Development of refurbishment concepts – The case of multi-family houses from the 1970s in Western Germany

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Structured Abstract:
The European housing stock is dominated by properties built before the 1980s. These buildings are to a great extent far behind current technical and social requirements. This paper presents a process for developing supply and demand-oriented refurbishment concepts for residential buildings, specifically in the case of multi-family houses from the 1970s in Western Germany. The process contains five steps pertaining to the building typology level and five steps pertaining to the individual building level. About 2.4 million dwellings and more than 13% of the entire multi-family housing stock in West Germany are located in multi-family houses from the 1970s, in many cases still without any major refurbishment measures. A large portion of this stock was or will be the subject of portfolio deals often involving foreign investors. Using data from housing corporations, more than 13,700 energy certificates, expert interviews, as well as a secondary analysis of a representative survey of housing demand in Germany, the key building characteristics and needs for action in the roof area for this type of the building stock are identified. Roofs are often damaged or have minor damages. Their refurbishments are often conducted in combination with thermal improvements of exterior walls and windows. Further, the specific requirements of the main target groups are found. The results show prioritised refurbishment measures in the area of roofs on the building typology level. These empirical results are useful for property owners such as housing corporations, municipalities, owner communities or foreign investors in Western Germany and other European countries to adopt and/or implement fundamental and demand-oriented refurbishment measures for their buildings.

Keywords: Residential property/building, refurbishment concepts, refurbishment measures, multi-family houses, building typology, user requirements, obsolescence

Article Classification: Research paper

1 Introduction

The European housing stock is dominated by properties built before the 1980s (Ministry of the Interior and Kingdom Relations 2010). One of the oldest housing stocks in the EU is located in Germany (Lechtenböhmer and Schüring 2011, p. 59). About 68% of the 40.5 million dwellings in approximately 19 million buildings were built before the first Ordinance on Thermal Insulation (I. WSchV) became law in 1978 (Zensus 2011 2014). These buildings are to a great extent far behind current technical and social requirements. Thus refurbishment[1] measures can create significant technical, functional, energetic and aesthetic improvements both in Germany and throughout Europe (see Nemry et al. 2010, p. 984; Di Giulio et al. 2012). Previous investments for refurbishments of residential buildings in Germany, are done mainly for post-war housing units built before 1968, due to necessary improvements in thermal insulation, layouts or balcony extensions (see Walberg 2011, pp. 53-54; BMVBS 2010, p. 78). Multi-family houses with construction years between 1969 and 1978, summarised as multi-family houses from the 1970s, will in the future have a higher priority for refurbishments (see BMVBS 2010, p. 81). About 2.4 million dwellings and more than 13% of the entire multi-family housing stock in Western Germany are located in multi-family houses from the 1970s (see Diefenbach and Born 2013, p. 2).[2] In many cases these are still without any major refurbishment measures. Integrated locations, contemporary layouts, existing balconies, generous outdoor space and good structural conditions for energy modernisation on important building components (e.g. exterior walls, windows or roofs) are key potentials of these buildings. A large portion of this stock was or will be the subject of portfolio deals often involving foreign investors.

The objective of this paper is to present a process for developing supply and demand-oriented refurbishment concepts for residential buildings, specifically in the case of multi-family houses from the 1970s in Western Germany. This process contains five steps pertaining to the building typology level and five steps pertaining to the individual building level. Using data from housing corporations, more than 13,700 energy certificates, expert interviews, as well as a secondary analysis of a representative survey of housing demand in Germany, the key building characteristics and needs for action in the area of roof for this type of building stock are exemplary identified. Roofs are often damaged or with minor damages. Along with exterior walls and windows, roofs are important components of the building envelop (e.g. for thermal insulation or humidity protection). Roof refurbishments are often conducted in combination with thermal improvements of exterior walls and windows because of technical (e.g. connections of roof and exterior walls can be coordinated) and organisational (e.g. shared use of scaffold for roof, exterior wall and windows) advantages. Further, the specific requirements of the main target groups are found. The results show prioritised refurbishment measures in the area of roofs on the building typology level. These empirical results are useful for property owners such as housing corporations, municipalities, owner communities or foreign investors in Western Germany and other European countries to adopt and/or implement fundamental and demand-oriented refurbishment measures for their buildings. Section II gives an overview and a brief introduction of the analysed data in the paper. The process for creating refurbishment concepts as well as the prioritised refurbishment measures are presented in Section III. A summary of the main results, practical implications and limitations are set forth in Section IV.

2 Data and methodology

The study uses building typologies literature to get first indications of building components (e.g. roof) in the original condition for the multi-family houses from the 1970s. Thirteen expert interviews with executive employees of housing associations in Western Germany were conducted from the end of 2012 through the end of 2013. The semi-structured interview guide included questions about typical characteristics and weaknesses, or useful realised measures. Data of housing associations contained information concerning 449 buildings with over 7,000 dwellings and ground plans. The Techem GmbH provided usage based energy passes of multi-family houses with at least three flats between 2003 and 2008. 13,711 energy passes for multi-family houses from the 1970s with over 206,000 flats were analysed to find modernisation conditions of individual building components (e.g. roof). Besides, the paper uses a survey about the German building stock, conducted by the Institut Wohnen und Umwelt GmbH from the end of 2009 through the beginning of 2010. The data set contained 7,510 buildings, of which 229 are multi-family houses from the 1970s. Through an analysis of the survey, quantitative and qualitative (e.g. construction, insulation thickness, time of modernisations) evidence about building components (e.g. roof) were found. In addition to the mentioned data sources, lifetime literature in Germany was evaluated and considered. Through the comparison of the actual lifetime of the building components with the empirical values, theoretical needs for action were recognised.

Residential target groups of the German housing market and their individual requirements are described in the living matrix model of the institutes InWIS Forschung und Beratung GmbH and Analyse & Konzepte. This model was introduced in 2008 and updated and confirmed in 2013. With 3,031 phone interviews randomly selected by state and municipality type in 2013, the study is classified as representative for Germany (GdW 2008; GdW 2013, pp. 97-98). The living matrix model was used for a secondary analysis in this paper and briefly introduced in the next section.

3 Development of the refurbishment concept

Residential building stocks in all European countries include a wide range of different buildings with several building characteristics according to historical events and building types (IWU 2012b, p. 6). Differentiations according to construction years are substantial due to typical construction methods and building materials. The TABULA project transferred national building stocks into building typologies for a large amount of European countries (IWU 2012b, p. 6). In principle, different building typologies have different needs for action. These depend on the building age, condition and characteristics as well as user requirements. However, research in Germany and many other countries has not addressed the link between building typologies and user requirements.

This paper discusses a process for developing supply and demand-orientated refurbishment concepts for building typologies, specifically in the case of multi-family houses from the 1970s in Western Germany. The process contains evaluations at two levels (see Figure 1). The first level is the typology level, which includes the building characteristics and conditions for large parts of the building typology as well as general user requirements. Based on these evaluations, general needs for action for the building typology can be identified. Additionally, by prioritising the needs for action and deriving possible refurbishment measures, recommendations for action can be articulated. The focus of this paper is to show the process in the typology level. The gained results support building owners' to assess building characteristics and needs for action more efficiently (e.g. for refurbishing single buildings or for appraisal of portfolios).

Next, at the level of individual buildings, the needs for action can be specified. For this purpose, present building characteristics and local user requirements of existing and potential new residents have to be analysed. Based on this analysis, the refurbishment targets of the owner can be clearly formulated, and the recommendations for action can be applied to the individual building to create different refurbishment concepts with useful refurbishment measures. The most appropriate refurbishment concept should be selected.

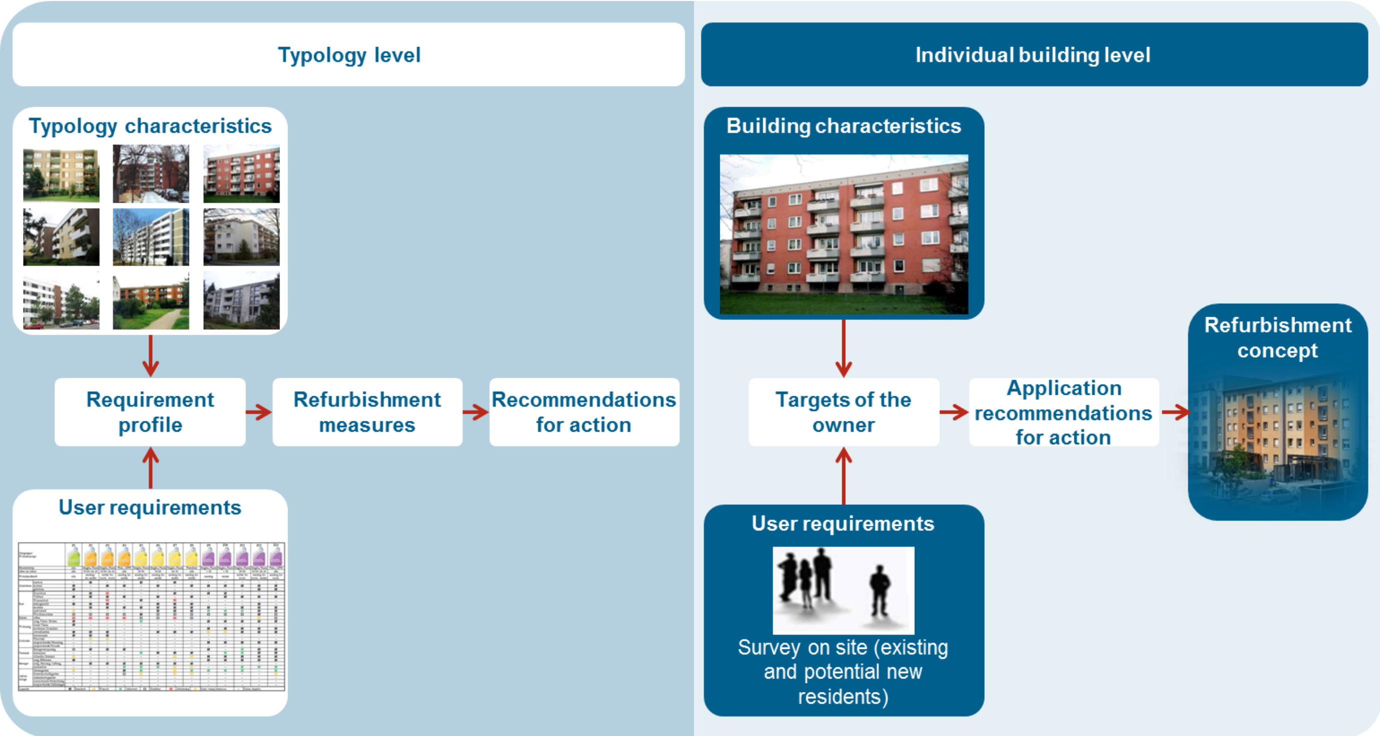


Figure 1: Process for developing a refurbishment concept. Sources: Own representation based on IWU 2012a, p. 35; Wohnbau Lörrach 2013; GdW 2008, p. 66.

3.1 The typology level

This section discusses a five-step process for developing a catalogue with recommendations for action for a specific building typology. The first step is to find key characteristics and needs for action for the building typology. The second step is finding appropriate target groups for the building typology. The third step uses the Kano model to prioritise needs for actions of the building typology and the users. Step four is utilising the prioritised needs for action as the basis for deriving possible refurbishment measures. The fifth and final step is identifying recommendations for action as a result of an assessment of the measures and the costs. These recommendations are the basis for developing different refurbishment concepts for an individual building as shown in 3.2.

Step 1: Needs for action for the buildings

Key characteristics and needs for action for the building typology are shown for the entire building with its building components and technical systems to identify possible areas of investigation. In the case of the multi-family houses from the 1970s one selected building component is presented, the typical characteristics and conditions of roofs. Needs for action are derived on the basis of common existing damages (damage management). Operator obligations with periodic inspections (e.g. for operational safety, fire protection, structural stability) as well as mandatory equipment and obligations to replace (e.g. changing over 30 year old heating systems, insulating of insulated heating pipes) are not considered. It is presumed that operator obligations are fulfilled. The Results intend to show typical characteristics and needs for action for a general amount of buildings for a specific building typology. These needs for action are formulated on a very basic level, without commitment to specific measures. Specific measures are found in step four.

Areas of investigation

The surveyed areas for a building typology do not differ from an individual technical building due diligence. The objective is to find strengths and weaknesses as well as potentials and risks for the typology. Thus, it is possible to concretise refurbishment causes and reasons, and derive needs for actions for the buildings (see Ma et al. 2012, pp. 890-891). Potential areas for a technical due diligence are shown in Table 1. These building components can then be structured by the DIN 276-1 on the basis of cost groups, as shown in the next steps of the investigation. Information about the components can be won by analysing existing building typology literature, lifetime literature, as well as generally accepted engineering standards during the construction time or energy passes. Predestined partners for investigations are building owners with a large build stock such as housing associations. These owners can offer a large amount of data (layout plans, building condition analyses, dwelling sizes, tenant surveys) and information (e.g. in an expert interview).

Substructure and construction waterproofing	Wastewater system and house connection	Ground and water level
Frame and tonnage	Exterior walls, exterior wall coverings	Interior walls and interior wall coverings
Balconies, stairways and staircase as well as additions to buildings	Ceiling construction und roof	Exterior and interior doors
Windows and sun protection	Installations	Heating installations with lines
Electric installation with lines and connections	Telecommunication	Sanitary installations with lines
Lifts	Conversions	Layout and space efficiency
Thermal protection and protection against moisture	Thermal bridges	Acoustic and fire protection
Contaminations	Damages (e.g. corrosion, plantations, animals, salt, mold)	Outdoor facilities (e.g. plantations, parking, lighting)

Table 1: Potential areas for a technical due diligence. Sources: Own representation based on BAKA 2009, p. 36; van Holm 2000, p. 85; DIN 276-1:2008-12.

Typical characteristics and conditions of roofs in the case of multi-family houses from the 1970s

Multi-family houses from the 1970s typically have been constructed with flat roofs.[3] The flat roofs can be distinguished into two types of construction: warm roofs (mainly) and cold roofs. Warm roofs are composite constructions while cold roofs have a double-layer structure. Both types are drained by integrated roof gully and gutters as well as external gutters (e.g. copper, zinc). Roof openings are installed for ventilation shafts, roof exits and chimneys. The ideal-typical construction of the different roofs is shown in Table 2. It should be noted that some constructions differ from the ideal-typical construction.

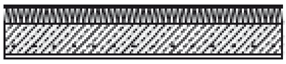
<table>
<tr><th colspan="2">Warm roof</th><th colspan="2">Cold roof</th></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td rowspan="3"></td><td></td><td></td><td>Gravel</td></tr>
<tr><td>Gravel</td><td>Screed (4-5 cm)</td><td>Roofing film</td></tr>
<tr><td>Roofing film</td><td>Roofing film</td><td>Waterproofing</td></tr>
<tr><td>Screed (4-5 cm)</td><td>Waterproofing</td><td colspan="2">Formwork made of gypsum or profiled boards</td></tr>
<tr><td>Roofing film</td><td>Compensation layer</td><td colspan="2">Air circulation</td></tr>
<tr><td>Thermal insulation (2-6 cm mineral wool, polystyrene, foam glass)</td><td>Thermal insulation (4-6 cm mineral wool, polystyrene, foam glass)</td><td colspan="2">Thermal insulation (2-6 cm mineral wool, polystyrene, foam glass) between wooden beams</td></tr>
<tr><td colspan="4">Adhesive layer</td></tr>
<tr><td colspan="4">Vapour barrier</td></tr>
<tr><td colspan="4">Steel-reinforced concrete roof (ca. 15 cm)</td></tr>
<tr><td colspan="4">Lime gypsum plaster (ca. 1 cm)</td></tr>
<tr><td>U-value 0,50-0,92 (W/m²K)</td><td>U-value 0,42-0,80 (W/m²K)</td><td>U-value 0,57-0,82 (W/m²K)</td><td>U-value 0,45-0,61 (W/m²K)</td></tr>
</table>

Table 2: Ideal-typical constructions of warm and cold roofs of multi-family houses from the 1970s. Sources: Own representation based on building typology literature; Dierks and Wormuth 2012, p. 690.

Flat roofs are often weaknesses of the multi-family houses. Leaks from damage in the area of roof connections and waterproofing are common as well as thermal bridges in the range of light domes, chimneys or roof attics (BMVBS 2010, p. 23). In the case of leaks, a favourable financial decision is often made to seal over bituminous sheeting. This measure extends the lifetime in the short-term perspective. Flat roofs with ten or more sealing sheets are not uncommon. About 70% of all flat roofs are now without refurbishment measures. Particularly for warm roofs, wet zones can cause significant thermal losses (see Dierks and Wormuth 2012, p. 602). Besides the impact on the thermal insulation, water with its chemical components can damage the steel-reinforced concrete roof culminating in corrosion of the reinforcement. Figure 2 shows the spread in lifetime of components of flat roofs, which were transferred to an exemplary building from 1974. The components are structured according to the DIN codes and terms of the DIN 276-1:2008-12. It is presented that waterproofings with roofing film have an empirical lifetime of at least 20 years (dark green). At best case the waterproofings can be used till 2017 (bright green). At the latest after 48 years (dark red, lt= lifetime) they have to be renewed. Most components of unrefurbished flat roof reach the end of their lifetime in the mid-term view. Steel-reinforced concrete roof and copper roof drains are usually useable for the long-term.

	Building component	1974	1984	1994	2004	2014	2024	2034	2044
360 roof	361 Steel-reinforced concrete roof								> 80 y. lt
	362 Light dome		20 -	40 y. lt					
	363 Waterproofing with roofing film		20 -	48 y. lt					
	363 Vapour barrier			30 -	58 y. lt				
	363 Roof drain (stainless steel, synthetic)			25 - 50 y. lt					
	363 Roof drain (copper)			33 -	> 80	y. lt			
	363 Roof drain (zinc)		20 -	42 y. lt					
	364 Thermal insulation			25 - 50 y. lt					

Figure 2: Typical lifetimes of flat roof components. Sources: Own representation based on building lifetime literature.

In sum, the needs for action in the area of flat roofs are:

- Full replacement of flat roof construction in case of material obsolescence
- Repair of minor damages

Step 2: Needs for action of the users

The needs for action from the perspective of the users can be described in four steps. First, different user groups have to be identified. Principally user requirements differ for several user groups according to socio-structural (age, household size) and socio-economic (purchasing power) circumstances as well as lifestyles (see Colom and Moles 2008, p. 917). Second, user requirements must be well known in order to create demand-orientated refurbishment concepts. The user requirements should be available for the most important requirement areas, such as location, housing costs, layout of the dwelling, flat size, equipment and quality of the dwelling, building or outdoor facilities. The third step is comparing the general characteristics and conditions of the building typology with the user requirements. Fourth, potential target groups and their needs for action should be derived.

The paper describes below a German model for classifying residential users and their requirements, and reasons for selecting this model. It will be shown how main target groups for multi-family houses can be identified and which needs for action the target groups have.

Classifying residential requirements – the GdW living matrix

The GdW living matrix developed by InWIS Forschung und Beratung GmbH and Analyse & Konzepte, classifies user requirements for different user groups in Germany. The concept is widely used by housing associations as well as municipalities. The living matrix represents the three dimensions of housing demand: the socio-structural with age group (18-30, 30-45, 45-65, 65+) and type of household (singles, couples, families/single parents, multiperson households), the socio-economic with purchasing power (low, middle, high as a relative value according to the individual housing market), and the living concepts (conventional, communicative, domestic, modest, sophisticated and functional) including lifestyles, attitudes and housing preferences. Each of these living concepts is differentiated into the socio-structural and the socio-economic categories. As a result, the model consists of 24 living profiles. Each living profile presents an individual demand group. The living profiles show user requirements for the dwelling, the building and the outdoor facilities (GdW 2008, pp. 41-44; GdW 2013, pp. 7&18-22). The living concept model has been chosen because of its specific focus on housing, the connection of requirements and willingness-to-pay, the topicality, and its free availability. By analysing the willingness-to-pay, user requirements can be prioritised as shown below. In principle, the transparency of the process and the methods (e.g. information about sampling procedure, amount of interviews, average duration and selected results) is higher for the GdW living matrix model than for other models (e.g. the Sinus-Milieus®) (see Gröger 2011, p. 109).

Potential target groups and their needs for action

Approximately 4.7 million people are living in the multi-family houses from the 1970s in Western Germany (7.2 percent of Western Germanys entire population).[4] Currently the main living concepts there are modest, functional and partly conventional households. In contrast, domestic, communicative and sophisticated households are strongly under-represented. Particularly older people above the age of 44 years live in the multi-family houses, in some cases as first tenants. Singles and couples (mostly retired) as well as families (with immigration background) are dominant household types. The households' purchasing power is often low or medium. Due to the high share of older households, a change of generations will take place in the middle-term in this part of the German building stock. Therefore, adaptions with a sole focus on existing inhabitants are not recommendable. Refurbishment measures should rather focus on new target groups and living concepts.

Target groups as well as general needs for action for an existing building stock can be found by comparing the location, building and outdoor characteristics of the real estate with the housing characteristics in the living profiles of the living matrix model. These profiles show 13 main user requirements for the location (e.g. local supply, transport connection, image), dwelling (e.g. type of surface, dwelling size, quality standards, price segment), the building (e.g. accessibility, energetic standard) and the outdoor facilities (see GdW 2013, p. 116). In the case of the multi-family houses from the 1970s, the housing characteristics of low or not refurbished multi-family houses were compared to the requirements in the living profiles. The comparison shows that modest, functional, conventional and partly domestic households in 13 living profiles are the main target groups for the multi-family houses from the 1970s. The structural requirements (e.g. location, dwelling and room sizes, layout, outdoor spaces) of these groups can in most cases be fulfilled by now. By refurbishing the multi-family houses, further requirements (e.g. energetic characteristics, equipment of bath rooms) could be fulfilled in the future. After the refurbishments' completion, domestic households could be attracted as new inhabitants of the multi-family houses.

Domestic households are classified into five living profiles (target groups). Table 3 exemplifies the five domestic target groups (no. 9-13) and their requirements, many of which are often still not fulfilled. Demands for family friendly integrated urban or district locations with good local supply and transport connection, are mostly satisfied by the multi-family houses. Since domestic households spend a lot of time in their dwellings, the household amenities are very important. A large bath room, a balcony, a storage room in the dwelling as well as on the property (e.g. for bicycles, buggy), a fast internet connection, a contemporary energy efficiency, and modern doors as well as flooring should be available in refurbished properties from the 1970s. Because of domestic households prefer modern layouts like penthouse or maisonette, it can be useful to add story in suitable locations – especially in the case of an incidental necessary roof refurbishment (see GdW 2013, pp. 122-126).

Target-group (no.)		**9**	**10**	**11**	**12**	**13**
Type of Household		Singles, couples	Singles, couples	Singles, couples	Singles, couples	Families, multiperson
Age (in years)		< 30	< 30	30-44	45-64/from 65	all
Purchasing power		low	middle	middle to high	low to high/middle	low to high
Residential quality	Normal	☑	☑	☑	☑	☑
	High	–	–	–	☑	☑
Bathroom	Shower bath	☑	☑	–	–	–
	Full bath	–	☑	☑	☑	☑
	Age appropriate	–	–	–	☑	–
	Modern	☑	–	☑	☑	☑
	Individual	☑	☑	☑	☑	☑
	Washing machine	☐	☐	☐	☑	☐
Dwelling	Modern doors/floors	☑	☑	☑	☑	☑
	Modern layout	☑	☑	☑	☑	☑
	Easily accessible	☒	☒	☑	☑	☑
Building	Attractive entrance	☑	☑	☑	☑	☑
Technology	Energy saving	☑	–	☑	☑	☑
	Security	–	☑	☑	☑	☑
	Fast internet	☑	☑	☑	☑	☑
Energy	Modern efficiency	☑	☑	☑	☑	☑
	Renewable	–	–	☑	☑	☑
Outdoor facilities	Tenant garden	☑	☑	☑	–	☑

Legend	☑	Standard	☑	desire	☑	Added value	☐	possible	☒	No/little interest	–	No information

Table 3: Needs for action of domestic living concepts. Source: Own representation based on GdW 2013, pp. 122-126.

Step 3: Prioritisation of needs for action by the Kano model

The implementation of refurbishment measures is primarily connected to financial restrictions. Thus, it is important to prioritise the discussed needs for action in a requirement profile. The requirement profile contains the results of the real estate analysis and of the assessment of the requirements of the target groups.

The requirement profile

The requirement profile prioritises the needs for action in three requirement groups utilising the model of Kano et al. (1984)[5]. The objective of the model is to find key user requirements with impact on user satisfaction. With this information product characteristics are developed (Matzler and Hinterhuber 1998, p. 28). The three derived requirement groups are (see Matzler and Hinterhuber 1998, pp. 28-30):

- "Must-be"-requirements: Basic criteria of a product. These requirements are not expected, but they must be fulfilled. If they are not fulfilled, the user will be not satisfied and will reject the product. In the refurbishment context “must-be“-requirements contain damages and material obsolescences.

- One-dimensional requirements: Explicitly expected requirements. The more they are fulfilled, the higher the user satisfaction. One-dimensional requirements are being compared with competitors or competing products on the local housing market by the users. The basis for one-dimensional requirements are the explicit described requirements of the users in the living matrix model.
- Attractive requirements: Not expressed or expected by the user. If they exist, the user is very satisfied. However, the user is not dissatisfied, if they do not exist. The attractive requirements show attributes with added-value for the users found by the living matrix model.

For the successful refurbishment of the multi-family houses, the “must-be”-requirements have to be fulfilled. To remain successful the multi-family houses in the market competition, the one-dimensional requirements should be fulfilled. In markets with fulfilled “must-be“- and one-dimensional requirements, attractive requirements are significant for selection behaviour (Matzler and Hinterhuber 1998, p. 30).

The requirement profile of the multi-family houses from the 1970s

The requirement profile for multi-family houses from the 1970s is shown in Table 4. Following the previous process the needs for action in the area of the roof are presented exemplarily. The “must-be”-requirements contain the elimination of damages, while one-dimensional requirements are in the area of creating contemporary thermal insulation and modern layouts especially for domestic households. Attractive requirements do not exist.

<table>
<tr><th>Requirement group</th><th>Requirement area</th><th>Measure</th><th colspan="13">Condition</th></tr>
<tr><td rowspan="2">“Must-be”-requirements</td><td rowspan="2">360 roof</td><td>Fully replacement of roof construction</td><td colspan="13">Damages in roof construction</td></tr>
<tr><td>Repair of roof</td><td colspan="13">Minor damages in roof construction and adequate thermal insulation</td></tr>
<tr><th rowspan="2">Requirement group</th><th rowspan="2">Requirement area</th><th rowspan="2">Measure</th><th colspan="13">Target-group</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th></tr>
<tr><td rowspan="2">One-dimensional requirements</td><td rowspan="2">360 roof</td><td>Creation of contemporary thermal insulation</td><td>☑</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>☑</td><td>☑</td><td>☑</td><td>☑</td><td>☑</td></tr>
<tr><td>Creation of modern layouts</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>☑</td><td>☑</td><td>☑</td><td>☑</td><td>☑</td></tr>
<tr><td>Attractive requirements</td><td>360 roof</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
</table>

Table 4: The requirement profile for the multi-family houses in the area of the roof. Source: Own representation.

Step 4: Refurbishment measures and costs

Table 5 illustrates possible refurbishment measures according to the cost groups (CG) of the DIN 276. These can be categorised into construction (CG 300) and technical (CG 400) components as well as into components in the outdoor facilities (CG 500).

Component/area	Measure
324 base plate	Insulate
326 construction waterproofing	Seal vertical
	Seal horizontal
331 + 332 external wall	Insulate inside/outside
	Core insulation
	Insulating plaster
334 exterior doors and external windows	Modernise house entrance door, windows (e.g. glasses, sealings)
	Replace house entrance door, windows
	Modernise window connections
	Install new window layer
	Optimise illumination
338 sun protection	Modernise, add roller shutter boxes
	Insulate roller shutter boxes
341 + 342 internal walls	Increase/reduce functional areas
	Extend housing space horizontal: e.g. break walls, join housing units
	Broaden doorways
	Modernise, replace wall surfaces (e.g. bathroom)
344 internal doors and internal windows	Modernise, replace
351 ceiling construction	Insulate highest storey ceiling/ basement ceiling (upstairs/downstairs)/balcony
	Remove barriers on balcony
	Repair, modernise, replace, add balcony
352 ceiling coverings	Repair, modernise, replace (e.g. for acoustic protection)
361 roof construction	Modernise, replace
	Insulate
	Extend housing space vertical: e.g. roof extension, addition of story
411 sewage installations	Replace, renovate lines
412 water installations	Modernise, replace lines
	Insulate lines
	Modernise, replace sanitary facilities
413 gas installations	Modernise, replace lines
421 heat production	Modernise, replace heating boiler
	Repair, modernise components (pumps, control systems)
	Convert energy source
422 heat distribution networks	Modernise, add lines
	Insulate lines
423 room heaters	Repair, modernise, add room heaters/surface heating
431 ventilation system	Repair, modernise, add
444 low-voltage system	Repair, modernise, add installations
445 lighting equipments	Repair, modernise, add lighting
454 electro-acoustic construction	Repair, modernise, add intercommunication systems
461 lift systems	Repair, modernise, add
484 room automation systems	Modernise, add thermostatic valve/smart meter
500 outdoor facilities	Repair, modernise, add tenant gardens
524 parking space	Repair, modernise, add (e.g. Car-Sharing)
551 general components	Repair, modernise, reshape waste facilities

Table 5: Possible refurbishment measures for residential buildings. Sources: Selk et al. 2007, pp. 67-68; BBR 2003, pp. 58-60; Ma et al. 2012, p. 896; Konstantinou and Knaack 2011, pp. 669; Kolokotsa et al. 2009, pp. 129-130.

Refurbishment measures and costs for multi-family houses from the 1970s

The needs for action in the area of flat roof according to step 3 are as follows: repair of minor damages, repair of damaged roof waterproofing, improvements in thermal insulation or addition of story. Measures in the area of minor damages can concern the replacement of light domes, the repair of roof drainage or the repair of roof waterproofing. Minor damages of roof waterproofing can be repaired by welding or bonding of individual or multiple sealing sheets (DIN 18531-4:2010-5). In the case of a roof with minor or no damages and without insulation, the thermal insulation can be built up over the (repaired) roof waterproofing. To reach the legal requirement of the EnEV:2013-11, 18 cm thick thermal insulation is necessary. For a roof with damaged waterproofing and/or damped roof construction, a complete replacement of the roof construction is necessary (consider waste disposal). Renewed ventilated flat roofs should be converted into an unventilated flat roof. Covering the roof with gravel can be used as a weather protection.

The addition of story on existing flat roofs can create more living space with modern layouts and, thus, enhance the profitability of the entire refurbishment project. However, this particular measure is recommendable for housing markets with a high demand for this type of living. In principle, buildings with an attractive view are most suitable for the addition of story. Further, the construction of the housing units should be of high quality in order to upgrade the visual appearance of the building and to attract high-income households. The addition of story should be built as timber frame construction (shorter construction time, reduced weight). But whether the addition of story can be realised depends primarily on the obligations of an existing land-use plan (e.g. building height, entire floors), the statics of the highest floor and the possibility to build a second emergency escape route. The cost range including value-added tax for the mentioned measures are given in Table 6.

CG	Measure	Unit	Investment cost [€]		
			Min.	Ø	Max.
360	Replacement of light domes, size 0,5-1,0 m²	piece	1,200	1,350	1,500
	Repair of roof drainage (zinc)	m²	12	13	15
	Repair of sealing sheets	m²	65	70	81
	Add new 3-layer bitumen sheeting	m²	70	77	90
	Add new 3-layer bitumen sheeting with gravel	m²	90	99	110
	Add new 3-layer bitumen sheeting, 16-20 cm insulation, gravel	m²	126	144	156
	Add new Synthetic roofing membrane, gravel	m²	85	95	106
	Add new Synthetic roofing membrane, insulation, gravel	m²	110	124	140
	EPS insulation	m²	41	44	48
	Addition of story	m² tfa	1,600	-	2,100

Table 6: Costs of measures in the area of flat roof. Source: Schmitz et al. 2014, pp. 191-198.

Step 5: Recommendations for action

The prioritisation of the recommendations for action follows the prioritisation of the requirement profile. Thus, the recommendations can be categorised as either “must-be”, one-dimensional or attractive. While the one-dimensional and the attractive recommendations can be further grouped into prioritised measures, all “must-be” recommendations are compulsory. The criteria for the prioritisations are the scope of the measures (as many user groups as possible should be reached), the potential synergy effects through bundling of measures (technical and organisational connections) and the cost-benefit ratio of energy saving measures. Specifically, the technical connections result in more economic construction (e.g. combination of exterior wall insulation and installation of windows), higher functionality (e.g. coordination of the heating system and thermal improvements of the building envelop) and longer durability (e.g. changing materials with short maintenance cycles to materials with longer cycles). The organisational connections consider rationalisation potentials for shortening of construction times (e.g. shared use of scaffold for the roof, exterior walls and windows or for storing materials), reductions in administrative effort (e.g. summarised tender) or reducing the stress of tenants (e.g. short and grave interventions instead of continuous measures) (see Weeber and Rees 1997, pp. 44-48).

Recommendations for action for multi-family houses from the 1970s

The recommendations for action correspond to the results in step 4. There are four recommendations for action in the area of the roof, two “must-be” and two one-dimensional recommendations (see Figure 3). On the level of the individual building there is only one possible current situation of those shown in M1, M2, and O1. The construction of living space with modern layouts should attract domestic households (O2).

No.	Area	Current situation	Target	Measure
M1	360 roof	1) Functional roof waterproofing with minor damages; existing thermal insulation 2) Functional roof waterproofing with minor damages and functionality; no existing thermal insulation	1) Repair damages 2) Repair damages, improve thermal insulation	1) Repair roof waterproofing 2) Repair roof waterproofing; insulate roof with 18 cm heat conductivity group 035 as unventilated roof
M2	360 roof	1) Roof waterproofing damaged 2) Damped roof construction	Repair damages, improve thermal insulation	Demolish existing roof waterproofing; insulate roof with 18 cm heat conductivity group 035 as unventilated roof
O1	360 roof	Functional roof waterproofing; no existing thermal insulation	Improve thermal insulation	Insulate roof with 18 cm heat conductivity group 035 as unventilated roof on existing roof waterproofing
O2	360 roof	Demand for modern layouts	Create new living space with modern layouts	Addition of story in timber frame construction

Figure 3: Recommendations for action for multi-family houses from the 1970s. Source: Own representation.

3.2 The individual building level

To develop a refurbishment concept for an individual building, five steps must be taken. The first and the second step are similar to the first two steps at the typology level. The local conditions have to be evaluated because they can fundamentally differ from the general. The third step is defining the targets of the owner. The fourth is the application of the recommendations for action in different refurbishment concepts. The fifth step is the selection of the most appropriate refurbishment concept.

Step 1: Needs for action for the buildings

Individual needs for action for the building components and the technical systems of the building have to be found through technical due diligence. The areas for the analysis are shown in Table 1. The aim is to find the level of maintenance, the visual quality, as well as the structural conditions of the building. Then positive building characteristics and potentials as well as damages and problem areas can be identified. The existing damages can be prioritised (damage management) (see Roulac 2000, p. 396). Here, essential documents are construction plans of the construction time, modification plans, maintenance data and energy bills (van Holm 2000, p. 85). Verifications of the desk research can be performed by a walk-through inspection (field research) (Kolokotsa et al. 2009, p. 123). Also useful are interviews with tenants, building operators or former owners (Petersen 2006, p. 14). This is the technical part. For further decision, a location analysis including hard and soft locational factors of the site, the micro- as well as the macro-location, has to be done (Kiel and Zabel 2008, p. 176). At the individual level, a legal (e.g. for legal protections of the existing construction, distance spaces) and an economic (e.g. possibilities for rent increases, future costs for maintenance) due diligence are also necessary. This information influences the decision for refurbishment measures and has to be considered.

Step 2: Needs for action of the users

In every individual case the local user requirements and the amount of target groups have to be checked. This can be done through a user survey (e.g. by the living matrix model) of a small sample (e.g. 100 participants) of current and potential tenants. For gaining new households in an existing building stock, these households have to relocate. Thus, the willingness and the ability to move have to be requested. The survey should be complemented with a market, a competition and a demand analysis. The recent and future housing supply can be estimated by analysing the market. Based on this, market gaps can be found and achievable rental incomes can be predicted (Graaskamp 1985, pp. 6-7). It is particularly interesting to find comparable projects (existing, in construction, in planning) (competition analysis) to identify ones own competitive standing (Lum 1972, p. 251). For bigger asset holders, it is conceivable to implement the results of the survey and analyses to the portfolio strategy with different target-group focuses (see GdW 2008, p. 15).

Step 3: Targets of the owner

Next, the targets of the owner have to be defined. Thereby, the findings of the building analysis and the user survey have to be considered. The targets depend on the planned holding period (short-, mid-, long-term). They can differ among several owner groups (see KfW and IW Köln 2010; Lohse and Pfnür 2008; BMVBS and BBR 2007). Table 7 shows potential targets. These can be classified as economical, ecological, social and procedural targets.

Economical	Ecological	Social	Procedural
Enhance equity return	Protect environment	Create user satisfaction	Divide investment costs
Enhance value of the building	Reduce energy consumption and CO_2 emission	Create rental solutions where the costs are offset by the energy savings	Implement measures in one work process vs. divide into parts
Enhance rental income	Chose products and services by life cycle assessment	Create barrier-free living space	Reduce bureaucracy (e.g. conduct measures in one work process)
Long-term secure of rentability	Use renewable energies	Enhance image of the district	Implement measures not in the housing units
Reduce vacancies		Enhance quality of living	Reduce stress for tenants
Use of public subsidies		Mix structure of tenants	
		Design living environment	
		Provide affordable rents	

Table 7: Potential targets of the owner for refurbishment measures. Source: Own representation based on KfW and IW Köln 2010, pp. 31-32; BMVBS and BBR 2007, p. 60; BBR 2003, pp. 46-54.

Step 4 and 5: Application of the recommendations for action in different refurbishment concepts and evaluation of the alternatives and selecting the most appropriate refurbishment concept

The application of the recommendations for action at the individual building level is the fourth step. The owner selects the recommended measures according to his targets, the current situation of the building and the local user requirements. According to his financial conditions different refurbishment concepts can be developed. Especially the energetic measures can be simulated for the individual building with a created reference building. The cost-effectiveness of energy measures can be assessed by life cycle cost analysis (Kolokotsa et al. 2009, p. 123). In the case of many measures in the category “must-be” recommendations, it is recommendable to implement comprehensive refurbishment measures. Lack of planning and limited budgets can lead to the solely implementation of damage management measures in the short-term. In these cases, cost-effective measures should be selected.

The final selection of refurbishment measures depends on the individual weighting of the refurbishment targets of the owner (see Ma et al. 2012, p. 892). „The more alternative versions that are investigated before making a final decision, the greater the possibility to achieve a more rational end result” (Zavadskas et al. 2004, p. 83).

4 Conclusion

The most part of the European, and more specifically, the German housing stock has been built before 1980. This housing stock has often high backlogged maintenance and is far behind the current technical and social requirements. Through refurbishment measures, major improvements for these buildings can be implemented. In Western Germany multi-family houses built in the 1970s, will have a high priority for refurbishments in the near future.

This paper introduces a two-level process for developing refurbishment concepts, especially for these residential buildings. The first level, the building typology level, is a process divided into five steps. The first step is to find key characteristics and needs for action for the building typology, whereas the second step is identifying appropriate target groups and their needs for action. The third is the prioritising of the needs for action in the requirement profile. The fourth step is an assessment of possible measures and costs, and in the fifth and final step, the selected measures are listed as prioritised recommendations for action. In the case of the multi-family houses from the 1970s, the needs for action in the roof area are examined. The roofs often have damages, and – similar to the exterior walls and windows – form essential components of the building envelop. Thus, roof refurbishments are often conducted in combination with thermal improvements of exterior walls and windows. Repairing minor or major damages, creating contemporary thermal insulation, as well as additions of new story, are the prioritised recommendations for the roof area.

The second level discussed in this paper, the individual building level, exhibits the specification of the needs for action in a five step process. Step one contains the collection of current building characteristics and step two includes local user requirements. Then, in step three the refurbishment targets of the owner are precisely formulated. Step four is the application, and if necessary, the modification of the recommendations for action to the individual building to create different refurbishment concepts. In step five the most appropriate refurbishment concepts can then be selected.

The empirical results of the typology level are useful for property owners such as housing corporations, municipalities, owner communities or foreign investors, to assess building characteristics and needs for action, as well as to calculate capital expenditures more efficiently (e.g. for single buildings or portfolios). Along with the evaluations of the individual building level, these named actors can implement demand-oriented refurbishment measures for their buildings more efficiently. Efficiency benefits could result in time and cost reductions, as well as improved quality in the planning stage due to the increased transparency. Improved transparency could cause an impulse for building owners for large-scale refurbishment measures, which could help to enhance the refurbishment rates to achieve the climate targets of the EU. Similar buildings to the multi-family houses are located in other European countries, which is why this two level-process can be applied internationally (e.g. Austria, Belgium) (see IWU 2012a, p. 133). Moreover, this process could be used for developing refurbishment concepts for other relevant building typologies in Germany and internationally (e.g. multi-family houses from the 1980s or even other building use types). In practice refurbishment measures are more and more frequently implemented in the form of district developments. Thus, the results on the typology level could be used to interconnect several buildings on the level of districts. It would be also of interest to give indications for the optimum timing of refurbishment measures.

The recommendations for action were derived and calculated from a very broad building stock. Thus the recommendations may vary for individual buildings. Such variations can depend on the property characteristics, the individual weighting of refurbishment targets of the owner, the interests of other shareholders and the local housing market.

Endnotes

[1] Refurbishment means comprehensive maintenance, renewal and modification measures like adaptions of the building technology, functionality, natural lighting, accessibility or equipment to fulfill present day requirements leaving the existing building structure intact (Mansfield 2002, pp. 24-28).

[2] High-rise buildings of nine number of floors or more are not discussed because they have other requirements on emergency routes, structural engineering, wind comfort or elevator technology (see Warszawski 2003, p. 423).

[3] Because pitched roofs represent only a small share of these multi-family houses, only flat roofs are discussed in this paper.

[4] Assumptions: 2.4 million dwellings, vacancy rate of 3.0 percent and a 2.05 average household size.

[5] Kano, N.; Seraku, N.; Takahashi, F.; Tsuji, S. (1984), "Attractive quality and must-be quality", *Journal of the Japanese Society for Quality Control*, Volume 14, Issue 2, pp. 147-156.

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