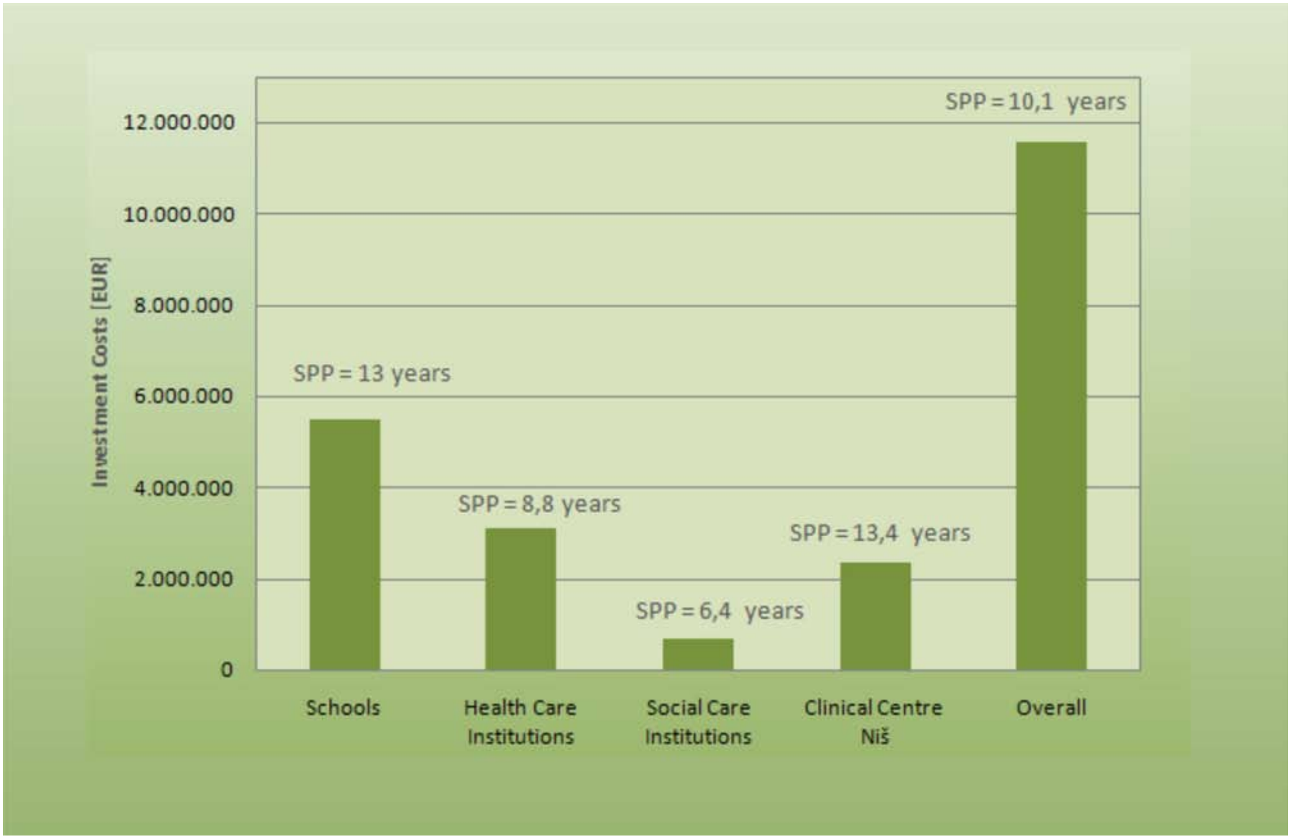

Figure 3. Investment costs and simple payback period associated with SEEP2 refurbishments.

heated area of the health care institutions amounted to about 124 000 m² in contrast to total heated area of the schools that reached approximately 70 800 m²).

Analysis of financial data points out to the conclusion that such situation was attributed to much complex layout of the schools considered, with many of them requiring additional repair or fine works in order to enable proper implementation of intended energy saving measures. With respect to simple pay back period (SPBP) of the investment made, **Figure 3** above illustrates that predominant use of low-price domestic coal, as in the Clinical Centre of Niš, resulted in SPBP of over 13 years. On the other hand, reduced consumption of expensive fuel, such as fuel oil, enables faster return on investment, evident in case of social care institutions. Higher SPBP associated with energy efficient refurbishment of educational institutions results from higher investment costs associated with reasons mentioned earlier.

Apart from energy savings and financial benefits achieved, environmental effects, reflected through reduced CO_2 emissions, and social benefits, manifested through increased public awareness about the energy efficient refurbishments, were deemed to be equally important.

Use of renewable energy sources

Besides SEEP project, Serbian public authorities have invested or have planned to invest in a number of similar refurbishment projects, with many of them aimed towards replacing traditionally used fossil fuels with renewable energy sources. For example, in 2008, a 14 kW heat pump based heating system, with energy extracted from the nearby well, was installed to heat elementary school in a village near the town of Varvarin in Central-Eastern Serbia. In addition, 35 kW solar collectors have been installed on the roof of Railway Student Housing building in Belgrade, generating energy sufficient to meet 63% of total heat demand of the facility mentioned. Installation of 28 kW solar collector system on the roof of an elementary school in Belgrade has again proven to be largely beneficial in terms that 72% of total energy demand of the school is now met by solar system installed.

A recent study, conducted with a goal to promote the use of geothermal energy in balneology, has shown that refurbishment of building envelope of Rehabilitation Centre in Mataruška Spa in Central Serbia would enable heat demand of the Centre to be reduced by 57%, thereby enabling a 96 kW heat pump utilizing locally available geothermal water to replace the existing 740 kW liquid fuel fired boiler [7]. Even if financial constraints manage to prevent the planned building refurbishment to be carried out, a 220 kW heat pump is deemed to be sufficient to meet the current energy demand of the facility considered.

Combined heat and power generation

As part of the Serbian national energy efficiency initiative, a 6.5 million EUR worth project was carried out in the Clinical Centre of Serbia, the top medical care, research and educational institution in the country. The Centre comprises 23 specialist clinics and 9 emergency and other centres housed in 76 buildings located in the very centre of the capital city of Belgrade. In order to replace formerly utilized 19 coal and oil fired boilers distributed throughout the heavily polluted Clinical Centre's area, a new, dedicated, gas-fired, combined heat and power (CHP) generation unit, as well as three hot water boilers, generating 40 MW_{th} in total, was constructed and commissioned in 2009. The CHP plant was designed to be of sufficient capacity to provide all the heat, auxiliary steam and power needed for uninterrupted operation of the Clinical Centre. The fuel switch was deemed particularly important having in mind sensitive population that uses services of the Centre, coupled with the fact that the Centre is located in the central, traffic intense area of the capital. Financial aspects of plant operation were made favourable by properly selected capacity of the CHP unit (1.8 MW_{th} and 1.8 MW_e) which was designed so as to be sufficient for all year round operation, while also providing necessary amount of sanitary hot water.

Conclusion

Based on the result achieved in the projects specified, it is concluded that implementation of energy efficiency improvements in public buildings in Serbia, as well as implementation of energy efficient technologies and use of renewable energy sources, has proven to be highly beneficial, both with respect to reduced energy consumption and carbon footprint, as well as associated financial and social benefits. In fact, following well documented success of energy efficiency projects conducted up to date, Serbia is now in the process of selecting another 56 public building that will be refurbished in energy efficient manner. Taken together, it may be concluded that energy efficiency projects carried out in Serbia demonstrate benefits of national energy-related policies and measures promoted through national legislation and carefully selected financial incentives.

References

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