Task 2.4

D2.2 PRESENTATION AND ANALYSIS REPORT ON MAIN TOOL FOR ASSISTING RENOVATION

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I-HEROS PROJECT DELIVERABLE ITEM 2.2

PRESENTATION AND ANALYSIS REPORT ON MAIN TOOL FOR ASSISTING RENOVATION

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SUMMARY

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SUMMARY

This document is a synthesis of a bibliographical study that details the potential and current support methods for the energy transition of a housing stock. It is applicable to the areas of energy efficiency but also to cross-cutting areas: thermal comfort, life cycle, air quality, etc.

The first parts focus on the different renovation paths, their stages and the issues related to the success of a project. Thus it is possible to understand the notion of an energy paradox that underlies the low renewal rate of the French housing stock.

With this in mind, the rest of the document focuses on integrated support pathways and one-stop shops. Various case studies and a benchmark of existing one-stop shops are compared according to their support pathways, how they link up with a classical renovation, and the impact they can have on the different obstacles studied.

Like any alternative method, one-stop shops can create new obstacles. Digital tools can improve the quality of renovation while reducing the time required to provide support. Several theoretical initiatives are detailed (energy passport, decision support tools, etc.) and then compared to existing platforms.

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INTRODUCTION

In the current context of global warming, the reduction of energy consumption is one of the central issues in research. Every day, part of the energy used is dedicated to the heating, ventilation and air conditioning (HVAC) of buildings. According to European Commission estimates, HVAC systems are responsible for 40% of the overall energy consumption and 36% of CO2 emissions[1] in Europe.

Residential buildings, which cover about 75% of the total building area in Europe, are responsible for 68% of the energy consumption of the housing stock, or 27% of overall European consumption [2]. By 2050, the Ministry of Ecological Transition aims to have reduced final energy consumption by 50% compared to the 2012 benchmark (155.1 Mtoe), with an interim target of 20% by 2030 for an equivalent reduction of 40% in GHG emissions.

It is estimated that three-quarters of the 2050 housing stock already exists [3], and yet more than 35% of dwellings are over 50 years old [4]. A key factor in energy efficiency in the building sector is therefore renovation to reach energy efficiency of the existing housing stock [5].

Toulouse territory context

The objective of this section is to define the characteristics of the territory of Toulouse. Understanding the needs of the territory is the only way to propose the right solutions for setting up a renovation support programme. Several similar studies have been proposed by Toulouse Metropole: the study foreshadowing the energy renovation platform for housing, overview of the situation and benchmark [6], [7]. To complete these, the Toulouse Planning Agency proposes several documents [8], [9].

In a few key figures, the metropolis of Toulouse:

- is made up of 37 municipalities
- has a population of 746,900
- covers 458 km^2 (i.e. 1,630 inhabitants/km^2)

The residential sector consists mainly of single-family houses (31.4%) and apartments (67.8%). Of the 446,996 dwellings identified, 90% are considered as main residences. Figure 1 represents the age of Toulouse's real estate stock.

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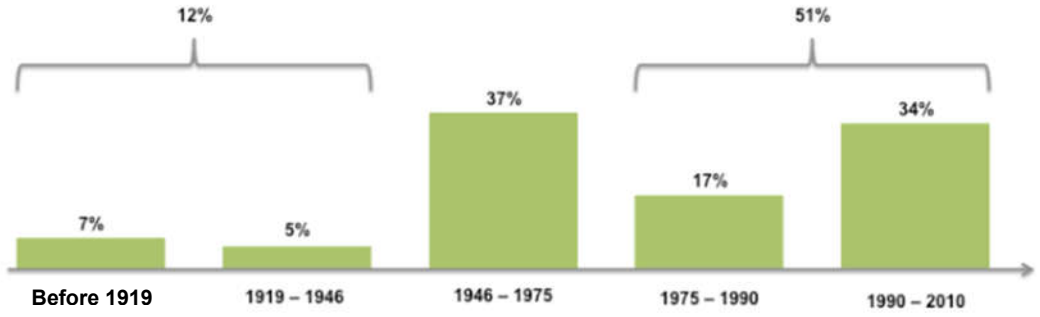

Figure 1 : Periods of construction of real estate of Toulouse

Three major periods of construction can be considered: building before 1945, building during the glorious '30s and building after 1975. The housing stock is relatively new as more than half of the dwellings are in the third category.

Despite this, the distribution of consumption according to the sectors and types of energy provided by RTE [9] emphasizes the preponderance of residential consumption (see Figure 2): 40% of the city's energy is consumed in housing – mainly in the form of electricity and gas.

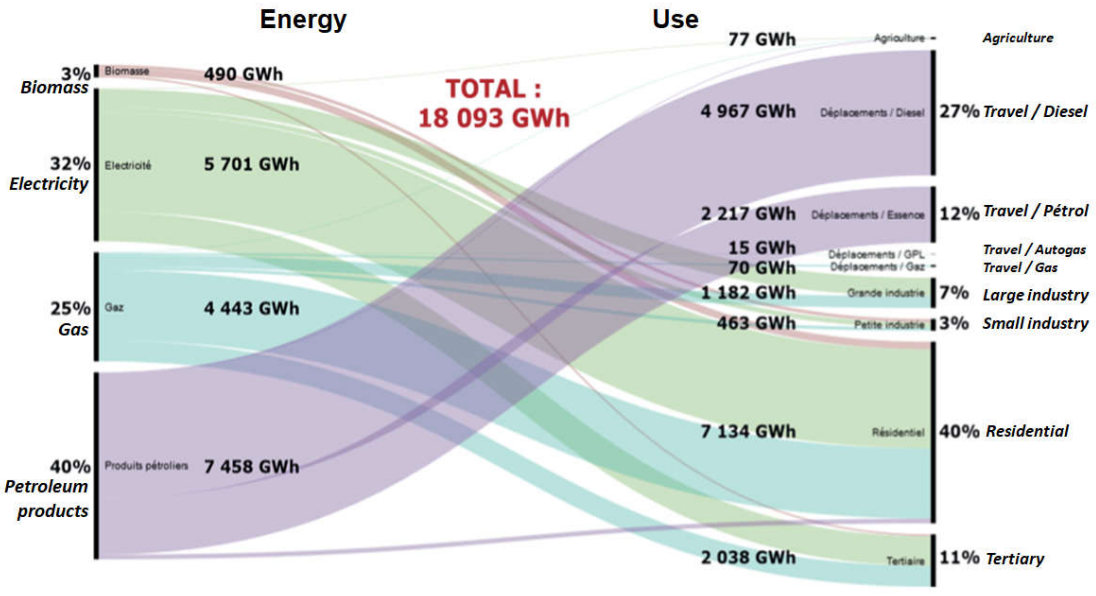

Figure 2 : Distribution of Toulouse Metropole's consumption by sector and type of energy

Figure 3 shows that more than 60% of dwellings fall into an energy class lower than C according to the regulatory environmental labels.

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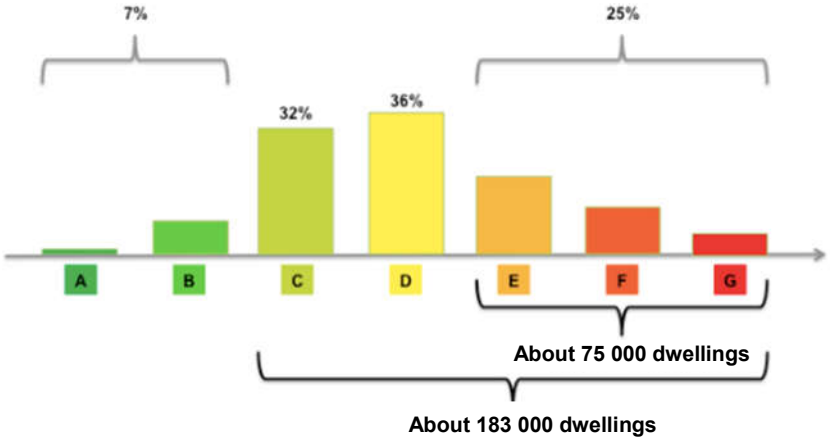

Figure 3 : Distribution of Toulouse housing by energy class [6]

Looking closely at the energy distribution according to the type of housing (see Figure4), we observe that, although single-family houses are half as numerous as apartments, their energy consumption is almost twice as high. Given that the apartments are twice as numerous, they represent a privileged target and should not be neglected.

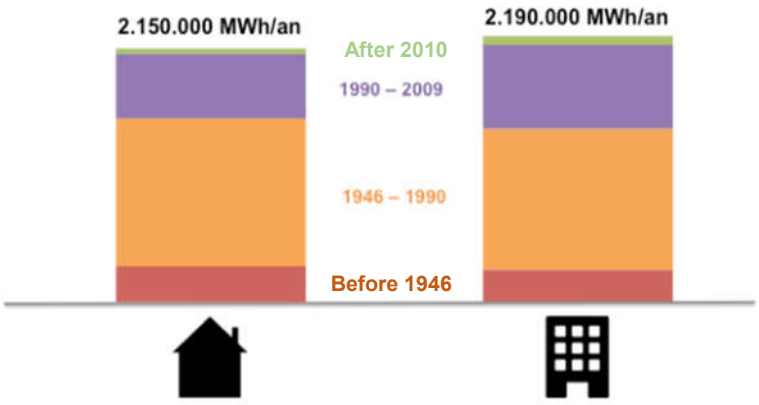

Figure 4 : Breakdown of energy consumption of Toulouse Metropole HVAC systems by type of housing and date of construction [6]

Finally, the proportion of individual houses is higher in Toulouse than in other major French cities when the share of individual housing versus collective housing is compared city by city. For example, the proportion of collective housing is 77% in the territory of Grenoble and over 80% in the Lyon area [7], [10]

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ENERGY RENOVATION: FEATURES AND ISSUES

As pointed out in the introduction, the context and literature present renovation as an effective strategy to improve the sustainability and control of existing facilities. A renovation can be defined as a modification or conversion project that does not involve complete replacement of the building. As the problems of building modernization are not new, the purpose of this part is to define what constitutes an energy/ecological renovation, what areas it should cover, and what it implies [3],[10].

The United States Green Building Council (USGBC) has defined ecological retrofitting as "any type of modernization of an existing building that is fully or partially occupied to improve energy and environmental performance, reduce water consumption, improve comfort and space quality in terms of natural lighting, air quality and noise, all in a way that the owner benefits financially"[12].

Several articles raise the idea that energy retrofitting should focus on economic, environmental and social areas [13]–[21].

ECONOMIC POINT OF VIEW

From a financial point of view, the refurbishment of a building is often less expensive than its demolition and reconstruction, or even its initial construction. As an example, Metin Arikan proposes the following average values: 218€/m2 for demolition and reconstruction against 1€ to 140€/m2 for renovation, depending on the degree of modernization [22].

In addition, since no demolition is undertaken and the construction period is reduced, the cost of financing the operation is reduced. Renovation of the buildings also has a strong impact on the value of the property. Finally, equipment modernization often makes it possible to reduce the cost of operating and maintaining systems.[12], [15], [22]

However, in the case of older building complexes or if stricter legislative requirements apply, the cost of modernization may exceed that of a new building [22]. The problem can be similar in the case of very deteriorated buildings. For this reason, it is important to determine whether or not decisions about energy retrofits are economically advantageous.

ENVIRONMENTAL PERSPECTIVE

At the time of renovation works, the impacts in terms of energy use, pollution and resource depletion are less significant in renovation than in new construction. There are several reasons for this difference [23], [24]:

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- The absence of demolition and therefore the recycling of all building materials
- Less transport of materials as most are already in place in the building.
- A shorter duration of works than an initial construction.
- The longer depreciation period of building materials enabled by the longer life of the building.

Modernizing the building stock is considered the best way to reduce energy consumption and greenhouse gas emissions in the building sector. The share of new buildings built each year corresponds to only 1.5 to 2% of the existing housing stock and, at this rate of construction, it would take between 50 and 100 years to replace the current stock, so the majority of existing buildings will still be inhabited for decades to come [5], [19], [25], [26].

Lifecycle analysis is an engineering tool for assessing the environmental impacts of a process over its lifetime, from construction to end of life. This type of analysis allows different strategies to be compared on multi-criterion approaches (e.g. climate change, water consumption, waste generation). [27], [28].

Existing buildings represent an energy investment that has already been spent at the time of construction (for manufacturing, transport, construction, etc.). Demolishing the existing building and replacing it with a new building, even an eco-friendly one, goes against the concept of overall energy savings. For example, the Pennsylvania Councils of History and Architecture Review estimates that it takes 65 years to recover the energy savings associated with an existing building when it is destroyed in order to rebuild it [29]. Renovating a building therefore reduces the environmental footprint of a demolition, while limiting the negative energy impact of the technical obsolescence of the installations. In this sense, "energy redevelopment" aims not only at addressing the need for renovation, but also to at ensuring the sustainability of the built environment.

Several papers suggest that environmental and social benefits may influence modernization decisions, even if economic costs are high[14], [15], [27], [30]. In addition, a building in poor condition can also lead to deteriorated air and water quality, thus increasing the spread of diseases, such as sick building syndrome. [31]

Finally, the renovation of a building must be considered within the neighbourhood in which it is located: a large difference in temperature between the urban and rural areas of the same city is defined as an urban heat island or microclimate [32], [33]. This temperature difference can lead to a deterioration of the thermal comfort of the occupants as well as an increase in energy consumption, especially for air conditioning [33], [34]. Working on a modernization of the building envelope and the surrounding urban public space would

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help to manage these problems [35], [36]. According to Santamouris et al. [34], in an urban heat island, thermal loads can be doubled and the air conditioning systems' performance ratios could be reduced by 25%.

SOCIAL VIEWPOINT

Under certain conditions, renovation can maintain or even improve the social and cultural assets of the existing built heritage.[37]

First, rehabilitation rather than demolition and reconstruction allows the occupants to maintain the uses of a building and its outdoor spaces (neighbourhood habits, neighbourhood relationships, neighbourhood associations, etc.).

Second, rehabilitation can provide an opportunity to change the distribution of rooms within the dwelling, or even to propose an extension, to suit the lifestyles of the occupants better.[14].

Third, in the case of rehabilitation on occupied sites, the question of rehousing occupants is no longer an issue. On the other hand, the inconvenience imposed on the occupants during the work must be taken into account and managed as well as possible [38], [39].

Finally, rehabilitation can preserve or enhance the architectural heritage or, on the contrary, conceal it. Some modifications must be submitted to the opinion of the Architecte des Bâtiments de France, who is responsible for the management and upkeep of the building. It should be noted that the need to preserve part of the historical architectural heritage can be perceived as a hindrance to architectural creativity and technological innovation.[38]–[40].

CONCLUSION

We have just seen that the renovation of buildings makes it possible to reduce energy use in the operation and construction phase as well as improving the general condition of the building, its use, its external appearance, its acoustic insulation and its comfort. Renovation extends the life cycle of buildings, which reduces negative impacts on the environment, increases the property's value and improves the health quality of buildings[30]. Therefore, energy renovation can be seen as an opportunity, not only to modernize a building, but also to improve all aspects of its performance.

However, despite a context that seems favourable to energy renovation, Europe has an annual renovation rate of around 1%[41]. If environmental targets are to be met, the

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European Energy Performance Directive considers that this rate should be at least 3%[42]. It is therefore necessary to look at the different contexts that have led to successful renovation operations and analyse them in order to propose relevant approaches or methods to the various actors and stakeholders of the renovation.

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CHARACTERIZATION OF A CLASSIC RENOVATION PROGRAMME

The previous chapter focused on the description and issues of the concept of renovation and concluded with the observation of a paradox between the potential and the implementation of the work. Despite the high potential for the rehabilitation of the housing stock, few steps are being taken by the owners. The purpose of this chapter is to understand the causes of this paradox. It is divided into two parts: the first evokes the path followed by an energy renovation project, while the second compiles a list of the various obstacles or barriers that may explain this discrepancy.

There are crucial differences between renovation and new construction projects. Some of these differences may turn into constraints that limit stakeholder intervention. For example, a potentially appropriate technical solution may not be feasible on an existing building [15], [43]. A better understanding of how these different barriers interact will help to best position a renovation project in order to propose the most suitable solutions to the characteristics of the housing stock. Our study will focus on the Toulouse context.

PROCESS SEGMENTATION

A renovation project is not usually approached as an ongoing process. It is rather a chain of delivery of different services. However, treating the renovation process as a single entity ensures continuity of service and proposes a comprehensive solution.

As mentioned above, the process of implementing a renovation project ideally involves the successive execution of at least 5 phases.[21], [38], [44]–[46]

PHASE 1: DEFINING THE SCOPE AND OBJECTIVES OF THE PROJECT

The actual scope of the project and the possibilities for renovation depend directly on the issues initially listed (discomfort, excessive energy bills, outdated equipment, etc.) and the available financing options. In this sense, it is important to consult the owners and take their expectations on the points of malfunction, thermal comfort and operation of the building into account.

Some project management support companies can assist homeowners in planning, managing and implementing the renovation project. These companies are responsible for collecting information from the owner, occupants, users, and companies that manage the facility, if they exist, about the building's current energy performance.

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During this phase, the main objectives of the project's results are also defined. For example, in renovation, the primary energy consumption target should not exceed 72 kWh/m2.year[47].

PHASE II: DIAGNOSIS OF THE ENERGY PERFORMANCE OF THE BUILDING.

The energy audit of the building identifies the reasons for the problems and inadequacies detected in the previous stage and quantifies their effects. The audit process focuses on energy analysis, identifying peaks in energy demand and proposing possible improvements in energy efficiency. It is also advisable to work on the quality aspects of the indoor environment.

In this phase, building behaviour, consumption data and the performance of energy systems are evaluated and analysed. As a result of this diagnosis, renovation programmes aimed at improving the thermal characteristics of the building and optimizing the efficiency of the equipment and their control schemes may be predefined.

The project management company or project manager is the most appropriate entity to carry out this work. This entity generally takes responsibility for preparing preliminary documentation, with technical requirements based on the results of the building's diagnosis, and for launching the tendering/quotation process to select the construction company.

PHASE III: GENERATING A WORK PROGRAMME

At this step, packages of renovation solutions are designed and evaluated from different points of view. The most appropriate technical renovation solutions, including envelope components, heating, cooling, ventilation, hot water and lighting systems are noted. The proposed options can be evaluated using energy models, financial analysis tools and evaluation methods, then the final package can be selected.

The project manager in charge of studying and choosing the best package of solutions from all existing proposals can use a wide range of selection methods in order to identify those among the possible alternatives that maximize the technical and economic benefits, minimizing all types of risks. Several articles in the literature offer numerical modelling methods (e.g. the use of STD), or decision-support algorithms for this step[48]–[52].

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PHASE IV: EXECUTION OF THE WORK AND COMMISSIONING OF THE BUILDING

The completion phase of the work corresponds to the implementation of the selected solution. The project manager who is in charge of carrying out the tender or consulting the companies can base the choice of companies on different technical or financial criteria. The chosen construction company is responsible for the implementation of the project on the site, with the help of all the subcontractor technicians.

Responsibility for monitoring work includes managing deadlines, questioning work done in the event of non-compliance, and making important decisions in the event of a work programme change.

PHASE V: VERIFICATION AND VALIDATION OF PROJECT OBJECTIVES

The final step is to validate and check the expected performance criteria defined in the first step. During this phase, standard measurement and verification procedures are used, e.g. compliance verification before work is received. The results must be verified, in turn, by owners and residents to assess the effectiveness of the measures applied as well as the satisfaction of the building owner and end-users.

Finally, the project manager leads the final acceptance of work by stating that it meets the expected specifications.

Figure 5 schematically retraces the path to energy renovation.

Definition of project scope and objectives	Energy and building performances diagnosis	Identification of packages of solutions	Execution of work	Validation and checks
• Definition of context • Determination of target objectives • Determination of resources	• Energy diagnosis • Diagnosis of equipment performance • Determination of lines of improvement	• Modelling/ estimation of energy and financial savings • Prioritization of solutions • Drawing up of schedule of works	• Call of tenders • Choice of firms • Monitoring of work	• Acceptance of works • Check on compliance • Monitoring of consumptions

Figure 5 : Five steps for building energy renovation

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OBSTACLES TO RENOVATION

Several documents in the scientific literature indicate that cost-effective energy measures are not always implemented. This gap between optimal implementation and actual implementation is called the "energy efficiency gap" or "energy paradox"[53], [54].

This energy paradox can be explained by the existence of obstacles to taking action in favour of energy efficiency. They are defined as mechanisms preventing investment in modernization technologies [15], [17], [26].

Several articles suggest that these barriers to renovation are specific to the context of each project. Yet it is necessary to understand these issues in order to define the right local strategies. [46].

This part is therefore dedicated to a study of some stumbling blocks and the different means existing to overcome them. It is based on a synthesis of various literature review articles on the subject [15], [38], [39], [41], [43], [46], [55].

The ways of classifying these obstacles are unique to each author. Here, we propose to take up those of Grun Bjorneboe[55]. According to this author, all barriers depend on an information-related context (how communication and education can be used to increase awareness to promote energy retrofit), financing (i.e. the economy expected of a renovation, subsidies, etc.) or the process itself (including physical and social context, decision-making and regulation).

A synthesised review of the various brakes on renovation and levers for decision support is proposed in Figure [6].

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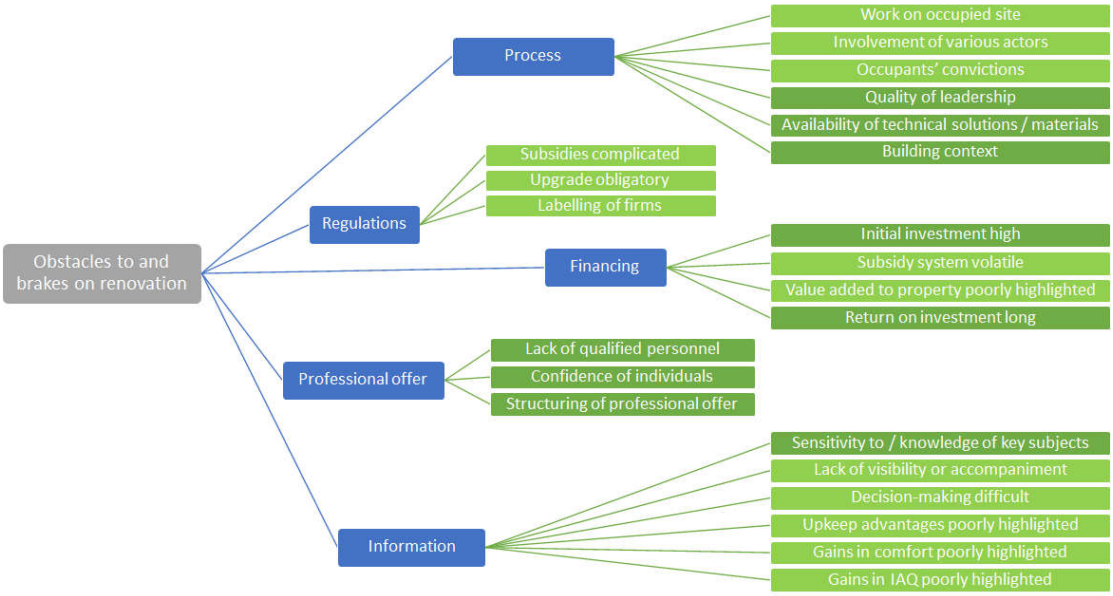

Figure 6 : Review of the various brakes on renovation and levers for decision support

INFORMATION

For this part, the various issues are related to a lack of stakeholder awareness of renovation techniques, the cross-cutting benefits of the work, and a lack of communication on the available solutions.

To begin, it is important to highlight the importance of homeowners' lack of awareness of the amount of energy consumed, the costs of use and the potential energy savings. In its 2017 report entitled "Detailed analysis of the existing residential stock", the Construction Quality Agency showed the potential of energy savings in renovation over France [10]. Yet, until households know the real consumption and economic potential of their homes, they cannot consider energy retrofits to be relevant.

The second obstacle, which arises from the first, is visibility and accessibility to an accompanying route. In order for the work programme to be as successful as possible, it is important that the individual can rely on assistance from the referring agency.

Problems related to the successful implementation of ecological modernization reflect other barriers, such as lack of information and communication between stakeholders at different levels of decision-making and the implementation processes, especially in the case of apartment blocks in co-ownership where decisions must be accepted by the majority of owners. One way to move a work programme forward is to ensure that the different stakeholders have common goals.

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Another important motivation for energy improvement is the environmental aspect and the long-term sustainability of the building. This argument requires an awareness of "good practice" by the occupants, as common reasons for poor building performance are poor use of the building's facilities by residents and/or facility managers: poor technology and systems in buildings can be highly energy-intensive.

Finally, the aesthetic context of the building can be either a motivating factor or a hindrance. On the positive side, the possibility of improving the architectural appearance by modernizing a façade is a powerful driver: it is the most visible aspect of a renovation. However, a change in aesthetics can be an obstacle in situations related to the preservation of historical heritage or when the building presents difficult construction conditions.

During a renovation, the objective should not be limited to a targeted energy consumption. It should also reconcile notions of sustainability, comfort of indoor environment, life cycle, etc. These points, which impact people's daily lives, can act as motivators at the time of the decision. It is therefore interesting to see them as an essential argument for promoting energy retrofit, rather than just as a secondary benefits.

In the case of France, several sticking points have been detected[40]:

- Professionals are familiar with aid measures but are not necessarily able to advise the occupants properly. There is therefore a lack of quality in terms of personalized advice;
- The 2014 IFOP study is a survey that demonstrates the lack of information faced by the general public[56]. 73% say they do not know what aid is proposed by the city/metropole/region. Paradoxically, 96% say they feel concerned about the problems of energy transitions related to housing;
- Unlike the situation in other European countries, the low price of electric power in France can lead to longer returns on investments [57]. For this reason, the energy efficiency angle is not always enough to convince people to start work. It is important to point out the value of other areas (value of property, thermal comfort, preservation of heritage...);
- The poor structuring of information concerning market supply makes it difficult for individuals to identify the right contact person.

FINANCING AND RETURN ON INVESTMENT

In matters of finance, four main obstacles have been identified: the availability of capital, the functioning of the subsidy system, capital gains, and repayment.

The most important obstacle to energy retrofit is the amount of the initial investment and the lack of available capital. A detailed study on this point is available in Shima

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Ebrahimigharehbaghi's article[58]. Other articles also mention fluctuations in the price of materials and available aids as a problem [15], [43].

Subsidies can be a way to motivate homeowners to start their energy retrofits. They reduce the initial investment cost. However, the number, administrative complexity and volatility of these aids make them a double-edged sword. A need for administrative support has been identified on this point [40]. This financing system can also have the effect of changing the balance of a market: companies whose work is subsidized may increase their prices knowing that households will have easier access to funds.

Savings in the maintenance and operating costs of systems can be achieved through energy retrofit. It is a lever that can motivate homeowners to make changes to their homes because future savings can contribute to a "return on investment." Similarly, a renovation can increase the overall value of a property in a future sale, so it is a form of added value. The increase in the real estate value of the property after the work is a point that can be put forward to convince owners.

Energy retrofit is often presented as an economic investment that should be achievable in a short period of time. This means that long periods of amortization can become an obstacle and the proposed solutions may be rejected for economic reasons alone. This is why it is important to stress the beneficial effects of a renovation on the quality of comfort, atmospheres and the durability of the building.

RENOVATION PROCESS

First, an important factor for the success of a renovation project is the involvement of the project owner. It is preferable for the syndicate of co-owners or the individual to feel involved in the renovation process rather than being constrained by a regulatory context. A project management support team must therefore include missions oriented towards consultation and the acceptability of an operation in order to ensure good involvement of the project manager.

Carrying out work on an occupied site can cause a number of problems. A renovation means a disruption of daily life, fear of noise, dust, etc. This will have an impact at the time of decision-making.

At the city level, in order for all renovations to be undertaken, it is essential for appropriate solutions to be available. Beyond technical solutions and products, there is a need for policies that give individuals (or trustees) simple access to solutions for energy

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improvement. Structuring a range of existing technical solutions can help provide the support and direction needed to make decisions about the solution to be implemented.

It is also important to standardize diagnostic methods and make them more reliable so that work can be predicted and gains estimated as well as possible. In the case of co-owned apartment blocks, energy audits have been mandatory since 2009. In the case of detached houses, the reference document may be similar to the French DPE (Diagnosis of Performance). This diagnostic method and its European equivalents are strongly disputed because of the difference between calculated and actual consumption [40], [59]. As part of the PREBAT programme, exemplary buildings were monitored and evaluated, including 54 rehabilitation operations. The feedback document[60] deals with the differences between the expected energy savings and those finally observed, up to 100% more in some cases. This discrepancy stems from installation techniques, how the buildings are used by occupants, etc.

The architectural or historical context of the building can also be a hindrance to its rehabilitation. In the context of historic or heritage-listed buildings, the search for technical solutions can be very limited. In the case of buildings with particular architectural specificities, targeted studies may be required to ensure the best design of the work programme.

In the case of France, several blocking points have been detected [40]:

- Thermal simulation computing software is not suitable for old buildings. Often, the technical data for these studies do not exist or are not accessible
- Work on existing buildings is more complex than on new buildings. There are many more unknowns, especially on the passages of water, electricity, gas, etc. pipes.

REGULATIONS

Regulations are an effective way to encourage homeowners to make energy improvements to their homes. For a regulation to be effective, it must be consistent and incentive so as not to impede progress. It must also be simple to apply in order to maintain all its initial impact. In addition, it is important to recognise that political objectives that set the bar too high can hamper the renovation processes.

Financial aid related to legislative support can also be problematic. In some cases it is possible to lose the financial incentive if the certification is not achieved. These same regulatory financial aids are often complicated to obtain, not uniform or have expiry dates that are too short to permit their proper implementation.

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In the case of co-owned properties, the regulations require owners to carry out regular work for conformity (risk prevention plan, upgrade of elevators, renovation of facades, etc.). This type of work programme can give an impression of constant solicitations. It is often better to undertake comprehensive renovation programmes with ambitious goals rather than a series of small works.

In the case of France, several blocking points have been detected[40]:

- Product evaluation and safety procedure slows down development initiatives for innovative solutions
- Despite the large number of financial aid mechanisms available, their effectiveness is strongly contested [61]
- Public aid is described by users as "complicated and poorly targeted"
- The text of the RT 2007 thermal regulation did not provide any clear measures for renovation. The 2012 RT is currently described as a poorly transparent system with an opaque computing engine. The RE 2020 is currently experiencing a wave of challenges by professionals in the field of renovation.

PROFESSIONAL BACKGROUND

The lack of experts, professionals and certification of good work with individual workers can all hinder the choice of an energy renovation. It is important to build a framework to structure the professional offer and ensure the technical skills of the various participants.

In order to reassure individual owners, it is important to continue the training and qualification of building professionals and to ensure that information on renovation solutions is clear, available and reliable [62]. Inexperienced teams may lack the skills to implement green technologies properly, which could compromise their effectiveness. The same problem also arises for entrepreneurs and project owners. In addition, the training of building professionals is now focused on interventions in new buildings. However, the techniques of intervention, the materials and the challenges in renovation are different.

The pivotal stages in planning a renovation project are the diagnosis and selection of a work programme. Several documents mention a lack of consultants specializing in renovation to provide information on construction systems and concepts in this area [15], [39]

In the case of France, several blocking points have been detected[40] :

- In the case of renovations to blocks of apartments in co-ownership, professional renovations tend to take “light” approaches that are not global enough.

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- Certifications that are supposed to guarantee the know-how of companies have lost their value. Some craftsmen prefer, for example, not to be labelled RGE

IMPACT OF THE OBSTACLES ON THE ACCOMPANYING ROUTE

Figure 7, which summarizes the impact of the different obstacles that can hinder the progress of a project, allows us to understand which stages are affected by the various problems. The process issues are present at every stage of the project.

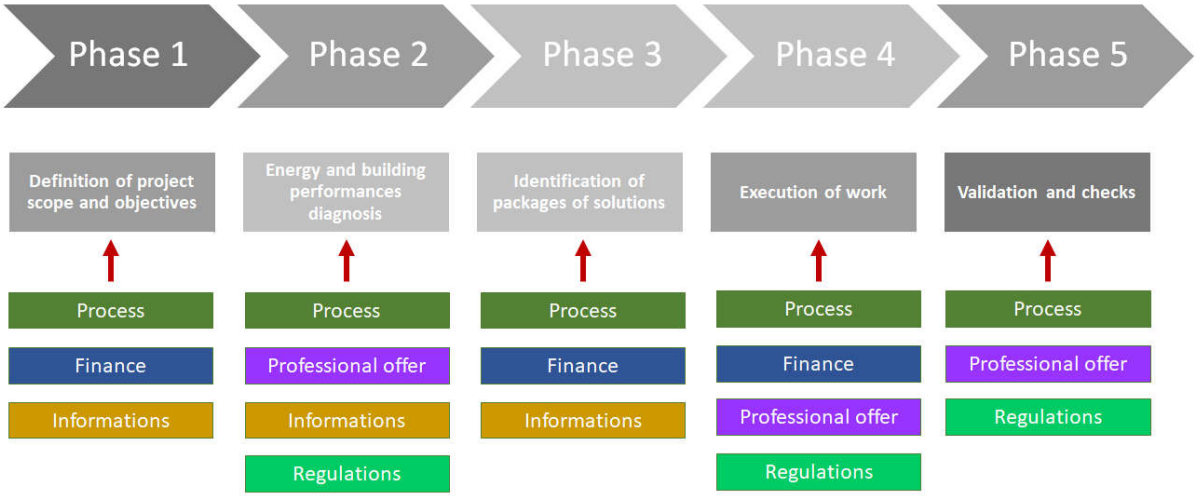

Figure 7 : Impact of obstacles to renovation on the accompanying route of a renovation service

In addition, conventional renovation programmes are characterized by fragmentation between the different phases of the process. Several articles propose more global approaches to renovation. Their authors believe that, by integrating these issues into a single path, it will be possible to lift most of the barriers leading to delays [38], [55].

The challenge of the "single path" now consists of reaching all groups of owners and covering the different specificities of buildings to approach energy renovation in a more global way.

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INTEGRATED RENOVATION PROCESS

In previous chapters, the potential for primary energy savings in the residential building sector has been highlighted. We have seen that the most relevant way to avoid excessive spending is to increase the pace and scope of renovations. To achieve these goals, building owners must be persuaded to invest in sustainable, efficient renovations. In order to overcome the different barriers faced by individuals, various solutions have been studied [38], [40], [55], [63]–[65]. At the same time, the subject of a new way of managing projects: the integrated renovation process, is regularly tackled in the literature [63], [66], [67].

This section looks into this process and how it successfully overcomes most of the informational barriers to renovation. In Part 5, we will explore how integrated renovation systems are implemented on one-stop-shop platforms. A benchmark of these one-stop shops will allow the different territorial initiatives to be compared.

DEFINITION

According to the definition given by the American Institute of Architects (AIA), the method of carrying out a project corresponds to "how the project will be designed and built". The integrated project is an execution approach "that integrates the different actors (people, business structures...) and practices in a process that leverages the skills and ideas of all to optimize project results, increase value for the owner, reduce waste and maximize efficiency at all phases of design, manufacturing and construction."[68]. The main benefits of an integrated renovation programme over traditional project management are listed below:

- Eases sharing and transfer of data.
- Facilitates the implementation of innovations.
- Involves all project participants upstream.
- Sets success goals before the project begins.
- Makes communication more open.
- Implements appropriate technology.
- Involves better organization and leadership.

ARTICULATION OF INTEGRATED ACCOMPANIMENT IN RENOVATION

The challenge of such a system is to succeed in attracting the attention of homeowners in such a complex sustainable renovation process. Unlike the classical course studied

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previously, the methodology of an integrated route is defined as a general or complete accompaniment process. It is a user-personalized methodology that is based on multi-criterion decision-making methods. When applied to renovation, the integrated renovation process supports, informs and accompanies homeowners towards a sustainable home renovation project while enjoying the associated benefits. It also helps construction experts to be more efficient in building analysis and the development of renovation scenarios. Thus, more time can be spent optimizing costs and qualitatively analysing the needs, wishes and behaviours of homeowners.[66], [67]. There is, therefore, a continuity and a logic of articulation between the different stages of the accompaniment offered to the owners.

The general process is iterative and can be segmented into several steps[66], [67], [69]. The list below and Figure 8 detail this route:

- Definition of the scope of the study and setting of the objectives of general results. The first step in an integrated renovation project is to determine what the work will cover as well as the expected results. It is from these two elements that the expected performance criteria are defined.

- Diagnosis of the apartment building or the house and analysis of data on the owners. The aim is to collect the information necessary to carry out the project. Solutions are possible for collecting and transmitting information: either the owners are able to provide specific documentation and information about the building and themselves, or it is necessary to use specific databases (public or governmental) to collect information useful for the diagnosis.

- Identification and selection of performance criteria matching the objectives for results with the profile of the building. These performance indicators will allow the quality of the different scenarios to be compared on quantitative criteria. They can be multiple and depend on different areas. For example, a consumption criterion coupled with the 72 kWh EP/m2/year target (associated with the BBC Renovation Label) or the NF HQE criteria for managing thermal comfort and air quality can be used.

- A multi-criterion evaluation under existing conditions. This initial diagnosis allows an overall assessment of the set of quality and performance criteria and thus helps to define a strategy for achieving the objectives set.

- Generation of renovation scenarios and pre-selection of scenarios to be evaluated. This step depends heavily on how the problem was defined. It is usually launched by construction experts. The process is iterative and the first scenarios must evolve according to the expectations of the owners. The scenarios initially generated may be

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minor or major renovation scenarios. They can also be combined with a step-by-step renovation approach to avoid too great an initial investment.

- Evaluation of performance criteria for pre-selected scenarios. Determining the success of each scenario is studied independently. This makes it possible to compare the extent to which each of them meets the objectives set. This is the same multi-criterion assessment structure as is used for the assessment of housing under existing conditions.

- Synthesis into a global evaluation and presentation of the results. A method based on multi-criterion decision algorithms, such as described by Galiotto et al, can be used here.[67]. This method compares the results obtained according to different criteria or domains. The area is widely covered in the scientific literature[49], [50], [70]–[73]. Using this type of evaluation method, a combination of local evaluations of decision criteria is obtained to produce a global synthesis. The result of this study makes it possible to compare the different scenarios objectively and qualitatively.

- Selecting the most favourable scenario and implementing the renovation measures: The active participation of homeowners leads them either to choose a favourable renovation scenario or to reject the shortlisted alternatives. In the first case, the project management team can initiate the process of implementing the work. In the second case, new alternatives are generated and evaluated. In both cases, the specific support of owners by construction professionals is the object of particular attention because, to be successful, the iterative process must achieve the objectives for results and meet the expectations of the owners.

- Implementation and reception of the site. These are the stages of project implementation; they stem from the completion of the preliminary work carried out up to this stage. Owners may or may not be accompanied in managing the work. The project does not end until an audit demonstrates that the project delivered is well in line with the objectives set. Otherwise, these earlier steps of the project are often repeated.

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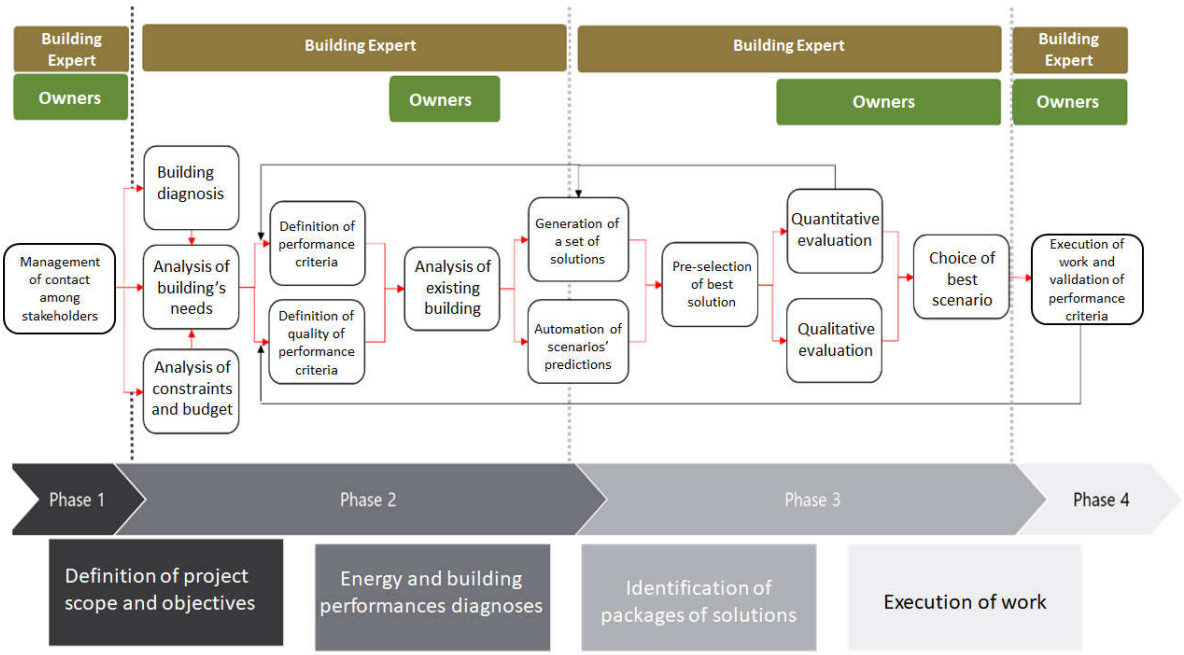

Figure 8 : Description of the accompanying route for an integrated renovation project

We have just presented the concept of integration of renovation projects. Figure 8 uses this description in diagram form to visualize the logic of this iterative process. It is this notion of articulation and coherence between the different stages that makes it possible to provide a solution to the various problems mentioned in the section **Obstacles to renovation**

DIFFERENT APPROACHES FOR AN INTEGRATED RENOVATION COURSE

The study of the segmentation of the different stages allows us to understand the path of these integrated renovation projects. However, even if the execution frame is similar to the different accompaniments, projects can have different dominants or angles of approach. They may differ in how they are managed, how they are used, how they are analysed and how solutions can be implemented. This section therefore concerns the differences between the integrated accompaniment routes, and several ways of doing things are presented below. Figure 9 summarizes the main characteristics of these different types of projects.

Multi-variant design and multi-criterion analysis

This is a methodology based on the use of an algorithm to analyse the design and evaluation criteria. For this purpose, the criteria are expressed through a system of

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indicators associated with different weights in order to manage a very wide range of alternatives. For example Kaklauskas [74] proposes a model capable of dealing with more than 100,000 solutions. Solutions can be discriminated according to the most technical, appropriate, practical, cost-effective needs...

The criteria expressed in quantitative form are related to the measurable aspects of the renovation, such as thermal insulation of the building envelope, comfort requirements, systems power demand, investment costs, etc. The qualitative criteria can also be taken into account and generally relate to the assessment of comfort, aesthetic aspects, social impact, the level of innovation of the applied solutions, etc.

Knowing that energy systems, components that contribute to energy performance, and building occupants are in direct and continuous interaction with each other, multi-criterion analysis can lead to very complex algorithms. In addition, there is no perfect solution as the different areas of interaction are often contradictory and owners must make choices according to their expectations, such as, for example, reducing energy consumption without degrading thermal comfort or indoor air quality. Several studies cover the subject[71], [75], [76] as part of the energy renovation.

Multi-purpose coupling and optimization models

Multi-purpose optimization models are common in the energy retrofit sector. They consist of pairing energy performance goals with other cross-targets. Thanks to these models, multiple technical and financial alternatives, based on specific requirements, are generated and evaluated in order to meet a double or triple objective. The most common related areas are life cycle analysis, thermal comfort and air quality [52], [66]

It is common to use digital simulation software to model the different solutions and quantitatively verify that the objectives set are being achieved [50], [52].

One of the difficulties of this type of approach is the definition of objectives at the start of renovation projects. We have seen previously that this is a key point that greatly conditions the success of the project see section **Articulation of integrated accompaniment in renovation.**

Renovation projects with a larger scale

Recently, many European cities have put comprehensive plans in place to renovate their housing stock in the aim of achieving their environmental goals [77].

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This scale gives a new dimension to the concept of renovation projects. Working at the scale of a neighbourhood or city can make it possible to better integrate a project into its environment. In his article, Häkkinen proposes a review of the principles and benefits of energy retrofit at the level of a neighbourhood rather than at the building level [78]. In particular, this highlight:

- The ability to manage energy consumption globally while simultaneously working on supply management, demand management and energy consumption management. This can lead, for example, to a renovation of a neighbourhood's energy production systems, while improving the characteristics of building envelopes and building consumption scenarios to reduce power demand.

- The opportunity to work on criteria to improve the thermal comfort and quality of life of the occupants of the neighbourhood.

Various articles also highlight the possible gain of thermal comfort in indoor environments by working at the neighbourhood level. A large-scale renovation can change the microclimate at district level.[33], [36], [79]

Key performance-based approaches.

Key performance indicators are one of the most commonly used concepts for managing renovation projects. They allow the success of the implementation of the project to be quantified with varying accuracy. Although the scope, criteria, structure or format of the tool vary, the evaluation process is common: the performance of the evaluated building is compared to one or more quantitative performance indicators.[21]. Over the past two decades, the number of building performance assessment tools has multiplied and their use has expanded to all types of multi-criterion analysis or multi-purpose optimization models. Some examples are LEED, BREEAM, CASBEE, HKBEAM, GBTool, Green, Star, and NABERS.

Given the variety and range of areas covered by these labels, the correct definition of a set of criteria directly determines the success of a project. To this end, several articles in the scientific literature offer reviews or comparisons of these outcome criteria[80]–[82].

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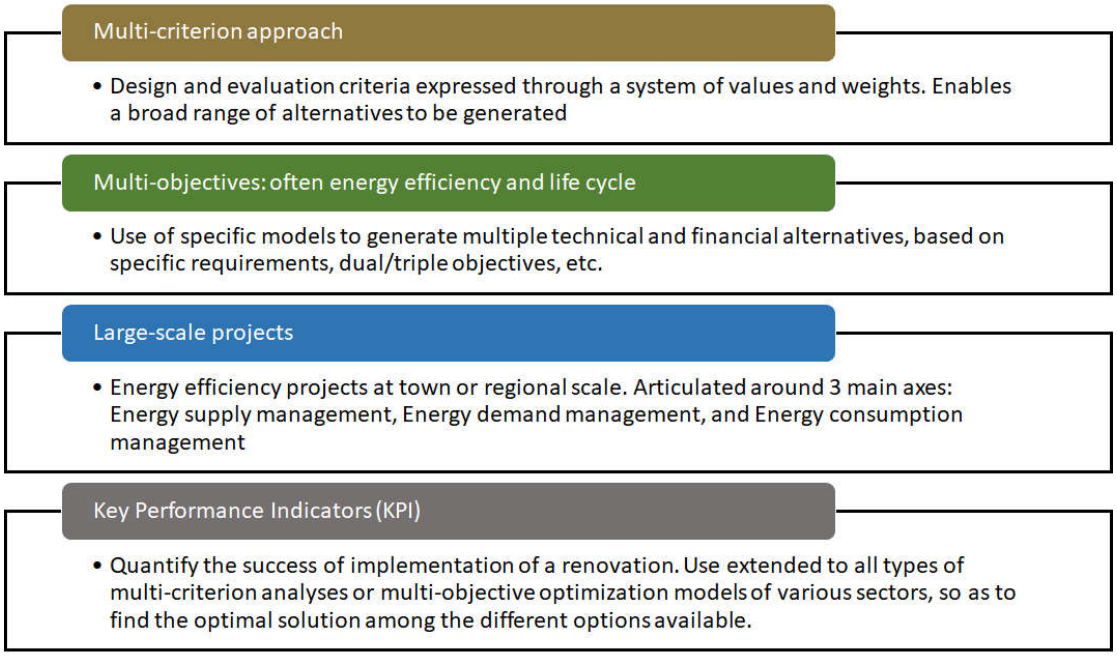

Figure 9 : Characteristics of the different dominants of integrated renovation projects

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ONE STOP SHOP: A GENERALIZED INTEGRATED RENOVATION SYSTEM

In the previous part, we saw what defines an integrated renovation programme, how its operation differs from a conventional renovation approach and what its main dominant approaches may be. The aim of this new part is to study how this concept can be applied to the massification of energy retrofits.

We will study the concept of the one-stop shop and its different characteristics. To extend this work, part of it will be devoted to a case study based on a European project. Particular attention will be paid to a comparative synthesis of different single-desk projects at different administrative scales. This chapter is based on scientific literature, documents from several integrated service programmes and benchmark documents from existing initiatives [7], [45], [69], [83]–[85].

DEFINITION AND CONCEPT

A one-stop shop can be defined as a virtual and/or physical place where owners can access all the information and services, they need to carry out their project. Thus, in an energy retrofit context, they can benefit from a package of services to help them manage all the steps useful to a renovation project. Regardless of the underlying administrative structure, this single access point is the interface between the recipient and the service provider. [84]–[88].

Single-desks therefore reduce the frequency of interactions among different stakeholders while improving access to the services offered [89]. The level of integration and the degree of execution of the renovation process may vary from structure to structure[90]. The criterion for successfully setting up a one-stop shop is to find the right packages of services that adapt the structure to the needs of the territory. For this reason, some initiatives are closer to the regulatory or commercial context[88].

The management of one-stop shops can be the responsibility several players. The stakes and the offer available to individuals are then different. According to comparative studies by the European Commission and the European project Turnkey Retrofit, single-desk projects can be run by different stakeholders[45], [84] :

- Industrial players: These are industrialists who have developed a technical renovation solution. The one-stop shop is then oriented towards promoting a specific market solution.

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- Energy consultants: They expand their core activities to gain visibility and cover a wider clientele.
- Energy services companies: These are suppliers or installers who aim to expand their customer base or improve customer service
- Local government bodies: Their programmes are mainly motivated by climatic and/or energy considerations, sometimes by social and/or economic objectives (e.g. developing a local economy).
- Co-operative players: They focus on societal benefits, without necessarily concentrating on energy savings/cost savings

The type of projects studied in our case is limited to projects carried out by local government agencies. It is this type of one-stop shop that the I-HEROS project must provide. Interest in this type of solution has increased in recent years and there are more and more initiatives from different territorial actors. ADEME says that, in 2016, it supported the porting of more than 100 national regional council platforms developing innovative tools and partnerships for energy retrofit.[83]

DIFFERENT TYPES OF ONE-STOP SHOPS

The one-stop shop is a physical or digital platform that connects the owners and providers of a renovation service. One-stop shops serve different issues, depending on who is leading the project. It is also noteworthy that, even within the initiatives put in place by the governing bodies, the paths of accompaniment and the levels of integration may differ.

THREE TYPES OF ONE-STOP SHOPPING (OSS)

In the document explaining how to set up a one-stop shop, the European association of cities in energy transition identifies three types of one-stop shopping [91].

These theoretical models are schematized and detailed in Figure 10 and Table 1. Depending on the type of benefit proposed, the one-stop shop may specialize in coordination or facilitation, for example. Details of the services and services associated with each model are given in the rest of the document.

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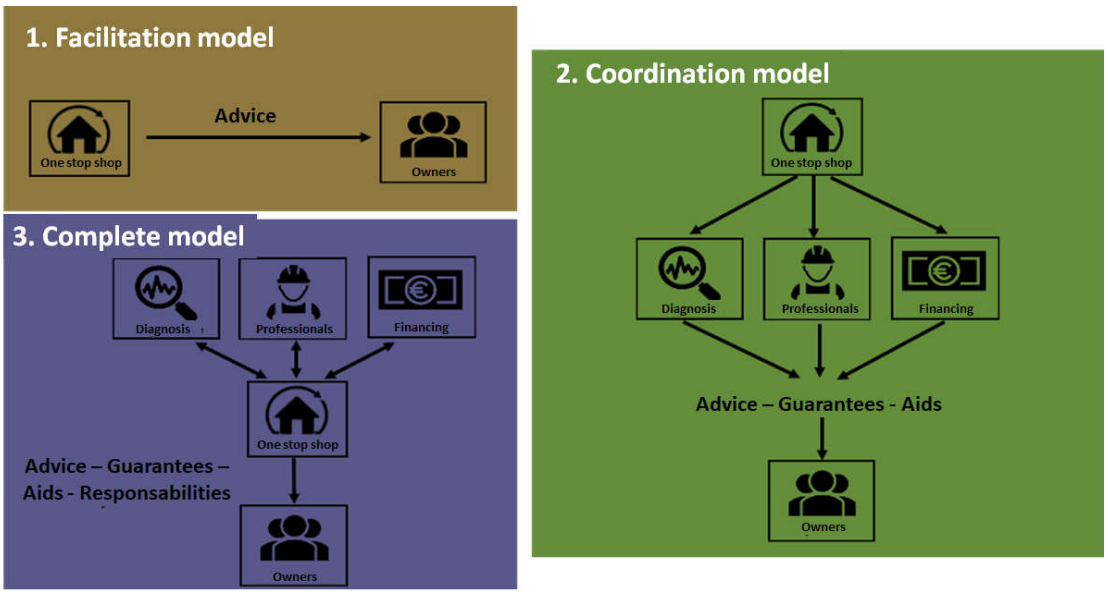

Figure 10 : Schematization of different types of one-stop shops

Type of OSS	Services available	Example of service offered to owners
Facilitation model	➢ Raise awareness of advantages of renovation ➢ Provide general information on renovation work ➢ First advice at orientation stage	Advice on how to renovate a dwelling Can provide list of suppliers
Coordination model	➢ Coordinate existing actors in the market (suppliers) ➢ Check that all services of the one-stop shop are offered to owners ➢ No responsibility for results of renovation work (only for the overall process) ➢ No responsibility for client's global journey (only for the first part)	Advice on how to renovate a dwelling. Can provide list of suppliers. Can push suppliers to respect their obligations, even though the OSS is not legally responsible for the successful completion of the work.
Complete model	➢ Offer owners a complete renovation programme ➢ Take responsibility for the result of the renovation works ➢ Take responsibility for client's global journey	The OSS is a contractor who sells all the services and is the main contact point should a problem arise with the suppliers

Table 1 : Different services depending on the different types of one-stop shops

THE VARIOUS SERVICES AVAILABLE TO INDIVIDUALS

We have just seen three types of one-stop shops depending on the type of service they offer.

Table 2 details the content of the services or services offered by one-stop shop type (OSS1: "facilitation" type; OSS2: "coordination" type; OSS3: "complete" type).

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Figure 11 allows us to visualize the range of services offered through the major steps we have identified in section 0Process Segmentation

- Phase 1: setting goals;
- Phase 2 : diagnosis ;
- Phase 3: programming the work;
- Phase 4: execution of the work;
- Phase 5: verification and validation.

Table 2 : Different services depending on the type of one-stop shop

Different services offered by one-stop shops	OSS 1	OSS 2	OSS 3
Marketing and Communication			
Awareness of and advice on the benefits of renovation	X	X	X
Communication with the various stakeholders during the progress of the renovation.	X	X	X
Promotion of services offered by different companies	X	X	
Promoting the OSS via a physical or digital location		X	X
Creating a specific support service depending on the territory or the target audience (e.g., energy insecurity, specific climate)		X	X
Development of a range of technical solutions tailored to the needs of affected households			
Introducing customized solutions for home renovation.		X	X
Standardized solutions for a specific type of housing stock			X

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Specific technical accompaniment			
Tips on energy-saving measures, technologies and relevant methods	X		
Energy audit/building diagnosis		X	X
Development of a package of energy solutions tailored to the results of the diagnosis.		X	X
Supplier selection: a list of suppliers certified by the single desk. Checking quotes and helping to select suppliers.		X	X
Personalized financial advice			
General advice on the existing financing options that the owner can claim (subsidies, tax credits, energy efficiency certificates, etc.).	X		
Assistance in the development of a tailored funding plan and the preparation of aid files.		X	X

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Coordinating renovation work			
Support for the management of the project for the coordination of companies and renovations		X	
Coordinating renovations and businesses on behalf of the owner			X
Guaranteed results and post-work follow-up			
Development of a certification system for companies: creation of a label / charter		X	X
Training local suppliers and allowing them to collectively coordinate renovation work		X	X
Responsibility for the quality of the work and the achievement of the estimated energy savings			X
Tracking consumption post-work		X	X

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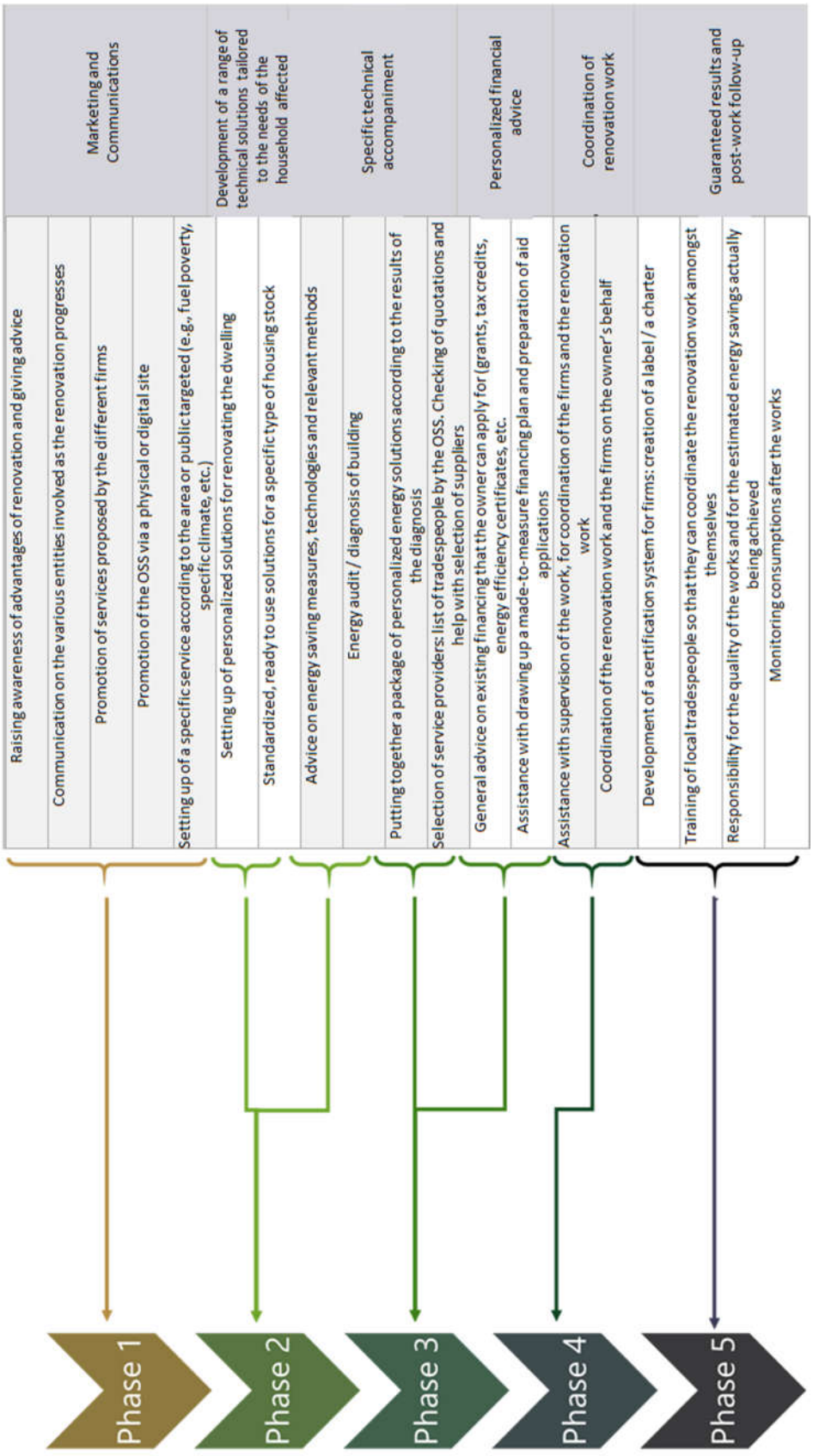

Figure 11 : Breakdown of one-stop-shop services in stages of renovations

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CASE STUDY OF OSS HAMBURG ENERGY PILOTS

After defining the concept of a one-stop shop (OSS) and quickly introducing the three main types of one-stop shops with the associated services, we will explore various existing initiatives.

A preliminary study of the Hamburg one-stop shop will illustrate the previous parts. Then, a comparative study will identify the main French and German projects

MODEL OF HAMBURG'S ONE-STOP-SHOP: HAMBURG ENERGY PILOTS

Hamburg is striving to become a "Climate City" by 2050 and has set itself a model for a city of the future in which climate protection and adaptation to the climate are elementary components of social interaction. With the goal of achieving a nearly climate-neutral building stock by 2050, a strategy must be developed that is effective both in the new construction sector and in the building stock. In order to meet Hamburg's climate protection targets in the building sector, the city's Authority for Environment, Climate, Energy and Agriculture issued a call for tenders for the implementation and consolidation of low-threshold, building-related energy advice in Hamburg in 2019.

As a result of this tender procedure, the "Hamburger Energielotsen" (Hamburg Energy Pilots) were established. Since the summer of 2019, the Hamburg Consumer Centre, the Hamburg Chamber of Crafts and the independent, semi-public North German network centre for building owners, planners and local authorities, ZEBAU GmbH, as cooperation partners of the Hamburg Energy Pilots umbrella brand, have been linked together for joint energy consulting. The Hamburg Energy Pilots represent Hamburg's independent energy advice service, which is available to all building owners, homeowners, tenants and also tradespeople at various points in the city.

The Hamburg Energy Pilots work on behalf of the Hamburg Authority for Environment, Climate, Energy and Agriculture and are partly funded by Hamburg's climate protection

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funds. The energy advice provided by the consumer advice centre is also funded by the Federal Ministry of Economics and Energy.

The Hamburg Energy Pilots can be classified as a 'facilitation model' within the business models of one-stop-shops. The services covered by the facilitation model in the Hamburg case are explained in detail in the following sections.

APPROACH

From 2019 to 2022 (optionally until 2024), the Hamburg Energy Pilots will fulfil the public consultancy mandate of the Free and Hanseatic City of Hamburg for the energy-related modernization of buildings in Hamburg. The Hamburg Energy Pilots are intended to remove the inhibition thresholds that often prevent the implementation of a necessary modernization of the building stock: lack of knowledge about the variety of possible solutions, the assistance provided, the clarity of technological solutions, the complexity but manageability of a building modernization and, ultimately, also a personal motivation and decision to implement it. To achieve this, the Energy Pilots follow an approach with three main pillars: Low-threshold offers, an integrated consulting approach, and supplementary offers for climate-friendly buildings.

- Low threshold offers
- initial information via telephone and website
- free, independent, product and manufacturer-neutral initial consultation in person /or via zoom
- free exhibition with models for climate-friendly building
- free information events for property owners and specialist events for architects, engineers and energy consultants to train them in sustainable building

Integrated consulting approach

- consulting not only for modernization but also for energy-efficient and climate-friendly new buildings, for example wooden constructions or buildings with green roofs or green facades

Supplementary offers for climate-friendly buildings

- consultation on climate change adaptation
- promotion of the use of renewable energies

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THE CUSTOMER'S JOURNEY TO MODERNIZATION IN HAMBURG

The special counselling approach is implemented through a diverse range of services, which are explained below. The customer's overall journey to modernization consists of four steps:

Figure 12 : Articulation of the accompaniment route of the one stop shop (OSS3 Hamburg energy pilots)

The Hamburg Energy Pilots are mostly involved in the beginning of this journey and help the customers in the first important steps towards energy-efficient living: to find out what they want, what is needed and how they can get an analysis of their building. And also, to know what is possible and how much it will cost.

At the beginning, there is the free initial energy consultation. It takes places in one of five advice centres spread over the whole city, where the customer receives initial information and tips on how the further course of action could look. The energy consultation provides free, independent, product- and manufacturer-neutral initial advice and information on all issues relating to energy modernization in existing buildings. The focus is on private residential property and commercial projects. Also, architects and engineers will be advised within their projects. For further enquiries, the Hamburg Energy Pilots cooperate with other institutions: Hamburg Chamber of Commerce (www.hk24.de), and Caritasverband Hamburg e. V. (www.stromspar-check.de/standorte/details/stromspar-check-hamburg.de) among others.

The free initial consultation often leads the customer to choose a permanent energy consultant, who then checks and evaluates the condition of the building with an analysis tool. The analysis of the energy requirements and the structural measures are the second step.

The third step is the financing of the project. Here subsidies also play a role and reduce the subsequent capital burden on the customer. The subsidy programmes in Germany always require a quality assurance check by an independent expert. This considerably improves the success of the modernization measure because quality assurance can prevent errors on the construction site. The quality assurance is also supported by funding programmes.

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The figure below shows the customer's journey to modernization and the difference between the support offered by the state and the city (which includes the Hamburg Energy Pilots) at the top and the additional services that the property owner has to order at the bottom.

In the next two sections, the role of the Hamburg Energy Pilots in the first two steps of (1) Information & Consultation and (2) Tools & Analysis will be discussed in more detail.

Figure 13 : Overview of the customer's journey to modernization guided by the Hamburg Energy Pilots. Source: ZEBAU GmbH

INFORMATION & CONSULTATIONS

The energy consultancy in Hamburg builds on each support step by step. The free advisory service includes initial advice by telephone or in person, a visit to the exhibition including personal advice, free participation in information events (currently only online due to the corona pandemic) and general information on technologies, subsidies, the regulatory framework, contact persons, etc.) via the homepage www.hamburg.de/energielotsen.

The consulting services offered by the Hamburg Energy Pilots therefore cover a total of five areas, all of which are provided free of charge. Figure 14 shows how the Energy Pilots guide the way to energy efficient living. The specific offers will be explained in the

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following

Figure 14 : Overview of the guidance for modernization offered via the Hamburg Energy Pilots (Source: ZEBAU GmbH)

The **telephone consultation** is the central service point that accepts all enquiries and passes them on to the expert team of trained energy advisors in a target group-oriented manner. In addition to initial counselling, the telephone consultation already includes a "pilot function", according to which those seeking advice can obtain information on further counselling options from other institutions that offer sustainable building services.

The **initial energy consultation** is a key offer of the facilitation one-stop-shop. In the first stage of the consultation, the person seeking advice is informed about the options for energy-related modernization: identification of the need for modernization, classification of measures and rough estimates of expenditure, subsidy programmes, technology advice, other contact persons). The energy consultant must find out what the customer is looking for in his property. Often the customer has a certain interest in a new heating system, but the advice he receives indicates that replacing the windows can be an important additional tool to effectively modernize the house. Afterwards, the property owner should take further steps via state-approved energy consultants and, for example, have the energy certificates issued, for a fee, which are required for applying for state subsidies for comprehensive modernization. The advisory recommendation to provide the customer with professional support in the following phases is an important feature for successful energy-related modernization of private residential property. This initial consultation is also necessary in order to prepare the person seeking advice for further steps with banks or to establish contact with craft enterprises (offers for individual measures). Independent information brochures will also be handed out during the consultations, or reference will

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be made to other recognised sources of information. It is possible for the customer to return to the initial energy consultation twice, if there are more questions or problems on their way.

In order to make sustainable building tangible, an **exhibition** has been created. This permanent exhibition covers around 2.000 square feet and it shows models of solar panels and battery storage, heating and ventilation systems, insulation samples, windows and boards with further explanations. The energy consulting can be combined with a visit of the exhibition in specially set up counselling islands.

Through a total of 17 **events** (Presentations, Workshops) per year, the house owner receives additional information about technologies, products, construction processes, legal issues or support programmes. There are also specialist events for architects, engineers and energy consultants to train them in sustainable building.

The **building checks** are also free to the house owner with federal funding. These on-site-consultations of about 90 minutes are documented with a report, where the most important facts about the condition of the building are recorded. Another offer is building checks for climate change adaptation, which are done on site. They last 2 hours and are free of charge for private or commercial property owners. These checks are not refinanced by the state, but only by the city of Hamburg. The Hamburg Energy Pilots offer 50 climate change adaptation checks per year.

Tools & Analysis

The Hamburg Energy Passport is issued by (accredited) experts who calculate the energy requirements of buildings. The aim of this complete energy consultation is to provide owners with a good basis for making decisions on renovation measures based on condition analyses and suitable modernization proposals. In order to be able to depict the actual condition of the building as accurately as possible, a structural and energy inventory of the residential building is carried out directly on site. Subsequently, modernization options for the individual building components, such as windows, roof and external façade, as well as the system technology used to provide heat or ventilation, are worked out on the basis of the initial condition. In the end, the customer receives documentation with a proposal for a complete modernization. To underline the advantages of refurbishment projects, the possible energy savings that can be expected if the structural and technical requirements of current funding guidelines are met are calculated and displayed (see Figure 15).

This offer is only available in Hamburg and costs between 1.000 and 1.500 Euros. Up to 80% of the costs are covered by the development bank of Hamburg (Hamburgische Investitions- und Förderbank, IFB).

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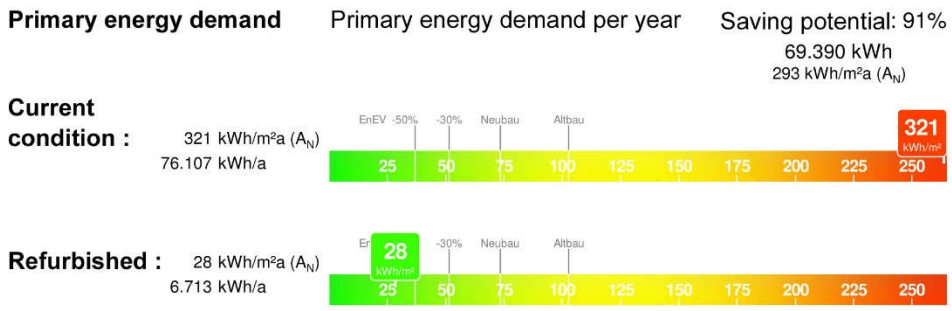

Figure 15 : Hamburg energy pilots Energy Passport

Individual Modernization Roadmap

The Individual Modernization Roadmap was introduced in Germany in 2018. It uses an approach via sensibly coordinated renovation measures, divided into individual packages, and considers user influence. A clear, comprehensible presentation of those packages is provided for owners. Furthermore, the interests and financial framework conditions of the owners are considered, as well as renovation and maintenance cycles.

During the drawing up of the Individual Modernization Roadmap, as for the Hamburg Energy Passport, a consultation is provided. The energy consultant makes a detailed inventory and communicates the condition of the house via a clear graph. The influence of the individual user plays a special role and the effects of user behaviour is made clear to the person seeking advice. For example, one-degree higher indoor temperature means 6 % more heating consumption. The special feature is that the customer can also make his own individual specifications. For example, an extension of the roof storey or renting of a partial area.

As a result, the customer also receives a report suggesting what a step-by-step modernization could look like in the next 10 to 15 years. The actual condition of the building is shown in different colours so that the homeowner can see directly which building elements require modernisation. The renovation packages, which build on each other, are mapped using a defined schedule: Step by step, the homeowner approaches his completely renovated building.

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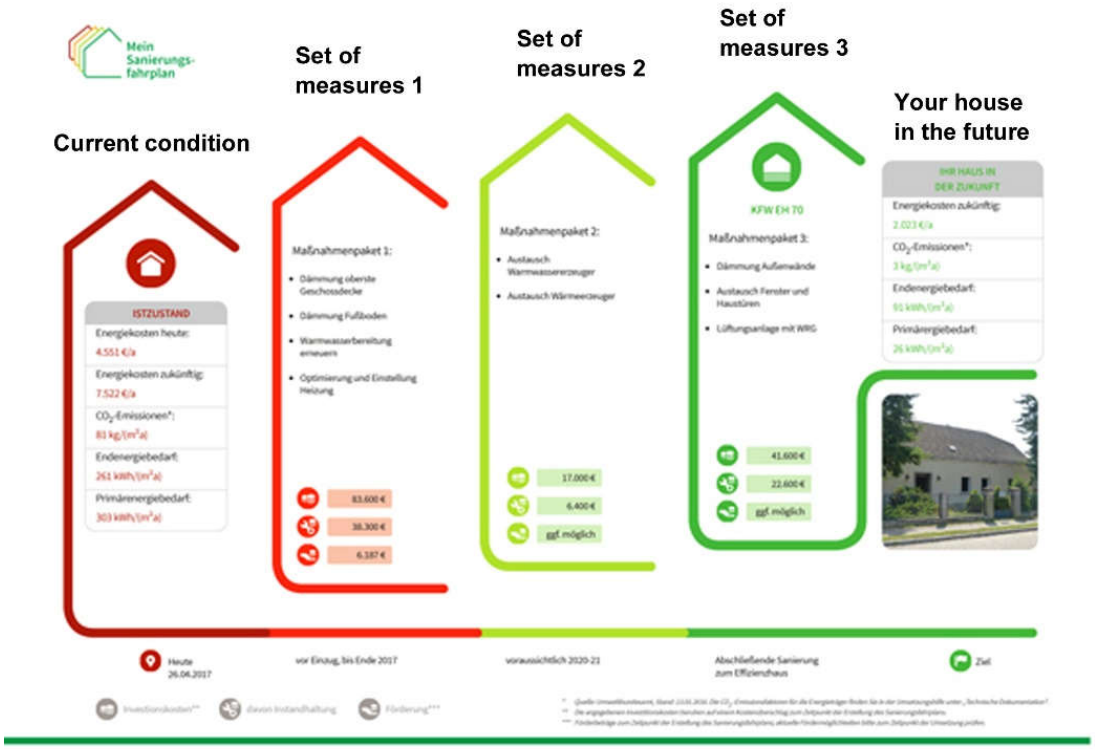

Figure 16 : Hamburg energy pilots' individualized work programme

INTERIM CONCLUSION AND RESULT

One and a half years after the introduction of the one stop shop, the first results can be summarized.

First of all, it became clear that the existing networks of the partner consortium were helpful to reach the target groups (building owners and architects/engineers) to disseminate the offers in a short time.

An important insight was that, most of the time, more than one contact is needed with building owners before they have a clear picture of their modernization plans. After the initial contact, clients should be registered as a case and be supported throughout the whole modernization process or recontacted after a while to check if there are problems. As a "facilitation model", the Hamburg Energy Pilots do not yet provide this all-round support and are primarily active at the beginning in order to advise the prospective builder in the right way. Nevertheless, it is possible for customers to come back to the Energy Pilots with the results of their analysis at any time and to discuss the next steps.

The results on the use of the services offered by the Hamburg Energy Pilots show that there is a great demand for advice on modernization (see Table 3). The Hamburg Energy Pilots exceeded the goal of more than 3500 energy consultations per year

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and implemented almost twice as many building-related energy checks as the target figure in Hamburg in 2020. The information events for homeowners as well as the specialist events were switched to digital-only during the year due to the corona pandemic. Luckily, this had a positive effect and the number of participants exceeded expectations.

Table 3 : Results on the use of the services offered by Hamburg Energy Pilots

Offer	Target figure 2020	Achieved figure 2020	Difference
Telephone & Online Consultations	3500	5255	**+1755**
Personal Consultations	1000	1337	**+337**
Building Checks	500	929	**+429**
Events	17	17	0
Participants at events	1000 - 1200 total (30 - 100 each)	1047	**+47**

BENCHMARK OF FRENCH OSS

Table 4 and Table 5 are summary tables of single-desk assembly projects in France. These territorial initiatives are deployed on several scales, ranging from the community of municipalities to the regional level.

Table 4 compares the "identity cards" of different projects (some of which are now completed). This will allow us to assess the types of buildings covered (individual houses/co-ownerships), the number of salaried workers involved in the one-stop shop, the budgets allocated, the number of renovations carried out, the pool of housing covered and the financing methods.

Table 5 summarizes the various tools offered by the OSS. Like for example thermal audit or diagnosis, infrared thermography "from the sky", help in drafting specifications, help in

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consulting companies or analysing quotes, assistance with site monitoring, assistance with financial editing, etc.

Table 4 : Benchmark of one-stop shops: Identity sheet of the various projects

Project name	Date	Target	Employees	Budget M€/yr	Number renv	Number concerned	Website	Financed by
Mur mur 2	2016 / 2020	Copro + MI	2	2	5 000	130 000	Oui	Subventions + CEE
Reflexenergie	2015 / 2020	MI	5,5	0,9	6125	61 890	Oui	Subventions
Savecom	2016 / 2018	MI	7	0,2	100	110 000	Non	Fonds publics / privées + Banques
Tinergie	2012 / 2020	Copro + MI	2,5	0,53	1800	80 000	Oui	Subventions + CEE
Vallée de kaysersberg	2014 / 2016	MI	1	0,53	60	7 130	Oui	Subventions Banques
Pays voironnais	2013 / 2017	Copro	1	0,35	1000	5 000	Oui	Subventions Banques
Biovallée	2014 / 2018	MI	2,25	0,23	1 311	35 000	Oui	Subventions + Autofinancement
Mon projet rehab	2015 / 2017	MI	2,5	0,28	400	33 000	Oui	Subventions + Autofinancement
Vir' volt	2013 / 2016	MI	2	0,85	2 600	50 000	Oui	Subventions + CEE + Banques
Pass'réno habitat 93	2015 / 2017	MI	4	0,35	3400	200 000	Oui	Fonds publics Banques
Oktave	2015 / 2017	MI	4,5	1,3	2 000	382 000	Oui	Subventions + CEE + Banques
Île-de-france energies	2013	Copro	11	**5,320**	2 000/an	3 330 000	Oui	Subventions + CEE + Banques
Ma rénov	2016	MI + Copro	3,5	**1**	2 000/an	770 000	Oui	Subventions + CEE + Banques
Ecorenov	2015 / 2020	Copro	11,2	6	6500	1 300 000	Oui	Subventions + CEE
Renoval	2015	MI + Copro	3	**0,066**	4 00/an	73 800	Oui	
Mon projet renov	2020 / 2027	Copro	-	7	700/an	656 000	Oui	

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Table 5 : Benchmark of one-stop shops: A journey to support the various projects

Project name	Thermo graphy	Diagnosis	Self diagnosis tool	Draw up schedule or spec.	Consult firm or quote	Draw up grant application	Help track works	Monitor consumpti on after acceptance	Type of OSS
Mur mur 2	Non	Non	Non	Oui	Oui	Oui	Non	Oui	Type 1
Reflexenergie	Oui	Oui	Non	Non	Oui	Oui	Oui	Non	Type 2
Savecom	Non	Oui	Non	Oui	Oui	Oui	Oui	Oui	Type 2
Tinergie	Non	Non	Non	Non	Oui	Oui	Non	Non	Type 1
Vallée de kaysersberg	Non	Non	Non	Non	Oui	Oui	Non	Non	Type 1
Pays voironnais	Oui	Oui	Non	Non	Oui	Oui	Oui	Oui	Type 2
Biovallée	Non	Non	Non	Non	Oui	Oui	Non	Oui	Type 1
Mon projet rehab	Non	Oui	Non	Non	Oui	Oui	Oui	Oui	Type 2
Vir' volt	Non	Oui	Non	Non	Oui	Oui	Non	Oui	Type 1
Pass'réno habitat 93	Non	Oui	Non	Oui	Oui	Oui	Non	Oui	Type 1
Oktave	Non	Non	Non	Oui	Non	Oui	Non	Oui	Type 1
Île-de-france energies	Non	Non	Oui	Oui	Non	Oui	Oui	Non	Type 1
Ma rénov	Oui	Oui	Oui	Oui	Oui	Oui	Non	Oui	Type 2
Ecorenov	Non	Oui	Non	Oui	Oui	Oui	Oui	Oui	Type 2
Renoval	Oui	Non	Oui	Oui	Oui	Oui	Non	Non	Type 2
Mon projet renov	Non	Oui	Non	Oui	Oui	Oui	Oui	Oui	Type 2

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IMPACT OF ONE-STOP SHOPS ON OBSTACLES TO RENOVATION

In conclusion to the previous parts of the Section: ***One stop shop : A Generalized Integrated Renovation System***, it should be noted that, in most cases, this type of accompaniment makes it possible to:

- Coordinate the renovation process and the various actions around the owner.
- Structure and organize business groups to provide a relevant response to the needs of owners.
- Develop global and packaged solutions, even for small projects.
- Develop industrialized renovation solutions tailored to the territory.
- Provide assistance for funding requests to help homeowners get started.
- Promote a multi-purpose approach including the enhancement of the property to enhance the renovation work.
- Involve new players: solicitors, authorities, property managers, etc., who are key players in the field.
- Ensure verification of results and post-work checks (quality of work and energy savings).

It is through these points that one-stop shops allow some of the obstacles mentioned above to be overcome. Some articles detail this phenomenon [45], [63] :

Fragmentation of construction trades, multiplicity of professionals involved in each step: the one-stop shop is a single entry, a platform linking the owner and the various participants.

Information and credibility: the work done on global renovation packages, solutions and benefits helps to better promote energy efficiency. The use of quality control and assurance systems or the requirement for partners to pass certification/training are some of the methods that allow one-stop shops to gain credibility.

The ability to implement the work: structuring the professional offer ensures a balanced and coordinated implementation. The one-stop shop can then act as the main manager of the renovation project

In order to decide whether the owners are involved in the decision-making of the project: the one-stop shop can guarantee the technical and financial viability of

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the project. In addition, developing a quality assurance or labelling system means that owners can rely more on the know-how of companies.

Discouragement when faced with the different administrative procedures: the one-stop shop is often a place giving advice and assistance in the administrative assembly of projects. The owners are therefore not left to their own devices on this aspect. Some one-stop shops offer to build up the application for a grant for individuals.

Discouraging budgetary stress: the one-stop shop **identifies** all the solutions and selects the most financially appropriate ones. Government support for the project leader in some cases allows for a loan or grant to support the renovation project.

Unattractive financial improvements: in the case of multi-purpose projects, it is possible to highlight other aspects in order to enhance the renovation project (thermal comfort, life cycle analysis, energy). A digital platform dedicated to simulation can test different combinations of renovations to find the most cost-effective.

All this knowledge and all these strategies and programmes have now entered urban practice with continuous improvements. It is the evolution of these different projects that has helped to remove a large number of the obstacles to renovation. Several recent European project documents illustrate this point [92]–[94]. Nevertheless, the use of these practices leads to the emergence of new problems (see Figure 17) [44], [93], [94] :

- Lack of human and financial resources for complex actions requiring multidisciplinary teams.
- Lack of vertical and horizontal coordination in urban renewal projects.
- Lack of planning on cross-cutting areas at the beginning of the project. For example, few projects incorporate social aspects from the outset.
- The lack of effective diagnostic tools or planning tools. This is defined as the biggest drag on planning.
- Lack of knowledge about the use of a large number of different indicators.
- The lack of reliable and open-source energy diagnostic data to date. For example, housing or DPE databases

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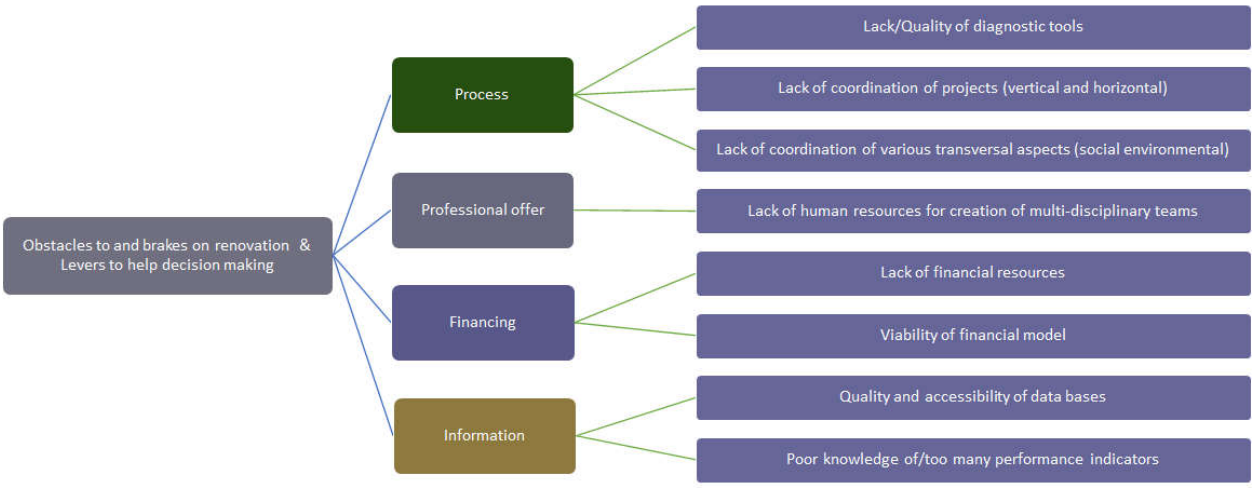

Figure 17 : Review of new obstacles to one-stop shop renovations

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DIGITAL TOOLS

We have seen in previous sections that the renovation process can be complex and that it is beneficial to understand the different stages in a process of global integration. Subsequently, we defined one-stop shops as places (administrative or commercial, physical or digital) that are intended to bring together all the services offered to individuals to ensure the continuity of the renovation process. This section looks at the impact of the platform and its digital tools on the success of a one-stop shop.

LOCAL AUTHORITIES' CHALLENGES FOR THE ASSEMBLY OF DIGITAL PLATFORMS

The success of the implementation of a renovation support programme depends on the quality of the renovation and the capacity to support the programme: reducing planning, design, construction, operation and maintenance times allows more projects to be taken in hand. It is also essential to ensure that cost/benefit targets are attainable.

In the case of one-stop shops, the digital tool helps guide owners and designers in planning the work. It can be defined as a privileged place for meeting and information sharing. The tool generally serves as a guide to optimize the application of the overall renovation process. For example, it can collect all the information about the initial condition of the building to be renovated together with the preferences, needs and wishes of the building owner. The platform can also be used as a support for simulation software or a decision-support algorithm to process information. Thus, its main advantage is the ability to manage the whole process in a comprehensive way. The use of the digital tool is then a means of deploying the instruments necessary for the success of the OSS [72], [73], [95].

Almost all digital platforms are based on creating methods, describing the needs of the renovation process, using databases and computational tools [71], [49], [73]. It is therefore necessary to make regular updates depending on the pace of evolution of the OSS. It is also important to be able to create reliable starting information about the housing stock and to provide a solid initial model. In order to reliably assess the potential of a work programme, the actors involved must have easy access to reliable tools. It is on this point that the quality of the initial information will have the greatest impact [96].

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DIFFERENT LEVELS OF ACTION AND INITIATIVES

INTEGRATION OF PROFESSIONAL SUPPLY

Cre et al. conclude from several surveys that companies consider a website as an important tool for knowledge transfer. A website should also serve as a portal to generate demand and connect customers with the supply and knowledge provided by companies.[63]

To go beyond a simple site that integrates the supply and demand for energy renovation, Mlecnik insists that an integrated renovation project site must develop to become a OSS in its own right. [64]

For example, the presentation of demonstration projects brings together the expertise of companies that carry out energy-efficient renovations. It also adds value to the companies involved.

TRANSFER OF KNOW-HOW

Mlecnik shows [64] that innovative knowledge and methods of renovation are not sufficiently disseminated to the different communities in relation to the renovation. Although there are companies that offer energy-efficient thinking services, they reach only a small share of the market.

To optimize the renovation process beyond this fragmentation, it is important to facilitate the transfer of knowledge among SMEs. In the context of OSS projects, this work can be carried out by mapping the main points of attention. When more complex situations arise and the modalities of execution require an expert approach, then a matrix approach to resolution can be considered, according to Vrijders et al. [65].

Another important aspect is the development or implementation of new and innovative solutions. European product designers and manufacturers are proposing new solutions to improve current construction and renovation practices. One-stop-shop projects can result in a compilation of available innovations. These "integrated solutions" have the advantage of being easy for businesses to understand and having an educational aspect for individuals [65].

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RENOVATION ENERGY PASSPORT

The Energy Passport is a single document that identifies the characteristics of a building. This identity card serves as a reference document throughout the accompanying journey. It is also used to collect data on building characteristics, energy efficiency and comfort levels. The aim of the passport is to make up for a lack of data and information sharing [96]–[98].

Building construction data can be found in the plans and records of everything that has been built. When this data is missing, databases that contain information on the building materials of French housing (MAJIC, BD TOPO, FILOCOM, MAPUCE, ERISCOPE etc.) can be used. [42], [98], [101], [102] . All of this data is constantly being enriched by the contribution of new practices and databases. However, there is no standardized method for archiving, using or sharing building composition data, and this results in loss of information in general. It is important that this data be codified, stored and processed so that it can be turned into information and refined into knowledge.

The EU Directive 2018/844 aims to accelerate the pace of building renovations and improve the performance of new buildings. It introduces a document optional called the Building Renovation Passport : the passport helps to provide a long-term, step-by-step renovation roadmap, for a specific building, based on quality criteria, following an audit energy efficiency, and describing relevant measures and renovations that could improve energy performance. Figure 18 summarises the issues related to the use of this passport. The Institute for the Performance of European Buildings also proposes a document on this subject with a method of using the renovation passport [102].

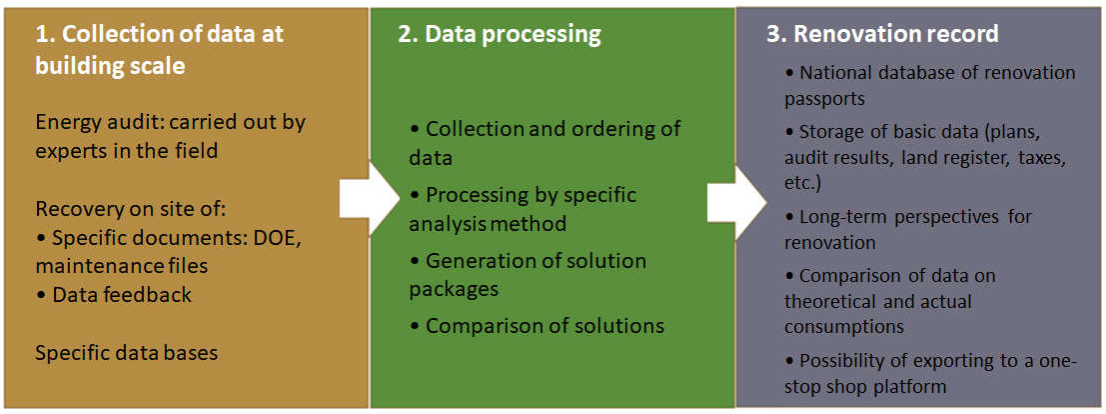

Figure 18 : Energy Renewal Passport Issues

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DECISION SUPPORT TOOLS AND MULTI-LENS OPTIMIZATIONS

One of the sensitive elements of the renovation process is the iterative approach of decision-making and evaluation of work scenarios to find the optimal solution (see Section: **Integrated renovation process**). However, the lack of technical skills or the choice of objective comparison criteria should not become a hindrance to the project.

It is in this context that decision support tools based on algorithms can be used to classify different solutions [49], [73], [103], [70]. The most common study method is the comparison of the criteria by a value and weighting analysis associated with each criterion [49].

We have also mentioned in previous chapters that the success of a renovation programme is not limited to reducing energy consumption after receiving work (see Section: **Energy Renovation: Features and Issues).**

An assessment can be difficult to undertake. A building and its environment are complex systems that span several levels (technical, technological, environmental and social). Owners can therefore have multiple expectations regarding, for example, comfort, lighting, air quality, etc.

Multi-criterion analysis can be seen as a decision-making process that must reconcile multiple and often conflicting objectives. The analysis uses algorithms to find the best possible compromise based on the interactions of different domains [48], [49], [104]. There are a very large number of multi-goal decision methods and associated mathematical models in the scientific literature. A review by Nielsen offers a comparison and a ranking of 43 models based on their use[49].

One can then imagine that the generation of renovation scenarios could be automated, according to building types, together with "pre-constructed solutions" to highlight different areas according to the work envisaged [104], [105].

BUILDING INFORMATION MODELLING (BIM)

Building information modelling (BIM) is a new approach to the design, construction and management of facilities, in which digital representation is at the centre of the construction process. This makes it easier to model, exchange and manage information in digital format. The BIM Handbook defines BIM as a modelling technology and a set of associated processes that produce, communicate and analyse building models. These same models

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are digital objects associated with graphs, calculation tables, parametric rules and data attributes [106].

Several articles in the literature suggest using this technology in the field of renovation to improve the design process of the work [107]–[110]. In particular, it allows better management of renovation measures and a more comprehensive approach to assessing the various possible options. For example, thermal and energy simulations are rarely taken into account for the renovation process. BIM-based tools offer this possibility from the early stages of renovation projects.

Ilter has explained that BIM can be used in renovation in three different ways [110] :

- To determine what level of certification can be achieved using the simulation (for example, the LEED label),
- To perform analyses related to the shape of the building: orientation, mass, envelope of natural lighting ...
- To carry out analyses on the use of energy, water, ventilation etc. in the building

The collection of information in order to simulate the energy performance of the existing stock is a sensitive point compared to new buildings. Although the calculation assumptions used for renovation projects are better known and better defined than for new constructions [107], for an existing building, knowledge of the materials used, the construction methods, and partial renovations varies greatly depending on the project.

Finally, the prototyping of the project in 3D modelling can allow homeowners to project themselves into a renovation programme. This is an item that can be used as a trigger to help homeowners in their choice. [108]

Farzad [52] proposes to integrate a multi-objective optimization algorithm approach and the use of BIM to highlight a construction approach centred on Life Cycle Analysis. It then becomes possible to study different aspects of the building and work on cross-cutting and environmental aspects of the project while facilitating decision-making.

CASE STUDY

An example of this type of assembly is the BetterHome one-stop shop in Denmark. Since the launch of the model in 2014, it has recorded a pace of renovation of 200 projects per year and is expected to continue to grow. The renovation process, which focuses on the owner, is based on two main mechanisms: structuring the process for installers and raising awareness among building owners.

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Although the essential aspects of the single-desk process are reproducible in most places in Europe, the model must be adapted to the local context. According to the consortium, different aspects need to be taken into account when mounting a digital tool[92], [111] :

Using digital solutions to add value for end-users: BetterHome shows that digital solutions can help the construction industry focus more on the consumer and move towards services. Through the use of innovative digital tools, building professionals can offer a smoother process for themselves and the owner. Alignment with existing market players, including banks and suppliers, creates a constructive situation where everyone wins.

Structuring supply: The success of the owner-centred one-stop shop model can be explained by the advanced role that businesses play – a service-based role. BetterHome trains and guides installers on how to approach the owner, from the first contact to the finalization of the process. The digital platform simplifies and structures the renovation process for the installer. It is these same innovative digital tools that allow a better evolution in the project for all concerned.

Raising awareness among end-users: Users and installers need training to make them aware of all the cross-cutting benefits (thermal comfort, sanitary framework, GHG emissions). The installer not only replaces the old building elements but creates a better living environment for users.

Safeguarding good reputation: In Denmark, the four companies behind BetterHome are highly respected and associated with quality. Thanks to the cooperation within BetterHome, companies have worked together to gain fame.

MY EP NOTEBOOK, IZGLOO

"My Notebook" (formerly Izigloo) is a digital service for single-family homeowners that offers a wide range of services going beyond energy performance. The platform can manage cost estimates for about 45 different types of work in a home. It provides homeowners with a comprehensive service to manage and improve their homes in a simple and cost-effective way.

Operated by the start-up Energie Perspective (EP), without public subsidy, it has already supported the renovation of more than 3750 houses, involving 55 million euros of investment. Originally launched in the Loire-Atlantique and Rhône regions of France, "My Notebook" is now available country wide. The aim of EP is to extend this service to the European level.

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The accompanying route takes place in different stages:

- 10 to 20 simple questions are asked of the owner. Collecting this data makes it possible to make a simple diagnosis based on an energy performance indicator

- Various energy-saving measures are offered to the owner. This offer includes encryption and available financial aid.

- The site proposes to contact a service to help the project management during the execution of the work. Professionals can then contact the individual according to the chosen work package. The use of an energy passport facilitates this process.

- The site offers a wide range of services that go beyond energy improvements: automation, improvement and housing development (for example, installing a new kitchen), moving assistance, changing energy suppliers, etc.

- The tool's financing plan works on the royalties generated for each link between local market participants and for the overall coordination of the work when the client decides to opt for full support/support for his renovation project.

CASBA-SITERRE, 19

The Casbah-Siterre digital suite includes two complementary tools aimed at facilitating the support and quality of renovations. Energies Demain and ARTE describe these platforms in their paper: "Call for expressions of interest Casbâ for the New Aquitaine region" [112].

According to their description:

- Siterre is a mapping information system from a database collection. It enables territorial monitoring of the needs and progress of renovation projects. Buildings are characterized according to their typology and construction methods to deduce energy consumption models and DPE labels – all the building-related estimates that allow a territory to be studied.
- Casba is a business software for the implementation and follow-up of renovation work by a councillor of the territory. A simulation component is used to estimate the impact of the work scenarios at energy and environmental levels.

Both tools are communicative, so Sierre supplies Casba with building input data. After the return from Casba, the enriched data is reassembled on Siterre to improve the accuracy of the database. Figure 19 illustrates the interaction between these two tools. Unlike other digital tools, this Energy Tomorrow suite offers automatic diagnosis of buildings and the opening of a complete health book adaptable to most projects.

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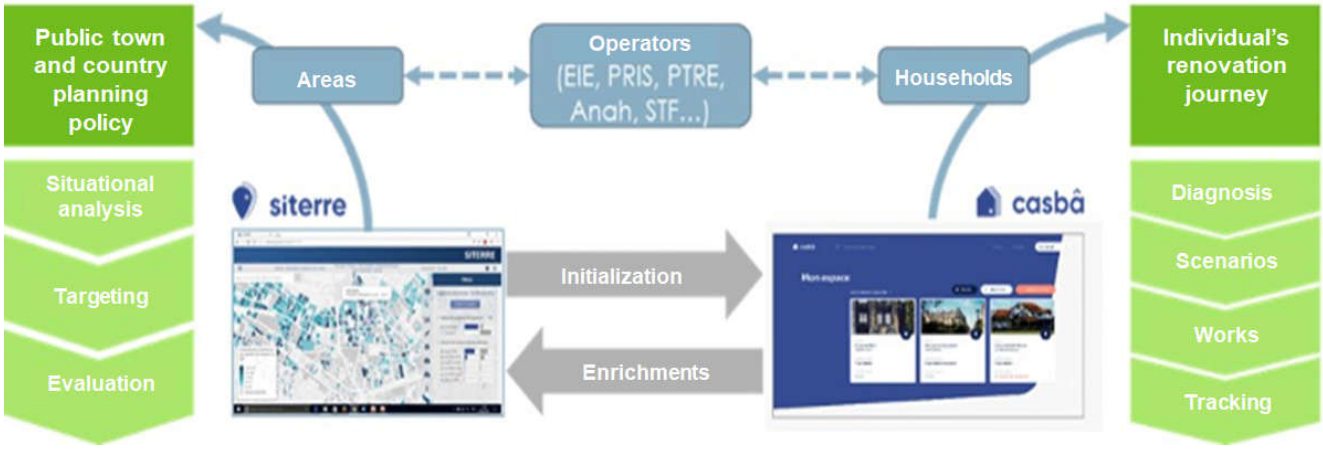

Figure 19 : Articulation of the two tools Casba-Siterre

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CONCLUSION

This summary of the literature has allowed us to point out the potential and the common methods of accompaniment in the field of energy of a real estate stock. It is applicable not only to the areas of energy efficiency but also to cross-cutting areas: thermal comfort, life cycle, air quality...

Given the age and the share of consumption attributable to buildings on a global energy mix, improving the energy efficiency of housing could achieve European environmental objectives.

To this end, the first part of this document defines and details the path of an energy retrofit project. A paradox then appears: despite the potential and the many related benefits that a work programme can bring, the annual renovation rate is less than 1% in France.

The rest of the document therefore introduces the main obstacles that are responsible for this paradox. These issues are classified and put into perspective with the different stages of a renovation journey.

The third part deals with a new method of project management mentioned in numerous articles of the scientific literature: integrated renovation is an iterative process that approaches the different phases as a single entity. This concept is defined, differentiated from a classical accompaniment and classified according to its different dominants.

Applied to multiple support initiatives, integrated renovation routes are often used in one-stop shops. Thanks to this method of management, these physical or digital places are able to offer all the services necessary for the successful implementation of a project in one place. Here, the one-stop shops are studied theoretically with the scientific literature and empirically with the feedback from various existing projects. The different types of one-stop shops are detailed according to their accompanying paths, how they relate to a conventional renovation and the impact they can have on the different obstacles studied.

Like any alternative method, one-stop shops can introduce new delays in progress. However, digital tools can improve the quality of renovation while reducing support times. Several theoretical initiatives have been detailed here (e.g., energy passport, decision support tools, etc.) and then compared to existing platforms.

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