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The Living Lab methodology for complex environments: Insights from the thermal refurbishment of a historical district in the city of Cahors, France

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ABSTRACT

The city centre of Cahors (southwest of France) is recognized as a historical heritage site and, like other city centres in Europe, it faces the complex challenge of the thermal retrofitting of old dwellings. This complexity is partly explained by the relative incompatibility of the French energy performance certificate with the retrofitting of old buildings, and by the frequent conflicts between heritage conservation policies and energy efficiency improvements. Today, the level of deterioration and the high vacancy rate of the dwellings, combined with the fuel poverty of their occupants has created an urgent need for an energy retrofit. In order to respond to this set of problems, the city council of Cahors has initiated the "Living Lab" approach, an original idea. The methodology, participants, objectives and obstacles of which are presented in this paper. Living Labs have emerged as a new research concept in which users, traditionally considered as observed subjects and end clients, become co-creators of the innovation process. As opposed to classical approaches, which may fail due to the contradictions among political, ecological, socioeconomic and technological interests, the user centred approach allows the emergence of a sustainable answer in a complex eco-system in a real life context. The first result of this study was the success associated with involving many participants – craftsmen, students, end-users, local authorities, material producers – which enabled an efficient and acceptable solution to be found for refurbishment. Another issue was the improvement of both energy efficiency and hydrothermal indoor comfort for the end-users. Longer term results will be the reduction of fuel poverty for occupants, and a city centre that is alive and enjoyable to live in again.

1. Introduction

The considerable development of suburban areas in recent decades has led, in Cahors and many other cities, to depopulation of the city centres. To overcome this, the town of Cahors is implementing the project "Coeur d'Agglo" (Heart of the city) [1], which seeks to revitalize the old centre to bring back the population. This includes the thermal renovation of old buildings through the ENERPAT project (standing for "Energie et pâtrimoine"), which examines how to combine energy efficiency of buildings and heritage. According to the priorities in thermal renovation (financial, economic, or ecological) the technical choices may differ. The listed historical dwellings of Cahors city centre are not subject to thermal regulation requirements [2], which facilitates the implementation of retrofitting thermal solutions using the vernacular know-how of craftsmen and the use of local resources. Craftsmen, heritage architects, the city council and universities are all actively involved the retrofitting of a dwelling used as a real life lab platform. Vernacular know-how, a geographic information system and diverse academic

Abbreviations: ANAH, National Agency for Housing Enhancement (France); ANVAH, National association of Cities of Art and History (France) Sites et Cités Remarquables de France since October 2016; Architecte des bâtiments de France, heritage architect of France; CAPEB, confederation of artisans (craftsmen) and small building firms; DPE, energy performance diagnosis; ENERPAT projet, "Energie et pâtrimoine" project; LMDC, laboratory of materials and durability of construction; LRA, laboratory of research in architecture; OREMIP, regional energy observatory; PFT, technological platform; PSMV, safeguard and enhancement plan; RT2012, French thermal regulations published in 2012.

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research tools (hygrothermal modelling software, in-situ monitoring) work side by side to enable the development of sustainable and ecological retrofitting solutions suited to historical city centres.

One of the objectives of this project is to involve best practices in regulatory governance (e.g., transparency, participation, etc.) that will affect the effectiveness of the energy solutions. The study will gather information and feedback to be more effective in influencing energy users and material producers. Therefore, social groups, such as craftsmen, end-users, or students, who are habitually excluded from energy decisions, will be engaged in the decision process. The final objective is to promote technology to foster the well-being of future generations, and also to reduce fuel poverty and meet development goals [3].

The ENERPAT project focuses on solutions using bio-based materials to develop local industries, and also on upstream considerations, with the distribution of raw materials and their implementation, by enhancing the skills of craftsmen and adopting a territorial approach to ecology [4]. However, the use of bio-based materials as technical renovation solutions brings its share of complexity to the project, in view of the many obstacles that may arise at every level of industry. Thermal renovation of the old centre of Cahors by the choice of solutions based on bio-based materials is an ambitious project, where the multiplicity of participants and the diversity of issues generate great complexity.

In this paper, an original, user centred, approach is presented. It is called Living Lab and is suited to projects of great complexity. "Living Lab" is a term that was first used at the Massachusetts Institute of Technology (MIT). It proposes a research methodology that is not only user-centred but "carried by the users" permitting the formulation, prototyping and validation of complex solutions in a multifaceted real-life environment [5]. One of the key components of the Living Lab is the real-life environment test. Testing a product or a service in realistic conditions of use and in the long term allows a technical solution to be drawn up that will be sustainable and full of value. The other pillar of the Living Lab is the principle of co-creation. In a Living Lab, users are not simply the end-users but a community of people interacting with the final product or service. This concept includes not only end users but also upstream users and secondary users.

"In industry, including the user of the research, the one who has posed the questions that had concerned him or her all along, is standard and usually ensures a sufficiently complete research design" [6]. This approach is identical to the standard definition of transdisciplinary research, which involves interdisciplinarity plus participation of all who are involved, as is the case in the Living Lab concept. "The core idea of transdisciplinarity is different academic disciplines working jointly with practitioners to solve a real-world problem. It can be applied in a great variety of fields" [7].

Everyone can take an active role as a contributor and co-creator mobilizing his knowledge and creativity. The Living Lab methodology also allows the intervention of scientific research – not in the usual academic setting, but in a real context enabling better communication with the future users. The three main pillars of a Living Lab identified in the Livre Blanc (White Paper) [8] are: experimentation in a real environment, co-creation, and the user as holder of the study. Living labs are thus an original approach to respond to sets of problems with a high level of complexity.

2. Problems treated in the case study

2.1. Complexity and problems regarding the retrofitting of historical cities

A system can be considered complex when it is open and when it generates issues and interactions that can be multiple, random and sometimes contradictory [9]. The urban context of the city centre is easily assimilated to a complex system because it focuses around political, cultural, social and economic issues in the same place and with many different players. Each transformation taking place in the urban centre may be a subject of conflict, because of contradictions of interests among those involved.

This is particularly the case for the thermal renovation of the old centre of Cahors. The conservation area was defined in 1972 and has been subject to specific regulations since 1988 through the Plan de Sauvegarde et Mise en Valeur (PSMV – Safeguard and Enhancement Plan) [10]. The fact of designating the conservation area therefore generates a systematic control procedure within the scope of the PSMV "before each work that will have an effect of changing the state of the buildings" (article L.313-2 of French urban code).

On the other hand, the improvement of energy policies, with ecological, social, and economic objectives, is leading to the rapid thermal renovation of existing housing. Due to rising energy prices, more and more French people can no longer meet the energy costs associated with their accommodation. In the Occitanie region, it is difficult to obtain recent data, but the Observatoire Régional de l'Energie (OREMIP – Regional Energy Observatory) has estimated that, on average, 15.6% of households are affected by fuel poverty [11]. To this must be added the ecological urgency, the construction sector being a major consumer of energy

When a decision is taken to improve the thermal performance of a dwelling, the choice the works to be undertaken are of course conditioned by the budget but, in the case of programmes financed by public subsidies, the theoretical energy performance to be achieved is an important part of the agreement between the owners and the funding authorities. In the case of Cahors, the financial help given by the Agence Nationale pour l'Amélioration de l'Habitat (ANAH National Agency for Housing Enhancement) for example, is only guaranteed if the work carried out improves the energy performance of the housing by at least 25% [12]. But often, the organization of various subsidies is based on a theoretical diagnosis of energy performance (DPE) or, at best, a thermal simulation, even though more and more studies are showing that the actual situation of old buildings does not match the DPE calculation [13]. Also, the buildings in the conservation area are not generally obliged to meet the requirements of the RT 2012 thermal regulations.

In fact, the design of old buildings was governed by a different physical mode of operation compared to post-war buildings, the design of which was significantly changed by the rapid growth of industrial processes. Mainly built from hygroscopic materials, old buildings have a subtle hydrothermal balance. This feature also makes the use of dynamic thermal simulations inappropriate as they do not take moisture transfers, to which old buildings are particularly sensitive, into account [13,14].

In comparison with old dwelling thermal refurbishment, the refurbishment of post-war buildings has been more investigated as in [15]. The IFORE (Innovation for renewal) project is an EU Interreg funded partnership including two large housing associations, one in England, one in France, and a state university from each country. This project is an exemplary large-scale retrofit: 100 houses have been retrofitted at Rushenden, on the Isle of Sheppey (Kent, England), and a similar number at Outreau, Boulogne (Pas-de-Calais, France), with the obligation to respect strong hydrothermal constraints. The paper gives an overview of the methods used by the project team to find common solutions, using dynamic thermal simulations with two different national software packages (ESP-r and Pleiades-Comfie®). The main point of similarity between the two sites is that both contain single storey housing for elderly residents. In France (Boulogne) they have a concrete or a solid brick structure rather than the brick cavity walls found in England. However, their overall likeness of form and the homogeneous pattern of occupancy, makes them suitable for both technical and community