Abstract – While the French law for energy transition has reinforced the insulation requirements of existing buildings and has set a significant pace for energy retrofitting (500,000 homes per year), it is important to promote a “responsible” rehabilitation approach for traditional buildings, allowing them to preserve their architectural values and to avoid pathologies potentially generated by the insulation works. The “CREBA” project was designed to create a national platform for online resources, aimed primarily at property owners, architects, consulting firms and renovation consultants. The multi-disciplinary team behind this, led by Cerema, is a consortium of engineers, architects and heritage specialists.

Keywords – knowledge centre; resources; case studies; responsible retrofit

1. INTRODUCTION

1.1 TO RECONCILE THE MASSIFICATION OF ENERGY RETROFITS WITH THE PRESERVATION OF HERITAGE VALUES OF BUILDINGS

During 2015, a major law for energy transition was adopted in France. This law set an important political objective: a clear commitment for massive energy retrofits, up to 500,000 homes per year in a 33 million housing stock. Of this stock, about 33 percent are of the “traditional building” type. French law considers all buildings built before 1948, whether rural or urban, as belonging to this type. It covers all constructions made of traditional materials such as stone and wood, which are clearly dissociated from “modern buildings”, built massively from the 1950s, using industrialized techniques and materials.

These traditional buildings that are the focus of the CREBA project, are a particular part of the existing housing stock eligible for retrofit. They are at the crossroads of many environmental, technical and cultural issues since they represent the majority of buildings with heritage value. Their rehabilitation must
be performed with care, using a “responsible” approach, reconciling energy, technical and architectural concerns.

1.2 CONTEXT IN FRANCE: A NEED FOR IMPROVEMENT IN PRACTICES, DISSEMINATION OF INFORMATION AND TRAINING OF PROFESSIONALS

In France, various surveys have been carried out in recent years to improve understanding of the complex behaviour of traditional buildings, and to propose suitable rehabilitation solutions, using a “responsible” retrofit approach.

As an example, in the east of France, the local representatives of the French Ministry of Cultural Affairs and Ministry of Sustainable Development have developed a guide [1] to promote sustainable rehabilitation of local traditional buildings. The guide in itself can be considered as a starting point to create more sustainable retrofitting scenarios that take into account not only energy efficiency but also comfort, moisture damage and heritage value. The criteria developed in this study have been adapted to other regions and to other challenges. Similarly, various cities and local authorities that are members of the Association “Sites et Cités Remarquables de France” (SCRF), such as Poitiers, Troyes and Grenoble, have developed technical guides [2] that provide solutions for the thermal rehabilitation of various types of old city-centres.

However, too many studies, research programmes and experiments are being relatively overlooked, despite their qualities. All the applicable output provide us with a large knowledge base about the behaviour of traditional buildings and the appropriate retrofit solutions, that needs to be widely disseminated throughout the large building community.

To encourage and develop the professional skills of architects, design offices and craftsmen, and thereby promote a responsible approach to the rehabilitation of traditional buildings, the CREBA project to create a resource centre for responsible retrofit was proposed. It is part of the national “PACTE” programme, an innovation programme supported by the ministry in charge of sustainable development.

This paper aims to explain how the CREBA knowledge centre project was structured and how its different contents were developed.

2. GENESIS OF THE CREBA KNOWLEDGE CENTRE

2.1 GENERAL STRUCTURE OF THE CREBA KNOWLEDGE CENTRE

The aim of the CREBA project, conducted throughout the French mainland territory, is to propose a set of online resources, such as tools, case studies and guides, for property owners, architects, consulting firms and renovation consultants. The ultimate challenge is to enable them to make responsible choices regarding the energy retrofit of traditional buildings and thereby promote the long-term quality of buildings.
The content proposed by the resource centre has several objectives, different recipients, and can be measured by different indicators:

Table 1. CREBA objectives and recipients

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Recipients</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>To provide centralized and structured technical and scientific resources dealing with rehabilitation of traditional buildings (see section 3)</td>
<td>Architects, consulting firms, renovation professionals (such as craftsmen) and to a lesser extent property owners</td>
<td>Number of online resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of resources downloaded</td>
</tr>
<tr>
<td>To share examples of good practices via a set of case studies (see section 4)</td>
<td>Architects, consulting firms, renovation professionals (craftsmen, ...) and property owners</td>
<td>Number of case studies posted online</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of case studies downloaded</td>
</tr>
<tr>
<td>To develop a decision support tool for responsible rehabilitation of traditional buildings (see section 5)</td>
<td>Architects and consulting firms</td>
<td>Number of operations that have benefited from the tool</td>
</tr>
</tbody>
</table>

2.2 GOVERNANCE OF THE KNOWLEDGE CENTRE

The constitution of such a resource centre requires the cooperation of people from different backgrounds with complementary missions, networks and skills. The founding members of the CREBA resource centre (Cerema, LRA/ENSA Toulouse, Arts & Métiers, Association “Sites et Cités Remarquables de France”, Association “Maisons Paysannes de France”) aim to bring together and develop:

- Different actions: research, support for construction and heritage stakeholders, capitalization of practices, dissemination of knowledge;
- Different networks: researchers, professionals, project managers;
- Different skills: building performance, architecture and preservation of built heritage.

This governance is intended to be extended to other institutional partners, as well as to be rolled out at the level of the French Regions, with the aim of creating local clubs for responsible retrofit.

3. DOCUMENTARY RESOURCE BASE

3.1 KNOWLEDGE REFERENCE SELECTION

It is largely admitted that the rehabilitation of traditional buildings needs a large interdisciplinary knowledge base, from scientific concerns regarding physical behaviour of materials to operational field experiences. As underlined previously, even though knowledge in all the branches of building has been growing for decades [3], efforts to bring this scientific and technical background to professionals have to be boosted. The objective of this platform is to make the technical and scientific knowledge about traditional building rehabilitation available to
professionals such as architects, consulting firms and property owners. The first task prior to creating the resource base is to select a panel of relevant studies dedicated to traditional building rehabilitation. These references in French fall into three main categories: guidance, case studies and research reports. From the 125 references primary identified and read by the CREBA members, over 100 were selected, as specifically addressing the subject. Most of these studies report on historical buildings and experiences in rehabilitation in mainland French territories in either rural or urban settings; some focus on historical city centres such as Paris or Grenoble, on natural parks or areas where a specific and protected heritage building exists, or are general reports applicable to France or European countries.

Many of the selected references can be considered as guidelines since they outline the good practices and the retrofit measures appropriate to specific conditions. The scope of the measures and concerns addressed is broad and can be listed as follows: energy efficiency, insulation materials and fabric of the building, sustainability, air tightness, user comfort, hygrothermal behaviour of walls and others. The topic “Should components or materials be maintained, repaired or replaced?” is often raised and solutions or advice are proposed.

A number of studies depict case studies and present quantitative data such as energy consumption, ambient temperatures and comfort evaluation before and after rehabilitation measures. These feedback data are precious since they may help to decide between several rehabilitation scenarios.

3.2 REFERENCE INDEXATION

For each reference, the objectives and contents, the measures and concerns developed as well as the materials, locations, and specific key words have been summed-up and indexed in a specific form. The level of understanding and the intended public of the reference are also of importance and are therefore also indexed in this form. Indexing each reference as detailed previously will enable the Guidance Wheel (see section 5) to connect a specific concern to one or more studies in the documentation resource base. The web platform will also allow a user to make a request within fields such as locations, concerns, measures and key words to target appropriate references in the knowledge resource base.

4. CASE STUDIES PRESENTING ENERGY REHABILITATION OF TRADITIONAL BUILDINGS

4.1 CONSTITUTION OF A CASE STUDY DATABASE

To share practices, CREBA offers a set of energy rehabilitation of traditional buildings case studies. Projects were selected by the CREBA team through a form [4], which was sent to a large group of heritage or energy professionals (architects, engineers, public institutions, experts) throughout France. The form consists of describing the historic interest of the building and how it was rehabilitated. Over fifty forms were completed within a six-month period.

These fifty buildings were then reviewed in technical partnership committees.
To finally select cases to be examined and to have a range that is as diverse as possible, several criteria were taken into account: location (each of the thirteen French Regions should be represented); type of building (residential and non-residential, listed as a National Heritage site or not); construction materials. Table 2 shows the thirteen selected buildings that are subjected to a case study and Figure 1 shows three of these located in the east of France.

This set of case studies is expected to develop in the coming years.

Table 2. The 13 selected buildings that have undergone a case study

<table>
<thead>
<tr>
<th>Location</th>
<th>Type of building</th>
<th>Main construction material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre-Val de Loire</td>
<td>Multiple dwelling</td>
<td>Stone</td>
</tr>
<tr>
<td>Bourgogne-Franche-Comté</td>
<td>Single dwelling</td>
<td>Stone</td>
</tr>
<tr>
<td>Grand-Est</td>
<td>Single dwelling</td>
<td>Wood and daub</td>
</tr>
<tr>
<td>Grand-Est</td>
<td>Non-residential (Primary school)</td>
<td>Stone</td>
</tr>
<tr>
<td>Grand-Est</td>
<td>Single dwelling</td>
<td>Brick</td>
</tr>
<tr>
<td>Hauts-de-France</td>
<td>Single dwelling</td>
<td>Wood and daub</td>
</tr>
<tr>
<td>Île-de-France</td>
<td>Single dwelling</td>
<td>Stone</td>
</tr>
<tr>
<td>Normandie</td>
<td>Multiple dwelling</td>
<td>Brick</td>
</tr>
<tr>
<td>Occitanie</td>
<td>Non-residential (University)</td>
<td>Stone</td>
</tr>
<tr>
<td>Occitanie</td>
<td>Single dwelling</td>
<td>Mud brick</td>
</tr>
<tr>
<td>Occitanie</td>
<td>Non-residential (Media library)</td>
<td>Brick</td>
</tr>
<tr>
<td>Pays de la Loire</td>
<td>Single dwelling</td>
<td>Stone</td>
</tr>
<tr>
<td>Provence-Alpes-Côte d'Azur</td>
<td>Non-residential (Office building)</td>
<td>Stone</td>
</tr>
</tbody>
</table>

Figure 1. Three of the 13 selected buildings located in the east of France. Photos: CREBA.

Once the buildings were selected, a CREBA member visited each. On this occasion, the project owner or the architect was interviewed. The presentation of each case study contains the same sections: the building and its context; diagnosis of the technical, energy and historic situation; preliminary design of the project; description of the works; summary of the rehabilitation.

4.2 TOWARDS A CHARTER DEFINING RESPONSIBLE REHABILITATION CRITERIA

It appeared that the notion of “good practice” had to be defined very precisely, in order to encourage heritage and energy professionals to apply it in their retrofit projects. A charter was therefore written, approved and shared by all the
members of CREBA. This charter is a reference document explaining the criteria for a so-called “responsible” energy rehabilitation of traditional buildings. It is composed of two main parts:

- General requirements that the operations must respect. The operation must follow a global and contextualized approach, from the diagnostic phase (state and character of the building) to the choice of energy-saving solutions. This global approach is defined by European standard EN 16883 “Conservation of cultural heritage–Guidelines for improving the energy performance of historic buildings” [5];
- Specific recommendations, element by element (walls, windows, floors, etc.), that must be respected for each operation according to their context.

5. DEVELOPMENT OF THE FRENCH VERSION OF THE GUIDANCE WHEEL

5.1 PRESENTATION OF THE ORIGINAL GUIDANCE WHEEL

The Guidance Wheel is an online decision-making tool for retrofitting traditional buildings, developed by the Sustainable Traditional Buildings Alliance (STBA) in the United Kingdom [6]. It aims to give a global approach for responsible energy

Figure 2. Guidance Wheel for responsible retrofit (STBA).
retrofit strategies by highlighting heritage, technical and energy issues to be considered in the planning process. The tool takes into account user type and building context, e.g. location, exposure, state of repair, etc. This is taken into account via a drop-down menu that is filled in before starting.

The retrofit measures are divided into three categories: building fabric, services and behaviour. For a selected measure, the Guidance Wheel identifies areas of risk to building fabric and occupants, e.g. damp problems, loss of heritage detail, lack of ventilation. At the same time it displays links to other measures that need to be considered in relation to the selected type of building work. The tool also makes it possible to select a series of measures and explore the links between them. For each project and set of measures, the user can explore its technical consequences, as well as energy saving and heritage issues. A side menu is used to explore these in more details, assess the risks and find out about suggested actions to minimise risk. Scrolling down, one finds the references and research which underpin the issues raised and provide further exploration. Examples of best practice help to understand and improve the retrofit building process.

Once the investigation is completed a report with all the advantages and concerns can be downloaded. For further study and the latest updates in the field the user can browse the STBA Knowledge Centre for Responsible Retrofit to which the tool is linked.

5.2 ADAPTING THE TOOL TO THE FRENCH CONTEXT

Exchanges with the STBA started in 2014 when the founding members of CREBA published the HYGROBA [7] study, a risk assessment of retrofit measures for traditional buildings in France based on hygrothermal simulations. One of the authors presented the results of the study at a seminar in London at the time when the STBA launched the Guidance Wheel in the UK. The idea of exporting the tool to France was soon voiced, and in 2016 the STBA provided the CREBA consortium with a 5 year license to develop the French version of the Guidance Wheel. This version will be finished and put online by late 2018, together with the national resource centre for responsible retrofit of traditional buildings.

It was apparent that it was not simply a matter of translating the Guidance Wheel into French, but that the tool had to be adapted to the French building context. With the consent of the STBA, the CREBA partners decided to add certain measures (e.g. thermal improvement) and eliminate others that were considered less relevant to the French context. Similarly, changes were made to the building context to which CREBA added a few more parameters, e.g. building type, which specifically applies to traditional solid walls. These are divided into fired brick, stone (hard and soft), earth walls and timber frame with daub infill. The hygrothermal impact of different insulation techniques and materials for each of these five wall types were assessed in HYGROBA [7]. Other additions to the French building context of the Guidance Wheel are “sources of humidity”, which replaces the original “exposure”. Furthermore, “location” adds three climate
categories commonly used in France (Mediterranean, oceanic and continental). For other context categories, such as heritage and number of exposed sides, minor changes were made in order to adapt them to the French situation.

Despite all the changes to the French version of the Guidance Wheel, CREBA and STBA have managed to keep the integrity and the original interface of the tool. This is also the case for recoding the risk levels for which we followed STBA guidelines, whereby each concern is assigned a risk level expressed by four colours in the Guidance Wheel (Figure 3).

A technical panel, consisting of CREBA members from Cerema and ENSA Toulouse, re-evaluated the risk levels for each measure and concern, in relation to both the existing and the added context (e.g. wall type, humidity, location).

The panel also reassessed whether measures and concerns are context sensitive, i.e. impacted by a changing building context. In certain cases concerns can be affected by several context categories at the time.

Test runs of the ‘new’ tool by the STBA programmer ensure that the French version functions properly. In addition, before launching, the French Guidance Wheel will be tested by a panel of building professionals and communication officers without a building technology background. CREBA wants to make sure that a wide audience of property owners, craftsmen, builders, architects, developers and engineers can use the decision-making tool with different interests and levels of energy retrofit knowledge.

6. CONCLUSION

The CREBA resource centre will promote a responsible approach for the energy rehabilitation of traditional buildings and help to increase the skills of building professionals in France. The centre has to be relayed and promoted locally, as close as possible to the people involved in the field. The extension of partnerships is being discussed at this point.

In addition to the initial CREBA resource centre, other services may be proposed in the future, in particular, training, education and the creation of a dedicated label for responsible energy rehabilitation of traditional buildings.
7. ACKNOWLEDGEMENTS
The authors would like to acknowledge Nigel Griffiths, Peter Cook and Isabel Carmona of the STBA for their advice and contribution to the translation and adaptation of the French version of the Guidance Wheel, especially at the more technical stage of risk assessment, recoding and reprogramming.

8. REFERENCES