Appendices

Appendix A

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT
Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Boyuklieva
initials: AD
given name: Alina
student number: 5178762
street & no.:
zipcode & city:
country:
phone:
email:

Your master programme (only select the options that apply to you):
IDE master(s): ★ IPD ○ DfI ○ SPD
2nd non-IDE master:
individual programme: - - (give date of approval)
honours programme: ○ Honours Programme Master
specialisation / annotation: ○ Medisign ○ Tech. in Sustainable Design ○ Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: Stella Boess — dept. / section: IDE/AED
** mentor: Tomasz Jaśkiewicz — dept. / section: IDE/DCC
2nd mentor: Juliëtte Mohamed
organisation: Municipality of Amsterdam
city: Amsterdam — country: The Netherlands

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

comments (optional): I believe that the combination between the design research expertise of Stella Boess and the more technical and hands-on knowledge of Tomasz Jaskiewicz can result in a well-balanced and valuable project.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

TU Delft

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair: Stella Boess — date: 10 - 12 - 2021 — signature: Stella Boess s - IO (Digitally signed by Stella Boess - IO Date: 2021.12.10 16:38:35 +01'00')

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 39 EC
Of which, taking the conditional requirements into account, can be part of the exam programme: 39 EC
List of electives obtained before the third semester without approval of the BoE:

★ YES all 1st year master courses passed
○ NO missing 1st year master courses are:

name: J. J. de Bruin — date: 14 - 12 - 2021 — signature: J. J. de Bruin, SPA (Digitally signed by J. J. de Bruin, SPA Date: 2021.12.14 10:22:12 +01'00')

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ★ APPROVED ○ NOT APPROVED
Procedure: ★ APPROVED ○ NOT APPROVED
comments

name: Monique von Morgen — date: 04 - 01 - 2022 — signature:

TU Delft

Designing for a more accessible zero-energy system — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date: 01 - 12 - 2021 — end date: 10 - 06 - 2021

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Amsterdam aims towards zero-energy housing until the 2040. In order to achieve this goal, many housing renovations are being planned and currently take place, one of which is the refurbishment of 280 housing dwellings in the Reigersbos neighborhood. Located in the southeastern part of the city, it consists of relatively old buildings, constructed in the early eighties. The project aims towards providing the inhabitants with a more comfortable indoor climate, improving their quality of life, while still complying to their budget and user needs. Completely replacing the ventilation and heating systems, as well as the facade, is believed to achieve that goal. Nevertheless, many challenges have been faced when introducing these technologies in similar contexts on other locations. The misfit between the user needs and the system's feedback mechanism and interface seem to be one of the main obstacles towards the acceptance of the new technology. Moreover, the actual usage of the systems differs from the scenarios that the system designers envisioned. That leads to residents breaking them, altering them towards hazardous environments, and feeling that they can't trust them (Boess, 2021). Solving that complex issue requires in-depth research into the topic on many levels that will reveal the reasons behind users' mistrust and unacceptance and also possibilities for improvement. The ambition is to make design proposals that are as independent as possible of the specific conditions of a refurbishment project and applicable to more kinds of renovation.

Currently a short-term monitoring project on resident needs, indoor climate and energy use is being conducted in a first prototype apartment. This apartment is available for user research and prototyping of solutions and its purpose is to develop requirements for the renovation. TU Delft is running this monitoring project. As part of this, also my graduation project will contribute knowledge on resident needs and requirements. It is currently in an exploration stage in which the Amsterdam municipality collaborates with the home owners' associations to identify requirements and possible solutions. The project has a wide net of stakeholders, it provides high autonomy of actions and requires self-initiative. These professional stakeholders have a mix of technical and social specializations.

Reigersbos' residents have diverse backgrounds, they come from different nationalities and age groups. However, the target group that will be the focus of this particular study is users with disabilities. Some of those dwellings provide a home for people who are living with assistance because of mental or physical disabilities. Some of the professional stakeholders have a direct contact with such residents and the institutions that support them and can provide us with connections if needed. After the initial research, it will be decided on which disabled group it would be most worthwhile to focus. The main goal of the project will be to develop a solution which is not only more accessible to people with certain disability but also extend it's usability to the wider public and make it desirable for everyone.

space available for images / figures on next page

TU Delft

introduction (continued): space for images

image / figure 1: Reigersbos neighborhood

image / figure 2: Users interacting with the system

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

The zero-energy systems that have been installed in the demo apartment have to be explored as their usability for users is still unknown. Several reasons might lead to their improper function, among which the misunderstanding of the user, not only in terms of mechanism of working but also concerning interface and feedback. Often, the system is working independently, without informing the user about what it does in any way, resulting into him/her unnecessarily intervening with it, for instance by changing settings. However, because of the low temperature heating technology, the system sometimes may take days until the new desired temperature is reached which is a too slow of a feedback for the user. This gap triggers actions, like opening a window for ventilation or putting the thermostat on a very high temperature setting for heat, that are not only needless but they are decreasing the efficiency of the indoor climate system. In order to avoid such situations, there is a need to design a more user-centered system mechanisms that would be trusted and understood by the user, leading to its adoption in the personal home space and its sustainable functionality. On the first place, the user has to understand the advantages of the system and has to be aware of its impact on both the indoor and outdoor climate. Creating a learning environment would allow that, at the same time engaging the user with the system and slowly building trust towards it. One of the clear critical points at the moment is the kitchen as it is located in the middle of the living unit, without any direct sources of ventilation except from the air extractor. Nevertheless, those insights are based on previous research and are not confirmed in the context of people with disabilities. Further research is needed to discover more details in that sphere.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

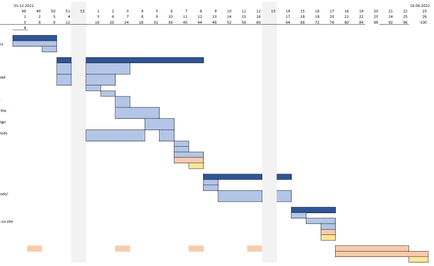
I will apply inclusive design methods to generate a set of requirements for accessibility and inclusion for the kitchen area including ventilation. In order to demonstrate their application in the context, I will make a prototype that illustrates the requirements applied.

During this project, the relationship between people with disabilities and the zero-energy system will be researched. In generating the requirements, I will select, apply and possibly iterate on appropriate methods of inclusive design. I will build upon already existing frameworks that help designers develop more inclusive products and demonstrate the effect of the new method in the applied case. I will organize co-creation sessions where I will involve the target group in the idea generation process. One of the milestones is selecting a concept that is based on the methods that I have analyzed and developed. After an idea is chosen, I will make a physical prototype. As it is not yet clear what it will be exactly, I still do not know what team and materials I will need to support my prototyping. Nevertheless, I will make sure to make this decision around the time of the midterm, so I am left with enough time to plan these actions accordingly. Moreover, the prototype is desired to be tested with real users on site as a demonstration of the approach. This is one of the critical points of the project, as I am required to be in The Netherlands for this process. One of the unique features of the product will be that I will also explore how it could be made customizable as previous research has yield that to be a valuable option for the chosen target group.

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 1 - 12 - 2021 10 - 6 - 2021 end date



In December I will work 3 days on my graduation and 2 days as a student assistant. From January, I will work 4 days on my project and 1 day as a student assistant. I will have the first two weeks of the project for a short 'Orientation' phase where I will have the time to research the context of the disabled users and how they interact with such systems. This will provide me with insights that will help me decide with which target group I would like to proceed.
After I have my target group defined, I will dive into the research phase. Some of the main goals of this research will be to define the user behavior towards the system and the critical points of the process in order to choose a specific element to work on. In the meantime, I will also research the inclusive design methods that are used in this context. If everything goes by plan and the corona measures allow it, in the 8th week of the project, I will travel to Amsterdam so I have the opportunity to validate my findings on site and conduct real-life user interviews and co-creation sessions. This will also allow me to reflect on the inclusive design methods available for the context and their application, if any. After my visit, I will take the time to analyze the newly gained insights and translate them into design requirements and refined problem definition if needed. I will then prepare my mid-term report and presentation.
In the 'Concept Development' phase I will evaluate the preliminary ideas based on the interviews that were conducted in Amsterdam and also through online questionnaires that will be sent out to designers as mainly they will be the ones to apply the inclusive design methods. Then 1 idea will be picked and applied into the context of the element. Either a new product will be developed or the old element will be re-designed in order to fit the needs of the users. Then the prototype will be tested in the environment of the demo-house with real users around the 19th week . On the basis of the findings of the user tests, I will develop a next iteration if there is time and if not - make recommendations for future development. The rest of the time, I will use for finishing the final report, video and presentation.

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

In the last quartile, I have taken numerous electives in my search for a graduation project. While all of them were interesting, the 'Inclusive Design' course influenced me the most. The value that those projects were bringing into people's lives impressed me and I wanted to actively contribute to it. At the same time, I have always been eager to work on real-life problems that actually help people lead a more qualitative life.

Concerning my future development, I would like to work in a company that also tackles social design issues. Working on real problems and collaborating closely with the users is what really motivates me. I believe that this project will help me develop considerably in the field of inclusive design. I will not only gain essential knowledge about the focus group in terms of their physical and mental necessities but also about suitable approaches for example for collaboration, co-creation, research, accessibility. I have always been intrigued by psychology, feelings and emotions and dealing with such a vulnerable target group will be a valuable experience for me and a good way to learn.

On the other hand, when designing, I strive not only for social sustainability but also in terms of the environment. This is why I am delighted that the main goal of the renovation will be not only improving people's well-being but also preserving our nature. Those two aspects merged form the perfect combination for me. Furthermore, I will be presented with an opportunity to dive deeper into the technology of zero-energy systems which I haven't tackled before. That is important as I see its wide future application. I am also interested in customization as it is still in a developing phase while I believe that it could be highly valuable for the topic of inclusivity. Therefore, a further exploration of the field could bring us a step closer to making customizable products also affordable price-wise.

I believe that having the opportunity to apply these insights to an actual case is what would make the project even more valuable. Moreover, working closely with the users and the client gives me the confidence that making progress on the topic is feasible. Having the chance to learn from and create with experts in the field motivates me.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Appendix B


helpless
burden
vulnarable
different
affraid
incapable


feeling of safety
sense of achievement
confidence
autonomy
personal growth
ability to perform any task
sense of belonging
comfort in a social setting

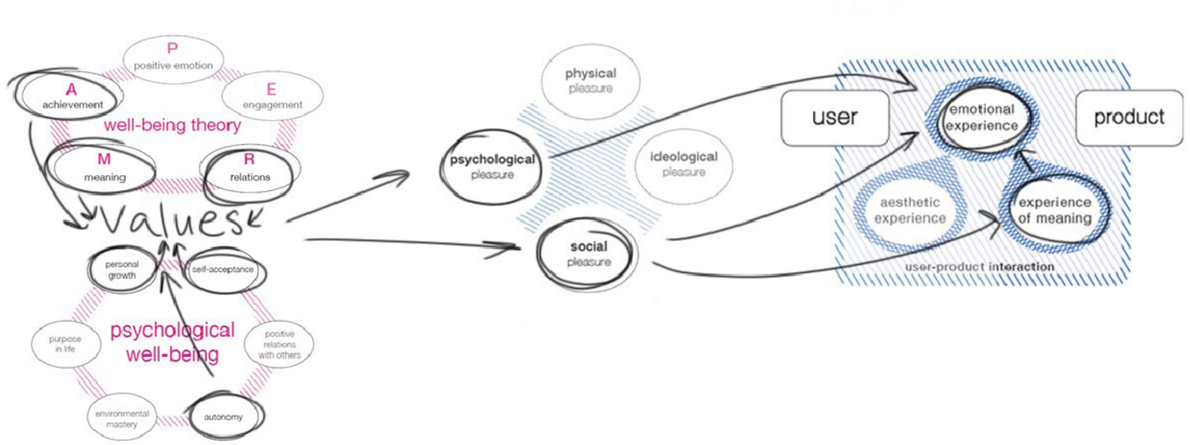


Figure 7, Relevant connections between the models based on the conducted case study, Jimenez, S., Pohlmeyer, A.E., & Desmet, P.M.A. (2015)

Appendix C

Initial user interviews

- What is your occupation?

- Do you live by yourself?

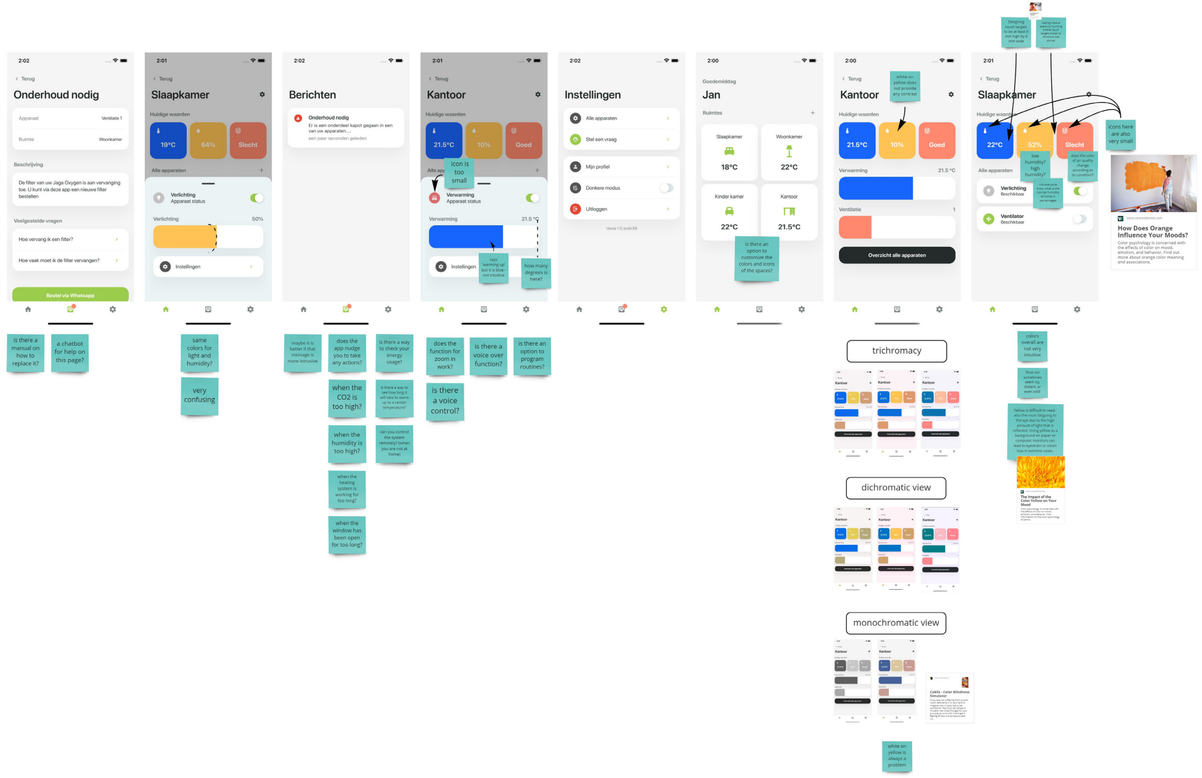
- How do you control your indoor climate? Could you please demonstrate?
- Which is your favourite part of the house?
- What are your associations with a nice indoor climate?
- What do you do when you feel uncomfortable?
- What gives you comfort?

- What are the biggest problems that you encounter in your home?
- Which products make your home more accessible?
- What kind of interactions do you prefer?
- Do you prefer the voice over function for control or you would rather have also physical controls?
- What kind of routines have you established that are connected to the devices that you are using every day?
- Do you have any smart systems?
- Would you like to have a system that could tell you what it is doing at any moment?

- Do you have a guide dog?
- Please Explain the perfect scenario for you.

Then, I explained about the systems in Reigersbos one by one and asked if they think that they would be able to use them.

Appendix D


Onderhoud nodig
Slaapkamer
Berichten
Kantoor
Instellingen
Jan
Kantoor
Slaapkamer
Is there a manual on how to replace it?
a chatbot for help on this page?
same colors for light and humidity?
very confusing
does the app nudge you to take any actions?
Is there a way to check your energy usage?
when the CO2 is too high?
when the humidity is too high?
when the heating system is working for too long?
when the window has been open for too long?
does the function for zoom in work?
Is there a voice over function?
Is there an option to program routines?
is there a voice control?
trichromacy
dichromatic view
monochromatic view
colors overall are not very intuitive
Yellow is difficult to read after the more beginning of the eye due to the high amount of light that is reflected. Using yellow as a background color can cause computer monitors can lead to eyestrain or short-term to extreme cases.
How Does Orange Influence Your Moods?

Appendix E

Designing for a more accessible indoor climate system

Alina Boyuklieva, MSc graduation student (TU Delft)
Stella Boess, mentor, Inclusive Design Lab, (TU Delft)

ENERGIE LAB ZUIDOOST

In collaboration with:
Gemeente Amsterdam
TU Delft

01 Introduction

WHAT?
- Refurbishment of 288 living units
- New air-tight facade
- New heating and ventilation systems

WHY?
- Humidity and insulation problems
- Improve residents' comfort
- Decrease energy bills
- Reach zero-energy housing until 2040

HOW?
- 1 demo apartment
- Field research with residents
- Involvement of residents in the design and decision process
- Systems testing

Demo-apartment Reigersbos

Stakeholders

Government — Residents
Researchers — Companies

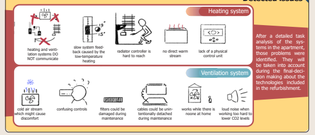
The goal
Discover users' needs and habits in order to successfully implement the new systems. Take inclusivity into account.

02 Current Research

Currently installed systems

1 Heat pump | 2 Bathroom radiator | 3 Ventilation system

Detected issues



After a detailed task analysis of the systems in the apartment, those problems were identified. They will be taken into account during the final decision making about the technologies included in the refurbishment.

03 Accessibility

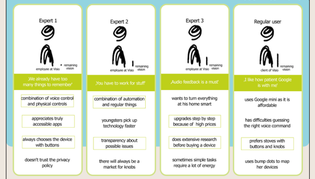
≈350 000
people in The Netherlands are Visually Impaired.

18% (196)
of the households in Reigersbos are likely to be affected.

Accessibility limitations in Reigersbos

Systems to control	Control options	Accessibility limitations
1 Heat pump	app	compatibility with other devices?
		how accessible is the app?
		app might be unreliable if the connection is not good
		complicated for users who are not familiar with such technology
		lack of alternative options
		lack of direct audio or tactile feedback
2 Bathroom radiator	tactile buttons interface	hard to reach
		buttons are too small
		buttons are not emaxed
		does not provide feedback on which setting it was set
		small screen with small text
3 Ventilation system	app	how accessible is the app?
	tactile button on the unit	no indication that the single button has three different functions
		too small light indications
		lack of coherent feedback
		complicated maintenance required

User interviews



04 Future Steps

- develop a product addressing one or more of the identified needs
- involve users directly in the process through co-creation and participation
- create a prototype
- evaluate the prototype with users
- yield conclusions and recommendations for future research and development

In case of any further interest in the project and/or desire to take part in the design process and making a contribution, please feel free to send an e-mail to:
a.d.boyuklieva@student.tudelft.nl

Appendix F

Please find it at the end.

Appendix G

Additions to the booklet based on the evaluation

1.

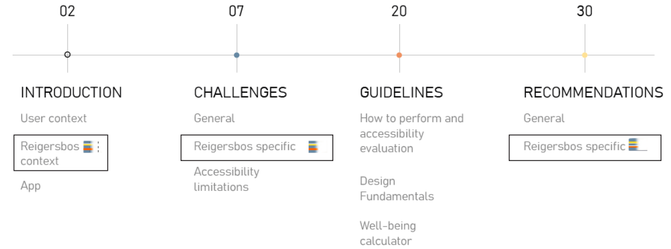
HOW CAN IT HELP YOU?

This booklet is meant to enable the members of the 'Demand' side of a housing renovation to **choose more inclusive products and systems**. If You are one of the people, responsible for these decisions, then this is for You!

In case that You are on the 'Supply' side, the content could still be beneficial. It can help You get to know the needs of your clients better and thus create more appealing offers.

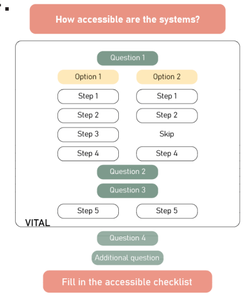
If You are involved with the case of Reigersbos renovation, then the whole booklet could provide valuable information. In case You are not, the parts that are labelled 'Reigersbos specific ' can be skipped.

2.



3.

4.



5.

FURTHER STEPS

Scale up

The Booklet currently includes mainly guidelines for accessibility for people with low vision. In the future, requirements for other dissabilities could be similarly structured and included as well. This will expand the usability of the tool.

Develop the app further

The AR app that complements the booklet opens room for countless future possibilities. In the short term, the interactions with the systems installed in a demo-apartment could be integrated in the app so some tests could be performed remotely. Then, those could turn into a VR version allowing more thorough experience, more accurate conclusions and **boost in inclusivity**. Current rendering softwares as Enscape already provide the opportunity to experience a 3D model in VR.

Bring it to the public

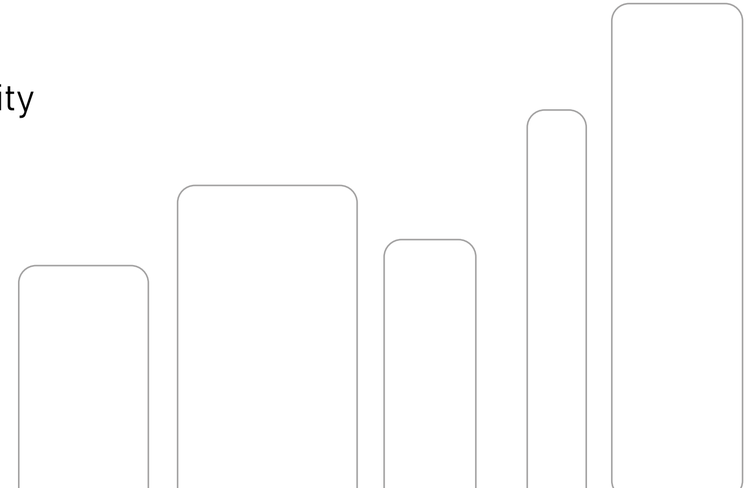
This booklet has to be promoted, so the stakeholders that could make use of it are aware of its existence. Initially, **presentations** and small **workshops** could be organised to introduce it to the public and explain its value. It can also be included in the weekly **newsletter**.

Appendix H

Design Guidelines and Recommendations

A human-centered approach
to zero energy housing renovations
with focus on visually impaired residents

Inclusivity is sustainability



Design Guidelines and Recommendations

A human-centered approach
to zero energy housing renovations
with focus on visually impaired residents

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Tomasz Jaskiewicz
Delft University of Technology

Company mentor
Juliëtte Mohamed
Sustainability Advisor
Ingenieursbureau Amsterdam

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In case that You are on the 'Supply' side, the content could still be beneficial. It can help You get to know the needs of your clients better and thus create more appealing offers.

If You are involved with the case of Reigersbos renovation, then the whole booklet could provide valuable information. In case You are not, the parts that are labelled 'Reigersbos specific  ' can be skipped.

CONTENTS

INTRODUCTION

Amsterdam aims towards zero-energy housing until 2040 (Gemeente Amsterdam, 2020). In order to achieve this goal, many housing renovations are being planned and currently taking place. Prior research in the filed of zero-energy housing renovations has discovered the importance of residents' engagement in the process. Performing an accessibility evaluation of a design before making final decisions, could not only **increase the satisfaction of the residents**, but also the **efficiency of the system in terms of social and environmental sustainability**.

Therefore, the content of this booklet aims to provide support from **human-centered design perspective in the form of guidelines and recommendations for renovation projects with focus on visually impaired residents**. Actionable steps for narrowing the gap between the residents and the newly installed heating and ventilation systems are proposed. This project is developed in parallel with the investigation of a demo-apartment in Reigersbos neighbourhood. Next to the **general** guidelines and recommendations, are included ones, **specifically targeting the case of Reigersbos**. In the foundation of the suggested methods and strategies, lie months of literature research, user studies, on-site research, data analysis and validation. The content is based on an extensive report 'Designing for a more accessible zero energy system' which could be found on the TU Delft Repository website.

USER CONTEXT

How would you feel if that happens to you?

Imagine this scenario:

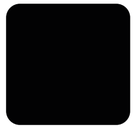
It is late in the evening, you are sitting on the couch and your halfway through a movie. After it ends, you want to take a shower as always. First, you want to preheat the bathroom. But then you remember - you cannot control the bathroom radiator because it is not accessible to you. Your wife can but she is already asleep. Should you wake her up or should you just go to bed without showering...

As one of the main goals of a renovation is to improve residents' comfort and well-being*, we should strive to avoid provoking such feelings in them, especially while in the safe space of their home. Therefore, **the decision-making process should be driven also by the thought of accessibility** next to all the other factors. Performing an accessibility evaluation of a design before making final decisions, could not only **increase the satisfaction of the residents**, but also **the efficiency of the system** and the sustainability of the building. Even though, we are explicitly mentioning residents with visual impairments, many of their needs overlap with those of other user groups, e.g. older people, ones unfamiliar with such technology, etc. Furthermore, **the insights, acquired during that phase could also serve as input for other future projects**.

*state of happiness and contentment, with low levels of distress, overall good physical and mental health and outlook, or good quality of life.' (APA Dictionary of psychology)

'There is a big difference between a product being usable and a product being accessible - it needs to be intuitive to use instead of needing adaptations.'

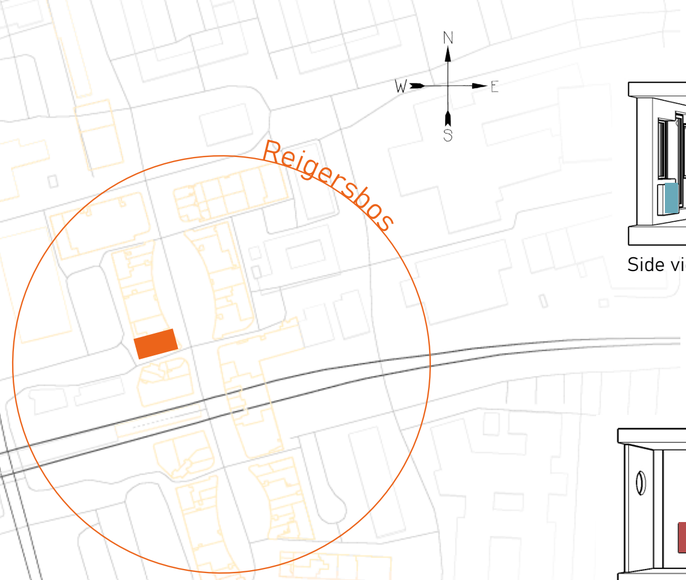
Try different kinds of visual impairments in real time through this app!

Expert user 1	Expert user 2	Expert user 3	Regular user
 Total vision loss	 Tunnel vision	 Loss of central vision	 Overall blur
'We already have too many things to remember'	*'Unexpected system errors make me frustrated'*	*'Audio feedback is a must'*	*'I like how patient Google is with me'*
combination of voice control and physical controls	combination of automation and regular things	wants to turn everything at his home start	uses Google mini as it is affordable
appreciates truly accessible apps	youngsters pick up technology faster	upgrades step by step because of high prices	has difficulties guessing buttons and knobs
always chooses the device with physical buttons	transparency about possible issues	does extensive research before buying a device	has difficulties guessing the right voice command
requires straight-forward intuitive interactions	there will always be a market for knobs	sometimes simple tasks require a lot of energy	uses bump dots to map her devices

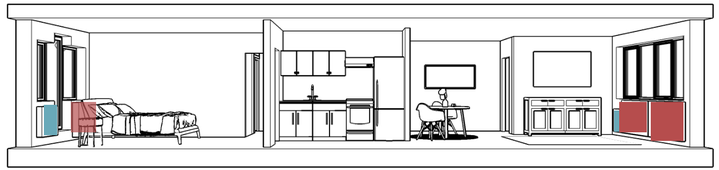
REIGERSBOS CONTEXT

The case study examined in the booklet is the refurbishment of 288 housing dwellings in the Reigersbos neighbourhood.(Fig. 1) Located in the south-eastern part of the city, it mainly consists of buildings, constructed in the early eighties. The project aims towards providing the inhabitants with a more comfortable indoor climate, improving their quality of life, while still complying with their budget and user needs.

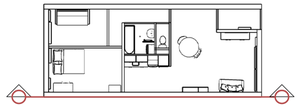
Figure 1, Reigersbos residential buildings

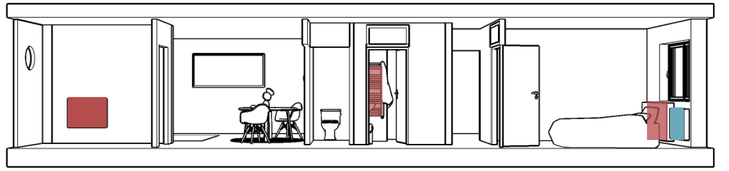


A **short-term monitoring project** on resident needs, indoor climate and energy usage has been conducted in a **first prototype apartment**. (Fig.1, 2) This apartment is available for user research and prototyping of solutions and **its purpose is to develop requirements for the renovation**.

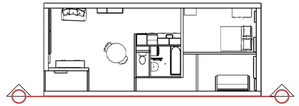


Side view from the South side





Side view from the North side



Newly installed systems

Heating system

Ventilation system

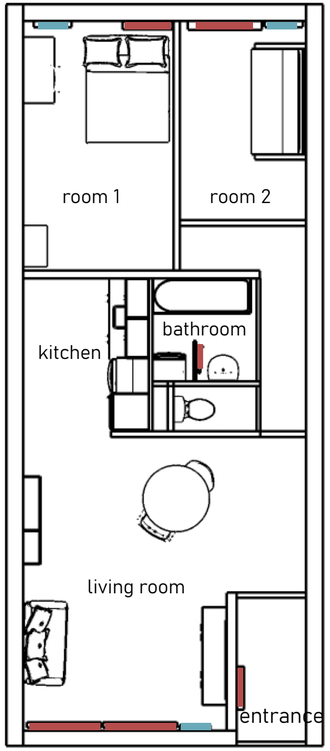


Figure 2, Demo-apartment floor plan

Before going further...

Reigersbos AR
educational

Google Play

In case you use iOS please use the QR codes next to the videos or click the play button on a digital version

App Store

Please download the app in order to have access to the interactive content of the booklet.

1. Scan the code
2. Choose 'Package Installer'
3. Install the app
4. Throughout the booklet, notice the images with a play button and this icon - AR
5. Open the app, allow camera access and point your phone camera towards the image
6. Wait for the video to play.

CHALLENGES

CHALLENGES // General

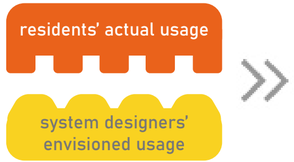


Fig. 3, Current undesired situation

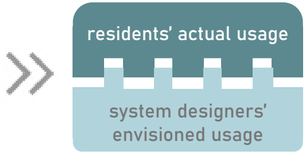


Fig. 4, Future desired scenario

Latest research has thoroughly examined the causes of various issues, emerging among residents as a result of zero-energy renovations. Many suggest that in the core is the misfit between systems' functioning mechanisms and residents' expectations about them. (Fig. 3) The concerned parties have to be well aware of the actions required for a successful implementation of a new technology. Good understanding of residents' needs is crucial, together with clear initial introduction and sustained support, as a steep learning curve is expected to occur. An improper approach is likely to result in a misfit leading to undesired interactions between the residents and the system as setting it on unrealistic values, turning it off, avoiding maintenance, etc.

User research conducted prior to the final implementation of the technologies could yield positive results instead. (Fig. 4) Correctly identifying the user needs' leads to choosing more suitable systems depending on the specific context. In the long-term that brings on one hand the satisfaction of residents and healthier indoor climate, while on the other - more energy efficient systems.

UNDESIRABLE SCENARIO

Implementation of new technologies **without** prior user research	+	Residents unfamiliar with it's working mechanism	=	Misfit between residents' expectation and system's functioning	+	Undesired interactions between the resident and the system
requires:		requires:		might lead to:		might lead to:


Steep learning curve by the resident


Initial introduction and training


Residents do not understand what the system is doing


Turning off the ventilation system


Establishment of new habits by the residents


Sustained support and monitoring


Setting the heating or ventilation to unrealistic values


Avoiding maintenance, leading to systems' damage

DESIRABLE SCENARIO

Implementation of new technologies **with** prior user research	+	Choosing more intuitive technologies	=	Match between residents' expectations and system's functioning	+	Residents interfere only when necessary
requires:		requires:		leads to:		


Small learning curve by the resident


Initial introduction and training


Residents understand and trust the system


Efficiently working systems


Evolving old habits by the residents


Sustained support and monitoring


Less unexpected undesired scenarios


Improved residents' comfort

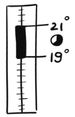
CHALLENGES // Reigersbos specific

Here, the challenges that are likely to occur with the currently installed heating and ventilation systems In Reigersbos are discussed. Numerous participants have stayed in the demo-apartment during a period of five months which allowed determining the most common issues.

Heating system

Feedback

Slow system feedback



consequences for the residents:
- hard to understand whether the system is working
- confusion why their needs are not met
- climate discomfort
- frustration because they do not know how to reach the desired result

consequences for the systems:
- being set on unrealistic setting (too high/too low)
- high energy consumption
- failure to keep up with residents' commands
- residents interfere needlessly and decrease the efficiency

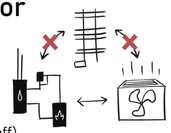
Lack of direct warm stream

consequences for the resident:
- unable to identify by touch whether the convector is working or not
- could not receive direct heat supply when feeling cold (hands, feet)
- discomfort

consequences for the systems:
- receiving unrealistic commands (too high temperature)
- that could lead to inefficiency and energy waste

Electric bathroom radiator

Heat-pump and electric radiator do not communicate



consequences for the residents :
- harder to operate with it in the most efficient way
- more factors to think about
- discomfort (if the residents forget to turn it on or off)
- inability to control everything remotely

consequences for the systems:
- not synced
- harder to function efficiently
- excessive energy usage if the radiator is put on a high setting and forgotten

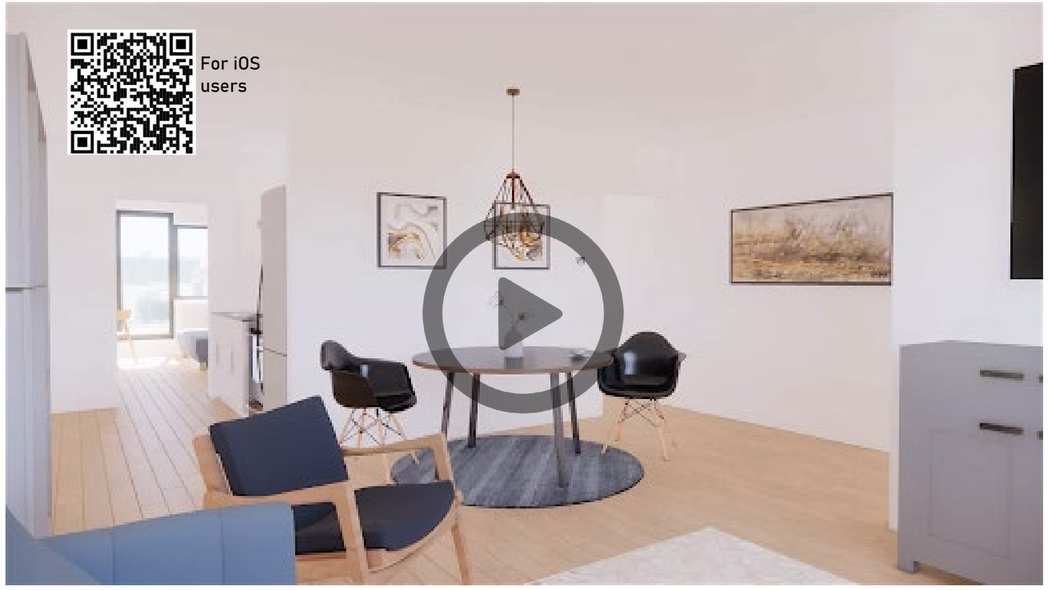
Bathroom radiator controller is hard to reach

consequences for the resident:
- difficult to control (hard to reach, hard to see)
- the residents might hit their head on the sink
- lack of other control option
- climate discomfort (if the residents could not operate with it as they wish because of it's location)

consequences for the systems:
- left on longer than needed - energy waste
- being set on a wrong setting because of the lack of visibility access

AR

For iOS users



CHALLENGES // Reigersbos specific

Ventilation system

Control

Confusing controls on ventilation units (Fig. 5)

consequences for the residents :
- difficult to set the system on the desired setting
- a cause for confusion and frustration
- self-doubt if they interact with it 'correctly'
- climate discomfort
- compromised air quality

consequences for the systems:
- undesired changes to some main settings
- hard to function efficiently and autonomously - energy waste
- working unnecessarily (when there is no one at home)

Fig. 5, Control units of the ventilation

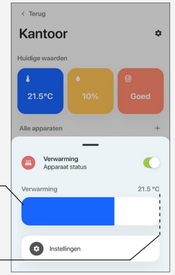
A newly developed control app for the system

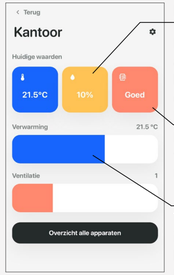
- some control instruments do not correspond with system's functionality
- some main rules for accessible interface are not kept (please find guidelines on page X)
- lack of option to connect other devices e.g. sensors, triggers, etc.
- does not support residents in keeping track of their energy usage easily
- illogical color usage

EXAMPLE:

Indicates that the system is warming up, however the color is blue which is associated with cold

What is at the end?





Is that good or bad?

Indicates that the air quality is good, however the color is orange which is attention-grabbing

It does not change when the indication turns to 'bad'

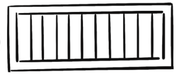
Too easy to move it back and forth - hard for the system to react to rapid changes

Maintenance

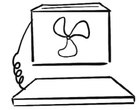
Complicated maintenance is required (cleaning and replacement of the filter)

consequences for the residents :
- fear of damaging the system
- avoiding performing maintenance
- experiencing worse air quality in terms of CO2
- opening the windows more often which could cause excessive energy usage of the heating system

consequences for the systems:
- inefficient working (not filtering well)
- long-term damage
- shorter life-span



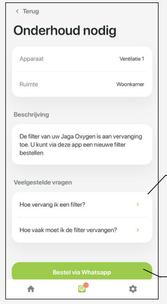
filters could be damaged because of the lack of clear indication of a grabbing spot



main cables could be easily detached

EXAMPLE:

Is the message supported with an explanation how that could influence the residents?



Is there easy access to visually supported manual about how to perform maintenance?

Is there direct connection to a professional who can support the resident during maintenance?

CHALLENGES // Reigersbos specific

CO2 sensors are situated too close to the fresh air

consequences for the residents :
- as the sensors read the CO2 values from the clean air, the average values at the apartment tend to be higher
- the system starts ventilating only when the values have become too high
- health hazards because of the higher CO2 density

consequences for the systems:
- inefficient working (not starting working on time)

Loud noise from systems

consequences for the residents :
- disturbance and annoyance
- using the ventilation system less than intended which could lead to high CO2 levels
- health hazards because of the high CO2 level

consequences for the systems:
- might be turned off directly from the plug
- inability to keep up supplying fresh air
- inability to maintain the balanced air pressure inside

Cold air stream from ventilation units (Fig 6, 7)

consequences for the residents :
- discomfort in terms of temperature
- sore muscles
- using the ventilation system less than intended which could lead to high CO2 levels
- health hazards because of the high CO2 level

consequences for the systems:
- might be turned off directly from the plug
- inability to keep supplying fresh air
- inability to maintain the balanced air pressure inside

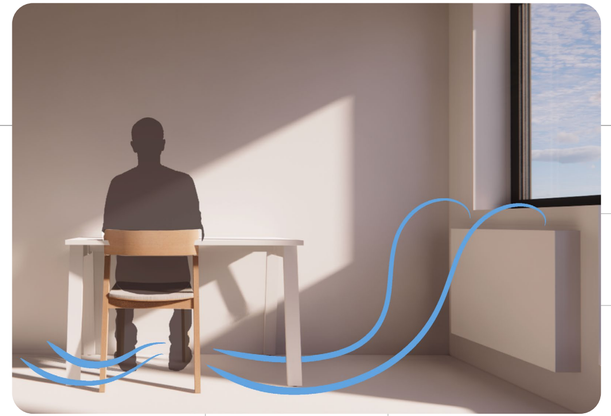


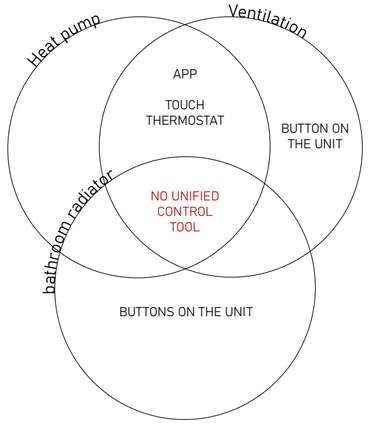
Fig. 6, The cold air from the ventilation goes to the feet of the working person

'Having the head close to the ventilation is not nice. Nice, clean air, but too cold.'

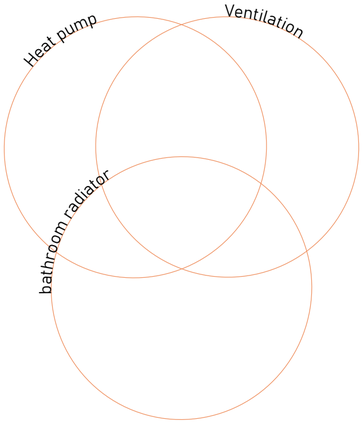
Fig. 7, The cold air from the ventilation goes directly to the sleeping person

CONTROL // Reigersbos specific

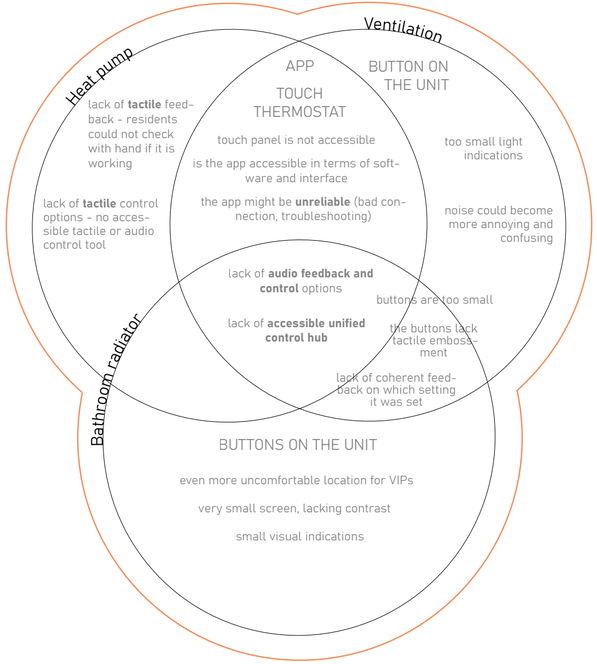
Current control tools



Current ACCESSIBLE control tools



ACCESSIBILITY LIMITATIONS // Reigersbos specific



In the **international standard for accessibility and usability in the built environment ISO 21542**, experts explicitly mention that it has to be ensured that 'ventilation and heating equipment are operational'[1] by everybody. Considering the guidelines which they have provided and supporting them with additional research, an accessibility evaluation of the systems in Reigersbos was performed in terms of control possibilities. From the graph on the left, it becomes clear that currently those systems are hardly accessible which would lead to huge obstacles for some residents. In order to prevent that, the next chapter provides a set of selected guidelines on how to prevent the selection of inaccessible systems for housing renovations.

[1] ISO 21542, 2021

GUIDELINES

From this link You can also download only the Guidelines section of the Booklet and use it in practice

How to perform an accessibility evaluation?

with focus on visually impaired users

Fill in the **'NEN 17210'[2] checklist of functional requirements for accessibility and usability of the built environment** according to the choice of technology for the specific case.

Requirements	YES/NO	Comments
1.Access and operate equipments and facilities		
2. Access and understand information via multiple senses (e.g. signage, apps)		
3. General ICT usability and accessibility		
4. Natural lighting		

Please find a biger, detachable version of the checklist on Page 41.

Questions to ask:

1. Are visually impaired residents able to access and operate the chosen technology freely?
2. Does each selected technology provide three options for interaction (visual, audible and tactile) ?
3. Does the digital interface provide accessible features for visually impaired residents?
4. What amount of natural lighting penetrates the living space?

[2] NEN -EN 17210, 2021

How accessible are the systems?

VITAL - Do that for each system.

Question 1

Option 1	Option 2
Step 1	Step 1
Step 2	Step 2
Step 3	Skip
Step 4	Step 4

Question 2

Question 3

Step 5	Step 5

Question 4

Additional question

Fill in the accessible checklist

Question 1

Option 1: **Facilitate user tests**[3] **with visually impaired users**.

Step 1: Define specific testing objectives depending on the case.

Map all the systems that are or will be installed in the demo-house. Then, for each system, list all the interactions which the user should be able to complete, e.g. turn on/off, set the temperature high/low, set a routine, etc.

Suggestion// First start with the functions that are vital for the resident. Try to list at least 5. Then continue with the ones that are of lower priority. Try to put yourself in the shoes of the user. You can use either the app that simulates low vision on Page 7 or the Simulation Glasses method from Page 26. Act out an imaginative scenario in order to come up with more possible interactions.

Step 2: Create a plan.

Where will the user testing take place? How long will it last? Would you recruit participants to stay at the apartment overnight or would you invite them only for a shorter period of time? Write a task scenario - what actions would you exactly ask them to perform and in what order? Prepare materials to keep track of the results. Think about what answers are you looking for specifically. You will most probably be interested in the process as well

Suggestion// Plan how long the user test would take - maybe it could be a usability user test of around 1 hour while for an in-depth user test for this case, you might need to recruit participant to stay overnight. Take into account that staying overnight would require more time for preparation. Decide how you will record the results - would you do it yourself, or would you involve another person to help you with that. Do you intend to record videos, or would you be only taking notes? If the person stays overnight, would you ask them to document anything themselves while there? When all this is ready, perform a pilot user test.

Step 3: Recruit participants.

Partner up with associations and companies involved with visually impaired users (e.g. Koninklijke Vision, Envision, WOON!, etc.) Provide information about the study in accessible manner - Braille print, audio, contrast colors, large text.

Suggestion// Recruit a minimum of 5 participants. Make sure that you have well explained the goals of the study and what will be required from them - in terms of actions and time. Decide how you would compensate them for their time - you could grant them giftcards for example.

[3]Delft Design Guide: Design Strategies and Methods

Step 4: Conduct the test

Depending on the context, you can refer to the explanation of Question 2 and/or 3 for accessibility requirements. Reflect on each user test and if needed, make changes to the following ones.

Step 5: Analyse the results and fill in the checklist from Page 41.

Look at all findings and think what they mean for the project. If any problems emerged, think what kind of solutions could be applied. You can evaluate them with the Design Fundamentals on Page 32.

Option 2:

Simulate visual impairment.

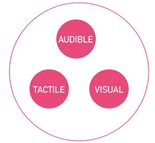
Step 1: Choose a tool which could assists you in simulating

- Simulation glasses (fig. 8) are proven to enhance designer's empathy and creativity.
- You could tie your eyes with a scarf.
- In case you wear glasses, obstruct the view of each lens with tape or paper.
- Get plastic safety glasses and paint them or scratch them.
- You could also use the guide by Erin Ringwald (eHow, UK)

Step 2: Follow the above procedure from 'Option 1' while skipping 'Step 3'.

Figure 8, Cambridge Simulation Glasses, Inclusive Design Toolkit

Question 2. By using the provided graph, assess to what extent each selected technology provides three different options for interaction. According to **ISO 21542**: 'Information in audible, visual, tactile and simple language formats should be provided where possible ... **visual information to be supplemented by audible information plus tactile information where appropriate...**'[3]



Audible

commands
feed-forward
feedback
questions

Tactile

big contrasting buttons
air stream
embossment, min. rise of 0.8 mm, preferred is 1mm to 1.5mm [4]
sliders
vibration
hot & cold
texture

Visual

light signals
accessible digital interface (Question 3)
text and color mapping
contrast

OTHER ACCESSIBILITY FEATURES TO KEEP IN MIND

solid
loud speakers
audio cues
offline voice dictation
NFC reading function
compatible with different visual add-ons
easy navigation (with a click of a button)
intuitive
big buttons - electrical switches should have large push plates to prevent accidental operation[3]
truly tactile buttons

[4] ISO 21542, 2021

Question 3. Evaluate all digital interfaces on the basis of the provided criteria for digital accessibility extracted from **EN 30154**.[5]

What? Provide at least one mode of operation that does not require vision

How?
- well formed semantic structure
- audio and tactile user interfaces

What? Provide features that enable users to make better use of their limited vision

How?
- magnification, reduction of required field of vision and control of contrast, brightness and intensity

What? Provide a visual mode of operation that does not require user perception of color

How?
- provision of additional methods of distinguishing between the features

Please fill in the checklist. A bigger, detachable version can be found on Page 42.

Requirements	YES/NO
Accessibility setting on the main screen	
Voice over	
Zoom in option	
Color filters	
Most important information on screen	
High contrast colors	

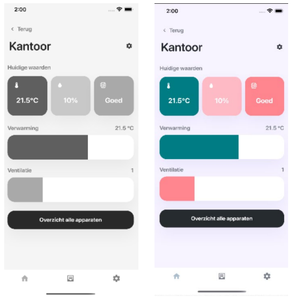


Fig. X, A simulation of color blindness on the app of Reigersbos systems, http://www.color-blindness.com/coblis-color-blindness-simulator/

[5] EN 301549

Question 4. Create a light study of the space using a 3D software in order to predict the movement of natural light in the dwelling

This has implications for the thermal comfort of the residents as well as for decisions on the light throughout of window panes, overhang and type of glass.

Step 1: Create a model of the space that you would like to examine in SketchUp.

Step 2: Import the correct geo-location and sync the orientation of your model.

Step 3: Turn on the shadows feature in SketchUp and explore how the light comes into the space throughout different times of the day and the year.

Suggestion// For a more realistic feeling, you can use the rendering software 'Enscape'.

Step 4: Make conclusions about how the thermal comfort could be influenced and what kind of means are the most suitable to control natural lighting in the specific case.

Example of a light study, Reigersbos' living room

January, 10 AM

March, 1 PM

June, 7 AM

AR

'I worked in the bedroom during the most of the day because there was sun in there and it was warmer and brighter than the living room'

Additional question: How to measure the psychological well-being of the residents ? (being one of the goals of the renovation) This evaluation tool can support designers in creating products that improve the well-being of disabled users by including the emotional layer in the project. The 'Well-being calculator' is a matrix, incorporating the most important criteria for the well-being of disabled users. This is a method that aims to translate the needs of the users in a scalable form. It can be applied in the initial phase of a project or in its final evaluation stages. Give a grade to each criterion in order to compare different products.

Well-being calculator

CRITERIA	GRADE	NOTES
ACHIEVEMENT	1 — 10	
MEANING	1 — 10	
SELF-ACCEPTANCE	1 — 10	
AUTONOMY	1 — 10	Example // Peter can control the heating all by himself.
PERSONAL GROWTH	1 — 10	
SAFETY	1 — 10	
SOCIAL INCLUSIVENESS	1 — 10	

DESIGN FUNDAMENTALS (DF)

By combining the accessibility research with the zero-energy renovation research, the following Design Fundamentals were formed. They serve as a set of requirements that guide us in the selection of suitable systems for accessible zero-energy renovations.

Design for accessibility

Inclusion is one of the main goals of this project. Therefore it is crucial that the designed solution is accessible to VIPs while also desirable for the wider public.

Design for trust

When leaving the control of your home to a smart system, you should definitely trust it. The user has to be sure that it is indeed executing the desired commands at the right time and he should be able to check that at any given moment. It is also desired that possible bugs are envisioned and being transparent about.

Design for low-maintenance

As the bigger part of VIPs usually need assistance for tasks that are not performed often, low maintenance products are preferred. Not only they need to ask for help more rarely but for them that also means a more reliable

Design for simplicity

Certain commands have to be executed with as little actions as possible. Moreover, the interactions should be natural and familiar. Only vital information should be presented, unless additional information is explicitly asked for. Simple interactions are in the core of accessible interactions. Simplicity in terms of maintenance is also desired.

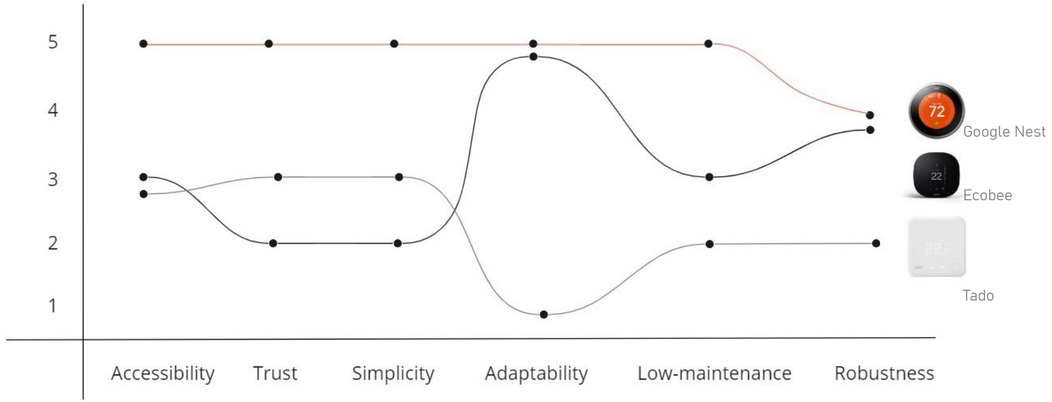
Design for adaptability

Each visually impaired user has different needs and habits. Some want more automation while others prefer to do things the old way and I want to give them the option to choose. Therefore, it is very important that the product is adaptable.

Design for robustness

The product has to be solid both in terms of physical characteristics and software. Reliability and easy troubleshooting are required.

HOW TO APPLY THEM?



This is an example on how the DF could be used. By creating an evaluation matrix- on their basis, different products can be compared so the most suitable one for the case is chosen.

IMPORTANT NOTE

Please, take into account that in that kind of user evaluations, it is recommended to use the services of a professional such as a Design Researcher for example. Their expertise will contribute to obtaining richer and more valuable results for your project.

RECOMMENDATIONS

RECOMMENDATIONS // General

One unified system to control all heating and ventilation units in the apartment (including the electric bathroom radiator)

Advantages

- more energy efficient systems
- less components for residents to learn and be aware of
- better control of the humidity in the bathroom
- allows residents to connect other devices and sensors
- provides better control
- better connectivity

Provide three control options of each system (tactile, audible, visual, on the basis of the above guidelines)

Advantages

- more reliable system
- more accessible system

Provide immediate feedback (audible, tactile, visual, on the basis of the above guidelines)

Advantages

- more energy efficient system because users would interfere less when they know what the system is doing
- more accessible system

Provide air recirculation hood in the renovation package, one with rounded edges

Advantages

- better fit to the other systems
- easier for the residents
- safer

Choose ventilation units that preheat the air

Advantages

- more energy efficient heating system because warm air comes in
- better comfort for the users because of the lack of cold

Collaborate with companies that are transparent about envisioned issues and troubleshooting

Provide an accessible troubleshooting manual - use clearly legible fonts and symbols with good visual contrast, standardized symbols; provide tactile and audible formats[7]

Implement a function (app) so users could make basic diagnostics themselves

Advantages

- allows taking better informed decisions
- the residents will perform maintenance more easily
- less interventions will be needed from professionals
- lower maintenance costs both for the user and the company
- better functioning of the system
- better reliability
- trust

[7]NEN 279091

Install balanced heating and ventilation system when possible

Advantages

- decreased heat loss
- highly automated
- better comfort for the resident
- more energy efficient

Include a reminder signal for residents to close the windows on time

Advantages

- more energy efficient heating system because there is no uncontrolled cold air inlet
- more energy efficient ventilation system because there is no uncontrolled unfiltered air inlet

Install automatic blinds

Advantages

- improved comfort for the users
- more energy efficiency system when the sun contributes to warming up the space
- better control of natural lighting

RECOMMENDATIONS // Reigersbos specific

Change the position of the CO2 sensor of the ventilation system

Advantages

- better air quality (because of the more accurate data)

Choose an electric unit for the bathroom equipped with a controller at the top and/or one that has a wireless control option

Advantages

- easier access and control
- safer

Provide a manual control option for the air extraction in the toilet

Advantages

- better comfort for the residents
- include auto turn off function after 10 minutes

FUTURE STEPS

FURTHER STEPS

Scale up

The Booklet currently includes mainly guidelines for accessibility for people with low vision. In the future, requirements for other disabilities could be similarly structured and included as well. This will expand the usability of the tool.

Develop the app further

The AR app that complements the booklet opens room for countless future possibilities. In the short term, the interactions with the systems installed in a demo-apratment could be integrated in the app so some tests could be performed remotely. Then, those could turn into a VR version allowing more thorough experience, more accurate conclusions and **boost in inclusivity**. Software developers will need to collaborate with professional researchers and designers in order to integrate the most suitable functionalities.

Bring it to the public

This booklet has to be promoted, so the stakeholders that could make use of it are aware of its existence. Initially, **presentations** and small **workshops** could be organised to introduce it to the public and explain its value. It can also be included in the weekly **newsletter**.

ANNEX

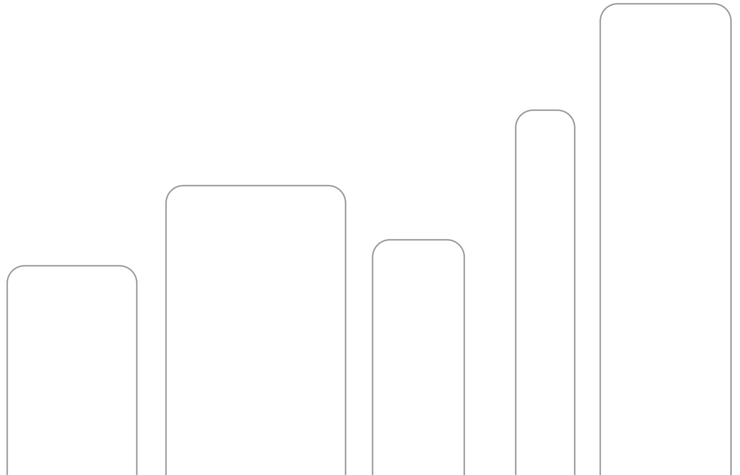
Product/System:

Requirements	YES/NO	Comments
1.Access and operate equipments and facilities		
2. Access and understand information via multiple senses (e.g. signage, apps)		
3. General ICT usability and accessibility		
4. Natural lighting		

Product/System:

Requirements	**YES/NO**
Accessibility setting on the main screen	
Voice over	
Zoom in option	
Color filters	
Most important information on screen	
High contrast colors	

“The one argument for accessibility that doesn’t get made nearly often enough is how extraordinarily better it makes some people’s lives. How many opportunities do we have to dramatically improve people’s lives just by doing our job a little better?”
— Steve Krug



Appendix I

Pamphlet

Context

Project title:

Designing for a more accessible zero energy system (with a focus on visually impaired users) // heating and ventilation systems are meant

Question for brainstorming session:

How to improve the communication between the system and the user in terms of understanding, control and functionality in the future?

Detected issues in the context of low temperature heating

- slow feedback from the system when a command is given
- lack of direct heat stream from the heating units
- users do not understand how the system functions which makes them to interfere too much which often leads to energy loss

Objectives

Create a future vision for a zero energy home considering the heating and ventilation systems and their accessibility.

'Make teams of people and machines.', Don Norman

*Desing for the 5 senses (sight, touch, smell, sound, taste) and the 6 emotions (sad, angry, scared, tender, excited, happy)

* serves as an inspiration

Home exercise prior session - 10 mins

I would like to ask you to do one exercise at home before the session. It would help you to better empatize with the target group (visually impaired users) and come up with more creative ideas. Please do it only if you feel comfortable!

Find a thin scarf and use it to blindfold yourself. Stay still for a while and think how your perceptions change - do you hear something new or maybe you notice a new smell? Then, try to walk around while being aware of the feelings that you are experiencing (positive or negative). Pay attention to the elements of your surrouding that you are noticing (obsatcles or things that help you navigate). Whie blindfolded try to perform one simple task - try to control your heating system if that's possible or if not - just try to wash your hands or any other task that you'd like. Then remove the scarf and take notes of all your thoughts during the exercise. Please bring them to the brainstorming session.

Results from home exercise

Touching the wall helps me to either

Breeze from the window guided me to find the window

using furniture and walls to orientate and find the display

Small lights helps me to navigate

didn't enjoy as much laying on my bed next to the window where usually is much hotter now that I couldn't see the view

- maybe because of the task - bit when blindfolded i was much more aware of the heat in the room - noticed more the warmth

open windows let the outside noise come inside and enabled me to find the open window

Also imagining the number of steps I've to do

Difficult to navigate, I had to use the wall to walk to the other room. I noticed I was way more alert.

the display lights up when interacted with, but this is so minimal it was not visible with the scarf

if there is no haptic or auditory feedback I had no clue what I was doing - when trying to adjust the heater etc.

Mostly visible cues on heating system, so difficult to know how much the temperature changed. Only small haptic feedback.

when turning the knob to change the temperature, it vibrates lightly with each step, indicating it went higher/lower 0.5 degrees

there is almost no way of knowing what temperature you are setting it to unless you know the current setting en calculate each step

it blinks to let you know its setting the new temperature, but this is barely visible because the minimal contrast of the black letters on the green background

I can adjust the heating system, is a rotary valve. but i can bring it or at the maximum or minimum without seing the numbers

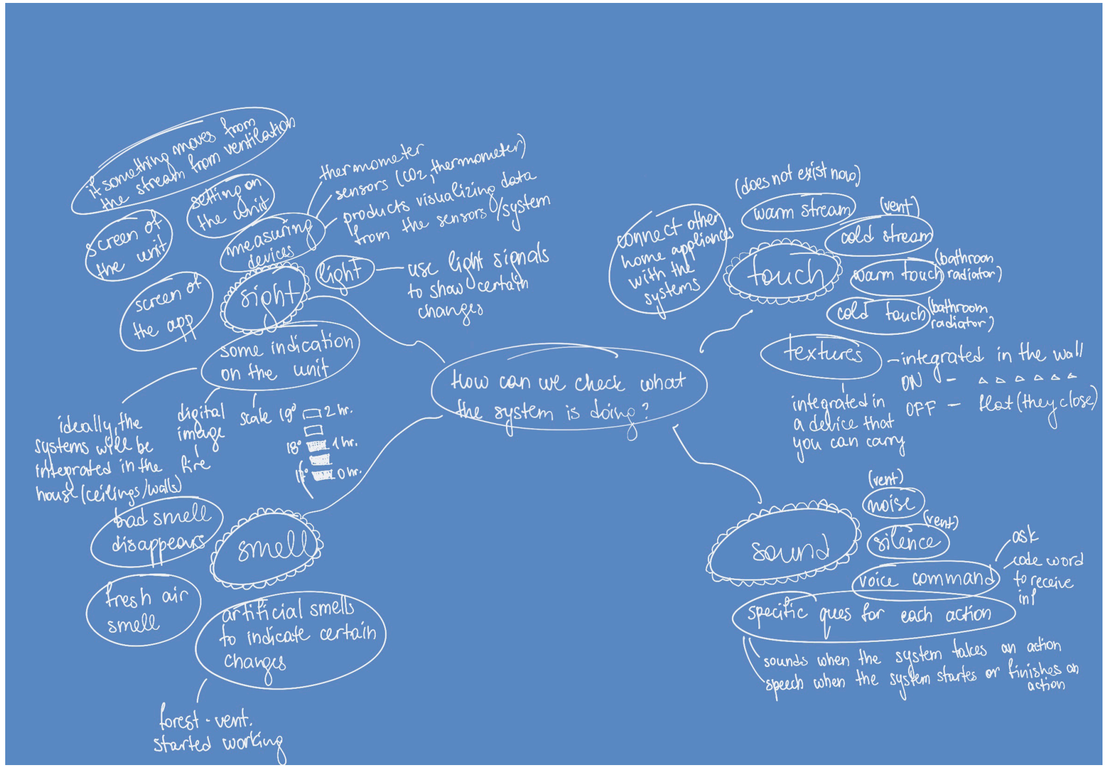
So, i try to ear when is the water flowing in the radiator

clean patways become much more important - every poping out furniture or thing on the ground became an obsticle

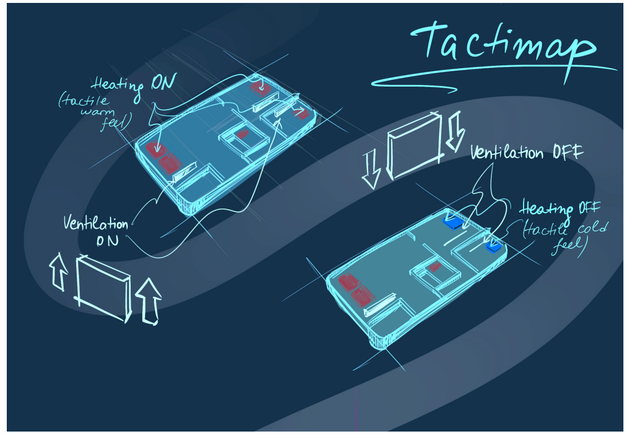
miro

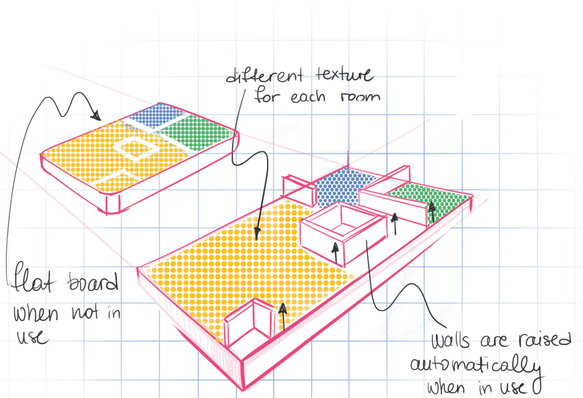
Synthesized ideas from brainstorming with fellow students

Individual brainstorming

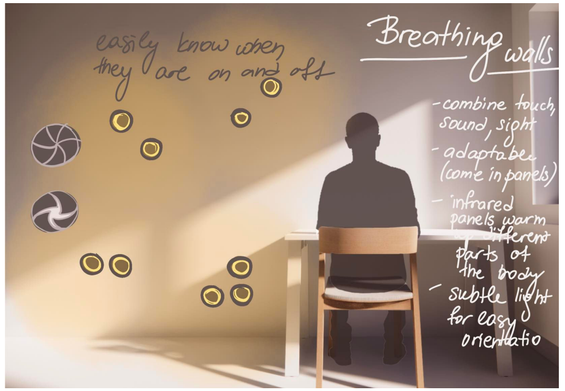


Idea sketching – Tactimap





Idea sketching - Breathing Walls



Appendix J

The future of heating systems

Some of the biggest cities in Europe are striving to become CO_2 neutral in the coming decades. In order to achieve that, many zero-energy renovations are taking place that transform old buildings into self-sustaining units energywise. Low-temperature heatpumps are being installed, together with solar panels and new air tight facades. These new technologies contribute not only to environmental sustainability but also increase the well-being of users in terms of health and comfort.

However, next to its many advantages, low-temperature heating also has some drawbacks that could create discomfort for the residents and lead to undesired interactions between them and the systems. One of the major disadvantages of this type of technology is the fact that the convector units do not provide a warm air stream. They do warm up evenly the whole space but if the user wants to understand if the heating is working by putting a hand over the unit, he won't feel anything. It was discovered that in many cases, that leads to residents turning up the heating to very high settings which only results into excessive energy usage, still without providing the desired intensive heat.

Therefore, here I present two concepts which are aiming to solve that problem in the future.

1. How old are you?

2. In what space do you live?

This is the first concept called 'Breathing Walls'. The heating convector is integrated in the facade while the interactive openings provide immediate feedback about the state of the system. There are 3 stages of opening - fully opened, indicating that it is heating up, half-opened, indicating that it is maintaining a constant temperature and closed - not working. The openings are also equipped with the function to provide direct heat supply.

Different shapes are available. The user has the freedom to install the panels wherever comfortable for him/her.

Furthemore, a subtle light is integrated which also provides feedback about what the system is doing at the moment. Blue for example means that the system is only ventilating. All preferences could be programmed through an app.

3. Would you like to have such product in your living space? Why or why not?

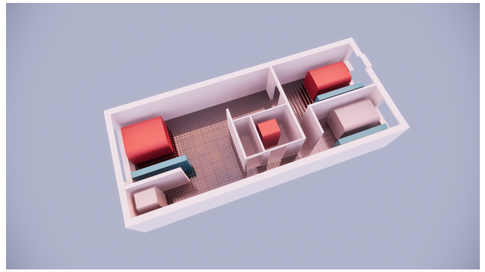
4. Would you prefer such interface rather than the classic grill openings?

5. Can you think of any other functionalities that you would like to include in the product?

6. What are the advantages and the disadvantages that you detect?

The second concept is called 'Tactimap', a portable 3D model of the living space which serves as an informational tool for the resident. It integrates all heating and ventilation units and through them provides tactile feedback about the current stage of the systems.

Tactimap connects to the heating systems and allows the resident to easily and remotely understand what it is doing at each specific moment in all separate rooms. If it heats up, the elements will become warm, otherwise they will stay cool, analogical to old school radiators. On the other hand, when the ventilation is working, an element will rise up - if not, it will stay flat.



7. Would you like to own this product as an add-on for your heating system? Why or why not?

8. What other functions would you like the product to incorporate?

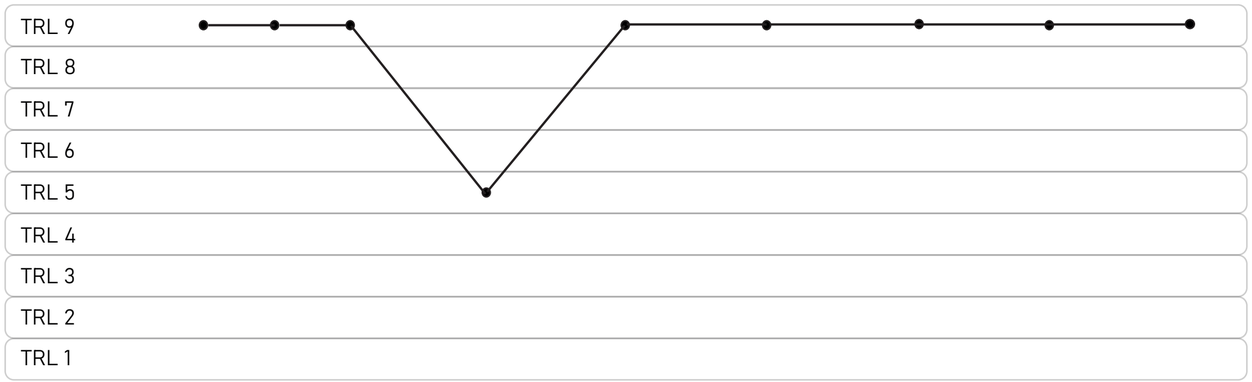
9. What are the advantages and disadvantages that you detect?

How old are you?	In what space do you live?	Would you like to have such product in your living space? Why or why not?	Would you prefer such interface rather than the classic grill openings?	Can you think of any other functionalities that you would like to include in the product?	What are the advantages and the disadvantages that you detect?	Would you like to own this product as an add-on for your heating system? Why or why not?	What other functions would you like the product to incorporate?	What are the advantages and disadvantages that you detect?
36		Yes, I like it. I like that is uses an app, it looks nice too.	I prefer this - it looks more modern.	Changing the light color and turning off the light	It looks modern and cool, I can not think of any disadvantages.	No, I would not like to own it, but it would be great to have it in an app.		It just takes up space in the house.
		Seems nice	It definitely seems more aesthetic but I'm not sure about the practicality of the system	Maybe cooling option?		Seems interesting but very error prone and complicated. A simple app with the temperature would be more than enough for me.		Error prone, complicated, inefficient, hard to implement, expensive
35	Apartment	Yes, because it saves space	Yes, this looks better aesthetically	Cooling in addition to heating	Saving space and ease of use; might be difficult for maintenance	Yes	To be able to use the product to manage the settings of the system, not only to monitor it	This product will be very suitable for visually impaired residents
26	Student House	Yes, it is sustainable and the aesthetic is pleasing. Also, the possibilities of different shapes are nice. Light feedback is very nice.	Yes, grills aren't the best anyway	Ambient lighting control, scheduled usage using the app	Adv: Sustainable, looks nice, can be placed in more convenient spots, Disadvantages: Not sure, maybe isnt as hot	Not really, if the room is warm it is warm I guess, extra information might not be that interesting. It also relies on the user to be more aware of their consumption to help be sustainable rather than directly address it, which, in my experience is not reliable since human tendency leans toward ignoring reading alot of things rather than just have something automatic.	I dont know, warning indicators if areas are unecessarily over heated or something	Adv: more information to provide awareness to the user on their heating. Disadv: user has to be motivated to loom at stuff and to care
24	Apartment	Yes, I would like to have one, as it is looks very convenient and also I like the design	Yes	No	Advantages: better aesthetics Disadvantages: what about the outer facade of the building, do you see the heating convector? , maybe some technical questions about whether this creates a thermal bridge in the room?	Yes as I will have a physical tool to understand the heating system and how it operates	Would be handy if it has also the real-life consumption values of the heating system	Advantages: It is a nice additional tool to the system Disadvantages: I find this tool helpful, not necessary, so it is something extra for the apartment
34	Apartment	Yes.	Yes.		It will save space comparing to other solutions because it is integrated in the facade.	Yes. It looks convenient.	Maybe if there is an app for this product as well.	It looks convenient to have this product and to be able to monitor the heating and ventilation systems.
25	House	I would like to try such a system. It seems like it will help me understand the heating system better which will then help me use it in a better and more efficient way and perhaps will ultimately improve my indoor comfort.	I would prefer it if I could choose the shape myself. But in general if it's directly visible for the user it seems nicer than the grills.	Maybe to be able to easily turn on and off the stats such as whether your overall consumption is high or below average etc.	The lights and the shape might be a bit intrusive if you are reading a book for example. Maybe there could be the option to turn off all interactions manually for a period of time.	I would like to have this product. It seems to provide a good overview and a better understanding of how you use your heating system.	It would be nice to be able to show statistic of how your indoor temperature changes depending on the outside weather for a period of time. For example daily, weekly, yearly. If the user then compares how he/she experienced the indoor comfort in relation to the weather one can learn how to use the heating and ventilation system more efficiently by adjusting it to the weather forecast in the future.	It would be very nice to become more aware of how the heating and ventilation systems work and even more of how your behaviour influences the system and its efficiency. On the other hand if the system is completely automatic perhaps the tool is not essential because the efficiency of the system will not depend on the userвЂ™s action.
30	Share flat with another person	I would prefer having the panels, if possible smaller versions, next to the heaters. Otherwise it becomes something hard to relate and more of an ambient lighting. But it looks nice tho!	I would prefer an integrated solution where the intervention involves the heaters grill openings.	I like that your design is not something sticking out, minimal and in the wall. I could think that you may put an hole right up the heater grill and when the user approaches that area (because of the light it is easy to detect where is interactive), the system provides a heat wave to provide feedback. By that the functionality of the heater is also involved and appreciated.	Advenage: looking nice, multi functional (ambient light) - Disadvantege:Hard to relate it to heating function but probably when you fisrt know what that is it would be okay but it may still feel weird for some.	It is an interesting idea. What is disturbing is the representation of the layout, so obvious. IF it is more abstract and minimal (flat), but still understandable I can be interested using it. It would look so iconic.	Controling lights, lock and unlock doors, actually everything that I can control in a living environment. It would be nice if an app version is available of the map.	3d shape is representing the obvious, I understand it should be understanable but people can handle it if it becomes more abstract. Is it going to be installed o a wall or Дat is conna be like a remote controller? or maybe both (the module can be attached to a dock on the wall or be used apart from it). Great ideas Alina! Good Luck!
34	Apartment	Yes. I would like to try this system in order to reduce the energy price	It is stylish	I want to see the data in the app. How much energy I spent in cold days.	The importance of Isolation if an apartment.	I need to install extra isolation to my apartment, it is expensive and I donвЂ™t know if it is a good investment.	The data of my energy expenditures	Advantage - stylish, easy to manage. Disadvantage - the need for renovation and isolation of the house.

Appendix K

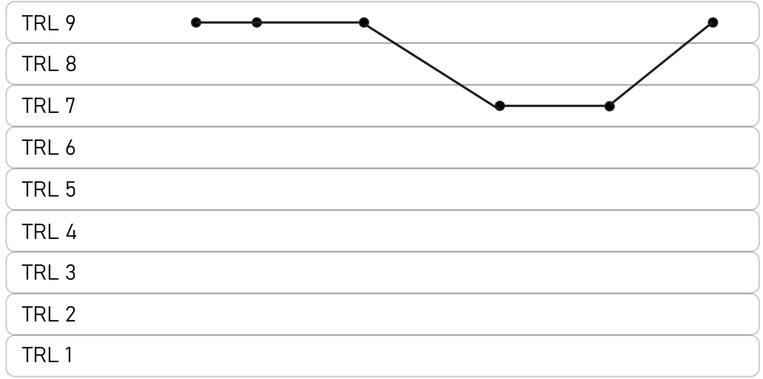
TRL analysis ‘Tactimap’

System	Housing			Feedback units			Smart system		
Sub - system	Walls	Floor	Lid	Heating elements	Ventilation elements	Light indicator	Electronics		Power
Components	Walls	Floor	Lid	Peltier element	Plastic	LED	Bluetooth element	Programmable chip	Alcaline battery
Key functions	Hold the electronics	Create the structure		Informs what the heating is doing	Informs what the ventilation is doing	Reminds to close the window	Translate data from the systems into		Supplies energy



TRL analysis ‘Breathing Walls’

System	Built-in convector					
Sub - system	body	thermostat	cover panel			
Components	body	LEDs	thermostat	cover	infrared foil	LED
Key functions	warm up the space	control option for the user	cover the hole	provide warmth	provide light	



Appendix F

Design Guidelines and Recommendations

A human-centered approach to zero energy housing renovations

with focus on visually impaired residents

INTRODUCTION

Amsterdam aims towards zero-energy housing until 2040 (Gemeente Amsterdam, 2020). In order to achieve this goal, many housing renovations are being planned and currently taking place. Prior research in the filed of zero-energy housing renovations has discovered the importance of residents' engagement in the process. As experts argue, that could not only improve the satisfaction rates of residents but also has the potential to increase the efficiency of the installed systems in terms of energy usage. In addition, involving residents early in the process could decrease the resources invested in support and maintenance following the renovation.

Therefore, the content of this booklet aims to provide support from human-centered design persepective in the form of guidelines and recommendations for renovation projects with focus on visually impaired residents. Actionable steps for narrowing the gap between the residents and the newly installed heating and ventilation systems are proposed. This project is developed in parallel with the investigation of a demo-apartment in Reigersbos neighbourhod. Next to the general guidelines and recommendations, are included ones, specifically targeting the case of Reigersbos. In the foundation of the suggested methods and strategies, lie months of literature research, user studies, on-site research, data analysis and validation.

USER CONTEXT

How would you feel if that happens to you?

Imagine this scenario:

It is a cold winter day and you are sitting in your living room, listening to music. However, you cannot fully immerse yourself in the experience as you do feel chilly. You have already put your thick sweater on, so in that case you think that increasing the temperature of the heating system is the best solution to improve your climate comfort. But then you remember - you cannot

actually access the control device of the system, only your sighted wife could. Should you call her while she is at work or should you just bear the cold...

An image that shows the negative emotions that could be provoked in a person following this experience - being a burden, incapable, helpless, dependent, different, frustrated.

As one of the main goals of a renovation is to improve residents' comfort and well-being, we should strive to avoid provoking such feelings in them, especially while in the safe space of their home. Therefore, the decision-making process should be driven also by the thought of accessibility next to all the other factors. Performing an accessibility evaluation of a design before making final decisions, could not only increase the satisfaction of the residents, but also the efficiency of the system and the sustainability of the building. Even though, we are explicitly mentioning residents with visual impairements, many of their needs overlap with those of other user groups, e.g. older people, ones unfamiliar with such technology, etc. Furthermore, the insights, acquired during that phase could also serve as input for other future projects.

USER Insights

'There is a big difference between a product being usable and a product being accessible - it needs to be intuitive to use instead of needing adaptations.', citation from a participant in the user study

Expert user 1
Loss of central
vision
'We already have too many things to remember'

- combination of voice control and physical controls
- appreciates truly accessible
- apps
- always chooses the device
- with physical buttons
- requires straight-forward
- intuituve interactions

Expert user 2
Tunnel vision
'Unexpected system errors
make me frustrated'

- combination of automation
- and regular things
- youngsters pick up
- technology faster
- tansparency about
- possible issues
- there will always be a market for knobs

Expert user 3
'Audio feedback is a must'

- wants to turn everything
- at his home start
- upgrades step by step
- because of high prices
- does extensive research
- before buying a device
- sometimes simple tasks
- require a lot of energy

Regular user
'I like how patient Google is with me'

- uses Google mini as it is
- affordable
- has difficulties guessing
- buttons and knobs
- has difficulties guessing
- the right voice command
- uses bump dots to
- map her devices

REIGERSBOS CONTEXT

The case study examined in the booklet is the refurbishment of 288 housing dwellings in the Reigersbos neighbourhood. Located in the southeastern part of the city, it mainly consists of buildings, constructed in the early eighties. The project aims towards providing the inhabitants with a more comfortable indoor climate, improving their quality of life, while still complying with their budget and user needs.
A short-term monitoring project on resident needs, indoor climate and energy usage has been conducted in a first prototype apartment. This apartment is available for user research and prototyping of solutions and its purpose is to develop requirements for the renovation.

AR App

Please download the app in order to have access to the interactive content of the booklet.
1. Scan the code
2. Choose 'Package Installer'
3. Install the app
4. Throughout the booklet, notice the images with a play button and this icon –
5. Open the app, allow camera access and point your phone camera towards the image
6. Wait for the video to play.

CHALLENGES // General

Latest research has thoroughly examined the causes of various issues, emerging among residents as a result of zero-energy renovations. Many suggest that in the core is the misfit between systems' functioning mechanisms and residents' expectations about them. The concerned parties have to be well aware of the actions required for a successful implementation of a new technology. Good understanding of residents' needs is crucial, together with clear initial introduction and sustained support, as a steep learning curve is expected to occur. An improper approach is likely to result in a misfit leading to undersired interactions between the residents and the system as setting it on unrealistic values, turning it off, avoiding maintenance, etc.

User research conducted prior to the final implementation of the technologies could yield positive results instead. Correclty identifying the user needs' leads to choosing more suitable systems depending on the specific context. In the long-term that brings on one hand the satisfaction of residents and healthier indoor climate, while on the other - more energy efficient systems.

CHALLENGES // Reigersbos specific

HEATING SYSTEM CHALLENGES

1. Slow system feedback

consequences for the residents:
- hard to understand whether the system is working
- confusion why their needs are not met
- climate discomfort
- frustration because they do not know how to reach the desired result

consequences for the systems:
- being set on unrealistic setting (too high/too low)
- high energy consumption
- failure to keep up with residents' commands
- residents interfere needlessly and decrease the efficiency

2. Lack of direct warm stream

consequences for the resident:
- unable to identify by touch whether the convector is working or not
- could not receive direct heat supply when feeling cold (hands, feet)
- discomfort

consequences for the systems:
- receiving unrealistic comands (too high temperature)
- that could lead to inefficiency and energy waste

3. Heatpump and electric radiator do not communicate

consequences for the residents :

- harder to operate with it in the most efficient way
- more factors to think about
- discomfort (if the residents forget to turn it on or off)
- inability to control everything remotely

consequences for the systems:

- not synced
- harder to function efficiently
- excessive energy usage if the radiator is put on a high setting and forgotten

4. Bathroom radiator controller is hard to reach

consequences for the resident:

- difficult to control (hard to reach, hard to see)
- the residents might hit their head on the sink
- lack of other control option
- climate discomfort (if the residents could not operate with it as they wish because of it's location)

consequences for the systems:

- left on longer than needed - energy waste
- being set on a wrong setting because of the lack of visibility access

There is a video here, showing how hard it is to reach the controller of the electric bathroom heater. It's goal is to provoke empathy in the decision-makers and trigger them to perform user research before making the final decisions.

LINK TO VIDEO

5. Confusing interface of the main controller board (for heating and ventilation)

consequences for the residents :

- difficult to set the system on the desired setting
- a cause for confusion and frustration
- self-doubt if they interact with it 'correctly'
- climate discomfort

consequences for the systems:

- undesired changes to some main settings
- hard to function efficiently and autonomously - energy waste

VENTILATION SYSTEM CHALLENGES

1. Confusing controls on ventilation units

consequences for the residents :

- difficult to set the system on the desired setting
- a cause for confusion and frustration
- self-doubt if they interact with it 'correctly'
- climate discomfort
- compromised air quality

consequences for the systems:

- undesired changes to some main settings
- hard to function efficiently and autonomously - energy waste
- working unnecessarily (when there is noone at home)

2. Complicated maintenance is required (cleaning and replacement of the filter)

consequences for the residents :

- fear of damaging the system
- avoiding performing maintenance
- experiencing worse air quality in terms of CO2
- opening the windows more often which could cause excessive energy usage of the heating system

consequences for the systems:

- inefficient working (not filtering well)
- long-term damage
- shorter life-span

3. CO2 sensors are situated too close to the fresh air stream

consequences for the residents :

- as the sensors read the CO2 values from the clean air, the average values at the apartment tend to be higher
- the system starts ventilating only when the values have become too high
- health hazards because of the higher CO2 density

consequences for the systems:

- inefficient working (not starting working on time)

4. Loud noise when the system is trying to lower high CO2 levels

consequences for the residents :

- disturbance and annoyance
- using the ventilation system less than intended which could lead to high CO2 levels
- health hazards because of the high CO2 level

consequences for the systems:

- might be turned off directly from the plug
- inability to keep up supplying fresh air
- inability to maintain the balanced air pressure inside

5. Cold air stream from ventilation units

consequences for the residents :

- discomfort in terms of temperature
- sore muscles
- using the ventilation system less than intended which could lead to high CO2 levels
- health hazards because of the high CO2 level

consequences for the systems:

- might be turned off directly from the plug
- inability to keep supplying fresh air
- inability to maintain the balanced air pressure inside

An image that shows a woman sleeping in a bed positioned in from of the ventilation unit on the wall. The cold air stream from the unit comes directly to her head.

'Having the head close to the ventilation is not nice. Nice, clean air, but too cold.', a citation from a participant in the study

An image that shows a person working on a desk in a room while the cold air stream from the ventilation unit goes to his feet.

CONTROL & ACCESSIBILITY LIMITATIONS // Reigersbos specific

In the international standard for accessibility and usability in the built environment, experts explicitly mention that it has to be ensured that 'ventilation and heating equipment are operational'[1] by everybody. Considering the guidelines which they have provided and supporting them with additional research, an accessibility evaluation of the systems in Reigersbos was performed in terms of control possibilities. From the graph on the left, it becomes clear that currently those systems are hardly accessible which would lead to huge obstacles for some residents. In order to prevent that, the next chapter provides a set of selected guidelines on how to prevent the selection of inaccessible systems for housing renovations.

GUIDELINES*

*Please keep in mind that this is a 'Starter Kit' for user evaluation. It is always recommended to collaborate with a Design Researcher if you have the opportunity.

How to perform an accessibility evaluation?

(with focus on visually impaired users)

Fill in the 'NEN 17210'[2] checklist of functional requirements for accessibility and usability of the built environment according to the choice of technology for the specific case.

Requirements

1. Do the choices of technology accomodate residents with impaired vision?
2. Do visually impaired residents have free access to the chosen technology?
3. Are visually impaired users able to operate with the chosen technology freely?
4. Does each selected technology provide three options for interaction (visual, audible and tactile) ?
5. Does the digital interface provide accessible features for visually impaired residents?
6. What amount of natural lighting penetrates the living space?

Questions to ask:

1. Accomodate to limited sensory abilities (in that case visual impairement)
2. Access equipments and facilities
3. Operate equipments and facilities
4. Access and understand information via multiple senses (e.g. signage, apps)
5. General ICT usability and accessibility

6. Natural lighting

TOOLS

Questions 1,2,3

Option 1: Facilitate user tests[3] with visually impaired users.

Step 1: Define specific testing objectives depending on the case.
Map all the systems that are or will be installed in the demo-house. Then, for each system, list all the interactions which the user should be able to complete, e.g. turn on/off, set the temperature high/low, set a routine, etc.

Suggestion// First start with the functions that are vital for the resident. Try to list at least 5. Then continue with with the ones that are of lower priotity. Try to put yourself in the shoes of the user and act out an imaginative scenario in order to come up with more possible interactions.

Step 2: Create a plan.
Where will the user testing take place? How long will it last? Would you recruit participants to stay at the apartment overnight or would you invite them only for a shorter period of time? Write a task scenario - what actions would you exactly ask them to perform and in what order? Prepare materials to keep track of the results. Think about what answers are you looking for specifically. You will most probably be interested in the process as well as the final results. Create a questionnaire for the interview which will take place after the testing.

Suggestion// Plan how long the user test would take - maybe it could be a usability user test of around 1 hour while for an in-depth user test for this case, you might need to recruit participant to stay overnight. Take into account that staying overnight would require more time for preparation. Decide how you will record the results - would you do it yourself, or would you involve another person to help you with that. Do you intend to record videos, or would you be only taking notes? If the person stays overnight, would you ask them to document anything themselves while there? When all this is ready, perform a pilot user test.

Step 3: Recruit participants.
Partner up with associations and companies involved with visually impaired users (e.g. Koninklijke Vision, Envision, WOON!, etc.) Provide information about the study in accessible manner - braille print, audio, contrast colors, large text.

Suggestion// Recruit a minimum of 5 participants. Make sure that you have well explained the goals of the study and what will be required from them - in terms of actions and time.

Decide how you would compensate them for their time - you could grant them gift cards for example.

Step 4: Conduct the test
Reflect on each user test and if needed, make changes to the following ones.

Step 5: Analyse the results and fill in the checklist.
Look at all findings and think what they mean for the project. If any problems emerged, think what kind of solutions could be applied.

Option 2: **Simulate visual impairment**

Step 1: Choose a tool which could assist you in simulating a visual impairment.

- Simulation glasses (fig. 1) are proven to enhance designer's empathy and creativity. (Appendix X)
- You could tie your eyes with a scarf.
- In case you wear glasses, obstruct the view of each lens with tape or paper.
- Get plastic safety glasses and paint them or scratch them.
- You could also use the guide by Erin Ringwald (eHow, UK)

Step 2: Follow the above procedure while skipping 'Step 3'.

QUESTION 4

By using the provided graph, assess to what extent each selected technology provides three different options for interaction. According to ISO 21542: 'Information in audible, visual, tactile and simple language formats should be provided where possible … visual information to be supplemented by audible information plus tactile information where appropriate…Information and communication technologies that provide information in a variety of formats (such as beacons, online support, two-way communication) can also be used, if they are in accessible formats.'[3]

AUDIBLE

- Commands
- Feedforward
- Feedback
- Questions

TACTILE

- Big clear buttons
- Air stream
- embossment, min. rise of 0.8 mm, preferred is 1mm to 1.5mm
- sliders
- vibration
- hot & cold

- texture

VISUAL

- light signals
- accessible digital interface
- text and color
- mapping
- contrast

OTHER ACCESSIBILITY FEATURES TO KEEP IN MIND

- Solid
- Loud speakers
- Audio cues
- Offline voice dictation
- NFC reading function
- Compatible with different add-ons
- Easy navigation
- Intuitive
- Big buttons - electrical switches should have large push plates to prevent accidental operation
- Truly tactile buttons

Question 6. Create a light study of the space using a 3D software in order to predict the movement of natural light in the dwelling
This has implications for the thermal comfort of the residents as well as for decisions on the light throughout of window panes, overhang and type of glass. 6

Step 1: Create a model of the space that you would like to examine in SketchUp.

Step 2: Import the correct geo-location and sync the orientation of your model.

Step 3: Turn on the shadows feature in SketchUp and explore how the light comes into the space throughout different times of the day and the year.
Suggestion// For a more realistic feeling, you can use the rendering software 'Enscape'.

Step 4: Make conclusions about how the thermal comfort could be influenced and what kind of means are the most suitable to control natural lighting in the specific case.

This is a video that shows how the light moves in one of the rooms between 13:30 and 18:30.

LINK TO VIDEO

Additional question: How to measure the psychological well-being (state of happiness and contentment, with low levels of distress, overall good physical and mental health and outlook, or good quality

of life.') of the residents ? (being one of the goals of the renovation)

This evaluation tool can support designers in creating products that improve the well-being of disabled users by including the emotional layer in the project. The 'Well-being calculator' is a matrix, incorporating the most important criteria for the well-being of disabled users. This is a method that aims to translate the needs of the users in a scalable form. It can be applied in the initial phase of a project or in its final evaluation stages. Give a grade to each criterion in order to compare different products.

Well-being calculator

CRITERIA

- Achievement
- Meaning
- Self-acceptance
- Autonomy
- Personal growth
- Safety
- Social inclusiveness

DESIGN FUNDAMENTALS

By combining the accessibility research with the zero-energy renovation research, the following Design Fundamentals were formed. They serve as a set of requirements that guide us in the selection of suitable systems for accessible zero-energy renovations.

Design for accessibility

Inclusion is one of the main goals of this project. Therefore, it is crucial that the designed solution is accessible to VIPs while also desirable for the wider public.

Design for trust

When leaving the control of your home to a smart system, you should definitely trust it. The user has to be sure that it is indeed executing the desired commands at the right time and he should be able to check that at any given moment. It is also desired that possible bugs are envisioned and being transparent about.

Design for low-maintenance

As the bigger part of VIPs usually need assistance for tasks that are not performed often, low maintenance products are preferred. Not only they need to ask for help more rarely but for them that also means a more reliable product.

Design for Simplicity

Certain commands have to be executed with as little actions as possible. Moreover, the Interactions should be natural and familiar. Only vital information should be presented, unless Additional information is explicitly asked for. Simple interactions are in the core of accessible interactions. Simplicity in terms of maintenance is also desired.

Design for adaptability

Each visually impaired user has different needs and habits. Some want more automation while others prefer to do things the old way and I want to give them the option to choose. Therefore, it is very important that the product is adaptable.

Design for robustness

The product has to be solid both in terms of physical characteristics and software. Reliability and easy troubleshooting are required.

HOW TO APPLY THEM?

By creating an evaluation matrix on the basis of the Design Fundamentals, different products can be compared so the most suitable one for the case is chosen.

RECOMMENDATIONS

- One unified system to control all heating and ventilation units in the apartment (including the electric bathroom radiator)
- Provide three control options of each system (tactile, audible, visual, on the basis of the above guidelines)
- Provide immediate feedback (audible, tactile, visual, on the basis of the above guidelines)
- Provide air recirculation hood in the renovation package, one with rounded edges
- Choose ventilation units that preheat the air
- Colaborate with companies that are transparent about envisioned issues and troubleshooting
- Provide an accessible troubleshooting manual - use clearly legible fonts and symbols with good visual contrast, standardized symbols; provide tactile and audible formats

- Implement a function (app) so users could make basic diagnostics themselves
- Install balanced heating and ventilation system when possible
- Include a reminder signal for residents to close the windows on time
- Install automatic blinds

RECOMMENDATIONS
// Reigersbos specific

- Change the position of the CO2 sensor of the ventilation system
- Choose an electric unit for the bathroom equipped with a controller at the top and/or one that has a wi-fi control option
- Provide a manual control option for the air extraction in the toilet

FUTURE VISION

So far, the booklet strived to contribute to finding short-term solutions of the discussed problems. Now, it will explore how those findings could be applied in a long-term plan. Therefore, the following pages are a source of possible direction and inspiration to the ones who will tackle this topic in the future.

GENERAL

DESIGN DIRECTIONS

TOOLS FOR IMPROVING ACCESSIBILITY IN RENOVATIONS // Example - VR/AR app

- for testing
- for support
- for monitoring

PRODUCTS PHYSICALLY DETACHED FROM THE HOUSE // Example - Tactimap

- for control

- for informing
- for receiving feedback

PRODUCTS INTEGRADTED IN THE HOUSE // Example - Breathing Walls

- for sensing
- for emitting
- for receiving

AR/VR app

WHAT?

An app that works in line with a booklet and expands its features. For example, it could provide remote simulation of experiencing a demo-house which is more efficient time-wise when doing an evaluation of systems.

HOW?

supports project managers in performing user-centered system analysis

WHY?

- remote usability testing
- easy distribution
- time efficient
- better choice of technology
- improves accessibility
- triggers empathy

Tactimap

WHAT?

A 3D mini map of the living space, including all heating and ventilation units.

HOW?

informs the resident through tactile feedback - hot/cold, up/down
3D model allows tactile navigation

WHY?

- transparency (on/off, energy usage, current state)
- immediate feedback
- trust (resident to system)
- less uninteded interactions
- more efficient systems
- tactile interaction

Breathing walls

WHAT?

Heating and ventilation system integrated in the wall with interface of interactive openings.

HOW?

warm and filtered air comes directly from the openings in the walls

different stage of opening means different setting

WHY?

- immediate feedback (light, heat)
- trust (resident to system)
- less uninteded interactions
- direct heat source
- subtle light for navigation
- tactile control through the walls
- adaptable panels

Thank you for reading the draft version of this booklet!

THE END