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Overlooked? Supporting Sustainable Renovation for People who are Blind or have Low Vision

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ABSTRACT: This paper addresses designing for accessibility of renovated housing. The investigated case evaluates interfaces of heating and ventilation systems in a demonstration apartment for an intended renovation of high-rise social housing in Amsterdam, the Netherlands. We selected a focus on people who are blind or have low vision (PBLV). We conducted two qualitative studies with different target groups, (expert) users and building domain experts, to answer two research questions: First, what are the accessibility limitations of the currently installed HVAC systems in social housing, using the example of the demo apartment? Second, in what way can we enable stakeholders aiming to commission a renovation to make decisions that improve accessibility? We argue based on interviews and remote observations that PBLV face many issues. For example, home control interfaces commonly lack features such as a voice control option or tactile buttons, making them inaccessible for this group and less accessible for everyone else. To tackle this challenge, we propose a guidebook supporting decision-makers in assessing and implementing accessibility in renovation projects of social housing. The final evaluation confirmed that such an intervention fills a gap for human-centred tools in zero-energy renovations.
KEYWORDS: accessibility, low vision, zero-energy, renovation, guidelines

1. INTRODUCTION

Currently, many older buildings are being transformed into more sustainable zero-energy housing. However, while these buildings may be equipped with technology needed for zero-energy operation, there are still many challenges preventing them from achieving that. One such challenge is the mismatch between residents' abilities, habits and knowledge and the home systems' functioning. A common example of such a mismatch is that residents do not know about or do not trust ventilation systems and maintain habits of long duration window-opening, reducing the energetic performance of the building [1]. Another example is that residents may struggle to understand and interact with the set of new interfaces they encounter in newly renovated homes. Such interfaces may be part of home energy management systems, system controls or home-control apps [e.g., 2, 3]. Often, these are new designs associated with new sustainable technologies. Usability issues with them can affect building's energy performance too. Usability issues can also have cross effects with residents' well-being in their daily home life [4, 5].

This paper addresses designing for accessibility of renovated housing. While accessibility encompasses a wide range of people and issues, in this paper we particularly focus on people who are blind or have low vision (PBLV). Based on interviews and remote observations in a newly realised demonstration apartment, we argue that PBLV face many issues, for example with dealing with home control interfaces. The demonstration apartment serves as a case for us to enquire: how could the decision-makers who commissioned this apartment be supported in commissioning technology that works better for PBLV?

To this end, we addressed the needs of the professional stakeholders/decision-makers in fulfilling the needs of PBLV. We produced a document that synthesises accessibility advice and evaluated it with two decision makers and four experts in accessibility for visually impaired. Based on this evaluation, we argue that guidelines support stakeholders in assessing and implementing accessibility in renovation projects of social housing.

The paper gives an overview of the context studied and explains the relevance and challenge of designing for PBLV. We then present two studies: first, a brief evaluation study of the demo apartment supported by interviews with a group of PBLV. A 'PBLV home energy guidebook' is developed based on this evaluation study. The second study is an evaluation of the guidebook with professional stakeholders. The paper concludes with a discussion of the implications of the intervention for PBLV and other possible target groups.

1.2 Accessibility in social housing

In 2023, WHO stated that 'at least 2.2 billion people have near or distance vision impairment' [6]. Anyone wearing glasses experiences the effects of visual impairment when being without them. While visual impairment itself is already associated with reduced sense of well-being, being or feeling excluded from the use of one's own home environment is likely to exacerbate this further. Since an important goal of a renovation is to improve residents' comfort and well-being, especially while in the safe space of their home, such exclusion should be avoided [7, 8].

Hence, the decision-making process in housing renovations should be driven also by the aspect of accessibility. In one of the European standards 'NEN 17210: Accessibility and usability of the built environment – Functional requirements' it is explicitly stated that it must be ensured that '*ventilation and heating equipment are operational*' for all kinds of diverse users [9]. That makes designing inclusively not just an option but a requirement. While we have chosen to focus on residents with visual impairments here due to limited scope, overlapping or contrasting needs of other user groups, for example older people, or ones unfamiliar with such technology, should also be considered in the design process. A recent study argues that even though modern home appliances bring benefits to our everyday lives, '*due to the lack of accessibility support from the manufacturers and designers, a considerable number of people in need of accessibility support have been ignored*'. [8]

1.3 Issues for PBLV

While the experience of each person with a disability is very specific and a one-size-fits-all approach is implausible [10], we identified some common problems that PBLV face on a daily basis and the ways they tackle them. For example, products that provide only one control option might be limiting access. From user testimonials that PBLV have published on the internet, it can be gleaned that: among the most essential features in an accessible product for users with low or no vision are high contrast colours, buttons with high tactility, loud enough speakers, audio feedback, offline voice dictation, high compatibility with visual aids, add-ons and customizability [11]. Affordability and sturdiness were found to be as important [12].

1.4 Context

This paper takes as its case the evaluation of interfaces of heating and ventilation systems in a demonstration apartment (demo apartment) (Figure 1) for an intended renovation of high-rise social housing in the Netherlands. The demo apartment was realised as a fully functioning full-scale prototype of the intended technology within a housing block planned for renovation. It was made available to the residents and the housing association to decide on the renovation. We were given the opportunity to engage this context in our research.

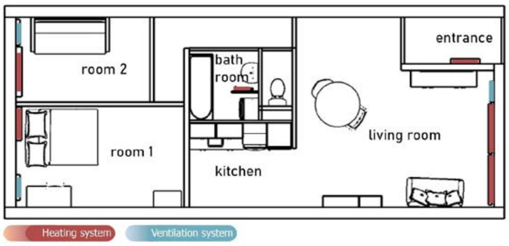

Figure 1: Floorplan of the demo apartment

1.5 Research questions

We defined two main research questions:

1. *What are the accessibility limitations of currently installed sustainable HVAC systems in social housing, using the example of the demo apartment?*
2. *In what way can we enable stakeholders aiming to commission a renovation to make decisions that improve accessibility?*

1.6 Method

We conducted two user studies. The first study addressed the first research question through gathering testimonials and conducting user interviews and observation (section 2) with PBLV including experts in visual impairment. We used this data to define the design space and propose an intervention (section 3) that contributes to answering the second research question. This intervention was qualitatively evaluated both with the initially interviewed users and an additional number of professional decision makers (section 4).

2. INTERVIEWS AND OBSERVATIONS WITH PBLV

2.1 Method

To expand and evaluate the findings from the desk research, we conducted six qualitative open-ended interviews with users with visual impairments. To obtain more diverse insights, the recruited participants had different nationalities and cultural backgrounds. Three were Bulgarian and three were Dutch. Expert user 1 was completely blind as a result of losing his vision 20 years ago. He was an expert in accessibility and coaches other visually impaired people how to use digital applications. Expert users 2 and 3 had a similar occupation but still had low remaining vision. The other three participants were regular users, one of which was fully blind (Regular user 2), one able to slightly distinguish light and bright colours (Regular user 3) and one with overall blurred vision and night blindness (Regular user 1). Each interview lasted approximately an hour and was semi-structured. Three of the interviews took place in real life and three were led online because of the

corona virus restrictions. One of the real-life interviews was combined with a field study where various accessibility products were evaluated in the context of use at a centre equipped with smart technologies, supporting PBLV in The Netherlands.
To assess the accessibility during the interviews, we sought to understand to what extent '*agents can convert a resource ... into a functioning*' [13]. This means, we studied whether the participants were able use the resources provided – the sustainable technologies – for something of benefit to them. We used storytelling to elicit responses from the participants. We explained the systems in the demo apartment, including their interfaces in terms of functionalities and controls. We then asked the participants to talk us through how they would perform specific tasks such as changing the temperature setting. That approach helped identify the possible accessibility limitations of the systems while also uncovering additional accessibility requirements. To discover the latent needs of the users, we asked them to talk about their habits, the products they liked using in their everyday life and the obstacles they meet. The focus of the discussion was on indoor climate and interaction controls.

2.2 Results

Some of the main usability and accessibility issues identified within the demo-apartment are similar to other zero-energy housing, for example the slow response to big changes in temperature of the low-temperature heating system [14]. Another example is the uncomfortable location of some controllers [15]. All the interviewed PBLV said that they will be unable to use them because of the lack of voice control option or truly tactile buttons. While the bathroom radiator and the ventilation units were equipped with buttons, the fact that they were not embossed, were too small and did not provide any kind of audio feedback made them not accessible. The position of the controller of the bathroom radiator increased the complexity of interaction further: it was positioned low behind the bathroom sink (Figure 2). There was an app to control those systems, but it was not accessible. Another problem was that a part of the system (the bathroom radiator) was not communicating with its other parts, which caused both confusion and inefficiency and as a result, also lack of trust.

Figure 2: Video still of access to the heating control. Link to video: https://openresearch.amsterdam/media/attachment/2022/9/5/video1_alina_boyuklieva_master_thesis-471954357.mp4

We discovered that the systems were missing basic accessibility controls, such as voice control option, tactile control option such as clear buttons, vibration, or quick temperature feedback. The visual accessibility, meaning possibility to zoom in, good contrast, etc. was also very low.

In discussions with the client stakeholders of the demo apartment, we sought to define what would be the most useful result from this research for them. In a complex context such as this one, various kinds of interventions could help stakeholders [16]. In this case, it was agreed that a useful result would be to not just present an evaluation of the existing solution, but to provide advice for the clients of the renovation solution (a housing association). This advice should support their decision process on the next iteration of the renovation solution. Clients could then use the advice to decide on and ask for more accessible products and solutions, some of which are available on the market.

Such products were discussed during the interviews. Two of the interviewees who were coaching PBLV (Expert users 1 and 2) shared valuable insights about common user behaviours observed in their practice. Expert user 2 mentioned that most people with whom he works prefer a combination of automated and regular devices. He also notices that youngsters pick up smart technology faster while the older generations still prefer physical interactions when available.

Overall, the systems that these people use in their everyday life to control their homes are mostly smart systems like Apple Home Kit, Google Home, and other similar devices that they control mostly by voice [14].

We categorised the main advantages and disadvantages of smart systems. App support seemed to serve as a great means of interaction and control when designed with accessibility in mind. Nonetheless, some users mentioned that they do not completely trust the privacy policies and would rather not use it. Voice control was another functionality, which was met with mixed opinions. While adding an accessibility layer to each device, it could be frustrating and confusing when the user cannot guess the exact command. That suggests that combining several control options (audible, tactile, and visual) will result in higher accessibility.

While some smart devices are misleadingly considered accessible, others positively contribute to the users' well-being by bringing them independence and empowerment. The interviewees, as well as the literature review, confirmed that the one-size-fits-all approach is implausible for users with disabilities [10]. Every person's disability is different, everyone has learned to tackle it in their own way. Therefore, a personal approach is one of the most important things to keep in mind when designing for this target group.

We found that accessible smart thermostats and electric heater controllers already exist. Some of those are not only more suitable for people with visual impairments but also for all residents because of their broad functionality and compatibility. However, they were not implemented in the current renovation. This indicates that there is an unaddressed need for connecting the right systems to the right scenarios. That could be achieved, for example, through careful investigation of systems available on the market and connecting them to users' needs. A method to evaluate a specific user scenario in terms of the accessibility of applied devices would be of use for the stakeholders responsible for the renovation.

3. INTERVENTION

In the consultation with the experts on the renovation client stakeholder side, the most desirable intervention turned out to be to develop clear and concrete guidelines, requirements, and recommendations. We produced a set of guidelines for the clients of the renovation on how to look for accessibility of proposed solutions. The clients should be able to apply them fast, leading to immediate results. The guidelines needed to be simple, straight-forward, easily comprehensible, and accessible. This way, the barrier to using them would be lower and the likelihood of people applying them would in-crease. The guidelines also needed to be motivating and reveal their value. As Expert user 2 mentioned: *'I am stunned that such information exists but is not being spread and applied.'* The set of guidelines was built in the form of a booklet with design guidelines (guidebook) (Figure 3) that provides concise, actionable steps towards accessibility in the easiest and least time-consuming way possible.

Figure 3: The cover of the guidebook, available for download under the title 'Booklet' at: https://openresearch.amsterdam/en/page/88258/msc-thesis----designing-for-a-more-accessible-zero-energy-system

An AR app connected to the guidebook provides access to interactive models and videos introduced earlier (Figure 1) that show a first-person view.

For transferability, the set of guidelines took the specific apartment as a starting point, but it was designed to be as independent as possible of the conditions of a specific refurbishment project. The content of the guidebook is tailored so that non-designers can follow it. It is based on European standards such as EN 17210:2021 [9]. While those standards provide rules, the guidebook provides steps such as how to perform basic user studies and evaluations to fulfil the rules. Furthermore, it summarises the basic accessibility requirements in a comprehensible manner and supports this with visual material underlining their importance.

In addition, the guidebook provides a tool which could further improve the product selection process, namely the 'Design Fundamentals' evaluation matrix. It incorporates six general requirements – accessibility, trust, simplicity, adaptability, low-maintenance, and robustness that a product should fulfil to be likely to succeed in the context.

4. INTERVENTION EVALUATION

4.1 Method

The guidebook was evaluated through six open-ended interviews. However, it could not be assessed in the projected use scenario, again due to covid restrictions. Four of the interviews were with the PBLV who also participated in the first study described in section 2 – they evaluated the content in terms of completeness, quality, and clarity. The other two interviews were with decision-makers on the client stakeholder side: a project manager for the renovation project to which the demo apartment belonged and an ICT specialist from a Dutch Sustainability Hub – they evaluated the tool in terms of usability, accessibility, and impact.

To provide the information to the PBLV, we created an accessible format of the guidebook by transferring only the text into Word so that they could access it through screen readers. We sent the document a few days before our meeting so that they could take as much time as they need to explore it.

4.2 Results

Both PBLV expert user interviewees were pleased with the guidelines and recommendation sections which they described as '*practical, implementable, understandable, good quality and elaborate'*. Expert user 2 even mentioned: '*Such guidelines are very much needed. I hope that they will use them!*' Expert user 2 and Expert user 3 suggested some ways to motivate people to use the guidelines by evoking empathy [17]. For example, by adding a link to an app that simulates different types and stages of visual impairments in real time. This approach could help project managers to take on a new perspective and make better informed decisions when it comes to selecting systems.

During the guidebook interview with Regular users 2 and 3, we summarised the information orally at our real-life meeting as the guidebook was only in English. They thought that it covered the basic principles of accessibility and did not have any other remarks.

The evaluation with the client-side decision makers was conducted in a combined interview. The project manager said that the guidebook is '*very needed*' and valuable. He gave some advice on how to improve it in terms of comprehensiveness. For example, he advised us to add a clear explanation about the target reader. He also proposed a flowchart on the steps that the user is expected to undertake so they do not get lost in the process. The ICT expert confirmed that the AR app makes it more appealing to read. He added that it complements the current form of the guidebook and opens room for future development. In the short term, he suggested that the interactions with the systems installed in the demo-apartment could be integrated in the app so that some tests could be performed remotely. Then, those could turn into a VR version allowing more thorough experience, more accurate conclusions, and boost inclusivity. Current rendering software such as Enscape already provide the opportunity to experience a 3D model in VR.

5. DISCUSSION

This paper addresses a significant gap in the current discourse on sustainable housing, particularly in the context of accessibility for PBLV. The transformation of older housing to zero-energy is a necessary goal. However, it brings to light the crucial issue of the interface between residents and home systems, in terms of accessibility —a gap that if not addressed, can undermine the energy-saving objectives and the quality of life of residents, especially those with visual impairments.

This study's findings illuminate the importance of integrating accessibility into the sustainable renovation of social housing, in this case with a focus on the experiences of PBLV. The development of a guidebook from these insights serves as a cornerstone for stakeholders, outlining essential steps to embed inclusive design principles in line with European standards such as EN 17210:2021 [9]. The research underlines the potential of smart home technologies to significantly improve the living environments for PBLV conditional on a design process that is deeply rooted in user feedback and iterative development. Our findings align with previous research [15] suggesting that more, easy to adopt, tools are needed for the planning and then decision-making phase. Only doing an evaluation post-occupancy is too late.

Feedback from PBLV and professional stakeholders during the guidebook evaluation underscores its usefulness and points towards a critical gap in current renovation practices. One of the most important takeaways is that when striving to develop an accessible product, the best strategy is to apply a participatory approach where you involve PBLV in the process. Yet, despite its advantages, the adoption of the guidebook is not without challenges. It is possible that the introduction of tools like these will meet systemic barriers such as resistance to costs and to changes in established practices.

Based on the study, we argue that the broader usability benefits of accessible design extend to all residents, not just PBLV, thereby enhancing the overall living experience. While the guidebook originated from a single case study, the principles it champions are scalable and adaptable, suggesting a model for inclusive design that could be replicated in diverse housing renovation projects.

Limitations of this research are the small sample size and the specific socio-cultural and building context of the case study. They may limit the generalizability of the results. Future research should include a more extensive and varied demographic. It should also cover different building projects to validate the guidebook's applicability across different contexts. Additionally, the long-term efficacy and impact of the implemented guidelines on energy consumption and resident well-being remain to be empirically tested.

6. CONCLUSION

In conclusion, the study contributes a practical, evidence-based resource aimed at reconciling the objectives of energy efficiency and accessibility. These are often perceived as disparate but may also often align. Our study calls for a shift in renovation practices towards an inclusive paradigm where sustainability is not at odds with accessibility, and where the living needs of all residents, especially those with visual impairments, are met with dignity and foresight.

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