Brussels Strategic Research Platform Environment
Retrofitting of the built environment

PROJECT B³-RETROTOOL
Sustainable retrofit of urban blocks and buildings in Brussels Capital Region – Development of a multi-scale and multi-criteria pre-assessment tool

WORKSHOP – 16th January 2015

B³-RetroTool : Methodology - “MULTI-SCALE” & “MULTI-CRITERIA” (<1945)

Urban Metabolism
City Blocks
Buildings

Energy performance

Environmental impacts

Heritage value

= B³-RetroTool
B³-RetroTool: Methodology - “MULTI-SCALE” & “MULTI-CRITERIA” (<1945)

B³-RetroTool: Research Approach
B³-RetroTool: Planning

<table>
<thead>
<tr>
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<th>Status</th>
<th>Start</th>
<th>End</th>
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<td>2014.12.31</td>
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B³-RetroTool: Main scientific results

- Sustainable Indicators
- Methodological principles for sustainable retrofit Part 1
- Methodological principles for sustainable retrofit Part 2

PROJECT B³-RETROTOOL
SUSTAINABLE RETROFIT OF URBAN BLOCKS AND BUILDINGS IN BRUSSELS CAPITAL REGION – DEVELOPMENT OF A MULTI-SCALE AND MULTI-CRITERIA PRE-ASSESSMENT TOOL
The pre-assessment tool provides:

- a clear vision and comprehension of the Brussels urban metabolism
- a clear identification of priority urban areas and city-blocks requiring an urgent retrofitting as well as a clear identification of different types of dwellings built before 1945 and their buildings specificities.
- various retrofitting principles assessed through 3 axes (Energy, Environment and Heritage Value) are proposed for each type of dwelling and city-block.
- prospective scenarios, in the longer term, for each component of the Region (city, district, city-block, and building)
- Energy, heritage value and environmental assessment at the three levels and the potential improvement of these values.

The pre-assessment tool B³-RetroTool offers a great potential of use for the retrofitting sector in the Brussels Capital Region. The tool is web based, but can be downloaded to use it on a non-connected computer.
B³-RetroTool: Conclusions of the two first years


The project involves 9 member countries and the Brussels Capital Region.

As a result for Brussels, several points has been enhanced but two of them must be improved:

• "forward-looking perspective to guide investment decisions"
• "estimate of expected energy savings and wider benefits"

B³-Retrotool is a real opportunity for the Region

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Introduction: objectives and research approach

WP1

WP2

> 4000 blocks
Workshop B³-RetroTool

PART 1 – SCIENTIFIC FRAMEWORK

City level:
EVALUATION OF THE URBAN METABOLISM

1. Evaluation of the Urban Metabolism
1. Evaluation of the Urban Metabolism
1. Evaluation of the Urban Metabolism

- Gas consumption
- Electricity consumption
- Water consumption
- Material stock
1. Evaluation of the Urban Metabolism

<table>
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<tr>
<th>Gas consumption</th>
<th>Electricity consumption</th>
<th>Water consumption</th>
<th>Material stock</th>
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</thead>
<tbody>
<tr>
<td>Density</td>
<td>Average income</td>
<td>Density of office space</td>
<td>Number of buildings</td>
</tr>
</tbody>
</table>

PROJECT B³-RETROTOOL
SUSTAINABLE RETROFIT OF URBAN BLOCKS AND BUILDINGS IN BRUSSELS CAPITAL REGION –
DEVELOPMENT OF A MULTI-SCALE AND MULTI-CRITERIA PRE-ASSESSMENT TOOL.
1. Evaluation of the Urban Metabolism

<table>
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<th>Data Repository</th>
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<td>Workshop B³-RetroTool</td>
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<tr>
<td>City-Block level:</td>
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<tr>
<td>TYPOLOGICAL CLASSIFICATION OF CITY-BLOCKS</td>
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<tr>
<td>CASE STUDIES</td>
</tr>
<tr>
<td>SUSTAINABLE RETROFIT PRINCIPLES</td>
</tr>
</tbody>
</table>
WP2: State Of The Art

Leon Krier 1984
- Public comfort
- Physical and social dimensions of the blocks

Arnis Siksna, 1997
- Size of the plots, the circulation pattern and the buildings
- Influence of form, size or shape?
- Optimal configuration?

- Sustainable tools
- Quantification of sustainability (environment, energy, social, ...)

Portzamparc, 1975
- New type of city block (open)
- Clear hierarchy
- Height
- Diversity

Case studies (Eixample Barcelona 2012)
- How to improve a block with the addition of a new construction inside.
WP2: Typological classification of City-blocks: Difficulties (examples)

1 - Information of the cadastral matrix relative to a plot, how to aggregate the data for each block?

Blocks’ file from UrbIS

Plots’ file from Cadastre

Thank to ArcGIS

Link:
0 – A, J, F, ...
1 – B, Q, R, ...
2 –

2 – Duplicates of plots’ ID in the Cadastral matrix

If several owners possess the plots (i.e. an apartment building)

<table>
<thead>
<tr>
<th>Plot ID</th>
<th>Numb. Stories</th>
<th>Useful Surface</th>
<th>Construction Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>1</td>
<td>86</td>
<td>1976</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>95</td>
<td>1976</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>72</td>
<td>1977</td>
</tr>
</tbody>
</table>

WP2: Typological classification of City-blocks: Difficulties (examples)

3 – Missing city-blocks in UrbIS file.

Parc Royal

Etterbeek Military barracks

4 – Processing billions of data

Cadaster: 350 000 plots (lines in the spreadsheet)

3D Maps: 204 maps of 1km²

50 000 polygons (roofs, walls and ground) per map
50 000 lines in Excel for each map to work with
Use of Matrix formulas
WP2: Typological classification of City-blocks: Blocks' database

City Block N°308
Source: google maps, ArcGIS, URBIS

Example showing indicators for city block N°308
WP2: Typological classification of City-blocks: First maps

WP2: Typological classification of City-blocks - Methodology

1st Classification: 2200 blocks classified (55% of the all)
- Based on morphological, typological, historical and functional indicators
- 9 typologies
- Inconsistency of the classification

2nd Classification: 4000 blocks classified (90% of the all)
- Based on morphological indicators
- 18 typologies (9 hybrids)

Creation of a magazine resuming each typology
WP2: Typological classification of City-blocks: Outcomes

08. High-Rise Blocks

WP2: Case Studies: Choices

1. Choice of 3 case studies into 3 typologies
   - These 3 typologies represent 64% of the blocks

2. Methodology to pick the most representative block in these 3 typologies
   - 5 indicators divided into 4-5 classes
   - The classes with the highest number of blocks are taken
   - Filter is applied on each indicator to keep the blocks corresponding to the 5 most numerous classes
   - In general, about 10-15% of the blocks are remaining
   - Two other indicators are used to find the average block

3. Example with the traditional typology – 2121 Blocks

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Most representative class</th>
<th>Number of blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built density</td>
<td>30% – 70%</td>
<td>1411 (67%)</td>
</tr>
<tr>
<td>Functions</td>
<td>&gt; 70% Residential</td>
<td>1416 (67%)</td>
</tr>
<tr>
<td>Year of construction</td>
<td>1850 - 1950</td>
<td>1377 (65%)</td>
</tr>
<tr>
<td>Empty plot</td>
<td>0%</td>
<td>1328 (54%)</td>
</tr>
<tr>
<td>Av. Height</td>
<td>10m – 20m</td>
<td>2082 (98%)</td>
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</tbody>
</table>
WP2: Case Studies: Outcomes

About Morphology
- Merging/Splitting of blocks
- Addition of buildings
- Heightening

About Energy
- Geothermics
- Solar
- Wind
- Biomass
- District heating

Additional Sheets
- Case study – Ilot des peintres (France)
- (Other) use of roofs
- Case study – Covering the inner courtyard
WP2: Sustainable retrofit principles: Example

E.1. GEO THERMICS

Introduction about the topics
- The 4 thermal classes in geothermics
- The 2 main systems
- Brussels’ potential

Overview about systems
- Additional information
- Best for the blocks

Pre-sizing
- Thumbs rules (surface needed, distance between probes, energy produced, ...)

Table 02: Examples of projects/programs realized by Geoforge:

<table>
<thead>
<tr>
<th>Program</th>
<th>Location</th>
<th>Year</th>
<th>Heat power [kW]</th>
<th>N° of probes</th>
<th>Depth [m]</th>
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<tbody>
<tr>
<td>Single house</td>
<td>Bry-sur-Marne</td>
<td>2011</td>
<td>17.2</td>
<td>4</td>
<td>86</td>
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<tr>
<td>City hall</td>
<td>Flers</td>
<td>2008</td>
<td>27</td>
<td>9</td>
<td>95</td>
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<tr>
<td>Kindergarten</td>
<td>Naamsebroek</td>
<td>2011</td>
<td>117</td>
<td>24</td>
<td>88</td>
</tr>
<tr>
<td>47 houses</td>
<td>Bover-Horn</td>
<td>2008</td>
<td>130</td>
<td>35</td>
<td>50</td>
</tr>
<tr>
<td>80 houses</td>
<td>Fermont</td>
<td>2008</td>
<td>300</td>
<td>60</td>
<td>80</td>
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</tbody>
</table>

Geoforge is a French company of geothermal installations' planning and realization active in Germany and Switzerland.
WP2: Sustainable retrofit principles: Example

Potential for open and closed systems
- Techniques used
- Influence of several parameters

Heating production potential
- Based on pre-sizing part
- Based on permeable surfaces in blocks
- Determine on which typologies geothermics suits the best

Traditional block - 4016
Sustainable Retrofit

- Heating demand: 2124.43 MWth
- Heating supply with vertical probes: 440.34 MWth
- Surface missing to supply all the buildings: 8.001 m²
Workshop B³-RetroTool

PART 1 – SCIENTIFIC FRAMEWORK

Building level:
DEFINITION OF DWELLING TYPOLOGY
CASE STUDIES
SUSTAINABLE RETROFIT PRINCIPLES

1. Definition of dwelling typology
1. Definition of dwelling typology

- Focus on dwellings built before 1945
  - This stock represents 60% of built areas
  - This stock is responsible for 62% of the region’s energy consumption
  - This stock gives to Brussels its identity, its architectural and its historical legacy

- Dwelling typology has been established from the late 17th century
  - Brussels dwelling stock built before 1695 consisted mainly of wooden buildings and thatched roof. This type of buildings will gradually be prohibited for fire protection but the bombing of Brussels by French army in 1965 definitely ended wooden building and construction.
  - Building permit, building regulations and construction standards were emerging from the mid-17th century to generalize the 18th century.

- Dwelling typology has been defined according to morphological and urban development in Brussels and suburbs but also to changes in way of living as well as construction methods and materials used
  - from 1700 to 1914: predominance of individual dwelling (houses) whose spatial organization will be based on the spatial organization of the “maison bourgeoise”
  - from 1920 to 1940: emergence of worker house in the garden cities and apartment building (building modest, standard and/or high status) that takes his real development after 1930

1. Definition of dwelling typology

Dwelling types – built before 1914

The single family row house is the most common form of dwelling in Brussels until 1914.

- Modest or worker row houses
  mostly located in the popular and industrial districts, in narrow streets or impasses and in the Brussels periphery (late 19th century)

- Maisons bourgeoises
  located in residential districts of the pentagon, mainly in the top of the city, along the main avenues and the extension areas. The spatial organization of the “maison bourgeoise” has also changed from 1700 to 1914. Therefore, we have defined three subtypes:
  • maison bourgeoise built before 1830
  • neoclassical maison bourgeoise, built between 1830 and 1870
  • maison bourgeoise bel étage – built after 1870

- Hôtels de maître
  built for the upper bourgeoisie and aristocracy, after 1830, along large avenues and in some districts extensions.

In addition to these three types, there is also houses with shop (maison de commerce) and apartment houses (maison de rapport) which are variations of the maison bourgeoise
1. Definition of dwelling typology

Dwelling types – built between 1920 and 1940

First World War, in 1914, marks the end of a specific period both in Western Europe in Brussels. Mentalities as techniques evolve significantly. The car is spreading, domesticity disappears, the role and place of women change. These changes have an impact on the spatial design of the habitat and the urbanization of the city.

- **Maison bourgeoise – evolution**
  
  built in still less urbanized areas in close proximity to Brussels (Uccle, Boitsfort-Auderghem, Garshoren, Anderlecht...). The spatial organization of the “maison bourgeoise – evolution” will be influenced first by the different architectural styles (art nouveau, art deco, modernism) and secondly by the emergence of new technologies, new materials (concrete, steel) and constructive processes but also by the emergence of the car.

- **Worker row house in garden-city**
  
  built on the periphery of Brussels from 1900 to 1930. They show mainly two types of houses: "English cottage" house and modernist, cubist and functional house. These workers’ houses are mainly terraced houses, with small dimensions and two or three façades according to their implantation.

- **Apartment building**
  
  - The modest or social apartment building
  - The standard apartment building for the period between the two World Wars
1. Definition of dwelling typology

Description of each dwelling type - methodology

Each dwelling types has been studied according to the following description:

- **General description:**
  - Urban situation
  - Spatial organization
  - Inner circulation and staircase
  - Building systems and materials
  - Roof and building materials
  - Façades and building materials
  - Technics (if they exist)

- **Main characteristics:**
  - Disposition in relation to the road
  - Size of the plot
  - Size of the building

- **Alternatives (if they exist)**
1. Definition of dwelling typology

Example: type "maison bourgeoise" – before 1920

Based on the precise description of each dwelling type, a simplified characterisation has been proposed to fit the data given in the cadastral matrix and to associate each lot to one type. As we can see in the figure here under, the characterisation is limited to three factors: date of construction, floor area, number of dwellings per building.
1. Definition of dwelling typology

Building stock analysis – Dwelling type repartition

B³-RetroTool building types

- Rejected: 0
- "Maison bourgeoise" before 1850: 1
- "Maison bourgeoise rénovée" (renovated): 2
- "Maison bourgeoise avec bel étage" (with upper class): 3
- "Maison bourgeoise avec bel étage" (with upper class): 4
- "Hôtel de maître" or "Hôtel particulier" (master hotel): 5
- Worker's house before 1930: 6
- Worker's house after 1930 (including garden city house): 7
- "Maison bourgeoise" - Evolution: 8
- "Maison bourgeoise" - Evolution: 9
- Apartment building after 1945: 10
- Not classified: 11

% of buildings

16% 5% 5%
52% 13% 6%
1. Definition of dwelling typology

Building stock analysis – Urban situation of dwelling types

Maison bourgeoise avec bel étage

Type 2

Maison bourgeoise - Evolution

Type 5

1a Maison bourgeoise d'avant 1850
1b Maison bourgeoise type leopoldien
2a Maison bourgeoise avec bel étage (1 logement)
2b Maison bourgeoise avec bel étage (>1 logement)
3a Hôtel de maître ou hôtel particulier
3b Maison de rapport
4a Maison modeste d'avant 1919
4b Maison modeste après 1918 (dont cité - jardin)
5a Maison bourgeoise - Evolution (1 logement)
5b Maison bourgeoise - Evolution (>1 logement)
6 Immeuble à appartement
2. Case studies

Presentation sheets
3. Sustainable retrofit principles

Assessment indicators and criteria

<table>
<thead>
<tr>
<th>General data</th>
<th>Energy</th>
<th>Heritage value</th>
<th>Environmental Impact</th>
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<tr>
<td>Plot area</td>
<td>Energy load for heating</td>
<td>Building quality</td>
<td>Bill of materials</td>
</tr>
<tr>
<td>Built area</td>
<td>Energy load for electric devices</td>
<td>Coherence quality</td>
<td>Bill of CO₂ emission</td>
</tr>
<tr>
<td>Floor area</td>
<td>Energy load for hot water production</td>
<td>Preservation quality</td>
<td>Water use</td>
</tr>
<tr>
<td>Number of building</td>
<td>Embodied energy of materials</td>
<td>Resilience quality</td>
<td>Permeable area</td>
</tr>
<tr>
<td>Number of inhabitant</td>
<td>Renewable energy production</td>
<td>Biodiversity index</td>
<td></td>
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### 3. Sustainable retrofit principles

Assessment indicators and criteria

<table>
<thead>
<tr>
<th>Contexte</th>
<th>Gabarit</th>
<th>Organ. spatial e</th>
<th>Techn.</th>
<th>Construct.</th>
<th>Façades</th>
<th>Finitions</th>
<th>Pratiqes</th>
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### Scénarios

- Scénarios Ne: Ne1, Ne1', Ne2, Ne3, Ne4, Ne5
- Scénarios Ns: Ns1, Ns1', Ns2, Ns2', Ns3, Ns3', Ns4, Ns4', Ns5, Ns5'
- Scénarios Nf: Nf1, Nf2, Nf3, Nf4, Nf5
- Scénarios Et: Et1, Et2, Et3, Et4, Et5
- Scénarios Es: Es1, Es2, Es3, Es4, Es5

### Scénarios O

- Scénarios O: O1, O2, O3

In terms of climatic change policies, the sustainability envelope - design criteria potential risks are the most important criteria according:

1. High
2. Medium High
3. Medium
4. Low
5. Very Low

The sustainability envelope (influence of the sustainability envelope):
3. Sustainable retrofit principles

Sustainable retrofit principles – for dwelling types 1, 2, 5

- Principles for envelope retrofit
  - PEB vs TEB
  - XPS/EPS vs Cellulose/Wood fibre

- Principles for equipment/technics retrofit
3. Sustainable retrofit principles

Sustainable retrofit principles – for dwelling types 1, 2, 5

- Principles for equipment/technics retrofit – renewable and water management

- Principles for densification
3. Sustainable retrofit principles

Sustainable retrofit principles

- Principles for densification

![Diagram showing sustainable retrofit principles]

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![Table and images related to sustainable retrofit principles]

9/02/2015

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Thank you for your attention
Questions?