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SUSTAINABLE RENOVATION IN KOSOVA

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Abstract

The built environment is one of the most obvious examples of the impact of human activity. Globally, buildings have a substantial impact on our energy use and the pollution of our environment. Buildings consume 35-40% of our primary energy. From that 35-40% of building-related CO2 emissions, 29% of that could be cut by 2020 using existing technologies.

Governments around the world are starting to define requirements for sustainable buildings. Targets are being set for reductions in energy consumption and carbon dioxide emissions.

As Kosova faces big energy challenges in both low energy production and at the same time high energy consumption, investing in energy efficiency measures (both in new and already existing buildings) is very important.

This research focuses on sustainable renovation possibility in Kosova, illustrated by a casestudy, more precisely an existing kindergarten building in Prishtina. The majority of these kinds of building were constructed about 30 years ago and apart from the ageing of the façade, roof and windows, the building

standards and material quality regarding energy saving at that time were significantly lower compared to

the one today.

Analysis done to inspect the existing situation is multi-disciplinary. Simulation software used to generate

data for U values and energy demand is Ecodesigner, a GraphisoftArchiCAD add-on.

This research aims to inform the local institutions for the possibilities on reducing energy consumption

and increasing energy independence, to promote a healthy educating environment, to serve as tool for

teaching about renewable energy and green construction, and finally to function as a pilot kindergarten, a replicable model for future sustainably renovated kindergartens. The results emphasize the big decrease of energy demand along with the increase of the thermal comfort and subsequently CO2 emission decrease. With this it is intended to raise awareness for ecological/economic concerns of existing buildings and contribute that this kind of renovation becomes enforced by law for all old public institutions.

Keywords: sustainable building design, renewable energy, energy efficiency, payback time, CO2 emission

1. Introduction

The Kosova energy sector faces difficult challenges. The main energy sources for both space and water heating in Kosova are biomass (mainly firewood) and electricity, each accounting for around 40% of consumption. The high consumption of firewood results in deforestation, giving rise to adverse environmental impacts. Electricity

generated from indigenous lignite is used inefficiently, leading to power cuts and expensive imports of electricity. The situation in the electricity sector is further aggravated by incomplete billing, very low collection rates and high technical losses. The highly energy intensive buildings sector of Kosova pays little attention to EE^{74} and today buildings account for some 40% of energy demand. If energy consumed in building construction is included, then this number grows to more than 50%.

This is why the building sector is a key to reducing energy consumption and reducing CO_2^{75} emissions. Kosova is a signatory party to the Treaty for the establishment of the Energy Community (EnC) of South-East Europe that entered into force in July 2006. Within this context, the Government of Kosova remains committed to developing the energy sector in compliance with EnC requirements.

Taking into consideration the three EU standards to be achieved by 2020, namely to improve EE by 20%, to reduce greenhouse gases by 20% and to have 20% of the total energy consumption covered by RES^{76} , Kosova drafted the national plan on energy efficiency and took an obligation to improve EE in total energy consumption by 9% until improvement approximately 2018. thus accomplishing an of 1% per year. The Commission considers the biggest energy savings are to be made in the following sectors: Residential and Commercial buildings, with savings potentials estimated at 27% and 30% respectively, the manufacturing industry, with the potential for a 25% reduction, and transport, with the potential for a 26% reduction in energy consumption.

2. **Objectives**

"7 percent of all energy consumed in America is used to light our homes and our businesses...from lighting to windows, heating to cooling, smart sensors and controls...we can make our buildings up to 80 percent more energy efficient"

Barack Obama

The aim of this research is to analyze the possibility of sustainable renovation application, as well as showing advantages of the same from economical/ecological and comfort point of view. It focuses on public kindergartens that have none or poor thermal insulation which degrades the day-care conditions in a kindergarten. Main objectives of this study are:

-Conduct an analysis including all energetic, functional and architectural deficits of the existing building;

-To draft a renovation design, transforming the building completely in order to raise the overall quality of the building - from energetic, functional, design, ecologic (material) to the user comfort point of view;

- To integrate innovative renewable energy technology;

-To analyze cost-efficiency and the payback time of sustainable renovation measures;

-To calculate how much energy could be saved, if all public kindergartens in Kosova would be renovated;

The purpose is to present new sustainable materials and techniques/design for reconstruction of existing building in order to raise society's awareness on sustainability in region of Kosova.

Research methodology: Case study kindergarten "Fatosat"

"Solutions which meet the needs of today without compromising the ability of future generations to fulfil their own needs" Christel Vaenerberg

2.1. Data collection

This section deals with analysis of all energetic, functional and architectural deficits of the building.

In order to discover these deficits, a detailed analysis of the materials used for the existing building and its layout had to be carried out. An important role plays also the behaviour of occupants and all the heat generating electrical appliances, called internal gains.

Table 1. Documentation data for surveying (Survey 2011-S.Kelmendi)

⁷⁴ Energy Efficiency

⁷⁵ 1kWh of electricity produced from <u>lignite</u> produces 1,0 - 1,6 kg of emitted CO₂.

⁷⁶ Renewable Energy Sources

Orientation	Degrees north
Size	Overall corpus dimensions
Building form	Building project
Distance from neighboring buildings	Shadow calculation
Children and staff members	Total number of occupants
Cost for heating	Construction layers Walls, Slabs, Roof
Type of heating	Wood, Coal, Electrical, Gas, other
Energy consumption	Data from KEK
Number of rooms and spaces	Heated and non heated
Internal conditions	Occupancy behaviour
Light gain	Types and position of lighting

2.2. Climate data

The climatic data for the simulations have been generated by NASA Atmospheric Science Data Center for the city of Prishtina. Pristina is located at the geographical coordinates 42° 40' 0" North and 21° 10' 0" East at an altitude of 652 meters above sea level (Wikipedia 2011). Prishtina has a humid continental climate with very warm summers and cold and often snowy winters.Data generated by NASA ASDC⁷⁷ were used because it was not possible to find detailed meteorological data from the local government. The local institutes provided only monthly mean values (IHMK⁷⁸ 2010) of temperatures and they were insufficient for a simulation which required statistics based on an hourly data. The results of weather data generated by NASA ASDC came up close to the actual weather conditions found in the region as presented in the following graph:



Figure 22. Average Temperatures in Prishtina last 2 years (IHMK/NASA)

2.3. Evaluation with Graphisoft Ecodesigner

Graphisoft EcoDesigner is an integrated, easy-to-use energy evaluation tool for architects. EcoDesigner is an addon to ArchiCAD. EcoDesigner enables architects to compare energy consumptions, monthly energy balances, operation costs, carbon emissions and other indicators to inform the design process and make the best design choices – regardless of the climate where the building is built or renovated. Using Graphisoft EcoDesigner architects can

⁷⁷ NASA Atmospheric Science Data Center

⁷⁸ Institute of Hydrometeorology of Kosova

easily analyze, at an early stage, their design for energy efficiency.





Providing invaluable feedback on the building's energy performance means the architect can make better decisions on how to conform to regulations and satisfy the interests of the client and the operator of the building.

2.4. Existing situation of the building

2.4.1. Site plan and surroundings

The building is located in the south-eastern part of the city, in the neighborhood called Ulpiana, street "Zija Shemsiu". It is surrounded by residential multi-storey blocks and lots of trees, especially in north-eastern and southern part.



Figure 1. Kindergarten surrounding ortophoto 2010 (Prishtina Municipality, Department of Urbanism, Cadastre, Construction and Environment Protection)

This building is built in 1978. Due to non-insulation and big height of corridors and common spaces, the temperatures in them are quite low and not comfortable.

2.4.2. Occupants and operation

The kindergarten operates from September 1st to July 31st, Monday to Friday and from 6:30 am to 17:00 pm. The total number of children attending the kindergarten is 250 in addition to 39 staff members. There is a big demand for child care, but the existing space is completely filled and cannot accept any additional children. Average number of babies (1-2yrs. old) per group is 14, and for children (2-6 yrs. old) is 20. The dining area doesn't suffice needs for all children, thus children have to eat in the classes/rooms.

2.4.3. Building layout

It is a 1 floor building with an area of 1480 m². There are 11 classrooms and plus 4 common spaces. The site visit was performed in different time periods, as well as short energy audits and measurements of all the spaces of the building. Table 6 presents the geometric data of the existing situation, with reference to its gross total floor area, the number of the windows and doors and their area, the external wall area, the internal height of the building and the calculated volume.

	Height (m)	Perimeter (m)	Surface (m ²)
Walls	3.5	324.5	1135.75
Windows			262
& doors			202
To	tal insulation	surface	873.75

Table 2. Geometric figures for insulation surface (Survey 2011-S.Kelmendi)

Openings on bu	ilding s	tell:							
Orientation	1	Opening type	Area [m ²]	Shading dev	Glass %	U-value[TST %	Infiltrati	
North	⊞	Window	16	None .	80	1	53	1	
East		Door	2	None	80	1	53	1	
South		Window	49	None	80	1	53	1	
East	⊞	Window	82	None	80	1	53	1	
North		Door	7	None	80	1	53	1	
South		Door	14	None	80	1	53	1	
West	E	Window	92	Curtain	75	3	66	4	

Figure 24. Window analysis with Ecodesigner (Survey 2011-S.Kelmendi)

The interior of the building is in a quite good condition and very well organized. Except the demand for more space from potential children to be enrolled, it suffices the current needs. It is important to mention that the low temperatures in common areas makes these otherwise cosy areas very uncomfortable, and subsequently unusable during cold season.

2.4.4. Materials

The walls are all non-insulated and made of brick. The windows have been replaced recently, instead of old wooden ones, now there are plastic double glazed ones in place. The roof tiles are made of asbestos, which usage in the time the object was built (1978) was allowed. Now it is forbidden as it is found that Asbestos has been classified as a known human carcinogen (a substance that causes cancer) by the U.S. Department of Health and Human Services, the EPA, and the International Agency for Research on Cancer.



Figure 2. Exterior material of Fatosat kindergarten (S.Kelmendi)

People may be exposed to asbestos in their workplace, their communities, or their homes. If products containing asbestos are disturbed, tiny asbestos fibres are released into the air. When asbestos fibres are breathed in, they may get trapped in the lungs and remain there for a long time. Over time, these fibres can accumulate and cause scarring and inflammation, which can affect breathing and lead to serious health problems. The parquet on floor is quite old and not polished. The radiators are old and inefficient.

2.4.5. Energy consumption

As can be seen on the chart below, the kindergarten spends tremendous amount of money in electricity every year, especially in last year, up to 2200ε per month (January) and 12.000ε per year (Fig.18).



Figure 25. Monthly electrical energy consumption in € (data from KEK bill)

The electrical energy consumed by the school is excessive and is not justified by the existing energy consuming devices.



Since the energy consumption in kWh was impossible to provide, an approximate calculation with the price data was performed. If 0.08€/kWh is we taken as the approximate tariff, it results that energy consumption of the building is 101.625kwh (100MWh) for year 2010, respectively 150 MWh for the year 2011. The total energy consumption per square meter of school space is 101 kWh/m² with existing poor thermal conditions (heating only classrooms and offices but not corridors, playrooms and events rooms).

Figure 26. Annual energy consumption (€)-(S.Kelmendi)

The main share of energy costs takes the heating. Since the district heating system is not operating last years, kindergarten management had to find alternative improvised ways to heat the spaces, especially children classrooms. Now each of 11 classrooms has 3 different heating devices, besides the ones in administrative offices. Lighting fixtures are half incandescent, half fluorescent. Boiler is also working on electricity.

3. Improvements

In order to make the object as sustainable as possible, several improvements are proposed.

3.1. Architectural improvements

The final measurements are used in order to compare them with the initial ones and to create, in ArchiCAD, the final "existing" plan view of the ground floor and 3D presentation of the building, in all directions (Figures 21 to 23). Enlargement of space is proposed, which besides fulfilling the needed capacities contributes to making the building's layout more compact. Adjustable window awnings (canopies) will be installed in the windows on the south facade. They will protect the southern facade from overheating in summer, but will allow winter sun to enter into the depth of the rooms.



Figure 3. Floor plan of the renovation project (S.Kelmendi)

The investment for the 6 canopies is estimated at 2.000 \notin . As the insulation of the building needed to be performed, it is proposed that after the mortar and net, to decorate the building with different colour ecological paints. In that way the building besides increasing the thermal resistance, increases also the attractiveness ecological contribution.





3.2. Energetic improvement

3.2.1. Applying thermal insulation

Leakage or loss of thermal energy there through walls, roof, and floor plate, if the inner surface layer does not contain adequate for avoiding the leakage or "air tight layer"

This leak raised energy consumption, thermal recovery of losses. The easiest, fastest and the most effective way to reduce costs of heating – and also of cooling in summer – is to apply a suitable thermal insulating protection. It is proposed to apply insulation and color materials which are environmentally friendly because they will also help to reduce the buildings carbon footprint. For the thermal insulation, EPS board is chosen. It has proven cheaper and its thermal performance is better than XPS' one. According to material's characteristics, if applied with brick (as it is our case), U-value is 0.30W/m²K. Besides walls, as the floor will be in construction due to heating systemchange, placement of also floor thermal insulation is proposed, as it would contribute to the efficiency of heating systemand of course comfort increase for children.

3.2.2. Using renewable energy sources:Installing Hybrid Photovoltaic-Thermal collectors



In order to increase the efficiency of the building, it is proposed to install new hybrid Photovoltaic-Thermal panels on the roofs, produced for the first time by Turkey-based solar company Solimpeks. Both electricity and usable thermal heat are generated at the same time from one panel. These systems combine a photovoltaic cell, which converts electromagnetic radiation (photons) into electricity, with a solar thermal collector, which captures the remaining energy and removes waste heat from the PV module.. Half of the building roofs are oriented south-north and half of them east-west. The "9" south-north roofs are proposed for installation of solar panels, more precisely only the roof's halves oriented toward south. To store the electricity, normal batteries, or a hydrogen fuel cell, could be used. Additionally, the PV-T panels can be used in conjunction with other technologies to further enhance energy efficiency if desired. It is proposed to c Figure 27. PV-T layers (Solimpeks) m.

3.2.3. Geothermal heating

Excess heat produced by the PV-T panels can be stored in the ground for use at a later time => summer heat can be used into the winter to maximize energy use. Consistent year-long underground temperatures are what make geothermal heat pumps work well in cold climates. A typical geothermal heat pump employs a closed loop of piping

containing a non-toxic liquid that circulates between the building and underground. The biggest advantages of geothermal heating systems are low cost heating (you can save up to 80% compared to fossil fuels) and a small amount of electrical energy compared to conventional heating systems. A geothermal heat pump requires a minimum amount of space for the outdoor coil or wells. As the kindergarten lot has enough outdoor space, this is not a problem. One underground loop can support many small indoor heat pump units, making it an ideal choice for schools and other buildings where heating and cooling by zone is desirable.

Environmental considerations

The improvement of the environmental performance of the building has an important environmental implication in the sense that less fuel is consumed for the same level of thermal comfort and thus less combustion emissions are released to the atmosphere.

By evaluation done in Ecodesigner, the proposed interventions would result in CO_2 reduction of little more than 245 tons per annum. The environmental benefits in the form of atmospheric pollution reduction as a result of the energy saving interventions, once installed, will be permanent provided that the energy systems are maintained properly and work according to their specified performance. All of the above is non-hazardous waste that nevertheless needs to be collected and disposed off to designated areas in cooperation with the local authorities. Reuse of waste should be encouraged when such opportunity arises, i.e. for glass panels that survive the replacement works. Insulation panels (EPS and XPS) can be recycled in many ways once they come to the end of its life. Furthermore, the proposed materials for insulation are environmentally friendly. Last, but not least, the materials and technology are chosen from local market and local companies that anyway import goods from the Balkan's region. The reason lies again in sustainability, in order to avoid additional transportation costs and by that, cause CO2 emissions and consequently pollution.

4. **DISCUSSION**

4.1. Estimating pv-t system size and cost

In this section are derived the systemspecifications by determining the load, available sunlight, and the size of the PV array and battery bank needed. In the second section, the system specification is converted into a cost for the PV-T system. The detailed load determination is performed by calculating "watts" of each of appliances with hours they operate per day.

Appliance	AC or DC	Hours	Quantity	Watt
	watts	Used/Day		hours/Day
Computer	75	6	5	2250
Computer	150	6	5	4500
Monitor				
Lights, Compact	20	3	63	3780
fluorescent				
Television	300	2	6	3600
Dishwasher	1200	2	2	4800
Total	•	•		18930

 Table 3. Kindergarten "Fatosat" electrical appliances and run times (Kelmendi 2011)

The amount of useful sunshine available for the panels on an average day during the worst month of the year is called the "insolation value." According to the Energy Regulatory Office (2011) average solar insolation values for Prishtina are 4.4 hrs/day of tilted panel. So, for a PV systempowering loads that will be used every day, the size of the array is determined by the daily energy requirement (Tab.8) divided by the sun-hours per day.

18930Wh: 4.4 h/day=4302Watt

According to the local market prices, a hybrid panel which provides 175W of electric energy and 750W of thermal energy is 1200ε . The number of panels needed to produce this energy is 25 which when multiplied by 1200 results in 30000ε of investment. Regarding hot water, users' number is very important. Calculation is shown in the table below:

 Table 4. Thermal energy demand and cost calculation (Kelmendi 2011)

Number of users	300
Number of l/user	15
Total number of l/day	4500
Design reheat time (h)	2
Total power input (W/day)	9000

To calculate number of panels needed to cover thermal energy demand, the total amount is divided by 610, which is the capacity for the PV-T panels.

Panel size: 86cmx166cm=1.43m². Roof area covered by hybrid panel is: 25x1.43=35.75m².

4.2. Estimating geo-thermal system size and cost

A closed-loop vertical systemcan be installed in the "Fatosat" kindergarten, consisting of two 17-kWe ground geothermal heat pumps, to cover the heating and possible cooling loads of the building. This will be obtained by drilling max 10 holes in the backyard of the kindergarten. The total cost is estimated at 60000 \notin without tax, including the heat pump systemand the system for heating the building (floor heating, circulating pumps, etc).

4.3. Economic appraisal of interventions

In this section the total energy savings and the corresponding financial benefit are calculated and presented in table 10. In table the simple payback period and the IRR is presented for each intervention and for all interventions applied simultaneously. Most of the applications have relatively short payback periods. The IRR is the discount rate for which the total profit generated by an intervention, once discounted, equals the initial investment. The IRR measures the profitability of the investment. The higher the IRR, the intervention is considered more profitable. The calculated IRRs for all interventions indicate that the proposed interventions are all profitable money wise, since all exceed anticipated discount rates at present money markets. The only requirement to continue obtaining the estimated energy savings over several years, an annual maintenance schedule is absolutely necessary.

Intervention	Surface	Unit Cost (€/m2)	Total Cost (€)	Energy Saving (kWh)	Net Profit (€)	Payback Period (years)	Internal Rate of Return
External Wall	873.76	25.00	21,844	84,120	7,570.80	2.9	35.61%
Geo-thermal pump	1.00	60,000.00	60,000	110,000	9,900.00	6.1	16.93%
Solar Collectors	36.00	830.00	29,880	35,000	3,150.00	9.5	12.11%
Accumulative			111,724	229,120	20,620.80	5.4	19.23%

Table 5. Economic investments and savings (Kelmendi 2011)

From the above table one can see that the payback time of investments is 5 years.

4.4. Awareness raising through sustainability measures

Electricity from the sun is a fascinating idea and solar electric panels capture the public imagination more than any other renewable energy technology. These public buildings are good examples of how investing in energy saving measures helps the environment as well as the economy, with a short payback period. In this way are presented new sustainable materials and techniques/design for reconstruction of existing building in order to raise society's awareness on sustainability in region of Kosova. With this it is intended to also contribute that this kind of renovation becomes enforced by law for all old public institutions.

5. **Conclusion**

In conclusion, it is proposed that the total investment is implemented, including the new heating systemand the shading devices, in order to have an integrated state-of-the-art intervention and provide the appropriate comfort to the children and employees. The total cost of the interventions proposed is approximately 111.726 Euro. The

expected payback period, without considering financial costs, is estimated at 5.5 years and the corresponding IRR is equal to 21%. Thus, all the proposed investments are viable and are expected to produce financial profits in a short period of time (max 6.5 years). All this having in mind that after the renovation all kindergarten surface will be usable, including the common spaces. The proposed interventions would result in CO_2 savings of little more than 245 tons per annum. As these buildings have been built long time ago and with no or insufficient thermal insulation and also because there is a big number of such building, a pro-active approach is strongly propose to improving their energetic performances in order to make the living environment more sustainable and ecologic, subsequently. In addition, the proposed interventions with the corresponding energy saving will improve the security supply of energy for Kosova. Last, but not least, this would contribute to achieving the set targets 20-20-20 of European Union.

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