

Sustainable building : barriers and drivers to energy-efficient refurbishment in the residential sector. Empirical findings from five European countries.

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Summary

In many European countries the share of existing old buildings – built before the first heat-conservation regulation - is large. These buildings represent a huge potential for energy saving but which is hard to exploit. Achieving this challenge depends not only on technical solutions but also on socio-economic drivers (willingness and skills of stakeholders, regulation and incentives, norms and values).

Our paper stems from a study involving five European countries. It aims to analyse the weight of these socio-economic factors in the decision making process, and to identify the supply conditions necessary to meet the needs of households for energy-efficient refurbishment. To do so, several energy-efficient-retrofitted houses in the private sector have been selected as case studies in Germany, Switzerland, Italy, Spain and France. For each case, on-site surveys have been conducted, including qualitative interviews with the owners, the residents and the involved professionals. In addition, a thorough context analysis has been conducted in each country in order to reveal specificities regarding the retrofit market, the housing building stock, energy uses and the support measures implemented by local or national authorities as regards energy refurbishment.

This study allows to compare experiences and to share knowledge about support actions able to boost energy-efficient retrofitting. The paper will examine what policies and measures are in use and how effective they are in the different countries, what is the role of financial incentives, what are the different levels of action (national / local) and which are the motivations and practices of actors involved in these energy saving projects.

Results show in particular that:

- people getting involved in projects of energy-efficient refurbishment aren't mainly and exclusively motivated by energy savings;
- there's a lack of skilled work force able to meet the requirements of energy-efficient retrofitting;
- public support schemes for retrofitting measures play a crucial role;
- the local embedding of projects is important.

Keywords

Energy-efficient building, sustainable built environment, energy refurbishment, incentives and barriers, European cases studies

1. Introduction

Considering the amount of energy consumption in the residential sector - 26% of total energy consumption in European Union - efforts need to be made to reduce energy demand and boost energy efficiency in European housing. Within this specific sector, the private housing units are particularly hard targets to reach, given the market stakeholders' extremely diffuse character (many professionals and small contractors), the non-professional project owner, the unique technical specificities of each housing unit (in particular of individual houses) and the existence of many obstacles to refurbishment on both sides of the equation (shortage of consumer information and of appropriate financial instruments on one side, lack of training, of professional culture and of a global technical approach and offer on the other side, etc.).

In order to better understand how energy-efficient refurbishment in the private housing sector can spread in Europe, public and private energy and environmental European organisations and companies, have conducted an exploratory study – discussed in this paper. This exploratory study has consisted in observing and comparing various European experiences in order to identify and understand the mechanisms enabling the supply side and the demand side to efficiently match.

To carry out this cross cultural study, five countries in northern and southern Europe with different levels of progress in the energy retrofitting markets were selected: Germany, Switzerland, Spain, Italy and France. In order to better characterise the different national contexts, an analysis of the socio-economic, political and regulatory contexts of each country has first been realised on the basis on existing literature and available statistical data collected by the different European project partners and summarized in a detailed report[2]. Subsequently, a field study was carried out. For each country, four to six energy-efficient-retrofitted buildings in the private sector were selected as case studies and qualitative interviews with the owners, the residents and the professionals involved were conducted to explore how the private-sector housing refurbishment market might become an energy efficiency market.

2. National context analysis in preparation of on-field interviews.

A previous European field study has shown that the efficient deployment of high-energy performance buildings in the residential sector is based on a combination of various factors. This kind of operation is initiated due to specific motivations of the project owners, but is also influenced by energy and research policies, favourable regulations, or even regulatory obligations, and financial incentives [1] [2]]. It is therefore important to know the specific context

of each country considered in the study to set the stage, to correctly analyze the information collected from the on-field investigation and to make informed choices as regards the selection of case studies. This national context analysis enabled to put the five countries' contexts into perspective with regards with the level of development of the energy retrofit market in the private housing sector, the regulatory and financial policies and measures implemented to support energy-efficient refurbishment of existing buildings. Only the main primary conclusions that came out of the national context analysis will be presented hereafter.

2.1 The energy-efficient retrofit market is not at the same stage of development in the five countries

In all five countries, over half of the housing units existing in 2000-2008 were built prior to the earliest heat-conservation regulations in the late 1970s and, consequently, have poor insulation and high heat demand.

If we attempt to draw a global picture of the renovation markets in the five, we would say that this market hardly exists in Spain, where housing-unit renovation consists of structural improvements and does not really take energy into account, whereas it appears to develop steadily in Germany and Switzerland, and more recently, in certain parts of Italy (the Northern part) and in France.

In Germany, the concept of global energy-retrofit of buildings is now well disseminated thanks to the support programs of the public bank KfW (from 2005 to 2008, 450 000 dwellings have benefited from this financial support) and to the demonstration programs developed by the German Agency for Energy (dena). In Switzerland, the concept of global-energy retrofit is also well disseminated, but the maturity of the market varies from one canton (local district) to the other. The public policies developed by the cantons play indeed a key role in this market. In France, the situation appears to be intermediate. An important rise of the private demand has been observed in recent years, partly as a result of the new financial tools put in place by national authorities, and of a rise of the public awareness, but this phenomenon is still recent and fragile, and it concerns mostly owners of detached houses – energy-efficient renovation of blocks of flats is still rare. In Spain, few energy-efficient retrofits are observed in the private housing sector, and when they exist, they are generally arising from a public authority initiative. Finally, in Italy, a strong contrast is observed between the northern part of the country and the southern part. The tax deduction system for instance is much more used by inhabitants of the North of Italy than of the South of Italy; likewise, initiatives like energy certification of houses are observed in the North and not as much in the South.

Whatever the differences between countries, it appears that, in all countries, many windows of opportunity for energy-efficient retrofits of housings are not used and energy retrofits are optimal only in a small share of cases. Some surveys conducted in France [3] and Switzerland (survey from Federal Office for Energy [4] show, for instance, that energy renovations, when they are undertaken, seldom achieve optimal results in terms of energy efficiency [2]. The renovations are made step by step over time and rarely follow a global approach. Changing windows is the most common type of energy-efficiency intervention in all the countries (although still rare in Spain); insulation work is the least frequent.

2.2 The regulatory framework and support measures in the five countries

2.2.1 The regulatory context related to energy-efficient retrofitting

France, Germany, Spain and Italy have transposed the European EPBD (Energy Performance Building Directive) into their national law. Still, regulatory obligations applying to building renovation vary greatly from one country to another. Germany's regulations seem relatively

strict compared to the other countries: the performance requirements applying to each “refurbished elements” is particularly high; global performance requirements apply as soon as 10% of a structural element’s area is refurbished, whatever the size of the building may be, or if the building surface is increased by more than 15 m²; moreover, the thermal insulation of the high living space must be carried out by 2011 if the roof void is non-heated and can not be occupied (Energieeinsparverordnung – EnEV, april 2009, 29). Regulations currently in force in France, Spain and Italy appear looser as only major renovations of buildings exceeding 1,000 m² are subject to a global performance requirement. As for Switzerland, regulations vary greatly from one canton (local district) to another.

Besides the regulatory obligations that address specifically the energy performance of buildings, other areas of regulation have an impact on the energy retrofit of buildings. Rules affecting the decision making process in buildings held in co-ownership are one of them. Germany adjusted its home ownership law in 2007 to facilitate renovation work in blocks of flats held in co-ownership; more recently, Spain, France and Italy have taken similar measures. Little evidence on the effective impact of these facilitating measures is available however.

As for the energy performance certificate introduced by the EPBD in order to raise the public awareness on the energy performance of the buildings and to encourage energy retrofitting, it is not yet perceived as a strong decision-making factor in the countries where it is implemented, although it is becoming more well known and recognized. In this respect, it is worth mentioning that in Switzerland, which is not party to the European Directive, a similar certificate was introduced in 2009 by the cantons and under which the first 15 000 certificates (which were subsidized) were taken up very quickly.

2.2.2 Common features and singularities regarding the financial incentives in place

Germany, France, Switzerland and Italy all offer financial incentives to promote energy-efficient retrofit of housing units, including direct support (subsidies, low-interest loans). These support mechanisms have been highly successful in all four countries and appear as key incentives. Spain on the other hand offers few financial incentives specifically dedicated to improving energy performance in existing housing units and, where they do exist, few people take advantage of them. This is partly due to a lack of communication : (ew people are aware of them and the eligibility criteria are not clear.

It is interesting to mention that several of the financial incentives that are in place in Germany, France and Switzerland encourage the combination of several works in order to reach a high energy performance for the building (i.e. encourage insulation works on the same time the heating equipment is replaced). For instance, this is the case of the loans granted by the KfW public bank in Germany, of the subsidies of the Building Programme of the Centime Climatique Foundation in Switzerland (2006-2009), of the subsidies of the Swiss cantons for Minergie renovations and of the zero-interest ecological loan put in place in 2009 in France.

Besides subsidies and low-interest loans, one should also mention the existence of: tax deductions and credits systems (in France and Italy), financial support to perform energy audits (in Germany, France and Switzerland) and the “white certificates” mechanism (in France and Italy) which functions as indirect financial incentive for individuals.

Based on an analysis of case studies in the five countries, the second part of the study aims to shed light on the necessary conditions for matching supply and demand, and to identify the levers driving the transition from a traditional, piecemeal approach to a more encompassing retrofitting approach for better performance of the building stock.

3. Main findings of the case studies in the five countries

The aim of the field study was to provide an analysis of the ways energy-efficient refurbishments are implemented in the field. 28 energy efficiently refurbished buildings were selected together with our European partners: the architectural and thermal design offices in Germany, France, Italy, Spain and Switzerland. These include: collective housing in Germany (4 cases), detached houses (3) and collective housing (3) in France, detached houses (2) and collective housing (4) in Italy, detached house (1) and collective housing (5) in Spain, detached house (3) and collective housing (3) in Switzerland.

Altogether 61 interviews were conducted with decision-makers and professionals involved in the decision-making and in the operational phase. All the interviews followed a semi-directive interview guideline. Interviews with decision-makers focused in particular on their residential history, the context conditions of projects, motivations for undertaking the works and factors influencing the decision-making process. Interviews with key stakeholders explored their experience in energy-efficient retrofitting, their perception of homeowners' needs and factors impeding or encouraging the implementation of ambitious refurbishment projects.

3.1 The decision making process: saving energy is not the main issue

Cutting energy use was never the main or only issue in the renovation projects studied in the five countries. In most cases, decision-makers did not even consider energy when they started thinking about the project. A conjunction of various factors led them to integrate energy into their renovation project, confirming a finding from previous studies in France, Belgium and Denmark [3] [5].

In few cases, the decision-makers did not even consider the issue at all : it was the professional responsible for the project (generally the architect), totally trusted by the owner, who integrated the energy aspects into the planning.

3.1.1 The renovations' overall context and triggering factors

The main goal of retrofitting detached houses was usually to adapt them to the needs of the families who live there or have just acquired their home. Typically, the owners wish to expand their housing unit as children grow older; they bought a new home and would like to improve the comfort; they purchased an old farmhouse and would like it to become their primary residence. In these cases, the works were a key step in the families' residential itinerary and lifecycle. The work is a way of fitting the building to the family; at the same time the work symbolically contributes to building the family as a previous study found [6]. The buildings' poor condition itself was not the primary driver of the refurbishment projects : it is rather the confrontation between the residential project and the buildings' rundown condition which spurred the decision to renovate.

In contrast, the poor building conditions were the trigger for retrofitting the blocks of flats owned by landlords and co-owners. Those owners made their decision because there was an urgent need to renovate or local officials had required the works (e.g. the obligation to retrofit façades in France and Spain). For landlords, the building's bad condition was an opportunity to bring it up to standards, increase the property's value and facilitate renting.

3.1.2 Motivations for improving energy efficiency

Motivations related directly to the energy issue

Many owner-residents of detached houses aimed to reduce their energy use. Some of them expressed their will to reduce their dependence on increasingly expensive fossil fuels. The desire for a comfortable, good quality home which is prominent in the bioclimatic philosophy (desire to "live with the sun", especially in Switzerland) is the second main motivation behind the objective to reduce energy consumption. Environmental protection plays a more or less important role depending on the project. Most decision-makers consider that aspect a side benefit rather than a triggering factor. Besides, most homeowners in Switzerland indicated that "preserving natural resources" was a important to them. They are not necessarily ecologically minded, but believe that it is normal to pay attention to natural resources and energy use –a finding that demonstrates that they have integrated environmental concerns into patterns and practices. Lastly, a small number of homeowners expected that energy-conservation measures would increase their properties' value.

In comparison, many owners of units in collective housing explained they were aiming to increase their properties value and improve their chances for renting (France, Germany and, to a lesser extent, Spain). Those landlords expect energy efficiency will become a quality criterion in the real estate market in the near future. Furthermore, they consider energy efficient retrofitting as an opportunity to rent their flats more easily. Tenants are expected to appreciate lower heating bills and better comfort. Some may also aim at environmental protection.

Some co-owners considered cutting their own or their tenants' energy bills, improving comfort and/or environmental protection as positive side benefits but those motivations were not a key factor in their decision-making process: the financial incentives were the key drivers.

The other factors that encouraged owners to take energy efficiency into account

Energy savings, better comfort and living quality are main motivations for owners of detached houses to undertake energy-efficient measures (France, Switzerland and Spain), but other factors strongly influenced the decision of owners of units in blocks of flats.

National and local support programmes and awareness of that assistance pushed many flat owners in collective housing to carry out energy-efficient renovations and opt for more comprehensive works (France, Germany, Spain, and, to a lesser extent, Switzerland). Most of the collective housing projects in France and Spain received important financial support, which shows at the same time that the step to make these kinds of refurbishments more widespread is still large.

Regional or municipal support and incentive programmes played indeed a key role in the decision-making process, not only due to the financial means provided, but also due to the advising coming with it. The possibility to benefit from of a collective dynamics, at a local scale, also played an important role in the case of French projects in the framework of regional calls for tender and those carried out as part of OPATB (Planned Heating and Energy Improvement Operation).

The prospect of tighter energy standards played a role in some projects. In France, for example, the possible introduction of stricter energy-efficiency requirements, put forward by OPATB officials, convinced co-owners of the importance of the topic. Overall, public policies play a decisive role when it comes to the deciding on energy-efficient refurbishments.

3.1.3 Some stakeholders encouraged or even led to take energy aspects into account

For many French and Swiss and most Spanish cases, architects played a key role for orienting homeowners towards comprehensive energy-efficient retrofitting. In the case of Spain, all architects involved in the collective housing projects were particularly receptive to the energy

topic, which is rather rare in that country, and integrated it into their projects. In most of these cases, Spanish landlords never considered this issue, leaving all decisions to architects as the trusted experts.

Existing local advisory bodies also played an important role in starting up projects. They have various forms and can act on different levels depending on the country. For many French cases, for example, local energy agencies advised individuals wishing to reply to a call for tenders.

An "intermediate actor" played a key role in the co-ownership decision-making process in France: a person mandated by the town who did an important supporting and communication work towards the co-owners inhabiting the buildings in the framework of the OPATB program (Planned Heating and Energy Improvement Operation). Because of his impartiality and thorough knowledge of financial support available for low-income persons, this expert had real added value by providing "customised" information.

In one Spanish case study, an insulation manufacturer explained the benefits of insulation to co-owners. This type of intervention is important in Spain, where homeowners pay little attention to energy issues. A previous study [7] already pointed out the growing influence of this "secondary network" (institutional and, in the economic sphere, manufacturers and retailers).

Weight of the various drivers identified for energy efficiency refurbishments

	(I) detached houses	(II) residential buildings with 1 single owner	(III) buildings in co-ownership
A. Points for support energy issues	(+++) lower bills (+++) comfortable temperature/quality of life inside the home (++) environmental dimension (<i>awareness of the environmental benefit or symbolic value</i>) (+/-) higher property values	(+++) higher property values (+++) easier to rent (lower bills, more comfort) (++) environmental benefit	(+/-) lower bills (+/-) comfortable temperature/basic comfort (+/-) environmental benefit
B. Other factors that influenced the consideration of energy aspects	(+) financial support (+/-) local dynamics/technical advising	(+++) financial support (++) local dynamics/technical advising	(+++) financial support (+++) local dynamics/technical advising
C. Stakeholders who influenced the decision	Architect Energy consulting bodies	Architect Energy consulting bodies	Architect Energy consulting bodies "intermediate" stakeholder from the community Insulation manufacturer
	<i>(difference depending on the country: these stakeholders' influence is strong in Spain and medium in the other countries)</i>		

Colour key:

	Little influence (of A, B or C) in the residential sector considered (I, II or III)
	Strong influence (of A, B or C) in the residential sector considered (I, II or III)
	Strong influence (of A, B or C) in the residential sector considered (I, II or III)

3.2 Planning and carrying out the works

3.2.1 Works definition and planning with the various stakeholders

The planning of the refurbishment works did not follow a unique, standard, pattern at all. However, some converging points were found cross the countries. For example, local advisory bodies in Germany, Switzerland and France are often involved in the choice of the refurbishment measures. Besides, in all countries, similar problems were experienced in the decision-making process in the collective housing sector.

The role of advisory bodies for the project preparation

Our interviews in Germany, Switzerland and France, report that local advisory bodies informed individuals before they start their projects and continue accompanying them in the later stages, for example by directing them to the most qualified professionals or in the framework of pilot programmes by offering technical support to professionals involved in the project. The advisory bodies are often attached to a city or region (or to a canton in Switzerland). Their added value is providing decision-makers with information on locally available financial support. They also centralise information that is sometimes scattered and confusing when many financial support programmes co-exist on national and local levels.

However, there are considerable differences with regard to their actions. For example, for most of the German cases energy consultants visited the property that will be renovated and performed an energy pre-assessment, whereas in the French cases consultants helped owners to carry out their projects rather than performing a pre-diagnosis. In fact, in the French cases studied, the decision-makers received more help from the advisory bodies than usual because they had applied for regional pilot projects partly managed by these bodies.

In all case, these bodies played an important role in several projects, especially in Germany and France. Owners received precious information, often leading them to modify the initial programme to make it more ambitious and eligible for financial assistance.

Defining the refurbishment programme: with architects or, in Germany, with "energy consultants"

In Germany, "energy consultants" were involved in defining the refurbishment measures of the four studied projects. These consultants should not be confused with consultants belonging to the previously mentioned advisory bodies. These professionals—energy specialists in building technologies—are registered on two lists which are available to the general public administered by dena (the German Energy Agency) and BAFA (Federal Office of Economics and Export Control). Despite this public listing, some interviewees are confused about the roles and responsibilities of the "energy consultants" due to the fact that this title can be obtained by people from different educational venues. In all cases, the German situation does not seem to have an equivalent in the other studied countries.

Project architects in France, Switzerland and Spain usually have the advisory responsibility regarding energy efficiency. Most of them are collaborating with a thermal office. Spain is an exception, as architects do not seem to draw upon the skills of thermal offices. Spanish professionals have not yet developed the practice to assess buildings' energy performance.

Simplified software helping to calculate the energy efficiency performance during the design process is just starting to be developed. The network of professionals taking care of buildings' energy performance is smaller compared to the other countries - a sign that the issue is only emerging.

In most French projects, companies gathering several skills did intervene, including the expertise of at least one architect and one energy efficiency expert, and sometimes of an economist. This organisation had not been observed in France in the previous study on new buildings [1] and provided real added value to the examined projects. It enabled to offer clients several refurbishment scenarios, which, according to the interviewed homeowners, facilitated the decision-making process. The scenarios allow decision-makers to compare several refurbishment projects based on costs, energy performance and financial support available in each case.

Difficulties in co-ownership decisions making

In France and Germany it was particularly hard to carry out comprehensive energy refurbishments in co-ownerships. Those problems are apparently related to high costs and uncertainties coming with the planned refurbishment measures. Young owners are more inclined than older ones. Third parties - energy consultants in Germany, municipality agencies or a co-op leader in France - often had to intervene to convince owners of the suggested work. The decision-making process therefore was often reported to be long and complicated: agreements on refurbishments are hard to find, and voting is only possible at general assemblies, which usually take place only once a year. However, final decision-making is facilitated by majority voting (rather than unanimously).

3.2.2 Doing the work

Difficulties in recruiting qualified companies

In France and Switzerland many owners paid high attention to the recruitment of qualified companies, capable to implement the required technical solutions and to collaborate with other involved professionals. This is because energy-efficient retrofitting projects require special qualifications that only a few professionals possess. Hence owners sought companies that meet these requirements or got closely involved in the worksite themselves to assure the project success. Spanish landlords did not share these preoccupations to the same extent. However, the expected levels of energy performance are not really comparable.

Landlords' involvement in the work

In several French, German and Swiss case studies, owners either monitored the worksite or took part in the refurbishment works. Some of them strived to supervise companies' work to assure the project success; in other cases the need for coordination explains this involvement, which helped to avoid harmful consequences, in particular concerning deadlines. In a few cases owners also aimed to cut costs. However, such a close involvement means huge efforts for owners and the willingness to look into technical details. Some of the interviewed German landlords who coordinated extensive works themselves considered it as a burden.

Quite differently, in the Spanish and Italian projects owners were not closely involved in the work and entirely trusted the mandated architects. This can probably be explained by the smaller scale of those projects (and therefore of a less intrusive nature) or done at an unoccupied site.

Technical difficulties

All in all, only a few major technical problems occurred in the studied projects. The problems concerned the ventilation system in a block of flats and, in another case, the airtight seal under the roof. These problems were not considered as major obstacles, but illustrate the need of professionals who are capable of adapting to unexpected worksite incidents. The issues were resolved thanks to the professionals' ability to innovate and adapt.

3.2.3 After the works

Residents' satisfaction, impacts on their living patterns

Overall, residents expressed their satisfaction with the works, despite the inconveniences some of them may have experienced. They generally like the comfort and good quality of living inside their refurbished homes (convenient, more even temperatures at summer and winter time, good light and air quality), except for rare cases where air quality is a problem or a feeling of confinement was reported. Some people also emphasize savings on their energy bills, although it is hard to have very precise quantitative information.

However, the study revealed that the new thermal qualities do not encourage residents to adopt more energy saving behaviours. Those who had always paid attention to their consumption simply continued to do so. The others haven't changed their habits either.

Finally, some of the studied projects helped to spread knowledge about energy-efficiency, either by providing the involved professionals an opportunity to upgrade their skills or, in some cases, through publicity about the works carried out.

Assessments of the achieved energy performance level

Only in very few analysed projects was post-work performance precisely monitored. According to the interviewees, this type of follow-up is not common practice but might be part of a research project. In Spain, consumption was monitored in two projects. In the first case the architect wanted to evaluate the effectiveness of the refurbishment works he had done in order to improve his future projects' performance; in the second public institutions required information as they were co-financing the project. A German interviewee reported that for ambitious projects - such as the ones carried out in the framework of the dena (the German Energy Agency) programme, - consumption is being monitored for three years in order to evaluate if results match objectives.

Most of the interviewed professionals agree that monitoring consumption would be worthwhile, but are not willing to do it because it is not part of their mission.

4. Conclusion

The field survey presented here helped to identify and understand various factors at work that can either facilitate or impede energy-efficient retrofitting projects. In conclusion, we want to sum up the key factors that, according to our observations, tend to encourage or impede ambitious energy-efficient refurbishments in the private housing sector. Where available we complement our findings by additional evidences from other studies.

Contexts favouring refurbishment: events in relation to people's lives and the life cycle of the building

An obligation or a need to carry out major building refurbishment or adaptation work was behind all studied energy-efficient retrofit projects. Particular events were seized as opportunities to

carry out major refurbishments: typically, the purchase of a detached house or the expansion of a dwelling unit, or, in the case of collective housing, the obligation to perform maintenance work.

Factors favouring energy efficient retrofitting

The prospect of increasing the real estate value of housing units that undergo energy-efficient retrofits, or the benefits associated with such renovations, such as lower bills and greater comfort, often led decision-makers to opt for "ambitious" energy components in refurbishment projects. The study shows that the prospect of boosting real estate value was a bigger driver for energy-efficient refurbishment measures in case of blocks of flats than in detached houses; benefits such as lower bills and greater comfort mattered more to owners of detached houses than co-owners.

A set of factors influenced both these aspects — the prospect of higher resale value and benefits associated with energy-efficient renovation. They have to do with social and cultural values attached to housing, to the idea of well-being in the local socio-economic context and, in a certain manner, in the normative context, which has a positive impact on real estate values.

Two other factors encouraged the adoption of an ambitious energy component into renovation projects: the prospect of tighter regulations and owners' concerns for environmental protection.

A need for incentive schemes to make energy-efficient retrofitting a reality: attendant measures and financial support

Owners' access to information often played a preponderant role in the decision. In several cases, technical and financial advice before the project, and accurate information about available financial support, appeared as key factors prompting the decision to carry out an ambitious energy-efficient retrofit instead of a conventional one. In some cases, local advisory bodies provided owners with important information; in other cases, professionals did. Yet, some owners were themselves well informed due to their profession or personal network.

In cases where individuals trusted the building or project manager's choices, the stakeholders' ability to recommend an ambitious energy-efficient retrofit was decisive.

Another decisive aspect was the amount and nature of financial support available and individuals' knowledge of that assistance. This was a key factor for most of the collective housing renovation projects. One person interviewed in Germany said that at first she had no intention to undertake a total energy renovation but the possibility of obtaining support convinced her to do it.

Local embedding favours energy-efficient refurbishment measures

In addition to support and incentive measures, local authorities' actions had a big impact on several projects. Some of them made access to information easier by creating a advisory service for private individuals; others set up support programmes combining financial support and advice services and launched local dynamics to promote energy-efficient retrofittings.

Regarding barriers to energy savings, this study confirms a number of obstacles found in other research projects [8] [9] [10] [1], in particular:

- *Lack of households' information on available solutions and the saving potential of comprehensive measures.* Individuals are insufficiently acquainted with the energy performance of their building (insulation and performances of equipment) and with the comfort and quality of

life an energy-efficient retrofit can bring, although the degree of unfamiliarity varies depending on the country. In Switzerland, there has been a major communication effort on the Minergie standard that emphasized the relationship between energy-savings and comfortable temperatures.

- *High expenses and opaqueness of costs.* In every sector studied, not just detached houses, energy-efficient retrofits entail costs that few people can actually afford. Some landlords with small properties may have trouble financing extensive work. For buildings held in co-ownership, including insulation in a renovation can add 40% to the bill, which is considerable for some owners. Financing is an issue for all types of residential buildings to spread energy efficient retrofits on a large scale.

- *Lack of incentives and changing policies.* Some interviewees in Germany complained about confusing political signals during the past two years. Budget cuts due to the economic and financial crisis have temporarily eliminated the economic development promotion programme, which supports facilities using renewable energy. Such political signals are confusing and may have harmful consequences on owners' and professionals' decisions to invest in energy-efficient buildings. Likewise, in France the "budget reorientations" the government has decided for in 2011, including less support for energy efficiency and renewable energy in the construction sector, may cause some confusion. Contractors, for example, have long feared a rise in the 5.5% VAT on renovation work, but the rate finally got unchanged. In Spain, the lack of regulatory constraints and incentives (such as energy performance labels) was lamented.

The supply side appears insufficiently structured and specialised and access to information is sometimes difficult. An important obstacle seems to be the workforce which is only partly capable of satisfying the demand. Skilled professionals in all involved building profession — engineers, architects and contractors — are still not numerous (see also outcomes from the European study Barenergy [10]). Many construction workers seem to lack knowledge about new products, be insufficiently aware of the need to coordinate with other professionals involved in the project (lack of "meta-skills") and lack a comprehensive view of the building. This assessment appears especially true for Spain, Italy and France, but in some cases, also, for countries more advanced such as Switzerland and Germany. There is consensus among experts in France on the need for better coordination between professionals to refurbish to create more low energy consuming buildings [11] [1] [7].

The wide range of intervening professionals caused some confusion, especially since there is not necessarily a good coordination between the various organizations involved. All in all, it was often hard for individuals to access information, which tended to discourage them from undertaking energy-efficient retrofits: people in Spain and Italy emphasized the lack of readability and the difficulty of accessing financial support. Often, the local institutional context (local consulting organization) encouraged the creation of a network facilitating information access. It also encouraged or penalised energy-efficient retrofit projects depending on whether building regulations were applied (in particular, the Italian ones on heritage and landscape preservation).

Social conventions and diverging priorities on the demand side. In addition to these economical and technical barriers which might hinder a move forward in the building sector, social conventions in relation to thermal and acoustic comfort, light, air quality can impede the progress of the energy efficiency refurbishment market (i.e. perceptions of inside air quality can affect technology diffusion as seen, in the previous study [1] in Germany and Switzerland with mechanical ventilation system). Furthermore, diverging priorities can affect the decision making process. In a context of high real estate prices more floor space is prioritised over environmental protection and some people reject certain kinds of thick insulation materials or façade insulation in order to preserve old building's aesthetic value.

Considering this body of evidences on key factors and impediments, which measures might be pushing energy-efficient retrofittings and sustainable building ?

Creating financial incentives for households (tax reliefs, loans and subsidies), establishing regulations based on an overall energy approach to buildings and training professionals seem crucial to tackle these barriers. The eco-building market needs to be boosted. The local level, in particular through calls for tenders, appears to be very appropriate to boost energy efficiency initiatives in the residential sector.

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