OVERVIEW AND RECOMMENDATION ON URBAN DENSIFICATION POTENTIAL IN LIÈGE, BELGIUM

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Abstract
Belgium, like many European Countries, has a serious challenge in the housing sector. The Federal planning bureau estimates the increase of population by one million inhabitants by 2030, which represent 600.000 additional family requiring accesses to new housing facilities. Population ageing (mainly due to increasing life expectancy) combined with a constant growing rate of individuals living in collective households, leads to a substantial increase of demand of collective households (Vandresse & Bureau, 2013). This highlights a substantial challenge underlined mainly in the need to live in cities, which as consequence will increase the demand for smaller housing with or without integrated services or equipment in common. Furthermore, the stringent European performance environmental regulations for the building sector require that by 2020, all new construction are zero or nearly zero energy, (equivalent to 15 kWh/m^2/year), with 60% efficient on-site coverage by renewable energy. The shortage of vacant land and the increasing energy performance requirements is pushing the idea of urban densification and zero energy construction households. During the recent 6 years, there has been a trend to use timber frame constructions as a sustainable solution facing the economic and environmental crisis in Belgium. However, there is lack of knowledge on the design, construction and operation of zero energy lightweight constructions for urban densification. The goal of this research is to provide an overview and recommendation on urban densification potential in Liège Province. The focused aim is to demonstrate validated design prototypes and products of different zero energy, timber frame construction systems and composite components. Thus inform and support the decision making of policy makers, municipalities, developers, and architects and building engineers in Belgium.

1 Introduction

Residential buildings account for more than 70% of the total Belgian Building stock. The average consumption is in range of 300-350 kWh.m^2/year (EIA, 2013). This is due to the old building stock and to the massive industrial construction that progressively started in the 19th century in association with the rise of the coal and steel industry (AIDL, 1993). It was at 1980ies when energy efficiency was started to be addressed in the Belgian building sector (Moniteur Belge, 1983). Today, we reached the zero energy buildings target and all new buildings in Belgium must perform in compliance with the Belgian definition of Passive House (Attia & Mlecnik, 2012b). However, between both realities Belgian cities suffer from a serious housing shortage (Albrecht & Van Hoofstat, 2011) and here emerges the importance of retrofits and urban densification (Attia, 2012)(Attia & Mlecnik, 2012a). Therefore, this paper reviews the existing building stock in Liège city and explores the high quality retrofit solutions and urban densification potential. The paper reviews literature and analysis several neighborhoods in Liège and relation to future renovation scenarios. The aim is to systematically classify and characterize the urban inventory and structural performance of the existing building stock in Liège Province. Building types, structural characteristics and typical building physics, static standards and in-house technical equipment of structures of multi-family houses (MFH), built between 1880 and 1964, will provide the conditions for further development steps and will show the potential for structural and economic feasibility for roof staking. The paper thus provides an overview on urban densification and highlights their benefits and suggested technology and construction systems. This paper is a first step towards a detailed analysis of the building stock in Liège to support decision makers for deep renovation.

2 Building stock in Belgium

In Belgium, the building stock comprises almost 4.400.000 building, where more than 40% of the building stock was built before 1945 (Vanneste et al., 2001). The building stock is distributed into three regions namely Flemish region, Brussels Capital region and Walloon region.

2.1 Walloon Region

Residential building stock varies significantly between those regions therefore; the study will focus on the Walloon region where Liège is part of. According to the Federal statistic office 1.626.000 buildings existing in Wallonia, 80 percent of them are residential buildingsi. 97.7% of those residential buildings are single family dwellings. Figure 1 indicates the breakdown of building vintages. The figure indicates that all buildings built before 1981 have no insulation. Until 1985 when the first thermal regulation was mandates. The K ratio was mandated that concerns the total level of thermal insulation calculated on the basis of a technical standard established by the Belgian Institute for Standardization (IBN) (INS, 2015). The K ratio takes into account mainly the insulation of the various shells but neither solar heat, nor occupant behavior nor the efficiency of heating. The lower the K factor the better the total insulation of a dwelling.

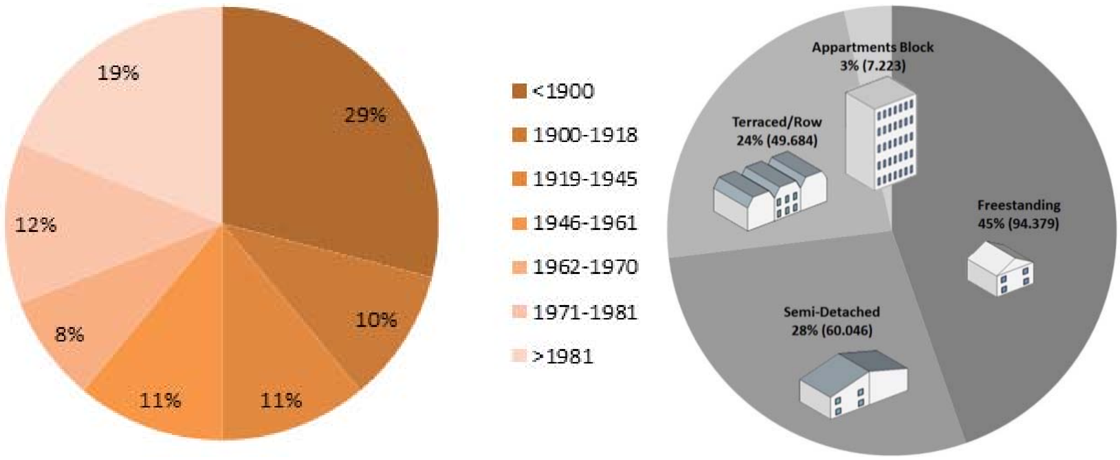

Figure 1 – Housing units in the Walloon region (left) and Liège (right) (INS, 2015)

With the introduction of the Energy Performance Building Directive (EPBD) in 2003 the EPBD calculation method and certificate was introduced. Between 2003 and 2014 249.236 certificates were issued in Wallonia representing 17% of the Walloon building stock. According to the Walloon region database the average annual consumption of building built before 1971 is 478 kWh/m^2, building built between 1971 and 1996 the consumption is 345 kWh/m^2 and 194 kWh/m^2 for building built after the year 1996.

2.2 Liège Province

Liège is a major city and the third most populated city of Belgium. As a post-industrial city most of it building stock was built during the first and second industrial revolution. Figure 2, represents the distribution of buildings built between 1863 and 2014 (Singh, Mahapatra, & Teller, 2013). The province is 69.39 Km^2 large with 195.000 inhabitants and has 27 districts or neighborhoods and the building stock in Liège Province can be divided into nine vintages as shown in Figure 2 (Halleux & Lambotte, 2008). According to Singh et al., 2013, 86% of the building stock in Liège province was built before 1965. The share of buildings before 1863 is 4%from 1863-1879 is 6%, from 1880-1899 almost 17%, from 1900-1919 20%, 1920-1944 22% and from 1945-1964 is 18%.

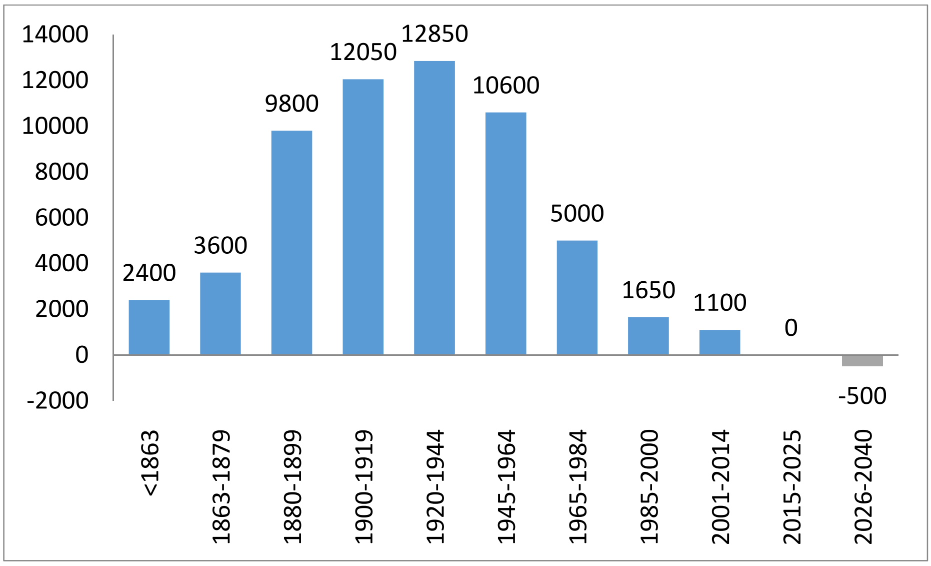

Figure 2 – Distribution of the houses per vintage in Liège (adapted from Singh et al., 2013)

2.3 Liège City

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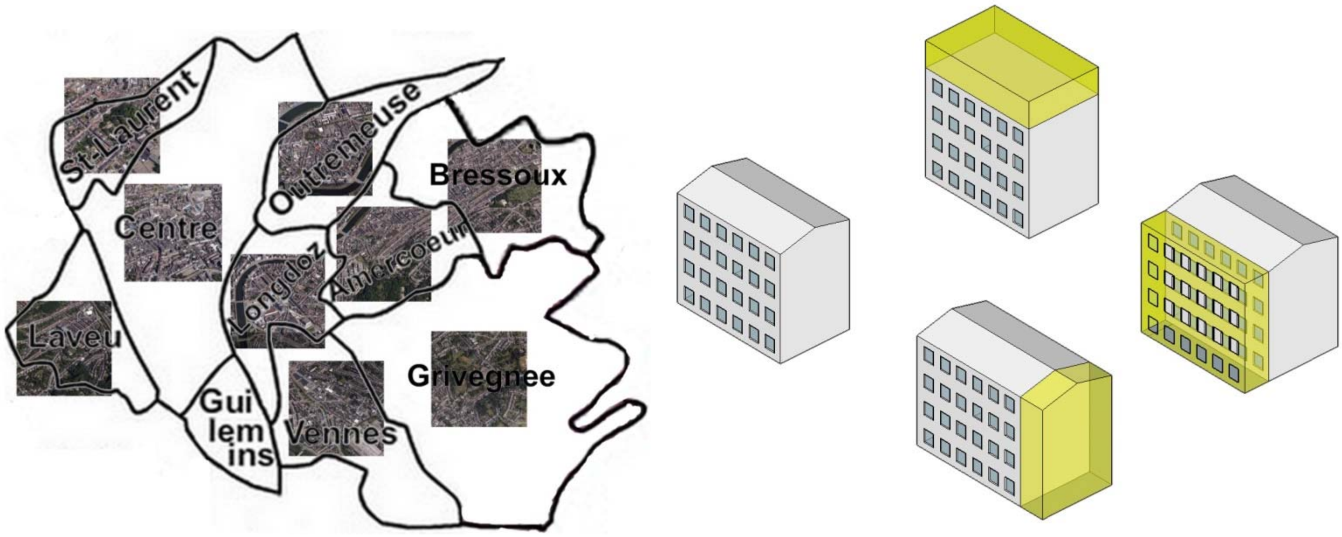
- The historical map of the city of Liège
- Map of structure types of buildings
- Map of energy performance (thermal characteristic)
- Building heights and roof types map
- Building Ownership

3 Recognition of the Renovation Potential and Urban Densification

Over the last 60 years the growth rate of Liège's new buildings stock has been declining drastically. The post-World War II (WWII) building boom stopped by 1980ies and since then and in association with the first energy crisis the growth rate has been declining by 50% now. According to Figure 2, we can estimate that the decline might reach zero new construction around 2025. By 2040, we might even face a shrinking of the building stock due to demolition the very old pre 1900 buildings. Thus, the share of the newly constructed buildings in the city of Liège will not exceed 10-12 percent of the current building stock. This confirms that by 2050, almost from 70-90 percent of the building stock currently exists (Attia 2012b). On the other hand, the renovation rate of existing buildings in Liège is very low and almost negligible. The most optimistic scenario for newly constructed building will be less than 0.3 % by 2020.Today up to 45% of the total energy consumption in Liège Province is due to residential buildings (Cuvellier, Marique, & Reiter, 2014). The renovation of present building stock will significantly lead to saving in energy (Attia 2012b). Example renovation projects indicate that consumption can be reduced up to three to five times while improving living indoor quality simultaneously. In Liège Province, residential buildings were built before the energy crisis and do not have any kind of insulation, tight envelopes, high performing glazing or efficient heating systems. 75% of Liège building stock has



	Longdoz	Amercoeur	Vennes	Grivegnee	Centre	St-Laurent	Laveu	Bressoux	Outremeuse
>5 Storey	10	4	23	3	19	0	4	4	76
3-5 Storey	1735	450	740	2340	1860	1583	2225	57	1780
< 2 Storey	38	650	1150	1350	22	78	86	765	23

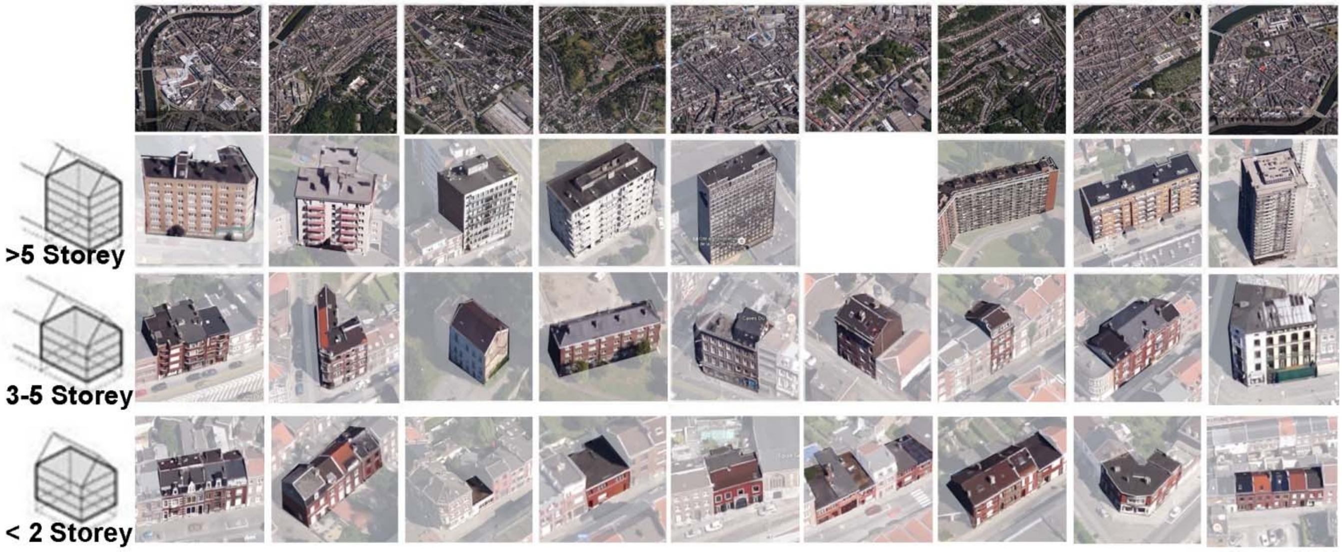


Figure 3 – Potential of renovation of residential buildings in 9 of Liège's neighborhoods

central heating system and use natural gas as fuel but 74% of boilers are relatively old and require renovation (Dujardin, Marique, & Teller, 2014) (Reiter & Marique, 2012) (Singh et al., 2013). 1981-1990 while the annual renovation rate is less than 0.4 %. According to the study of Singh et al. 2013 there is a large part of the building stock in Liège with poor thermal comfort conditions. Fuel poverty due to low incomes in combination with old non insulated buildings is cause to health and comfort problems in buildings. Many household's in Liège face the difficulty of the inability to adequately heat dwellings and maintain a proper indoor environmental quality (Reiter 2013).

We estimate that only 10 percent of the building stock in Liège has been renovated in the period In the same time, the city of Liège, like many European cities, has a serious challenge in the housing sector. The Federal Planning Bureau estimates the increase in population over 250.000 inhabitants by 2050, which represents more than 100,000 families requiring additional access to new housing facilities. The shortage of vacant land, the increasing housing prices due to energy performance requirements and the declining access to middle incomes are creating the demand for urban densification and compact household's construction. Thus it estimated that most of those families will live in Liège city and urban dense renovation will play a major role in hosting this population increase.

4 Urban Densification Scenarios

Urban densification is a sustainable urban strategy that many European countries advocate for the compact city to limit mobility, share resources and infrastructure and reach maximum efficiency. The strategy as positioned in contrast with car based urban sprawl that many cities promoted in the second half of the 20th century. In the case of Liège, urban densification can be achieved through vertical and/or horizontal extension of existing dwellings.

4.1 4.1 Infilling and Demolition

Urban infilling and demolition for urban densification are a very effective way. With the stringent performance requirements of EPBD all new construction in Liège must comply with the nearly zero energy targets. The 2015 performance requirements already mandate a K35 performance in 2014 equivalent to 70-90 kWh/m^2/year. Thus any new construction on an urban plot in the city will have a high performance by default. The market conditions of high land cost and housing shortage will guarantee a multistory densification.

4.2 Horizontal Extension

Horizontal extension is an improvement that adds extra area to building property. This is generally building extra rooms or extending current balconies. In the case of 9 studied neighborhoods of Liège the chances of horizontal extension is mainly possible through rear extension for single family houses. Front and side extension is difficult to achieve and does not increase urban density significantly (see Figure 03).

4.3 Vertical Extension:

Roof raising has been often considered as a way to increase the built density in a city where the external growth is either limited or not convenient. The progressive densification of the Brussels city center between the 19th and the 20th centuries is a remarkable example of a building regulation encouraging the densification by such practices (Marchand, 2008). Liège and other Belgian cities have some historical precedents for roof raising. In 1965, when a consistent number of guest workers installed themselves in the city with the urgent necessity of increasing the number of dwellings within the city walls (Godart, Halleux, & Hanin, 2013). Roof raising is particularly strategic in those cities presenting a consistent land pressure, as it allows to increase the built volume without real estate (Marchand, 2008). Furthermore, it is also a valid strategy to face urban sprawl increasing density within compact cities, as well as to encourage energy retrofitting of existing building stock thanks to the added value resulting from selling or renting the new dwellings (Marchand, 2008). However, the application of roof raising is frequently limited by regulations not allowing further exploitation of the built surface. For this reason, cities where roof raising is applied on a frequent basis have emanated special policies (e.g. Brussels, Geneva, Paris) or appointed building committees (e.g. Wien) regulating this practice (Peronato, 2014).

5 Recommendations

The complexity of the real situation in Liège makes it difficult to provide generic recommendation. In fact, Liège is a medieval city situated in the valley of the *Meuse* River and the built environment has a very strong identity.

5.1 Recommendation 1:

The horizontal extension is not effective to densify the built environment in Liège because most of the buildings have double façades. The front extension in not possible due to the roads and sidewalks spatial limits and the rear extension in the not possible in most investigated building in the 9 neighborhoods due to the limited back space. Even if this was possible the effect of rear and front extension is not significant to densify the city.

5.2 Recommendation 2:

Demolition should be never excluded for any urban densification scenario for Liège City. In a City where more than 86% of its building stock was built before 1965 and the renovation rate did not exceed 0.5 percent, in the last 30 years, a large percentage of buildings are in a serious degraded state. Prior to renovation it might be easier and cheaper to demolish existing buildings and achieve urban densification through urban renewal. On a district level, demolition can be strategically a choice as an acupuncture intervention to provide new housing units and finance the renovation of other buildings.

5.3 Recommendation 3:

Vertical extension can play a significant role in the urban densification and renovation of the built environment of Liège. Combining envelope renovation through prefabricated facades with stacked up new story or penthouse units for mid-rise (2-4) buildings seems to be very promising. According to Figure 03 most of the building stock is in this mid-rise category and there is a large chance to efficiently rebuild and densify a large part of buildings. Lightweight timber construction of sandwich structures can allow stacking up of the Lightweight floors for urban densification.

5.3.1 Challenge 1

The first challenge of the combined renovation will be the urban regulation for each neighborhood in Liège. The street aspect ratio and maximum height in relation to solar access will define the maximum height and consequently stacking ability. Another important challenge will be the car parking facility and ability to provide parking space for every new household.

5.3.2 Challenge 2

The second challenge will be the façade typology. If the façade has an evident identify or is considered as an architectural heritage the prefabricated facades system will not be accepted. Balconies and façade profiles will be another challenge. Most facades in Liège are built before WWII and appear with their unique red brick masonry and stone structures. In the same time, internal insulation will reduce internal space and will not achieve the passive house performance targets on the side, the demolition of the building while retaining the façade will be very expensive. However, if the prefabricated facades system can allow reformulating or adapting the expressed identity of the existing facades elements this could be a breakthrough.

5.3.3 Challenge 3

The third challenge of the combined renovation will be the structural stability and accessibility of the staircase. Any renovation solution must make sure that loads can be carried to the foundation including the one, two or three added floors. Also access to the fifth floor through a common staircase shaft has to be guaranteed.

5.4 Recommendation 4:

The optimal solution should start with picking low hanging fruits. In the case of Liège this is represented mainly by high rise post WWII towers. Despite that renovation of those towers will not add new spaces however, it is an important start to test and apply industrialized prefabricated facades and show their ability to promote the quality of architecture. The next step will focus on social housing and low income neighborhoods and building clusters that suffer from fuel poverty in Liège. Ensuring the proper selection of the starting project and avoiding heritage conflicts around the city center can bring urban densification into action.

5.4.1 Challenge 1

Ownership will play a major role in acerbating the renovation and allowing the staking up concept from getting implemented. If there is a single owner of the selected building in the form of individuals, association of owners or social cooperation the process will be much easier. Without having a consensus from all owners finding agreement will be very hard.

5.4.2 Challenge 2

A social consensus must be built before introducing the combined renovation method of urban stacking and facades renovation. Also the urban and land policies together with subsidies formworks must prepare building owners to go for the renovation.

6 Discussion and Conclusion

This study aimed to provide an overview and recommendation on urban densification potential in Liège Province. St-Laurent, Center, Laveu, Cointe, Grivegnee, Guilemnins, Vennes, Longdoz, Amercoeur and Outremeuse neighbourhoods were mapped and analysed. At this stage Liège City should focus on urban densification combined with renovation. Vertical renovation seems to be the most economically feasible solution in order increase the increase the urban density in the centre and renovate old existing buildings in an cost effective and highly energy performing. Social acceptance and funding frameworks will be necessary to encourage citizens and break the owner tenant problem. Subsidies are needed and legal frameworks that can facilitate the process of mid-rise combined renovation method of lightweight construction. Large scale urban densification is an essential step to meet the expected housing demand and in the same time renew the existing building stock and renovate it in a sustainable way. With the introduction of the decisions on asset management were related to the technical quality of the buildings. Local developed renovation strategy and plans should be provided within a strategically densification framework. In order to support building owners to invest in renovation with affordable and economically viable feasibility. Finally, the study is still in its initial phase and requires a more detailed building stock analysis on the building scale to generate discrete and specific data for Liège City.

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