REFURBISHMENT OF AN INDUSTRAL ESTATE INTO HOUSING COMPLEX IN BELGRADE: ECONOMIC AND ENVIRONMENTAL ASPECTS

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Summary

Environmental and ecologic aspects of a building refurbishment design can often be confronted in making decisions whether to rebuild or reconstruct in practice. In most cases the economic aspects overcome in the decision making process in practice and therefore all environmental benefits from the process of reconstruction just follow the economic drivers. This paper presents an analysis of both of these aspects in a case study refurbishment project of an industrial estate located in downtown Belgrade and its transformation into an exclusive housing complex. Basic characteristics of this refurbishment process are defined through analysis of its functional, structural and environmental aspects. Then two scenarios for analyses are defined: the first is the existing scenario (some buildings are refurbished, some demolished and rebuilt) and the second, hypothetical, where the entire complex is demolished and rebuilt. These analyses result in some environmental indicators of the refurbishment process (amount of saved energy and waste) which are compared to their economic feedback.

Keywords: Sustainable refurbishment, industrial buildings, environmental aspects, economic aspects

1 Introduction

Only a few strategies can be considered as a universal solution that addresses most of the environmental issues. One of those strategies, sort of a “recipe” of environmental building, is the refurbishment process of existing buildings. From the environmental point of view, refurbishment process is considered extremely favorable, primarily because of savings in construction material, which correlates to the savings in primary energy, and also because of reusing the building lot. The economic aspect often drive the decision making process in practice. In the paper environmental and economic parameters of the refurbishment process of a former textile industry complex into a luxurious housing estate in Belgrade downtown area are analyzed. Basic characteristics of this refurbishment process are first defined through analysis of its functional, structural and environmental aspects. Then a hypothetical model, a new construction of the same function and size, but contemporary materialization, is created and its environmental parameters are calculated. These results are then compared to the environmental parameters of the actual, refurbished case where most of the buildings were completely refurbished, while a few buildings were demolished and rebuilt (these served as model for materialization of the hypothetical model). Conclusions are derived through the method of cross analysis of these data.

1.1 Environmental and economic aspects of refurbishment process

There are several key parameters that are regarded very favorable in environmental terms which are shown in the form of a diagram in (**Fig. 1**), together with their economic aspects. Capability to adapt the existing structures to new function can be defined as a *refurbishment potential,* which has the greatest impact on both of these aspects. Determination of criteria which define the quality of inherited structure is based on analysis of existing state, heritage protection measures and volume of necessary works [1].

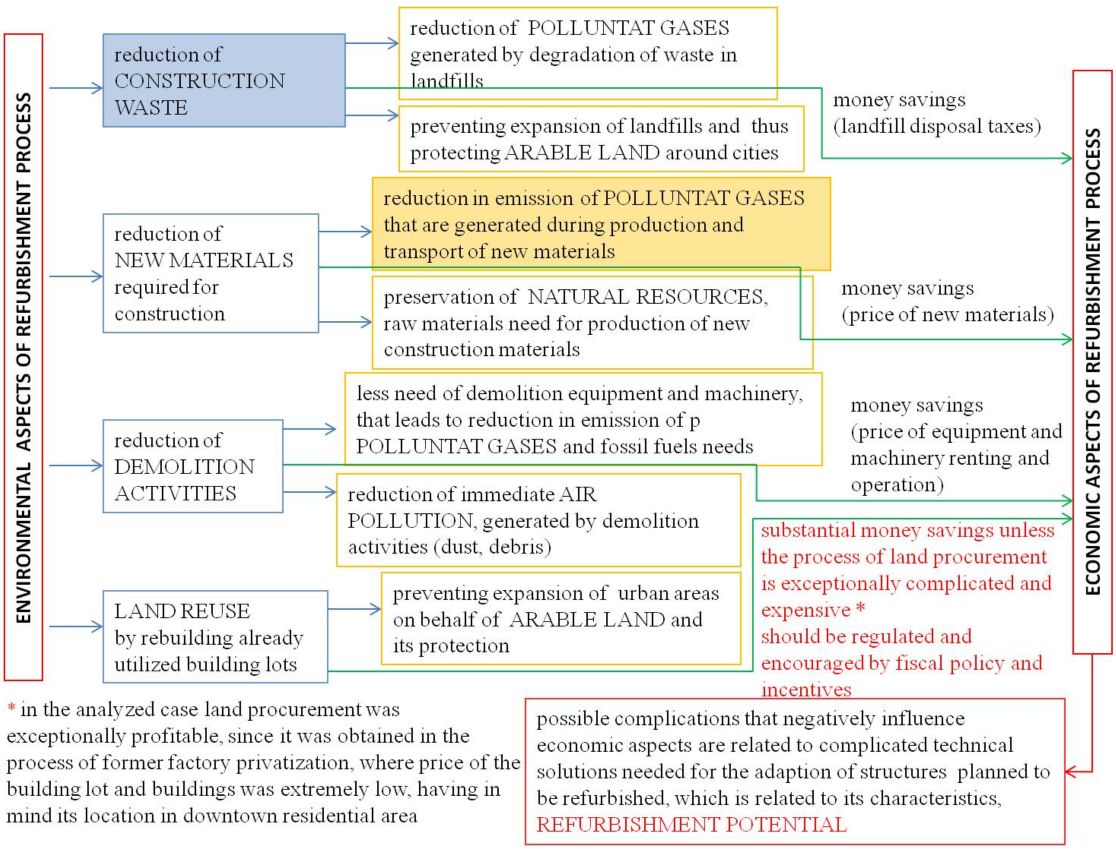

Fig. 1 *Interdependences between economic and environmental aspects of refurbishment process*

2 Results

2.1 Environmental aspect

Energy savings are one of key economic and environmental parameters of refurbished buildings, achieved by strategies of *energy rehabilitation*. In this case, massive facade brick walls are suitable for energy rehabilitation, since even minimal additional layers of thermal insulation significantly improve thermal characteristics (U value of brick wall of 51 cm thickness with only 5 cm of additional insulation drops from 1.19 to 0.47 W/m^2K), so all applied structures easily fulfilled contemporary demands regarding thermal protection. Parapet walls and above-window beams are insulated on both inside and outside, which eliminates linear thermal bridges around openings. However, applied glazing on facade openings, which are larger than usual for residential buildings, has a rather high heat transmission coefficient (3 W/m^2K) for contemporary standards, since reference values are more than twice lower. Also, neither passive nor active solar systems were planned, as well as no other system for use of renewable energy. Metering of heating energy consumption by unit represents an innovative measure in current conditions of district heating consumption metering, but not sufficient for the energy efficiency upgrade of a luxury housing estate.

Fig. 2 *Building C and D during refurbishment*

Fig. 3 *Building C and D after refurbishment*

Reduction of pollutant gases is also related to energy savings where a substantial part of those savings are those of primary energy, achieved by reuse of structural elements.

Tab. 1 *Results for both scenarios*

Case scenario	Phases	Concrete	Brick
Hypothetical – rebuilding	Demolition	2 302	2 754
	Construction	5 344.6	2 579.4
Total		7 646.6	5 333.4
Amount of CO_2 emissions (kg)		**2 514 202.08**	**2 457 097.38**
Energy consumption (kWh)		**3 670 368**	**18 133 560**
Actual – refurbishment	Demolition	683.8	1 040.1
	Construction	4563.1	1602.5
Total		5246.9	2642.6
Amount of CO_2 emissions (kg)		**1 725 180.72**	**1 217 445.82**
Energy consumption (kWh)		**2 518 512**	**8 984 840**

For calculating ecologic footprint the quantity of waste which would be generated by demolition of all preserved buildings was determined and also the amount of CO_2 that would have been exempted in production of that quantity of new material. Only brick and concrete were taken into account (energy consumption for production of 1 T of concrete/brick is 200/2000 kwh/T [2], while the amount of CO_2 released in production of 1 T of concrete/brick is 137/271 kwh/T [3]), since all other materials (wooden constructions, window framing, glass, etc.) are replaced in both scenarios. Results obtained by cross analyses of two scenarios are shown in (**Tab. 1**).

2.2 Economic aspect

Since the decision of complete refurbishment of almost all buildings in the complex was brought without any heritage protection restrictions, it is expected that the economic aspect was favorable. Entire complex was bought for approx. 900000 € and investment value is about 2.5 million €, which is approx. 250 €/m^2. Investment value for a rebuilt complex of same size would be up to three times higher. Possible disadvantage of a certain loss in useful space due to thicker outer walls than in new construction was determined based on existing size and materialization of building B, where difference between net areas of two case buildings is 7.62 %, giving about 800 m^2 on total complex size (10500 m^2). Having in mind that price per m^2 net area in this location was around 3000 € in the time when the project was completed (2005), it can be concluded that even with this slight lose of area economic aspects deffinitely favor the actual state.

3 Conclusion

In the analyzed refurbishment process emission of CO_2 related to production of new materials has been lowered for about 2000 T than if the whole complex was rebuilt, while energy savings for material production amount 10 million kWh. Based on these environmental indicators and some economic parameters which have been determined, it is shown that this refurbishment process has proved to be multiple times more favorable than the process of demolition of the existing structures and rebuilding of new ones. Even the basic analysis of energy efficiency aspect, as an important ecological parameter, shows that even with minimal additional improvements, exceptional results could have been achieved, since the large potential was inherited with the existing state.

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References

[1] DIRLICH, S. *The building stock and traditional building principles: sustainability assessment for historic buildings.* Proceedings of the 1st International Conference on Building Sustainability Assessment, Porto, 2012, Green Lines Institute for Sustainable Development, May 2012, pp. 31–38.

[2] HARRIS, C., BORER, P. *The Whole House Book: Ecological Building Design and Materials.* Centre for Alternative Technology, Powys, 2005.

[3] ZABALAZA BRIBIAN, I., VALERO CAPILLA, A., ARANDA USON, A. *Life cycle assassment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-eficiency improvement potential.* Building and Environment 46, 2011, pp. 1133–114.