SMART ENERGY REGIONS

COST AND VALUE

Editors: Phil Jones, Vincent Buhagiar, P. Amparo López-Jiménez and Aleksandra Djukic.

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IN SCIENCE AND TECHNOLOGY

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Executive summary

Ever since the landmark Earth Summit in Rio in 1992, global awareness of sustainability has come a long way in terms of reduction of carbon emissions and increasing energy efficiency in the context of environmental issues. Moreover, in view of our limited land resource and the realisation of finite earth resources, there is currently an ever-growing thrust in favour of retrofitting and reusing existing buildings for re-use. Underpinning all this, perhaps stemmed from the aftermath of the financial crisis in 2008, there has been an equally important financial sensitivity to the cost of a project.

An investment in retrofitting a building may take various forms, including its façade restoration, indoor refurbishment for a designated re-use. These inherently bring with them an added value to the building in its new state, for the given capital cost. Equally in today's energy-conscious, carbon-reduction era, such a retrofit would typically include upgrading the building fabric to improve the building's energy efficiency, through passive design, complemented with RES, without compromising the general comfort and well-being of its occupants. Today the latter is considered to be higher on the owner's agenda, given evidence that it increases productivity. This is perhaps one way of 'doing more with less' – a smarter way towards building design.

This COST Action, purports to do just that. It promotes smarter use of energy at both building and regional levels. Workgroup 3 focuses explicitly on demonstrating the link between cost and value of such retrofitting, applicable to both new and old buildings, as well as infrastructure and energy systems, at regional and national levels. Chapters collate papers from different member states covering aspects related to cost and value, covered under four principal chapter headings, namely Environmental Design, Sustainable Retrofitting, Energy Systems and Technologies as well as Smart energy Regions, touching on strategies for a top-down versus a bottom-up approach. The book starts with an introduction to the subject area by the Action Chairman and ends with a concise set of Conclusions by the workgroup chair. This publication covers the deliverable of Working Group 3 for COST Action TU1104, better known by the acronym, Smart-ER.

Vincent Buhagiar

windows at night, missing out on free cool air throughout summer.

Scope for further research

The following list assesses possible future research into adaptive thermal comfort and retrofitting:

- the compilation of reliable weather files for present and future conditions;
- verification of the adaptive comfort model for the local population and climate by conducting Class II (at least) field studies on several building typologies. This could eventually result in incorporation of adaptive comfort in local design guides;
- a catalogue of the in-situ thermal properties of locally used masonry elements;
- the development of a durable and reliable mechanism which provides operable wall and roof insulation;
- research into enhancing the rate of natural ventilation through typical shafts in terraced houses;
- examining the effects of desiccant-based cooling systems, possibly in combination with heat wheel exchangers, downdraught towers, ground cooling and radiant cooling systems.
- an experimental study of the potential cooling effect of thin metal radiators used in different applications, including combination with low-flow air inlets.

This list is however not exhaustive.
Each subject area could be the springboard for new ideas to follow up further research in the respective thematic area.

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Retrofitting of multifamily housing: life-cycle costing aspects

This Life-Cycle Costing (LCC) analysis deals with the feasibility of measures taken to improve thermal performance of building envelope in order to reduce energy demands for space heating. LCC analysis is carried out on one exemplary apartment in multifamily buildings with recently refurbished façades in Karaburma, a settlement in Belgrade. Results of the analysis show that by improving properties of envelope with poor thermal U value, the reduction of electricity consumed for heating in Belgrade climate is 28 %. Considering Serbian system for electricity charging, reduction of monthly costs for electricity can be doubled.

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Introduction

Recent research has shown that Serbia has experienced a temperature increase in the last century and that in the last two decades there were 14 years with temperatures above the normal recorded in the period from 1960 to 1985 (Krstic-Furundzic, and Djukic 2009). Three years were designated as distinctly warmer, while the years 2000 and 2007 were the warmest in the previous century. The region of Belgrade has gotten the most pronounced growth with an increase over 1.4C°/100 years (Karadžić and Mijović (eds.) 2007). At the same time, it is important to emphasise that Serbia, as well as Belgrade's region, belong to the sub-region of South-Eastern Europe where a higher temperature increase than that of the global level is forecast. This increase will be from 2.2°C to 5.1°C by the end of the 21st century (Karadžić and Mijović (eds.) 2007), especially during the summer months. Furthermore, humidity will decrease on the annual level, which will lead to increased risk of summer droughts. Increase in air temperature contributes to the facts that the energy consumption in buildings is rising over the summer months because of the cooling systems and that the energy efficiency of the buildings is important not only for decrease of energy consumption during the winter time but during the whole year.

The existing residential buildings have an important role in contributing to the carbon emissions and energy consumption in Serbia and Belgrade`s region. More than one third of energy consumption, primary as well as finally, (Sumarac 2010) in Belgrade`s region are from housing sector, one half being in Serbia. Average energy consumption in residential housing sectors are between 150kWh/m^2 and 200kWh/m^2 (Sumarac 2010) which is three times more than the average consumption in the EU. According to the draft version of the report prepared under the auspices of UNFCCC and presented in October 2010, a total of GHG emissions are approximately 8.9t per capita (Djukic and Stupar 2011). The largest emitter is the energy sector, with a share of 76.19 %, followed by agriculture with 14.32 % and CO_2 is the gas with the highest share in total emissions (over 90 %).

Most of the CO_2 emissions originate from the burning of fossil fuels for energy. However, 48 % of the CO_2 emissions from energy sector are caused by construction sector and almost 65 % from that part are from residential buildings. According to the data collected by the Serbian Statistical Office, about 50 % of existing buildings in Serbia and Belgrade`s region were built before 1975, without consideration to energy demands and consumption (Krstic-Furundzic and Bogdanov 2003). Those buildings are without thermal insulation and with box-type timber windows, single glazed, with 4mm float glass and badly maintained during the past half century. Belgrade`s settlement Karaburma was built during the fifties and sixties in the 20th century as housing for workers in nearby factories. The settlement is placed on a north slope and organised as detached apartment buildings, surrounded by free open space. Until energy crises in the seventies, there were no regulations in Serbia that treated minimum thermal properties of buildings envelope or energy consumption in a residential sector. As a result, these buildings were built with poor material quality and with poor thermal properties of the envelope. Over the years, poor quality and lack of maintenance led to deterioration of buildings in this settlement. As Belgrade city expanded its area, the settlement is no longer on the far periphery of the city. However, considering real-estate sector, Karaburma settlement still has one of the lowest residential prices per square metre.

In 2009 the refurbishment of Karaburma settlement began (Krstic-Furundzic and Djukic 2014). Most of the renovated buildings expanded by one floor at the top of the building, terraces were added or they widened the existing ones, exterior walls were lined with thermal insulation and old wooden windows were replaced. Part of the settlement along the street Dr. Nike Miljanica is analysed in this paper (Figures 1 and 2).

Figure 1 - Position of retrofitted buildings in Karaburma, Belgrade

Figure 2 - Position of the retrofitted building on the street, Dr. Nike Miljanica,Karaburma, Belgrade

Figure 3 - Building appearance before refurbishment, street Dr. Nike Miljanica, Karaburma, Belgrade

Figure 4 - Building appearance after refurbishment, street Dr. Nike Miljanica, Karaburma, Belgrade

In addition to above mentioned interventions, some tenants have expanded living space by closing the balcony (Figures 3 and 4). Façades were painted in different colours which improved the identity of the neighbourhood.

Subject of this LCC analysis is one of the apartments from the renovated building in Karaburma settlement (Figures 5, 6 and 7). The goal of this LCC analysis is to evaluate economic efficiency and feasibility of façade improvement on prefabricated, multifamily housing in Karaburma, Belgrade. LCC analysis evaluates feasibility of measures taken to improve thermal performance of building envelope in order to reduce energy demands for space heating.

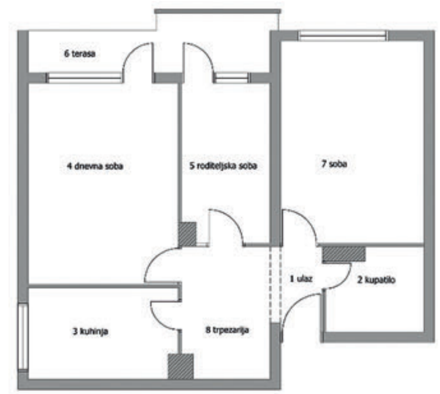

Figure 5 - Plan of the apartment before the refurbishment (source: B. Begenisic, S. Markovic)

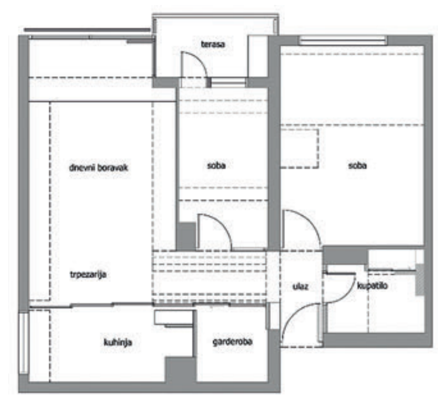

Figure 6 - Plan of the apartment after the refurbishment (source: B. Begenisic, S. Markovic)

Figure 7 - Interior of the apartment after the refurbishment (authors: B. Begenisic, S. Markovic

LCC analysis - envelope improvements

The refurbishment of the façade, on one of the Karaburma multifamily buildings, was carried out in spring 2011. The refurbishment focused on replacement of envelope components such as, windows and laying of thermal insulation on façade walls in order to match the properties usability to, increasing demands of energy efficiency. For the purpose of this analysis one apartment of $64m^2$ was selected as representative example of reduction of energy consumption due to improved façade properties.

LCC analysis is carried out by Net Present Value Methodology, which implies present value of investment, plus discounting of all future costs to present value.

In this study the selected tool for LCC analysis is BLCC (Building Life Cycle Cost) software, version 5.3-13 (BLCC5 Program 2013). BLCC software was developed by the United State Department of Energy and it is used for the calculation of buildings life-cycle energy savings. The LCC calculations are based on the FEMP (Federal Energy Management Program) discount rates and energy price escalation rates which are updated and published every year on April 1. With certain modifications, this software was used in several investment analyses in Serbia which required feasibility study for different models of optimisation of façade, building structure, lighting and heating system (Plavšića and Grujić 2005).

Evaluation criteria of the analyses results are divided into criteria that concern financial efficiency of investment and criteria that concern external effects (Plavšić2004).

Evaluation criteria that concern financial efficiency of investment include:
• net Present Value (NPV);
• adjusted Internal Rate of Return (AIRR) and;
• simple Payback Period (in years).

Evaluation criteria that concern external effects include:
• protection and conservation of the environment (CO_2 emissions);
• market value of the apartment.

Criteria for efficiency evaluation

Economic efficiency criteria
As stated above, the criteria for the evaluation of financial efficiency of investment include: Adjusted Internal Rate of Return (AIRR), Net Present Value (NPV) and Simple Payback Period (SPP).

Net Present Value (NPV) is the sum of costs/ income during building life cycle which is reduced to its first year value (present value). Net Present Value presents an absolute indicator of profitability of the design, taking into account the time preferences and using the discounting technique, which reduces all future design effects to their present value.
NPV is calculated as a specific design profit. For practical reasons, the initial investment period of building economic life cycle (beginning of investment study) is taken as base time for calculation of NPV. Discounting is performed according to a previously established discounted rate which is usually, the individual discount rate that makes the weighted arithmetic mean of real interest rates on funding sources. The discount rates of 10 – 12 % are traditionally used by The World Bank for all funded projects. However, as the entire calculation in this study was done in Euro currency, the average interest rate in the EU was taken into account. In the EU, recommended real discount rates for infrastructure investments was recently lowered to 5 %.

Adjusted Internal Rate of Return (AIRR) represents the discount rate which is the investment value reduced to zero. This data indicates optimal ratio of income (savings) and expenses (costs) during economic life cycle of building.

Simple Payback Period (SPP) refers to necessary time (in years) for return of initial investment. Invested funds are returned in the year when the cumulative net effects of economic life cycle become positive. The aim is to reduce a simple payback period (value SPP), in order to be as short as possible.
The acceptable payback time of the initial investment is considered to be before the end of last year of the economic life cycle.
Data such as initial investment, annual costs and balance savings during life cycle of the design are used to calculate SPP. Building Life Cycle Cost (BLCC) software operates with simple payback period, which is a simple ratio of initial investment increases for all annual costs and savings (as the equivalent of income in one year).

External effects
External effects are represented by different social and economic effects which do not need to be quantified. For improvement of energy efficiency these effects are of great social benefit such as, conservation of the environment and non-renewable resources, influence on technical progress, quality of life of the population, increase of consumer surplus, etc.

LCC input parameters

LCC analysis for thermal performance improvements of the building envelope takes into account initial investments and costs of electricity for heating through certain periods of building use. The overall results of façade improvement are measured according to: (a) initial capital costs and (b) energy costs only. Operating, maintenance and repair (OM&R) costs are not included in the analysis since these costs are the same for façade before and after refurbishment, so these costs would not influence results of the analysis. Capital replacement costs are also not included in the analysis since the observed period of the analysis is based on life expectancy of the whole façade, which represents life cycle period of 30 years.

Investment
A capital investment is considered as a one time cost in the first year of the economic life cycle of the project.

Façade refurbishment of the existing building included placing of thermal insulation on external wall surface and replacement of old wooden windows. Placing of 5 cm expanded polystyrene provided external wall U value of 0.46 W/m²K. Windows were replaced with double glazed components within five-chamber PVC frame (U=2.3W/m²K). Façade area of selected apartment is about 40m² (approximately 33 m² of wall and 7m² windows). Capital investment share for selected apartment in whole façade refurbishment was € 1,540.

Energy costs
The price of electricity was adopted according to the current price list approved by “EPS - ElektroprivredaSrbije” (February 22, 2013; EPS–ElektroprivredaSrbije. 2013). It should be noted that price per kWh in Euro currency has not been changed in Serbia for more than a decade. EPS pricing system is divided into green, blue and red zones of residential sector energy consumption, each with different value per kWh, which depends on monthly amount of consumed energy (10). Consumption of electricity within the blue zone (351-1,600 kWh per month) represents the zone average of household electricity consumption per month and is charged 0.06 €/kWh. Electricity consumption within the red zone (above 1,600 kWh per month) represents households with high electricity consumption per month and is charged double than the blue zone - 0.12 €/kWh.

Depending on energy consumption of a particular month the price of 0.06€/kWh or 0.12€/kWh was established as an input for electricity costs calculation.

Energy consumption for selected apartment
Detailed energy consumption for heating of a selected apartment was not available. Electricity consumption for heating was derived from monthly bills for overall electricity consumption (for whole apartment) before and after façade refurbishment.

Measuring electricity consumption for specific use within a building is an expensive, time consuming procedure and requires a lot of equipment. Methodology which uses monthly electricity bills, to verify savings from energy conservation measures, is much cheaper and by now well established. Most studies that use this methodology are based on statistical regression models where utility bills and outdoor dry-bulb temperature have been applied to baseline monthly and annual energy use. In this case, since there were no long-term observations of electricity consumption before and after refurbishment, only monthly electricity bills during two heating seasons were used (heating seasons before and after refurbishment). Presented energy consumptions for heating, during selected seasons, are not precise but represent an approximation of energy used for heating, which was derived by subtracting average energy consumption for the apartment in periods where no heating or cooling is required in Belgrade`s climate. This energy consumption for heating was corrected according to climate mean temperatures, in order to make energy consumption before and after refurbishment comparable.

Overall monthly electricity consumption for a whole apartment was selected in consideration of the heating period in Belgrade climate, which lasts about six months, from mid-October to mid-April. Energy consumption before the façade refurbishment (heating season 2010/11) was compared with energy consumption after façade refurbishment (heating season 2011/12) (refer to Table 1). From Table 1 it can be concluded that after the refurbishment, overall electricity consumption for the selected apartment, during heating period, was reduced from 8,518 kWh to 6,382 kWh (around 25 %).

Table 1 - Real monthly overall electricity consumption for selected apartment for Winter period before refurbishment (Winter 2010/11) and after refurbishment (Winter 2011/12)

Real monthly overall electricity consumption for selected apartment (kWh)		
Month	Winter 2010/11	Winter 2011/12
October	1,013	815
November	1,112	1,088
December	2,326	1,176
January	1,468	1,351
February	1,605	1,116
March	994	834
Σ=	8,518	6,382

Detailed analysis of monthly electricity consumption for the whole year, for the selected apartment, led to the conclusion that average energy consumption, in months when no cooling or heating is required, is around 350 kWh. As a result, overall electricity consumption for the selected apartment was reduced by 350 kWh (Table 2).

Table 2 - Monthly electricity consumption for selected apartment - heating only - Winter period before refurbishment (Winter 2010/11) and after refurbishment (Winter 2011/12)

Monthly electricity consumption for selected apartment – heating only (kWh)		
Month	Winter 2010/11	Winter 2011/12
October	663	465
November	762	738
December	1,976	826
January	1,118	1,001
February	1,255	766
March	644	484
Σ=	6,418	4,282

A part of this reduction, about 33 % in energy use, might be due to a little warmer winter 2011/12. Monthly mean temperatures for selected heating months before and after refurbishment, are shown in Table 3. In order to make energy consumption before and after refurbishment more accurately comparable, energy consumption in selected months for both heating periods needed to be adjusted according to climate mean temperatures for selected months. Typical climate mean monthly temperatures calculated for period 1981-2010 (Republic Hydrometeorological Service of Serbia 2010) are also shown in Table 3.

Table 3 - Monthly mean temperatures for selected heating moths: climate averages, before (winter 2010/11) and after refurbishment (winter 2011/12)

Temperature T (C°)			
Month	Climate	Winter 2010/11	Winter 2011/12
October	12,9	10,6	12,1
November	7,1	12,2	4,4
December	2,7	2,5	5,5
January	1,4	1,6	2,1
February	3,1	-1	7
March	7,6	8	10,1

Selected real energy consumption for heating (from Table 2) was corrected according to climate mean temperatures in selected heating months. Correction factor (presented in Table 5) represents ratio of ΔT (difference between outside and desired inside temperature - 20°C) for climate mean temperature and ΔT for measured mean temperature (heating period before refurbishment 2010/11 and heating period after refurbishment 2011/12) (refer to Table 4).

Table 4 - Monthly temperature difference between outside and inside desired temperature (20°C): climate ΔT, ΔT before (Winter 2010/11) and ΔT after refurbishment (Winter 2011/12)

Temperature difference - ΔT *			
Month	Climate	Winter 2010/11	Winter 2011/12
October	7.1	9.4	7.9
November	12.9	7.8	15.6
December	17.3	17.5	14.5
January	18.6	18.4	17.9
February	16.9	21	13
March	12.4	12	9.9

* temperature difference between outside and inside designed temperature (20°C according to Regulations on energy efficiency of buildings, Serbia)

Table 5 - Correction factor for ΔT (difference between outside and designed inside temperature - 20°C) for adjustment of energy consumption in selected seasons

Correction factor for ΔT		
Month	Winter 2010/11	Winter 2011/12
October	0,76	0,90
November	1,65	0,83
December	0,99	1,19
January	1,01	1,04
February	0,80	1,30
March	1,03	1,25

Adjusted energy consumption presented in Table 6 is an approximation of heating energy consumption for the selected apartment before and after façade refurbishment which is corrected according to Belgrade climate mean monthly temperatures for heating period.

According to Table 6 average reduction of electricity consumption for heating per year is 1.863 kWh (around 28 %) which is a substantial reduction. Also, considering the current electricity pricing system in Serbia, with improved thermal properties of façade, this apartment is not reaching overall energy consumption within the red zone. Table 6 shows only electricity consumption for heating, but overall energy consumption would be around 350 kWh higher. Marked fields in red in Table 6 show that, before refurbishment of façade during November and December, overall electricity consumption for the selected apartment was within red zone (above 1,600 kWh consumption per month) and all whom consumed electricity was double charged during these two months (0.12 €/kWh).

Table 6 - Adjusted monthly electricity consumption for heating only - Winter period before refurbishment (Winter 2010/11) and after refurbishment (Winter 2011/12)

Adjusted monthly electricity consumption for heating only (kWh)		
Month	Winter 2010/11	Winter 2011/12
October	501	418
November	1,260	610
December	1,953	986
January	1,130	1,041
February	1,010	996
March	665	607
Σ=	6,520	4,657

Results of life cycle cost analysis

Financial efficiency

Life cycle cost analysis is performed for improved thermal properties of façade on a selected multifamily building. Using BLCC software, financial efficiency of investment in façade refurbishment is determined. All future costs are discounted to present value using a discount rate of 5 %. Basic assumption is that inflation has a neutral effect on building life cycle.

The results of LCC analysis and savings in 30 year period life cycle of thermally improved façade in a Karaburma building apartment are shown in Table 7 and Table 8. Results of LCC analysis for façade thermal performance improvements compared to LCC analysis before refurbishment are shown in Table 7. Results of Life cycle savings analysis are shown in Table 8.

Table 7 - Results of LCC analyses for façade thermal performance improvements compared to LCC analysis before refurbishment

Scenario	Before refurbishment	After refurbishment	
Annual electricity consumption for heating (kWh)	Blue zone 0.06 €/kWh	3,306	4,657
	Red zone 0.12 €/kWh	3,214	
	Σ	6,520	4,657
Total Initial capital costs (€)	-	1,540	
Annual electricity costs (base-year) (€)		584	279
Discounted total energy costs (€)		8,908	4,296
LCC(€)		8,908	5,836

There is quite a big difference in reduction of energy consumption and discounted energy costs before and after refurbishment of building façade. The reduction of discounted energy costs, from € 8,908 before refurbishment to € 4,296 after refurbishment, is around 52 %.

On the other hand, the reduction of energy consumption is around 28 %. Such high difference is due to energy consumption in November and December before refurbishment, when energy consumption was above 1,600 kWh and was charged twice as much then the consumed energy below 1,600 kWh.

Table 8 - Results of Life cycle savings analysis for thermal performance improvements of the building envelope

	Scenario	After refurbishment
Energy savings (+) or cost (–) (kWh)	Blue zone 0.06 €/kWh	-1,351
	Red zone 0.12 €/kWh	3,214
	Σ	1,863
First year savings (€)		305
Simple Payback Period (SPP)* (year)		5.06
Adjusted Internal Rate of Return (AIRR) ** (%)		8.97
Total discounted operational savings (€)		4,683
Savings to Investment Ratio (SIR) ***		3.04

* total investment/first-year savings
** (1+d)*SIR^(1/n)-1; d=discount rate, n=years in study period
*** total discounted operational savings/total investment

Almost 50 % of energy consumption was charged 0.12 €/kWh. That is why Annual electricity costs before refurbishment were doubled comparing to annual energy costs after refurbishment.

Total Life Cycle Costs are lowered after refurbishment around 35 % (from € 8,908 to € 5,836). The difference between LCC's is 35 % and Discounted Total Energy Costs of 52 % is due to Initial Capital Costs (investment in façade refurbishment). Such a small Initial capital cost of € 1,540 can produce such high energy savings (1,863 kWh or 28 %) and cut energy costs by double (€ 4,683 or 52 %) (Table 6). The initial investment in upgrade of façade thermal properties is returned within 5/6 years. All this makes Savings to Investment Ratio very favourable (3.04).

External effects

Greenhouse gas emissions

Analysis of greenhouse gas emissions for façade thermal performance improvements compared to greenhouse gas emissions before refurbishment are shown in Table 9. Greenhouse gas emissions are also lower by 28 % after façade refurbishment. Electricity consumption for heating is also reduced by 28 % (Table 8).

Table 9 - Analysis of greenhouse gases emissions for façade thermal performance improvements compared to greenhouse gases emissions before refurbishment

	Before refurbishment		After refurbishment	
	Annual emissions	Life-Cycle emissions	Annual emissions	Life-Cycle emissions
	(kg)	(kg)	(kg)	(kg)
CO_2	2,284.73	68,532.37	1,631.90	48,950.19
SO_2	6.08	182.38	4.34	130.27
NO_x	3.12	93.65	2.23	66.89

Effects of façade improvement on property value

Since the building's envelope refurbishment, in spring 2011, Serbian real-estate market has suffered the consequences of world economic crises and value of apartments has dropped by 30 %. Unpredictability of prices per square meter in present and future real-estate markets is the reason why this analysis is focused on economic effects on property value immediately after building's envelope refurbishment.

Similar apartments to the selected one in the analysis, with improved envelope thermal properties, at the same location in spring 2011, had a market value around 1,150 €/m², while apartments with poor envelope thermal properties had up to 25 % lower value per square meter (900-1,000 €/m²) (Figure 8). These prices per square meter are valid for apartments with good living conditions.

Figure 8 - Seven year back period: example value of one bedroom apartment at the end of year 2010 in Pere Cetkovicastreet in Karaburma, Belgrade

It can be concluded that average price per square meter of this 64 square meter apartment, before envelope refurbishment, was around 950 €/m². The price of 950 €/m² generates property value of €, 60,800 and the price of 1,150 €/m² generates property value of € 73,600, which is about 21 % higher value.

Conclusion

LCC analysis was carried out on the basis of real monthly electricity consumption during heating seasons before and after façade refurbishment. Real consumption was adjusted to match long term Belgrade climate temperature conditions during the heating season. So, the results of this analysis may be considered as an approximation of heating energy reduction for an average apartment in Belgrade settlement Karaburma.

Results of this analysis show that a relatively small investment in improvement of façade thermal properties can produce heating energy reduction by about 28 % and considering the Serbian system for electricity charging, reduction of monthly costs for electricity can be doubled. Although monthly costs for electricity are reduced to half, Net Present Value for selected apartment is lower after façade refurbishment by 35 %, due to initial capital investment. This investment is returned within 5 years.

In the real estate market, apartments in buildings with improved thermal properties of façade reach up to 25 % to 30 % higher price per square meter, which depends on location and state of living conditions of the apartment. Façade refurbishment is also making these buildings more appealing for potential buyers.

Benefits of energy use reduction, for every apartment in this settlement, can be noticeable in local environment preservation (mitigating city's heat island effect). Huge benefits of energy use reduction, for settlements like Karaburma in Belgrade, are at 28 % and thus, also 28 % of green gas emissions, which is a very high reduction of energy consumption in residential sector. For comparative purposes, the EU 2010 Directive on the energy performance of buildings (recast) is demanding 20 % reduction of energy consumption by 2020, so every energy reduction above 20 % is contributing to this goal.

However, the quality indicators of value of the entire neighbourhood have also increased. This is due to the improvement of the visual identity of the buildings and whole settlements, improving of the living comforts of outdoor / indoor space and better maintaining of the whole area. The environmental benefits of retrofitting the buildings in Karaburma settlements and Belgrade`s region are in decreasing the emission of GHG and CO_2 due to the fact that retrofitted buildings are more energy efficient.

Existing residential buildings that were built before 1975 in Belgrade`s region form the main bulk of the building stock and they are significant consumers of energy. Upgrading the existing residential buildings by retrofitting can increase the value of property but also the value of neighbourhood and settlement. The LCC analyses shows that investment in retrofitting of those buildings could be returned within 5 years.

Aside from energy efficiency, many other significant sustainability improvements can be made in existing residential buildings. In terms of resource use, significant reductions can be achieved in potable water use and waste reduction via recycling programs, as well as use of renewable's (solar and geo-thermal energy). Also, sustainable purchasing policies, procurement, ongoing operations and maintenance procedures can improve a property's performance.

The only obstacle in retrofitting the existing residential buildings in Serbia is in a fact that 90 % of apartments are owned by tenants in Serbia and Belgrade`s region and that retrofitting should be privately invested. Furthermore, all tenants would have to agree to retrofitting their building which could be problematic and a challenging task. In this case study, this problem was overcome by choosing an investor who succeeded to find his interest in gaining the right to annex the attic or a new floor, which resulted in new housing units which become his property.

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This book presents work undertaken as part of the COST Action Smart Energy Regions (SMARTER). The link between cost and value is demonstrated for both new buildings and for the retrofitting of old buildings, as well as infrastructure and energy systems, at both regional and national levels. Aspects investigated within this book related to cost and value include environmental design, sustainable retrofitting, energy systems and technologies as well as smart energy regions. The impact of both a top-down and bottom-up approach are considered in relation to progress the low carbon agenda relevant at a regional scale.

This work supports the broader aims and objectives of the Smart Energy Regions COST Action to investigate the drivers and barriers that may impact on the large scale implementation of low carbon technologies in the built environment essential to meet the targets for sustainable development set by the EU and national governments. This publication is part of suite of outputs from the Smart Energy Regions COST Action investigating different aspects associated with implementation of the low carbon agenda at a region scale.

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