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**Project of the Energy Efficiency in Serbia**  
**IDA Credit 3870 YF**  
**Part B: Public Buildings – Schools and Hospitals**  
***Final Results of the Project***

Technical paper

*In the frame of the Project “Energy Efficiency in Serbia”, proposed and elaborated by the World Bank, accepted and supervised by the Republic of Serbia and financed according to IDA conditions, Energy Efficiency Agency of the Republic of Serbia was implemented body of the Part B of this Project, according adopted Plan of the Implementation and World Bank Procedures for equipment supplies, works and services. The paper presents implementation process, final results and achievements on energy efficiency refurbishment of 28 public buildings (12 hospitals and 16 schools) in Serbia.*

Key words: *energy efficiency, buildings stock, public buildings*

**Introduction**

In September 2004, Credit Agreement was signed between the Republic of Serbia, as the borrower, and the International Development Association, as the creditor, towards the costs of Serbian Energy Efficiency Project – 1<sup>st</sup> Phase (SEEP-1).

Project has been established through three parts:

- Component A – The rehabilitation of energy supply system of Clinical Center Serbia (CCS),
- Component B – Energy Efficiency Retrofit of Public Buildings – Schools and Hospitals, and
- Component C – Technical assistance to Serbian Energy Efficiency Agency (SEEA).

In the frame of the SEEP-1, proposed and elaborated by the World Bank, accepted and supervised by the Republic of Serbia and financed according to IDA conditions, SEEA was implementation body of this Project, according adopted Plan of the Implementation and World Bank Procedures for equipment supplies, works and services. Project was funded by World Bank’s credit, with local participation of the Government of Serbia and financed on IDA terms. The total project size is 25 million USD and has been realized in period 2005-2010.

The paper presents implementation process, main final results and achievements on energy efficiency refurbishment of 28 public buildings (12 hospitals and 16 schools), have been defined through the part B: Energy Efficiency Retrofit of Public Buildings – Schools and Hospitals in Serbia [1]. The project size of the component B is 14.12 million USD.

### Implementation proces

On the beginning of the Project realization, a working group established of WB representatives, WB consultants, SEEA, and representatives of the Ministry of Energy and Mining, Ministry of Health, Ministry of Education and Sports, and Ministry of Finance was carry out early selection process:

- identified and proposed potential candidates,
- SEEA developed and processed the filled questionnaires, and
- SEEA have been carried out energy audits and established a preliminary ranking list of buildings.

Based on these inputs and non-technical criteria (as were as geographic distribution, number of users, *etc.*), the Ministry of Health and Ministry of Education and Sports selected candidates for next phase of Project implementation, listed in tab. 1 and 2.

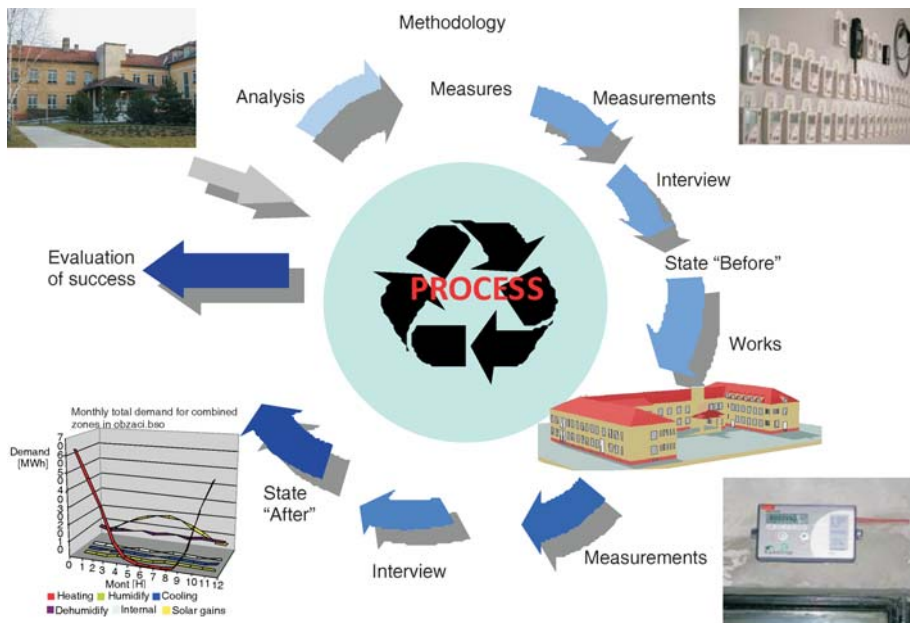
**Table 1. List of the retrofited public buildings**

	Education sector – “Schools”	Municipality
1	Elementary School “Miroslav Antić”	Odžaci
2	Elementary School “Stevan Čolović”	Arilje
3	Elementary School “Milinko Kusić”	Ivanjica
4	Elementary School “Dušan Jerković”	Užice
5	Secondary Technical School	Vranje
6	Elementary School “Vuk Karadžić”	Surdulica
7	Secondary Agricultural Vocational School “Radivoje Uvalić”	Bačka Palanka
8	Elementary School “Miroslav Antić”	Čonoplja (Sombor)
9	Secondary Agricultural Vocational School “Dr Djordje Radić”	Kraljevo
10	Secondary Vocational School	Vršac
11	Elementary School “Svetozar Marković”	Leskovac
12	Elementary School “Stari grad”	Užice
13	Elementary School “12. Septembar”	Majdanpek
14	Elementary School “Ljuba Nešić”	Zaječar
15	Elementary School “Vuk Karadžić”	Priboj
16	Elementary School “Branko Radičević”	Uljma (Vršac)

**Table 2. List of the retrofitting public buildings**

Health sector – “Hospitals”		Municipality
1	Medical Center Senta	Senta
2	Medical Center Vranje	Vranje
3	Medical Center Knjaževac	Knjaževac
4	Medical Center Aleksinac	Aleksinac
5	Institute for Gynecology and Obstetrics, CC Serbia	Belgrade
6	Medical Center Požarevac	Požarevac
7	Medical Center Kladovo	Kladovo
8	Medical Center “Studnica”	Kraljevo
9	Medical Center Valjevo	Valjevo
10	General Hospital Šabac	Šabac
11	General Hospital Priboj, Medical Center Užice	Priboj
12	General Hospital Prijepolje, Medical Center Užice	Prijepolje

SEEA conducted the Project in accordance with approved Project Implementation Plan and methodology of project implementation presented on fig. 1, and in accordance with



**Figure 1. The methodology of project implementation**

standard World Bank's procedures for procurement of goods, works, and services. In addition to evaluating, proposing, designing and supervising implementation of packages of energy efficiency measures in buildings, one of the main aspects of the project implementation was to analyze and verify the successful implementation of these works by comparing performances *BEFORE* and *AFTER* the refurbishment had been completed [2-4].

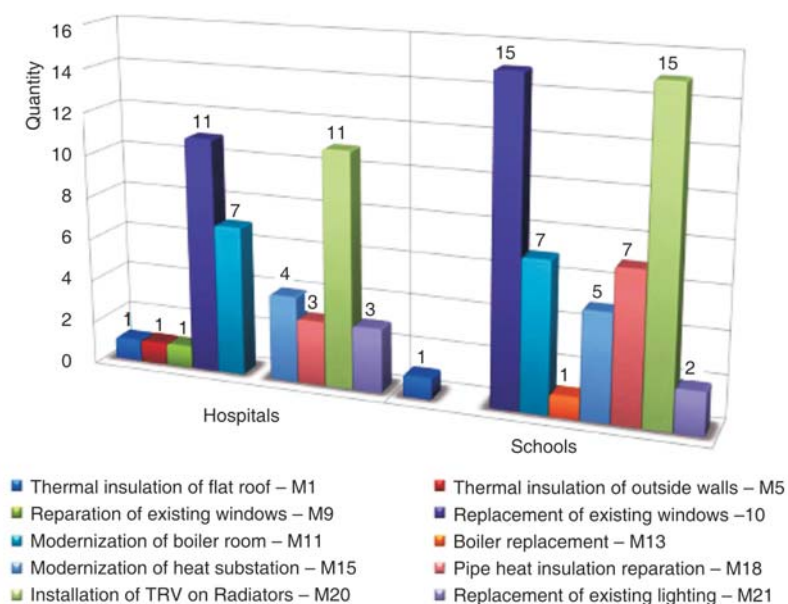
*Design and Supervision Support for Implementation of the Energy Efficiency Improvements in Public Buildings (Schools and Hospitals) in Serbia* has been undertaken by a joint venture (JV) between BDSP Partnership Ltd., London, UK, and Energoprojekt ENTEL, Belgrade in close co-operation with the SEEA.

### Implemented measures and energy consumption overview for the condition "Before"

SEEA has contracted various consulting services with Joint Venture BDSP Partnership from London and Energoprojekt, ENTEL from Belgrade. The most important service was measurement of the heat consumption, before and after the implementation of selected measures for energy rehabilitation of the building accompanied by monitoring of the achieved indoor comfort for end users [2].

Measurements should point out parameters which are of a crucial importance for building's energy "behaviour", that is outdoor air temperature, wind speed and direction, sunshine intensity.

During 2005, BDSP Partnership and Energoprojekt, ENTEL staff, visited and surveyed all the selected buildings to be refurbished and after preliminary examination, identified and evaluated packages of complementary energy efficiency improvements.



**Figure 2. Energy efficiency measures overview**  
(full color figure is available in electronic version)

The proposed measures have been related on three general groups: (1) upgrading the building envelope (*e. g.* insulating walls; replacing windows; *etc.*); (2) upgrading the heating system (equipment and controls – both central plant and local terminal units); and (3) upgrading lighting systems and graphically presented on fig. 2, selected in the 9 energy efficiency implemented measures.

The measurement process, measurement results and explanation of the package of applied energy efficiency measures were explained on the case of the Senta Hospital building [2, 4].

The most frequently specified measures carried out were replacement of windows (due to the poor condition of existing windows in many buildings) and installation of thermostatic radiator valves (TRV) on radiators to allow improved control of heating systems.

Figures 3 and 4 show climate influence, represented by number of the heating degree days (dd), on average annual specific energy consumption for heating [kWh/m<sup>2</sup>], for selected buildings (hospitals and schools) „Before” the refurbishment had been completed. Data were measured for different regions of Serbia: Central, East, North, South, West, and South-West region and used for “energy audits” [2-4].

Also, the annual specific energy consumption for buildings heating „Before” are presented on fig. 5, mutually with energy consumption „After”.

Figure 5 shows the percentage of the total investment made in each of the 9 energy efficiency measures implemented (without replacement of existing lighting). Replacement of windows accounted for 84% of the total budget alone, whereas on other measures were spent 16% of the total budget [1].

All potential measures were proposed and evaluated in terms of: energy savings, improvement of occupant comfort, capital costs

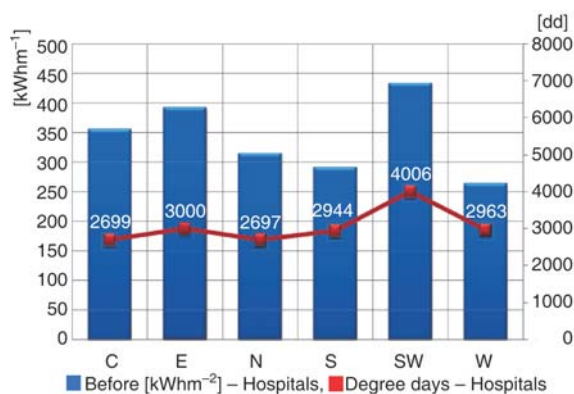


Figure 3. Average „Before” specific energy consumption and heating degree days by region for hospitals (full color figure is available in electronic version)

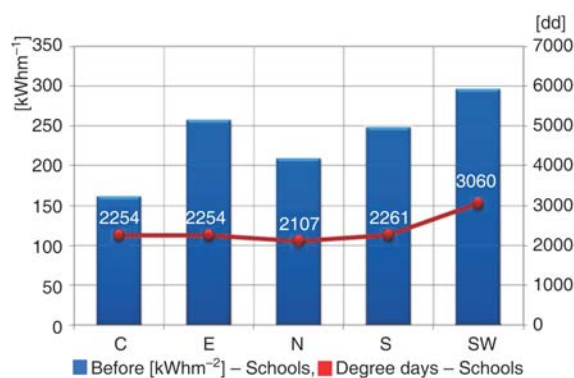


Figure 4. Average „Before” specific energy consumption and heating degree days by region for schools (full color figure is available in electronic version)

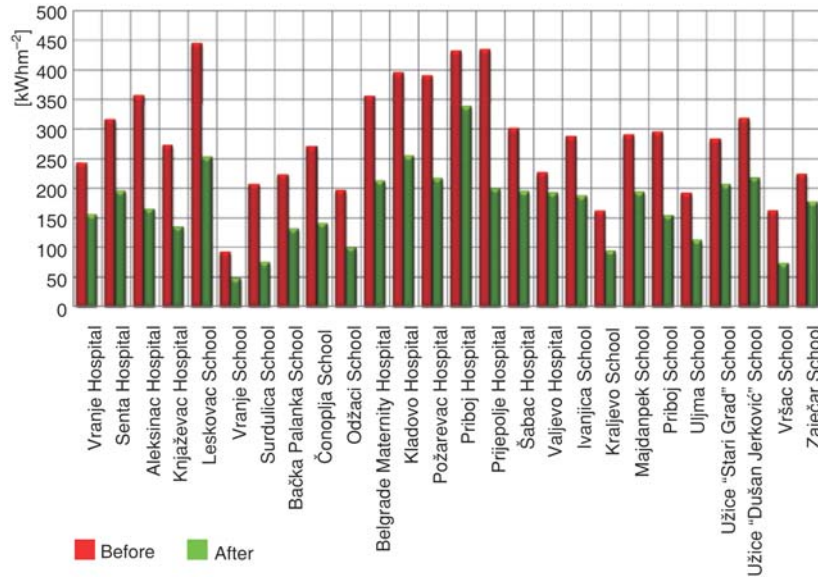


Figure 5. Annual specific energy consumption for heating by building (full color figure is available in electronic version)

and return on investment, CO<sub>2</sub> emission reduction, etc. by use of “energy audits” based on 3-D dynamic thermal modeling.

**Final results of the project**

Final results of the project are presented on graphs and compares data for each individual building or as average relevant values „Before” and „After” refurbishment,

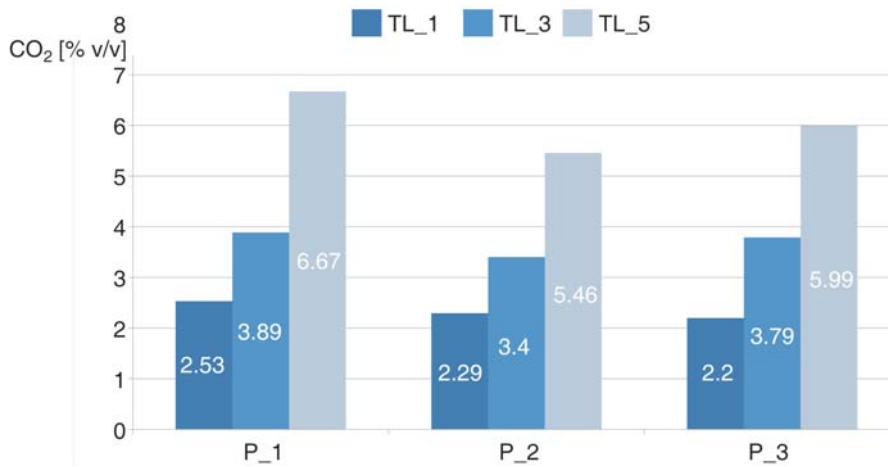


Figure 6. Total financial investment by energy-efficiency measures (full color figure is available in electronic version)

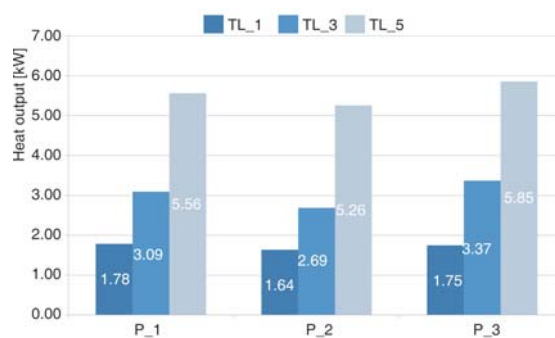
based on the use of a weekly regression that considers correlation between heating energy consumption and degree hours during each week of the heating season monitored, and extrapolation of monitoring results to a whole heating season. Climate files from the “Meteonorm” database used in the dynamic thermal modelling for evaluating the packages of selected measures in the initial energy audits have been used for consistency [2, 4].

Figure 6 compares the normalized or specific energy consumption [kWh/m<sup>2</sup>] for each individual building „Before” and „After” refurbishment.

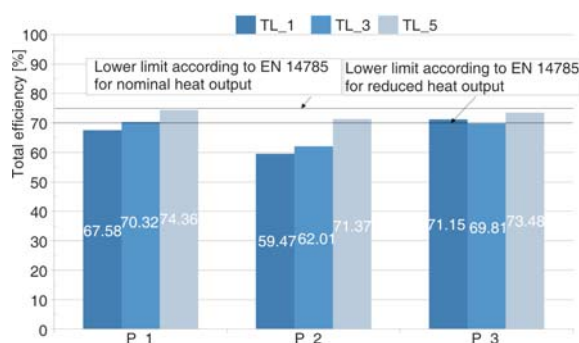
The predicted energy consumption savings in percentage terms varies from around 15% up to 63%. Aleksinac, Knjaževac and Prijepolje Hospitals, Surdulica and Vršac Schools are buildings where energy savings of more than 50% are expected.

On fig. 7 are compared the average specific annual space heating energy consumption for the 15 schools and 11 hospitals „Before” and „After” refurbishment. The hospitals use about 30% more energy on an annual basis due to their continuous year operation, while the schools have breaks at weekends and holidays and often are heated intermittently. The average specific energy consumption for an annual heating were: for schools – 243 kW/m<sup>2</sup> „Before” and 144 kW/m<sup>2</sup> „After”; and for hospitals – 339 kW/m<sup>2</sup> „Before” and 205 kW/m<sup>2</sup> „After” refurbishment [1].

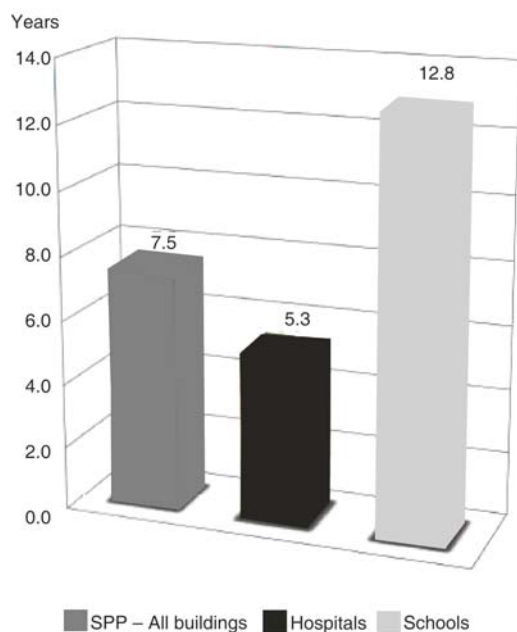
On fig. 8 are compared the average specific annual CO<sub>2</sub> emissions for space heating „Before” and „After” refurbishment. The average specific annual CO<sub>2</sub> emissions were: for schools – 72 kg/m<sup>3</sup> „Before” and 43 kg/m<sup>3</sup> „After”; and for hospitals – 96 kg/m<sup>3</sup> „Before” and 57 kg/m<sup>3</sup> „After” refurbishment. The results have been extrapolated to approximate annual figures based on the results of 1 month of pre-refurbishment and 1 month of post-refurbishment monitoring [1].



**Figure 7. Average specific energy consumption for heating**  
 (full color figure is available in electronic version)



**Figure 8. Average specific annual CO<sub>2</sub> emissions for heating**  
 (full color figure is available in electronic version)



**Figure 9. Simple payback period – hospitals and schools – whole project graf**

pitals and 16 schools) defined and processed through the part B: Energy Efficiency Retrofit of Public Buildings – Schools and Hospitals in Serbia [4-6].

The major goal of the project has been the verification of the energy and cost savings as well as CO<sub>2</sub> emission reductions achieved through implementation of the energy efficiency measures. However, achieving improvements in occupant comfort and the aesthetic appearance of the buildings were also important targets.

Significant energy consumption savings have been achieved for all refurbished buildings with annual savings in the range of 15% to 63% and an average of 40% over entire project (cumulative energy savings of some 13,630 MWh per annum of pre-refurbishment consumption of some 21.000 MWh per annum);

Associated annual CO<sub>2</sub> emission reductions vary between 15% to 64% with an average reduction of 41% (reduction of some 4.200 tones per annum) and associated average emission after buildings refurbishment of some 5.800 tones per annum;

For the 15 schools monitored, the specific annual space heating energy consumption (*i. e.* normalized by heated floor area) varied between 92-445 kWh/m<sup>2</sup> before refurbishment and was reduced down to 48-252 kWh/m<sup>2</sup> after refurbishment. The average specific annual space heating energy consumption for the refurbished schools is ~144 kWh/m<sup>2</sup>.

The specific annual space heating energy consumption for the 11 hospitals monitored was between 227-435 kWh/m<sup>2</sup> before refurbishment and has been reduced down to 135-338 kWh/m<sup>2</sup> after refurbishment. The average specific space heating annual energy consumption for the refurbished hospitals is ~205 kWh/m<sup>2</sup>.

On fig. 9 is presented the Simple Payback Period (SPP) for whole Project defined as “total Serbian Energy Efficiency Project 1 (SEEP 1) investment in relevant measures divided by the value of total annual energy savings, taking into account the average price of fuel” [1]. Calculated on this basis the SPP of whole investment is 7.5 years, separately, for the hospitals and the schools is 5.3 and 12.8 years, respectively.

As the SPP is inside the 10 year credit grace period of loans indicating that such loans can be paid off through the energy savings accrued over this period.

## Conclusions

In the frame of the SEEP-1 project, funded by a credit from the World Bank, SEEA has conducted the energy efficient refurbishment of 28 public buildings in Serbia (12 hos-



The simple payback period (SPP) on investment across all buildings was found to be about 7.5 years. For hospitals, due to their continuous operation, the SPP is 5.3 years and for schools, due to their interrupted operation, is 12.8 years.

As the SPP is well inside the 10 year credit grace period of loans indicating that such loans can be paid off through the energy savings accrued over this time and it also indicates that investment in energy efficiency in public buildings could be attractive.

Implementations of component B in the 1<sup>st</sup> Phase of the Project, with justified energy savings CO<sub>2</sub> reduction, provide a sufficiently wide range of experiences and knowledge, thus enabling continuation of the Project in the Phase II.

By approved new World Bank loan, the Project, *The Energy Efficiency in Serbia, IDA Credit 3870 YF; Part B: Public buildings – schools and hospitals*, is extended in 2<sup>nd</sup> Phase of the Project, on a further 80 schools, hospitals, and social care facilities.

## References

- [1] \*\*\*, Final Monitoring Report – SEEP 1, BDSP Partnership LTD, Belgrade, 2009
- [2] \*\*\*, Energy Efficiency Evaluation Reports, JV, Belgrade, 2005
- [3] \*\*\*, Monitoring Report Before, JV- BDSP Partnership LTD and Energoprojekt Entel , Belgrade, 2005
- [4] Durković, A., Stojanović, G., Lilić, D., Project of the Energy Efficiency in Serbia, IDA Credit YF3870 World Bank, Senta Hospital, 38. kongres o grejanju, hlađenju i klimatizaciji, Beograd, 2007
- [5] Durković, A., The Experience of the Agency for Energy Efficiency in the Implementation of Energy Audits, Seminar, Energy Efficiency of Buildings in the Light of EU Directive 2002/91/EC, Belgrade, 2006
- [6] Lilić, D., Energy Efficiency in Buildings – The Current Situation in Serbia and the Role of the SEEA, Seminar, Energy Efficiency of Buildings in the Light of EU Directive 2002/91/EC, Belgrade, 2006

**Апстракт***Димитрије ЛИЛИЋ***Агенција за енергетску ефикасност Републике Србије,  
Београд, Србија****Пројекат енергетске ефикасности у Србији  
ИДА кредит 3870 YF  
Компонента Б: Јавне зграде – школе и болнице  
Финални резултати пројекта**

У оквиру пројекта *Енергетска ефикасност у Србији*, предложеног и разрађеног од стране Светске банке, а прихваћеног и подржаног од стране Републике Србије, који је финансиран из зајма по ИДА условима, Агенција за енергетску ефикасност Републике Србије је као имплементациона агенција Компоненте Б овог пројекта била задужена за реализацију у складу са усвојеним Планом имплементације пројекта и процедурама Светске банке за набавку опреме, радове и услуге. У раду је дат опис процеса имплементације и презентација финалних резултата постигнућа пројекта код унапређења енергетске ефикасности адаптацијом 28 јавних објеката (12 болница и 16 школа) у Србији.

Кључне речи: *енергетска ефикасност, зградарство, јавне зграде*

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