ECONOMIC ANALYSIS OF THE PASSIVE AND INTELLIGENT MULTIFAMILY RESIDENTIAL BUILDING IN BELGRADE

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Abstract: *This paper presents some technological and economic aspects of the project inspired by numerous initiatives in extremely low energy consumption energy efficient building in modern architecture. Project main aim was to present a new model of the integral application of science, education, enterprise and the public sector in the future transformation of cityscape, thus forming guidelines for urban residential development in Serbia.*

Key Words: *economic analysis, passive building, innovation.*

1. INTRODUCTION

Global economic and energy crisis have reinforced changes in European legislative and regulative in the field of energy efficiency. This resulted with the European Parliament resolution on the 31. January 2008. (2007/2106(INI)) which promoted and even reinforced passive house construction standards starting from 2011 onwards.

Building of the ultra energy efficient objects, as passive objects are, increases investment costs in the EU countries comparing to the standard buildings, on the level of 12% in Germany and about 30% in Poland.

Strict application of the accepted standard in the Republic of Serbia from 1987. would result in average installed power for residential buildings of 95 W/m^2. This is much less than the republic average level of 160 W/m^2 valid for district heating systems and central heating systems based on boiler [5]. This is also confirmed in the case of Belgrade [6]. It is notified that renewable energy sources usage is very small. It is concluded that strict application of existing standards for design and building would result in much better energy efficiency in residential sector. Passive house standards go further.

2. PROJECT INITIATIVES

Nineteen scientists form faculties of Architecture, Mechanical, Electrical and Civil Engineering University of Belgrade started the „Project of the Passive Building with Active Occupants“. Project of the first multifamily residential passive building in Serbia was promoted in September 2008. Project team members earned numerous official letter supports as this project was accepted as necessity. Feasibility Study [2], discusses technical and economic possibilities for implementation of one

prototype, passive-intelligent object, in Belgrade area. Realization of numerous passive building projects in EU countries was accomplished through state and local institutions and their support [4].

3. PASSIVE AND INTELLIGENT BUILDING FOR THE CITY OF BELGRADE

Expression "passive building" originates from the "passive" elements which together with a building, make pleasant inner temperature. Expression "passive" means no electrical energy use, as the functioning is based on the spontaneous natural processes. Passive technology is totally ecological. Passive building, quantitatively expressed, is the object with extreme low energy consumption of which maximum energy consumption for heating is only 15kWh/m² per annum.

Basic elements of the passive solar architecture are correct building orientation (south in the northern hemisphere), windows, radiant barriers, wall and furniture colors, Trombe's wall, verandas, underground energy accumulation, etc. In this project some additional system which are based on the primary energy are incorporated. Photovoltaic systems would be active parallel to the electro distributive network, with possibility to deliver electrical energy extras to the network.

Project incorporates two architecturally different concepts. Basic concept presents conventional object solution with orthogonal constructive system, and realization which is in wide use at the Serbian market.

Improved concept represents solution which is presented as a synthesis of the functional form inside the object and envelope innovative solution made of prefabricated elements outside.

Windows areas can function as solar panels. In this sense movable panels as well as outer barriers are necessary. Building envelope should satisfy criteria ≤0,6ACH (Air change per hour) at relative pressure 50Pa.

It is planned to employ floor and wall heating and cooling without radiators. For multilevel building, with total surface of 2500m^2, four heat pumps will be installed, type ground/water, energy very efficient [1].

As wall and furniture colors influence the solar radiation gain, it was planned to use materials with defined absorption coefficient values.

Philosophy of the passive buildings demands use of waste heat from the air and water and all other sources like, body heat from the people and pets, low-energy lighting, high-efficiency electrical appliances, etc.

4. ECONOMIC ANALYSIS

4.1. Investment

The study [2] gave a structure and dynamics of the total investments in the passive house of the total surface of 2500m^2 and heating surface of 2000m^2, with presumed location Zvezdarsko brdo. Beginning of the building was planned to be in March 2010. Building period would be 16 months. All previous calculation expenses are based on the constant prices, for the course of 95 RSD for 1€. In estimation of the material and workers costs a pessimistic scenario was used, with prices equal to those before the economic crisis.

Structure and dynamics of investments is divided in four parts, as preparatory activities (26000 €), construction works (914100 €), various vocational works (918000 €) and final works (180000 €), what makes building investment in total, without city taxes, of 2038100 €, i.e. 193619500 RSD. Construction average price is then 1019,05 €/m^2, i.e. 96809,75 RSD/m^2.

City taxes, expenses of the connection to the electrical, water and sewage systems increase total investment to the amount of 2488942 €, i.e. 236449500 RSD. District heating system is not included as the heat pump is planned.

4.2. Preliminary calculations of the possible income

Estimation of the residential square meter price in this part of the town is based on the econometric model with data base with 6160 units of flats and houses for Belgrade:

$$Y = \alpha_0 + \sum_{i=1}^{12} \alpha_i X_i,$$

where Y presents flat average price in Belgrade, X_i are influencing factors (location, size, heating system,...) and coefficients α_i are characteristic model parameters [3]. Solving this model by OLS the relevant tests of the statistical significance have shown that only five of these twelve variables are statisticaly significant (X_2 - location, X_3 - size of the living space, X_4 - size of the non-living space, X_5 - heating system and X_7 – usage, living or business space). Average market price of 1575,08 €/m^2 for the residential flat on the location Zvezdarsko brdo is obtained by introducing relevant values in the previous model. Diffence between the average selling price per square meter and average investment cost is 330,61 €/m^2. It represents average nondiscounted benefit for the investors.

4.3. Project feasibility study

Standard procedure of the discounted cash flow was used for the project feasibility study. Planned deadline for the building construction is 480 days: March 2010.-June 2011. It was planned to realize all the location expenses, participations and earthworks in the first two months. Main construction activities, except some insulation works and gray water systems, should be realized in the period of March-October 2010. Vocational works are planned for the period September 2010-June 2011.

It is assumed that investor does not charge flats in advance. All money incomes are dated to the end of the construction period, in June 2011. Investor should then count on the precisely dated financial outcomes what is the worst case.

Planned cash flow is precisely elaborated in the Feasibility study [2]. Average interest rate on the international credit market was adapted as the credit sources and conditions (payback period and possible grace period) were mostly unknown. Monthly discount rate of 1% was used in the calculation of the discounted cash flows. Net present value calculated by discount rate of 1%, is 25936 € in constant prices. Internal rate of return is 2,08%. It means that invested capital in the building in the period March 2010 – June 2011 would have average monthly profit rate of 2,08 %. Net present value of the total expenses is 2427160 €, i.e. 1213,58 €/m^2. With sale price of 1423 €/m^2 net present value equals zero, and internal rate of return is equal to the relevant discount rate of 1%. This price is considered as critical sale price of the passive building. This conclusion stands only in the case if other project parameters, like workers payments, material prices, construction deadlines, capital price, remain unchanged.

Economic effects of savings in natural gas, electricity and drinking water for the period of exploitation of the geothermal, photovoltaic and gray water systems are projected on the present value and located in the month of June 2011. Annual discount rate for the exploitation period of these facilities is 12%. Time location of these effects on the construction deadline ensures calculation consistency of the determination of the net present project value and economic internal rate of return.

Economic net present value of the building for adopted selling price of 1575 €/m^2 is 436707 €, and economical internal rate of return is 2,87% monthly. Passive building project with all these systems is then economically approved. Economic internal rate of return is above the average capital productivity in the construction sector, what estimates passive building project as approved and acceptable.

4.4. Sensitivity and risk analysis

Sensitivity analysis is the first phase in estimation of the risk investment analysis. It is started with the most possible input values. Selling price per m^2 and construction expenses are the changeable values throughout the period of project realization. These fluctuations surely influence on relevant parameters for feasibility study. Sensitivity study is made in the way that one input value is changed for a certain per cent, while the rest inputs remain constant. It is, therefore, static approach without simultaneous change of input values. Choice of the critical parameters is based on the try and effect approach. It means that after the variation of one input for a certain per cent, variation of the level of the estimation parameter is observed. Selling price and construction expenses were located as the

critical parameters. Risk analysis have shown relatively significant changes of the estimation parameters for risk investment analysis. Decreasing selling price for 10% would decrease profit for around 60% and average month profit rate for around 40%. Decrease of 20% would result in losses and makes it economically unacceptable. Decrement of 16%, i.e. price of 1319 €/m^2, is the lowest limit of the passive building feasibility. Construction of the passive building is less sensitive on the construction expenses. Increment of the construction expenses of 20% results in profit decrement of 50%, i.e. average month profit rate for 37%. In this case, besides significant decreasing of the estimation parameters, project acceptability is still satisfying.

It could be concluded that this project has moderate acceptable risk investment intervals.

5. CONCLUSIONS

Implementation of the Project of the first multifamily passive building in the Republic of Serbia incorporates numerous technical, technological, social and other ecologically oriented innovations of importance for domestic energy efficiency standards and industry. Benefits of the project are numerous and listed below.

Experimental – building and realization of the object for exploitation in defined working regimes.

Expert – application of the results for forming legislative, regulations, standards and recommendations.

Scientific – application of the results and methodology from Belgrade and other parts of Serbia in international exchange of experiences and development of the scientific institutions and researchers with the main idea to improve energy efficiency.

Educational – application of the experiences and results in student education and even younger generations, what would widely implement rules and energy saving psychology in our society.

Economic – total constructing cost is 2038100 €. Average construction price is 1019,05 €/m^2, i.e. 96809,75 RSD/m^2 what is almost a double price the conventional building in the Republic of Serbia. It should have in mind that project includes, besides passive building highly demanded construction concept, also innovative intelligent and ecofoot print technologies. Net present value of the project is 436707 €, and internal rate of return is 2,9 % monthly. Covering sale price is 1319 €/m^2. On the basis of the aims, applied technical solutions, financial and economic estimation of the investment, as well as acceptability of the investor, it is possible to conclude that this project is technically possible and economically proved.

In addition, success of the passive house projects in the world show that there will be no conflict between ecology and economy, as all participants will profit from it [4].

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