

Retrofitting multifamily buildings with prefabricated modules – RETROKIT

STAKEHOLDER NEEDS AND VIEWS



SINTEF Research

Tommy Kleiven, Ruth Woods and Birgit Risholt

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ABSTRACT

Multi-family apartment buildings have the highest energy demand in Europe, consuming 68% of the total final energy use in buildings in Europe (Economidou et al., 2011). Most of them were built between 1945 and 1980 and are now ready for retrofitting and have a huge energy-saving potential. The apartment buildings located all around Europe share many common features; architecture, structure and materials. This makes them suitable for retrofitting with prefabricated modules which allow for cost efficient mass production. In addition building service technologies can be integrated in the modules and the residents can stay in their homes during retrofitting. Quantitative research methodology in the form of a questionnaire has been used to provide data about the use of and expectations for retrofitting with prefabricated modules in 11 European countries among stakeholders in retrofitting. Due to the exploratory nature of the research the intention has not been to test a hypothesis but to provide indicators with which to understand societal trends associated with deep retrofitting.

The findings show that the most important requirements a prefabricated retrofit solution has to offer to be an attractive alternative are; energy performance, adaptability to the building, efficient construction, flexibility in design, and adaptability to the resident's needs. The three most referenced characteristics of good retrofitting design were energy efficiency, cost and aesthetics. The greatest pitfalls associated with prefabrication were limited architectural freedom with poor architecture as a result and high costs.

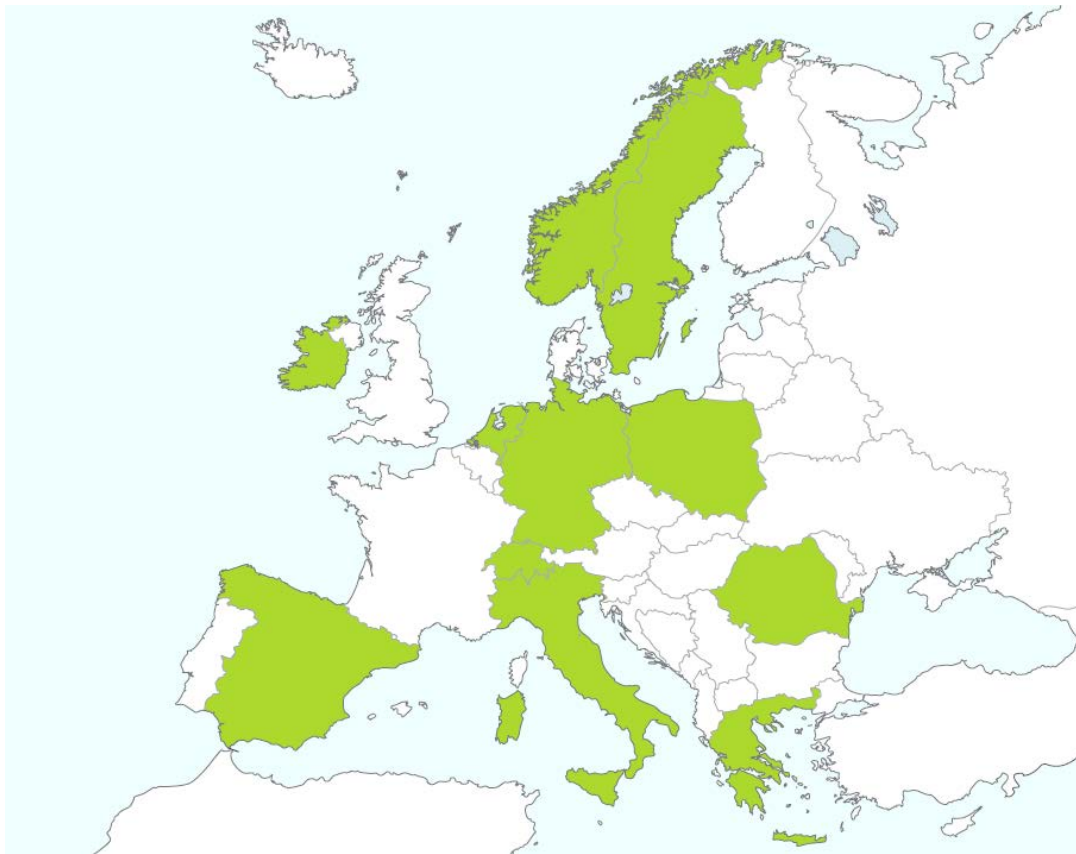
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1 Summary in Norwegian

I forskningsprosjektet "RetroKit – Toolboxes for systemic retrofitting" (2012-2016), finansiert av EUs syvende rammeprogram og Husbanken, samarbeider 11 land om å utvikle prefabrikkerte løsninger for ambisiøs oppgradering av etterkrigstidens boligblokker. Det overordnede målet er å bedre komforten til beboerne samtidig som energibehovet reduseres. Boligblokkene fra perioden 1945-1980 utgjør en stor del av den totale europeiske bygningsmassen og står også for en betydelig del av dens energibruk. De byggetekniske løsningene og det arkitektoniske uttrykket er veldig likt for denne bygningstypen over hele Europa, noe som gjør dette til et massemarked egnet for oppgradering med prefabrikkerte og standardiserte løsninger. I løsningene som utvikles i RetroKit-prosjektet, integreres teknologier som ventilasjon, solavskjerming, passiv kjøling og fornybar energiproduksjon. Løsningene skal prøves ut i oppgradering av tre boligblokker bygget i etterkrigstiden i Sverige, Tyskland og Spania.



Figur 1.1 Kartet viser de 11 landene som er partnere i RetroKit-prosjektet og som har bidratt med empiri inn i spørreundersøkelsene og kartleggingene som er gjort: Hellas, Romania, Italia, Polen, Sverige, Norge, Tyskland, Nederland, Sveits, Irland og Spania.

For at løsningene og konseptene som utvikles i prosjektet skal bli best mulig, trengs kunnskap om behovene og synspunktene til aktørene i byggenæringen. En elektronisk spørreundersøkelse ble derfor gjennomført i de 11 partnerlandene, se kart, blant aktører i byggebransjen (arkitekter, konsulenter, entreprenører, byggeiere, myndigheter og produsenter av prefabrikkerte moduler og systemer). I tillegg ble lover og regelverk analysert i forhold til krav til arkitektonisk kvalitet i forbindelse med rehabilitering og oppgradering i de samme 11 landene. Forbildeeksempler på ambisiøst oppgraderte boligblokker, helst med en grad av prefabrikasjon, ble også kartlagt i de 11 landene. Funnene fra disse undersøkelsene samt hvordan de ble gjennomført er presentert i denne rapporten. Kort oppsummert er de viktigste funnene at:

- ✓ Alle de 11 deltakerlandene i RetroKit-prosjektet har krav til arkitektonisk kvalitet i sine lovverk og forskrifter, men kravene varierer i stor grad mellom landene. Felles for alle land er at det hersker stor grad av usikkerhet om når, og i hvilke tilfeller, gjeldende lover og forskrifter (på bl.a. energi og universell utforming) trer i kraft i et oppgraderingsprosjekt.
- ✓ Det finnes få eksempler på boligblokker som er oppgradert med prefabrikkerte bygningselementer/moduler i de 11 landene. De som ble funnet ligger i Tyskland, Nederland og Sveits. Bruk av prefabrikkerte bygningselementer er mer utbredt i eneboliger og da spesielt for nybygg.
- ✓ Fordelene med å benytte seg av prefabrikkerte moduler for oppgradering av boligblokker er at beboerne forstyrres i mindre grad samt en mer effektiv byggefase der det er lettere å sikre en tørr byggeprosess. Færre byggefeil og forbedret byggekvalitet ble også ansett som en fordel ved prefabrikasjon kontra tradisjonelt plassbygg.
- ✓ Bakdelen med å bruke prefabrikkerte moduler for oppgradering av boligblokker er begrenset arkitektonisk frihet, at det blir kostbart og at oppgraderingen resulterer i arkitektur med lav kvalitet.
- ✓ De tre viktigste karakteristika for et godt oppgraderingsprosjekt blant de som svarte på det elektroniske spørreskjemaet er, i prioritert rekkefølge, energieffektivitet, kostnader og estetikk (arkitektonisk uttrykk).
- ✓ Den viktigste grunnen til at en byggeier går for en ambisiøs oppgradering er det faktum at bygningen er i en tilstand der det er behov for rehabilitering. Typisk har en eller flere sentrale bygningselementer nådd sin levetid og må erstattes. Den nest viktigste grunnen for at byggeiere går for en ambisiøs oppgradering er for å forbedre bygningens energieffektivitet. Den tredje viktigste grunnen er å forbedre termisk komfort og inneklima.
- ✓ Byggeieren ansees som den mest innflytelsesrike aktøren i beslutningsprosessen, arkitekten som den nest mest innflytelsesrike og myndighetene (lover og regler) som den tredje mest innflytelsesrike aktøren i beslutningsprosessen.

Norge hadde den høyeste svarprosenten (figur 3.2) og en god og jevn fordeling av aktører som svarte på spørreundersøkelsen (figur 3.4, øverst). De norske svarene skiller seg i svært liten grad ut fra svarene fra de 11 landene sett under ett.

Denne rapporten bygger på leveransene D1.1 "Requirements of societal aspects for a successful and beneficial RetroKit Toolbox", D1.2 "Design guidelines for an architectural attractive RetroKit Toolbox" og deler av D1.4 "Success criteria for market implementation" som kan lastes ned gratis i sin helhet fra RetroKit prosjektet sin hjemmeside: <http://www.retrokitproject.eu/reports>

2 Introduction

The residential buildings dating from 1945-1980 were built during the high post 2nd World War construction activity in Europe. Producing enough houses for the European population was a far more prominent design criterion than energy efficiency. As a result, this building type (multi-family apartment buildings) is the one with the largest energy demand in Europe, consuming 68% of the total final energy use in buildings in Europe in 2009¹. Due to age, most of them now require retrofitting or refurbishing intervention and large energy savings may be achieved by retrofitting these buildings¹. They are located all around Europe and share many common features with respect to architectural, structural, material, and energy consuming equipment/processes.

In the RetroKit project 11 partnering countries collaborate in developing prefabricated solutions for ambitious and holistic retrofitting of multi-family apartment buildings in Europe built between 1945 and 1980. The overall project goal is to increase comfort for the residents and at the same time reduce the buildings energy demand. This is to be done by developing modular and multifunctional prefabricated solutions that can be installed in a single retrofitting intervention with minimum disturbance for inhabitants. To make sure that good concepts and solutions are developed, knowledge on the needs and views of the stakeholders involved in retrofitting is needed. Therefore a survey has been conducted. The architectural regulations and requirements have been mapped in the 11 partnering countries as well as best practice building examples. In addition an electronic questionnaire survey has been carried out among stakeholders involved in retrofitting. Together, these three sources of evidence provide the empirical input to this report on the requirements of societal aspects for a successful and beneficial implementation of RetroKit Toolbox.

2.1 Society and societal aspects

Society is a term which is associated with social organisation or social structure. It is generally conceived as a human group which is relatively large, autonomous, self-perpetuating and distinct in demographic terms. In *The Division of Labour in Society* Emil Durkheim suggests two kinds of social solidarity which connect the individual to society (Durkheim, 1997 [1893]). The first is mechanical solidarity which is a society without intermediary, where all members of the group are organised collectively and share the same set of beliefs. Small scale societies are associated with mechanical solidarity. Larger more civilised societies are associated with organic solidarity, which is a system of different functions that work together. Each individual has a distinct job or action and a personality that is his or her own. Durkheim believed in harmony rather than conflict as defining society. Social functions are understood as facilitating social cohesion. Marx and Weber on the other hand understand social order as the regulation of opposing interests. Conflict rather than order is seen as defining society. Society can therefore be understood as incorporating a group of individuals and the set of principles by which they work together and/or reach a collective understanding in which to achieve goals or interests.

In the case of RetroKit the society that we refer to consists of those groups of stakeholders who would be directly involved in the retrofitting of apartment buildings. These are:

- Building resident
- Building owner
- Architect
- Consultant
- Contractor
- Manufacturer (materials and building components)
- Local authority

¹ Europe's buildings under the microscope, October 2011, Published by Buildings Performance Institute Europe (BPIE)

These stakeholders represent different roles and functions working together in a retrofit project. The interaction between the stakeholders, and their individual views and needs with a special focus on retrofitting using prefabricated elements, are documented in this report.

2.2 Questionnaire on stakeholders needs and views

The focus of the questionnaire is on the experience and thoughts of stakeholders in using prefabricated modules in retrofitting of buildings. The survey covers the 11 European countries Poland, Romania, Germany, Switzerland, Ireland, Italy, Spain, Greece, Sweden, Norway and The Netherlands. The informants that received the questionnaire were building owners, architects, consultants, contractors, prefab manufacturers and authorities.

The objective of the survey is to identify the views and thoughts of stakeholders involved in retrofitting on the use of prefabricated modules in retrofitting. This knowledge is to be used as input to the development of the RetroKit Toolbox later on in the project period. The main research questions in the survey are:

1. What are the architectural requirements for prefabricated solutions?
2. What are the success criteria for prefabricated solutions from decision makers' point of view?
3. What make building owners agree to ambitious retrofitting?
4. What characterizes good retrofitting design?

2.3 Requirements and regulations

A template was developed for the partnering countries to fill in information on architectural requirements and standards for retrofitting in their country. The basic contents of the associated template, a summary of the feedback from the participants and a commentary on the feedback are outlined in this report. The objective of this mapping is to get an overview of the regulations and standards that apply in the countries representing the market for the RetroKit Toolbox modular retrofit solution.

2.4 Best practice building examples

Best practice examples are required in order to demonstrate the types of retrofitting taking place in apartment buildings in Europe currently. The best practice case studies were submitted by project participants in a coherent way by filling in the data in a predefined template through the dissemination of the two templates will be assembled in a database and used in dissemination activities in later work packages.

Good examples of Best Practice case studies already documented are In the IEA ECBS Annex 50 research: *IEA ECBE Annex 50 Prefabricated Systems for Low Energy Renovation of Residential Buildings – Building Renovation Case Studies*². Many of these case studies fit the RetroKit requirements of low energy retrofitting of apartment buildings using prefabricated solutions.

² http://www.ecbcs.org/docs/ECBCS_Annex_50_PSR.pdf

3 Stakeholder needs and views

The overall RetroKit project goal is to increase comfort for the residents and at the same time reduce the buildings energy demand by developing prefabricated solutions for ambitious and holistic retrofitting of multi-family apartment built after Second World War. To make sure that good concepts and solutions are developed, knowledge on the needs and views of the stakeholders involved in retrofitting is needed. Therefore, a web based questionnaire was developed and distributed to a target group consisting of building owners, architects, consultants, contractors, prefab manufacturers and authorities in the 11 European countries Poland, Romania, Germany, Switzerland, Ireland, Italy, Spain, Greece, Sweden, Norway and The Netherlands. The findings from the questionnaire survey will be used as empirical input to the development of the RetroKit Toolbox together with the results from the mappings of architectural requirements and regulations as well as best practice retrofitting examples in the 11 partnering countries.

3.1 Focus and objective

The focus of the questionnaire is on the experience and thoughts of stakeholders using prefabricated modules in retrofitting of buildings.

The objective of the survey is to identify the views and thoughts of stakeholders involved in retrofitting on the use of prefabricated modules in retrofitting. This knowledge is to be used as input to the development of the RetroKit Toolbox later on in the project period. The main research questions in the survey are listed below.

1. What are the architectural requirements for prefabricated solutions?
2. What are the success criteria for prefabricated solutions from decision makers' point of view?
3. What make building owners agree to ambitious retrofitting?
4. What characterizes good retrofitting design?

3.2 Method

The research method aims to reach a valid verifiable outcome in relation to the intentions defined by the research questions above. Quantitative research methodology in the form of a questionnaire has been used to provide data about the use of and expectations for retrofitting with prefabricated modules. A quantitative research approach has its roots in positivist theory where the intention is to empirically test hypotheses explaining and predicting the what, where, why, how and when phenomena occur (Gilje and Grimen, 2002). However, due to the exploratory nature of the research the intention here has not been to test a hypothesis but to provide indicators with which to understand societal trends associated with deep retrofitting with prefabricated modules. A quantitative approach was chosen because the research project aspires to provide a statistical understanding of phenomena connected to retrofitting and the relationships between them.

A questionnaire was chosen as a quick and effective method to collect the statistical data. A questionnaire is a set of questions with a choice of answers, devised for the purposes of a survey or statistical study (oxforddictionaries.com, 2013). The questions used in the questionnaire fall primarily in the ordinal-polytomous category, where the respondent has more than two ordered options.

Quantitative methods, such as questionnaires, provide numbers and offer the means to understand, describe and explain them. Quantitative research relies on an objective standpoint; this means that different points of view may be compared; it also makes it possible to verify, if necessary, the research at a later date (Olsson and Sörensen, 2003). It should therefore be possible to repeat the same questionnaire and achieve the same results. The development of the questionnaire and its scope is presented below and it is therefore possible to follow the same procedure again. However, the key research questions which the RetroKit project supplies are not of a nature which is easily quantifiable. The questionnaire does not ask

respondents to number how many projects they have participated in involving retrofitting with prefabricated modules or when these activities took place. Instead it asks about architectural requirements and success criteria from the decision makers' point of view. These aspects are based to a large degree on subjective experience and taste, making the answers less unambiguous and more subject to fluctuation. It is hard to measure subjective data quantitatively (Thomsen and Eikemo, 2010). The data from the questionnaire does not give in-depth information on the respondents' motivations and personal perceptions. Qualitative methods such as structured in-depth interviews provide this kind of information. In-depth interviews will take place in association with the pilot buildings in task 1.2 and will be presented in D1.3. The data from the questionnaire instead provides indicators about societal requirements, success criteria for prefab solutions and characteristics of good retrofitting design.

3.3 The questionnaire

Development of the questionnaire

The questionnaire was developed in an iterative process amongst the researchers in the RetroKit project, starting off with a kick-off workshop in Norway in October 2012. The questionnaire was then tested by a representative test group of 8 persons who gave feedback with ideas for improvements. The questionnaire was then reformulated ready to be presented in its final digital form. SENTIO research³, which is a leading Norwegian market- and opinion research institute, gave in addition valuable input about question formulation, answering alternatives and the general set-up of the questionnaire during the whole development phase. The original questionnaire, written in English, was then translated into Romanian, Italian, Polish, German, Greek, Spanish and Norwegian. The survey was conducted during the spring of 2013 using the electronic questionnaires system EasySurvey⁴ by SENTIO research. The informants received an e-mail with an invitation to answer the survey and a link to the questionnaire (see appendix "invitation to answer the questionnaire"). A reminder to answer the questionnaire was sent to all informants a few days before the answering deadline.

The structure of the questionnaire

The intention was to create a concise list of questions which could be answered within a period of 5-7 minutes and which would be easily understood by the stakeholders to encourage a high response rate. The survey is anonymous, the information received cannot be traced back to the respondent. The questionnaire consists of 16 questions arranged in four thematic sections:

- Background information (role, nation, experience with ambitious retrofitting and awareness of regulation requirements for retrofitting).
- Choosing prefabricated modules for retrofitting (important selection criteria when choosing a particular prefab system, advantages and pitfalls when retrofitting with prefab modules compared to on site production).
- Architectural requirements for prefabricated retrofit solutions (architectural requirements that should be met in a prefab retrofit solution, aspects concerning flexibility in architectural design).
- Agreeing to ambitious retrofit (reasons for building owners to agree to retrofitting, important areas to be addressed in retrofitting, actors influencing the decision making process the most, and the characteristics of good retrofitting).

Firstly, after selecting the preferred language on the first screen picture, a brief description of the RetroKit project and the objective of the questionnaire are presented on the respondents' screen before they are led to the questions that are arranged in the four sections described above. The majority of the questions are

³ <http://www.sentio.no/>

⁴ <http://www.easy-surveys.eu/>

closed, meaning there is a set of predefined answering alternatives the respondent can choose from (multiple choice). The last question in the questionnaire is open, allowing the respondent to answer freely in his or her own words. Questions 7 and 11 also have an open answering option giving room for the respondents to share their own comments, thoughts and ideas. See appendix "The questionnaire" for a full presentation of all questions and answering alternatives.

The informants

The questionnaire was directed towards a number of key informants; building owners, architects, consultants, contractors, prefab manufacturers and authorities. The great majority of the informants were approached by direct e-mail request to participate in the survey. Mailing lists with the target group of the questionnaire were provided by the RetroKit project partners from the 11 participating countries. An invitation to take part in the survey was sent to 4697 genuine e-mail addresses among the target group in the 11 countries. See appendix "invitation to answer the questionnaire". Approximately 400 of the addresses had issues and were therefore rejected from the survey. In addition to the direct mail approach, a number of organizations associated to the building industry distributed newsletters about the RetroKit project among their members with a request to answer the questionnaire. Some of these organisations also promoted the survey on their home pages on the internet. Both the newsletters and the home page promotion of the survey used another link to the survey than the direct email approach so that we could separate the two sources of informants. The majority of answers came from direct e-mail approach. Only 32 answers were derived from newsletters and home page promotion.

A total of 526 answers to the questionnaire give a response rate of close to 12%. This is a slightly lower response rate than we had hoped for, but according to SENTIO also quite typical for this type of research. It is not possible to draw 100% reliable conclusions on this empirical data; however the material gives a good indication of the views and needs of the stakeholders involved in retrofitting. It also provides useful input towards the development of questions for the interviews with the stakeholders in the three pilot buildings in Spain, Germany and The Netherlands that will be carried out on a later stage in the RetroKit project.

The distribution of answers by role is shown in figure 3.1. Four roles are dominant, together accounting for 83% of all the answers. These roles are, in descending order, architect (30,3% of the answers), other (18,9% of the answers), authority (18% of the answers) and consultant (15,4% of the answers). In the three countries with the highest response rates, architects dominate the response rate in Germany and Spain while authorities have the highest response rate in Norway (figure 3.3). The three roles with fewest answers are Building owner (8,9% of the answers), contractor (5% of the answers) and lastly prefab manufacturers (3,5% of the answers).

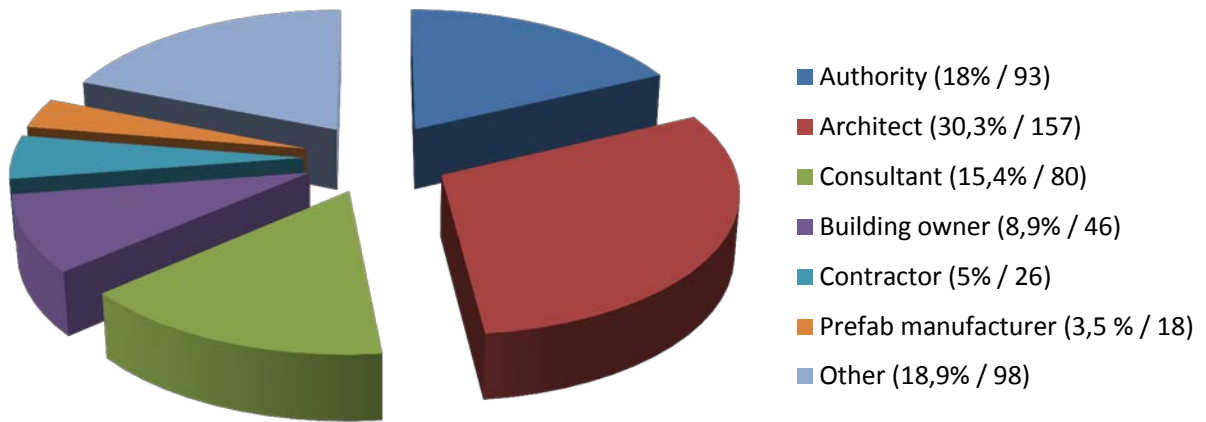


Figure 3.1 Distribution of answers in relation to role. The two numbers in parenthesis separated by a slash denotes the percentage of answers and the number of answers (frequency) for that group.

The distribution of answers by country is shown in figure 3.2. Norway, Germany and Spain stand out with the highest response rates with a share of 35%, 17,5% and 17,1% respectively. The survey results for each of these three countries are therefore collected separately for reference use when relevant. The rest of the countries in the survey have a share of 2-5% of the total number of answers which means that only 10 to 30 persons responded in these countries. The dispersal of stakeholders answering the questionnaire by country shown in figure 3.3 and 3.4 indicates large variations between countries.

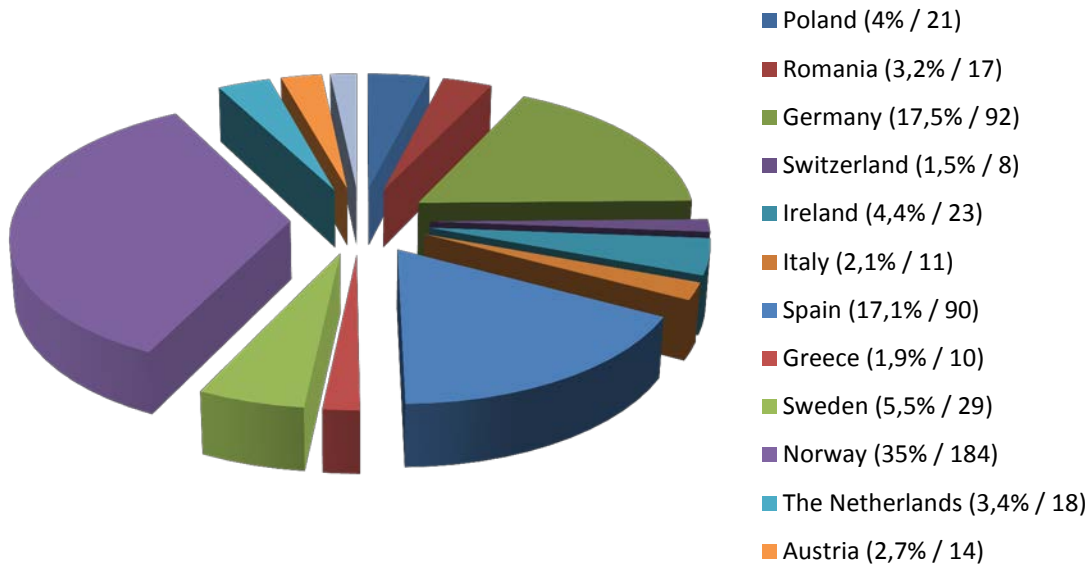


Figure 3.2 Distribution of answers in relation to country. The two numbers in parenthesis separated by a slash denotes the percentage of answers and the number count of answers (frequency).

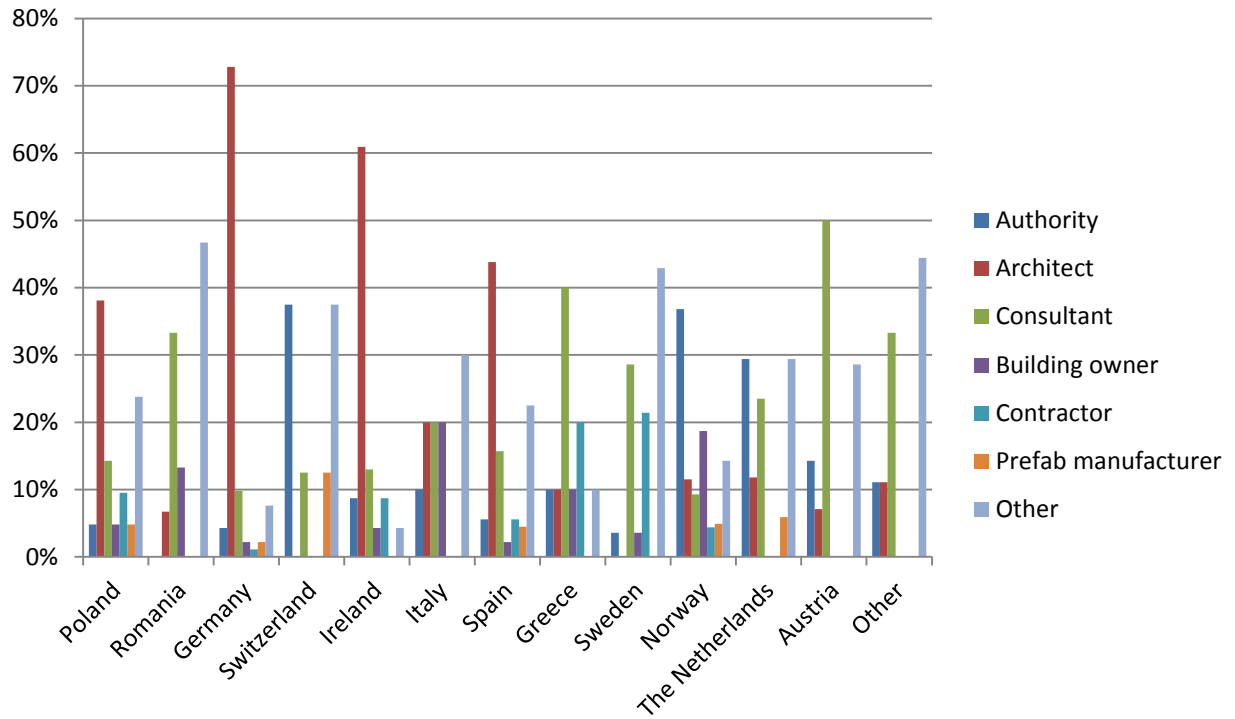


Figure 3.3 Chart showing the role of the respondents answering the survey in the different countries

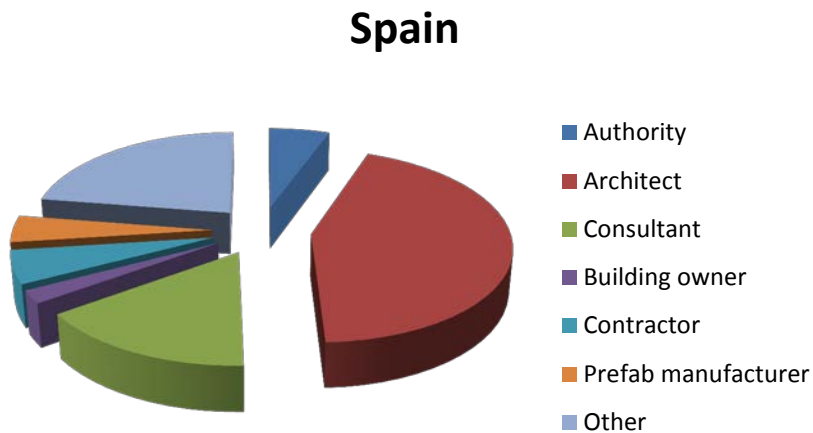
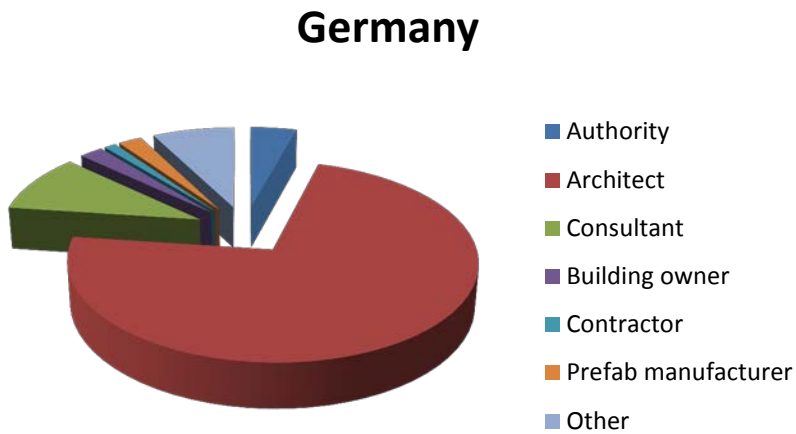
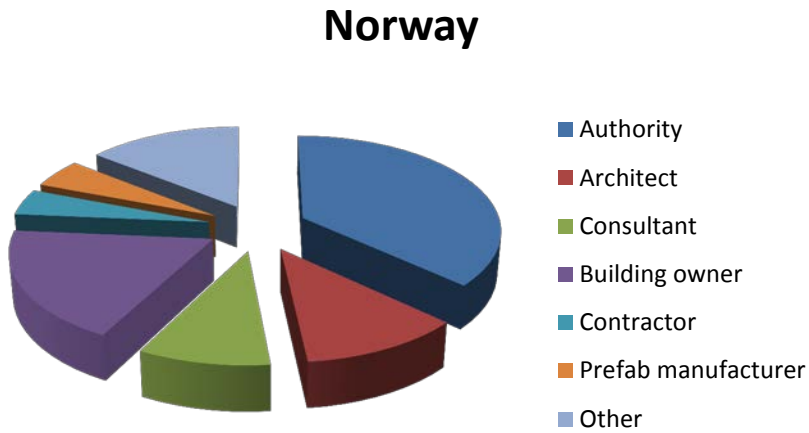


Figure 3.4 Charts showing the role of the respondents answering the survey in Norway, Germany and Spain respectively, the three countries with the highest response rates. Architects dominate in Germany (73%) and Spain (44%) while authorities dominate in Norway (37%).

3.4 Findings

The findings from the questionnaire survey are presented in the following subchapters. The results are structured in thematic sections similar to the questionnaire: Stakeholders knowledge and experience with retrofitting, Regulation requirements for retrofitting, Choosing and using prefabricated modules for retrofitting, Architectural requirements for prefabricated retrofit solutions, Agreeing to ambitious retrofitting and lastly Characteristics of good retrofitting design.

3.4.1 Stakeholders knowledge and experience with retrofitting

The respondents were asked to rate their knowledge and experience with ambitious retrofitting. The respondents report more knowledge than experience with ambitious retrofitting, indicating that, according to own perception, the stakeholders are well educated for the retrofitting task lying ahead. A total of 80 % of the respondents report neutral to extensive knowledge on ambitious retrofitting, while 64% report neutral to extensive experience with ambitious retrofitting.

While there seems to be more knowledge than experience with ambitious retrofitting, the findings still indicate that approximately 2/3 of the respondents have experience with ambitious retrofitting. It must be noted that is likely that the response rate in the sample is highest among those having special knowledge and experience in building renovation and energy use in buildings. Thus the real percentage of stakeholders having this kind of knowledge and experiences is probably lower.

The respondents were also asked to rate their experience in using prefabricated modules in retrofitting. The survey reveals that the majority has limited experience in using prefabricated elements. Only 6% report extensive experience while 43% report limited experience in using prefabricated modules in retrofitting. A total of 80 % of the respondents report neutral or less experience in using prefabricated modules in retrofitting (figure 3.5).

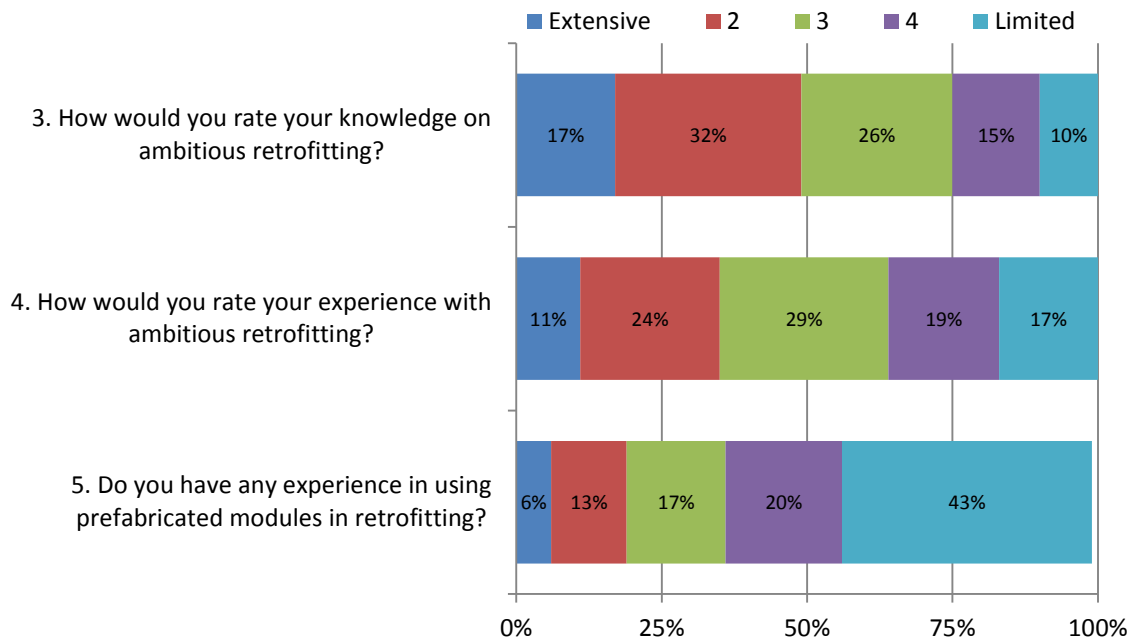


Figure 3.5 The respondents self-rating of own knowledge and experience with ambitious retrofitting (top and middle) and experience in using prefabricated modules in retrofitting (bottom).

3.4.2 Regulation requirements for retrofitting

The respondents were asked if they were aware of the regulation requirements for retrofitting in their country. Only just 50% answered that they were aware of the regulation requirements for retrofitting in their country. Close to 40% answered that they were partly aware of the regulations while 14% answered that they were not aware of the regulation requirements for retrofitting in their country (figure 3.6). This is presumably due to the fact that many of the countries do not have regulation requirements for retrofitting and that it is unclear when current regulations on e.g. energy efficiency and universal design will come into force during a retrofitting intervention.

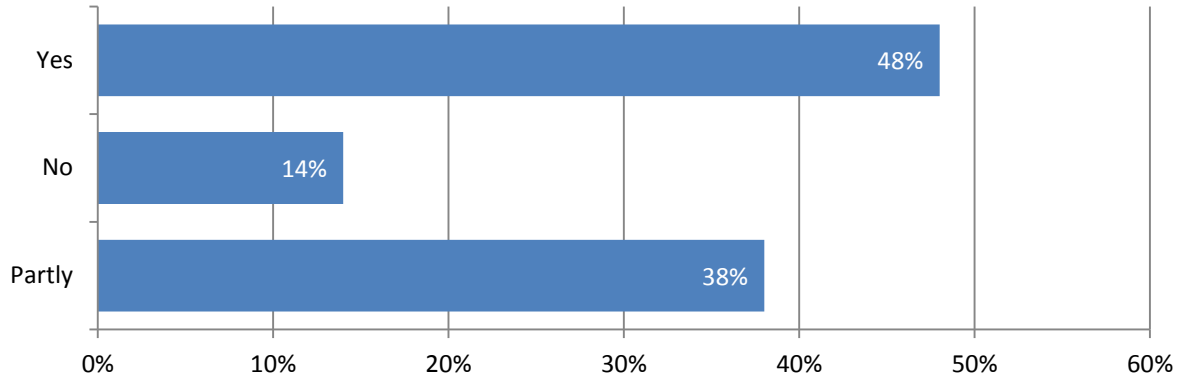


Figure 3.6 The respondent's knowledge on regulation requirements for retrofitting in their home country.

In a follow up question the respondents were asked to point out the main challenges with the regulations as they see them. 15% answered that the regulations are ok as they are, while 20% answered that they are incomplete (figure 3.7).

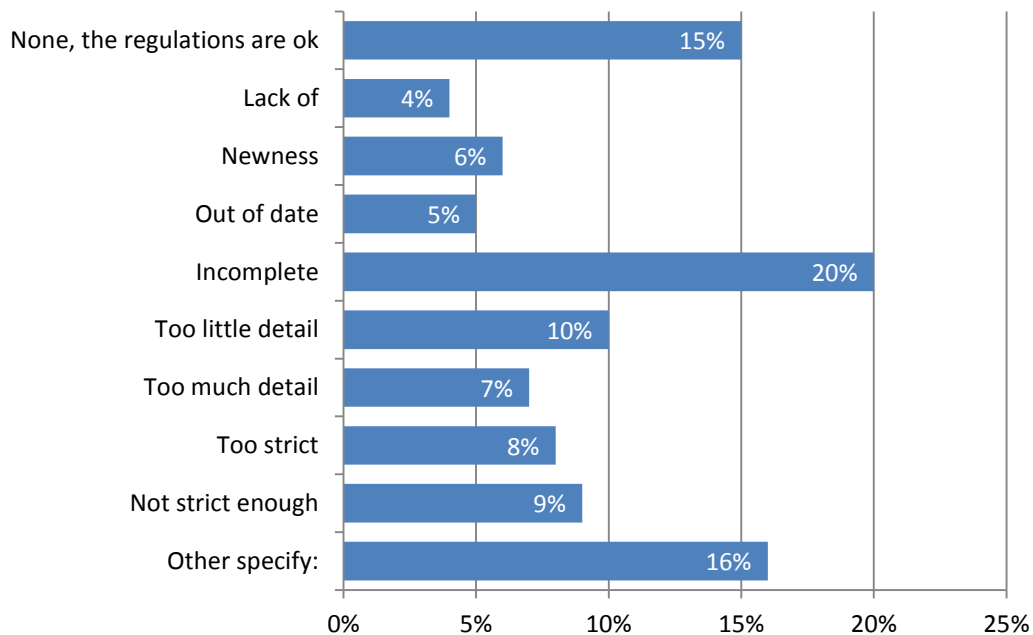


Figure 3.7 Distribution of answers to the question: What are the main challenges from your point of view related to the regulations?

In addition to the multiple choice alternatives provided, the recipients also had the opportunity to specify other opinions when asked what the main challenges from their view point were of the current regulations. A generally negative response was document among the respondents of frustration, confusion and inefficiency. According to a Spanish respondent the regulations are "complete chaos", and an Irish respondent reports that the challenges are "mixed messages and lack of clarity in approach". A Romanian respondent notes that regulations do "not support systematic long-term renovation with high ambitions". Proactive suggestions were given in response to the question of challenges. More refinement of the regulations was suggested by 17% of the specified opinions to the question. Respondents requested clarification. A specification is "required for different building types" according to an Irish respondent and a Swiss respondent noted that regulations were "mostly linked to new buildings, but must now be applied to existing ones". A Spanish respondent noted that the application of regulations and greater specification "must be boosted with new tools".

Of all the responses given to the question about the main challenges associated with the regulatory requirements within the country of practice, the greatest percentage of responses (23%) noted that the regulations need "to be compulsory" and "compliance monitored". Additional mention was given to "the potential adverse effects on historic buildings" by an Irish respondent. It was noted by a Swedish respondent that the regulations are "difficult to fulfil at the same time as architectural and cultural historical values are safeguarded and economic feasibility reached".

3.4.3 Choosing and using prefabricated modules for retrofitting

In order to find out which qualities a prefabricated retrofitting module should possess the respondents were asked which criteria would be most important in their choice of a particular prefab system for deep renovation in question 8. The respondents were asked to rate the importance of 11 different criteria on a scale from 1 (not important) to 5 (very important).

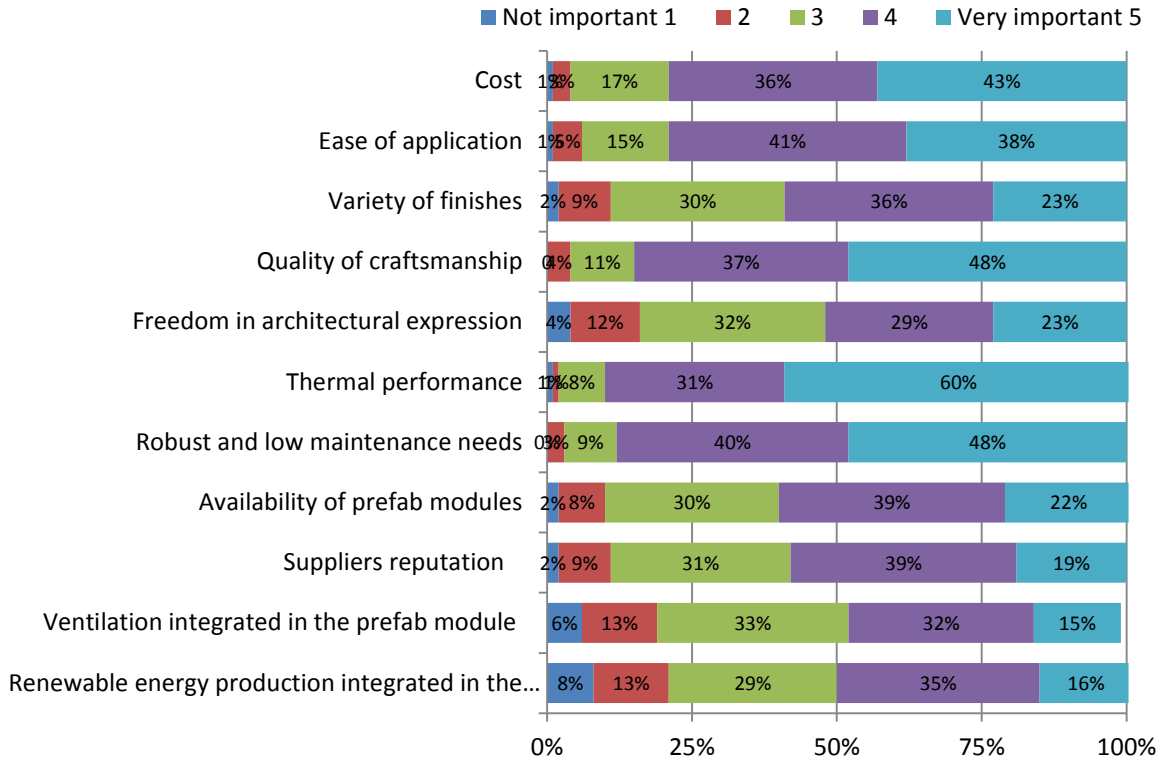


Figure 3.8 What would be the most important criteria in your choice of a particular prefab system for deep renovation?

By summarising score 4 and 5 for each criteria and ranging them by importance we can reveal a profile which suggests the mutual importance of the different criteria. The three criteria receiving the highest score were *Thermal performance* (91%), *Robust and low maintenance needs* (88%) and *Quality of craftsmanship* (85%). These three leading criteria were closely followed by *Cost* (79%) and *Ease of application* (79%).

Then there is a step down to the next three criteria which scored within the range of 58-61%, namely *Availability of prefab modules* (61%), *Variety of finishes* (59%) and *Suppliers reputation* (58%). Finally, the least important criteria are *Freedom in architectural expression* (52%), *Renewable energy production integrated in the prefab module* (51%) and *Ventilation integrated in the prefab module* (47%). It can be argued that all the criteria are rated important as they receive more than 50% (except integrated ventilation just under 50%), but it is still possible to rank them. The low score on *Freedom in architectural expression* is rather surprising, considering the high response rate from architects.

In order to uncover the difference between prefabricated and on site production the respondents were asked to identify the advantages (question 9) and the pitfalls (question 10) of retrofitting with prefabricated modules as opposed to on site production.

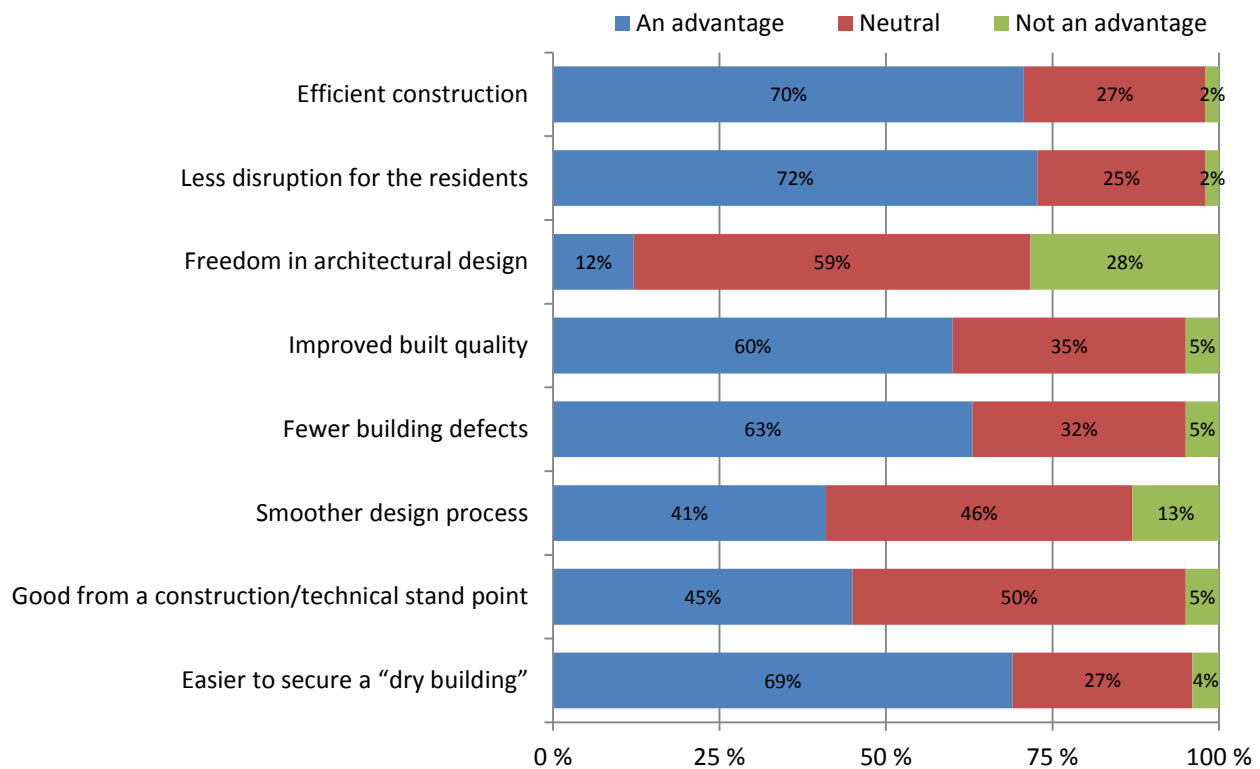


Figure 3.9 What do you think are the advantages of retrofitting with prefabricated modules as opposed to on site production?

The advantages of retrofitting with prefabricated modules according to the survey lie primarily within the practical implementation of a retrofitting project. Respondents suggest that retrofitting with prefab modules will encourage *Efficient construction* (70%), make it *Easier to secure a dry building* (69%) and cause *Fewer building defects* (63%). *Improved built quality* also scores high as an advantage with prefabricated modules (60%). In addition, 72% of respondents believe that retrofitting with prefabricated modules will cause less disruption for residents during the rehabilitation process.

41% suggest that retrofitting with prefab modules will encourage a smoother design process and 46% were neutral on this point. The lack of clear enthusiasm for prefab in the design process ties in with the point on *Freedom in architectural design*, which has the lowest score of all criteria on the advantage side and the highest on the not-an-advantage side for prefab. Only 12% of the respondents believe that it will be an advantage, whilst 28% believe that prefab will not be an advantage in terms of freedom in architectural design. The majority are neutral on this point, suggesting that retrofitting with prefabricated modules is relatively unknown and that experience therefore is lacking. The response to question 5 supports such an assumption, see figure 3.5. The functional and technical aspects are more predictable and hence more easily placed within the framework of building renovation.

Response to question 9 indicates that retrofitting with prefabricated modules does not encourage freedom in architectural design. When asked about the pitfalls associated with retrofitting with prefabricated modules in question 10, 47% regard limited architectural freedom as the greatest of all pitfalls on the list (figure 3.10). 31% of the informants also suggested that retrofitting with prefabricated modules would result in poor architecture as the third greatest pitfall (figure 3.10). The implication from the response to these two questions is that respondents believe that retrofitting with prefabricated modules will result in limited architectural freedom in the design phase and poor architecture as a result.

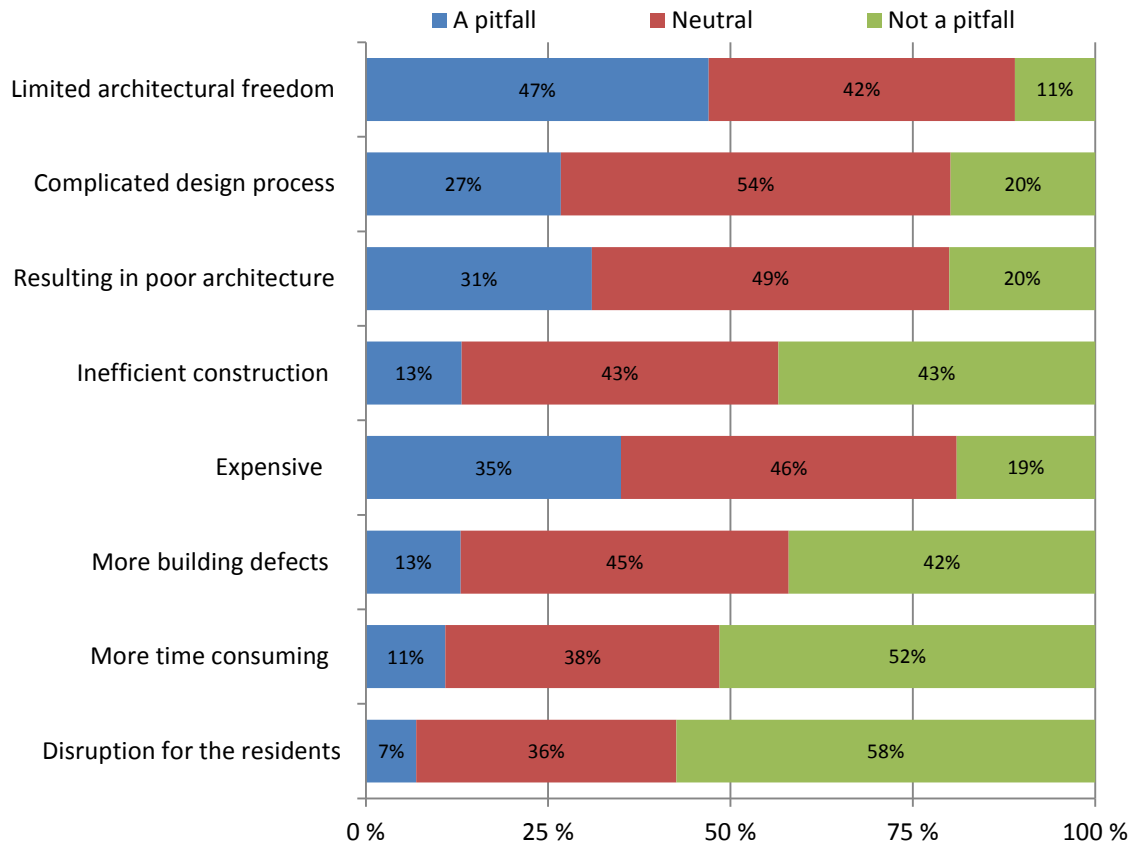


Figure 3.10 What do you think are the pitfalls of retrofitting with prefabricated modules as opposed to on site production?

27% of the informants suggested that prefab would make the design process more complicated, 20% suggesting this not as a pitfall. The rest were neutral, which again suggests uncertainty about how the design process will turn out when retrofitting with prefabricated modules.

The cost of retrofitting with prefabricated modules is considered as the second greatest pitfall of the ones listed, 35% of the respondents considered it a pitfall (expensive). However, few respondents saw pitfalls in relation to inefficient construction, more building defects, more time consuming and disruption for the residents, which confirms the response given in question 9.

3.4.4 Architectural requirements for prefabricated retrofit solutions

This section deals with the architectural requirements that prefab solutions will have to meet to be attractive in general and aspects related to flexibility in design in particular. In question 11 respondents were asked to select the 5 most important requirements that a prefab system would have to meet to be attractive (figure 3.11). The informants were provided the opportunity to elaborate in his or her own words, but only a few did that (20 informants). It is unclear whether the multiple choice options cover the field well, or whether the respondent did not take the time to fill in comments.

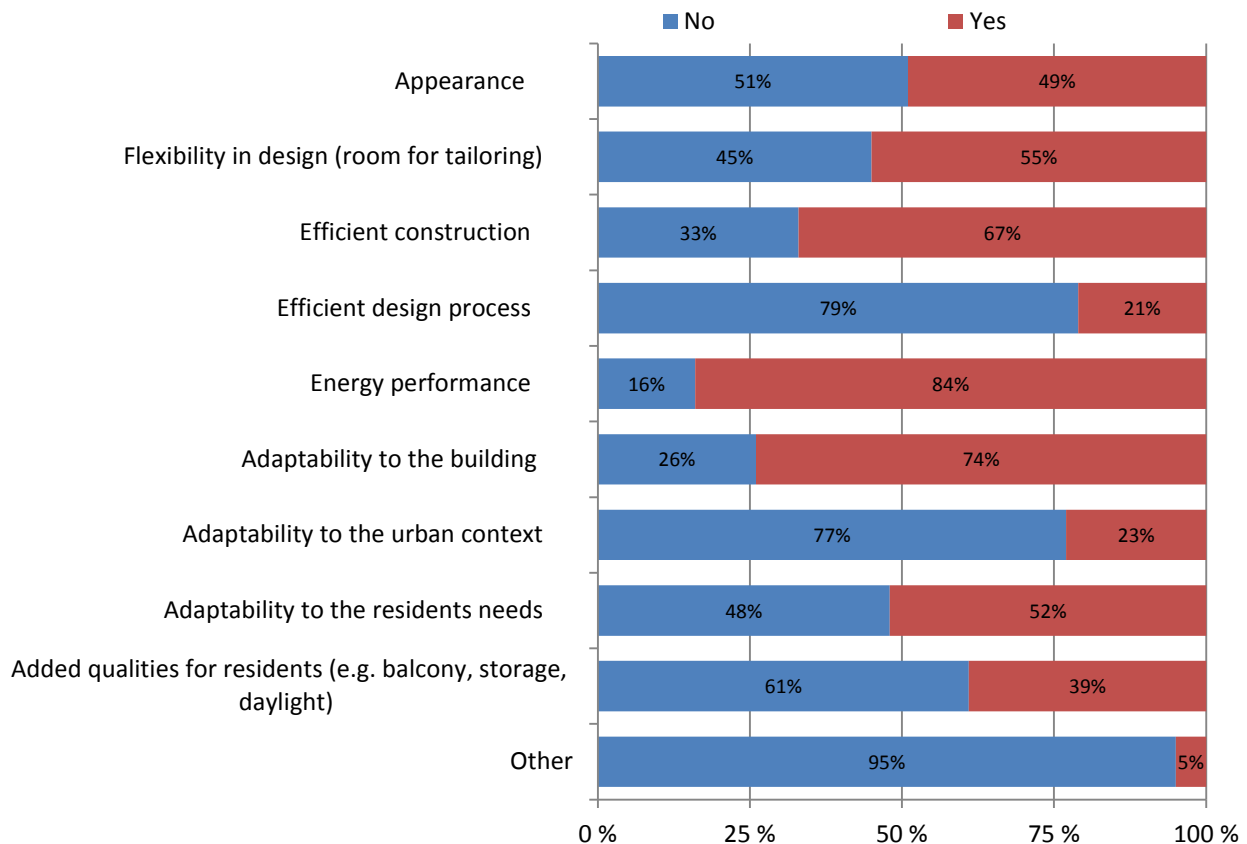


Figure 3.11 Which architectural requirements does a prefabricated retrofit solution have to meet to be an attractive alternative?

The results show that the most important requirement a prefabricated solution has to meet is *Energy performance*, scoring 84%. The second most important requirement is *Adaptability to the building*, with a score of 74%. *Efficient construction*, scoring 67%, is regarded the third most important requirement. The fourth most important requirement is *Flexibility in design (room for tailoring)*, with a score of 55%.

Adaptability to the residents needs is also rated quite important with a score of 52%, making it the fifth most important requirement. *Adaptability to the urban context* on the other hand is not regarded important in comparison to the other alternatives, scoring only 23%.

Appearance, which can be seen in correlation with flexibility in design, scored 49%, placing it in the lower middle on the scale of important requirements a prefab solution has to meet to be attractive.

This leaves us with the following list of the 5 most important architectural requirements a prefabricated retrofit solution would have to meet to be an attractive alternative:

1. Energy performance
2. Adaptability to the building
3. Efficient construction
4. Flexibility in design (room for tailoring)
5. Adaptability to the residents needs

The three least important requirements a prefabricated retrofit solution will have to meet to be attractive are *Added qualities for residents* (39%), *Adaptability to the urban context* (23%), and lastly *Efficient design process* (21%).

The response to questions 9 and 10 suggests uncertainty about how the design process will turn out when retrofitting with prefabricated modules, but it is suggested here that it is not of primary importance to improve the efficiency of the design process to make retrofitting with prefabricated solutions more attractive.

The open answers suggest a breadth in potential requirements and solutions:

"Unrestricted planning freedom". Germany

"Prefabricated packages need to be adaptable to variations in existing building design e.g. brick facade, joining with adjacent dwellings, meeting different roof finishes". Ireland

"Good integration with the use of ICT technologies (Information and Communication Technologies, red.)". Spain

"Low maintenance, it does not help much with nice aesthetical solutions that get shabby in a short time (...) changes in surface quality, colour, for instance". Norway

"It is important to consider and safeguard cultural and historical values". Sweden

"To allow vapour diffusion through wall composition ("breathing walls")". Romania

In a follow up question to the theme of architectural quality, the respondents were asked in question 12 to rate the importance of various aspects related to flexibility in architectural design.

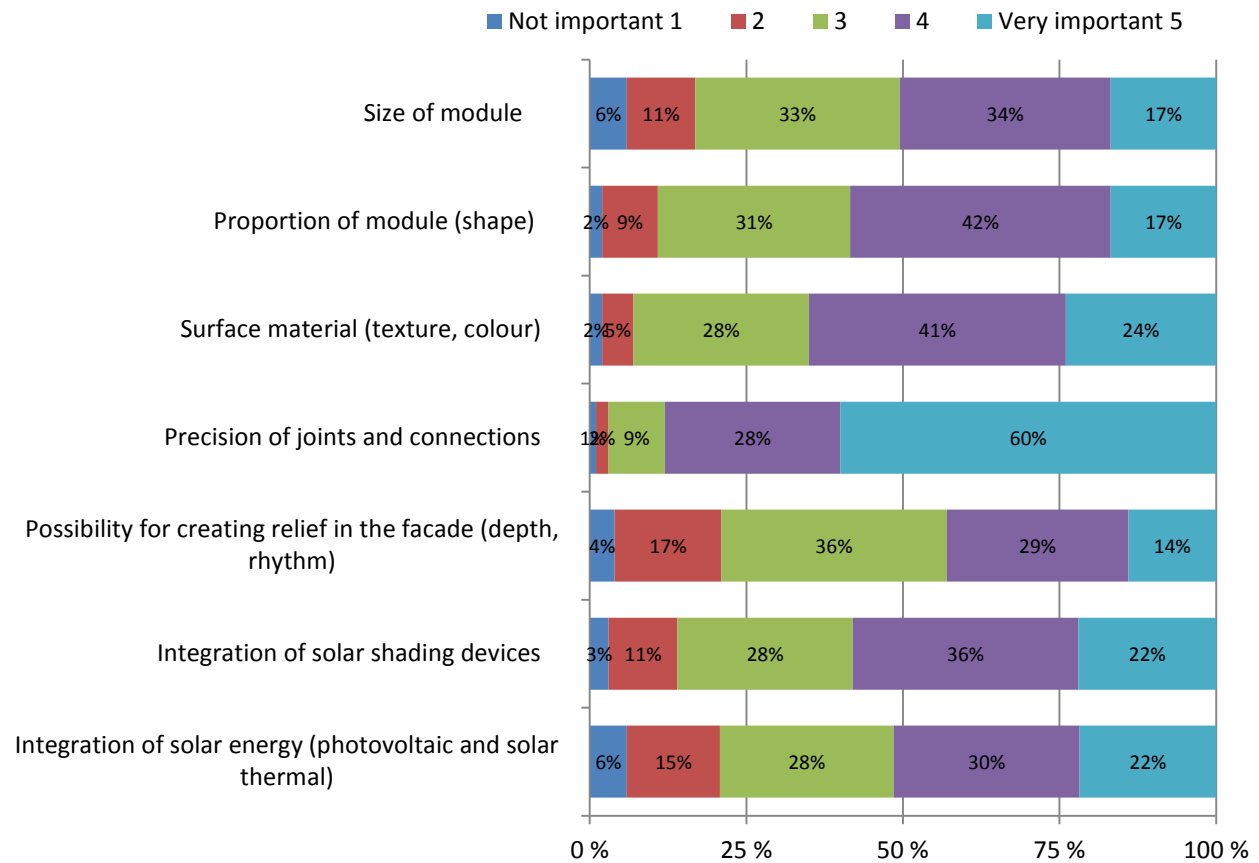


Figure 3.12 With regard to flexibility in architectural design, rate the importance of the aspects under from 1 (not important) to 5 (very important).

More than half of the respondents consider all the suggested aspects as important, but *Precision of joints and connections* stand out with a high score on "very important". 88% of the respondents rate it as very important (60%) or as important (28%).

There are minor variations in importance among the other aspect that were rated. *Surface material (texture, colour)* is the second most important aspect where 65% rated it as very important (24%) or important (41%). *Proportion of module (shape)* and *Integration of solar shading devices* were rated equally important with a score of 59% and 58% respectively (important and very important summarized).

Possibility for creating relief in the facade (depth, rhythm) stands out as the least important aspect with regard to flexibility in architectural design. 43% rated it as very important (14%) or important (29%).

All the suggested aspects are considered important with regard to flexibility in architectural design, scoring over 50 % on either important or very important (except relief in the facade). They all score low under not important, under 6%.

3.4.5 Agreeing to ambitious retrofit

In question 13 the respondents were asked to rate what in their opinion make building owners agree to ambitious retrofitting (figure 3.13). The two reasons that stand out with the highest score are that the building is in *need for rehabilitation*, closely followed by *energy efficiency*. The fact that a building is in need of rehabilitation in the first place opens up for introducing energy efficiency measures as part of the rehabilitation works. The extra cost for improving energy performance is fairly low compared to the benefits achieved, which was also found in the BESLUTT project (Hauge, Thomsen and L fstr m, 2013). This is most likely the reason for the high score of *need for rehabilitation* in this question. A couple of examples that illustrate this are adding extra insulation when the exterior cladding needs to be refitted or installing extra insulation when the drainage around a structures basement has to be renewed. Improving a buildings' energy efficiency in itself was rated as the second highest reason for building owners to decide on ambitious retrofitting. This indicates that there is a focus on reducing running costs (for heating, cooling and ventilation primarily) and being environmentally conscious.

The third most reported reason for ambitious retrofitting is *improved indoor environment quality and comfort for residents*. This either implies a concern for the residents' well-being and health, or that the residents have complaints on the indoor environment quality in their flats that trigger retrofitting. This reason for retrofitting goes hand in hand with, or is rather the result of, improving the buildings' energy efficiency.

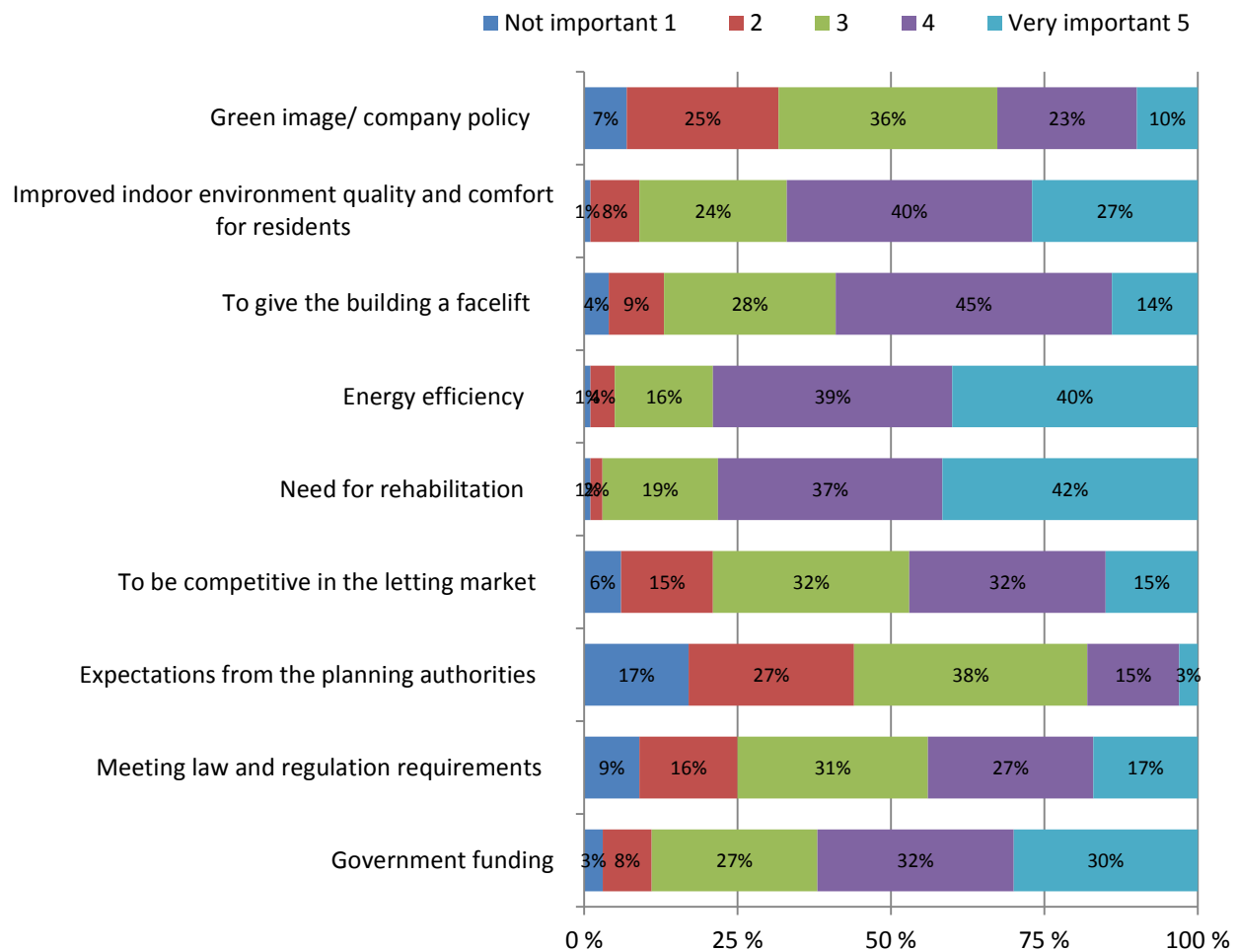


Figure 3.13 What in your opinion makes building owners agree to ambitious retrofitting?

The possibilities of receiving *government funding* and *giving the building a face lift* (improve the quality of the architectural expression of the building) were reported as the fourth and fifth most important reasons for ambitious upgrading respectively.

Expectations from the planning authorities stand out as the least important of the listed reasons for building owners to carry out ambitious retrofitting. *Meeting laws and regulation requirements* also scores low as a reason to retrofit. This is in line with the response to the questions related to laws and regulations as well as the mapping of retrofitting laws and regulations in Europe. Both surveys reported absent, unclear or vague regulations on retrofitting.

The prospects of giving the building a *green image* was not reported as a viable reason for ambitious retrofitting, scoring inn as the second least important reason for doing ambitious retrofitting. To be *competitive in the letting market* also scores on the lower side, making it not such an important reasons for ambitious renovation either. This implies that a green image or an ambitiously renovated building is not seen as a big enough advantage in the letting market to trigger an ambitious renovation. Figure 3.14 show the same information as Figure 3.13, albeit with coarser resolution. This representation gives a somewhat clearer picture on how the various reasons for ambitious retrofitting score relative to each other, albeit at the price of less detail.

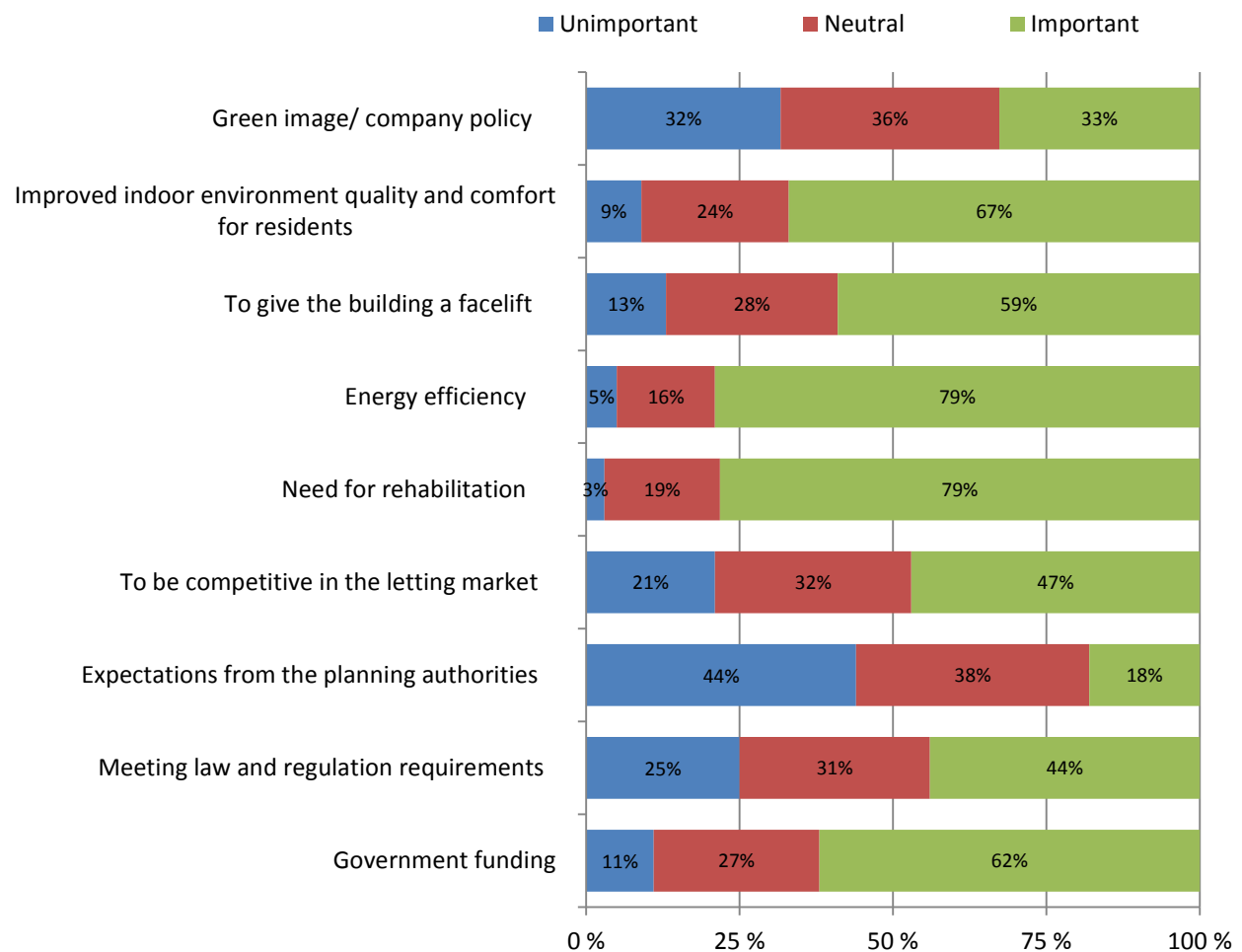


Figure 3.14 Same as figure 3.13 but with coarser resolution. Scores 1 and 2 are grouped and labelled as unimportant, score 3 is labelled neutral and scores 4 and 5 are grouped and labelled important.

In question 14 the respondents were asked to select the three most important areas to be addressed in retrofitting from a list of seven different areas. The results of the answers are shown in Figure 3.15, indicating which areas were most frequently selected as being the most important in retrofitting.

Reducing energy demand is perceived as the most important area to be addressed (79%) followed by *thermal comfort and indoor air quality* (69%). *Cost* (47%) and *durability* (45%) is regarded approximately equally important, but moderately important compared to the other areas listed. The areas that were least selected as important from the list were improved day lighting (13%), architectural quality (21%) and added qualities for residents (23%).

Overall, energy efficiency, indoor air quality, cost and durability are regarded significantly more important than improved daylight, architectural quality and added qualities for the residents. This is also the trend throughout the survey. The exception is the response to the open questions where the "softer qualities" of architecture and aesthetics are given more weight and higher importance relative to the response to the surveys' closed questions.

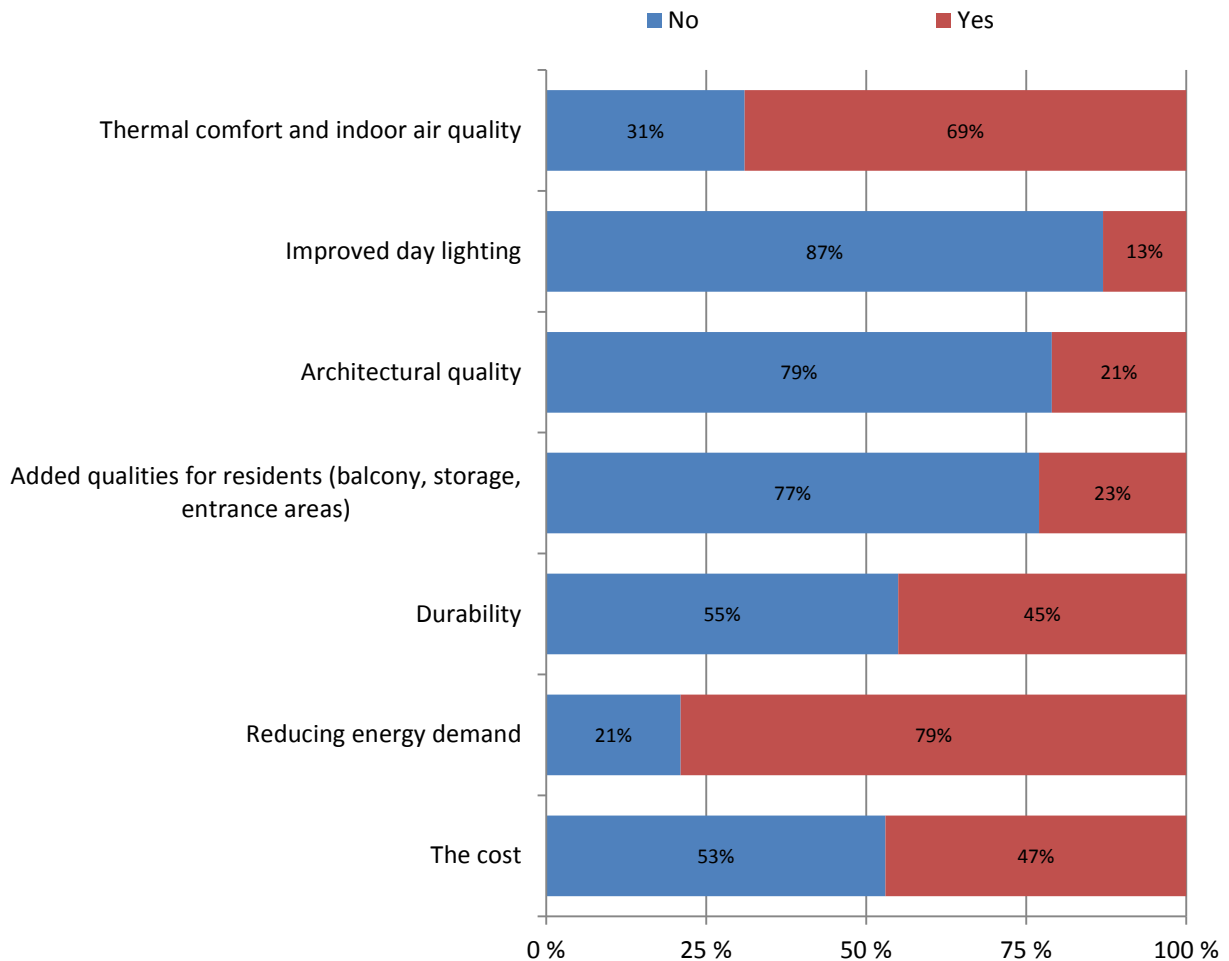


Figure 3.15 What do you see as the most important areas to be addressed in retrofitting?

In question 15 the respondents were asked to select which actors they experience as the most influential in the decision making process. The most influential, the second most influential and the third most

influential should be selected from a curtain menu containing owner, resident, architect consultant, contractor and authorities. The results for each actor are shown below in Figure 3.16.

The most influential: The owner is by far perceived as the most influential actor receiving 67% of the votes as "most influential", followed by the architect who receives 14% of the votes as "most influential". Authorities receive 8% of the votes as "most influential".

The second most influential: The second most influential actor is the architect with 26% of the responses as "second most influential", followed by the authorities (22%) and then the owner (18%). Residents and consultants receive both 13% of the responses as being the second most influential actors.

The third most influential: The third most influential actor is the architect with (23%) of the responses as "third most influential", followed by the contractors (22%) and then the authorities (18%). Residents receive 13% of the votes as being the third most influential and the consultants 11%.

Summing up all responses, we see that the most influential actor is seen as the owner, the second most influential is seen as the architect and the third most influential is seen as the authorities according to this questionnaire survey. Building owner and architect is self-explaining actors and easily identifiable. Authorities are less clear, but in this context we should think of them as the maintainers of building laws and regulations. Hence, the RetroKit Toolbox should communicate to, and meet the needs of building owners and architects especially, and be in accordance with or adaptable to current laws and regulations.

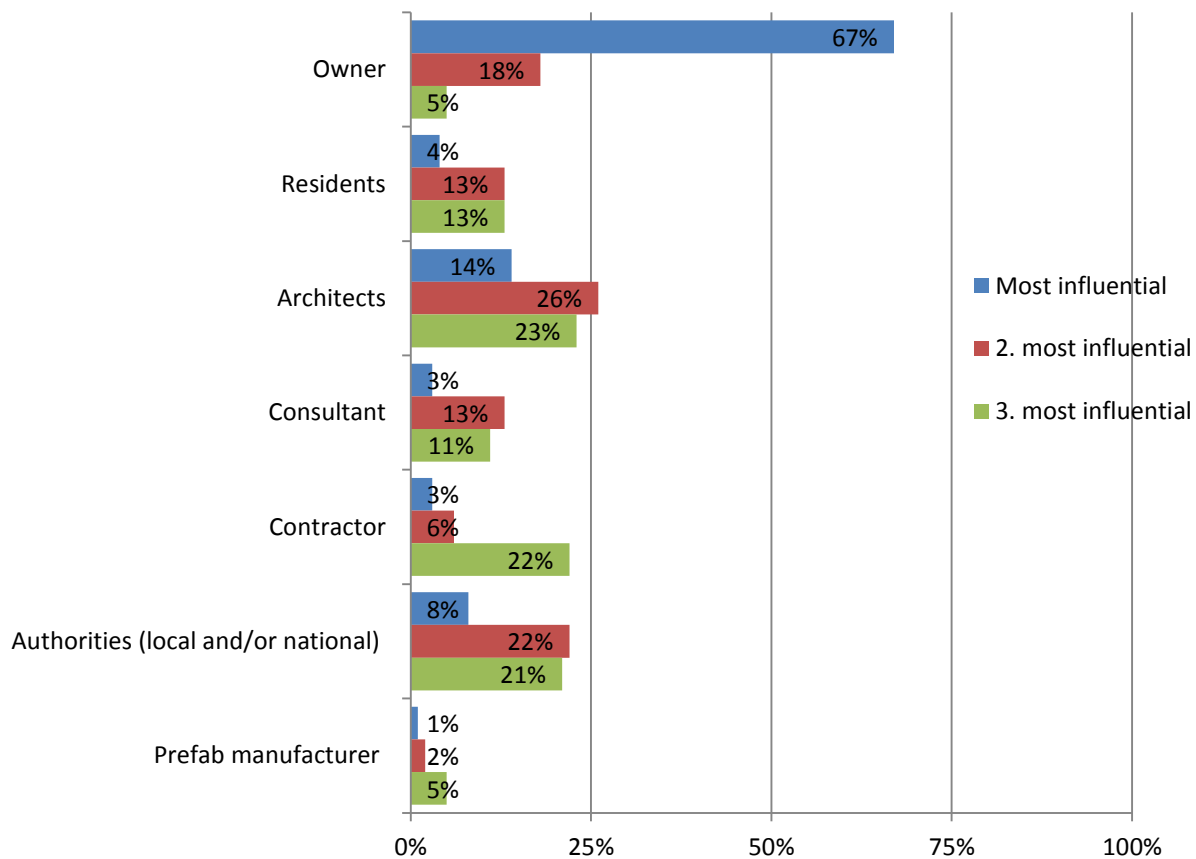


Figure 3.16 Which three actors in your experience influence the decision making process the most? (Most influential – Second most influential – Third most influential)

3.4.6 Characteristics of good retrofitting

The final question of the questionnaire provided respondents with open opportunity to elaborate upon the questions previously asked by summarising what they personally prioritise in retrofit design. A total of 176 responses were received and analysed. However, when evaluating the open answers in question 16 we have chosen to focus on the answers from the countries where there was the greatest number of responses, Norway, Germany and Spain. 38 respondents from Norway provided comments, 29 from Germany and 45 from Spain. Out of these responses, seven basic areas of focus were identified:

- energy efficiency
- cost
- ease of application
- flexibility
- maintaining existing integrity of the architecture
- improvement of the aesthetic quality and user comfort

Interest in the seven areas of focus varied dependent on the country answering. This difference was determined by evaluating the relative number of responses which were counted across the seven topics of interest within each of the three countries. Amongst the responses the most referenced element in good retrofitted design was energy efficiency. Cost was noted as the next most important and aesthetics (architectural expression and design) as the third most important.

Amongst the Norwegian open answers several respondents point out that more than one consideration is important when considering retrofitting. For example a respondent from a Norwegian housing cooperative states that there is a need for a "Combination of several requirements, e.g. the need for facade rehabilitation, balconies, ventilation, repairing moisture damage etc. combined with energy-related upgrades, improved comfort, architectural lift etc. It is important that the process is good, fast and efficient, the residents should have acceptable living conditions or be offered good temporary solutions if they have to move out, good financial management and control of progress and good calculations when it comes to finances and effects (energy saving etc.)."

Within the terminology used by respondents there is a focus on certain words or phrases. Energy efficiency is a central consideration. Within the 38 open answers, 14 suggested that energy efficiency was an important consideration, but it was rarely the only factor considered. For example a materials producer suggests that "Good energy efficiency, good layout, more space, better utilization and renewal" are important factors. Other factors which are mentioned are cost (8 respondents), aesthetic quality (7 respondents) and easy maintenance (5 respondents).

Amongst the 29 open answers from German respondents 7 showed an interest in preserving the original appearance of the building is an important consideration, for example a respondent stated that "preserving the original character and appearance of the building with additional modern design components if allowed". Only 2 of the Norwegian respondents commented on conservation issues. In addition 7 respondents mentioned that the architectural or visual quality of the building was also important. These 14 open answers from German respondents show therefore a marked interest in the visual appearance of the buildings being retrofitting. 7 respondents commented on the importance of keeping costs down and 6 stated that energy efficiency was an important consideration. Aesthetic issues appear therefore to be more important in Germany than energy efficiency. Another term which is referred to by German respondents is technology.

The cost of implementing a deep retrofit is the primary consideration among Spanish respondents. 25 of the 45 respondents mentioned cost in their open comments. Energy efficiency is a common requirement

amongst Spanish respondents, when considering retrofitting. 19 respondents suggested that this was an important consideration. A Spanish architect suggests that a good project has "sufficient sensibility to highlight and protect the elements which need to be kept and which take into account energy efficiency." Aesthetic quality is an important aspect, 14 respondents mentioned design, architecture, conservation or the visual appearance of the building as being important qualities during retrofitting. User comfort or requirements is an aspect which Spanish respondents focus on but which is not primary for Norwegian or German respondents. 14 respondents mentioned usability, user needs or comfort in their open answers. As is the case in the Norwegian and German responses, the majority of answers combine a number of aspects when aiming at a good retrofitting process "functional design for users. Reduction in energy demand. A rigorous technical and economic study but one which is understandable to users." An efficient process was mentioned by 7 respondents as being important.

3.5 Conclusions

The main finding from the questionnaire survey is that the practical and functional aspects (energy efficiency, cost, construction) of retrofitting with modular elements are regarded more important than aspects related to aesthetics, freedom in design and resident needs by the informants that answered the survey. This was rather surprising given the great number of architects answering the questionnaire. That said, aesthetics scored higher in the open questions than in the closed questions. The main findings are structured by the themes of the questionnaire itself in the following.

3.5.1 On informants and regulations for retrofitting

- The stakeholders that responded to the survey have more theoretical knowledge than practical experience with ambitious retrofitting.
- The majority of the stakeholders have little experience in using prefabricated modules in retrofitting.
- More than half of the respondents are not fully aware of the regulation requirements for retrofitting in their country.
- Incompleteness was reported as the greatest weakness with the regulations for retrofitting and a generally negative response was document among the respondents of frustration, confusion and inefficiency.

3.5.2 On choosing prefabricated modules

- *Thermal performance, Robust and low maintenance needs and Quality of craftsmanship* are the three most important criteria in choosing a particular prefab module system. *Freedom in architectural expression, Renewable energy production integrated in the prefab module and Ventilation integrated in the prefab module* were rated as the least important qualities of all listed qualities to be rated.
- The advantages of retrofitting with prefabricated modules according to the survey lie primarily within the practical implementation of a retrofitting project. Respondents suggest that retrofitting with prefab modules will encourage *Efficient construction*, make it *Easier to secure a dry building* and cause *Fewer building defects*. *Improved built quality* also scores high as an advantage with prefabricated modules. In addition, 72% of respondents believe that retrofitting with prefabricated modules will cause less disruption for residents during the rehabilitation process.
- When asked about the pitfalls associated with retrofitting with prefabricated *limited architectural freedom* was regarded as the greatest of all pitfalls. *Cost* was regarded as the second greatest pitfall (expensive) and the informants also suggested that retrofitting with prefabricated modules would result in *poor architecture* as the third greatest pitfall.

3.5.3 On architectural requirements

- The five most important architectural requirements a prefabricated retrofit solution have to meet to be an attractive alternative are (after importance):
 1. Energy performance
 2. Adaptability to the building
 3. Efficient construction
 4. Flexibility in design (room for tailoring)
 5. Adaptability to the residents needs

- With regard to flexibility in architectural design, *Precision of joints and connections* is most important, followed by *Surface material (texture, colour)* and *Proportion of module (shape)*.

3.5.4 On agreeing to ambitious retrofit

- The most important reason for a building owner to carry out ambitious retrofitting is that the building already is in need of retrofitting. The second most important reason was to improve the buildings energy efficiency. A reduction in energy use reduces running costs, typically improve comfort for residents and make the building more environmentally friendly. The third most important reason for ambitious retrofitting is to improve thermal comfort and indoor air quality for the residents.
- The building owner is seen as the most influential actor in the decision making process. The architect is seen as the second most influential and the authorities are seen as the third most influential actor. Building owner and architect are self-explaining actors, easily identifiable. Authorities are less clear, but in this context we should think of them as the maintainers of building laws and regulations.

3.5.5 On characteristics of good retrofitting design

The final question of the survey provided the respondents the opportunity to elaborate freely on retrofitting. Seven basic areas of focus were identified in the responses; energy efficiency, cost, ease of application, flexibility, maintaining existing integrity of the architecture, improvement of the aesthetic quality and user comfort. Amongst the responses energy efficiency was the most referenced and thus seen as most important. Cost was noted as the second most important and aesthetics (architectural expression and design) as the third most important. However, it is important to note that the focus on the three most referenced elements varied between Norway, Germany and Spain. For example amongst the German respondents there is marked interest in visual or aesthetic qualities, whilst there is less interest in energy efficiency. In Norway the opposite was the case, there was more interest in energy efficiency than there was in aesthetic qualities. The severe financial crisis may explain the strong focus on cost in Spain. It is possible that the difference in focus is not a basic cultural difference, but that it is due to the role of stakeholders who have answered the questionnaire. For example a greater number of architects answered the questionnaire in Germany than in Norway (See figure 3.4 on page 13).

4 Requirements and regulations

The Energy Performance of Buildings Directive (Directive 2002/91/EC, EPBD), published in 2002, required all EU countries to improve their building regulations and to introduce energy certification schemes for buildings⁵. The EPBD was recast in 2010 (Directive 2010/31/EU), introducing new requirements. Most important of these was the move towards new and retrofitted nearly zero energy buildings by 2020 (this is 2018 for Public Buildings)⁶. Member States are required to: “*draw up national plans for increasing the number of nearly zero-energy buildings*” and “*following the leading example of the public sector, develop policies and take measures such as the setting of targets in order to stimulate the transformation of buildings that are refurbished into nearly zero-energy buildings*”.⁷

The EPBD is an overarching requirement of all EU countries. This relates to this task in that it requires all buildings being bought, sold or rented to have an energy assessment and certification (the implementation of this may vary from country to country across the EU). As the requirement (Directive 2010/31/EU) for Nearly Zero-energy retrofitted buildings isn't due until 2020 many countries have not yet implemented retrofitting regulations or guidelines.

Predominantly throughout Europe there are few requirements and standards for retrofitting, some are being developed but currently the lack of guidance on retrofitting is a barrier to its implementation.

Guidelines are not necessarily requirements of law, but there are a number of guidelines in existence in the EU that relate to retrofitting. A good example is guidelines for retrofitting developed in *IEA ECBE Annex 50 Prefabricated Systems for Low Energy Renovation of Residential Buildings – Retrofit Strategies Design Guide Advanced Retrofit Strategies and 10 steps to a Prefab module*⁸.

4.1 Retrofit requirements and standards

This section outlines information received from project partners in relation to requirements and standards for retrofitting in their country. A template was developed for the partnering countries to fill in. The basic contents of the associated template, a summary of the feedback from the participants and a commentary on the feedback are outlined. The Norwegian requirements and standards are provided in this report, for all countries see the full international report "Requirements of societal aspects for a successful and beneficial implementation of RetroKit Toolbox" which can be downloaded at <http://www.retrokitproject.eu/web/guest>.

The objective of the survey was to ascertain the level of requirements in existence at present in the different RetroKit partnering countries. The survey templates for regulations and standards were designed with a focus on three main sections that are described in table 4.1. The questions in the template inquire about each country's requirements and guidelines in the area of planning and architectural regulations.

There are requirements for retrofitting in most countries, however, in many countries it was not entirely clear whether the regulations mentioned relate both to new construction and to buildings being retrofitted. As the requirement (Directive 2010/31/EU) for nearly zero-energy retrofitted buildings (nZEB) is not due

⁵ <http://www.epbd-ca.eu/> [last accessed 2013-05-08]

⁶ <http://www.epbd-ca.eu/> [last accessed 2013-05-08]

⁷ <http://www.epbd-ca.eu/themes/nearly-zero-energy> [Last accessed 2013-05-08]

⁸ http://www.ecbcs.org/docs/ECBCS_Annex_50_PSR.pdf

until 2020, many countries have not yet implemented targets with regulations or guidelines for the implementation of nearly zero retrofitting.

Table 4.1 – The template used for mapping regulations and standards.

Summary of questions for regulations and standards for retrofitting	
1.	Requirements for architectural quality
	Are there such requirements in building regulations, national or local planning requirements and cultural/historic buildings requirements in your country?
2.	Requirements for retrofitting
	Does your country have regulations with specific requirements for buildings being retrofitted? Does your country have any 'stop gap' interim plan to bridge between the current lack of requirements and future requirements?
3.	Specific requirements
3.1	Specific energy requirements relating to existing buildings
	<ul style="list-style-type: none"> • U-values • Airtightness • Ventilation • Provision of energy by renewables
3.2	Universal access requirements for existing buildings.
3.3	Planning requirements for existing buildings.
3.4	Other requirements

4.1.1 Requirements and standards in Norway

Requirements for architectural quality

Yes, aesthetical requirements are described in The Norwegian Planning and Building Act.

Requirements for retrofitting

Yes, in The Norwegian Planning and Building Act, Chapter 31. Current energy regulations are described in "Regulations for Technical Requirements in Buildings" and will apply for projects undergoing a so called "general renovation". The definition of a "general renovation" is not clear and varies from county to county, see chapter 4.2.1. A specific regulation for retrofitting has been suggested, but no such regulation presently exists.

Specific requirements

Yes, in "Regulations for Technical Requirements in Buildings".

- U-values: Yes
- Airtightness: Yes
- Ventilation: Yes
- Provision of energy by renewables: buildings > 500 m²: min 60% of net heating demands should come from other energy sources than direct electricity (i.e. electric panel oven) and fossil fuels. Buildings < 500 m²: min 40% of net heating demands should come from other energy sources than direct electricity and fossil fuels.
- Note: Oil heating is no longer allowed in Norway.
- Note: balanced ventilation with heat recovery (80% or better) is a requirement in Norway.

- Universal access requirements for existing buildings: Yes, Regulation on technical Requirements for buildings, there are some requirements from current laws and regulations that will apply in a "general renovation" project.
- Planning requirements for existing buildings: Yes, in The Norwegian Planning and Building Act and Regulation on technical Requirements for buildings
- Other requirements: Own set of requirements for building conservation/protection.

4.2 Concluding remarks on regulations and requirements

The requirements and regulations vary substantially throughout Europe. Climatic differences, cultural and societal differences and differences in the building and architectural tradition are some factors that may explain this. As an example; Germany has quite specific requirements for retrofitting whereas Ireland has few or none.

From the feedback received, it was noted that there is a correlation between good regulations and guidelines for retrofitting and best practice case studies for retrofitting. As all EU countries are now required to develop targets for nearly zero energy performance, good building examples will follow in all countries.

Some concluding remarks are given in the following on the feedback received from the participating countries' response on regulations, requirements and standards.

4.2.1 Requirements for architectural quality

Architectural quality is mentioned in the regulations in each of the participating countries. As an example, The Norwegian Planning and Building Act⁹ have some paramount and general architectural requirements in § 29-1 and § 29-2. The law is in Norwegian, this is our translation:

§ 29-1. Design of the project

Any project after chapter 20 shall be designed and executed in such a way that it will have good architectural design in accordance with its function following the rules given in or in approval of this act.

§ 29-2. Visual qualities

Any project after chapter 20 shall be designed and executed in such a way that it by the municipality's judgment holds good visual qualities both in itself and in relation to its function and its built and natural environment and placing.

§29-2 is deepened by the county governors in each of Norway's 19 Counties, explaining how it should be understood and put into practice. The interpretation of §29-2 can vary between counties. The County governor of South-Troendelag's deepening on § 29-2 is shown below, as an example. Again, this is our translation from Norwegian to English:

"The wording of the law state that the building authorities must make a judgment whether or not a project holds "good visual qualities". The judgment is done by free assessment meaning that it should be done by objective criteria based on professional quality norms and not based on personal opinion on good/poor design. Examples of fundamental criteria are building height, volume, choice of materials, harmony and interaction between surfaces etc. Even if a project in itself has good visual qualities the building authorities can decline an application if the project does not fit in the context or in the surroundings. Projects that are dominant in relation to their built or natural surroundings, face stricter requirements. The judgment of what is good and what is poor aesthetic design is highly approximate. There will always be room for debate on which solution is the best".

⁹ <http://www.lovddata.no/all/hl-20080627-071.html>

4.2.2 Requirements for retrofitting

There are requirements for retrofitting in most countries, however, in many countries it is not entirely clear whether the regulations mentioned relate both to new construction and to buildings being retrofitted. In some countries current laws and regulation will apply also for retrofitted buildings depending on how extensive the retrofitting measures are. To give an example, chapter 31 in the Norwegian Planning and Building Act deals with requirements for existing buildings:

§ 31-2. Measures to existing structures

Measures on existing buildings shall be designed and carried out in accordance with the provisions given in or in sustain of the law. For buildings or use of buildings that are in conflict with later enactment of law the following can only be permitted when in accordance with the law: a general renovation, addition to a building, extension to a building, underpinning of a building, change of use or principal enlargement or change of former operation¹⁰.

According to § 31-2, current laws and regulations come into force in cases of "general renovation". What a "general renovation" is can be debated and the answer to that will vary from county to county in Norway. The RetroKit facade and roof concepts would in any case classify as a "general renovation" and subsequently current laws and regulations would apply. The most essential parts that would affect the retrofitting design are those concerning universal design (Chapter 12) and energy efficiency (Chapter 14) in "Regulations for Technical Requirements in Buildings"¹¹.

The requirement for 'Nearly Zero Energy' retrofitted buildings (Directive 2010/31/EU) is not due until 2020, therefore many countries have not yet implemented targets with regulations or guidelines for the implementation of nearly zero retrofitting.

4.2.3 Specific requirements

Specific energy requirements relating to existing buildings

Because of the requirements of the EPBD there are energy requirements in all countries, however it is not always clear again whether the regulations listed for new buildings apply to buildings being retrofitted.

Universal access requirements for existing buildings

Most countries have universal access requirements; however, it is not always clear again whether the regulations listed for new buildings apply to buildings being retrofitted.

Planning requirements for existing buildings

Most countries have planning requirements, many have requirements at a national level, and more specific requirements that relate to specific states or zones within the country. The standard of these requirements seems to vary substantially from one country to another.

¹⁰ <http://www.lovddata.no/all/tl-20080627-071-040.html#31-2>

¹¹ <http://www.lovddata.no/cgi-wift/ldles?doc=/sf/sf-20100326-0489.html#map032>

4.2.4 Regulatory gap - barriers to retrofitting

There are no sufficiently clear and concise regulations and standards for retrofitting that apply throughout the EU. Barriers to retrofitting are discussed in detail in the *FP7 EASEE (G.A. 285540) Envelope Approach to improve Sustainability and Energy efficiency in Existing multi-storey multi-owner residential buildings D1.1 – Identification of barriers and bottlenecks*¹².

The data from this research was obtained from interviews with various stakeholders in 2012. A total of 17 stakeholders were interviewed in Italy, Sweden, Ireland and Germany.

“Although sanctions could be imposed through regulations, the implementation speed of these regulations could be very slow in some countries.” (..) “the degree and speed at which EU Directives, such as the EPBD, has been implemented by autonomous regions within a Member State had a significant effect. In addition, despite the vast improvements in recent years as a result of the current EU legislation, the field of building renovation is not covered to a satisfactory extent. Regulation requirements for insulation measures in renovation projects can be a significant driver.” (EASEE)

“Building control procedures prior to, during and upon completion of the construction phase typically involve announcement to authority, application for permits, approval of plans, inspections by authority and completion of certificates. The long processes associated with obtaining a building permit can also be a barrier. The enforcement of the relevant regulations can be an issue, as often no strict enforcement procedures are followed.” (EASEE)

Depending on the regulations and requirements in any particular country and region there may be barriers to different types of retrofitting solutions. Since 2009 in Germany, it is stipulated in DIN 1946-6 (Ventilation requirements for residential buildings) that a mechanical ventilation system has to be installed in a retrofitted building as soon as one third of the windows are replaced. This rule has resulted in that the windows are not replaced in many cases. Thus, instead of having more residential buildings with mechanical ventilation systems, there are residential buildings with old windows with low air tightness. From the research in RetroKit it has also been seen that it is not necessarily the type of legislation that is the barrier, but the lack of legislation give no incentive and is therefore a barrier to retrofitting. This does not run through for every country, e.g., Greece has very strict requirements for construction in general and these requirements apply to retrofitting whereas in Poland there are no requirements for retrofitting. Some countries, e.g. Ireland, stipulate requirements for certain types of alterations to buildings, but as of yet it is the lack of regulation that is causing a barrier.

Another point that has to be taken into account, is who pays for the retrofitting. When a building has a great number of owners, as occurs in many cases in e.g. Spain and Norway with a high percentage of owned houses, it is very difficult to have the agreement of the owners to pay for retrofitting the building. Only with regulations which impose sanctions, it could be possible to increase the number of buildings being retrofitted.

The “Technical inspection of buildings” has been mandatory since 2011 in Spain for buildings older than 50 years. The objective is to assess the adequacy of buildings to the legally required conditions of safety, health, accessibility and beautification, and to determine the conservation works that are required to keep the building under required conditions. Energy aspects are not considered.

¹² <http://www.easee-project.eu/>

5 Best practice building examples

Best practice building examples are required in order to demonstrate the types of retrofitting taking place in apartment buildings in Europe currently. The best practice case studies submitted by project participants through the dissemination of the two templates are assembled in a database to be used in dissemination activities later on in the project.

Good examples of best practice case studies are documented in the IEA ECBS Annex 50 research: *IEA ECBE Annex 50 Prefabricated Systems for Low Energy Renovation of Residential Buildings – Building Renovation Case Studies*. Many of these case studies fit the RetroKit requirements, being low energy retrofitting of apartment buildings using prefabricated building elements.

The templates for best practice examples were designed with a focus on four main sections that are described in table 5.1. The feedback received from the partnering countries is summarised according to country, and the structure of the table in the full international report "Requirements of societal aspects for a successful and beneficial implementation of RetroKit Toolbox" which can be downloaded at <http://www.retrokitproject.eu/web/guest>. The Norwegian findings are presented below in subchapter 5.1.

Table 5.1 – The template used for mapping best practice building examples.

Summary of questions for Guidelines and regulations for retrofitting	
1.	TYPES OF TENURE
	<ul style="list-style-type: none"> ▪ Describe the residential building types in your country ▪ Describe the forms of tenure for residential buildings in your country
2.	TYPES OF RETROFITTING
	<ul style="list-style-type: none"> ▪ Describe the types of retrofitting happening in your country
3.	BEST PRACTICE CASE STUDY
	<ul style="list-style-type: none"> ▪ Please indicate whether you have an example of deep retrofitting of multi-family building using prefabricated solutions in your country ▪ If no, please describe an example of best practice retrofitting of multi-family buildings in your country
4.	PREFABRICATION
	<ul style="list-style-type: none"> ▪ Provide information on pre-fabricated companies and their capabilities in your country ▪ Provide examples of prefabrication companies in your country. Indicate percentage of prefabrication companies involved in retrofitting. ▪ Indicate the types of buildings these companies are working on. ▪ Describe the types of prefabrication units these companies are producing.

5.1 Norway

Types of tenure

Percentage apartments: 22.7% of residential building stock is apartment buildings

Forms of residential tenure generally for residential buildings in Norway:

Owner-occupiers:	77% own their own home. 17 % own their home through self-owned housing cooperatives.
Renting from private landlord:	16%
Social housing:	5 % including privately owned and local authority owned
Local authority housing:	4 % where this is social housing including homes for the elderly and for refugees. There are also a few cases of non-social housing related to renting to employees, but this number is too low to be significant for the percentages.
Other (please describe):	3 % including other forms of private tenure

Types of retrofitting

Norway appears to have good information about the types of retrofitting taking place in the country. Measures happening predominantly in apartments built 1956-1970 are: Changing to high performance windows, additional insulation in walls, roofs and floors accompanied with new cladding. Addition of balconies is often done in conjunction with facade rehabilitations.

Best practice case study

There are no best practice examples of prefabricated retrofitted apartments in Norway. The chosen best practice example is Myhrerenga housing cooperative in Skedsmo, Norway. Myhererenga was part of the IEA SHC Task 37 project. There are, however, examples of retrofit of schools and office buildings using prefabricated wooden façade elements. Two projects are documented in the ERANET smarTES project¹³.

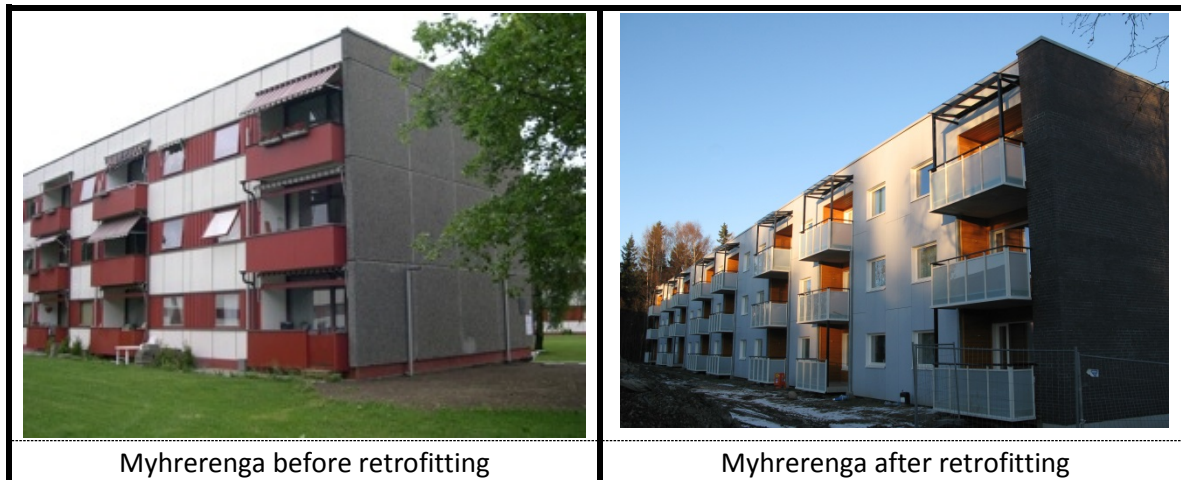


Figure 5.1 Photos of Myhrerenga before and after retrofitting.

Number of Floors : Three
Number of Units : 168 apartments before and after retrofitting
Retrofit measures : Major renovation including facades, roofs, floors, windows and doors (see table below), new central balanced ventilation system (SFP<1,4 kW/(m³/s)) with heat recovery ($\eta=79\%$). Improved air tightness (0,64 ach after renovation) and new radiators in the apartments. Approximately 70% reduction in heating needs. New heating central with renewable heat sources covering 80–90 % of total heating need for rooms and hot water (4 chained air-water heat pumps and 44 vacuum solar collectors on roof).

Component	U-value before	U-value after	Solution
Wall	0,40 W/m ² K	0,12 W/m ² K	100mm + 200mm additional insulation externally (rockwool) + new cladding
Roof	0,35 W/m ² K	0,11 W/m ² K	100mm + 200mm additional insulation blown into existing cavity
Floor towards basement	0,58 W/m ² K	0,23 W/m ² K	50mm + 100mm additional insulation under basement floor slab
Windows + balcony doors	2,8 W/m ² K	0,8 W/m ² K	Passive house windows
Doors	2,7 W/m ² K	1,2 W/m ² K	

¹³ <http://www.tesenergyfacade.com/>

Prefabrication companies

There are many Norwegian companies manufacturing prefabricated elements. These elements are mostly used for constructing new buildings. Some examples of prefabricated elements manufactured in Norway are:

Wood frame elements insulated with mineral wool

- Steel structure elements
- Sandwich panels
- Roof elements
- Concrete elements

The following companies are certified, i.e. approved, to sell to other companies as contractors:¹⁴

6 companies offering building modules

7 companies offering building elements

1 company: both of two above mentioned certifications.

In addition, there are several contractors who prefabricate the wooden structure before bringing it to the building site. These do not need a certification as long as they do not sell it to other companies.

There are also 12 foreign companies who have Norwegian certification for building modules and elements:

Modules: 6 companies

Elements: 5 companies

Both: 1 company

5.2 Concluding remarks on best practice building examples

As RetroKit is aimed at the retrofitting of entire apartment buildings, the template required that people answer in relation to numbers and percentages of residential buildings in their country. In the answers provided, some discrepancies have been noted; some answers are given in numbers of buildings while others were given in numbers of residential units. This may be a result of two factors, one being the misinterpretation of the question and the other being the format in which country data is collected. It is important to note that the data presented is different for different countries. For example, in Ireland residential data is collected as it relates to residential units and not in relation to entire buildings. Germany had data that related to residential buildings and then Sweden's data appears to relate to percentages of apartments only.

5.2.1 Tenancy

The findings show the numbers and percentages of apartments in countries, and the percentages of tenancy types. What was not clear, however, from the template question, is the types of tenancies associated with apartments in each country. In some countries apartments are predominantly owned and rented out by local authorities whereas in others there is a culture of owner occupiers of apartments. This is important information, as it will help understand who the building owner is. The type of tenancy also plays an important role on the technical point of view. In buildings where all dwellings are owned by the same owner and rented to the occupants, it is often preferred to use central technical installations (e.g. heating and ventilation) because the owner does not want to disturb the residents for retrofitting work or

¹⁴ Data from February 2013

for maintenance. The owner might also think that there is less risk of degradation or misuse if the device is in a cellar or on the roof and not in the dwelling. In buildings where the occupiers also are the owners, decentralized installations may be preferred, so that everyone has the freedom to decide which type of equipment to install and to organize maintenance themselves. The decision to replace these installations is also easier if the installation belongs to only one owner.

One of the issues with gathering this information is the differing understanding of terminology and the different types of terminology used in different countries. Eurostat uses the term 'flat', most countries refer to 'apartments', and some countries refer to 'multifamily houses' and 'multifamily buildings'.

5.2.2 Types of retrofitting

The template requested information relating to types of retrofitting taking place in each country. Feedback indicates that there is little deep retrofitting or retrofitting using prefabricated solutions taking place in the partner countries. Most forms of retrofitting appear to consist of one of the measures, such as new windows. There are however a number of examples of deep retrofitting of apartment buildings using prefabricated elements in Germany, Switzerland and the Netherlands.

5.2.3 Best practice case study

Few countries had examples of deep retrofitting and/or retrofitting with the use of prefabricated solutions, only Germany, The Netherlands and Switzerland had examples. The reasons for this could be that these types of retrofitting are not taking place or that they are taking place but have not been documented. This indicates the importance for countries to document, record and disseminate best practice case studies in order to promote the use of this approach to retrofitting. The *IEA ECBS Annex 50 – Prefabricated Systems for Low Energy Renovation of Residential Buildings* report is a very good record of case studies of best practice.

5.2.4 Prefabrication

The aim of this question was to get an idea of the type of prefabrication taking place in each partner country and whether prefabricated solutions are being used for retrofitting apartment buildings. The answers to this question demonstrate that prefabrication is predominantly used for new single family houses. Few of the companies appear to be involved in retrofitting.

6 Design guidelines for an architecturally attractive RetroKit Toolbox

A set of Design Guidelines has been developed for the concepts and solutions that will be provided by the RetroKit Toolbox based on the findings in the surveys¹⁵. By meeting the Guidelines, the proposed RetroKit solutions will overcome the major problems normally associated with prefabricated solutions and strengthen their advantages. Before describing the Guidelines, some background on architectural quality and preferences for the built environment are presented.

6.1 What are the hallmarks of attractive architecture?



Figure 6.1 Le Corbusier, photo P. Almasy

"You employ stone, wood and concrete, and with these materials you build houses and palaces. That is construction. Ingenuity is at work. But suddenly you touch my heart, you do me good, I am happy and I say: "This is beautiful." That is Architecture. Art enters in".

Le Corbusier (Trachtenberg and Hyman, 2003)

The quote by Le Corbusier is a statement about beauty in architecture, and achieving an attractive retrofit is an important goal in the RetroKit project. However, the terms *architecture* and *attractive architecture* are qualitative terms and their use and understanding may be expected to vary between cultures, countries and individuals. It is of course not our intension to make a definition of attractive architecture here, but instead to provide a basic framework with which to understand the design guidelines for the solutions provided by the RetroKit Toolbox.

The Roman writer, architect and engineer Vitruvius (ca. 80BC–15BC) wrote *De Architectura*, known today as *The Ten Books on Architecture*, where he asserts that a structure (building) must exhibit the three qualities *firmitas*, *utilitas*, *venustas*. That is, it must be solid, useful and beautiful. It is agreed even today that architecture can be described by these three fundamental qualities (Hearn, 2003), often translated as technical quality, quality in use (function) and aesthetic quality. All three qualities have to be present in good architecture. If one or more of the three qualities are absent, we are not dealing with good (attractive) architecture.

Even though we split architectural quality into three quality criteria, it is apparent that the three perspectives are closely related and that they in reality cannot be completely divided from each other. The division is anyway useful because it offers the opportunity to discuss the different perspectives separately, but also to understand how they collaborate (Høyland et al., 2012).

¹⁵ The design guidelines are also provided in a "flyer" format that can be downloaded at the RetroKit site.



Figure 6.2 A 1684 depiction of Vitruvius (right) presenting *De Architectura* to Emperor Augustus¹⁶.

These three qualities, technical quality, quality in use (here known as function) and aesthetic quality, are often considered primary within architectural practice and they provide a basic framework with which to understand the architectural requirements the RetroKit solutions have to address.

6.2 Technical quality

Technical quality focuses on a building's qualities related to structure, building physics technical installations and the building as a climate envelope. The focus is on the physical structure, building elements and technical installations. A large part of traditional building research focuses on this field. The building is seen as an object which may be measured and analysed. Methods from natural science are applied to develop new knowledge that results in the increased technical quality of the building. For example, changes in the climate and the amount of available resources for the production of energy and building materials have encouraged a focus on energy efficiency and zero emission building design.

6.3 Functional quality

When the public criticises architecture, they often use words such as impractical, uncomfortable, ugly and expensive. The impractical aspect is based on an understanding that there exists a disparity between the way people live and the architectural framework provided (Norberg-Schulz, 1967). Another established term for function is usability, which focuses on how the building works in relation to the everyday life taking place in the building. The usability of a building should therefore be evaluated in relation to the goals, purposes and activities happening in the building. Depending on how well a building supports the activities of its users, a building contributes to effectiveness, goal achievement and user satisfaction. This is what is referred to as usability, or a building's quality in use. Research on usability is typically interdisciplinary and tries first and foremost to give insight in why a design is successful or not successful rather than revealing accurate and definitive truths. It is through attention to function that the social quality of architecture is most in focus. Although the needs of the user/public are also present in the attention played to technical and aesthetic qualities.

6.4 Aesthetical quality

The aesthetical quality of a building is experienced through our senses, primarily sight, but touch, smell and sound are also important in the aesthetic experience of architecture. It is in other words a phenomenon of the senses. Aesthetic theory in art and architecture has its origins in the work of the Enlightenment philosopher Alexander Baumgarten and his "Doctrine of Sensibility" (Baumgarten, 1988). It is often assumed that there is an aesthetic attitude which is in contrast with practical, moral, scientific and

¹⁶ <http://en.wikipedia.org/wiki/Vitruvius>

economic factors (Dickie, 1974). This understanding of aesthetic experience isolates it from the social and physical context around it. However, according to Vitruvius's understanding of architecture there is a close association between aesthetic quality, technical quality and functional quality in architecture. There are numerous qualities of a building, both interior and exterior, which may be associated with the aesthetic experience. Form, colour, light, construction, materiality, size, proportion, space, spatial connections and hierarchies, acoustics, thermal sensations, views, and smell, are all examples of elements that affect our experience of a buildings aesthetic quality.

Aesthetic judgements are value judgements which are closely associated with personal taste and cultural values. Value judgements are not universal, they will depend on subjective experience (Cassirer, 1955). Aesthetical quality is closely related to the terms "ugly" and "pretty". There is no universal truth on what is ugly and what is pretty. The answer will vary from person to person, being subjectively dependent on the beholders references and previous experiences. The perception of aesthetical quality (beauty) has changed throughout history and continues to change. It is culture dependent and it varies with social context. Nevertheless, there are still some universal "truths" on what is perceived as attractive, nice, pretty or desirable when it comes to our preferences for the built environment.

6.5 General preferences regarding the built environment

A great number of preference studies on built environment and surroundings have been summarized by J. L. Nasar (Nasar, 2000). Six properties of great importance describing our built environment and surroundings were pointed out as common denominators in all of the studies, see table 6.1.

Table 6.1 – Six positive and negative properties describing our built environment and surroundings.

Positive properties	Negative properties
Order, coherence, completeness	Disorder
Moderate complexity	Low or high complexity
Inclusion of natural elements	Importunate built elements
Good maintenance, clean	Deterioration, trash
Openness, perspective, overview, light	Blocking of views and perspective, dark
Historical meaning	Indifferent, no historical meaning

Nasar and a colleague developed a model to get hold of the underlying motivations of a layman's aesthetical preferences as opposed to an expert's aesthetical preferences (Purcell and Nasar, 1992). The layman's preferences are based on *confidence* where the values of recognition and emotional experience are fundamental. The expert's preferences on the other hand, are based on *interest* where the values of outer form and aesthetical experience together with information and history are vital.

A study on jury statements of the yearly awarded prize for good architectural design in Norway analysed which qualities of the 25 winning project from 1961 to 1986 were most often used to describe the prize winners (Cold, 1990). The qualities were ranked by how often they occurred in the jury statements.

1. Wholeness, cohesion and harmony
2. Originality and innovation
3. Connection and belonging to the context (place and landscape)
4. Cultivated simplicity

These qualities can serve as indicators on aesthetical quality in architecture (Cold, 2010), and even though slightly different descriptive words are used here, they still comply very well with the findings of Nasar. For the RetroKit Toolbox, this translates to the following:

The RetroKit Toolbox solutions must leave room for the design team to adapt the new and retrofitted skin of the building to the original context and expression of the building (historical connection, recognition), provide room for cultivated simplicity and moderate complexity to strike the right balance between too low and too high complexity.

6.6 Design guidelines

A set of design guidelines have been developed for the RetroKit Toolbox solutions based on the findings from the surveys carried out in the RetroKit project countries (figure 6.3).

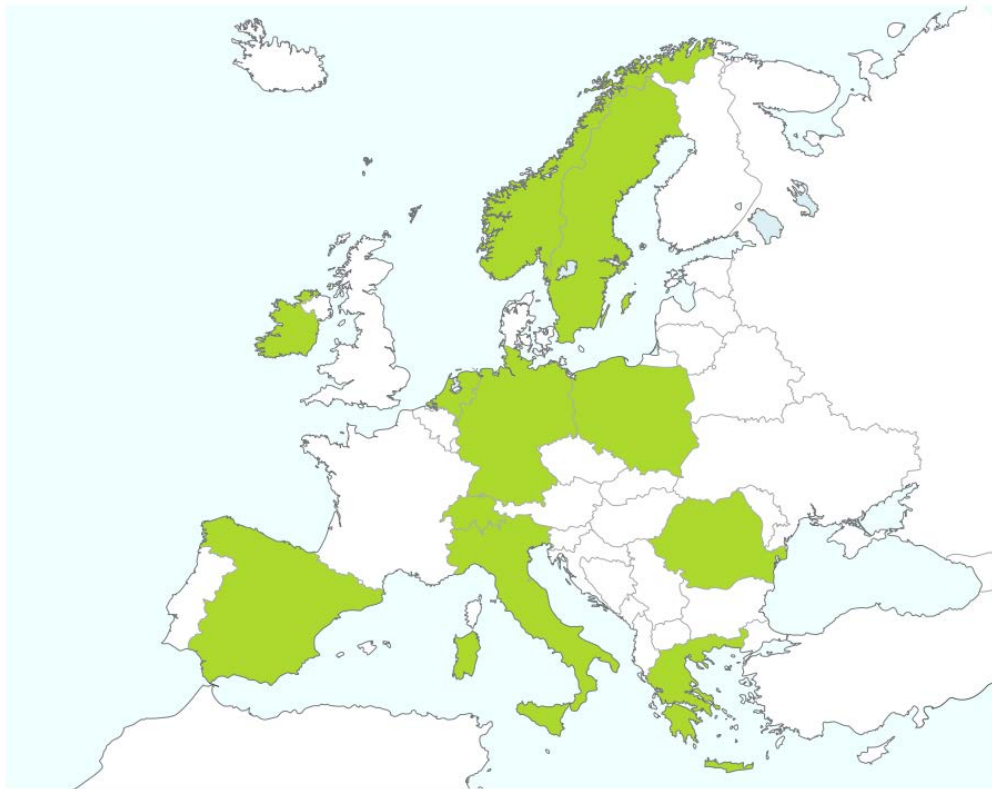


Figure 6.3 Map showing the partner countries in the RetroKit project where the surveys were carried out

We found that the requirements and regulations vary substantially throughout Europe. Climatic differences, cultural and societal differences and variations in the architectural tradition are factors that may explain this. All countries have requirements to architectural quality in their laws and regulations and there are requirements for retrofitting in most countries. However, it is often not entirely clear when current regulations are put into force in a retrofitting intervention. It was found that there are no sufficiently clear and concise regulations and standards for retrofitting that apply throughout the EU. For the RetroKit Toolbox, this translates into a general design guideline requirement that:

The proposed RetroKit solutions will have to be robust and adaptable enough to tackle differences in laws and regulations in the European countries.

The majority of the stakeholders that responded to the questionnaire survey, have little experience in using prefabricated modules in retrofitting. This suggests the need for good examples where the involved stakeholders' experience with prefab retrofitting is widespread. The mapping of best practice buildings in the partnering European countries provided few examples of ambitious retrofitting utilising prefabricated modules or elements. This translates to a requirement that:

Best practice building examples are needed to show that ambitious retrofitting with prefab elements can yield attractive architecture with low energy needs at an affordable price. The RetroKit pilot buildings have the potential to provide such good examples.

In the questionnaire survey conducted in 11 European countries, stakeholders in the retrofitting industry were asked a range of questions regarding retrofitting in general and retrofitting using prefabricated elements/modules in particular. According to the respondents, the most important requirements the RetroKit Toolbox solution have to meet to be attractive, are, in order of priority:

1. Energy performance
2. Adaptability to the building
3. Efficient construction
4. Flexibility in design (room for tailoring)
5. Adaptability to the residents needs

With regard to flexibility in design the most important factors were reported to be, in order of priority:

1. Precision of joints and connections
2. Surface material (texture, colour)
3. Proportion of module (shape).

The three most referenced characteristics of good retrofitting design in the questionnaire survey were, in order of priority:

1. Energy efficiency
2. Cost
3. Aesthetics (architectural expression and design)

The greatest pitfall associated with retrofitting using prefabricated modules were reported as limited architectural freedom with poor architecture as a result. In addition, high costs were reported as a pitfall. For the RetroKit Toolbox, this translates into a design guideline requirement that:

The RetroKit concept must provide flexibility in design and execution so that the modules can be adapted to the actual building and the design team left with room for creativity and tailor made solutions.

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[References to laws and regulations and resources on the internet are provided as footnotes at the relevant page in this document.]

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Appendix questionnaire



Please select your language:

- English
- Română
- Italiano
- Polski
- Deutsch
- Ελληνικά
- Español





Language:

RetroKit – Toolboxes for systemic retrofitting

This survey is part of the research project RetroKit that aims at developing concepts and prefabricated modules for ambitious and holistic retrofitting of multi-family apartment buildings built between 1945 and 1980.

The overall goal is to increase comfort for the residents and at the same time reduce the energy demand of the building. See link for more information on the RetroKit project <http://www.retrokitproject.eu/home>.

The purpose of the survey is to gather information from stakeholders involved in retrofitting and to identify their needs with a view to holistic retrofitting with prefabricated modules.

3%

Next



Language: English

Background information

1. What is your role?

- Authority
- Architect
- Consultant
- Building owner
- Contractor
- Prefab manufacturer
- Other, specify:

2. In which country are you located?

- Poland
- Romania
- Germany
- Switzerland
- Ireland
- Italy
- Spain
- Greece
- Sweden
- Norway
- The Netherlands

16%

Previous

Next



Language: English

3. How would you rate your knowledge on ambitious retrofitting?

Extensive 1 2 3 4 5 Limited

4. How would you rate your experience with ambitious retrofitting?

Extensive 1 2 3 4 5 Limited

5. Do you have any experience in using prefabricated modules in retrofitting?

Extensive 1 2 3 4 5 Limited

28%

Previous

Next



Language: English

6. Are you aware of the regulation requirements for retrofitting in your country?

- Yes
- No
- Partly

7. What are the main challenges from your point of view related to the regulations?

- None, the regulations are ok
- Lack of
- Newness
- Out of date
- Incomplete
- Too little detail
- Too much detail
- Too strict
- Not strict enough
- Other specify:

38%

Previous

Next



Language: English

Choosing prefabricated modules for retrofitting

8. What would be the most important criteria in your choice of a particular prefab system for deep renovation?

Rate from 1 (not important) to 5 (very important).

	Not important			Very important		
	1	2	3	4	5	
Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Ease of application	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Variety of finishes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Quality of craftsmanship	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Freedom in architectural expression	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Thermal performance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Robust and low maintenance needs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Availability of prefab modules	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Suppliers reputation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Ventilation integrated in the prefab module	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Renewable energy production integrated in the prefab module	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	

47%

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Language: English



9. What do you think are the advantages of retrofitting with prefabricated modules as opposed to on site production?

	An advantage	Neutral	Not an advantage
Efficient construction	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Less disruption for the residents	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Freedom in architectural design	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Improved built quality	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fewer building defects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Smoother design process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Good from a construction/technical stand point	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Easier to secure a "dry building"	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

53%

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Language: English

10. What do you think are the pitfalls of retrofitting with prefabricated modules as opposed to on site production?

	A pitfall	Neutral	Not a pitfall
Limited architectural freedom	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Complicated design process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Resulting in poor architecture	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Inefficient construction	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Expensive	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
More building defects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
More time consuming	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Disruption for the residents	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

59%

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Language: English



Architectural requirements for prefabricated retrofit solutions

1.1. Which architectural requirements does a prefabricated retrofit solution have to meet to be an attractive alternative?

Select the 5 most important requirements.

- Appearance
- Flexibility in design (room for tailoring)
- Efficient construction
- Efficient design process
- Energy performance
- Adaptability to the building
- Adaptability to the urban context
- Adaptability to the residents needs
- Added qualities for residents (e.g. balcony, storage, daylight)
- Other, specify:

69%

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Language: English

12. With regard to flexibility in architectural design, rate the importance of the aspects under from 1 (not important) to 5 (very important).

	Not important					Very important	
	1	2	3	4	5		
Size of module	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
Proportion of module (shape)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
Surface material (texture, colour)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
Precision of joints and connections	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
Possibility for creating relief in the facade (depth, rhythm)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
Integration of solar shading devices	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
Integration of solar energy (photovoltaic and solar thermal)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		

75%

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Language: English ▼

Agreeing to ambitious retrofit

13. What in your opinion makes building owners agree to ambitious retrofitting?

Rate from 1 (not important) to 5 (very important).

	Not important					Very important				
	1	2	3	4	5	1	2	3	4	5
Green image/ company policy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Improved indoor environment quality and comfort for residents	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To give the building a facelift	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Energy efficiency	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Need for rehabilitation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To be competitive in the letting market	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Expectations from the planning authorities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Meeting law and regulation requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Government funding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

84%

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Language: English

14. What do you see as the most important areas to be addressed in retrofitting?

Select the 3 most important areas in your opinion.

- Thermal comfort and indoor air quality
- Improved day lighting
- Architectural quality
- Added qualities for residents (balcony, storage, entrance areas)
- Durability
- Reducing energy demand
- The cost

91%

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Language: English ▼

15. Which three actors in your experience influence decision making process the most?

- Most influential --- Select alternative --- ▼
- 2. most influential --- Select alternative --- ▼
- 3. most influential --- Select alternative --- ▼

16. What in your opinion characterizes good retrofitting design?

Give a short description. Please provide building examples if possible.

100%

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Done

Retrofitting multifamily buildings with prefabricated modules – RETROKIT

STAKEHOLDER NEEDS AND VIEWS

Multi-family apartment buildings are the building type with the highest energy demand in Europe, consuming 68% of the total final energy use in buildings. Most of them were built between 1945 and 1980. Due to age, most of them now require retrofitting and large energy savings may be achieved. This building type is located all around Europe and share many common features like architecture, structure and materials, making them suitable for retrofitting with prefabricated modules.

In the RetroKit project 11 partnering countries collaborate in developing prefabricated solutions for this building type. To make sure that good concepts and solutions are developed, knowledge on the needs and views of the stakeholders involved in retrofitting is needed. A questionnaire survey has been carried out among stakeholders involved in retrofitting in the 11 countries. The architectural regulations and requirements have been mapped as well as best practice building examples in the same countries.

The findings show that the most important requirements a prefabricated retrofit solution has to offer to be an attractive alternative are; energy performance, adaptability to the building, efficient construction, flexibility in design, and adaptability to the resident's needs. The three most referenced characteristics of good retrofitting design were energy efficiency, cost and aesthetics. The greatest pitfalls associated with prefabrication were limited architectural freedom with poor architecture as a result.