KEEPING THE HISTORICAL HERITAGE ALIVE:

Methodology for the energy renovation of the historic residential stock of the east extension in Brussels.

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ABSTRACT: Keeping the historical heritage alive is part of European culture. There are a huge number of historical buildings in Europe, the majority of which are still wasting large amounts of energy [1]. Although a certain degree of caution should be maintained when thinking up renovation plans for historical buildings, the simple argumentation that they can't in anyway be adapted to integrate new renewable energy installations for fear of changing their nature and appearance is not endurable in the societal move towards sustainability [3].

This study defines a pre-assessment methodology for the retrofitting of historical building stock in the east extension in Brussels and the rules to understand the factors influencing the efficiency measures applied. Beginning with the evaluation of the building stock characteristics and its urban structure context under a holistic approach, we are able to identify the synergies and/or incompatibilities between the different techniques applied. The result is a tool that identifies in an early stage the benefits or impacts of different actions and the solutions that better fits, achieving an energy efficiency improvement from a technical, legal and economic point of view.

Keywords: Energy integration strategies; renovation; renewable energy.

INTRODUCTION

It is necessary, at all levels, to revise our use of non-renewable resources. In all the EU-27, the building industry is one of the highest energy consumers along with the transport sector and the industry. The building sector accounts for over 40% of EU's energy demand, which means the sector faces the inevitable challenge of producing more efficient buildings to fulfil the 20% primary energy consumption reduction target fixed by the EU.

According to the Directive 2010/31/EU, new buildings will have to be nearly zero energy buildings by 31st December 2020. However, it entails no specific targets regarding the existing buildings, which present a large proportion of the building stock and the first cause of CO2 emissions from the building sector.

Gaterell and McEvoy [4] suggest domestic sector could potentially make a significant contribution to reducing energy consumption. Residential buildings account for the 2/3 of final energy consumption in the building sector and 70% of buildings floor area, so it seems important to focus the strengths on the improvement of energy efficiency in the existing residential building stock.

In this paper the need for energy renovation in historical residential buildings is highlighted as the main element to achieve energy efficiency targets.

There is a huge number of historical buildings in Europe, the majority of which are still wasting large amounts of energy. A prejudice widespread in many countries is that historical buildings, and particularly those under monument protection, should not be equipped with renewal energy technologies, and should thus be exempted.

Although a certain degree of caution should be maintained when making up renovation plans for historical buildings, the simple argumentation that they can't in anyway be adapted to integrate new renewable energy installations for fear of changing their nature and appearance is not endurable in the societal move towards sustainability.

Keeping the historical heritage alive is part of European culture. Historical buildings have witnessed a series of debates, over the decades and even centuries, in terms of their facilities. Most historical buildings still in use today have already endured the introduction of running water, centralised space heating, cooling, ventilation, electricity and telecommunication networks. It can even be argued that if they had not allowed these changes to take place, they would, by now, have become unusable ruins.

Attractive case-study projects involving historical buildings can contribute massively to spreading a positive image of renewable energy technologies.

There is a need to develop a certain methodology to tackle the energy renovation analysis in historical residential building that assures success from the beginning of the design phase. An individual and often fragmental approach to the energy renovation projects exists even when the solutions are applied in a single residential building, without a previous analysis of all the solutions seen as a whole to identify synergies and/or incompatibilities between the different techniques applied that results in lack of efficiency and unsuccessful solutions. This individual approach results, because the lacks of a whole vision of the project, in a raise of the final budget and, in most of the cases, without achieving the expected energy efficiency improvements.

If we had to consider the possibilities, the number of scenarios would be too broad to be handled. Therfore, in this paper, the deciding variables have been defined by the catalogued building typologies, so the renovation techniques are analysed with regard to the building system where they are applied.

This paper discusses an approach to the design of refurbishment projects, as a way to upgrade the residential stock in terms of energy efficiency. It presents answers to specific technical problems and determines how improvements in the environmental performance can be reached. Different refurbishment options are proposed and systematically organised. The impact of the different retrofitting solutions into the energy performance of the building is assessed. The methodology will provide a roadmap for the refurbishment strategy. In this way, the tool will support the decision making process of refurbishment projects.

SUSTAINABLE DEVELOPMENT PRINCIPLES AND MODEL OF BUILDINGS REFURBISHMENT

Regarding the limited supply of non-renewable energy resources and the emission of greenhouse gases affecting global climate, it had been postulated that a sustainable energy system requires an overall reduction of present energy consumption levels, primarily in industrialized countries.

Housing refurbishment is taking a central place in the efforts of integral refurbishment and revitalization of larger areas, especially in larger housing states (Ruano, 2002).

Sunikka (2003) concludes that the real potential for sustainable building and CO2 reduction lies in management of the existing stock of residential buildings. According to Papadopoulos, Theodosiou and Karatzas (2002), Gorgolewski (1995) and Hong, Oreszczyn and Ridley (2006) the energy efficient refurbishment of existing buildings is an important tool for the reduction of energy consumption in the building sector and for the improvement of environmental conditions in urban areas.

Keeping and Shiers (1996) have listed the benefits of “green refurbishment” and Sitar, Dean and Kristja (2006) have emphasized some important integrated sustainable principles.

The concept of sustainable refurbishment should cover and integrate every possible economic, social and environmental need. Reddy, Socur and Ariaratnam (1993) offer a frame-based decision support model for building refurbishment, while Rosenfiels and Shohet (1999) and Lavy and Shohet (2007) talk about a decision support model for semi-automated selection of renovation alternatives. Alanne (2004) proposes a multi-criteria model to help designers choose the most feasible refurbishment actions in the conceptual phase of the project.

Numerous sustainable buildings refurbishment models are proposed in the literature. Among the most typical approaches there are developed models for energy efficiency renovation, which through the use of new materials and the testing of new techniques also support different branches of the construction industry.

Sustainable refurbishment must reconcile further dimensions:

- Social (collaboration, public awareness and education, social safety, etc)
- Ecological (ecological construction materials, energy, waste, noise, land use, health, air quality, etc)
- Economic (cost-efficient price, fair price and good service, energy saving reliability, etc)
- Cultural (cultural heritage, behavioural norms, etc)
- Architectural (comfort, aesthetics, decoration, environment, buildings purposes matching exterior, etc)
- Technical (innovative HVAC technologies, energy saving technologies, etc)

All of the abovementioned dimensions are closely related, complementing each other and influence general refurbishment efficiency.

Particularly energy consumption encourages environmental problems. In order to ensure energy efficiency in building modernization and refurbishment, the main attention must be paid on building insulation, heating, cooling, conditioning, lightening system design. Sustainable refurbishment should encourage efficient construction materials and natural resources use, as well as the extension of building life cycle and environment reaching waste quantities decrease.

According to sustainable development principles, buildings refurbishment encouraging environment conservation and favourable living conditions must be affordable to people and not too expensive (Chwieduk, 2003)

DECISION MAKING PROCESS

In order to design and implement buildings refurbishment based on sustainable development principles it is necessary to follow these principles from the beginning of the idea till its implementation. Suitable decisions must be made starting from projecting stage.

When refurbishment reasons are clarified, further activities to achieve the main tasks are discussed. It must be decided if the complete refurbishment of the building is needed or just a partial modernization.

Once the needs for refurbishment are defined, the next and very important phase, is decision making, which means the selection of the best alternative from numerous alternatives. In this phase the information about already implemented refurbishment projects, best practice examples, projects strengths and weaknesses are needed.

In practice, the detailed carrying out of the measures has to fit the individual project in terms of the building´s existing condition, location, project specifications, budget and ambition of client as well as architect´s decisions.

The objective of the methodology is not to dictate an optimised solution, but rather to assist in affective choices. The different measures are systematically compiled and organised in the methodology according to the building components. This methodology is an essential database of the possible measures which can be implemented in the refurbishment project, sorted by its construction components. The information is organized in a matrix, including the key components of the building. Addressing solutions for all of the above aspects, composes integrated refurbishment strategies.

HISTORIC RESIDENTIAL BUILDINGS

Speaking about uncountable values, building retrofitting can be considered as one of the most culturally enriching architectural strategies, as the expression of different historic periods makes the built environment much richer. Reusing existing buildings can be, thus, an efficient way of spreading culture, to which respect to previous interventions is necessary.

Common practice in the retrofitting of historic buildings is based on the improvement of the envelope. It is the first step when updating these buildings, which are generally the un-insulated heavyweight constructions. Modern construction techniques have to be carefully applied to old buildings, which have a delicate thermal balance. Yet historic houses have severe drawbacks that prevent them from good environmental performance: poor daylight, high-energy consumption or limited opportunities for natural ventilation are common characteristics of the housing type.

Historic houses might seem an improbable target for development of energy efficiency dwellings. However, the scope for improvement is certainly large and the benefits of their preservation go beyond mere technical considerations. On the one hand, they are valuable constructions that must be especially protected. On the other hand, they are buildings whose inadaptability to current demand can be a threat to their preservation.

The historic cities require renovation of their residential architecture, in order to ensure their preservation. It is considered possible to reach contemporary comfort standards in historic houses without compromising the architectural heritage. This implies not only to the retrofitting of the constructions but also to the redesign of the spaces.

CASE STUDY

This research focuses on the study of new tools for the refurbishment of historic residential buildings in the Extension East of Brussels (see Figure 1). The revitalization of old cities would imply the increase of dwelling availability in areas where greater social diversity is needed and higher population density can be beneficial. The older the construction, the more delicate and necessary the upgrading process is and the more specialised knowledge is required.

This paper focuses on the study of the context and the identification of the main characteristics that are common to the listed historical housing in the East Extension, linked to their environmental performance.

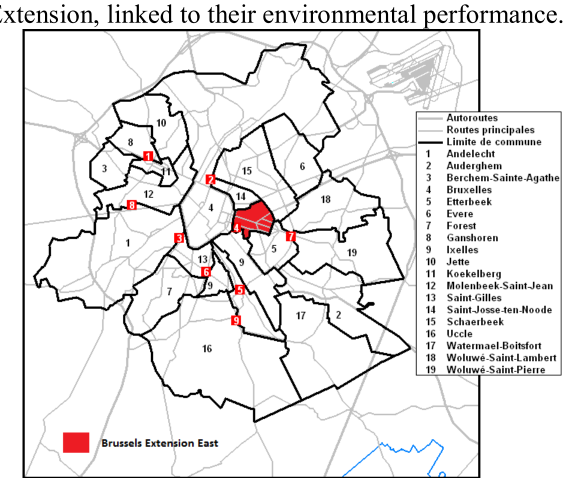

Figure 1. Location of the case study area on the map of Brussels. http://www.skyscrapercity.com/

Brussels has an oceanic climate being under the influence of marine air masses coming from the Atlantic Ocean due to its proximity to coastal areas. **Nearby wetlands also ensure a maritime temperate climate. On average, there are approximately 200 days of rain per year in the Brussels-Capital Region. Snowfall is rare, generally occurring once or twice a year**. The climate has influence the design of dwellings to deal with the humidity of this climate and to collect the maximum solar radiation in sunny days.

The Extension East of Brussels is a predominantly residential area, where Maison d´habitation, Maison d´architecte and Hôtel Particuliere represent the main types of dwellings (see Figure 2).

Building Typology	Number of Buildings	Example
Hôtel Particulier	21	(1) Rue Philippe Le Bon 70 (1901)
Maison d'habitation	More than 900	(2) Maison Saint Cyr (1903)
Maison ouvrière	1	(3) Rue de l'Inquisition 37 (1895)
Maison d'architecte	22	(4) Avenue de la Brabançonne 7 (1894)
Maison et Atelier d'artiste	4	(5) Rue des eburons 63 (1904)

Figure 2. Building typologies.

In addition to the strict building regulations, socio-economic homogeneity of the neighbourhood gives it a rare unit. The majority of the houses are built for well off middle class family with almost invariably the same plane-type three rooms in a row, along with attic reserved for domesticity. The facade has usually two or three equal spans, decorated with a balcony or loggia. The homes of the middle class respond to the same pattern, in however modest proportions.

In contrast, this program can be found amplified in mansions for the upper class. Moreover, their plots allow the development of additional parts such as lobbies or an office. The facades are richly ornamented and with cubicles, with bow-windows or even turrets.

The obstruction of neighbouring houses and large building depth, due to urban density, are very restrictive parameters in this architecture. Although these seem to be unalterable characteristics, they may actually be modified without altering the appearance of the building.

The deep and narrow building form is very restrictive for a positive performance of the dwellings (see Figure 3-4)

Figure 3. Square Marie Louise 66 (photo 2007).

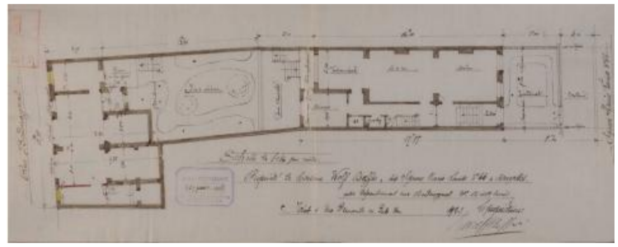

Figure 4. Example of deep dwelling: Chaussée de Louvain. Charles and Carousel, AVB / TP 14969 (1876).

However, the potential of the roof and the courtyard for improvement is high. The patio can be found in some houses, which is often small and partially occupied by the staircase, as a space with large possibilities for raising daylight levels and ventilation rates. The increase of its surface might counterbalance the impact of the building depth. (see Figure 5)

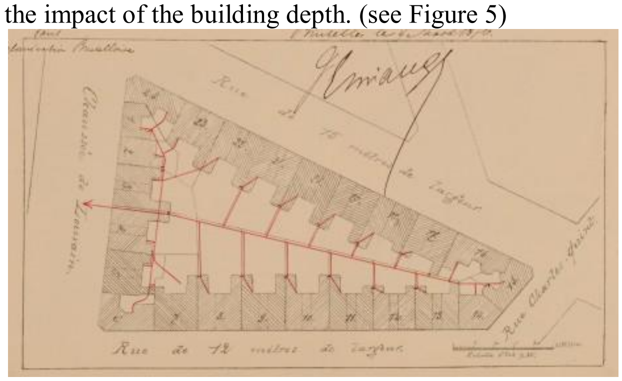

Figure 5. Example of the building depth: Chaussée de Louvain and the streets of Pavia, Charles and Carousel, AVB / TP 14969 (1876).

The potential of the patio is both environmental and architectural. Enhancing its size allows the increase of solar gains in the building and strengthens a semi-public space with great possibilities. The patio shapes that occupy the longer side facade, with a surface-oriented south, are proved to be effective, as they favour solar access in the long axis of the building, increasing solar ray penetration into the dwellings.

The surface of the roof can represent around 50% of building's envelope. It is also the surface of the envelope that receives solar radiation the most. Thus, the rooftop house might have greater opportunities or good environmental performance than the flat house. A responsive design of the volume of the rooftop might increase the solar access of the lower levels, improving the performance of the whole building. (see Figure 6)

Figure 6. UrbIS®© Aerial thermograph Extension east of Brussels.

On the other hand, natural ventilation is crucial in this climate, due to high levels of humidity, and it is especially important in historic buildings, which use evaporation and ventilation to reduce the moisture in the walls to an acceptable level. In a deep building, the central area of the house may have little opportunities for ventilation, which could cause damage to elements of historical value.

Common practice in the retrofitting of historic buildings is based on the improvement of the envelope that it is generally un-insulated. When insulating during the retrofitting of the historic building, it is critically important to consider the constraint of the building itself as the uniqueness of the building, the characteristics of its materials, the climate in which it resides, and the specific building methods that were used in its construction. Adding insulation where it is not needed, inappropriate, or ineffective can lead to irreparable damage in historic features. Therefore, it must be considering whether or not to include insulation and if so, the fact that this could be a reversible insulation that does not make drastic changes in the air flow that could damage historic building fabric. It must be taken into account the importance of preserving historic construction material that makes the isolation of the walls less recommendable that the insulation of attic and basement.

Due to the form and the physical configuration of the area, city blocks work as a whole not only in terms of structure but also in terms of thermal performance. It is because of this reason that the impact of refurbished houses on neighboring buildings is remarkable. Improvements in some buildings can positively influence others, if linking elements are provided, such as openings on the mediator walls.

Although this research focuses on passive measures exclusively, being its main challenge to improve historic buildings through redesign, it has been found necessary to approach active systems as well, due to the big energy problem identified through fieldwork.

Solar energy and wind power, geothermal and aero thermal energy might be inadequate on this location from aesthetic reasons, archeological constraints and climatic restrictions, respectively, although the third one might be appropriate for district heating systems. Low temperature and condensing boilers might improve energy efficiency and reduce energy bills but they would imply changes on the distribution systems. Biomass, because it responds to the same principles as those of the traditional heating systems in historic houses, might be a suitable option, easy to accept by the users and to install in the buildings.

FUTURE STEPS

The study will continue with the analysis of the current regulations and the socio-demographic framework. This will be followed with the application of sustainable retrofitting strategies and the consideration of its implicit cost.

The impact of the street width, the impact of the floor height and of building depth, on the named non-passive zone will be analyzed. This analysis on the dwelling non-passive zone can be a simple tool for measuring the “sustainability” of the buildings, as it illustrates the grade of contact between the indoor and the outdoor environment. It can be applied to any house and be used as a means of comparison.

Due to the interesting amount of climate data, building components data, sustainable techniques and historic residential building catalogue, results of the study, it will be interesting to develop a web tool accessible to different stakeholders so to help in the decision and design process.

CONCLUSION

Sustainable refurbishment is significant problem in current buildings stock, taking much of a scientists’ attention as well as European Commission initiatives. Sustainable refurbishment is widely discussed in the literature and various models and decision making tools proposed. This paper integrates sustainable development principles decision making process and influencing factors into one unique conceptual sustainable refurbishment model.

Model involves macro and micro environment factors analysis, integrates participating in refurbishment stakeholder’s decisions and needs. According to sustainable refurbishment principles, refurbishment not only decreases energy consumption but also improves whole condition of the building.

Much attention is paid on decision making process. In order to design and implement buildings refurbishment basing on sustainable development principles it is necessary to follow these principles from idea till implementation.

There is still the need of specialised knowledge to assist the design of holistic refurbishment strategies in the early stages when decisions have bigger impact.

This paper presents an integral approach to the energy upgrade refurbishment that gives specific answers to key parameters of integrated refurbishment. It also determines how improvements in the energy performance can be achieved. In this approach, different options for each parameter are studied, calculated and designed in a level of construction detail, providing a database of options and solutions. This systematic approach to the strategies, divided into key aspects and different options, can be organised in the form of a matrix.

This approach recognises the diversity of each project as well as designer decision freedom. The tool will provide solutions for the technical issues to be solved at the implementation phase. Its aim is to be a support instrument throughout the design process which will provide knowledge on the effectiveness of the measures.

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