Abstract – The AWAP [1] coordinates and manages archaeology, heritage protection and the restoration of listed monuments in French-speaking Wallonia. This article sets out the current process for managing the conservation and restoration of listed monuments in Wallonia and the integration of energy retrofits into the legal restoration procedures.

Two buildings of very different sizes, shapes and structures, illustrate how property owners, their architects and our agency can provide practical and realistic technical solutions to support heritage and the overall energy upgrade strategy.

Keywords – restoration; energy audit; priorities; return on investment

1. INTRODUCTION

1.1 THE AWAP’S PROCESS FOR WORKING ON LISTED BUILDINGS

1.1.2 What is the AWAP?

Created on 1st January 2018, the AWAP brings together the former Walloon Heritage Institute (responsible for assistance to individuals, training in heritage skills, publications and public buildings) and the Heritage Department of the Public Service of Wallonia (responsible for heritage listing, authorizations, financial aid, works control and archaeological research).

1.2 PRIOR TO RESTORATION PROJECTS–THE SANITARY STATUS DOCUMENT

The Walloon Heritage Agency (AWAP) has created the so called sanitary status document, rendered compulsory in 2010 by Article 212 of the Belgian Heritage Code [2], to ensure consistent quality and comparable treatment of the condition of monuments.

The author’s task in the AWAP is primarily to write sanitary state sheets as an architect, and secondly, to control and advise the owners and their architect on the energy improvements of their listed building as an expert in energy audit.

The sanitary status document includes:

- a full description of the listed parts of the building;
- the damage affecting it;
- the ranking of the intervention priorities.

It must be updated every five years.

The priorities are on four levels, which last from six months to over five years. Respecting the established priorities gives right to a grant supplement of 10 percent of the amount of the restoration work.
It will soon be supplemented by the “heritage assessment” element to form the “heritage document”.

1.3 RESTORATION, DEVELOPMENT OR CONVERSION PROJECT

1.3.1 The heritage certificate
The “heritage certificate” procedure set out by the Heritage Code is a prerequisite for any work on a listed monument.

A support committee is formed to establish the conditions for this work, from the initial sketch to the work documents (plans and specifications).

The support committee is primarily comprised of the owner, the architect and representatives of the AWAP, the Royal Commission of Monuments, Sites and Excavations (CRMSF) [3], and other relevant authorities.

1.3.2 The planning permission
Planning permission is compulsory for all construction and modification projects, and is required for all listed and unlisted buildings [4].

Compliance with energy efficiency standards is set out in the Territorial Development Code (CoDT) [4]. The heritage certificate must therefore incorporate these standards into the project, together with fire, the wellness of employees, and safety standards.


Article 10 of the decree states the exemptions for buildings that are listed, in the process of being listed, or included in the inventory of heritage sites. These exemptions apply to the extent that the application of certain minimum energy performance requirements may change inconsistently their character or appearance with the objectives of the classification.

- This exemption must be justifiable: the building’s status as a listed monument is not sufficient;
- The owners of listed monuments wish to upgrade the energy performance of their building;
- The AWAP must enforce the regulations and also help the owner by limiting the risk.

This retrofit involves two complementary aspects:

- the external structure: insulation of the walls, ground and roofs, and the replacement of the external woodwork;
- the systems: the choice of energy and the heating, ventilation, hot water and lighting installations.

1.3.3 The context for improvements to listed buildings
The role of the AWAP is to structure interventions to prevent any risks to the integrity of the listed building.
From experience, the life span of a development is much shorter than that of the building:

- a commercial development will be modified after a maximum of 10 to 15 years;
- the installations in a residence or museum are updated every 20 to 30 years;
- the complete restoration of a monument is scheduled within 50 to 100 years.

1.3.4 Total energy balance or audit

According to the cases, I recommend performing an energy audit to optimize the improvements and ensure they are relevant to the context [7].

This is an estimated and standardised energy balance of a heated building. The full evaluation covers the outer structure and the systems.

- The intervention scenarios must be appropriate for the listed building and the project;
- The dynamic calculation (assessed over a period of 2 to 4 years) of the dew point for each type of wall and the unfavourable thermal bridging, is generally requested.

Consequences for the project:

- the improvement of the envelope will be limited according to established risks and therefore less efficient than expected;
- the improvement of the systems and the choice of energy must compensate this deficit.

Every improvement made to the building must be reversible to allow other improvements in the future in line with technological progress.

2. PRACTICAL EXAMPLES

2.1 THE CASTLE OF FREÝR IN HASTIÈRE

The original fortified castle was destroyed by the French in 1554 during the wars against Emperor Charles V. The oldest part of the current castle, the east wing, was built in 1571. Most of the 17th century castle was expanded and redesigned in the 18th and 19th centuries. The castle and the site have been listed since 1956. The entire site is included in the list of exceptional heritage of Wallonia [8] [9] [10].

Figure 1. Castle, main entrance to the south. Photo: www.all-free-photos.com.
2.1.1 Energy audit of the castle

The energy evaluation was performed as follows:

- calculation of the simplified thermal balance of the outer structure of the protected areas;
- thermography to pinpoint the structure’s thermal weaknesses;
- measuring of the temperature of the rooms and the exterior over a full year from March 2012 to March 2013;
- different Blower door tests were carried out;
- standardised consumption calculations by degrees/days;
- estimation of real, realistic and maximum consumption.

Four groups of rooms were identified according to their use, the temperature set points and the periods of use during the heating season from 15 September to 15 May.

Prioritising groups makes it possible to optimise the generation capacity and the investments in accordance with consumption.

(a) Structure and composition of the existing outer structure:

Heated floor surface: 3,076 m²  Protected volume: 11,014 m³

Table 1. Loss from walls

<table>
<thead>
<tr>
<th>Walls</th>
<th>Composition of the walls</th>
<th>Value U calculated (W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>walls</td>
<td>brick, internal panelling or coating</td>
<td>1.5</td>
</tr>
<tr>
<td>low floors</td>
<td>brick</td>
<td>2</td>
</tr>
<tr>
<td>intermediate floors</td>
<td>layer of plaster, an air space between the wall plates and an oak parquet floor</td>
<td>2.05</td>
</tr>
<tr>
<td>insulated attic roof</td>
<td>insulating plasterboard (5 cm MW) under slate</td>
<td>0.46</td>
</tr>
<tr>
<td>non-insulated roof for the occupied attics</td>
<td>coating, air space and slate</td>
<td>4.5</td>
</tr>
<tr>
<td>frame</td>
<td>oak, single glazing</td>
<td>5.13</td>
</tr>
<tr>
<td>external doors</td>
<td>solid oak</td>
<td>2.75</td>
</tr>
</tbody>
</table>

(b) Existing heating system:

- Groups 1+4: atmospheric oil boiler + cast-iron radiators;
- Group 2: atmospheric oil boiler + cast-iron radiators;
- Group 3: local heating from electric radiators.

2.1.2 Improvement scenarios:

- Several saving simulations were created on the basis of the three types of consumption, the groups of rooms, and the possible interventions: sliding temperature burner or installation of three separate boilers; insulation of interior walls of heated/unheated areas, double glazing;
- The selected intervention scenario is the following, in accordance with the groups of rooms;
- roof or floor insulation of the attics in occupied areas;
• high-performing glazing + improvements to the seals of the frames;
• replacement of wet insulation;
• air-tightness, parasitic losses, automatic door closures, etc.;
• replacement of heat production by a single boiler: fuel oil or wood chip;
• Internal wall insulation was not selected, as the estimated 500 L savings (< 1 %) did not justify the investment;
• The castle’s existing energy balance is currently average for performances in Walloon properties in 2010;
• The improved result is in line with the current requirements for new housing (< 115 kWh/m².yr).

Table 2. Comparative balance

<table>
<thead>
<tr>
<th>Existing</th>
<th>Projected</th>
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<tbody>
<tr>
<td></td>
<td>Oil</td>
</tr>
<tr>
<td>Standardised annual</td>
<td>53,000 L</td>
</tr>
<tr>
<td>consumption</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary energy consumption</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2 in full cycle - Gemis 4.5 value</td>
<td></td>
</tr>
<tr>
<td>Oil (10.647 kWh/L)</td>
<td>kWh</td>
</tr>
<tr>
<td>Electricity (*2.5 in Belgium)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>635,541</td>
</tr>
<tr>
<td>wood chip version</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Extrapolated balance on the certificate</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>kwh.yr/m² heated floor</td>
<td>206.61</td>
</tr>
</tbody>
</table>

2.1.3 Improvement of the heating system
The principle of replacing the two boilers was established. The following still had to be studied:

• the replacement of the electric heating with central heating or heating cogeneration;
• the installation of one boiler or several smaller boilers;
• the choice of energy: fuel oil or wood chips.

Transforming the wood produced on the site made it possible to choose a separate collective boiler room with a single 150 kW wood chip boiler.

The farm’s former barn, part of which is unused, could house the boiler and all the necessary equipment: the hot water buffer tank, the controls and the wood drying and storage silos.
A hot water heat network would distribute the castle’s circuits via an exchanger for existing circuits and the farm’s new circuit, as well as being a reserve to other buildings to be heated in the future.

The investment is important. However, the use of firewood from the property’s large forest allows significant savings. Furthermore, the relative neutrality of the selected system’s CO$_2$ production should be noted.

### 2.1.4 Improvement of the frames and windows

The idea was to retain the existing frames and add an additional internal frame, in the tradition of central and Eastern Europe and highland countries.

Figure 2. Installation of an over-frame and isotherms.

The consulting company studying the solutions for adding an over-frame recalled the technical constraints of such an intervention:

1) five types of embrasure of different designs: coated or paneled walls, wooden shelves, different depth of embrasures, etc.;
2) the presence of a radiator in the breast wall requiring an insulating plaque to be placed between it and the buffer area;
3) the aesthetic problem of incorporating an internal frame;
4) the cooling of the buffer space and the resulting internal condensation constraints;
5) the thermal stresses of the wooden embrasures and the damage they might cause;
6) the behavioural changes in the walls around these windows with the moving of the cold zones and the resulting reduction in comfort;
7) the worsening thermal weakness of the wall.

The support committee wanted to continue the discussions on this basis and a prototype was put in place to assess the visual and technical impact.

Following the CRMSF ‘s unfavourable intermediate report [3], I was consulted to deliver an opinion on the relevance of the proposed solution.
Advantages:
• Maintaining the uniformity of façades.

The recent frames (1952) have no archaeological value: they could be replaced.

Disadvantages:
• Replacing them at a later date would result in removing the over-frames;
• The solution is too complicated and onerous for an energy balance that is expected to be mixed;
• The output of the radiators masked by the façade of the counter-frame will drop.

The proposal for over-chassis installation was suspended.

I would agree to adapt an internal over-glazing on the frame.

• The thermal comfort will be improved and the sensation of comfort increased;
• The solution is economic and therefore more profitable;
• The thermal behaviour of the walls and the bay windows will not be modified.

2.2 THE LAMBRETTE RESIDENCE IN VERVIERS

2.2.1 Description of the building

The Lambrette building in Verviers is a 17th century half-timbered semi-detached house in an urban environment. The listing from 1970 applies to the façades and the roof. This is probably the oldest house in the town, and it is unoccupied. The City of Verviers bought the house in 2013 for development into four social housing units for vulnerable people [11][12].

The planned programme involves:

• development of four 3- or 4-bedroom apartments, on four levels;
• maximum compliance with current housing and energy standards;
• housing for socially disadvantaged people.

2.2.2 Preliminary studies

The initial energy balance was not useful. The project completely modified the layout of the building’s premises. The energy balance of a half-timbered wall is well known.

A dynamic behaviour study was carried out for the walls and thermal bridging.

The dynamic calculation allows to study the behaviour of a wall over a long period with seasonal variations. It is possible to check if the condensation accumulated in wet and cold periods can be eliminated during the dry period.
The dynamic behaviour study was required to provide guidance for the architect with regard to the techniques needed to reach an acceptable level, taking the following into account:

- the conservation of the wooden façades and plaster cob;
- the remaining useful surface areas after the internal insulation of the half-timbered walls.

### 2.2.3 Insulation of the outer frame

- **Roof insulation:**
  - the architect proposed insulating the sloping parts of the roof with a mineral wool mat, a vapour barrier and a trim panel under lathing. It would be necessary to insert mineral wool between the rafters to avoid any empty spaces;
  - the horizontal roof on the 3\(^{rd}\) floor would be insulated with a mineral wool mat, leaving the rest of the unheated attic free;
- **Insulation of the floor over the cellar:**
  - ten centimetre polyurethane panels on a stabilised bed of sand separated by a polyethylene film;
  - OSB panels under the covering stuck onto sandstone tiles;
- **The half-timbered outer walls:**
  - the restored, treated existing oak frame and the renovated cob filling covered with a layer of whitewash with hydrated lime or silicate paint;
  - a 14 cm insulating layer of hemp wool that gives the wall the threshold value of 0.24 Wm\(^2\)/K;
  - a variable permeance vapour seal creates a vapour barrier in winter and allows the walls to breathe in favourable weather conditions;
  - an internal top plate of covered plasterboard on 3 cm wooden battens;
- **New reliable double-glazed wood frames that complies with PEB standards.**

### 2.2.4 HVAC installation

- High quality ventilation must allow the dew points to dry out permanently and automatically. The support committee suggested the installation of a Smart Evo C+ system which combines automated mechanical air evacuation and supply;
- Heating is provided by hot water radiators connected to an individual natural gas condensing boiler with a modulating temperature regulated by a climatic sensor. Hot water is produced by the boiler.

### 2.2.5 Progress of the project

- Internal setbacks within the municipal administration have delayed the project, which is ready for the heritage certificate to be issued and the deadlines for certain types of funding have expired;
- The AWAP will continue the procedure once the new funding plan has been produced.

### 3. CONCLUSION

- The energy improvement of a listed building is globally identical to all other buildings, new or old: the design of the project must result in a good compromise between the investment and the hoped-for economy;
• A multidisciplinary dialogue is essential between the owner, the architect and the design offices. It is this dialogue that will make it possible to find the necessary compromises;
• AWAP adds to this dialogue the constraint of respecting the integrity of the listed building and requires guarantees that the planned interventions will meet this constraint;
• The main difficulty for AWAP agents is to overcome their reluctance to allow the desired improvements. Many still consider classified heritage as a cultural exception.

The presence of an expert in energy audit within the AWAP is very useful:
• to make the technical evolutions known;
• to allow their application;
• to change mentalities.

4. REFERENCES