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Procedia Engineering 21 (2011) 1161 – 1168

Procedia Engineering

www.elsevier.com/locate/procedia

2011 International Conference on Green Buildings and Sustainable Cities

Evaluation and feasibility study of retrofitting interventions on social housing in Italy

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Abstract

While there are an increasing number of new projects aiming at combining high residential quality and low power consumption, it is clear that the main challenge in the short term concerns the performance upgrading of the existing residential buildings stock. The feasibility analysis should consider the economic implications of the retrofit projects. A Disocunted Cash Flow analysis can be implemented in order to investigate the economic aspects of such interventions. The DCF approach allows the analysis of costs as well as the revenues and savings with the objective of understanding the period of time needed to recover the initial investment.

Keywords: social housing; economic evaluation; sustatinable retrofitiing; energy efficiency.

1. Introduction: the paradigm of suburb areas

The suburbs of modern cities have become key elements of the ever changing cities: once considered problem areas, now they are considered in the planning projects as significant components for the urban redevelopment [1]. As a matter of fact, the issue of suburbs is today ever present in the processes of strategic planning and of urban redevelopment; they are considered as areas of integrated transformation that is areas presenting a **diversified** system of transformation actions, ranging from the landscape and cultural heritage enhancement to buildings retrofitting interventions, up to an economical lifting and to an improvement of the infrastructural systems.

The redevelopment of suburbs - in terms of open spaces, social or economical aspects - is not limited to just their physical recovery, or environmental restoration or to an improvement of roads access, but it

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1877-7058 © 2011 Published by Elsevier Ltd.
doi:10.1016/j.proeng.2011.11.2125

also has an impact on their overall regeneration, through actions that not only influence the social and relations sphere, but also on the architectural and urban ones.

The decline of urban expansion has indeed lead to new needs for the re-use and regeneration of significant parts of the urban areas: the issues of recovery, renewal, conversion, redevelopment and reorganization of urban areas have become the focal points of the urban planners.

This type of intervention is becoming a process common to all European cities, which once exhausted their growth and expansion phase, now have to rethink their own global position and have to find effective solutions to ensure an acceptable quality of life for their citizens.

However, this trend, aimed at reusing of urban land and already built areas, requires the application of innovative techniques on both the physical and social context in order to rethink and re-plan urban spaces so to achieve the goals of renovation, requalification and restoration.

The main Italian case studies and the conditions of the suburban areas in modern cities (in decadence, or interested by upgrading processes) have identified some of the prevailing critical aspects of the planning carried out up till today. The first aspect concerns the suburb very nature: it may be marked by marginalization, where the fracture from the urban fabric caused a state of environmental degradation that often characterizes public housing estates; or, on the other hand, it may merge with the urban area where local services and facilities have kept alive the suburban context.

Another important aspect concerns the multi-functionality of the suburb areas: in many Italian urban experiences the strict application of mono-functional zoning policies has created situations of land use that has broken the variety and the urban liveliness. On the contrary, urban planning should forego the mono-functional zoning concept, favoring a social and functional mix. The promotion of a mixed use of the suburban areas is an opportunity to diversify and revitalize the urban fabric, avoiding the marginalization of the area, due to the single use application.

2. The housing stock

Generally speaking, the housing stock is characterized by low performances (as you can see in Fig. 1. (a); (b); (c)): it consumes high energy and does not offer suitable levels of comfort. It is characterized by different variables, from its historical background to the more recent suburban additions, and requires flexible methods of approach to define objectives and modalities of intervention.

This subject, considered very important in European Union countries, has been object of international operations related to specific local conditions both through researches and Community programs (as the program Concert-Polycity "Sustainable energy systems" within the Sixth Framework Program - FP6, 2005-10; Cost Action TU0701 [2]). These initiatives aim at focusing the attention on the energy issue, improving the level of performances and increasing the database of available experiences.

In Italy, the situation of the existing residential stock is very unsatisfactory. The level of energy demand for winter heating, the usual benchmark, is extremely high: for older buildings it is around 250 kWh/m2y, decreasing to an average of about 150 kWh/m2y in constructions built after the coming into force of Law n.10 of 1991. The comparison of these buildings with the more energy-efficient ones is rather discomforting: a passive building does not consume more than 15 kWh/m2y; a Gold CasaClima building consumes no more than 10 kWh/m2y, a Class A building in the Emilia-Romagna region consumes less than 25 kWh/m2y, the production of hot water included.

Therefore, it is important to define methods of requalification to improve energy and morphological performances of construction in relation to the different operational areas.

It should be noted that our national climatic context is mainly characterized by Mediterranean conditions with significant seasonal alternations and notable differences in relation to the cold climates of central and northern Europe, where many of the reference experiences were carried out.

The requalification actions aim at ensuring balanced conditions in accordance with the different climatic conditions; they must provide high levels of thermal insulation to retain heat looses; the clear parts must allow intake of natural sunlight useful for indoor lighting and for a passive heating of the interiors, as well as maintaining adequate levels of phase displacement and reduction of heat wave during the summer. Depending on the location and on the seasons alternation, issues linked to protection from summer heat or winter energy savings are to be considered.

Fig. 1. (a); (b); (c) Residential building stock in Berlin: it needs strategy of social, morphological and re-use regeneration.

3. Sustainable retrofitting and energy efficiency

The retrofitting of existing buildings is one of the most environmentally friendly and efficient solution to optimize the energy performance of buildings [3]. As a matter of fact, when compared to new buildings construction, this kind of intervention reduces the consumption of land and energy and could be applied to a large building stock, characterized by low architectural quality (see Fig. 2 (a) and (b)).

The issues related to sustainable restoration are particularly felt in suburban areas, especially with reference to the public housing stock.

This stock, built mostly in a period ranging from the 1960's to 80's, often represents the quickest and most economical answer to a strong and urgent demand for housing. The common practice of building with poor quality products and processes of construction, has lead to a stock that is now in a condition of urgent need of repair and requalification, and sometimes interested by real physical decay.

Secondly, as stated above, the evolution of households structure and the establishment of new family models, often requires a new redistribution of the spaces of buildings to meet the needs of these new and diversified family structures.

It is also necessary to consider structural performances, especially with reference to seismic standards; the energy retrofitting of the envelope and the systems compliance are therefore just one aspect of a much more articulated requalification process that involves the entire building and the contest it is in. Consequently, the requalification of existing buildings is not just limited to technical improvements, but it is also a response meeting all technological, energy and functional requirements, which, overall, even justify interventions that involve higher costs.

Fig. 2. (a) Regeneration of social housing complex in Bolzano (IT). The building, with 70 flats, was erected during '50s. The picture shows the building before the intervention; (b) The energy retrofitting of the envelope and the installation of centralized systems have improved the indoor comfort with an energy requirement of less than 40 kWh/m2y and a cost of intervention of 500 €/m2. The average cost for heating is 237 €.This is the first retrofitting intervention classified CasaClima B.

4. Trends and strategies

The Italian context, compared to other national situations, is characterized by widespread presence of buildings of historical importance. Therefore, the retrofitting intervention must be compatible with the preservation and protection of the morphological characteristics of the buildings and of the urban fabrics. To improve their quality the industry offers increasing options aimed at the renovation of the stock, through the application of high performance materials and innovative technological solutions.

Apart from the most important monuments which need particular protection, the intervention on residential fabric can be carried out considering environmental restrains, even in the case of restrictive limitations, considering the economic and social aspects as parameters of feasibility. The alternative is the abandonment of entire sectors of urban areas, in severe state of decay and under-utilization: only by improving the performance of the historical stock it is possible to promote an efficient policy for a social and use regeneration.

Most of the requalification interventions on the existing social housing, in Europe, mainly concerns buildings of large dimension and no particular value, located in suburban areas. The recovery provides intervention strategies for redefining the volume of the buildings, with partial demolition and elevations, the addition of balconies and loggias with independent structure, a change in the dimensions and layout of the flats and of their surrounding areas.

The morphological regeneration can affect entire buildings or be limited to some of their parts, such as the entrances of the block of flats, it can foresee the replacement of the envelope or part of it and a performance improvement of buildings components, in order to make the buildings more attractive and recognizable to the users.

A current trend is addressing the application of innovative technologies of light and dry prefab, mostly using wooden or metal elements, which can ensure high levels of quality, speed and precise execution, cost containment and forecasting [4]. The increasing flexibility of the construction systems allows their application even in interventions of small size: the use of prefab systems of wood bearing panels for additions characterized by low weight and optimum seismic behavior is of particular interest.

5. Intervention program

The programming and the priority order of interventions plays an essential role in the efficiency of the strategy of requalification and are developed according to the degree of impact on the objectives to be achieved (see Fig. 3). In complex areas the procedure consists in evaluating the volume changes (demolitions, additions, supplements) of the buildings, taking into consideration the architectural and technological issues.

Fig. 3. Retrofitting of a social housing building in Forli, Emilia Romagna region. The building, which was erected during the '80s, has 8 floors and contains 34 flats. The project strategy provides these progressive stages: Phase 0, current situation: the overall energy performance index (Eptot)153.37 kWh/m2y; Phase 1, retrofitting of the envelope: the overall energy performance index (Eptot) 55.98 kWh/m2y (63% decrease); Phase 2, integration of balconies, greenhouses and systems: the overall energy performance index (Eptot) 17.12 kWh/m2y (89% reduction); Phase 3, addition of high efficiency volumes:, the overall energy performance index (Eptot) 13.40 kWh/m2y (91% reduction).

In a requalification project it is essential to re-define the thermal envelope (as you can see in Fig. 4), that is selecting which parts of the buildings have to be included within the climatic controlled area. Ground floors or basements and utilities rooms, elevators, stairs, lodges, non-usable under-roof areas may or may not be considered in the thermal envelope in relation to design decisions, defining different values of the ratio S/V of the project (where S is the surface that surrounds the heated volume; V is the gross volume of the heated parts of the building defined by the surfaces that surround it).

Therefore, with regards to an existing building, the requalification project involves a careful study of the various available options. It is important to define the priorities of interventions to improve indoor comfort and energy performance, to obtain the thermal balance, that is to say the set of heat exchange between the building interior and exterior. It is fundamental to identify the parts and components of the building which determine heat losses to gradually implement them. In general, requalification interventions distributed on more than one technical element tend to better balance the environmental conditions generating a high degree of well-being and evenness conditions. To the contrary, partial interventions to solve specific problems, if not considered part of a common strategy, may lead to secondary problems. Therefore, it is necessary to constantly maintain an overall control of the issues involved to ensure an actual effectiveness to the interventions [5].

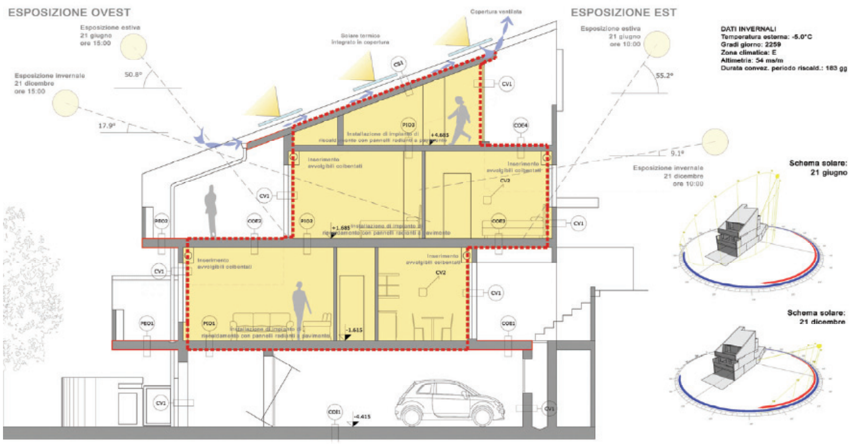

Fig. 4. The case study analysis of energy requalification of terraced houses attended by the Faculty of Architecture of the University of Bologna at SAIE 2009. Energy analysis for retrofitting: the line of thermal envelope identifies the heated volumes. The overall energy performance index (Eptot) is 206.37 kWh/m2y. After the intervention it is less than 75 kWh/m2y.

6. **The economic analysis: the discounted cash flow approach for retrofitting projects**

The economic analysis of a typical investment in energy efficient projects or retrofitting projects is usually undertaken according two different approaches:

- the first approach considers only costs and revenues which are expressed in monetary terms;
- a second approach, usually called cost – effectiveness analysis, considers also indicators of performance (emissions removal, reduction in pollutions, health impact, etc) which do not have indicators expressed only in monetary terms.

Usually, in order to perform an economic analysis, the following steps needed to be define:

- 1. define the set of projects (usually mutually exclusive) to be considered;
- 2. define the horizon or the period of analysis of the projects;
- 3. develop cost and revenue profile in monetary terms for each project;
- 4. specify the discount rate, the growth rate and the inflation rate to be used;
- 5. compare alternatives with economic criteria;
- 6. perform supplementary analysis as sensitivity, break –even, risk analysis;
- 7. select the alternative.

In the cost – effectiveness analysis, at the point 3, different evaluation criteria are established as performance criteria, reliability, etc, which conduct to a multi – criteria analysis of the project.

Typically the investment feasibility calculation are carried out using DCF (see Fig. 5) where all the present and future inflows and outflows are discounted to obtain the Net Present Value (NPV), the Internal Rate of Return (IRR) or the discounted payback period (DPBP).

The Discounted Cash Flow is calculated as follows:

$$DCF = C_0 + \frac{(R_1 - C_1)}{(1+r)^1} + \frac{(R_2 - C_2)}{(1+r)^2} + ... \frac{(R_n - C_n)}{(1+r)^n} =$$

$$= \sum_{t=1}^{n} \frac{(R_t - C_t)}{(1+r)^t} \quad (1)$$

Where:

C0 are the investment costs of the project;

Cn are the operative costs (maintenance, energy, etc);

R are all the incomes/revenues (or savings) during the life cycle of the project or the investment period considered;

r is the discount rate.

To evaluate the project some methods of investment are used, in order to develop an approach that can be regarded as being economically defensible.

The first method is called the net present value, which represents the present value of all incomes and costs during the period of analysis of the investment. If the present value gives us a number larger than zero, then the project can be accepted, as incomes are greater than costs. If the NPV is negative, the project must be rejected or modified. The IRR is the discount rate that makes the net present value equal to zero. The IRR of an investment is the rate at which net present value of all costs equals the net present values of all incomes or revenues of the project. Usually the IRR must exceed the cost of capital or the hurdle rate, a rate that the investor aims to get from the investment. The discounted payback period for a project is the time it takes to recover the cost of investment. The cash flows are added up after taking account of the time value of money. The decision is based on comparing the different payback periods with a predetermined cut off period decided by the decision maker.

To undertake the economic analysis, it needs to identify all the critical variables and assign appropriate values to them based on an analysis of the current market.

There is no decision rules which can be consider for all investors in the energy market. A rule of thumb considers a proper payback period for those investments which is shorter that the life cycle of plants and/or a period suitable for the investor. Usually projects with 15 – 20 years payback period are preferred. Of course this is not a rule of the market, but comes from a large numbers of projects analysed during the last decade. At the same time, considering the IRR, the investors prefer project with “double digit” returns, which means that the IRR considered should be greater than 10%.

NPV or IRR or the payback period can completely modify if we evaluate the alternatives based upon the effectiveness criteria [6].

7. Conclusions

The retrofitting of social housing requires to take into consideration, among the limiting factors, the containment of the cost for interventions, management and maintenance. The evaluation of the cost/benefit ratio of the operations is essential in order to take the most appropriate decisions. In addition to the cost of the intervention, the investment economic consequences should be considered in terms of maintenance and management impact, which concern mainly the public body, and in terms of consumption for the end-users, traditionally belonging to the weakest social class.

Therefore, particular attention should be paid to the management and realization criteria of the interventions; a sharing with the end- users is usually required for obtaining a good final result and for the application of correct management methods.

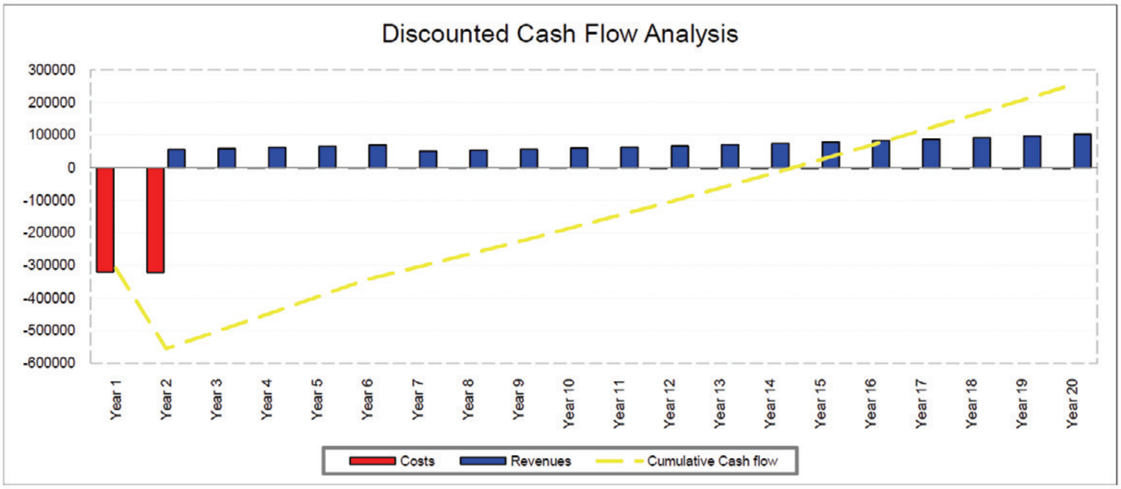

Fig. 5. The graph shows the investment costs and the running cost (in red), the revenues (incomes and savings, in blue), and the yearly cumulative cash flow (in yellow) which defines the payback.

The approaches to the retrofit project are complex and require an architectural, technological, economical and energetic assessment, according to the building characteristics, and therefore they also imply the need to refer to experiences and experts in different fields.

Flexible programs, new and old housing typologies, the use of traditional and innovative materials and technologies, interesting financial solutions are key factors in ensuring an economically accessible social housing, characterized by architectural quality and compliant with all safety and environmental standards, in terms of energy-saving requirements.

In this context, the new housing and retrofitting projects may also provide the opportunity for managing even the transformation of the city and the territory, through the application of technologies and typologies capable of providing new living spaces that respond to the pressing needs for environmental and economical sustainability of the interventions.

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