APPLICATION AND IMPORTANCE OF COST-BENEFIT ANALYSIS TO ENERGY EFFICIENCY PROJECTS IN PUBLIC BUILDINGS: THE CASE OF SERBIA

by

Marko M. MIHIĆ[a*], Dejan Č. PETROVIĆ[a], Aleksandar M. VUČKOVIĆ[a], Vladimir Lj. OBRADOVIĆ[a], and Dejan M. DJUROVIĆ[b]

[a] Faculty of Organizational Sciences, University of Belgrade, Belgrade, Serbia
[b] Laboratory for Thermal Engineering and Energy,Vinča Institute of Nuclear Sciences, University of Belgrade, Belgrade

Oriignal scientific paper
DOI: 10.2298/TSCI110911090M

The main objective of this paper is to present the advantages of using Cost-Benefit analysis in energy efficiency projects implemented in public buildings, and to prove the hypothesis that Cost-Benefit analysis boosts the effectiveness and efficiency of the said type of projects. The paper offers theoretical and practical explanation of the implementation of Cost-Benefit analysis in the relevant area. Since energy efficiency projects in public buildings usually represent a part of a broader portfolio of similar projects and their implementation demands allocation of substantial financial resources, communities are often be interested in achieving maximal economic and non-economic benefits. This paper aims to demonstrate that Cost-Benefit analysis can represent an excellent contribution when attempting to select the projects for implementation within a broader portfolio of energy efficiency projects in public buildings. This hypothesis was demonstrated by putting a greater emphasis on non-economic benefits and the costs arising from implementation of the aforementioned types of projects. In addition, a practical test of this hypothesis was performed through the implementation of an energy efficiency portfolio in public buildings, worth several tens of millions of dollars – the Serbian Energy Efficiency Project. The paper concludes that the use of Cost-Benefit analysis can help us to effectively evaluate and manage projects of this type aimed at achieving maximum benefits for the community in question.

Key words: *energy efficiency, Cost-Benefit analysis, projects, effectiveness, efficiency, public buildings, community.*

Introduction

Global problems such as exhaustion of non-renewable energy sources, excessive fluctuations in energy prices on the global market, uncontrolled environmental pollution, and global warming largely contribute to economic crisis on both the global and regional level. Also, a number of countries, including Serbia, are facing various local issues when it comes to energy consumption. About 80% of Serbia's oil demands come from import, as well as 90% of its total

* Corresponding author; e-mail: mihicm@fon.bg.ac.rs

gas demands [1]. In 2009, USD 2.6 billion was spent on importing energy products, which accounts for 16.9% of the country's entire volume of imports [2]. Energy consumption in public buildings, as well as in other sectors, is much higher than in developed countries, which significantly influences economy and living standard [3]. Consumption of thermal energy in public buildings in Serbia amounts to 200 kWh/m^2 on average, as opposed to 60-80 kWh/m^2 in Sweden with cooler climate and longer heating season [4].

One of the possible solutions to this problem is a wider application of energy efficiency measures in the said buildings. This idea implies a set of technical measures and behavior, implemented with the ultimate goal of minimum energy consumption in public buildings with the same or greater level of comfort for occupants of these buildings [5]. The implementation of energy efficiency projects is often very complex and requires substantial financial investments. Institutional investors, the most frequent type of investors when it comes to public building energy efficiency projects, often try to allocate their funds into as many projects as possible, in such a way as to contribute to fulfilling the strategic goals of their country, region or municipality in the best possible way [6]. These goals mostly refer to the development of a community through better economic environment, improved environmental protection or social wellbeing. Nevertheless, it is not easy to decide which projects most deserve to be funded; in fact, this process implies analyzing numerous factors [7]. The costs and benefits a project yields for a community are among the dominant factors in such analyses. The type of analysis best suited to encompass the said factors is Cost-Benefit analysis (CBA). Its goal is to identify and calculate all costs and benefits a project might bring to a community. If the identification and evaluation of all costs and benefits of a project is adequate, decision-makers are offered with an opportunity to choose the projects with the lowest expenses and the greatest benefits [8, 9]. In addition, if we take into account all costs and benefits, our project management becomes more efficient, making our project goals more easily attainable.

The procedure for applying CBA to energy efficiency projects in public buildings

In order to realistically consider and evaluate an energy efficiency project, it is necessary to identify and analyze the overall effects that the implementation of this project would produce. Most commonly, the effects of energy efficiency projects in public buildings can be divided into economic and noneconomic effects. The economic effects, expressed through savings in energy consumption, represent the most common results of implementation and are the easiest to measure and display. When it comes to non-economic effects, they can sometimes be more important than economic, but they are much more complicated to measure. Also, the effects yielded by a project can be significant not only for investors but also for the community in general.

To measure the costs and benefits resulting from implementation of energy efficiency projects in public buildings, CBA uses fixed market prices, commonly called accounting prices, which are often significantly different from market prices. Market prices used in financial analysis are not suitable for accurately measuring and expressing all social effects of projects, and, therefore, are not adequate for CBA. Calculated prices are used to correct distortions and irregularities typical for market prices; these irregularities occur either because markets are not perfect, or because of poor economic policies, the existence of monopolies or other reasons [10]. In order to transfer market prices into accounting prices, we use conversion factors. Even though conversion factors may be set for each product separately, they are usually assigned to groups of similar goods. When we cannot determine the specific conversion factors, we use a standard conversion factor, which represents the average conversion factor for all the goods [10]. Accounting prices are calculated by multiplying the market prices of project inputs with an appropriate conversion factor [5]. In addition to input prices, in practice it is often necessary to adjust interest rates for loans, because some investors are able to loan money from international funds under very favorable conditions, which would not be the case if they were to borrow on the open financial market [11].

Benefits such as indoor comfort or the satisfaction arising from preserving the environment are difficult to quantify because of subjective feelings. Therefore, in order to express subjective feelings through financial factors, it is necessary to apply the consumer surplus method [12]. The basis of this method lies in the utility theory. According to this theory, the utility of a product or service indicates satisfaction, subjective pleasure or benefit of the user consuming that good or service [13]. Consumers, depending on the situation, have different subjective feelings for the same material goods. If users do not own a certain material good, they may be asked how much they would be willing to pay for it (willingness to pay – WTP) [12]. In the case of energy efficiency projects, WTP represents the amount of funds that occupants of a building or inhabitants of a city are willing to earmark for indoor comfort and environmental pollution [14]. The sum of individual WTP values per user represents the total WTP for the whole building or city. The amount of these funds often deviates from the market value of energy efficiency measures. This deviation can be positive or negative. If it is a negative deviation, *i. e.* market value is higher than WTP, the project is not justified by this criterion. When WTP is higher than market value, the positive deviation in this case has an additional value for customers, *i. e.* the size of the intangible benefits that users can potentially enjoy after the project [12].

Energy efficiency projects implemented in public buildings yield three types of benefits [5]:
- economic benefits,
- environmental benefits, and
- benefits arising from better working and living conditions.

Economic benefits have the largest stake in the overall number of benefits yielded by public building energy efficiency projects. They represent the financial value of energy savings brought on by the implementation of energy efficiency measures. Economic benefits are calculated by multiplying the prices of energy products with the difference between the actual and the future estimated (lower) energy consumption [5]. Savings in energy consumption provide nations with an opportunity to improve their energy balances *i. e.* to decrease the import or increase the export of certain energy products.

Environmental benefits are becoming increasingly important when it comes to evaluating projects, especially when we take into consideration problems such as global warming or polluted air in urban areas. The use of energy efficiency measures to decrease energy consumption naturally leads to a lower emission of harmful gasses and particles. From the point of view of CBA, environmental benefits represent a financial expression of lower emission of harmful gasses and particles caused by a decrease in energy consumption. Environmental benefits are calculated by multiplying the difference between the actual and future estimated (lower) emission of harmful gasses with the price of these gasses on the global market [5]. Harmful gasses are traded at special markets located all around the world [15]. We have to stress that a lower emission of harmful gasses and particles contributes to a cleaner air in urban areas, which can be quantified by conducting a survey regarding citizens' satisfaction and by applying the consumer surplus method.

Besides leading to energy savings, many public building energy efficiency projects also strive to provide benefits relating to improved living and working conditions. Some of these benefits are: prevention of health problems, a boosted feeling of comfort in occupants of a building and better productivity of people employed in public buildings [5]. By preventing health problems, we also generate savings for the healthcare budget, which can be calculated by monitoring the number of diseased persons before and after a project is implemented and then multiplying that difference with treatment expenses. The increase in productivity arising from better thermal conditions was proved in numerous studies and can be measured through standard methods [16]. The feeling of comfort, since it is intangible, is often expressed through consumer surplus method. In addition, the community benefits from a higher awareness level when it comes to energy efficiency, which boosts the number of similar projects [5].

In the implementation of public building energy efficiency projects, CBA identifies costs relating to the following activities: identification and analysis of a public building's characteristics; preparation and production of project documentation; procurement of consents and permits, procurement of materials and equipment, construction works, insurance of equipment, materials, devices, installations, etc., paying interests for loans, promotional activities aimed at raising citizens' awareness level regarding energy efficiency, maintenance during project implementation, and procurement of certificates for a public building's energy efficiency system [5].

CBA encompasses costs and benefits regardless of the persons affected by them. Certain costs or benefits have nothing to do with investors; nevertheless, they influence the community and, therefore, have to be included in the analysis [10].

Importance of CBA in achieving objectives of energy efficiency projects in public buildings

A portfolio represents a group of selected and mutually coordinated projects collectively managed by an organization with the aim of achieving its strategic goals [17]. In order for a portfolio to be optimal, *i. e.* in order for it to yield maximal results, we need to follow a certain procedure when selecting the projects that will be included in that portfolio. Public building energy efficiency projects are often grouped into portfolios. The formation of a public building energy efficiency project portfolio implies the following phases [18]:

- the analysis of socio-economic context and definition of general goals of a portfolio,
- the definition of a wider list of projects likely to be a part of a portfolio,
- the analysis of the defined project proposals, and
- the selection of projects and optimization of portfolios.

The effectiveness of a public building energy efficiency project portfolio represents a degree to which the results of a portfolio correspond to the goals of occupants and employees in public buildings, as well to the goals of a nation and community in general [18]. The maximal effectiveness of a portfolio depends on an adequate selection of buildings, as well as on measures to be implemented in those buildings [6]. Therefore, the indicators of a portfolio's effectiveness are the selection of public buildings and energy efficiency measures. Consequently, the formation of an optimal public building energy efficiency project portfolio depends precisely on them. CBA is best used in the phase involving the analysis of project proposals. The analysis of project proposals has to encompass all characteristics of a project and their quantitative indicators (where possible), which is crucial to the project's successful execution and the production of the envisaged benefits. The output of this phase is a precisely defined set of project characteristics which will enable project ranking according to the level of benefits for the community, as well as later selection of the best projects.

Selection of the optimal technical solution as a factor in achieving objectives of energy efficiency projects in public buildings

Selection of the optimal technical solution involves the selection of energy efficiency measures that could be implemented in a building, where the maximum benefit is achieved without exceeding the anticipated costs. In order to successfully define energy efficiency measures, we have to gather information on the physical characteristics of a building (size, number of floors, windows and doors, number and purpose of rooms, *etc.*), the structure of the energy system, annual energy consumption, the conditions necessary for occupying a building, the impact on the environment and so on. Some of the criteria that could provide guidelines for the selection of optimal energy efficiency measures are: amount of potential energy savings, amount of harmful gas emissions per energy source unit, energy prices, simplicity and implementation speed of the measures, *etc*.

The most important criterion in the selection of energy efficiency measures is certainly the size of potential energy savings. The planned level of savings can be achieved by applying one or combining more different measures, in which case it is necessary to take into account the costs of implementation. The budget of a project is an important factor in choosing a technical solution. As a general rule, the measures that yield the greatest savings usually require the biggest investments. This can be a problem if investors such as government agencies or ministries have limited resources earmarked to be allocated to a number of projects. In such cases it is often not possible to use the entire potential of energy savings measures. Be that as it may, there are minimal requirements in terms of energy savings, comfort and environmental protection that a technical solution must meet.

When selecting the optimal energy efficiency measures one should also take into account the environmental component of the project. However, the reduction in pollution due to the implementation of certain measures may be more than proportional to the reduction in energy consumption in a building. This effect is achieved by substituting the heating systems that use fossil fuel with systems that use cleaner fuels. A good example is the elimination of an inefficient boiler fueled by coal and the installation of a gas-fueled boiler. Gas as a fuel produces less pollution than coal, oil and firewood. By installing a gas boiler, benefits would arise from the cost-effective use of heating, *i. e*. lower energy consumption (replacement of an inefficient boiler with one that is economically more efficient); nevertheless, much greater environmental benefits would be generated in this way than by the implementation of other measures that involve keeping the existing heating system. Major environmental benefits generated by implementing energy efficiency measures are particularly gaining momentum in urban areas that suffer from significant air pollution.

Another aspect of heating system substitution is the price of energy. When considering the option to replace an inefficient boiler with a new one, one has to take into account the cost of energy used by the potential new boiler. Installation of the boiler that uses cheap fuel (*e. g.* gas) enables us to save in two ways: we spend less energy and we use cheaper fuel. However, switching to gas-fueled heating systems often requires the construction of appropriate infrastructure, which is not possible in certain areas; therefore, CBA should include these costs and compare them with the potential benefits.

The possibility of quick and easy implementation can be an important factor in the selection of energy efficiency measures in those portfolios that include a large number of public buildings (several hundred). Due to cost constraints, is often not possible to implement various projects simultaneously. If the selected measures are complex, implementation period could be very long which would postpone the benefits. By using quick and simple means, a portfolio can be fully implemented in a relatively short period of time; naturally, its benefits would be detectable shortly after the beginning of implementation.

Energy efficiency measures to be applied in a particular building are a matter of assessment by a team of experts from complementary fields, which typically includes energy, civil engineering and mechanical engineering.

Selection of buildings as a factor in achieving energy efficiency objectives in public buildings

Another important factor contributing to the effectiveness of energy efficiency measures in public buildings is the selection of the building where a project will be implemented. The level of costs and benefits largely depends on the characteristics of the building and its location. This means that the application of technical solutions in identical buildings used for different purposes, or located in different places, brings different costs and benefits to the community. Therefore, a proper application of CBA requires the gathering of relevant information about each building. Some of the features of public buildings and their environment that need to be analyzed are:
- the purpose of the building,
- the number and behavior of users,
- ability to transfer knowledge,
- readiness for implementation,
- environmental protection,
- opportunities for staff development,
- economic development of the municipality in which the project is being implemented,
- socio-economic situation in the country, and so on.

The purpose of public building is a factor of great importance when a project aims to achieve certain noneconomic benefits, such as raising the awareness about energy efficiency in the population. An investor can estimate that the implementation of an energy efficiency project in a hospital or school could attract more media attention and, therefore, cause better promotion of energy efficiency, than an energy efficiency project implemented in an administrative building. Investments in schools and hospitals still face a positive public reaction, so that successfully implemented projects in these buildings provide a good example for private investors (both in business sector and households). This is also a good way to boost the number of projects implemented in a country, thus providing additional benefits for the community.

The number of users and thermal conditions in the building are also important factors when selecting projects. If public building users were to be included in a survey of WTP for comfort prior to the implementation of a project, this would provide information about consumers' needs, as well as about the current situation in terms of comfort. As a general rule, the worse the comfort, the more money users are willing to spend. Adding up individual WTP amounts gives us the total WTP for all consumers of a building. If the total WTP is greater than the cost of implementation of energy efficiency measures, then the social benefits can be represented in the form of consumer surplus. Projects that achieve the highest consumer surplus have the greatest chance to become a part of a portfolio. It can be concluded that the greatest consumer surplus is recorded by projects implemented in buildings with a large number of consumers (*e. g*. over a thousand) and with extremely bad thermal conditions (*e. g*. low winter temperature, humidity, drafts, *etc*.). It should be pointed out that the users of a facility could also become pro bono energy efficiency promoters. Therefore, more users of a facility implies a higher overall contribution to energy efficiency awareness rising.

The possibility of the knowledge transfer can be a significant factor in the selection of a building when one takes into account the implementation of similar projects in the future. In addition, thanks to the knowledge and experience transfer, we can expect lower implementation costs. CBA sees cost-cutting as a benefit.

The analysis of the readiness for implementation collects data on resource availability (*e. g*. availability of contractors, existence of infrastructure, skilled workforce, *etc*.). Amount of costs and, therefore, the justification for a project, largely depends on the availability of resources. In accordance with this criterion, the higher the readiness for implementation, the lower the implementation costs.

In the implementation of energy efficiency projects, great attention is also paid to the effects in relation to maintaining a healthy environment. As noted earlier, residents of certain urban areas that are facing air pollution issues, are more willing to pay for the clean air than the population not facing these problems. Hence, we can conclude that the consumer surplus for the residents of urban areas is higher, which provides additional justification for implementing energy efficiency projects.

Many local self-governments lack sufficient personnel qualified for the implementation of projects of this kind and are often forced to hire consultants [9]. Energy efficiency projects implemented by ministries and state agencies enable employees in local self-governments to gain new knowledge and experience through participation in these projects, which then facilitates the implementation of future projects. In this way, the need to hire consultants disappears, creating opportunities for significant savings. According to this criterion, projects that are implemented in underdeveloped municipalities, *i. e*. municipalities where the professional training of municipal officials has the most sense, would have an advantage.

The management of educational, healthcare and other public institutions is partly the responsibility of local self-governments, and they often bear the costs of energy used for heating. These costs represent a burden for the underdeveloped municipalities and funds spent for energy products could be used for development projects. Therefore, from the point of view of CBA, the implementation of energy efficiency projects would be more justifiable in municipalities where energy savings in public buildings significantly contributes to the prosperity of the community [19].

Also, it is necessary to consider the socio-economic situation in the region or country when analyzing a project. The analysis of socio-economic context in public building energy efficiency projects should include data on the GDP of a municipality, region or country, the number and structure of buildings, environment, transport and energy infrastructure, energy consumption per unit, national and international regulations relating to energy sector, natural resources, unemployment, demographic situation, average wages, structure of education and prospects for further economic development. All factors listed above more or less directly affect the potential costs and benefits, and therefore the selection of projects eligible for becoming a part of a portfolio.

The importance of CBA in the efficient implementation of energy efficiency projects in public buildings

The efficiency of a project represents the relation between achieving project goals and the funds spent during the implementation of that project. CBA identifies several criteria of project efficiency, including the present value of net benefits, economic rate of return, Cost-Benefit ratio and payback period. All these criteria are essentially based on the ratio between costs and benefits, and, therefore, the project in which benefits exceed costs is considered effective.

Implementation of a project often takes several months and requires significant financial resources. Also, the implementation of a project has to be in accordance with previously established quality standards. Possible risks may slow down project implementation, increase costs and affect the quality of the planned energy efficiency measures. To efficiently manage a project, we need to have constant access to the progress of each stage of project implementation and monitor the risks likely to endanger the planned course of activities.

CBA, as noted, aims to identify and evaluate costs and benefits during and after the implementation of energy efficiency projects. This analysis can include a variety of costs and benefits that financial analysis does not take into account. In the case of energy efficiency projects noneconomic benefits are often more important than economic benefits. For example, this happens if the comfort of patients and hospital staff is more important than the potential energy savings. In such cases the project is still regarded as efficient although its costs exceed the planned budget, while the economic benefits fail to have the required effect. The essence of the efficiency of such projects lies in the quantification of intangible benefits and their inclusion in the calculations. The quantification of intangible benefits increases the amount of total benefits yielded by a project. This allows us to exceed costs incurred by risk events without endangering the completion of the project. Nevertheless, more important than this is the fact that the evaluation of overall benefits provides us with the possibility of using more expensive energy efficiency measures, which, as a rule, imply better quality. These measures can exploit the full capacity of the energy savings and maximize benefits for the community.

Case study analysis – Serbian energy efficiency project 1

Serbian energy efficiency project (SEEP) is the name of the portfolio of energy efficiency projects in public buildings in Serbia, whose implementation began in 2005 [20]. Participants in the projects were line ministries, the energy efficiency agency and the Clinical Center of Serbia [20]. Dozens of public buildings of great social importance, as well as the complex of the Clinical Centre of Serbia, were included in the project [20]. The main objective of this portfolio is to obtain benefits such as lower energy expenses, optimal living and working conditions and reduced emissions of harmful gasses and particles into the atmosphere through the implementation of adequate energy efficiency measures in public buildings [20]. In addition, the goal of this portfolio is to produce important benefits for the community by demonstrating the positive effects of implemented energy efficiency measures, thus motivating other potential investors [20]. This case study contains data relating to the implementation of energy efficiency measures in public buildings during 2005 and 2006. Some researchers refer to this part of the portfolio as SEEP 1 [21]. During these two years, the investment program covered 16 schools whose overall surface equaled 1,000 m^2 and 12 hospitals whose overall surface equaled 68,000 m^2. The types of eligible measures were inter alia: roof and wall insulation, window repair or replacement, basement ceiling insulation, piping insulation, balancing valves, thermostatic valves and automatic temperature controls [20]. The total investment for the implementation of energy efficiency measures in 28 public buildings amounted to 5,148,930 € (18, calculation by authors).

The role of CBA in improving the effectiveness of energy efficiency projects is to assist in the selection of projects encompassed by a portfolio. The selection of projects should include the selection of buildings and the selection of technical solutions for energy efficiency measures that will yield the best possible benefits for the community. The aim is to achieve maximum benefits with minimal costs across the entire portfolio. The investor was considering several alternatives regarding the type of public buildings in which to implement energy efficiency projects. It was concluded that the inclusion of schools and hospitals in the portfolio provides most opportunities to demonstrate the positive effects of implementation of energy efficiency measures in areas such as economy, energy, environment, health and education. Also, the implementation of projects in schools and hospitals would additionally contribute to raising awareness on rational use of energy. The selection of schools and hospitals to be included in the portfolio was coordinated with education and health ministries, the provincial government and municipalities to ensure an equitable treatment based on clearly defined and transparent selection criteria that are also consistent with primary sector objectives of education and health sectors. The eligibility and selection criteria include [20]:

- sites with high energy savings potential, electricity substitution, and environmental impact,
- sites which are not likely to be closed or privatized,
- buildings of which the basic function will not be significantly changed,
- good geographical distribution,
- sites with significant number of users, and
- sites with substantial social and demographic impact.

These criteria clearly indicate that the main interest of investors, besides financial benefits of energy efficiency, was to achieve significant environmental and social benefits. These criteria unquestionably reveal investors' effort to promote the implementation of energy efficiency measures among citizens. Projects chosen to be a part of this portfolio undoubtedly satisfy the said criteria. This is obvious if we take a look at the data on the results achieved by this portfolio as whole and individual projects within it in relation to the established criteria.

The effectiveness of energy efficiency in public buildings is reflected in the size of benefits. The average level of savings is 39% per building, while in some cases it exceeds 50% [21]. Total savings in energy consumption amounted to 13,630 MWh per year [21]. When it comes to environmental effects, such as reduction of CO_2 emissions, the portfolio also yielded significant results. In addition, the average level of CO_2 emission reduction is 42% per building, while in certain locations it exceeds 50% [21]. The total level of reduction in CO_2 emissions during the heating season was 4,223 t [21]. In relation to the benefits yielded by this portfolio, we can also offer the overview of envisaged and achieved energy savings and CO_2 emission by individual buildings (figs. 1 and 2).

Based on the planned savings, we can conclude that all buildings included in this portfolio had significant energy efficiency potentials. In most cases the actual values of energy savings correspond to the ones predicted.

Just as in the previous case, we can conclude that the buildings with significant energy potential became a part of this portfolio. Again, it should be noted that the objectives energy efficiency measures were fulfilled to a satisfactory level.

As for social benefits, they were considered in the context of the analysis of results provided by a survey conducted before and after the implementation of the project. The survey

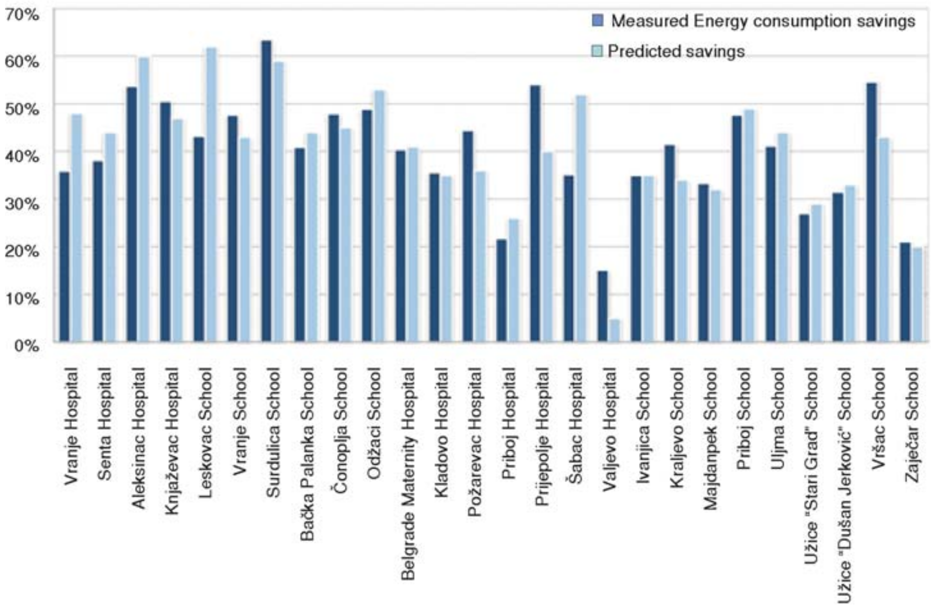

Figure 1. Comparison of predicted and actual energy savings in projects SEEP 1 [21]

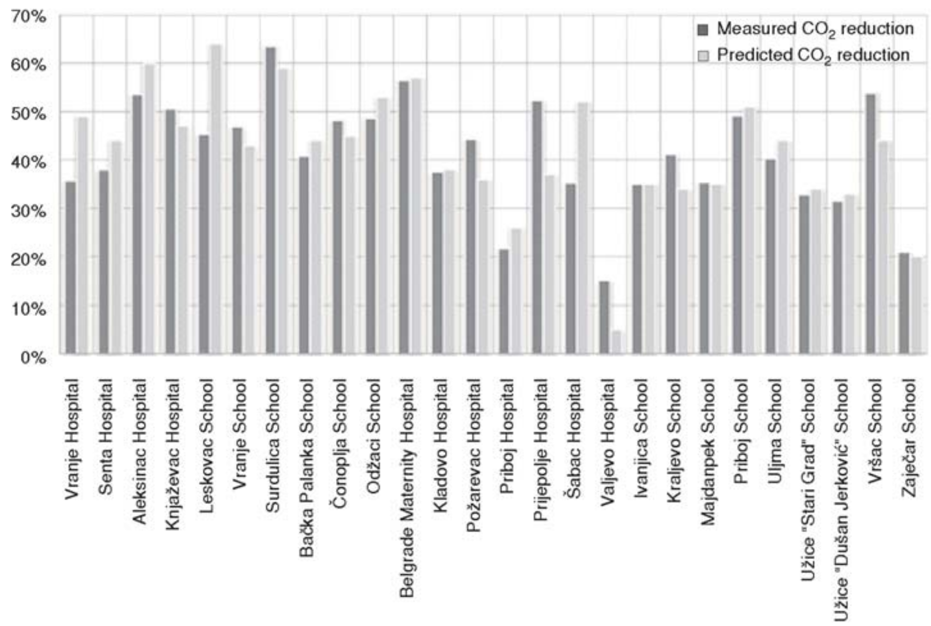

Figure 2. Comparison of predicted and actual reduction of CO_2 emission in SEEP 1 [21]

included questions regarding working and living conditions in the said buildings. The results of this analysis are shown in tab. 1.

Table 1. Results of surveys regarding the thermal comfort in schools before and after the implementation of portfolio SEEP 1 (1 – the worst, 5 – the best) [22]

Year of implementation	2005		2006	
Answers	Before	After	Before	After
Grade 1	35.6 %	6.2%	20.8%	9.2%
Grade 2	20.0%	7.7%	18.5%	5.7%
Grade 3	25.6%	41.5%	24.7%	24.5%
Grade 4	12.2%	24.6%	23.0%	39.7%
Grade 5	3.3%	18.5%	10.7%	19.7%
They do not know	3.3%	1.5%	2.2%	1.7%
Total:	100.0%	100.0%	100.0%	100.0%

In 2005, the average grade of school users' satisfaction before the implementation of energy efficiency measures equals 2.18 and 3.37 after the implementation. When it comes to projects implemented in 2006, the average grade of satisfaction before the implementation of energy efficiency measures equals 2.77 and 3.50 after the implementation. We can conclude that the sense of satisfaction regarding living and working conditions has improved by one grade. This increase gains even more importance if we take a look at the indicators showing that the number of persons least satisfied with the conditions (grades 1 and 2) is significantly lower. The results of social monitoring confirmed that customers and employees in hospitals also noted the improvement of indoor comfort. Project evaluation has also proved that there has been some progress in terms of awareness of users of public buildings about the need for rational energy consumption Serbia [22]. These benefits have not been expressed through financial gain, but represent an undoubtedly significant contribution to the community's wellbeing in general.

As we have mentioned before, the portfolio included energy efficiency projects in schools and hospitals, *i. e.* buildings of the greatest social importance. In this way, the portfolio yielded benefits caused by caring for the most sensitive groups, *i. e.* children and patients. The implementation of energy efficiency projects in these buildings has a positive impact on the quality of healthcare and education, which contributes to the general wellbeing of the community.

When it comes to the criterion referring to the wide geographical distribution of the portfolio, we have to say that the projects were implemented in all regions of the country (Kosovo and Metohija excluded) and that most of these projects were implemented in poor municipalities [23].

This project portfolio also encompasses a large number of users. In 2005 and 2006, 14,294 students attended the schools included in this portfolio. Each school had 300-1,500 students [technical assistance provided by schools included in the portfolio]. The data on the number of users in hospitals were not available, but the very purpose of the buildings implies a large number of users, having in mind that all hospitals belong to the network of healthcare services provided by the Republic of Serbia.

In order to prove the efficiency of this investment, which is partly the result of CBA, we will offer an overview of calculation methods applied to certain indicators of the portfolio's success from the point of view of the community. Further reading contains the results of calculations of the ratio between the expenses on one side and economic and environmental benefits on the other side.

Investment funds in this portfolio are allocated during a two-year period (2005 and 2006), with the total investments amounting to 1,421,350 € in the first and 3,727,580 € in the second year, amounting to a total of 5,148,930 € [21]. This value is the result of adding up all investments for each individual project. When the discount of 5.5%, recommended by the EU [11], is applied to this value, we get the net present value of the investment amounting to 4,954,601 €. On the other hand, the discounted total financial benefits of reduced energy consumption in public buildings amounted to 7,883,455 € [21, calculation by authors]. This value stems from an analysis of available indicators, such as simple payback period (7.5 years in the case of this portfolio). The period of exploitation of each individual project is 20 years [20]. The discount rate for benefits is also 5.5% [11]. The present value of net benefits of the portfolio, represented as the difference between the present value of benefits and costs, and taking into account only the economic benefit, is 7,883,455 € – 4,954,601 € = 2,928,854 €.

Benefits of reduced CO_2 emissions should be added to the value of total benefits yielded by a project. Taking into account the average cost of CO_2 emissions on the market, *i. e.* 17 € per ton [21], one can calculate that the present value of environmental benefits in SEEP 1 adds up to 857,930 €. The implementation of SEEP 1 portfolio generates significant benefits in terms of improved comfort for users of public buildings, as well as when it comes to raising awareness about energy efficiency. These benefits, though very important, are not quantified and used for evaluating this portfolio. Therefore, the project indicators would be even better if all social benefits are taken into account.

Taking into account all the previously presented calculations and notes, the indicators of project success are as follows.

- Total discounted benefits in SEEP 1 portfolio are 8,741,385 €. On the other hand, the discounted value of invested assets is 4,954,601 €. The present value of net benefits representing the difference between discounted benefits and costs amounted to 3,786,784 €. This value is greater than zero, which means that the portfolio is justified.
- The economic rate of return in a SEEP 1 project is 14%. This rate is higher than the economic discount rate (5.5%), therefore the project is justified by this criterion.
- Benefit-Cost ratio of the portfolio is 8,741,385€/4,954,196 € = 1.76, which means that every euro invested in this portfolio returns 1.76 € to the community.
- Payback period is approximately 9.6 years, which is more than two times less than the project exploitation period, and therefore the project is justified.
- In 2007 SEEP1 won the Green Award 2007 – the best project in the world in 2007 in the field of energy efficiency and environmental protection on the World Bank list of projects [24].

Regardless of the results of SEEP 1 project, the fact is that the level of energy efficiency in Serbia is still low and that improvements in this area are inevitable in order to encourage social development. However, Serbia's focus on joining the European Union has made improving energy efficiency an obligation for the country. Specifically, in 2010 the EU has adopted a sustainable development strategy for the period until 2020, which envisages a 20% improvement in energy efficiency for all member-states in the upcoming decade [25]. According to that document, these strategies are a part of the itinerary for countries aspiring to join the EU, not just its current members. Furthermore, Directive 2002/91/EC is dedicated to energy efficiency of buildings and its provisions are binding for the countries in the accession process. This directive seeks to achieve goals such as lower power consumption, lower emissions and optimal comfort conditions in buildings in the European Union. One of the requirements of the directive is that all public buildings with useful surface greater than 1,000 m^2 have to have energy certificates not older than 10 years [26]. These certificates are a guarantee that the building is energy efficient.

With the new energy law and policy documents drafted for this field, Serbia has partially met the EU requirements in terms of improving energy efficiency in buildings. First steps in this direction were made in 2001, when the Ministry of Science and the Environmental Protection established the National Energy Efficiency Program [27]. The Energy Law from 2004 set a framework for the development of the energy system in accordance with the EU legislation. According to this law, energy efficiency is a very important item. Also, this law established the founding of the Energy Efficiency Agency, whose main responsibility is the development of energy efficiency in Serbia [28]. The Energy Development Strategy in Serbia drafted for the period until 2015 recognizes the improvement of energy efficiency as one of the five priorities for the development of this sector. The strategy envisages an 8% reduction in the use of fossil fuel for the heating of public and other buildings by 2015; according to the same strategy the use of electricity should drop by 2,310 GWh within the same timeframe [29]. The Sustainable Development Strategy of the Republic of Serbia stresses the importance of future improvements in energy efficiency in buildings aiming to boost environmental protection [30].

The abovementioned documents represent an important basis for future development of energy efficiency in Serbia. However, in order to further develop this area, it is necessary to adopt specific legislation on energy efficiency, and a series of laws, *i. e.* regulations that would define the implementation of energy efficiency measures in various fields, including public buildings. By-laws concerning the implementation of energy efficiency measures in public buildings should pay special attention to CBA. Specifically, the objectives of implementing energy efficiency measures in public buildings are connected to the generation of economic, environmental, social and political benefits. These benefits, as noted above, are not only a social need, but also a domestic and international obligation. In order to fulfill these obligations to the greatest extent possible, it is necessary to generate maximum benefits in energy efficiency projects in public buildings. CBA provides an opportunity to reduce all types of benefits to the same pecuniary expression and to objectively carry out evaluations of projects that are to be implemented. In this way CBA enhances the effectiveness of an energy efficiency portfolio, *i. e.* generating maximum benefits at the social level. Since the state is involved in most of these portfolios, its interest is to ensure their effectiveness and efficiency. This can only be possible if the application of CBA is required or at least recommended for evaluating energy efficiency projects in public buildings.

Conclusions

Numerous energy problems Serbia is currently facing impose the need to promote energy efficiency in all sectors. Over the last couple of years, public building energy efficiency projects have been in the limelight. These projects are usually grouped into portfolios. The goal of institutional investors, the most frequent type of investors when it comes to public building energy efficiency projects, is to contribute to the development of the community in general. Consequently, energy efficiency project portfolios implemented in public buildings have to be maximally effective and efficient.

Strategic goals of a community and the needs of public building users are responsible to a great extent for the shape of public building energy efficiency project portfolios. These portfolios opt for projects that will contribute to fulfilling the said needs and goals in the best possible way. Differently put, these portfolios include projects that yield the best benefits for the community at the lowest expense. Taking into account a public building's characteristics, specific energy efficiency measures and socio-economic context, it is possible to perform a precise calculation of costs and benefits generated by this type of projects. Some of the project characteristics that influence the volume of costs and benefits are the purpose of a building, the number of users, the readiness to implement such project, *etc*. Taking into account non-economic benefits such as environmental protection or indoor comfort, it is possible to see the bigger picture when it comes to the needs of a community. Incidentally, projects that do not contribute significantly to economic wellbeing, however, may be of great benefit to the community due to important noneconomic benefits. With the help of CBA, it is possible to identify and evaluate the costs and benefits of a project from the aspect of the community. This provides decision-makers with an opportunity to identify and measure all costs and benefits and, consequently, rank projects and select the ones with the highest degree of adequacy for a portfolio. Therefore, CBA is able to significantly improve the effectiveness of a public building energy efficiency project portfolio.

CBA enables us to identify and quantify most of the costs and benefits of a project, which provides us with an opportunity to calculate adequate project success criteria. These criteria allow us to follow the progress of a project and direct it towards maximal efficiency. By adding noneconomic benefits to the process of calculating the said criteria, we are able to see the bigger picture when it comes to the efficiency of public building energy efficiency projects. This is the main contribution of CBA to improving the efficiency of projects from this field.

CBA was partially responsible for the successful implementation of expensive and complex public building energy efficiency project portfolios, including the Serbian Energy Efficiency Project. Predicting and evaluating all costs and benefits guaranteed that the portfolio only included the projects with the largest savings in terms of energy consumption and emissions. This is one of the reasons why this portfolio was awarded the prestigious World Bank acknowledgment. Due to exceptional results yielded by the application of CBA, it is rightfully expected that this analysis should become an important stage in the evaluation of energy efficiency in public buildings in the future.

Acknowledgments

This research was supported by Ministry of Education, Science and Technological Development of the Republic of Serbia, Project OI 179081.

References

[1] ***, Energy Balance of the Republic of Serbia for 2008 (in Serbian), Ministry of Mining and Energy, Belgrade, 2009
[2] Crnomarković, J.,Overview of External Trade of the Republic of Serbia in the Period 1988-2009 (in Serbian), Statistical Office of the Republic of Serbia, Belgrade, 2010
[3] Oka, S., Sedmak, A., Djurovic-Petrovic, M., Energy Efficiency in Serbia – Research and Development Activity, *Thermal Science, 10* (2006), 2, pp. 5-32
[4] ***, Implementation Programme for Energy Development of the Republic of Serbia in Autonomous Province of Vojvodina (from 2007 to 2012) (in Serbian), Executive council of the Autonomous Province of Vojvodina – Provincial Secretariat for Energy and Mineral Resources, Novi Sad, Serbia, 2007

[5] Mihic, M., Petrovic, D., Vuckovic, A., Possibilities of Application of Cost-Benefit Analysis to Energy Efficiency Projects in Buildings, *Economic Themes, 49* (2011), 3, pp. 355-378
[6] Mihic, M., Vuckovic, A., Vuckovic, M., Benefits Management in Energy Efficiency Projects in Public Buildings, *Management, 17* (2012), 62, pp. 57-65
[7] Ghasemzadeh, F., Archer, N. P., Project Portfolio Selection through Decision Support, *Decision Support Systems, 29* (2000), 1, pp. 73-88
[8] Pohekar, S. D., Ramachandran, M., Aplication of Multi-Criteria Decision Making to Sustainable Energy Planning – A Review, *Renewable and Sustainable Energy Reviews, 8* (2004), 4, pp. 365-381
[9] Meglic, J., *et al*., Influence of Polyvalence Professionals on Product Development Process Efficiency, *Strojarstvo, 51* (2009), 2, pp. 105-121
[10] Jovanovic, P., Mihic, M., Petrovic, D., Investment Project Decision Making Methodology in Serbia, *Project Management Journal, 3* (2005), 3, pp. 42-48
[11] ***, European Commission, Guide to Cost-Benefit Analysis of Investment Projects, Brussels, 2008
[12] Mankiw, N. G., Principles of Economics, Cengage Learning, Mason, O., USA, 2008
[13] von Neumann, J., Morgenstern, O. Theory of Games and Economic Behaviour, Princeton: Princeton University Press, Princeton, N. J., USA, 1953
[14] Banfi, S., *et al*., Willingness to Pay for Energy-Saving Measures in Residential Buildings, *Energy Economics, 30* (2008), 2, pp. 503-516
[15] Boemare, C., Quirion, P. Implementing Greenhouse Gas Trading in Europe: Lessons from economic literature and International Experiences, *Ecological Economics, 43* (2002), 2-3, pp. 213-230
[16] Seppanen, O., Fisk, W.J, Faulkner, D., Control of Temperature for Health and Productivity in Offices, *ASHRAE Transactions, 111* (2005), 2, pp. 680-686
[17] ***, A Guide to the Project Management Body of Knowledge, 3rd ed., PMI Standards Committee, Newton Square, Penn., USA, 2004
[18] Mihic, M., Petrovic, D., Vuckovic, A., Energy Efficiency Project Portfolio Optimization for Public Buildings, *Metalurgia International, 17* (2012), 6, pp. 166-174
[19] Gvozdenac-Urosevic, B., Energy Efficiency and Gross Domestic Product, *Thermal Science, 14* (2010), 3, pp. 799-808
[20] ***, Project Appraisal Document on a Proposed Credit in the Amount of SDR 14,1 Million (US$ 21 Million Equivalent) to Serbia and Montenegro for a Serbia Energy Efficiency Project, The World Bank, Washington D.C., USA, 2004
[21] ***, Final Monitoring Report – Serbian Energy Efficiency Project 1 (SEEP 1), BDSP Partnership Ltd.,London, UK, 2009
[22] ***, Knowlton & Hill: Serbian Energy Efficiency Project, component B – Evaluation Report of the First Phase, 2005 and 2006, Energy Efficiency Agency of Serbia, Belgrade, 2008
[23] ***, Serbian energy efficiency agency, www.seea.gov.rs
[24] ***, The World Bank, www.worldbank.org
[25] ***, Europe 2020 – A Strategy for Smart, Sustainable and Inclusive Growth, European Commission, Brussels, 2010
[26] ***, Directive 2002/91/Ec of the European Parliament and of the Council of 16 December 2002 on the Energy Performance of Buildings, *Official Journal of the European Communities*, 04.01.2003
[27] Oka, S., Sedmak, A., Djurovic-Petrovic, M. National Energy Efficiency Program – Strategy and Priorities for the Future, *Thermal Science, 10* (2006), 4, Suppl., pp. 7-16
[28] ***, Energy Law of the Republic of Serbia, *Official Gazette of the Republic of Serbia*, No. 84/2004, Belgrade, 2004
[29] ***, Energy Development Strategy by 2015, Ministry of Mining and Energy of the Republic of Serbia, Belgrade, 2005
[30] ***, National Strategy of Sustainable Development (in Serbian), Government of the Republic of Serbia, Belgrade, 2007

Paper submitted: September 2011
Paper revised: June 1, 2012
Paper accepted: June 1, 2012