PRESERVING BRUSSELS IDENTITY: METHODOLOGICAL PRINCIPLES FOR THE RETROFITTING OF CITY BLOCKS

G.G.A. Galan Gonzalez Aránzazu[1,2]; D.Q. Deltenre Quentin[1,3]; Athanassiadis A.[1]; Trachte S.[4]; Evrard A.[4]; Acha Román C.[2]; Bouillard Ph.[1,5].

1: Building, Architecture and Town Planning (BATir), Université Libre de Bruxelles, Avenue F.D. Roosevelt 50 CP 192/4, 1050-Brussels, Belgium. Aranzazu.Galan.Gonzalez@ulb.ac.be

2: Construcción y Tecnología Arquitectónica, Escuela Técnica Superior de Arquitectura de Madrid, Spain (ETSAM)

3: Faculteit Ingenieurswetenschappen,Vrije Universiteit Brussel, Begium (VUB)

4: Architecture et Climat, Université Catholique du Louvain, Belgium

5: School of Engineering, Nazarbayev University, Kazakhstan (NU)

ABSTRACT

The form of Brussels Capital Region city blocks is part of the identity of the city. Preserving the built environment includes preserving the urban form while allowing them to adapt to the new necessities without losing this identity. The city block is not first defined as an architectural form but as a set of plots attached ensemble that acquire meaning because a dialectic relation with the surrounding roads grid [1] The urban block is formed by the complex dialogue between the distribution of properties, the constructions and the public spaces.

This paper aims to stress the role of the city blocks as a main contributor to the heritage value of the city and present a set of methodological principles to approach their retrofitting.

Under the scope of the project B³-Retrotool [2], several scenarios of retrofitting have been developed and assessed over three representative case studies. This research has pinpointed the importance of transforming the city-blocks as a basic unit of the urban matrix. Its originality is to identify new determinants in designing modern, economic and efficient city-blocks using a multi-criteria and multi-scale approach.

Using different mapping tools, a thorough and new classification of the city blocks is provided based in their morphology and urban function. A series of so-called "retrofitting sheets" divided in energy and morphological approach will be presented to illustrate the results.

The paper concludes by presenting these results integrated in a pre-assessment tool developed to provide a clear vision and comprehension of the city of Brussels from a bottom-up and top-down approach. It identifies priority city-blocks requiring an urgent retrofitting and proposes various retrofitting principles to enhance their energy and environmental performances while preserving its identity and cultural heritage.

Keywords: city-blocks, urban form, built environment, retrofitting guidelines, pre-assessment tool.

INTRODUCTION

In the last decades, energy has become one of the most popular topics in research. As a matter of fact, since the continuing increase of oil price starting in 1973, the scarcity of energy resources and the Kyoto Protocol adopted in 1997, energetic strategies emerged all around the world. The 27 Member States in Europe set an energy savings target of 20 percent as well as 20 percent of reduction in greenhouse gases (GHG) emissions by 2020.[3, 4]

In Europe, the dire need to reduce the energy demands and the GHG emissions concern every line of activity but it appears that the building sector is the most energy consumer.

The indicator for energy efficiency is heating demand, as it accounts for the largest percentage of energy consumption in residential buildings [5]. Namely, more than half of the final energy consumption of residential buildings in the EU is used for space heating, reaching up to 70% [4],. In terms of CO_2 emissions, buildings are responsible for around 36% in Europe [6]. Belgium emits around 70 Kg of CO_2 per m² of useful floor area [4]

There is so a big necessity to tackle the big tasks of renovating this old building stock to achieve the ambitious energy performance goals [5]. Till date, all the improvements have been done at the scale of the building. Due to the big number of interventions, it seems complicated to see important results in the planned date. Nevertheless, the hypothesis that big improvements could be perceived by working in the city-block scale is lately explored by several researches. The city-block is perceived as the first urban particle to have an influence at the city scale. This scale highlights the impact of urban geometry in the energy performance of the individual buildings and allows tackling biggest interventions with renewable techniques.

It is not an easy task, however, to work in this scale. Until now, the models created to analyze the energy performance tend to restraint their view at the building level, neglecting the effect of urban geometry acting on energy consumption. One of the reasons is probably the difficulty of modeling complex urban geometry. For instance, establishing the shadow pattern at the city block scale is extremely complex because of too much vectorial intricacy [6].

Nevertheless, there is an increasing interest in city-blocks. Collective equipment appears to perform better efficiency than equipment for each single house. Moreover, a number of community projects at the city-block scale have arosed in Europe: BedZED , Hammarby Sjötad (SE) or l'Espoir (BE).

Several classifications have also emerged, either theoretical or more practical, mixing morphological, typological, social, energetic and environmental indicators. No guidelines to retrofit the city-blocks in a sustainable manner have resulted, though, from these classifications. This increasing concern and interest in the retrofitting of the city-blocks, lead to the need of developing a framework that can help in the decision making from an early design stage to assure the expected results.

This research is one of these attempts: beginning from a brand-new classification of Brussels' city-blocks based in morphological and heritage indicators, a series of so-called "retrofitting sheets" have been developed. These take into account the current state of the city-block and propose a series of retrofitting guidelines for its renovation.

METHODOLOGY

City-blocks could be defined from different indicators: morphology, social and heritage value, energy consumption, urban function and so forth. In order to develop guidelines to retrofit the Brussels city-blocks, some main values had to be established as a starting point.

A few classifications have been done in recent years focusing in one or several of the aforementioned domains. These were twofold: theoretical and practical classifications. Theoretical classifications were achieved through literature studies, but not applied directly to the blocks, which makes them unusable to base the guidelines on. Practical classifications represented the ones which have been developed through the use of quantitative indicators that have been then applied physically to the blocks. The problem lies in the fact that none of these practical classifications were available.

Nonetheless, the conclusions of the previous studies provide very valuable data that helped to develop indicators at the city-block level that led to create a new classification. This classification, taking into account a larger number of indicators than the previous and the relation and impact of the selected among each other, is the strong base over which the retrofitting guidelines have been developed.

Classification of the City-Blocks

Two main data sources have been used during the research: the Brussels Capital Region cadastral matrix and the UrbIS maps. The first one is a database developed by the Federal Public Finance Department (Service Public Fédéral des Finances) in Belgium, which is responsible for the Real State inventory.. It provides for each plot and owner, information such as the year of construction, the number of stories, and the number of housings in the plot, the heated area, and so forth. The second one is a map database of Brussels in 2D and 3D.

The aforementioned data was treated with cartographic tools which allowed that more than 20 indicators could be calculated for each one of the 4500 city-blocks in Brussels.

The two main concerns regarding the retrofitting guidelines were focused in the energy performance and the morphology of the city-block. Therefore, the classification was mainly based on morphological indicators.

These indicators would show the potential to develop large renewable energy solutions, such as geothermic or solar farm, but also to emphasise the city-blocks in need of densification, heightening or construction of free plots. Very specific building-blocks of Brussels have been taking into account for the classification (e.g. garden city-blocks).

Several attempts were made in order to find the most suitable indicators to classify the blocks. As a result, eighteen block typologies have been developed and gathered in the catalogue where the most relevant information about each typology is presented. Figure 1 shows the seven chosen indicators and their value for one of the typologies and the map generated to illustrate each of them.

Blocks' Indicators	Unit	Values
Area	m²	>1000
Number of Plots		>1
(A) Average Height	m	>10
(B) Maximal Height	m	>1 & <30
(B) - (A) Height Diff.	m	-
Building type		2 facades
Built Density	%	>30

Map designed by Quentin Deltenre
Sources: ArcGIS, Cadastre, own calculations
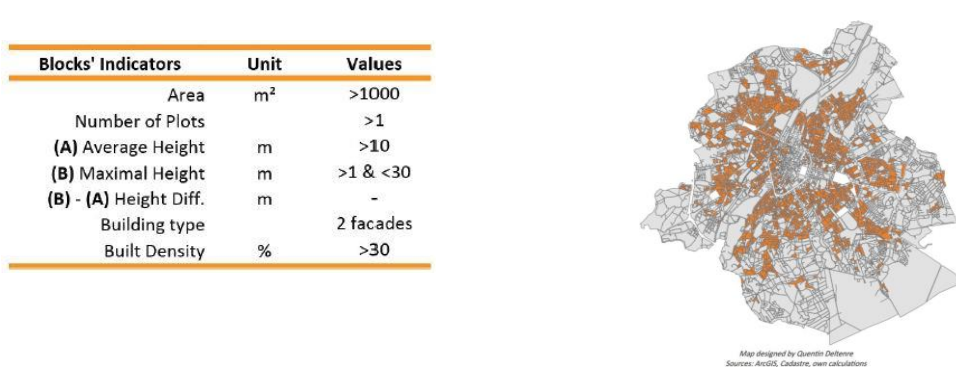
Figure 1: Indicators and value to enter in the traditional typology (left) and map of the blocks which categorise in this typology (right).

Case Study Analysis

Three case studies, among the most representatives of Brussels' stock, were selected to illustrate the retrofitting guidelines methodology. These case studies illustrate the most numerous typologies, namely the traditional city-blocks (2121 blocks), the traditional-high-rise city-blocks (384 blocks) and the traditional detached city blocks (412 blocks). The average-type block in each of these typologies was chosen according several indicators. Each indicator is divided into classes (e.g. built density has 4 classes: 0-10%, 11-30%, 31-70% and 71-100%) and the most representative one is kept. To finally have the selected case study, the average between the number of plots and the area is used.
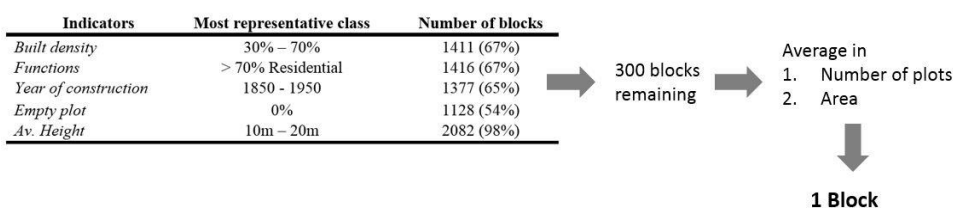

Indicators	Most representative class	Number of blocks
Built density	30% – 70%	1411 (67%)
Functions	> 70% Residential	1416 (67%)
Year of construction	1850 - 1950	1377 (65%)
Empty plot	0%	1128 (54%)
Av. Height	10m – 20m	2082 (98%)

300 blocks remaining

Average in
1. Number of plots
2. Area

1 Block

Figure 2: Selection process of the most representative block in the traditional typology

Each case study is then thoroughgoing analysed by means of pictures, plans and charts. (Figure 3).

Surrounding typologies — Built fabric — Green & blue areas — Connectivity BUS-TRAM-TUBE-TRAIN

Morphology

Area	m²	10475,3
Footprint	m²	6065,3
Built density	%	58
Floorspace	m²	15067
Number of plots		50
Average height	m	14,8
Maximum height	m	28,5

Share of years of construction

	Nb Plots
1900 - 1950	37
1950 - 1990	13
1990 - Today	1
No Data	7

Figure 3: Part of the analysis of the chosen traditional city-block, representative of the typology.

Retrofitting Sheets

Based on the classification and on the City-Blocks' database, methodological principles to retrofit the Brussels' blocks have been developed by means of retrofitting sheets. These are twofold: energetic and morphological. Energetic retrofitting includes geothermic, solar and PV panels and biomass solutions, while the morphological retrofitting concerns heightening and densification concepts.

Each sheet follows a pre-established layout. Firstly, the current state of such retrofit is emphasised in Brussels and compared with the rest of the world. Secondly, guidelines to implement this retrofit to an entire block are highlighted and the most suitable typologies are extracted. As an example, the main results for the geothermic scenario are explained below.

The first part includes an introduction about the topic, what are the different systems used (hot-cold storage, extraction, drilling/storage, geothermal probes, etc.) and what the case of Brussels is so far. The pre-sizing section, based on a literature review, gives rules of thumb and tips depending on the chosen system. The references section shows between 4 to 6 existing projects in Brussels, Belgium and Europe that have been applied to city-blocks or buildings with more than 50 households. The legal framework is also discussed. *L'institut Bruxellois de la Gestion de l'Environnement*, *IBGE*, provides guidelines for open and closed systems. Both need an environmental permit to exploit the ground surface. As well, the potential of use in Brussels according to previous studies (As an example, VITO, an European independent research and technology organization developed two maps for open and closed systems at the Brussels' Region)

The second part highlights which city-block's typologies are most suitable for geothermic purposes according to the pre-sizing section and the developed database (Figure 2).

In a step forward, and thanks to satellites pictures, it was possible to approximate the amount of permeable surface, surface assumed favorable to install geothermal facility, in every city-block [7]. The Cadastre also provided the total heated surface for every house. It allowed approximating the total heating demand for every block, based on the average heating consumption per m² provided by Sibelga (grid manager of electricity and gas distribution in Brussels).. Figure 4 shows the final table with the percentage of city-blocks wherein the implementation of geothermic could sustain the entire block in heating.

Blocks' typologies	Number of Blocks	YES	NO	No Resid' Plot
BlockPlot	38	0%	18%	82%
Detached	166	78%	22%	0%
Empty Block	85	1%	4%	95%
Extremely low densification	83	61%	1%	37%
Garden City	109	48%	48%	5%
HighRise	357	17%	63%	20%
Hyb(BlockPlot-Highrise)	70	1%	17%	81%
Hyb(Green-Detached)	17	100%	0%	0%
Hyb(Green-Tradi-Detached)	11	100%	0%	0%
Hyb(Green-Traditional)	94	60%	40%	0%
Hyb(Traditional - Detached - Highrise)	1	100%	0%	0%
Hyb(Traditional - Detached)	414	35%	65%	0%
Hyb(Traditional-Highrise)	384	5%	95%	0%
Interregional Block	68	3%	35%	62%
Not classified	455	15%	61%	24%
Traditional	2121	1%	99%	0%

Figure 4: Percentage of blocks in each typology wherein vertical geothermic probes could provide enough heating energy for housings. Considering distance between probes: 10 meters

Figure 5: Retrofitting sheets consist in several different pages depending on the amount of data (e.g. Geothermic)

CONCLUSION

This research gives the Region and other interested parties a clearer insight of the City-Blocks in Brussels. For the first time, a database has been developed at this scale, giving information about diverse aspects such as the general morphology (average and maximal height, footprint, surfaces, facades …), main functions (Residential or non-residential), year of construction, and so forth. Insofar the purpose of this study was to create guidelines to retrofit the city-blocks' stock of Brussels. As a result, a set of 18 blocks' typologies have been created gathering the blocks with the same morphological aspects.

Based on a literature studies and the aforementioned database, retrofitting scenarios have been developed for several energy and morphological concerns such as densification (in height or on ground), and geothermic, solar and wind potential. These scenarios suppose a first approach to emphasise the best retrofitting solutions for each block typology in Brussels.

The possibilities to extend the research are manifold. First, the typologies' classification has been performed according to 7 morphological indicators. Other aspects such as social, economic or consumption indicators have not been implemented in this research. Either sub-classifications of the existing typologies or a new classification taking into account all these aspects could be foreseen.

The retrofitting scenarios have been developed with rules of thumb from literature review. It is likely that these numbers are far from reality. For instance, the geothermal potential is very dependent on the type of soil as well as on the system used and the depth of the probes. The values given in this research are focused on one specific system and give an approximate production of energy. For each system, precise production values could be calculated. Currently, the data for solar potential and land permeability is being refined. These new databases will allow providing accurate numbers of energy performance.

To conclude, the outcomes presented in this paper would be available in the Web Tool developed under the name B³ RetroTool. This project started in 2012, grant-aided by the Bxl-Retrofit platform. It was launched both by the Université Libre de Bruxelles and the Université Catholique de Louvain-la-Neuve. It concerns the retrofitting of the Brussels Region following three scales (city, city-blocks and houses) and three criteria (environment, energy and heritage) [2]. (Figure 6)
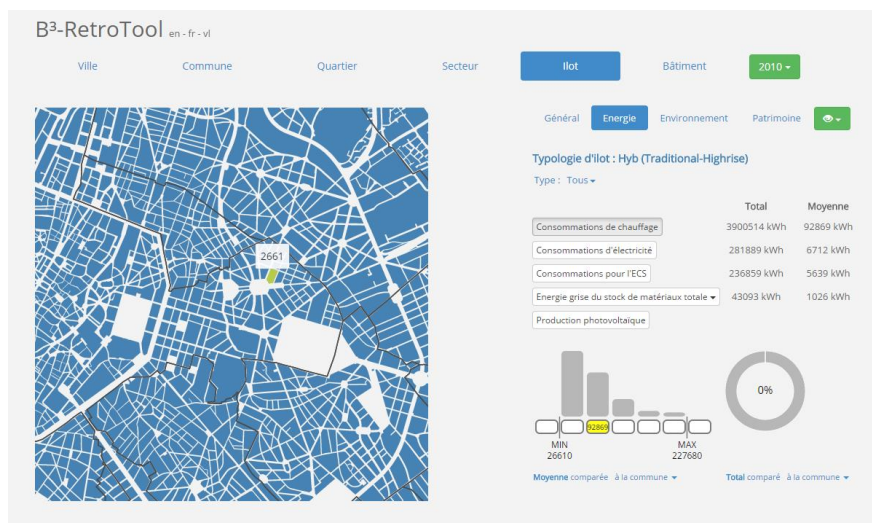

Figure 6: Screen shot of the Beta version of B³ RetroTool. It shows how the scale of the city-block would be visualised and the data available at each scale.

ACKNOWLEDGEMENTS

REFERENCES

1. Samuels, I., et al., *Urban Forms*. 2012: Routledge.

2. UCL-ULB. B³-RetroTool - Innoviris Strategic Research Platform 2012 - Brussels Retrofit XL. 2015.

3. Protocol, K., United Nations framework convention on climate change. Kyoto Protocol, Kyoto, 1997.

4. Economidou, M., et al., *Europe's buildings under the microscope.* A Country-by-country review of the energy performance of buildings, 2011: p. 131.

5. Konstantinou, T., *Facade Refurbishment Toolbox. Supporting the Design of Residential Energy Upgrades.* A+ BE| Architecture and the Built Environment, 2014. **4**(9): p. 1-420.

6. Energy., E.C.-. ec.europa.eu/energy/efficiency/buildings/buildings_en.htm. June 2011.

7. Stessens, P., Ecosystem Service Optimisation for Cities. ULB- BATir. On going Doctoral Thesis.