ENERGY RETROFITS OF RESIDENTIAL BUILDINGS IN BRUSSELS: WHAT IMPACTS ON STOCKS AND MATERIAL FLOWS?

Gobbo Emilie R., Trachte Sophie

Architecture et Climat, Université catholique de Louvain (UCL),
Place du Levant, 1, B-1348, Louvain-la-Neuve, Belgium.
E-mail : emilie.gobbo@uclouvain.be
Phone: +32/10.47.26.36

ABSTRACT

One of European Union's main goals is to promote efficient resource management via conservation and preservation of these natural resources. Waste reduction and recovery improvements are key components as well. Moreover, within the context of present energy efficiency, the renovation of the old and energy-consuming housing stock has become a major issue. Although the renovation process generates energy gains during the operation phase of the building, it also leads to resource consumption and waste production that are rarely taken into account in the design process. Therefore, the initiatives essentially based on energy efficiency alone have to be extended in order to incorporate the future value of recyclable and recoverable materials. In this way, the research proposal is to consider buildings as a bank of materials that could constitute local resources on a medium or long-term basis?

Considering the context and issues mentioned above, the present contribution aims to answer the followed question: what impact will the energy-retrofit of buildings have on material stocks and flows? The data in this field is currently non-existent or incomplete. Our proposal is to analyse case studies in terms of intervention trends of sustainable retrofit on the one hand - considering demolition and insulation - and in terms of *material balances* on the other. Particularly, we considered the energy retrofit operation in metabolic terms: the purpose is to identify and quantify the material stocks and flows created before, during, and after the renovation process. Because it is one of the most important elements of the building that has to be upgraded to achieve energy efficiency, this contribution focused on the building envelope.

Keywords: material stocks & flows, energy retrofit, construction material, construction & demolition waste

INTRODUCTION

The European economy requires a significant amount of resources for operations: material use is estimated at 16 tons per capita per year. It also produces a huge amount of waste: about 6 tons per capita per year. Despite management that is more and more efficient, this level continues to grow with devastating consequences for our ecosystems.

The construction sector plays a major role in this context. The sector is responsible for 40% of the raw depletion and energy consumption, and 35% of the European waste generation. Existing building stock represents about 25 billion square meters with a high percentage of dwellings built before 1960.

These ratios are similar in the Brussels Capital Region (BCR). The housing stock is important (almost two thirds of developed areas), as well as being old and energy-consuming. The construction sector is responsible for a large part of waste generation and material consumption. Indeed, it represents more than a third of the non-domestic waste of the region.

Therefore, the challenges facing the sector in the reduction of energy and raw material consumption, as well as waste production, are monumental.

As players in the construction sector, the architect's primary concern relates to reducing energy consumption during the use phase of the building. Actually, this concern is greatly influenced by the implementation of new energy efficiency regulations, and the many financial incentives making the energy retrofit of buildings more cost effective. New concepts and certifications have appeared, such as passive houses, and Nearly Zero Energy Building. What about the reduction of material consumption and waste generation of the construction projects? These considerations are little known and rarely taken into account by designers and other actors in the sector.

METHOD

Goal and scope of the research

In light of the fore going, the research has enlightened some questions and assumptions:

- First, why not consider waste as material resources? This could be an answer to the waste and resource challenges cited above
- Applied to the construction sector, the building could be considered as a material deposit. In other words, a source of potential reusable materials. In a wider scale, our existing environment may represent a bank of local resources. To achieve this objective, end of life must be introduced and considered in the design stage of a project, and not after construction. When we currently design a building, we rarely think about its end of life. By doing so, we compromise the opportunities of recovery.
- As energy retrofits of buildings have become absolutely necessary from an energy perspective, what impact will these upgrades have on material stocks & flows?

This contribution highlights the impact of sustainable renovation not only on the energy side but also in terms of materials. The proposal is presented in the figure below:

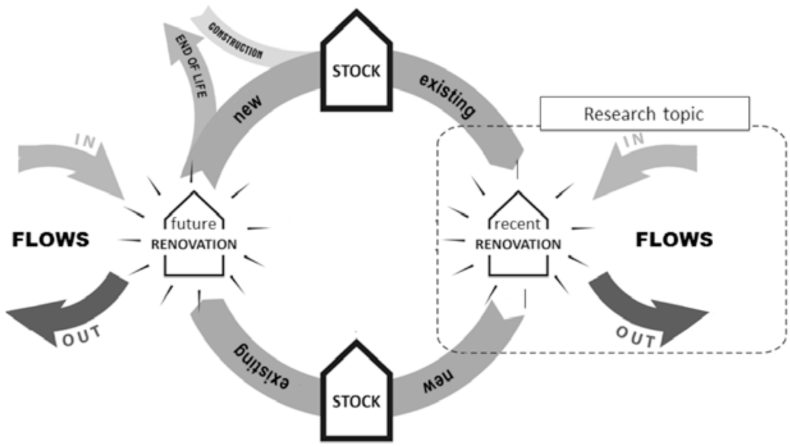

Figure 1: Proposal of the research

Globally, we illustrate the building life cycle with its initial construction phase, its end-of-life and intermediate upgrading processes. We have particularly focused on the analysis of what currently happens during retrofit operations in terms of material:

- What material stock does the building contain prior to an energy retrofit?
- What materials flows (in / out) are involved in this operation?
- What influence will the renovation have on the existing material stock (new stock)?

The present contribution intends to identify and quantify all these material stocks and flows.

Structuring

We chose a subject sufficiently representative at a regional scale considering the Brussels Capital Region.

We focused on dwellings built before 1945 and renovated with high criteria of sustainability and energy efficiency. Specifically, this analysis has been based on the competition « Bâtiments Exemplaires ». A competition developed by the Brussels Environment Administration to support sustainable construction & renovation in Brussels. Actually, this kind of renovation represents one of the primary objectives of the Region in terms of sustainable construction: 23 projects met these specifications.

Then, to provide a systematic approach, we propose to categorize the building in systems (envelope, interior space limits, and equipment), components (roof, façade, and floor) and layers (external, internal and structural). We specifically focused on the envelope, due to having the most effect on the energy efficiency of buildings.

The analysis is developed in 2 steps:

- Intervention trends of the sustainable energy retrofit: 10 on 23 retrofitting projects were analysed.
- Material balances to identify & quantify material stocks & flows: 1 retrofitting project was analysed.

RESULTS

Intervention trends

The following figure illustrates the renovation trends on the envelope in terms of demolition.

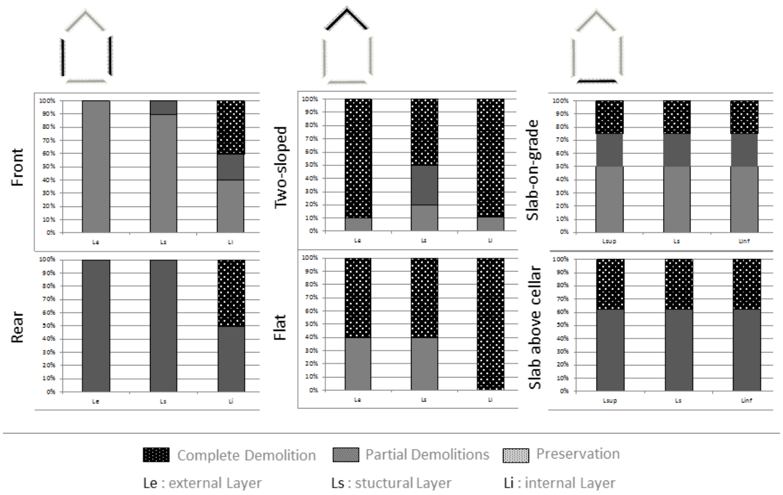

Figure 2: Intervention Trends in term of demolition

Results show that demolition rates differ between components and layers considered. The roof is commonly the component for which the most important demolition is conducted. Primarily on its internal layers while the structural layer is more preserved than the others. Regarding the front façade, preservation is commonly applied, except for its internal layer. Unlike the front façade, the rear one is usually subject to partial demolition (Le & Ls) or complete demolition (Li). Concerning Floors, all layers show the same conclusions: this means that when a demolition occurs, it will be on the total floor thickness.

The third figure below illustrates the trends in terms of an insulated envelope.

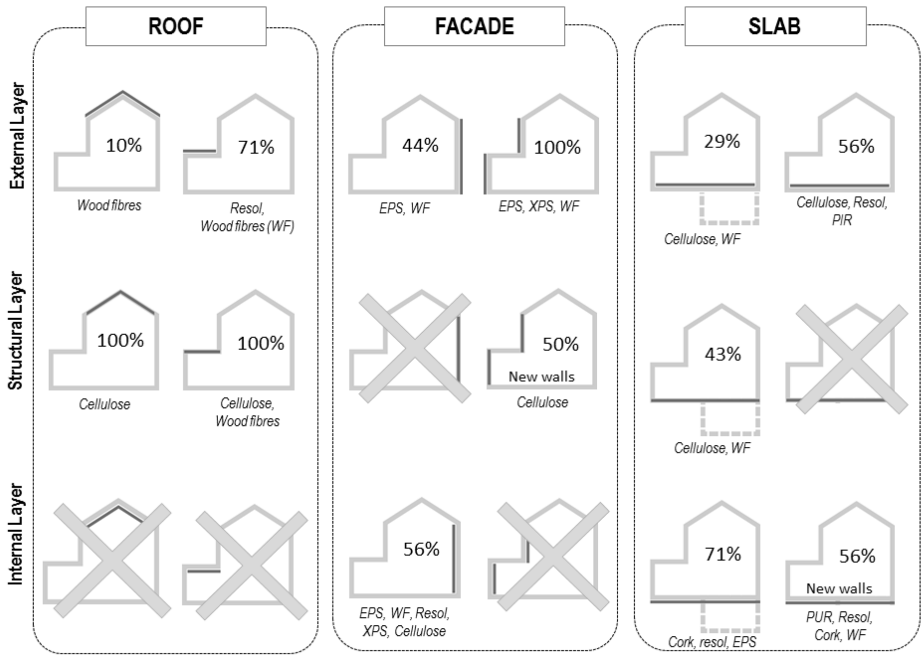

Figure 3: Intervention Trends in term of insulation

Insulation opportunities depend on the components and how they are built. Insulation in the external layer is usually preferred to avoid thermal bridges and some indoor moisture disease. Some exceptions do exist: when the structure allows the insulation in the structural thickness (in the case of existing or new wood structure especially for roofs), when some planning regulations require the preservation of the component appearance (for example, concerning the front façade), or the external layer is not accessible (existing slab-on-grade). Sometimes, insulation is made at the level of two different layers in a simultaneous and complementary way (for example in flat and two-sloped roofs).

Material balances

We focused the *material balances* analysis on one project. We identified and quantified the different fractions of materials contained in the building, before and after the energy retrofit operation. We also analysed inflows and outflows generated by the renovation process. We considered two distinct measurement units: weight and volume. The results of these *material balances* are showed below.

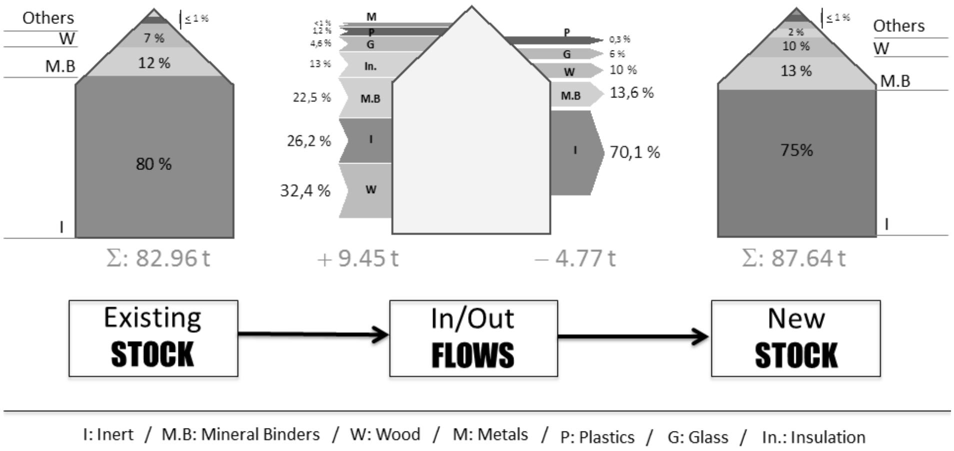

Figure 4: Material Balance in term of weight (tons)

In terms of weight, the findings confirm that inert represents a major part of the construction materials total weight. This tendency is similar after renovation. Inert waste also have a dominant place in the outflows. While inflows are more widely distributed with fractions of wood, inert, mineral binders, insulation etc.

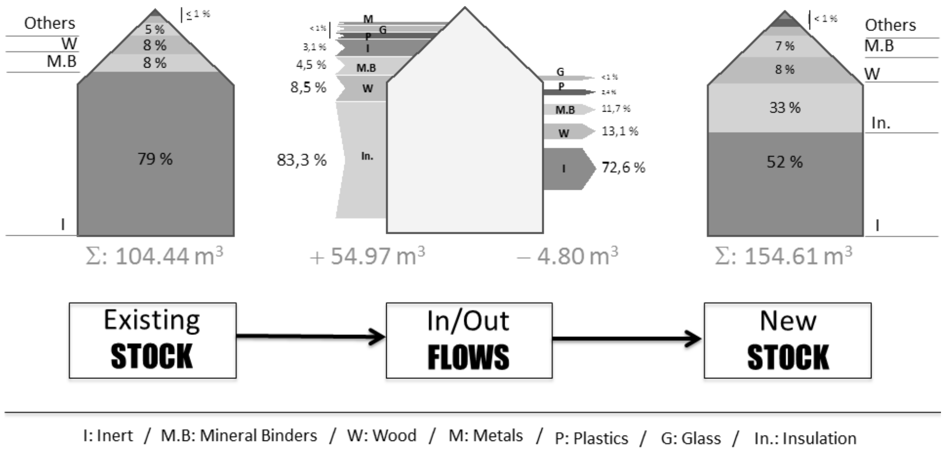

Figure 5: Material Balance in term of volume (m³)

In terms of volume, the comparison with the previous findings is quite interesting:

Before refurbishment, inert materials are still the dominant part of the construction. This trend changes after energy retrofitting. Insulation accounts for a third of the entire volume of the materials contained in the construction. That is quite significant. We can also see the huge impact of insulation on the inflows during renovation: 83% of the volume of the new materials. In the future, insulation may represent a key fraction to handle.

Obviously, the differences with the previous results are due to the disparate densities of all these materials: inert has a considerably higher mass to volume ratio when compared to insulation. Even if weight is the reference unit in the waste sector (except for evacuation on worksite), we believe that these two measurement units must be considered in flows and stock analysis. Or, we may « miss » some future key fractions, such as insulation.

DISCUSSION & CONCLUSION

This study contributes to:

- Introduce material (considering its 'value') into renovation processes mainly turned toward energy efficiency of buildings. By 'value', we mean the potential of possible resources the materials used in building can represent.
- Provide previously lacking data concerning material deposit. Developing a method and applying it on a case study to identify and quantify stocks and flows generated by energy retrofit operations.

The *materials balances* and renovation trends allow us to establish some key fractions and material ratios per square meters. The study of these ratios, could lead the region to a useful planning tool for a better waste and resource management. We don't currently have enough case studies to offer such a reliable tool. But, we believe they can positively affect our material deposit knowledge, and optimal valorisation. By considering the urban renovation policy, they could help the region to anticipate material flows and to reach an integrated resource and waste management.

Outside the scope of this research, it could certainly be interesting to extend the proposed analysis to other case studies, other building types, and other systems (like equipment). We could also develop demonstration or pilot projects involving waste and material for their possible value, and as potential resources in an integrated approach, considering end-of-life. Furthermore, in a long term vision, an improved understanding of the material stocks contained in our cities could lead us to a better resource & waste management... Including positive impacts on our dependency for supply & waste treatment. In this way, we are joining currents as urban metabolism, urban mining, and lending momentum to a more circular economy.

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