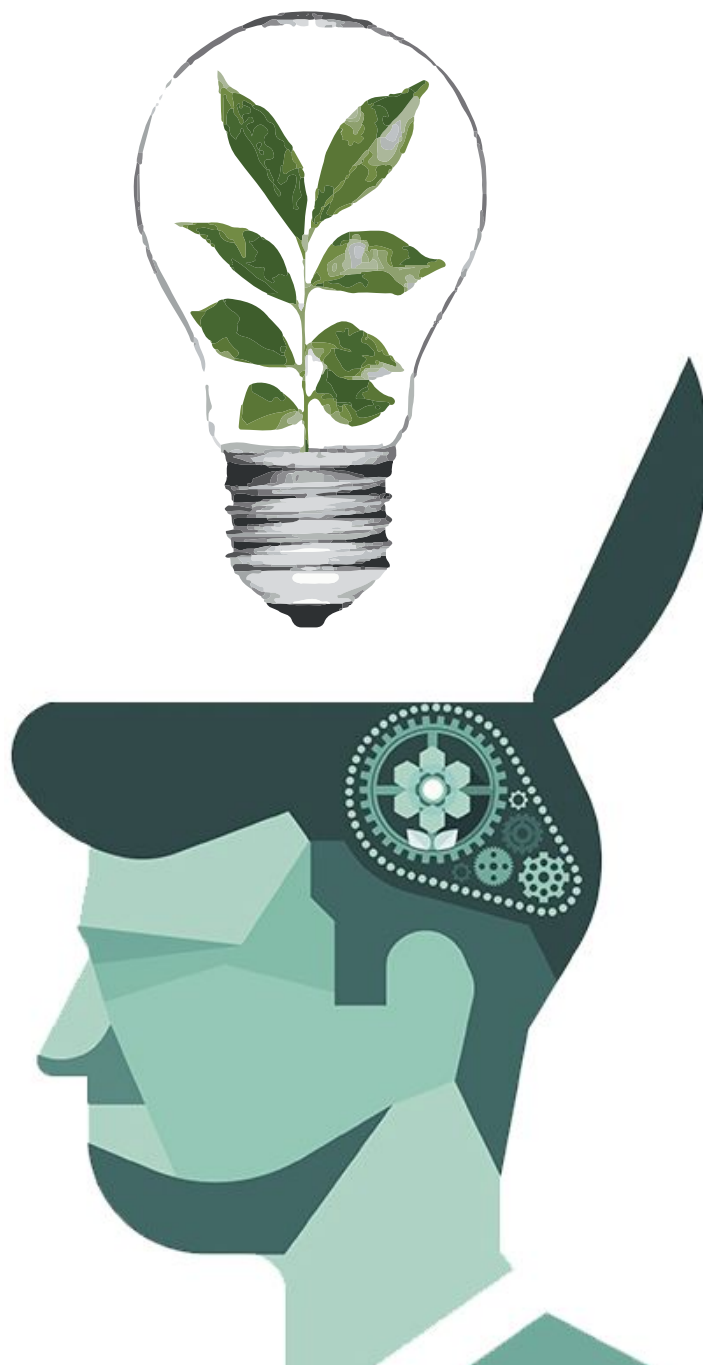


GRADUATION THESIS

“Triggering elderly’s behavior to an energy neutral and healthy use of the facade”

Building Technology

P5 version - 29 October 2015



COLOPHON

Graduation thesis report

Version P5 - 29 October 2015

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PREFACE

This research was conducted for the purpose of my master (MSc) track in Building Technology at the faculty of Architecture in Delft. I started this graduation with the research topic 'intelligent door handles' on behalf of the company ALCOA Architecture systems. One of my mentors introduced the topic and since I always doubted whether I had to study Architecture or Industrial Design and this topic seemed related to both of these studies, I decided to go for it. Therefore one of my supporting mentor during the whole graduation period was from the faculty of Architecture, Dr. Ing. T. Klein, and my other (second) mentor from the faculty of Industrial Design, Dr. Ir. S. Silvester. Through the company, ALCOA, I was guided by Wijnand van Manen.

This research started with a focus on door handles and the operation of it, but soon it was clear to take a broader perspective; the interaction between façade and user. Therefore the topic changed a lot during my process and the project came involved with a second company: BAM. The project of BAM focuses on renovating porch apartments in the Netherlands by applying a 2nd skin façade to achieve the goal of energy neutral buildings in 2020. The research topic thereby changed and from there on focused on the energy neutral use of the façade by the occupants.

Users can differ a lot in habits, behavior and abilities, therefore I chose to design for the most difficult user group; elderly. Since the government came up with new laws according to home care, elderly have to age in place longer. They have to stay healthy independently. The topic of my graduation research therefore changed in: *"Triggering elderly to an energy neutral and healthy use of the façade"*.

The whole graduation process and topic was a very educative experience to me. It was new for me to design with an user-centered perspective instead of focusing only on the technical aspects. By involving the target group in the graduation research by observing and interviewing them, the final designs became much more real and relevant.

As mentioned, during my graduation I was supported by my two mentors Dr. Ing. T. Klein and Dr. Ir. S. Silvester. I wouldn't have become this far without them. They have always supported me, not only in the ideas I had, but also by motivating me mentally during the obstacles that I was confronted with. Besides them I was also supported by my mentor from ALCOA, Wijnand van Manen. He was always very open minded in the ideas I had and always made time to guide me where necessary. My sincere to you three.

Furthermore I would like to thank M. Wolthoorn, G. Maiburg, L. Bergenhenegouwen and J. Greven for their willingness to participate in my research. They were not only very flexible in letting me interview them several times in short time periods, but also gave me much insight in their ideas and habits. Without them I wouldn't have come to these final designs.

And last but not least I'd like to thank my parents for their all-time support and faith in me.

ABSTRACT

The goal to achieve energy neutral buildings in 2020 is getting closer. To achieve energy neutral buildings, not only new buildings have to be innovative, also the existing building stock has to be improved in terms of energy efficiency. Besides that, the occupants have to be involved in this process too, in the end they have to use the façade in an energy efficient way.

The purpose of this research was to find suitable solutions for the renovation of porch apartments in the Netherlands. The 2nd skin that will be applied in this design should not only be energy efficient, but should also trigger the occupants to use it in an energy efficient and healthy way. The target group on which these designs were tested are elderly. Because of their different deterioration aspects and the fact they have to live independently longer, we should make sure they are able to use this façade too (in an energy efficient and healthy way).

This research has resulted in a few integrated final designs that mainly consist of two parts; a design for a home energy management system (HEMS) and a façade element design. The HEMS designs focus on how to trigger different user profiles of elderly to live energy neutral and besides that make elderly aware of the necessity to ventilate regularly (to improve the health of their indoor climate). The façade element mainly focuses on the comfort preferences of elderly and the improvement of their mental and physical health. Besides that of course the façade element meets the stricter rules regarding to the energy efficiency.

All designs are projected on a reference project; the BAM 2nd skin project in Rotterdam. Several participating elderly gave me insight in their behavior and habits according to energy efficiency and comfort. The designs have been evaluated by them, the defined user profiles and a requirement list several times.

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I. INTRODUCTION

This section provides an introduction of my graduation project. The first chapter provides general background information about the topic of my graduation research. Followed by the second chapter in which the objectives, problem statement and scope of this research is determined. The third chapter is dedicated to the relevance of my graduation research.

1. BACKGROUND

The project started with the idea of designing an ‘intelligent doorhandle’ on behalf of the company ALCOA. While discussing this topic, we decided to look at it from a broader perspective: the interaction between façade and user. The interaction between façade and user is especially interesting when you look at the energy consumption of buildings; the energy consumption of a building in the end always depends on the behavior of the users (DeltaWonen, 2014). From the 31st of December 2020, new buildings have to be delivered “nearly energy neutral” (Janssen, 2011). Renovations have less stringent requirements, but the renovations should lead to very low energy consumption (Simons, 2014a). Because the height on the energy bill is a direct consequence of human behavior, energy neutral buildings will only be energy neutral with the appropriate human behavior. By changing human interaction with a façade, a lot of energy could be saved.

Not only buildings change over time, the formation of the building users changes too. The composition of the population is changing a lot now in the Netherlands because of the so called babyboom. In the period between World War II and 1970 the birth number raised in a lot of countries in Europe. As you can see in figure 4, from the 1970s this birth number declined and the amount of elderly raised. The growing ageing population in the Netherlands causes problems in the care sector, this also happens in other European countries. In the southern part of Europe these problems are smaller; it’s common that children live with their parents and care for them (Houben, 2001, p. 655). In the Netherlands there is no tradition like this, so we try to find other solutions. Because of the growing amount of elderly, we are trying to find innovative solutions for elderly ageing in place instead of moving to a care institution.

While behavior change is needed to cope with the stricter energy consumption rules and more (deteriorating) elderly (have to) age in place, we are trying to find innovative solutions to change human’s behavior and make these solutions understandable and easy for elderly. We want to try to trigger elderly’s behavior to an energy neutral and healthy use of the facade.

To have a better view on the new rules for energy consumption in dwellings and the changing rules for the ageing population, two short paragraphs will provide the necessary information.

1.1 ENERGY CONSUMPTION IN THE NETHERLANDS

SAVING ENERGY IN BUILDINGS IN THE NETHERLANDS

Buildings are responsible for 40% of the total energy consumption in the EU; low energy consumption means low CO₂ and NO_x emissions and less climate changes (less contribution to global warming) (AgentschapNL, 2013). Therefore the government came up with a plan; from the 31st of December 2020 new buildings have to be delivered “nearly energy neutral” (Janssen, 2011). So, from the 1st of January 2015 it is mandatory to hand over an Energy-label-certificate when renting or selling a house in the Netherlands. Homeowners can compose their own simplified Energy-label online (Simons, 2014a).

The Energy-label shows how energy efficient a building is (Rijksoverheid, 2015b). The Energy-label of a dwelling is determined on different aspects: building type, year of construction, living space, insulation façade, insulation roof, insulation floor, heating system, ventilation system, window glazing type, etc. (Overheid, 2015). The most energy efficient dwellings get an A-label (green color), the least energy efficient dwellings get a G-label (red color) (figure 1). The Energy-label indicates the energy consumption of your dwelling. It’s no guarantee that you will actually use the energy that is stated on the label, the actual energy consumption depends on your behavior (DeltaWonen, 2014).

One third of all Dutch dwellings are built between 1945 and 1975. The energy rules at that time were not as strict as they are now, so a lot of dwellings have to be renovated now. The three most common dwellings at that time were: porch apartments (*portiekwoning*), gallery apartments (*galerijwoning*) and single-family-houses (*eengezinswoning*) (Kolk & Peters, 2008).

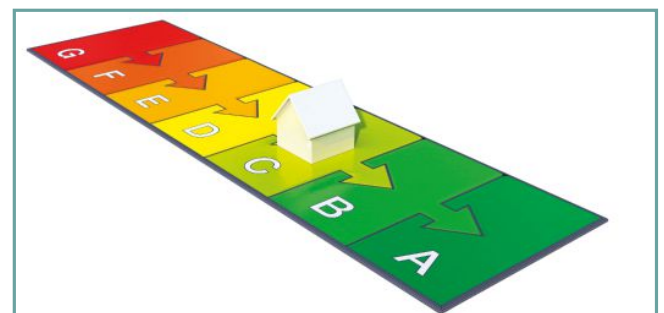


Figure 1; Energy-label (Simons, 2014a)

Figure 2 shows the energy consumption and facilities of these three common dwelling types in the Netherlands. These dwellings were hardly insulated when

built (first column, figure 2), in 2008 they were renovated (column 2), but these dwellings should be improved (column 3) (Kolk & Peters, 2008). As figure 2 shows, the energy-label can and should be improved from an F-label to an A-, B- or C-label. The energy-index for these dwelling types is also shown and presents the energy performance.

As these figures show, a lot of dwellings have to be renovated to reach the aim of “nearly energy neutral” in 2020. But as said before, these targets won’t be reached if we are not changing our behavior.

	Oorsprong		Huidige situatie		Verbetermogelijkheden	
	Verbruik	Voorzieningen	Verbruik	Voorzieningen	Verbruik	Voorzieningen
Eengezinswoning	2.655 m ² 305 kwh EI 2,75 F-label	CR-ketel ¹⁾ CR-combi Natuurlijke ventilatie	2.056 m ² 229 kwh EI 2,18 E-label	VR-ketel VR-combi Natuurlijke ventilatie	862 m ² 348 kwh EI 1,07 B-label	HR107 HR107 Zon + natuurl. ventilatie
Portiekwoning	1.045 m ² 0 kwh EI 2,35 F-label	lokaal gas geiser Natuurlijke ventilatie	654 m ² 195 kwh EI 1,35 E-label	VR-ketel VR-combi Natuurlijke ventilatie	389 m ² 281 kwh EI 0,97 A-label	HR107 HR107 Zon + natuurl. ventilatie
Galerijwoning	1.326 m ² 217 kwh EI 2,47 F-label	collectief CR collectief Natuurlijke ventilatie	1.058 m ² 217 kwh EI 2,01 E-label	collectief VR collectief Natuurlijke ventilatie	722 m ² 219 kwh EI 1,45 C-label	collect. HR107 collectief Zon + natuurl. ventilatie

Figure 2; Three most common dwellings for the Netherlands and their energy performance (Kolk & Peters, 2008)

1.2 AGEING POPULATION IN THE NETHERLANDS

In the next years there will be a growing aging population in the Netherlands, as you can see in figure 4. The amount of 65-plus elderly will grow from 2,7 million in 2012 to 4,7 million in 2041 (CBS, 2014).

CONSEQUENCES FOR THE HEALTH CARE SYSTEM

The growing ageing population causes problematic space issues for healthcare centers and retirement homes, therefor more elderly have to age in place. As an attempt to deal with these problems, the government came up with a new law for social support in January 2015. This law found his origin because of the growing amount of elderly ageing in place and describes new rules for home care. The purpose of the law is to encourage people to age in place as long as possible, therefor greater demands will be made on the responsibility and power of the society (Kok, 2014, p. 22). The municipalities in the Netherlands are responsible for the home care facilities and therefor benefit from elderly living independently (without home care) as long as possible (Rijksoverheid, 2015a).

While more elderly are ageing in place and behavior changes are needed to cope with the stricter energy saving rules, we are trying to find innovative solutions to change human’s behavior and make these solutions understandable, easy, healthy and comfortable for elderly.

oud	energielabel	nieuw
	A++	0,00 - 0,50
	A+	0,51 - 0,70
0,00 - 0,60	A	0,71 - 1,05
0,61 - 0,75	B	1,06 - 1,30
0,76 - 0,90	C	1,31 - 1,60
0,91 - 1,05	D	1,61 - 2,00
1,06 - 1,20	E	2,01 - 2,40
1,21 - 1,35	F	2,41 - 2,90
1,35 -	G	2,91 -

Figure 3; Energy-label and energy performance table (Kolk & Peters, 2008)

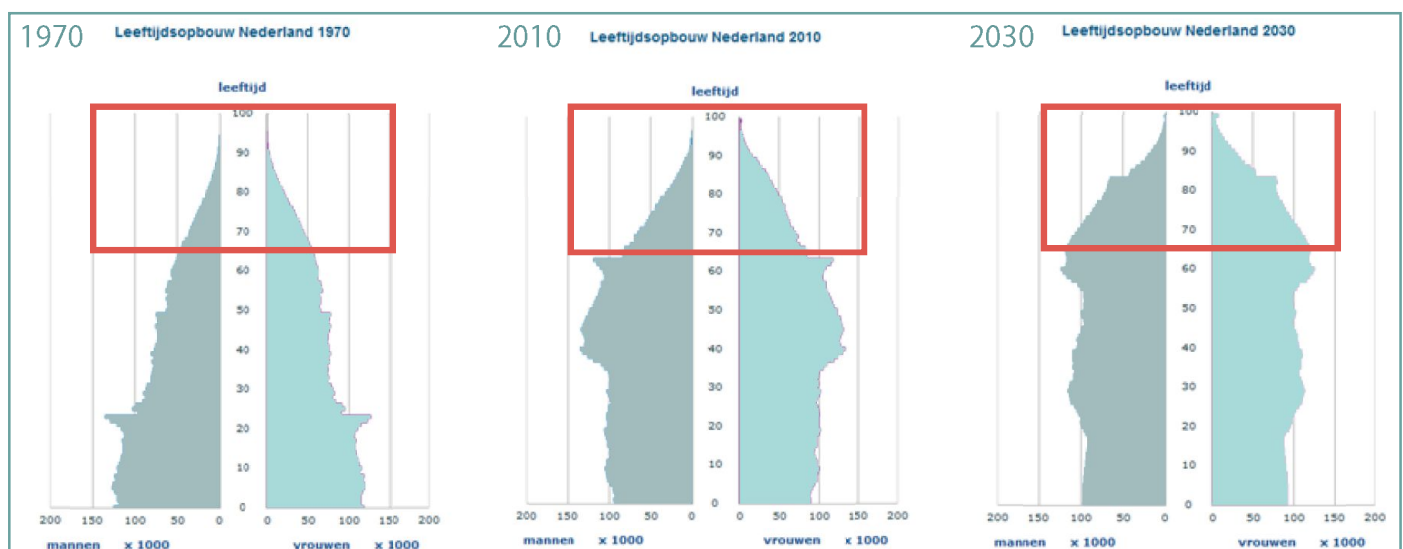


Figure 4; Age range of the Netherlands for 1970, 2010 and 2030 (CBS, 2014)

ALCOA

During my research, a second company became involved; Royal BAM Group. BAM wants to renovate porch apartments in Rotterdam to energy neutral dwellings by applying a second skin facade. Below more information will give a clear view on this project.

At the moment BAM (in cooperation with TU Delft) is designing renovation elements for porch apartments (*portiekwoning*) in Rotterdam. Currently these apartments have an Energy-label E (Rijksoverheid, 2015c).

BAM in association with Spee Architects, Eneco, StorkAir, HRO and the TU Delft are trying to develop and realize new facades for these dwellings. These new “2nd Skins” should be applicable to a lot of porch apartments in the Netherlands. But what should we have in mind when talking about ‘energy neutral’ buildings?

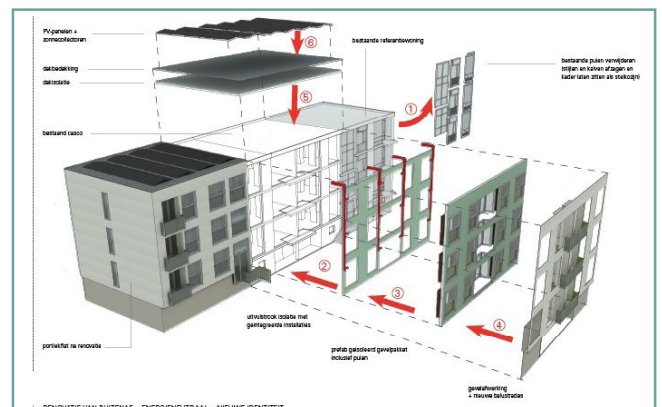
“A project is energy-neutral if there is no annual net import of fossil or nuclear fuel from outside the system boundary to construct the building, to use the building and to break down the building. This means that the energy within the project boundary is equal to the amount of renewable energy that is generated within the project boundary or attributed to the project on base of external measures. The energy that comes from the creation and demolition of the building is settled into an annual contribution based on the expected life of the building”.

(PEGO, 2009, p.28)

Figure 5; New building ALCOA Harderwijk (ALCOA, 2015)



Figure 6; Energy label Second Skin project BAM (Rijksoverheid, 2015c)



A large, multi-story brick apartment building with many windows and balconies, situated in a green park area. A person is walking a dog in the foreground, and another person is running on a path.

Figure 8: BAM 2nd Skin Principles (Spee, 2015)

little amount of energy, generates renewable energy and uses the energy energy-efficient (MilieuCentraal, 2015). Still an important aspect is to make sure the users are using their dwelling energy-efficient.

Figure 7 shows the principles of the BAM 2nd Skin porch apartments by Spee architects. Solar panels and solar collectors should be placed on the roof, generating renewable energy. New ventilation systems with heat recovery should be placed in the facade, reachable from outside. Insulation and windows will be placed onto the facade, to improve the insulation layer. The existing situation (figure 8) will also be renovated with a new cladding.

The BAM 2nd Skin project focuses on porch apartments in Rotterdam. The porch apartments consist of 4 floors; the groundfloor with storage and technical rooms and 3 floors with apartments (these floorplans are attached in the appendix A.1).

Each apartment consists of a small hall, living room, kitchen, bathroom and 2 or 3 bedrooms. The living room has a small balcony and two bedrooms are connected to a balcony.

Spee Architects is an architectural office that made a few facade options (in cooperation with different parties) for the second skin project, two of these options are shown in floorplans in the appendix, clarified by visual design options of Spee Architects.

The building assumptions of the BAM 2nd skin project are (SpeeArchitecten, 2014);

R_c - Roof	8
R_c - Facade	6,5
R_c - Ceiling	3,5
Windowtype	Aluminium
Glasstype	HR ⁺⁺

Another building assumption of the BAM 2nd Skin project is to integrate the installations into the facade.

THE TWO PRESENTED OPTIONS (appendix A.1.)

- In the *first option* they interrupt the cold bridges of the balcony by wrapping up the balconies with thermal insulation. New insulated facade elements are attached to the old ones and the balconies are provided with new balustrades.

- In the *second option* they also attach new better insulated panels to the old facades, but these panels go around the existing balconies.

In both of the options the balconies of the bedrooms are removed and replaced by big glass facades. Both of the options and the existing situation are shown in

elevations and sections in the appendix.

LOCATION AND OCCUPANTS

The porch apartments of the BAM 2nd skin project are situated in Rotterdam; Schere 65-75. This project is the starting point of a lot of other renovation projects of porch apartments in the Netherlands.

The porch apartments are inhabited by mainly three user types (Guerra-Santin, 2014):

1. *Elderly*, alone or with partner.
They live in the residence approximately 15 years.
2. *Families with on average 3 or 4 children* (often with migration background).
They live in the residence approximately 4-5 years.
3. *People with little local connection*.
(students, PhD, working abroad temporarily).
They live in the residence approximately 1-2 years.

Elderly are the most important target group, because they live in the apartments on average longest.

2. THESIS DEFINITION

This chapter provides a brief description of the research of my graduation, in which the problem statement, research questions, the objectives and methodology are plotted.

2.1 PROBLEM STATEMENT

2.1.1. MAIN PROBLEM

We are looking for a change in human behavior to reach the goal of “nearly energy neutral” buildings in 2020. Simultaneously more elderly have to age in place because of the new health care rules. Solutions should be found to deliver a facade that is used energy neutral and contributes to a healthy, safe and independent life of elderly ageing in place.

2.1.2. SUB-PROBLEMS

1. Energy neutral behavior
2. Human behavior - changing behavior or changing technology to change behavior?;
3. Ageing population – Deterioration of mental and physical health;

1. ENERGY NEUTRAL BEHAVIOR

Energy neutral buildings will only be used energy neutral with the right approach of the occupants. To make sure occupants use their facade energy neutral, we have to make sure what the right use of an energy neutral facade is.

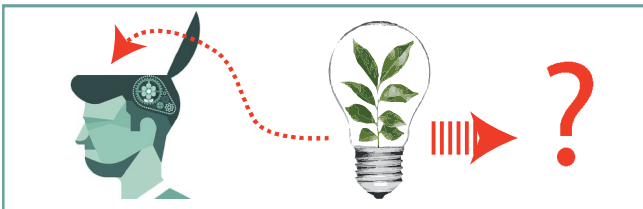


Figure 9; Sub-problem 1 (own illustration)

2. HUMAN BEHAVIOR - HARD TO CHANGE

To achieve energy neutral buildings, a change in human behavior is necessary. The question is how human behavior could be changed. Should the design trigger human behavior to a different approach, or should the object be designed for behavior change?

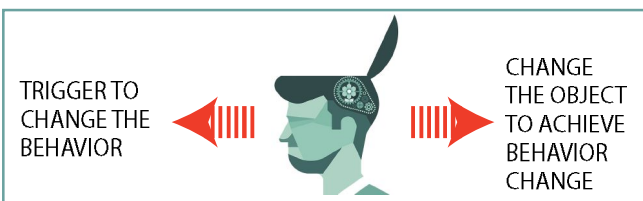


Figure 10; Sub-problem 2 (own illustration)

3. AGEING POPULATION

The ageing population faces mental and physical health problems. These deterioration aspects could be postponed or provided with excellent environmental conditions. What are the most common deterioration problems and how could these be postponed or pre-

vented to make sure the ageing population can live independent and healthy longer?



Figure 11; Sub-problem 3 (own illustration)

2.2 THESIS OBJECTIVE

“Triggering elderly’s behavior to an energy neutral and healthy use of the facade”

2.2.1. GENERAL OBJECTIVE

The general objective of my graduation project is to design an innovative, interactive façade element that triggers elderly to energy efficiently use their façade. Elderly should be able to use the façade element independently and the idea of the element should lead to a healthier way of living for elderly, implementing new technologies could lead to these solutions.

The goal of this research is to provide a (range of) idea(s) for ALCOA which can be implemented in their existing products. Because the composition of the population is changing, it’s attractive for ALCOA to offer multi-ageing-understandable products on this market.

RESEARCH QUESTION:

“How can elderly be triggered to an energy neutral and healthy use of the facade?”

2.2.2. SUB-OBJECTIVES

Design an interactive facade element which stimulates people to use their façade energy efficiently and triggers elderly who age in place to use their senses to prevent or postpone possible ageing issues. The façade element(s) should be;

- Triggering/ changing human behavior

The façade element should trigger people to an ‘energy neutral-behavior’. The design of the element should be smart; not everyone understands how to use their home energy efficient. The element should be smart in changing human’s behavior.

- Energy neutral

The façade element should help to have a nearly energy neutral building and should be used with an energy neutral approach.

- Easy understandable (for elderly)

The interactions between façade and (ageing) people have to be simple but attractive. While elderly don't understand all new technologies and face mental problems, interactions have to be attractive but obvious.

- Integrated in the Second Skin design

The design of the façade element(s) should be integrated in the Second Skin design. It should give an answer to the different energy efficient aspects. It should be an all-in-one interface.

- Independent and healthy living environment

The actions which result in an energy neutral building, should also provide an independent and healthy living environment for elderly.

- Added value

The design of the 2nd skin should not only aim for energy neutrality, but should also have an added value for the occupants. The design should provide overall comfort.

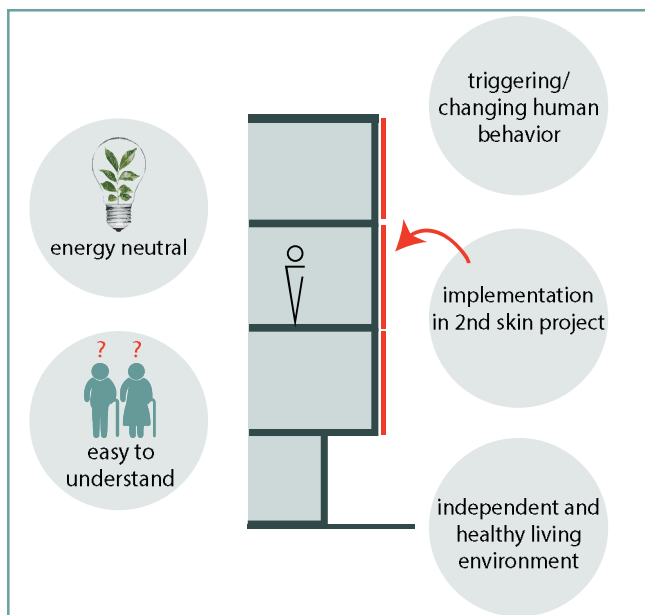


Figure 12; Sub-objectives (own illustration)

2.3 METHODOLOGY

The method of this research consists of several stages (figure 13). The literature study was focused on energy consumption according to human behavior, elderly's deterioration, design for behavior change and designing for personas. Therefore books, websites, articles and input from ALCOA and my tutors are used.

Case studies are used to look at the existing market of my research subject. The BAM 2nd Skin project is used as a reference project to apply the final design to.

Interviews are done with specialists and elderly (the target group) to get more specific information on their needs and demands.

From there on concepts are translated into first designs. The designs are evaluated with the outcomes of the previous research, interviews and other input. From there on several designs are chosen.

These designs will be developed more in detail. The designs will be evaluated afterwards.

2.4 BOUNDARY CONDITIONS

2.4.1. ENERGY NEUTRAL - 2ND SKIN PROJECT

An application of the goal of nearly energy neutral buildings is shown in the BAM 2nd Skin project. To improve the behavior of using the 2nd skin project energy neutral, the research will give answers on how to achieve this. Not all research conclusions can be applied in the BAM 2nd Skin project in this time of graduation period. One aspect of the BAM 2nd skin project therefor will be designed into detail.

The BAM 2nd Skin project focuses on the facades, the roof and the ceilings. In my graduation project I will only focus on the facades. The goal is to achieve energy neutral buildings. An energy neutral building needs a little amount of energy, generates renewable energy and uses the energy energy efficient. In this project my focus will be on the energy efficient use of the facade.

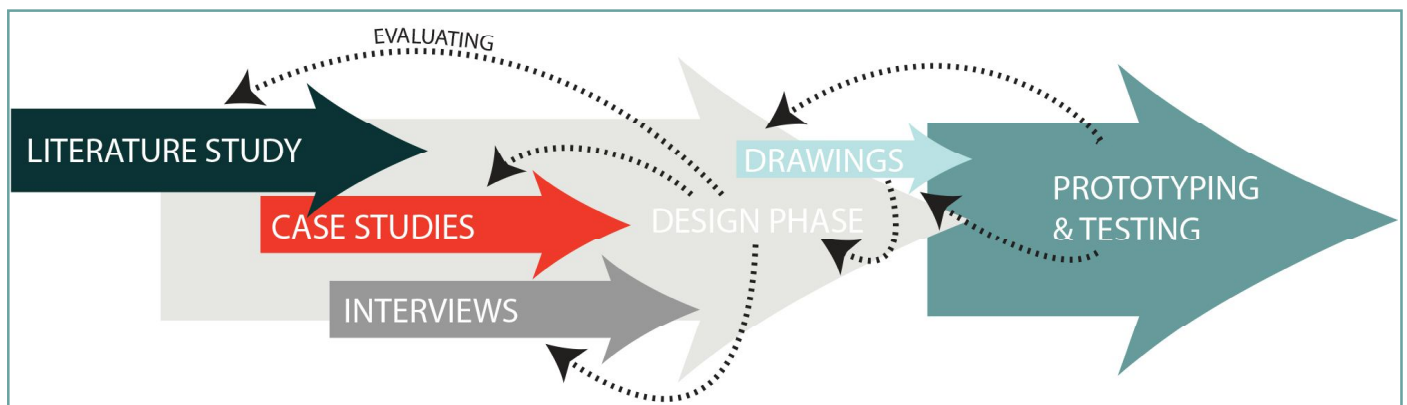


Figure 13; Methodology (own illustration)

2.4.2. ELDERLY LIVING INDEPENDENT AND HEALTHY

The research focuses primarily on elderly, but also gives answers for other user types. New laws in the care sector and therefore the higher amount of elderly ageing in place, makes this the most important target group of this time. Their health, comfort preferences, abilities and safety should be taken into account.

2.4.3. TECHNOLOGY - ALCOA

The technologies which will be used in the final design should be in agreement with ALCOA. In the end the final design could be an input for new devices in ALCOA's products.

2.4.4. INTEGRATED DESIGN

The design should give an answer to different health demands of elderly and simultaneously to the energy efficiency goal.

All outcomes should be considered to be designed as integrated as possible, so the design will be seen and used as a completely integrated object.



Figure 14; Boundary conditions (own illustration)

2.5 DESIGN ASSUMPTIONS

The design assumptions are supposed design directions which are important related to the research questions. These assumptions are divided in two directions; 'energy consumption' and 'healthy life of elderly'.

2.5.1 ENERGY CONSUMPTION

With the same building conditions, some occupants still use twice as much energy as other occupants do. To reach the goal of energy neutral buildings, not only building characteristics should be improved also occupants behavior should be changed. The question is if occupants should be able to regulate their own comfort or should the facade take over the whole control in living comfortably and energy efficiently.

OCCUPANTS HAVE CONTROL OVER THEIR COMFORT

Occupants mostly prefer to have control over their own comfort. To make sure occupants use their facade

energy neutral, occupants should be more aware of their energy consumption. How should occupants use their facade in different situations (winter/summer & day/night) and how can we make sure they will use their facade energy efficient?

FACADE TAKES OVER CONTROL OF OCCUPANTS' COMFORT

To prevent the problem of variations in energy consumption with similar building characteristics, the facade should take over the control of occupants' comfort. While occupants prefer to have control over their own comfort, we should take a look at which comfort aspects according to energy consumption could be taken over by the facade.

2.5.2 HEALTHY LIFE OF ELDERLY

Elderly deteriorate. Their deterioration will be postponed or prevented when they live in a healthier environment. A healthy environment doesn't only point to physical health, but also to mental health.

PHYSICAL HEALTH

Households with elderly prefer different comfort settings than households without elderly. People more often notice odour air in households with elderly for example. How could the physical health of elderly be pursued while elderly still feel comfortable?

MENTAL HEALTH

Elderly deteriorate of physical health, but also mental health could be the causing factor of deterioration. Optimization of environmental aspects of elderly could prevent or postpone deterioration of elderly.

The quality of the environmental air and comfort should be optimal and clear for elderly to prevent or postpone deterioration of elderly's health.

3. RELEVANCE

What is the societal and scientific relevance of this research? Will the outcome have a financial advantage on the current market? These issues are described in this chapter, followed by a timeframe of the whole graduation period.

3.1 SOCIETAL AND SCIENTIFIC RELEVANCE

In 2020 all new buildings have to be 'nearly energy neutral'. While the energy consumption of a building in the end always depends on the behavior of the user, innovative user interactions have to be invented. The types of building users can differ a lot, the population is changing. The amount of 65-plus elderly grow from 2,7 million in 2012 to 4,7 million in 2041 (CBS, 2014). A direct consequence will be the growing amount of elderly ageing in place. So elderly should be able to live with these innovative user interactions too. While the ageing population is growing and the demand for energy neutral buildings increases, this research is very relevant for the society.

With this research I want to prove the link between human behavior and energy consumption of buildings. The interaction between human and the use of their façade should be improved to save energy and provide healthy comfort. I want to prove this with an innovative user interaction design. The design can trigger human behavior, whereby people will use their façade energy efficiently and healthy.

Below a few recent and relevant newspaper articles and reports about energy consumption, behavior and elderly represent the relevance of today:

Actual energy consumption in dwellings

The effect of energy performance regulations and occupant behaviour

Figure 15; The effect of energy performance regulations and occupant behavior (Guerra-Santin, 2010)

EEA Technical report | No 5/2013

Achieving energy efficiency through behaviour change: what does it take?

Figure 16; Achieving energy efficiency through behavior change (EuropeanEnvironmentAgency, 2013)

LEUVEN 12/07/2014

"Help ouderen om energie te leren besparen"

Groen vraagt dat er in het kader van Leuven Klimaatneutraal specifieke acties komen voor oudere mensen. Zij behoren vaak tot een kwetsbare groep, omdat zij omwille van hun onzekere woonsituatie vaak nalaten om te investeren in energiebesparing. "Een gerichte aanpak dringt zich op volgens ons. Er lopen momenteel al enkele goede initiatieven, onder meer bij het OCMW, maar er is meer nodig. Wij vragen een geïntegreerd initiatief van de verschillende betrokken partners", aldus gemeenteraadslid Marleen Demuyne. "Met een gerichte aanpak kunnen we bij de rijkere ouderen aanzienlijke kwantitatieve energiebesparingen realiseren, en voor de armere ouderen de energielast naar beneden krijgen. Wanneer we voor ouderen die dat nodig hebben het hele 'gedoe' van energiebesparende maatregelen kunnen vergemakkelijken, kan er veel mogelijk zijn. En dat is dan ecologische en sociale winst." (KHK)

Figure 17; Help elderly to learn to save energy (HLNregio, 2014)

Vergrijzing: kans voor energiebesparing

De kans dat betaalbaarheid- en energiebesparingsdoelen op één lijn liggen is het grootst bij gepensioneerden: ouderen verdienen minder, zijn vaker thuis, prefereren een hogere kamertemperatuur en wonen op termijn vaker in grotere eengezinswoningen. Vergrijzing draagt daarmee bij aan een hoger huishoudelijk energiegebruik. Het zorgbeleid (langer thuis wonen) en het groeiend eigenwoningbezit onder ouderen (lagere verhuismobility) versterken dit. Uiteindelijk biedt vergrijzing dus kansen: door het hogere energiegebruik loont energiebesparing voor ouderen (nog) meer. Mochten deze kansen niet benut worden, dan volgt vanaf 2020 een tweede kans doordat steeds meer ouderen de woningmarkt verlaten en het aantal natuurlijke momenten voor renovatie toeneemt.

Figure 18; Ageing: a chance for energysaving (Middelkoop, 2014)



Verplicht energielabel nu écht verplicht

JANUARI 2015: IEDEREEN AAN HET ENERGIELABEL

Gepubliceerd op: 20 juni 2014 | 9.412 x gelezen

Hij was al verplicht: het energielabel voor je woning. Toch spraken kopers en verkopers vaak onderling af dat het energielabel geen rol speelde in de verkoop van het huis. Waarom? Er volgde geen boete als je het niet deed. Het gevolg: het energielabel flopte en Nederland werd door de Europese Commissie op de vingers getikt. Daarom in januari 2015 een nieuwe poging waarbij iedereen automatisch een "voorlopig" energielabel krijgt. Je kunt dit voorlopige energielabel dan zelf omzetten in een definitief label.

Figure 19; January 2015: everyone needs an energylabel (Wegwijs, 2014)

do 23 okt 2014, 14:55 | lees voor

Kabinet wil toch meer energie besparen

DEN HAAG - Het kabinet gaat toch het voorstel van de Europese Commissie steunen om tot 30 procent energiebesparing te komen in 2030. Dat heeft staatssecretaris Wilma Mansveld van Milieu donderdag aan de Tweede Kamer geschreven.

Ze komt daarmee tegemoet aan de wens van een meerderheid in de Kamer. Eind vorige maand liet het kabinet nog weten dat het zou inzetten op een energiebesparing van 25 procent, onder meer omdat een hoger percentage veel meer geld zou kunnen gaan kosten.

In Brussel praten 28 Europese staats- en regeringsleiders donderdag over de klimaatdoelen voor de periode 2020-2030. De Europese Commissie stelt voor om in 2030 ten minste 40 procent minder CO₂ uit te stoten ten opzichte van 1990. Verder moet 27 procent van de energie duurzaam zijn opgewekt en dus 30 procent energie worden bespaard.



Staatssecretaris Mansveld. Foto: Paul Dijkstra

Figure 20; The cabinet wants to save more energy (ANP, 2014)

Energiezuinig wonen loont vooral bij ouderen, maar blijkt in de praktijk lastig

Nieuwsbericht | 11-06-2014

Figure 21; Energyefficient housing pays off especially with elderly, but is in practice difficult (PBL, 2014)

3.2 FINANCIAL RELEVANCE

Changing the interaction behavior between facade and human/elderly should save a lot of energy. This would provide financial advantages for the residents and would also help to reach the goal of nearly energy neutral buildings in 2020. Therefore in financial perspective it is really interesting to do this research.

3.3 TIMEFRAME AND PRODUCTS

The time span of this graduation research is approximately nine months. Because of personal issues, I decided to do this research project in approximately 12 months instead of 9 months. The timeframe is presented in *figure 22*.

In this period of time different method stages will be gone through and several products will be produced. These products are;

- Final thesis/ report
- Final design(s)
- Drawings and visualisations
- Details of the final design(s)
- Evaluation, conclusions and recommendations
- Presentation

II. PRELIMINARY RESEARCH

This part of my thesis goes more into detail on the target group, elderly, and their deterioration. Followed by a research part about behavior according to energy consumption.

Chapter 4 will give you a detailed view on elderly and their deterioration while ageing. This will be followed by a chapter in which different user profiles are defined regarded to the different interviews I did. These user profiles are usefull to test and evaluate later design decisions on.

Chapter 6 will provide information on occupants' behavior according to energy consumption. And the last chapter of this section will go deeper into designing for the desired behavior according to energy consumption.

4. ELDERLY

In the Netherlands between World War II and 1970 the birth number quickly raised, the consequence of this so called babyboom is the rising amount of elderly in our population coming years. The growing ageing population in the Netherlands causes problems in the care sector, there is no space for everyone in health and care institutions. For this reason more elderly have to age in place.

The first paragraph of this chapter is about the situation in the Netherlands and the amount of elderly that has to age in place.

Elderly often suffer from different deterioration factors, which makes it harder for them to age in place. The most common deterioration factors are discussed in paragraph 4.2.

When elderly age in place, they also have to regulate their own comfort and energy consumption. Elderly are big spenders of space heating because of their higher temperature preference and their presence at home is larger. The energy consumption of elderly will be discussed in paragraph 4.3.

Paragraph 4.4 will provide conclusions about the most important deterioration factors elderly face and what the consequences are for the energy consumption in these situations.

4.1 ELDERLY AGEING IN PLACE

The amount of 65-plus elderly will grow from 2,7 million in 2012 to 4,7 million in 2041 (CBS, 2014). Most of these 65-plus elderly are women (*figure 24*), because women live on average 5 years longer than men (CBS, 2012).

In 2012 4% of all 65-plus elderly in the Netherlands lived in a care or health institution. *Figure 25* shows that most elderly in health and care institutions are between 80 and 94 years old, most of them are women.

Elderly prefer to age in their familiar and safe home as long as possible instead of going to a care institution. Care institutions are mostly impersonal environments for them (Satteliet, 2014).

The need to control the care costs and the desire to age in place as long as possible are mutually reinforcing motivations that through the implementation of new technologies is rapidly actually achievable.

Ageing in place gets harder when you have to do it on your own, especially when you have some kind of ageing phenomena. Most women stay behind, by the age

of 78 half of the women are widowed (*figure 26 and figure 27*) (CBS, 2012). Therefore it is necessary to take all possible deteriorations into account when considering ageing in place.

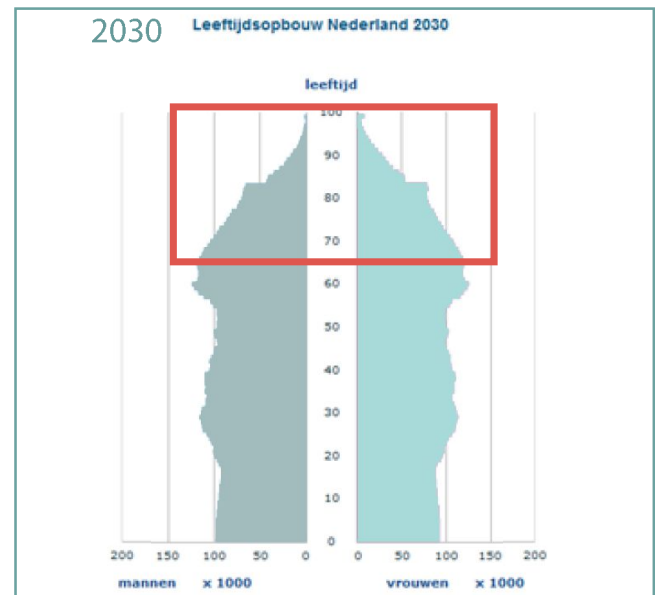


Figure 23; Age range of the Netherlands for 2030 (CBS, 2014)

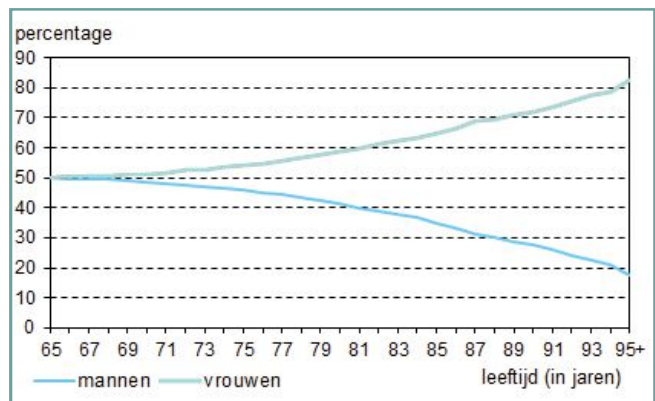


Figure 24; Percentage of men and women in the older population (persons 65 years and older) by age (CBS, 2012)

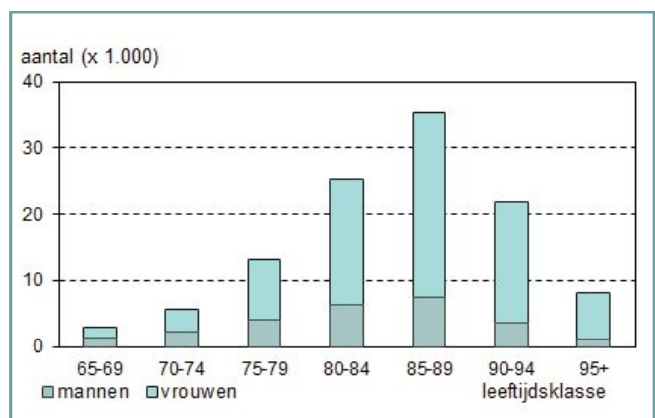


Figure 25; Amount of elderly in health and care institutions by age and gender (CBS, 2012)

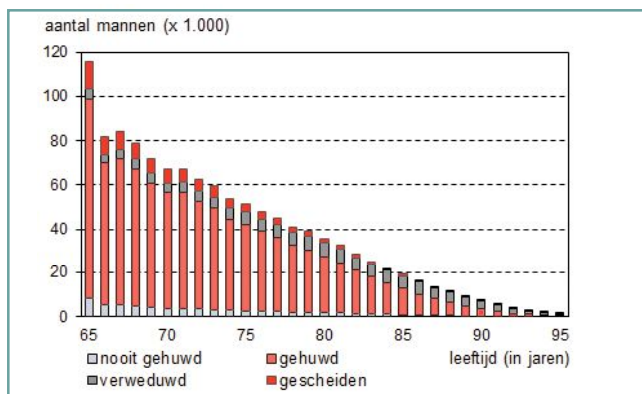


Figure 26; Men by age in marital status (CBS, 2012)

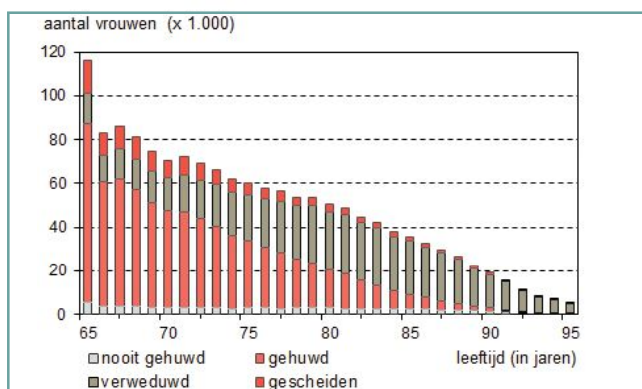


Figure 27; Women by age in marital status (CBS, 2012)

4.2 DETERIORATION OF ELDERLY

The geriatric giants are the most common deterioration factors elderly face as Marjolein van der Pol says (2014). The geriatric giants are; mobility problems (in-stable and immobile), sensory disorders, incontinence and cognitive disorders.

If someone suffers from one of the geriatric giants, the cause of this syndrome is always a consequence of multiple diseases simultaneously. A geriatric syndrome can be treated most effectively, when you deal with the problem from different angles (Olde-Rikkert, 2013).

Twenty-five percent of 65-plussers in the Netherlands have one or more disorders and already 53 percent of all 80-plussers experience one or more disorders (figure 28) (CBS, 2011). The next subparagraphs will go deeper into the different geriatric giants.

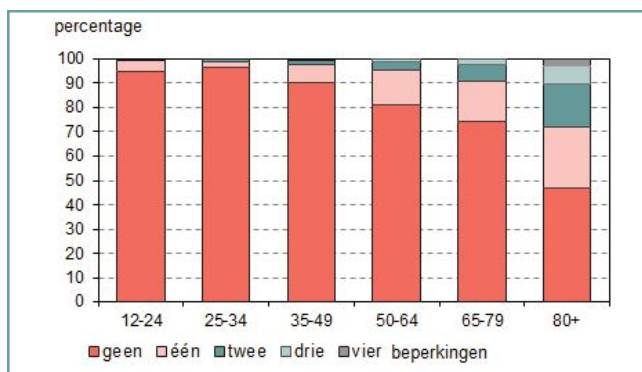


Figure 28; Percentage of none, one, two, three or four disorders in hearing, seeing, mobility and daily activities, by age in the Netherlands (CBS, 2011)

4.2.1 MOBILITY PROBLEMS (IMMOBILITY AND INSTABILITY)

Twenty-six percent of 65-plus elderly have mobility issues. Most of these mobility problems are walking issues, issues carrying bags (force issues), and stand up and bend down issues (Olde-Rikkert, 2013). As figure 29 and 30 show elderly are most vulnerable for mobility issues and most of these elderly are women (CBS, 2011).

Most mobility issues are caused by severe back pain, joint problems (artrose), arthritis (reuma) and elderly falling more easily. The best way to prevent mobility problems is to exercise enough (at least 30-60 minutes on a moderate intensity on at least 5 days a week). Also fall prevention measures can help to prevent elderly falling more easily (Olde-Rikkert, 2013).

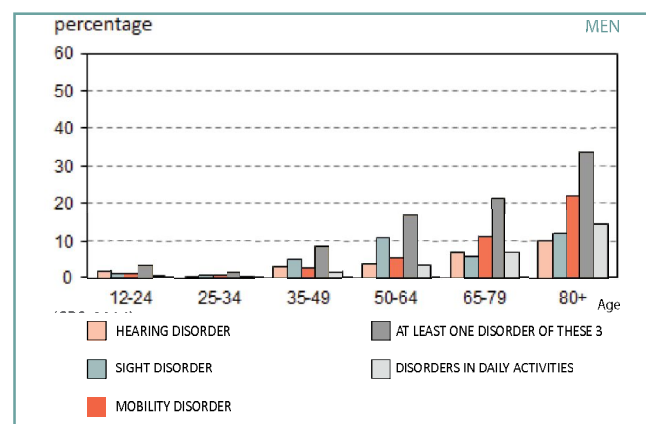


Figure 29; Percentage of difficulties in performing activities which have to do with hearing, seeing, mobility and daily activities, men by age in the Netherlands (CBS, 2011)

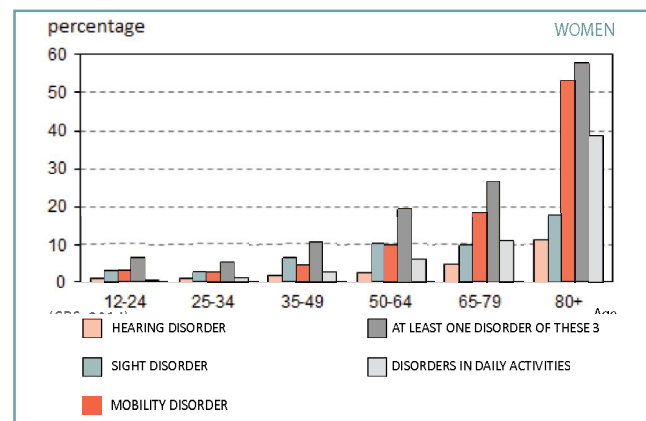


Figure 30; Percentage of difficulties in performing activities which have to do with hearing, seeing, mobility and daily activities, women by age in the Netherlands (CBS, 2011)

Mobility, sight and hearing disorders are also listed by highest level of education (figure 31). It seems that people with lower education have more disorders than people with higher education.

Most elderly with mobility problems also suffer from other diseases. These diseases are mostly the cause of their mobility problems. For example, as figure 40 shows, 73% of all elderly with arthritis (reuma) also suffer from mobility disorders (GGD, 2007, p.3).

Elderly who live alone (without a partner) considerably have more mobility disorders than elderly who live together with their partner (figure 33). Education, health (mental and physical), frequency of social contacts and satisfaction of contacts all play roles in mobility disorders of elderly.

For example elderly with a limited social network will earlier face mobility problems, because it is less easy for them to ask for help.

But, limited social contacts could also be the consequence of mobility problems (GGD, 2007, p.4).

Exercising enough can prevent a number of chronic diseases, not only mobility problems will be prevented or postponed. People who get enough exercises are less likely to face cardiovascular disease, obesity, osteoporosis and depression. Their reactiontime, coordination of movements, memory, self-sufficiency and well-being are better than with people who move less.

Also elderly with limited movement possibilities should try to exercise, depending on their individual possibilities and limitations (Olde-Rikkert, 2013).

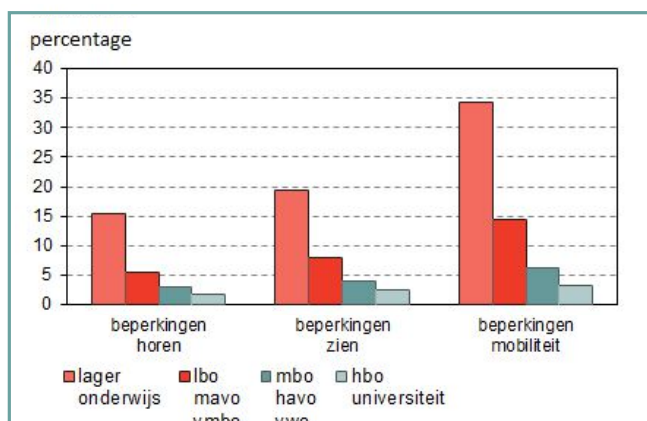


Figure 31; Percentage of difficulties in performing activities which have to do with hearing, seeing, mobility and daily activities, by highest level of completed education (CBS, 2012)

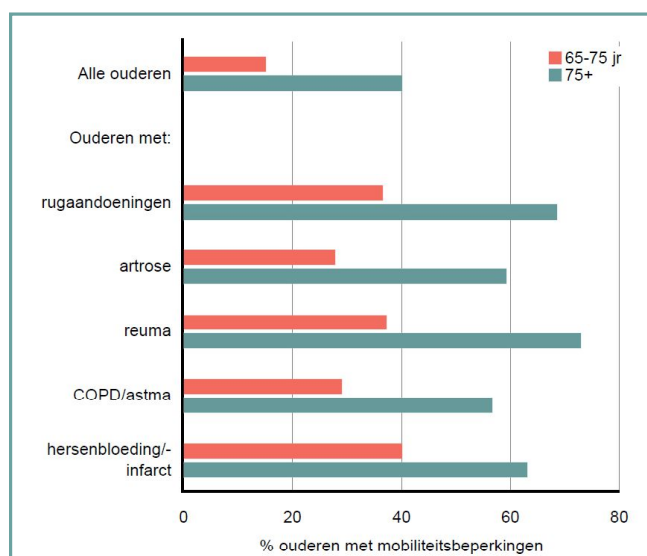


Figure 32; Mobility disorders at elderly with chronic diseases and disorders (GGD, 2007, p.3)

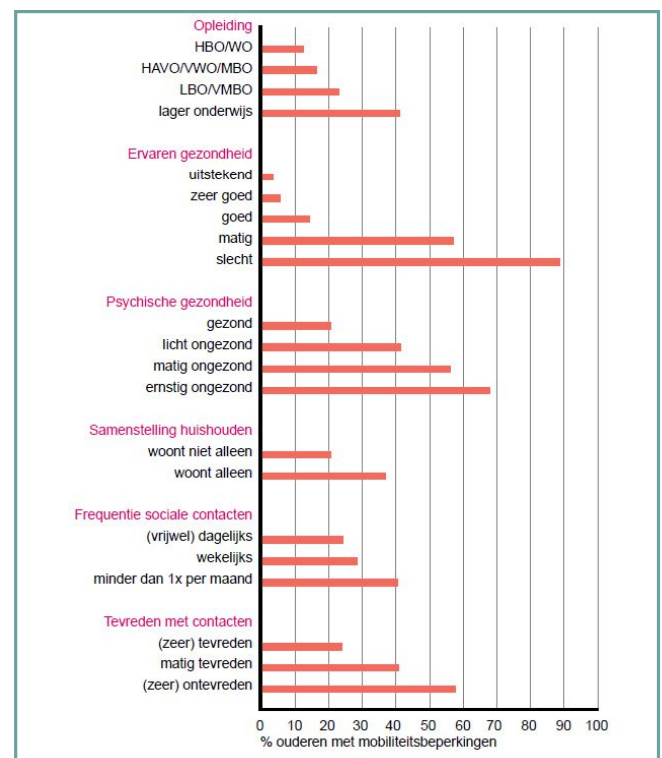


Figure 33; Mobility disorders at elderly in comparison to well-being (CBS, 2007, p.4)

4.2.2 SENSORY DISORDERS

While a stimulating and thoughtful environment helps to stimulate the senses, most new technologies only stimulate the visual sense. Stimulating senses helps to contribute to recovery and has a great influence on the mental and physical health and behavior of people (Hoogland, 2011). Changes in using senses can be triggered by creating interactions between people and their environment. Sensory plans (figure 34) are innovative design tools that empower the designer to deliver optimal supportive environments for the ageing community (Farrelly, 2014, p. 111).

One important sense receptor is hearing. It is said that noise is to people with dementia what stairs are to wheelchair users (Farrelly, 2014, p. 110), so extra attention on this receptor by ageing in place is necessary.

A second important receptor is smell. The smell sense can activate apparently forgotten experiences and events from the past (Dieren, 2011, p. 28), so could in some way contribute to areas where occupants feel at home.

A third main receptor is vision. While ageing, the amount of light intensity people need changes, elderly need more light. Using contrasting colours can help elderly to distinguish between surface levels and furnishing (Fiello & Warren, 2001, p. 240). Impairment of the visual receptor can also be directly related to sleep issues (Farrelly, 2014, p. 110). Color temperatures change during the day which have an influence on how active/ sleepy you are (Dieren, 2011, p. 16).

Next to the main receptors, others such as the sense of space, time, pain and balance are all important in the ageing process. A sense of time is especially important to elderly facing dementia (Farrelly, 2014, p. 111).

Stimulus-poor areas don't trigger people to understand or answer their environment. To integrate sensory plans into a design elderly can feel more comfortable in their environment, but more information is necessary to understand sensory disorders of elderly.

As figure 29 and 30 in paragraph 4.2.1 already showed, impairment of sight and sound are the most common sensory disorders. Vision disorders occur more often than hearing disorders and again more women face these disorders than men (CBS, 2011). While sight and sound are the most common disorders, these will be discussed in detail on the next pages.

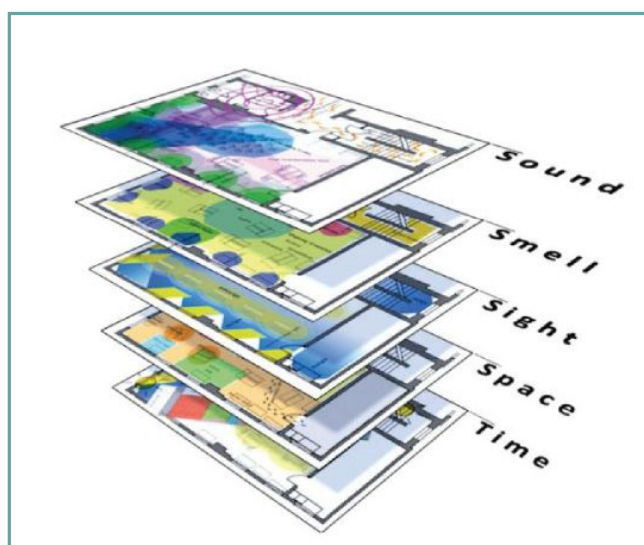


Figure 34; Sensory plans developed by IBI/Nightingale (Farrelly, 2014, p. 111)

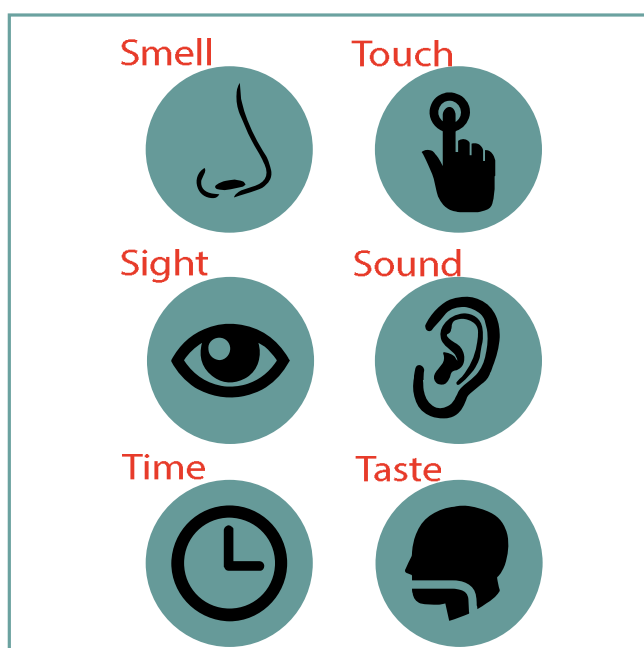


Figure 35; Interaction with the environment activates different senses, these senses are most important and most used (own illustration)

4.2.2.1. HEARING DISORDER

Age related hearing impairment is a form of sensori-neural hearing loss or neuro-sensory impairment. This is caused by a disorder of the inner ear and / or the auditory nerve. This means that the sound vibrations are still collected, but the signals are not processed correctly anymore and are no longer transported by the auditory nerve.

Deterioration of the inner ear does not only provide attenuation of the sound but also distortion of sounds: the sounds are sometimes duller and sometimes just very sharp. Elderly with hearing disorders often suffer more from environment sounds, while most people think elderly can only hear loud noises.

There are different types of hearing disorders:

- CONDUCTIVE HEARING LOSS

The sounds seem softer. This type of hearing loss is usually temporary. Sometimes it comes naturally, sometimes your ears must be ejected or sucked or surgery is needed.

- OBSERVATION- OR PERCEPTION LOSS

The sounds seem not only softer, but can also be deformed, which makes them sometimes not sound normally. Loud noises can be painful or unpleasant. Perception hearing loss is permanent. A hearing device can help in most cases.

- MIXED LOSS

Mixed loss includes both conductive hearing loss and perception hearing loss.

The causes of hearing disorders are not totally clear yet, but what we know; prevent exposure to loud noise (Gezondheid.be, 2012).

The figures on the next page show how many people face hearing disorders and what it costs for the health-care sector. Again women are the biggest group facing hearing disorders and between the age of 65 and 85+ the amount of hearing disorders increases a lot (CBS, 2011).

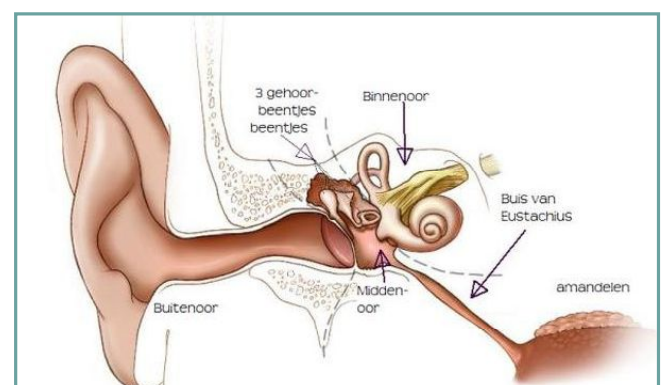


Figure 36; Structure of the human ear (Gezondheid.be, 2012)

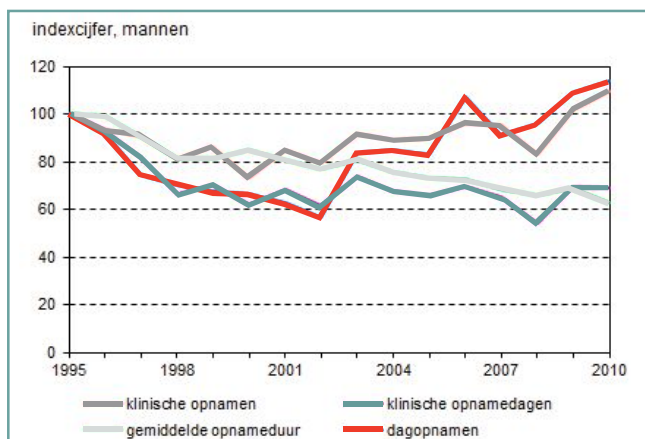


Figure 37; Clinical admissions, inpatient days, average length of stay and daystays for hearing disordered men (primary discharge diagnosis) in the period 1995-2010 (Nationaal Kompas, 2014)

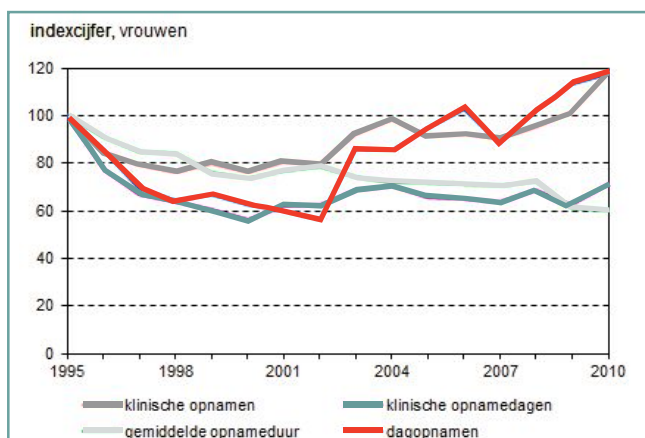


Figure 38; Clinical admissions, inpatient days, average length of stay and daystays for hearing disordered women (primary discharge diagnosis) in the period 1995-2010 (Nationaal Kompas, 2014)

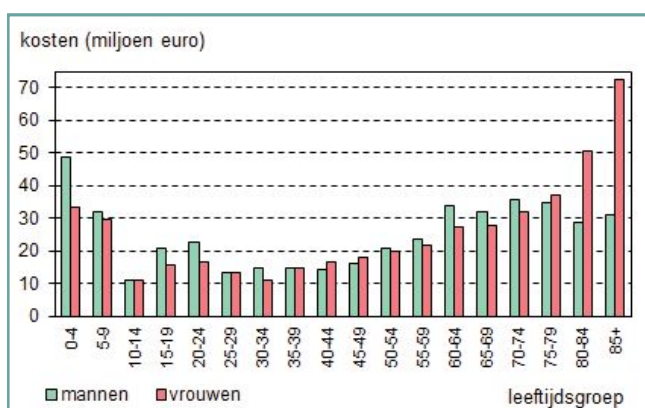


Figure 39; Healthcare costs for people with hearing disorders by gender and age (CBS, 2011)

4.2.2.2. SIGHT DISORDER

There are four most common sight disorders. The four sight disorders (*macular degeneration, diabetic retinopathy, glaucoma and cataract*) have in common that their occurrence rises sharply with age (figure 40). Several graphs show the point prevalences of the different sight disorders by age and gender. To get a better idea; different pictures of the same computer screen show the different sight disorders in appendix A.2.

MACULAR DEGENERATION

Macular degeneration results in failure of the central part of the vision field and leads eventually to severe visual impairment and blindness. Sometimes the failure goes so quick that someone is seriously impaired within a few days. The first symptoms are usually a distortion of the observed images (metamorphosis) and the sight is less sharp (Nationaal Kompas, 2011).

DIABETIC RETINOPATHY

Initially diabetic retinopathy often progresses without any symptoms. In a more advanced stage the visual acuity decreases often dramatically. Early detection (and treatment) of diabetic retinopathy may be effective, it can prevent damage to the retina (Nationaal Kompas, 2011).

GLAUCOMA

Due to the gradual loss of the visual field complaints occur quite late. People mostly find out about glaucoma when they suddenly bump into objects or make chunks in traffic.

If you do not undergo treatments when having glaucoma, it will result in tunnel vision, followed by complete blindness (Nationaal Kompas, 2011).

CATARACT

There will be a gradual decrease in visual acuity, which leads to (severe) impairment and blindness without treatment. The first symptoms are blurred vision, double vision in one eye, impaired color perception and quick glare at backlight (Nationaal Kompas, 2011).

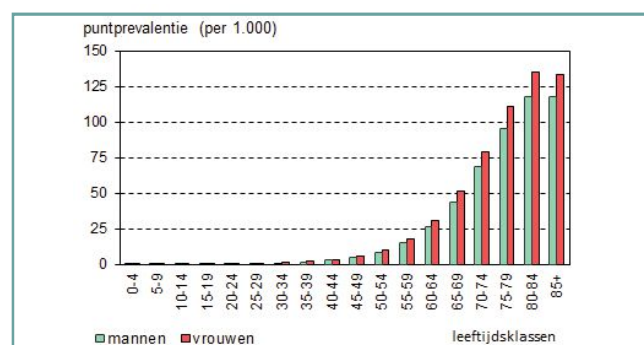


Figure 40; Point prevalence of sight disorders by age and gender (Nationaal Kompas, 2011)

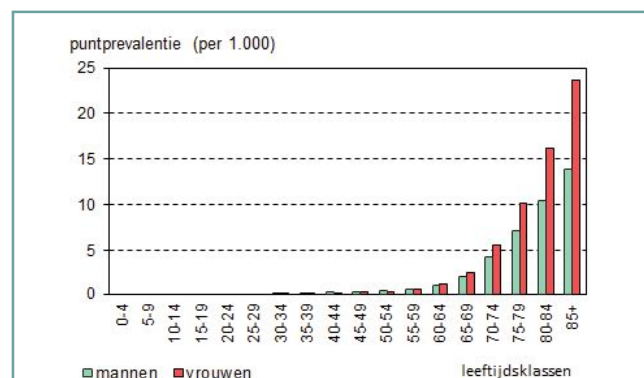


Figure 41; Point prevalence macular degeneration by age and gender (Nationaal Kompas, 2011)

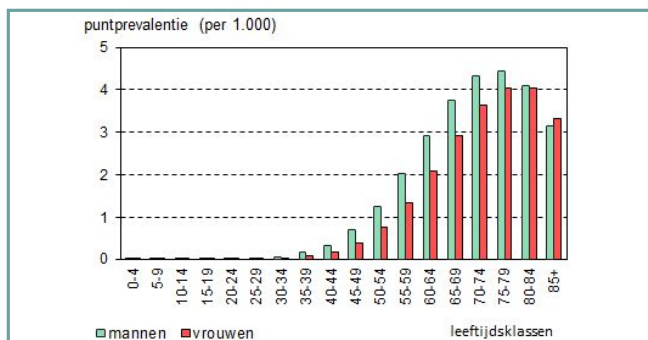


Figure 42; Point prevalence diabetic retinopathy by age and gender (Nationaal Kompas, 2011)

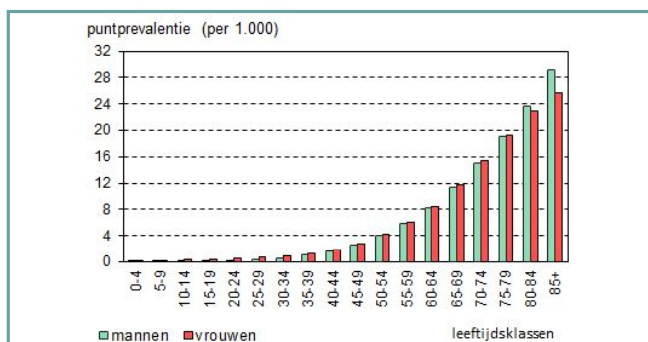


Figure 43; Point prevalence glaucoma by age and gender (Nationaal Kompas, 2011)

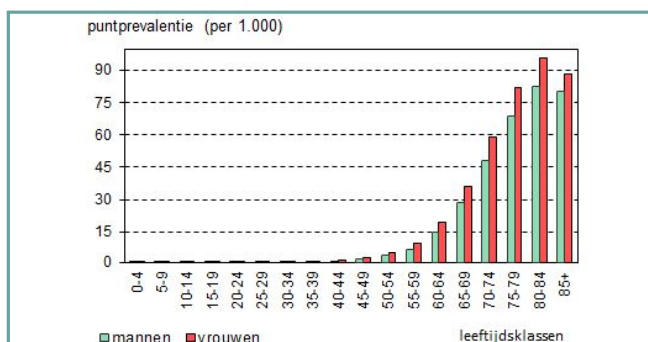


Figure 44; Point prevalence cataract by age and gender (Nationaal Kompas, 2011)

4.2.2.3. ACTIONS WHEN FACING SIGHT- OR HEARING DISORDER

Different devices for sight- and hearing disorders can solve mostly (part of) the disorder, like hearing devices and different types of glasses. Still specific environments for elderly with deteriorations in sight and hearing could improve their comfort levels.

HEARING DISORDER

People mostly think when talking to elderly with a hearing disorder, they have to talk louder to make sure they are understandable. In fact this is not always true. Hard noises can be unpleasant and painful for elderly. Also surrounding noises can sound very loud to them. Elderly often suffer from low frequency noise disturbance. Hearing impaired people mostly hear low frequency noises better (Seniorennet, 2015). Due to the long wavelengths low frequency sounds can differ a lot in the same room; in the corners of the room the noises sound harder than in the center of the room (Hattem, 2014). Figure 45 presents a table of noise levels and sound perceptions of these levels.

To improve elderly indoor comfort low frequency noises have to be filtered. While surrounding noises can be very annoying too, noises with a level of 50 dB and higher have to be avoided too.

LAeq in dB(A)	waarneming	voorbeelden
130	bovenste hoorbaargrens	straalmotor op 25 m
120	oorverdovend	motor met vrije uitlaat
110	onuitstaanbaar	knetterende motor cirkelzaag
100	intens	compressor buitenboordmotor drilboor
90	zeer luid	motor vrachtwagen dieselmotor koffiemolen op 1m
80	luid	fabriek station wekker op 0,60 m bromfiets
70	redelijk luid	auto stofzuiger op 3 m
60	reeds hinderend	stromend water wasmachine op 3 m
50	gematigd	luide stem veld in de zomer (vogels, insecten)
40	zeer gematigd	normale stem rustige ontspanningszaal
30	zwak	gefluister zacht stemgeluid
20	uiterst zwak	rustige tuin rustige kamer 's nachts radiostudio
10	nauwelijks waarneembaar	zacht geruis
0	onderste hoorbaargrens	stilte

Figure 45; Sound perception scheme (Seniorennet, 2015)

SIGHT DISORDER

Next to using glasses, enough light can also improve the sight of elderly a lot. At a higher age the sight becomes more blurry, because only a small part of the amount of light reaches the retina (Starremans, 2011, p.11). Therefore it is important to keep the rooms of elderly light enough.

A light enough room not only provides a better sight for elderly, it also makes them more active and alert (Starremans, 2011, p.11). Research also confirms that elderly's orientation and memory are better in a room that is light enough (Starremans, 2011, p.12).

A transparent facade is therefore healthy for (ageing) people. Still, in the winter not enough daylight enters the building, only a transparent facade is not enough. Therefore they invented daylight lamps. These lamps provide enough light, the light intensity is 500 lux (Starremans, 2011, p.13).

Stimulating daylight should not only be done for better vision for elderly. Sunlight also has an influence on the health of their bones and muscles. Our body creates vitamin D under the influence of direct sunlight, vitamin D contributes to the health of your muscles and bones. Normally 2/3 of the vitamin D we need is created due to direct sunlight (Dalen v., 2013). While

elderly stay inside more than other households, direct sunlight through the facade is very important.

4.2.3 INCONTINENCE

Incontinence may not seem very relevant for this research, but incontinence occurs mostly simultaneously with various other diseases or disorders and is therefore interesting too.

Incontinence occurs mostly simultaneously with reduced mobility, mental and physical deterioration or loneliness/ loss of partner. Incontinence is therefore hard to prevent, but by preventing or postponing the simultaneously disorders incontinence can be postponed or prevented too.

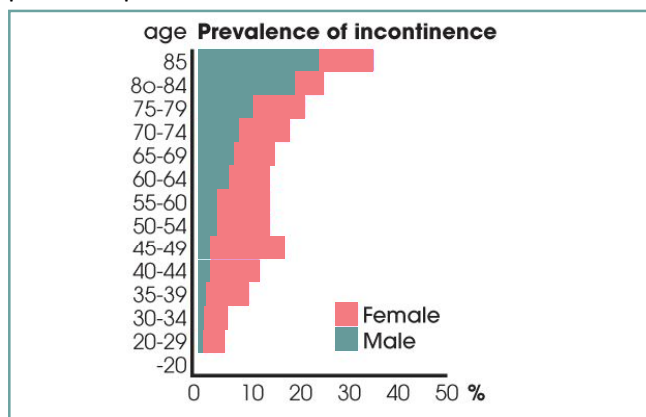


Figure 46; Prevalence of incontinence in the Netherlands (Tena, 2014)

4.2.4 COGNITIVE PROBLEMS

The number of people with dementia in the Netherlands is estimated at 230,000 people. Because of the aging population and increasing life expectancy, it is expected that this number will rise to over 500,000 in 2050. The chances of someone getting dementia in his life is 20% (Dimence, 2015).

With age everyone has to deal with gradual deterioration of the functioning of the brains. But when this happens quickly or dramatically, there may be a cognitive impairment. The deterioration of brain function can cause disturbances in perception, attention, concentration, memory, orientation, language and performing practical skills.

Cognitive impairment can be temporary or permanent. Temporary changes occur, for example with psychological problems such as depression. They may have a physical cause, such as a disordered metabolism or bladder or pneumonia, of which especially elderly suffer. Examples of permanent disorders are the various forms of dementia, Alzheimer's Korsakov and the effects of other acquired brain injury (Dimence, 2015).

PREVENTION OR POSTPONING COGNITIVE PROBLEMS

There are a lot of theories about preventing or postponing cognitive problems, but no hard evidence is found yet.

People try to force elderly to train their brains by doing a lot of memory games and training, but in the end it only works for a few percentage of the target group.

Engineers try to find new technology based solutions, but most of the time these solutions are too hard for elderly to understand.

As figure 47 shows, the amount of elderly using the internet daily is already 76% (CBS, 2015). Elderly are getting more modern, but they seem to get familiar with technical stuff when they have been using it for a while (certainly when they are facing cognitive problems).

So by implementing a technology soon enough, elderly can get familiar with the technology and keep on using it easier and more often.

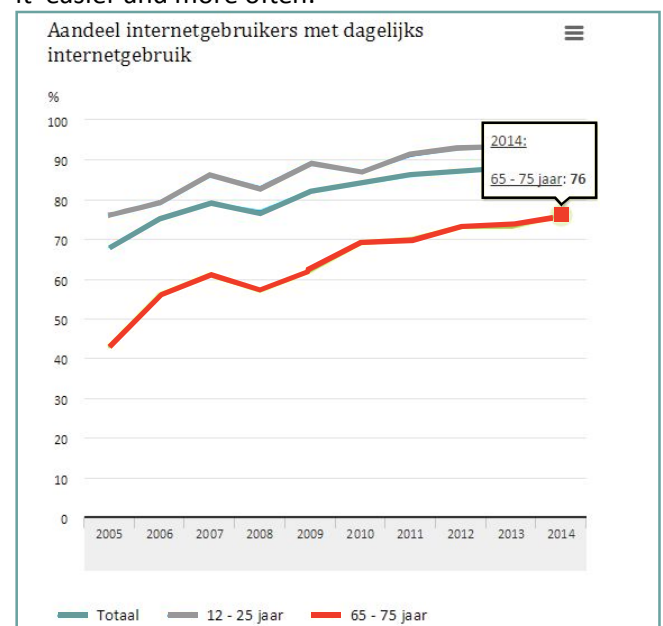


Figure 47; Daily users of internet by age (CBS, 2015)

4.3 ELDERLY AND ENERGY CONSUMPTION

Households with elderly seem to consume more energy than households without elderly. Guerra-Santin and Tweed (2013) did a research on the energy consumption of space heating and cooling of a care home in the UK. Their goal was to find out how to dramatically reduce the requirement of space heating and cooling, whilst keeping or creating air quality and an healthy comfortable environment (Guerra-Santin et al., 2013, p.1).

Factors causing increase of the energy consumption were the overused air conditioning during summer and heated unoccupied rooms (Guerra-Santin et al., 2013, p.3). Using air conditioning not only causes high energy consumption, but has also effects on the health of the occupants. Strong variations in temperature are not healthy (Fareilly, 2014).

The staff also noticed stale air and odours in the rooms and therefore opened windows every morning, especially in the bedrooms the CO₂ level seemed high (Guerra-Santin et al., 2013, p.3). As elderly tend to ven-

tilate less than other households, logically more stale air and odours are considered. This indicates the need to greater ventilation.

Due to the age and health conditions of the residents, the residents were less able to achieve comfortable conditions. It was hard for them to open/ close a window and to turn on/off the radiator.

Guerra-Santin and Tweed (2013) concluded their research with the assumption that with the right interaction between people and building, better indoor conditions could be reached.

4.4 CONCLUSIONS

The geriatric giants are the most common deterioration factors elderly face as shown in the previous paragraphs. Elderly suffer most from mobility, hearing and sight disorders.

These deteriorations can't be fully prevented by a facade design, but we could try to postpone them by de-

signing for elderly's comfort and health.

As *figure 48* shows, the problems elderly face most are mobility disorders. Followed by sight disorders and hearing disorders.

Cognitive problems occur often too. Research and interviews show that with implementation of a new helping tool elderly will use and understand the tool if you implement it soon enough (before getting cognitive problems).

Elderly prefer higher temperature settings than younger people. Also their behavior towards ventilation is different; they ventilate too little, with the consequence of inside stale air and odours. They overuse their airconditioning during the summer, which can also be bad for their health. Besides that it is hard for elderly to achieve comfortable conditions because of mobility issues (Guerra-Santin et al., 2013).

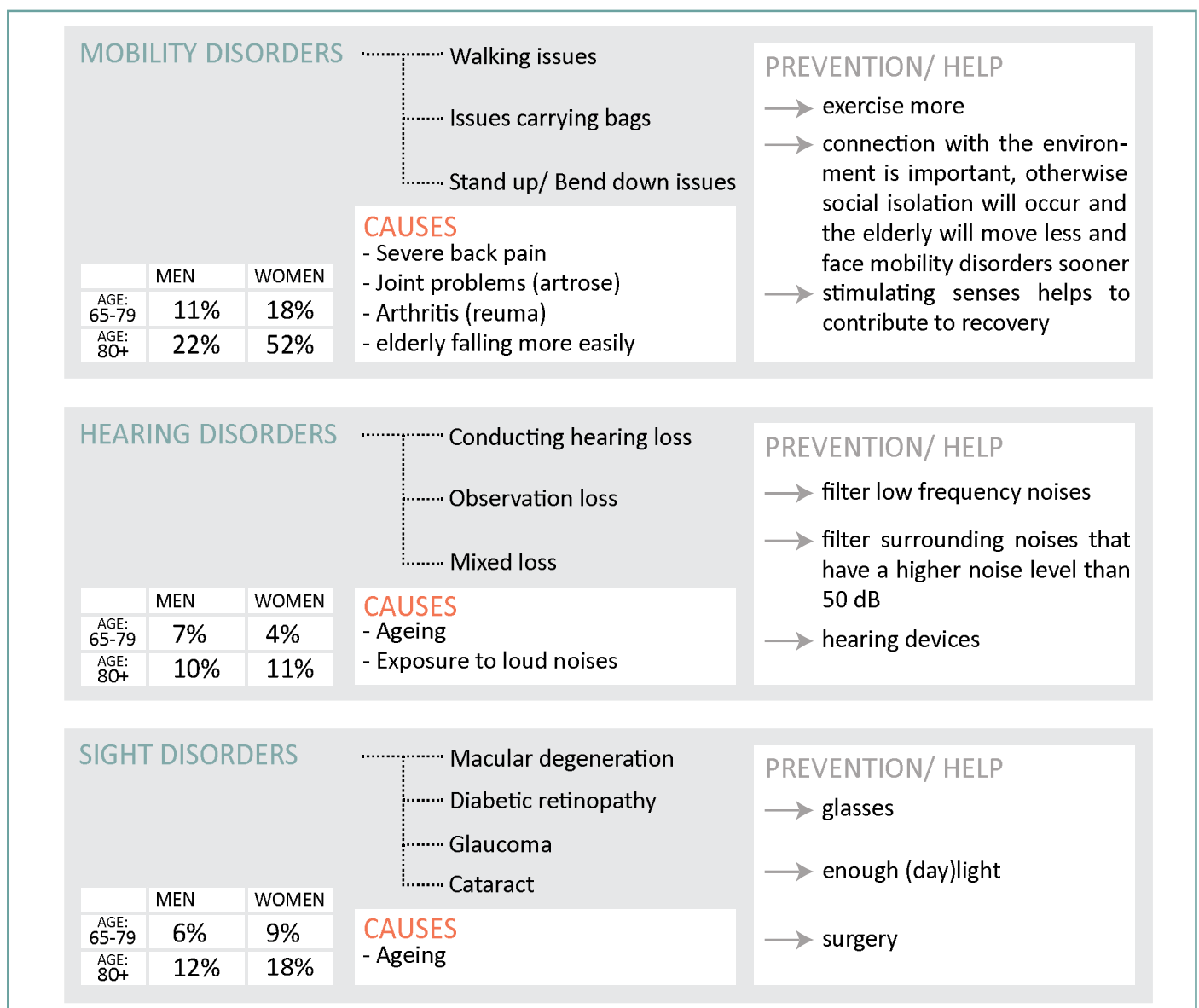


Figure 48; Most common disorders elderly scheme (own illustration)

5. USER PROFILES

User profiles (personas) are necessary to define the design requirements, which will be discussed later in this thesis. The first paragraph of this chapter will go into user profile (persona) literature and why the use of personas improves the design process. This will be followed by several interviews I did, to get to know the goals and different behavioral aspects of the target group; elderly. These four different interviews (*figure 50*) are all discussed in paragraph 5.4 and elaborated in the appendix A.3. Paragraph 5.3 concludes how these user profiles and demands will help to define the design requirements.

5.1 INTRODUCTION PERSONAS

Using personas/ user profiles to design and test products is a method to represent and communicate customer needs. Customer needs should always be in the center of the design process of a product. Many organizations fail to consider the customer needs as the focal point, as a result they don't reach their target, consumers or users (Miaskiewicz & Kozar, 2011, p.417).

By using different personas for your product design, you present an aggregate of target users who share common behavioral characteristics which you can use to test your product specifications on (Miaskiewicz & Kozar, 2011, p.418). Use of personas could lead to limited options of your design, which leads to simplicity and avoids complexity (Miaskiewicz & Kozar, 2011, p.428).

Personas differ in behavior, goals, occupation, likes and dislikes. Typically between 1 and 7 personas are developed to support a project (Marshall et al., 2013, p.1).

In this research the target group is elderly. Older users are often seen as one homogenous persona, whilst in reality they are heterogeneous as any other (Marshall et al., 2013, p.2). As seen in chapter 4 elderly suffer from different disorders and have different preferences. Therefore it is useful to create different personas of elderly.

In the end the usability of a product is most important. If the target group can use a product in a way that is efficient and satisfying for them, they will use the product (Goldberg et al., 2011, p.188). The user should be in the center of the design (*figure 49*).

After having done a lot of research on the target users and the energy efficiency of dwellings, it's time to talk with the target users in person. In the end they have to buy and use the product.

5.2 INTERVIEWS

As the target users for this research are elderly, it was time to search for elderly living in the neighbourhood to have a chat with about their daily life, their perception of energy consumption and their comfort preferences.

To reach the target group, one of my mentors brought me in contact with Johan Molenbroek, an employee of the TU Delft. Johan set up an elderly network around Delft, containing elderly who are willing to participate in research projects of the TU Delft. In a few days there were already enough enthusiastic elderly who were willing to participate in my research project.

The elderly who participated all lived in different streets and different types of houses. They all behave differently according to energy consumption.

The interviews were done in four parts:

1. *Face-to-face* interview according to their perception of energy consumption;
2. Interview *by email* according to research results and design concepts (evaluation);
3. *Face-to-face* interview according to their perception of comfort;
4. Interview *by email* according to research results and design concepts (evaluation).

The aim of the first interview was to find out how the occupants behave according to their energy consumption and if they were willing to save energy or not.

The second interview was an interview by email with some hypotheses according to saving energy and some design concepts to be evaluated by the elderly.

The aim of the third interview was to find out more about the perception of comfort according to the facade. In the end the product should not only save energy but should also have an added value for the occupants. Otherwise they won't buy it or won't use it in the right way.

And in the last interview new design concepts were presented to and evaluated by the elderly.

The questions and notes of all the interviews are attached in the appendix, the first and third interview are discussed in this chapter, the second and fourth interview are discussed in the evaluation.

After face-to-face interview 1 several personas were defined, but after the evaluation of design 1 and the second face-to-face interview, the demands of the per-

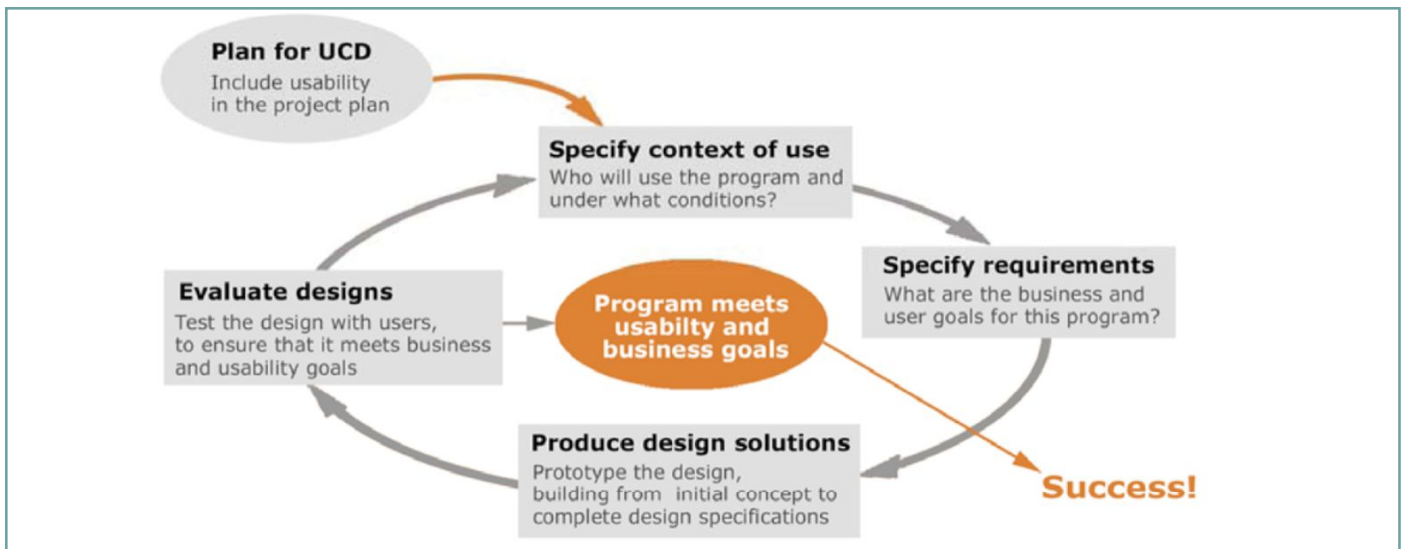


Figure 49; User-centered-design (UCD) scheme (Goldberg et al., 2011, p.189)

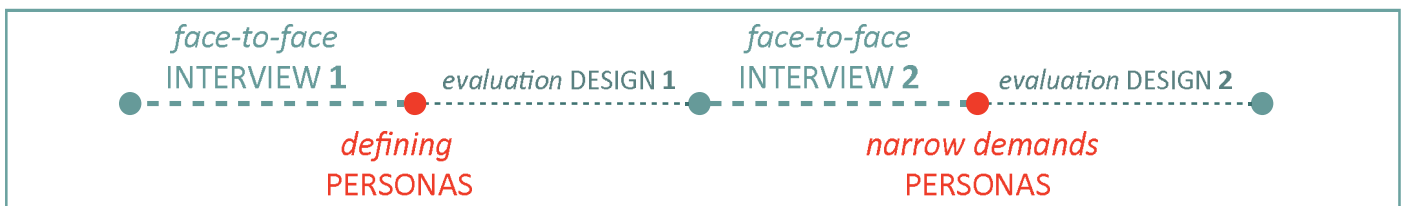


Figure 50; Process defining personas (own illustration)

sonas were narrowed. This helped to make the design requirements better and therefore the final design more focused on the user.

In the appendix A.3.1. the types of dwellings and some building characteristics are described, attached some pictures of the dwellings.

5.2.1 INTERVIEW 1 - ENERGY CONSUMPTION

The first interview was an introduction interview to find out the way of living of different elderly, the types of dwellings they live in and the way they control their comfort according to energy.

The interview was done with four different elderly;

1. Magda Wolthoorn, (age: 90 years)
2. Lida Bergenhenegouwen (age: 67 years)
3. Guus Maiburg (age: 70 years)
4. Johannes Greven (age: 90 years)

5.2.1.1 RESULTS INTERVIEW 1

The interview questions and answers of the different participants are attached in appendix A.3.1.

The interviews helped to confirm some research results, but also led to new perspectives.

By taking these first interviews with different elderly, their way of living became more realistic. The higher temperature setting of elderly, which was found in the research, was confirmed by the elderly who participated in the interviews. Most of the elderly are willing to save more energy, but don't want to put much effort in it. The devices to achieve energy efficiency also have to be clear and simple.

Most elderly don't have an extensive ventilation system, they mostly ventilate by opening windows. Their heating system is mostly regulated by a (programmable) thermostat. They were not really aware of what a healthy indoor climate is and what a healthy ventilation behavior would be. One of the elderly was missing an innovative insect screen to project insects flying in when opening a window. All interviewed elderly were provided with modern technologies (computer, telephone, etc.) and able to use these technologies.

The interviews show that a comfortable indoor climate is most important for elderly. They are willing to save energy, but only if their indoor comfort stays the same.

They are mostly ventilating by opening windows. They tend to ventilate less in winter than in summer. They are not aware of the importance of ventilation for their own health.

Most deterioration is seen in mobility, hearing and vision disorders. They use devices to resolve their hearing and vision problems. Most of the elderly try to go outside a lot, especially in summer, but their mobility disorders can sometimes be a struggle to go outside. Most mobility problems are seen in walking. The second largest deterioration is sight. Elderly have problems with overexposure and need more light to do their daily activities.

In the appendix A.3.1., the outcomes of the interviews are elaborated in a narrative form, illustrated by pictures of the dwellings.

5.2.1.2. DEFINING PERSONAS INTERVIEW 1

As the introduction of this chapter explained, using personas/ user profiles to design and test products is a method to represent and communicate customer needs. The user should be in the center of the design, to make sure the product is used in the intended manner and to make sure the users are willing to buy the product.

The first interviews and read literature helped to define the first 'concept' personas to support the design process. From the first interviews and literature five different personas are defined: the "easy comfortables", the "all time savers", the "spenders", the "mobility sufferers" and the "sight sufferers". These different personas differ in deterioration, likes and dislikes, perception of saving energy, etc. Below these different personas are described attached with a picture to bring the personas 'alive'.

1. THE "EASY COMFORTABLES"

The "easy comfortables" are elderly who spend a lot of time in their apartment, most of it in the living room.

They don't spend time on reprogramming the thermostat, they just want to feel comfortable. They open a window now and then. They don't really spend attention on ventilating enough and having a healthy indoor climate.

They don't really want to put a lot of effort in saving energy, but if it is easy they would like to save more energy.



2. THE "ALL TIME SAVERS"

The "all time savers" are elderly who moved to more elderly-friendly apartments because they are very aware of elderly's deterioration possibilities.

They have a manual thermostat which they set every day, they are very much into saving energy.

If there are possibilities to save more energy, they would like to integrate them, but they should be integrated soon enough to be sure to get familiar with the system before deteriorating.

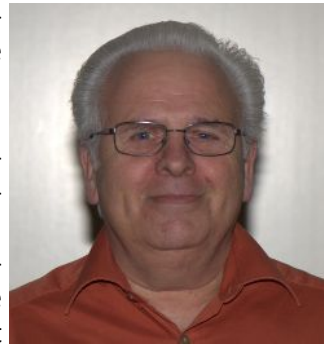


3. THE "SPENDERS"

The "spenders" are elderly who are at home approximately all day.

Their thermostat is programmed on 22-23 degrees all day and night. They want to feel comfortable all the time and don't want to put effort in saving energy. Their comfort is the most important thing.

They are interested in new technologies, but only if it has enough advantages to make their life more comfortable and more fun.

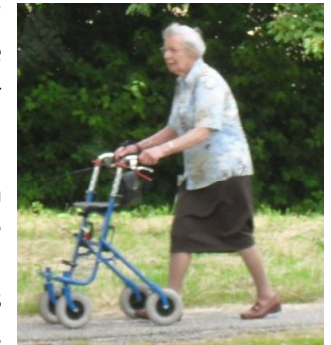


4. THE "MOBILITY SUFFERERS"

The "mobility sufferers" are elderly who have difficulties in their mobility.

The most common mobility problems are walking and reaching. They have difficulties reaching high objects, for example opening a window on a big height is difficult for them.

Moving is important, especially for elderly. So they should be triggered to keep moving, but we should take their mobility deteriorations in mind while designing.

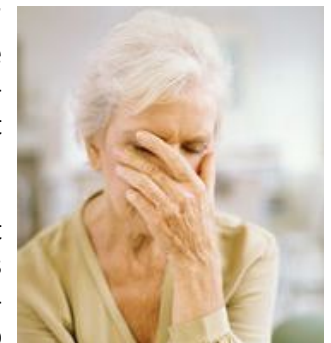


5. THE "SIGHT SUFFERERS"

The "sight sufferers" are elderly who have difficulties with their vision (reading and light intensity).

Elderly need more light for different activities than others, but overexposure should also be avoided. They prefer to read in daylight instead of artificial light.

While enough light is important, but overexposure should be avoided, we need to make sure that the daylight transmissions are adjustable and the artificial light can provide the rest.



These different personas can occur simultaneously, so someone (persona 3) who doesn't want to save energy (the "spender"), can also partly be persona 4 (the "mobility sufferer").

These different personas will help to define the design requirements. In a later stage of the design and research process the same participants will be asked to take part in a second face-to-face interview (they all agreed to be able to take part in it).

5.2.2 INTERVIEW 2 - EVALUATION 1

The personas defined after the first interviews helped to make the first design concepts of the 2nd skin project (appendix A.5). These design concepts and some hypotheses were evaluated by the participants.

The evaluation part is elaborated in chapter 12. After the evaluation a second face-to-face interview was set up to re-define the personas more. The first face-to-face interview was focused more on behavior and energy consumption, while the second face-to-face interview more focused on the perception of comfort of the occupants.

5.2.3 INTERVIEW 3 - COMFORT PERCEPTION

The third interview (second face-to-face interview) was an interview to find out more about the comfort preferences of elderly. We want them to live more energy efficient and in a healthier way, but they will only use the product if the added value (comfort) is large enough.

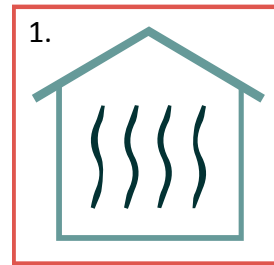
The interview was done with three different elderly;

1. Magda Wolthoorn, (age: 90 years)
2. Lida Bergenhenegouwen (age: 67 years)
3. Guus Maiburg (age: 70 years)

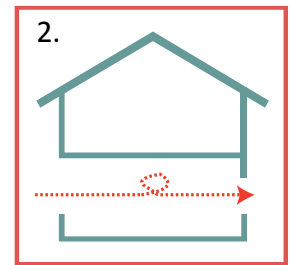
The questions and elaboration of the interviews are attached in the appendix, clarified by pictures.

By having done these interviews it became much clearer what the preferences of elderly are according to the facade. The first and second face-to-face interview show a lot of similarities between the different participants. These similarities in preferences and behavior are all visualized in this paragraph.

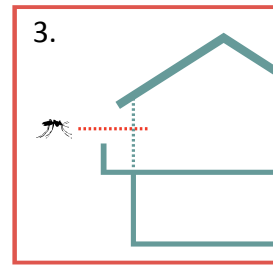
These preferences do not really change the different personas but they narrow the demands of the personas. Both the personas and the preferences have to be taken into account when defining the design requirements for the final design. In total 15 preferences of the elderly are visualized and explained here.



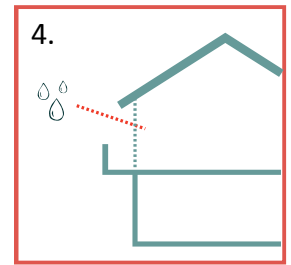
1. **ELDERLY TEND TO VENTILATE TOO LITTLE**
Most of the elderly have a mechanical ventilation system, but hardly use it. Especially in winter they therefore ventilate too little.



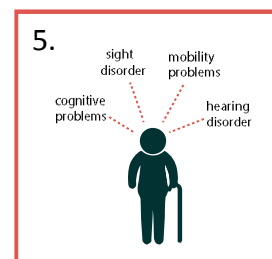
2. **NATURAL VENTILATION IS PREFERRED (LARGE OPENINGS), BUT PREVENT DRAFT**
Lida: *"I can only open a small upper part of the window, that makes ventilating very hard for me."*



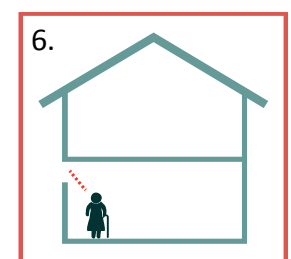
3. **INSECT PROTECTION**
Magda: *"In summer the door of the balcony is always open. In front of the opening I place an insect curtain. But it is difficult for me to hang the insect curtain on its place."*



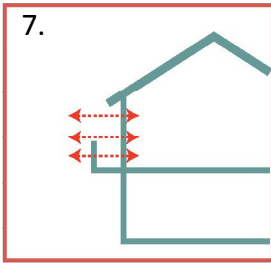
4. **RAIN PROTECTION**
Guus: *"I am happy with my indoor balcony, in this way we are still protected against rain while ventilating naturally."*



5. **DETERIORATION ELDERLY**
All different deterioration factors of elderly should be taken in mind. The most important ones are mobility and sight disorders.

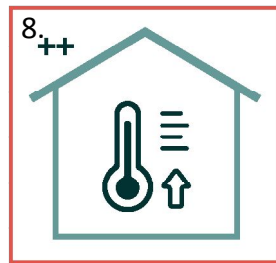


6. **REACHABILITY**
Lida: *"I made a stick with a rod on top to open and close the windows, otherwise I cannot reach them."*



7. TRANSPARENCY ON ALL LEVELS

Guus: *"Connection with the environment is very important. Therefore transparency is essential, the balustrade should be transparent too."*



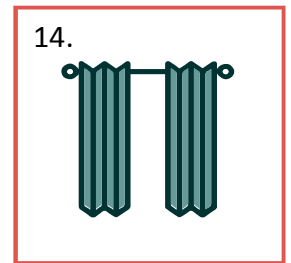
8. COMFORT (HIGHER TEMPERATURE PREFERENCE)

Magda: *"I get cold very fast, the new design should provide overall comfort. I don't want to get cold feet."*



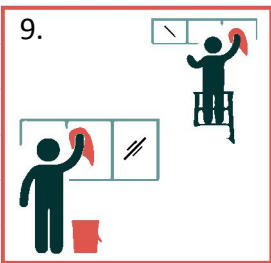
13. ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)

Magda: *"I mainly use my balcony for my plants and to sit outside in summer. I increased the width of my windowsill to place my plants on them to catch enough daylight."*



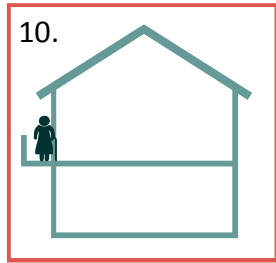
14. ABILITY TO HANG CURTAINS

Guus: *"We have too layers of curtains: one against cold and draft, a second one to provide privacy (this one is more transparent)."*



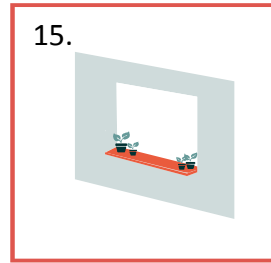
9. ABILITY TO CLEAN ALL WINDOWS

Lida: *"I can not rotate or open the side window on my balcony, therefore the window is never cleaned and became non-transparent."*



10. OUTSIDE AREA/ BALCONY

Most elderly only have a balcony and no other outside area. They all prefer a fixed balcony instead of a temporarily balcony so their plants and furniture can remain on the same place.



15. WINDOWSILL INSIDE

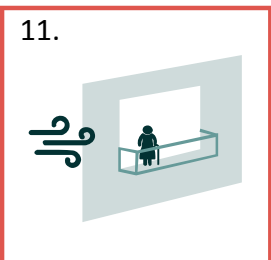
Magda: *"I increased the width of my windowsill to place my plants on. In this way they can catch enough daylight."*

As shown in the visualization, the participants have a lot of similarities in facade and comfort preferences. These outcomes can be seen as starting design requirements, which still should be sharpened before the designs can be checked on these requirements.

The outcomes of interview 3 help a lot in the design process of comfort, still both the outcomes of interview 1 (the personas) and 3 should be taken into account while defining the design requirements.

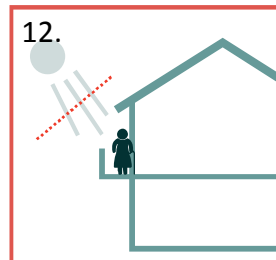
5.2.4 INTERVIEW 4 - EVALUATION 2

The personas defined after the first interviews and the preferences visualized after interview 3 helped to make a step forward into the process of designing concepts for the 2nd skin project. These design concepts and some hypotheses were evaluated by the participants. The evaluation part is elaborated in chapter 12.



10. PROTECTION AGAINST WIND

Lida: *"The glass panel at one side of the balcony is not fully connected to the wall, this causes a cold airflow, which is a disadvantage. I solved it by adding an extra strip to overcome the airflow."*



11. REGULATABLE DAYLIGHT

Magda: *"During the daytime I close the curtains to prevent overexposure when I am using my computer."*

5.3 CONCLUSIONS

Sometimes you think one interview is enough to understand the situation, preferences and daily life of the participant. But as shown in this chapter, you get to know a lot more about someone after doing more than one interview.

The personas defined after the first interview helped to make some first design steps. After the first evaluation it seemed that these design still missed some essential aspects according to the users. The second face-to-face interview made much more clear what the comfort demands and preferences were of the elderly.

These personas and demands should still be specified stricter, but are already a step forward in defining the design requirements for the final design.

6. OCCUPANTS' BEHAVIOR AND ENERGY CONSUMPTION

In 1980 about 75 percent of the energy consumed in the residential sector in the Netherlands was used for home heating (Verhallen & Raaij, 1981, p. 1). This percentage is reduced a lot already due to governments regulations on making buildings more energy efficient. Most of these measures are technical and relate to heating and ventilation installations.

Although these new building regulations reduced the energy consumption of households, Jeeninga et al. (2001) presented numbers of the actual energy consumption of households living in dwellings with the same theoretical energy performance. The energy consumption of these households can vary by up to a factor of two (Guerra-Santin, 2010, p. 14). This confirms the findings of DeltaWonen; the energy consumption of a building in the end always depends on the behavior of the users (2014). We are looking for the influences of occupants' behavior to these large variations in energy consumption and a way to bring these to further reductions in energy consumption.

Figure 51 shows the energy consumption of households between 1990 and 2012. The figure shows that the **gas consumption** in 2012 declined compared to 1990. This decline is the consequence of improving the insulation of dwellings, replacing installations for more efficient ones, more new buildings, etc.

The figure also shows that since 1990 the **electricity consumption** increased and gets more stable now. This increase can be declared by the raising amount of technical devices occupants use in their houses.

As figure 52 shows more than 75% of the **gas consumption** goes to space heating. Followed by domestic water heating and cooking (Energieloket, 2013):

- Cooking	50 m ³
- Domestic water heating	300 m ³
- Space heating	1.150 m ³

In households most of the **electricity consumption** goes to cooling, cleaning, lighting and domestic water heating (figure 53).

According to the energy neutral facade *space heating*, *cooling* and *lighting* are most relevant for this research. In the next paragraphs these will be discussed in detail.

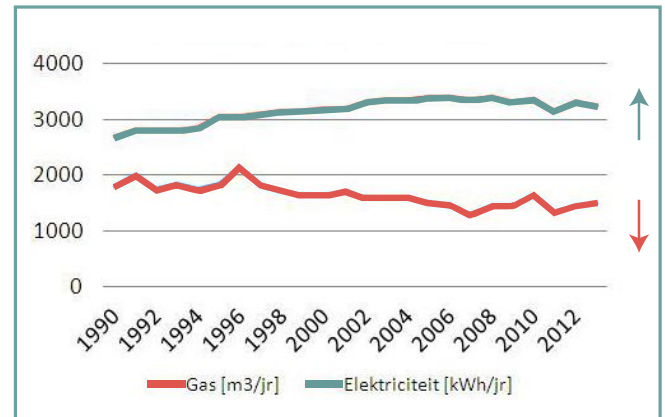


Figure 51; Energy consumption households (Energieloket, 2013)

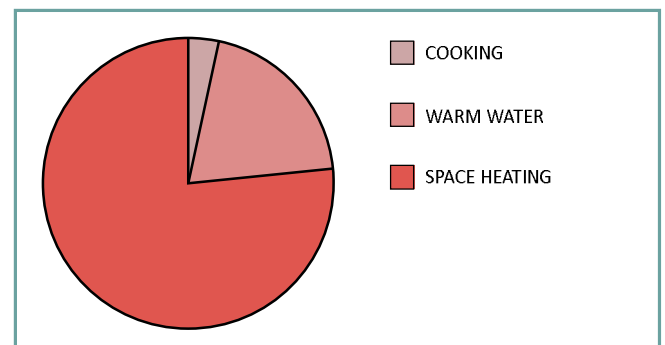


Figure 52; Gas consumption households (Energieloket, 2013)

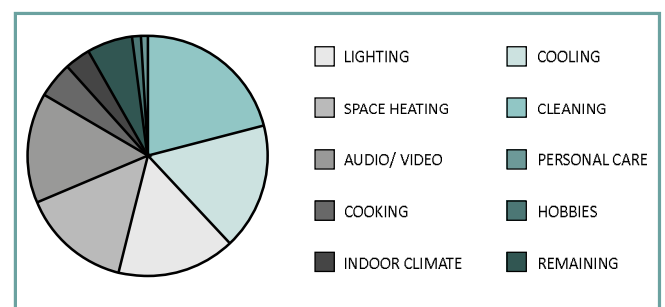


Figure 53; Electricity consumption households (Energieloket, 2013)

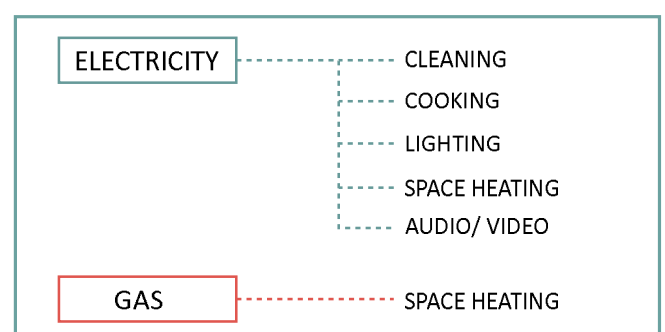


Figure 54; Summary figure of energy consumption (own illustration)

6.1 DIFFERENT INFLUENCES OF OCCUPANTS' BEHAVIOR ACCORDING TO ENERGY USE

Olivia Guerra-Santin did a broad research on the effect of energy performance regulations and occupant behavior. Building and household characteristics have a big influence on occupants' behavior according to energy consumption (*Figure 55*).

Also the type of dwelling has an influence on the amount of energy consumption. *Figure 56* shows the gas consumption of different types of dwellings. A detached dwelling uses about 45% more than the average gas consumption of all different dwelling types. A 2-under-1-roof dwelling uses approximately 10% more than average and a corner dwelling about 8% more than average. A terraced dwelling uses 10% less than average and a flat-floor dwelling even 30% less than average (Menkveld, 2009, p. 5).

Building characteristics (like building type, heating system, ventilation system, window glazing type, etc.) influence the behavior of the occupants. For example, if the residents have a manual valves radiator they will use their heating system differently than people who have a programmed thermostat.

Secondly the household characteristics (like income, household size, presence at home, presence of elderly etc.) have an influence on the occupants' behavior. For example elderly mostly prefer a higher inside temperature than occupants of other ages.

The occupants' behavior itself is also dependent on the type of user, personal background, attitudes, perception of comfort, lifestyle and preferences. All these different influences are shown in *figure 57* (Guerra-Santin, 2010, p. 89).

While building characteristics get improved due to the stricter energy regulations, we have to look at the behavior according to energy consumption. In this range four domains are important according to energy consumption for dwellings:

- Use of heating system;
- Use of ventilation system;
- Use of rooms and presence at home;
- Use of lighting.

These domains will be discussed in the next paragraphs.

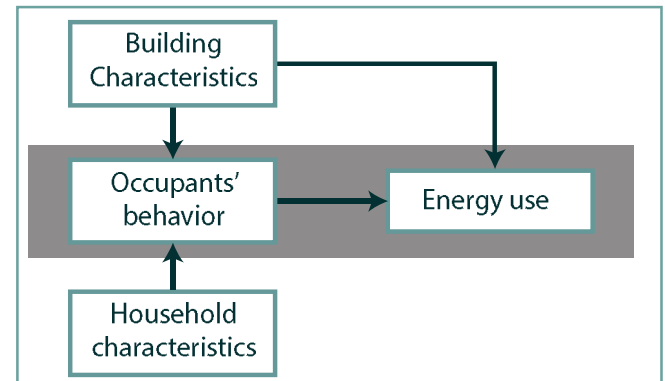


Figure 55; The effect of occupants' behavior on energy consumption (Guerra-Santin, 2014, p.89)

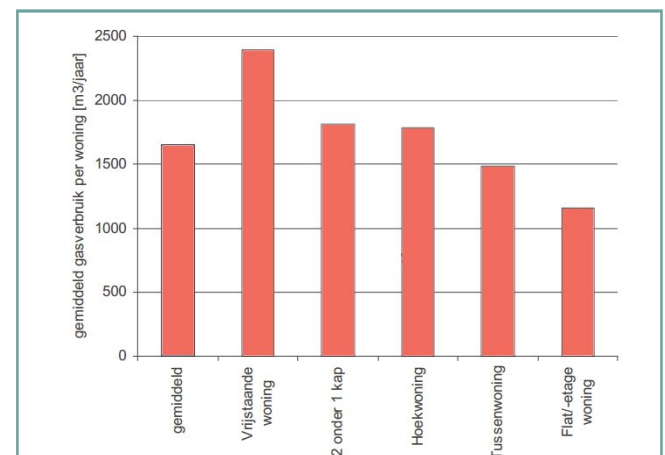


Figure 56; Overall gas consumptions by dwelling type (Menkveld, 2009, p.5)

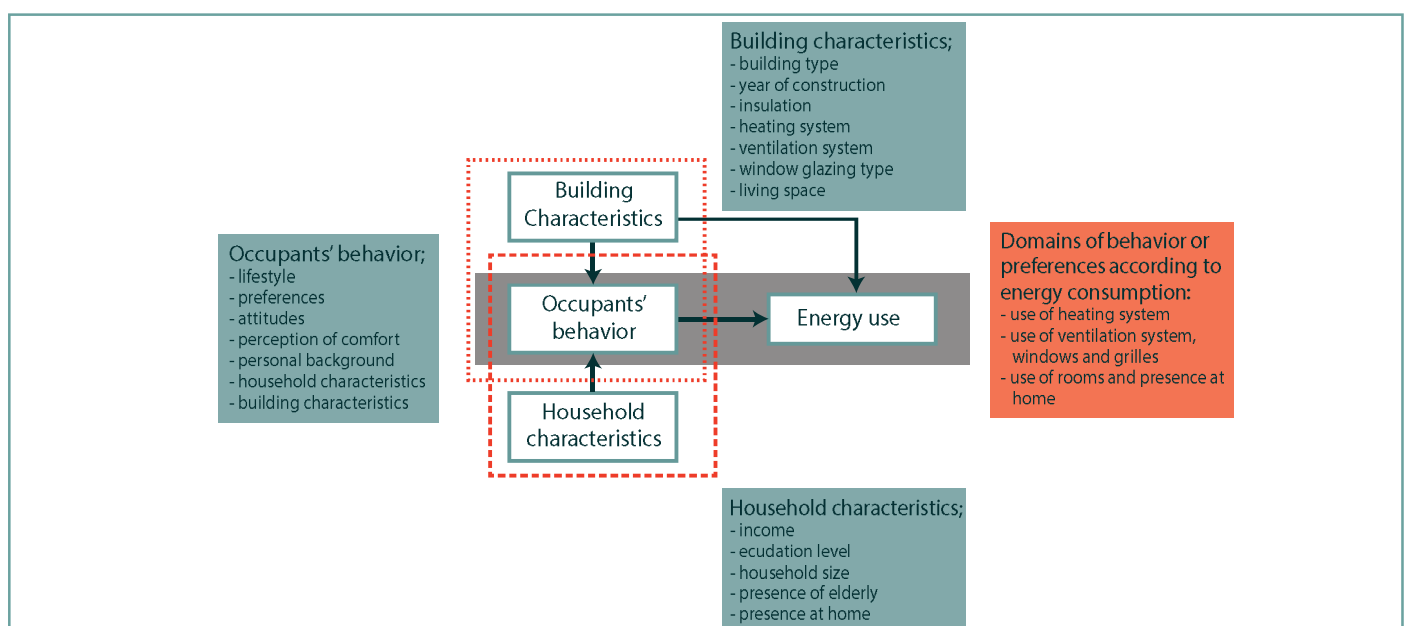


Figure 57; The effect of occupants' behavior on energy consumption, elaborated (Guerra-Santin, 2014)

6.2 OCCUPANTS' BEHAVIOR ACCORDING TO HEATING

Figure 58 shows the development of the average gas consumption of different dwelling types. The average gas consumption is reduced from ca. 3150m³ per dwelling in 1980 to ca. 1950m³ per dwelling in 1999. This reduction is mainly caused by the strict insulation rules and the improvement of the efficiency of the boiler, as a consequence the energy consumption for space heating is reduced.

Also changes in lifestyle have a big effect on the reduction; the average attendance rate at home reduced and the average family size decreased (Jeeninga et al., 2001, p.31).

Figure 59 shows the development of the average gas consumption for space heating per dwelling type. The figure shows that for all type of dwellings the gas consumption reduced a lot between 1980 and 1999 (Jeeninga et al., 2001, p.32).

Since 1999 the energy consumption rules on space heating became stricter. Energy consumption for space heating is reduced a lot already, but could be reduced more when you look at the results from the research of Olivia Guerra-Santin. The results show that the amount of energy consumption depends the most on the type of heating system (Guerra-Santin, 2010, p. 109) and the way occupants use their heating systems.

While most occupants think they save energy by using a programmable thermostat instead of using a radiator with manual valves, Guerra-Santins research shows the opposite (Figure 60).

Households with a programmable thermostat tend to have their radiators on for more hours a day and more rooms heated than households with a manual thermostat or radiators with manual valves.

The reason of this high energy consumption for people with a programmed thermostat is because they have their heating programmed on a high temperature when they are at home and on a lower temperature when they are absent. While manual valves radiator users put off their radiators when absent. So the amount of usage hours have a stronger effect on energy consumption than temperature setting.

6.3 OCCUPANTS' BEHAVIOR ACCORDING TO VENTILATION

Households with mechanical exhaust ventilation use their ventilation systems fewer hours per day than households which make use of balanced ventilation (Guerra-Santin, 2010, p.109) (figure 61).

Households tend to ventilate more often with grilles and windows than with mechanical ventilation. Windows were usually open for a few hours a day, grilles were usually closed or open all day (Guerra-Santin,

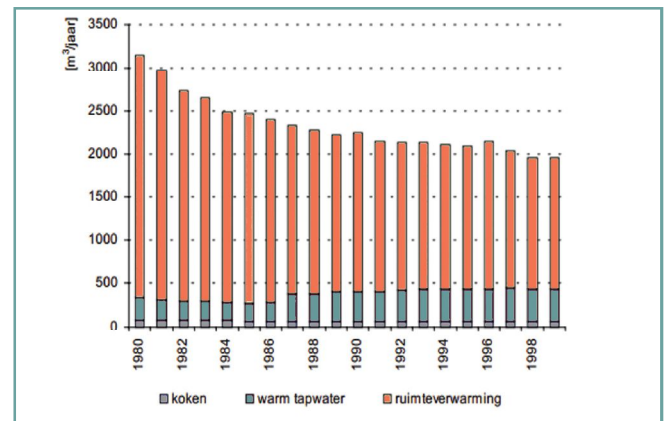


Figure 58; Development of average gas consumption for space heating, domestic hot water and cooking for homes with a connection to the natural gas network (Jeeninga, Uytterlinde, & Uitzinger, 2001, p.31)

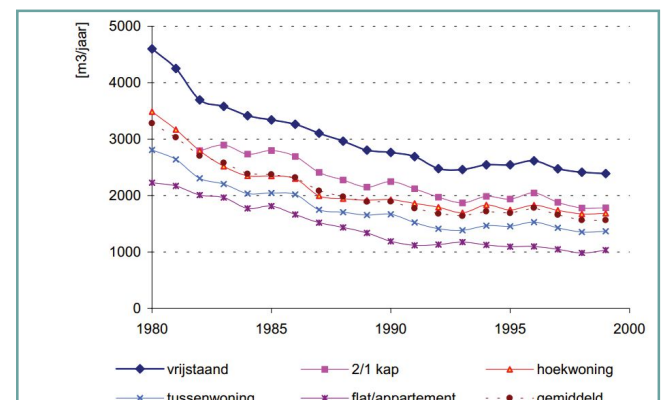


Figure 59; Development of average gas consumption for space heating per dwelling type, for homes with an individual central heating installation (Jeeninga et al., 2001, p.32)

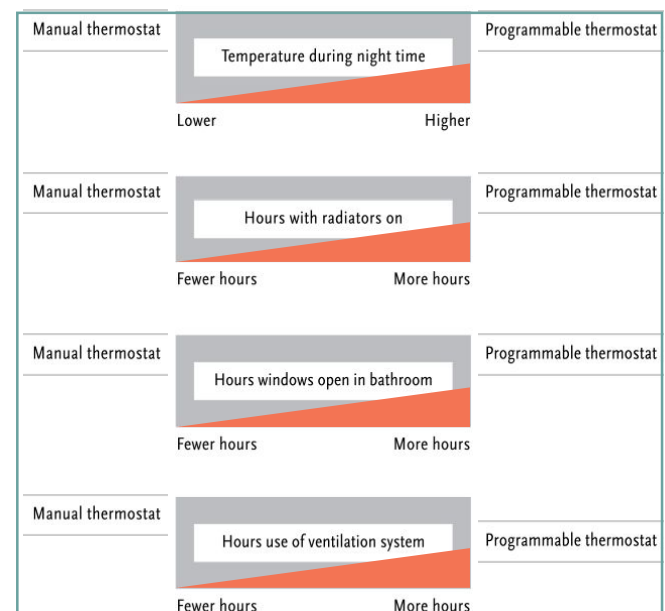


Figure 60; Relationships between the type of temperature control, use of the heating system and energy consumption (Guerra-Santin, 2010, p. 109)

2010, p.111). Half of the respondents always kept the grilles open (Guerra-Santin, 2010, p.111) and most of the respondents always kept the windows open in bed- and bathrooms (Guerra-Santin, 2010, p.112).

Households with a mechanical ventilation system kept the system either always off or at the lowest setting (Guerra-Santin, 2010, p.112).

By ventilating your home enough, you can also save heating costs. When there is too much moisture in your room in the morning, it is harder to heaten up your room again (it costs more energy) (Vestide, 2014).

Too less ventilation can cause moisture, but also odour air and harmful polution (Vestide, 2014).

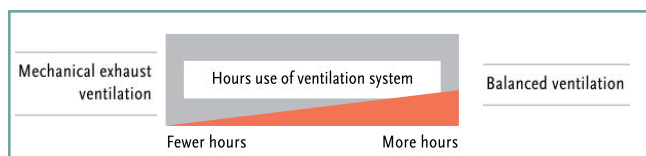


Figure 61; Relationships between the type of ventilation control and use of energy consumption (Guerra-Santin, 2010, p. 109)

6.4 OCCUPANTS' BEHAVIOR ACCORDING TO USER TYPE

Presence at home of course has an influence on the amount of energy you use, especially the presence of elderly.

Elderly prefer higher temperature settings than households without elderly (Guerra-Santin, 2010, p.115). Households with elderly are also more hours present at home than others.

Elderly tend to keep their windows open for fewer hours per day in living room and bathroom than households without elderly (Guerra-Santin, 2010, p.116).

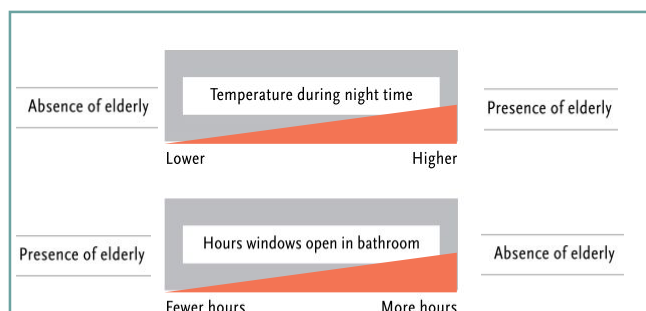


Figure 62; Relationships between the type of temperature control and the presence of elderly (Guerra-Santin, 2010, p. 109)

6.5 OCCUPANTS' BEHAVIOR ACCORDING TO LIGHTING

Especially for elderly lighting is important because of the deterioration of their eyes. Elderly need more (day)light than others.

In figure 63 different lamp types are compared according to energy consumption. The graph shows that LED and energy saving lamps are most energy efficient.

Besides that daylight is an important light source. It does not only provide light, but also vitamin D. Vitamin D contributes to the health of elderly's bones and muscles.

When the transparency of the facade is large and elderly are able to regulate the let in of daylight, they will use the artificial lighting inside less.

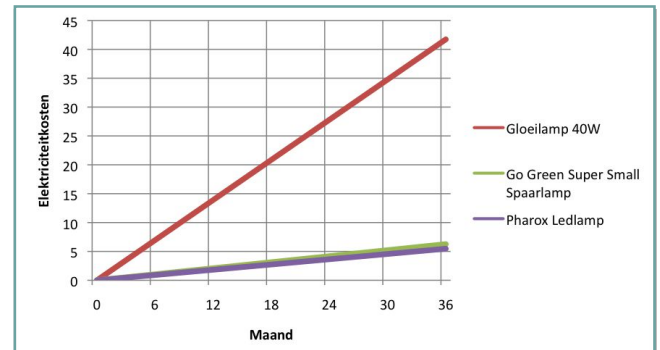


Figure 63; comparing energy costs between incandescence, LED and energy saving lamp (Agt v., 2009)

(Day)light has a big influence on the day- and night rhythm of elderly. When too little light reaches the eyes, people get tired sooner. Besides that different activities require different light intensities, so the light intensity should be adjustable. Also the colours of the light can have an influence on behavior. Light with a green-bluish colour prevents the sleepy feeling most (van Hoof, Schoutens et al., 2007, p.16). Furthermore daylight has an influence on the increase of the body temperature (van Hoof, Schoutens et al., 2007, p.16).

6.6 CONCLUSIONS

Figure 84 on the next page shows some important findings on energy consumption according to energy use in Dutch dwellings. These findings are explained in the text below, and translated in conclusions which will be used as design drivers in the design process.

TYPE OF HEATING

Households with different types of heating systems consume different amounts of energy according to space heating. Households with a programmable thermostat tend to use their heating system for more hours a day and heat more rooms per day and households with radiators with manual valves appear to be the least energy consumers, while most people think the opposite.

Users turn out to be more aware of their energy consumption when they have to control the temperature each day by themselves instead of using a preprogrammed device that controls the temperature for them.

So, to make people save more energy, they should be made more aware of their energy consumption. This should be done by a device that does not only trigger them to undertake an action, but also makes them aware regularly.

TYPE OF VENTILATION

Households tend to ventilate more often with grilles and windows than with mechanical ventilation. While mechanical ventilation (with heat recovery) is much more energy efficient than ventilating by opening windows or grilles, especially because households with grilles mostly keep their grilles open all day.

Households do not seem to realize the importance of ventilation according to their health and energy consumption. Occupants should be made more aware of the importance of ventilating.

The implementation of a sensed device that shows the health of the indoor climate should make the occupants more aware of the importance of ventilating. Besides that there should be a link between ventilating by mechanical ventilation or by opening windows, so windows won't be open simultaneously while ventilating by mechanical ventilation. Especially during the wintertime the occupants should be made aware of the advantages of ventilating by mechanical ventilation (with heat recovery).

PRESENCE OF ELDERLY

The presence of elderly correlates with higher temperature settings and fewer hours of ventilation. Elderly prefer higher temperatures and therefor also tend

to ventilate less. While a healthy climate is important especially for elderly because of their longer presence at home and higher chance on deterioration.

TYPE OF ROOM

The living room seems to be the most energy consuming room. Fifty percent of the respondents always keep their radiators on and simultaneously fifty percent of the respondents always keep the grilles open in the living room.

A larger percent of the respondents always kept the windows open in bed- and bathroom.

Occupants should be made more aware of their energy consumption according to opening windows and using the heating system at the same time.

LIGHTING

Elderly need more (day)light than others because of the deterioration of their eyes. The inside lighting lamps should be energy efficient. Besides that the facade should be transparent for a large part (large window surface) to save lighting costs and provide daylight. Large openings of the facade should be possible to provide vitamin D to elderly.

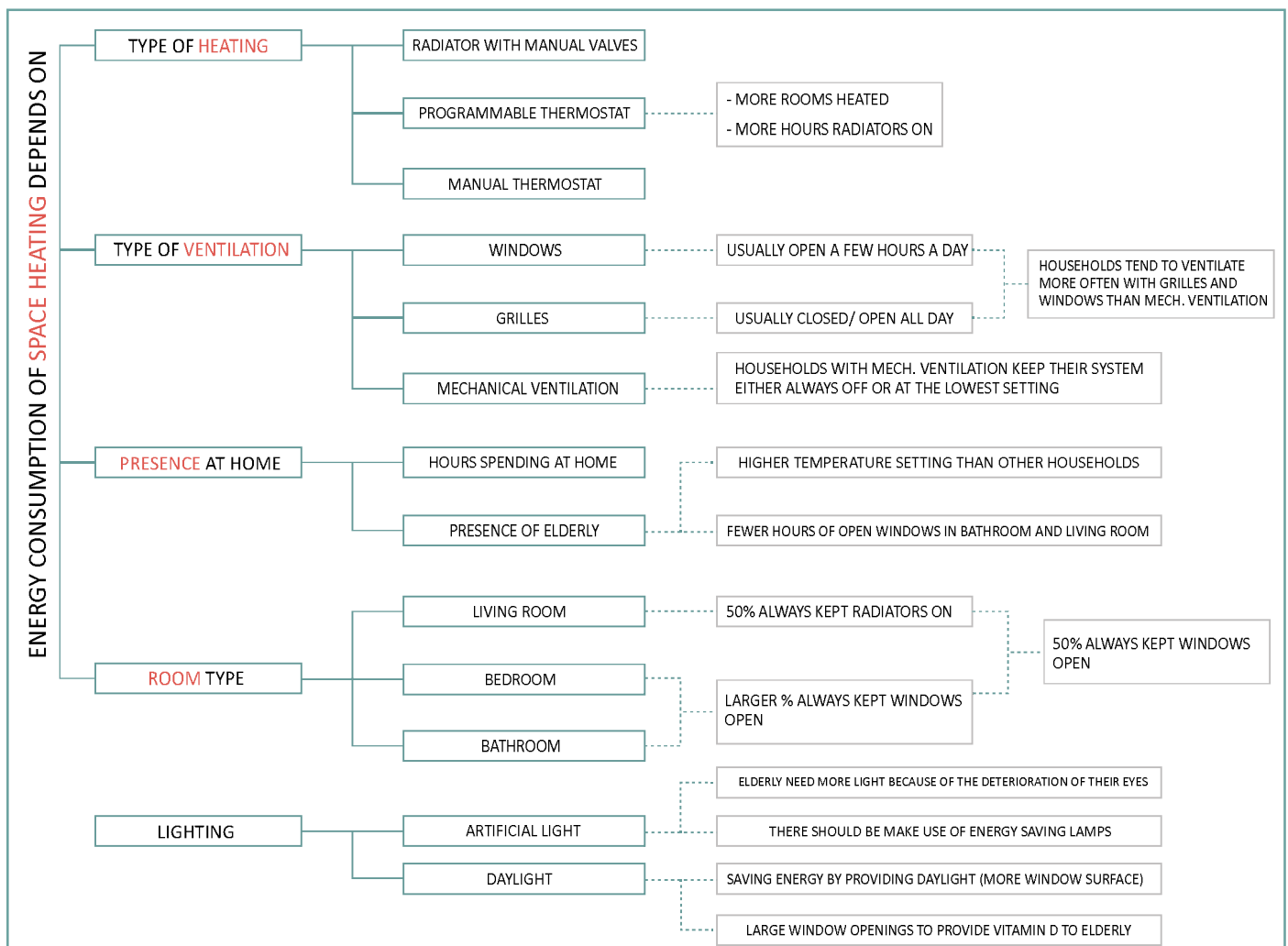


Figure 64; Findings energy consumption according to occupants' behavior (own illustration)

7. DESIGNING FOR THE DESIRED BEHAVIOR

The 2nd skin project aims to develop an integrated and effective renovation solution for porch apartments in the Netherlands. Today the differences in energy consumption between different households are huge, we need to get more insight in the relation between energy consumption and the users. The endeavor is to ensure the zero-energy target, in which both building-related and user-related energy consumption are considered. So, to achieve these energy neutral buildings, not only building regulations get stricter, but also a change in user behavior is necessary. In the end the energy consumption of a building depends on the behavior of the user(s) (DeltaWonen, 2014). Encourage people to change their behavior are generally about trying people to do something, or trying people not to do something. Many strategies have been developed to explore which methodology works best to achieve users to consume less energy.

The goal of the 2nd skin project is to develop a methodology for a zero energy approach in renovation projects. To reach this, part of the strategy consists of monitoring and evaluating the right feedback to the users to decrease their energy consumption. Different devices have been developed to monitor, evaluate or even manage the energy consumption of occupants. Different types of these management systems will be discussed in this chapter.

7.1 SMART METER

Smart meters (*figure 65*) are intended to benefit the gas or electricity supplier and distributor (Dam, 2013, p.35). These meters record the energy consumption in intervals of an hour or less and communicate these back to the supplier and distributor.

One benefit of the smart meter is the end to estimated bills (Wikipedia, 2015). A second benefit is that smart meters provide up-to-date information on the energy consumption of a household, they give occupants more insight in their daily consumption (Wikipedia, 2015). Still many occupants have no idea what the numbers on their smart meters say. There the 'home energy management system' comes in.

Paragraph 7.2 will give an extended explanation about 'home energy management systems' and in what way these should be designed.



Figure 65; Smart meter (Wikipedia, 2015)

7.2 Home Energy Management Systems (HEMS)

Home energy management systems (HEMS) cover a wide range of devices like energy monitors, eco-feedback devices and energy consumption indicators (Dam, 2013, p.34). HEMS are developed to provide households accessible insight into their energy consumption (gas and electricity) by visualizing, managing and/or monitoring the energy use of products of entire households (Dam, 2013, p.35).

HEMS are intended to help the users to reduce the overall energy consumption of their household, this makes them different from smart meters (Dam, 2013, p.35). HEMS really focus on the computer-human interaction, where smart meters don't (Dam, 2013, p.85). Still households differ so much, that we have to take all influencing factors into account. *Figure 66* shows a framework of influencing factors on the use and effectiveness of HEMS.

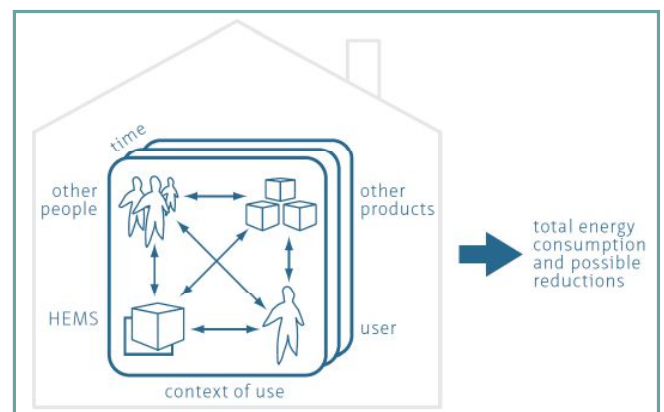


Figure 66; Framework on factors influencing the use and effectiveness of HEMS (Dam, 2013, p.82)

Variables	Explanation
Type of energy measured	Gas and/or electricity
Level of feedback	Differs, e.g. feedback on overall household utility consumption, detailed information for separate appliances (disaggregated) or limited to one appliance.
Type of feedback	Varies from factual (e.g. showing real-time, numerical consumption data) through social (e.g. using smiling/frowning faces) to comparative (e.g. current versus historical consumption data).
Strategies to influence energy consumption	Monitors: only give feedback, leaving it to the user to decide whether to act on the feedback Managers: (also) help users control whether and, if so, when their appliances consume energy.
Architecture of the HEMS	Varies with regard to mono-functional or multifunctional, type of interaction and physical location of HEMS (e.g. local appliance-specific solutions, central in-home touchscreens, online web applications).
Intended purpose	Varies: achieving energy savings within the home or peak shifting of the grid load, i.e. creating a more even grid load.

Figure 67; Typology of HEMS (Dam, 2013, p.35)

As we saw in the chapter of the user profiles/ personas, users differ a lot. Therefore HEMS cannot be designed into one right product for everyone. HEMS have six variables to try to meet people's different preferences. These six variables are (figure 67):

- The type of energy measured (gas and/or electricity);
- The level of feedback (feedback on overall household consumption, information for separate appliances, feedback to just one appliance);
- The type of feedback (factual, social or comparative, figure 68);

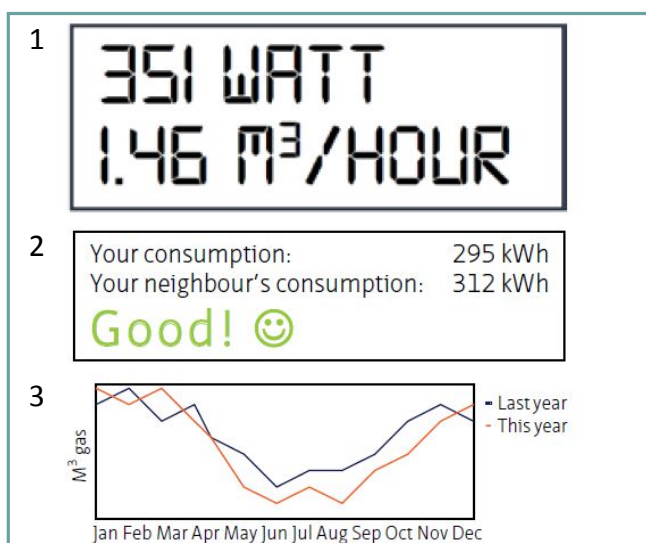


Figure 68; Different types of feedback (1: factual feedback, 2: social comparative feedback, 3: historical comparative feedback) (Dam, 2013, p.107)

- Strategies to influence energy consumption (Do they only monitor or also manage the energy consumption?);
- The architecture of the HEMS (touch screens, online

web applications, standby-killers, etc.);

- The intended purpose (energy saving or peak saving) (Dam, 2013, p.107).

HEMS visualize the energy consumption in a way that the users can mentally interpret the actual energy figures (Dam, 2013, p.109).

Unfortunately most of the time HEMS slowly drift into the background of people's attention. This could be explained by the fact that at a certain point users understand their energy consumption patterns more and more and thereby use their HEMS less. But of course it can also be expected that people loose interest in using the HEMS. Sonja van Dam (2013, p.110) gives three possible solutions to prevent HEMS from drifting into the background:

1. We should make people develop habits around the HEMS, by increasing the interaction with HEMS. Existing habits are seen as a major problem for energy reduce, new sustainable habits take time to develop (Dam, 2013, p.111).

2. The design of the HEMS and the feedback could be improved by doing more long-term case studies on the use of HEMS and the behavior patterns around them.

3. Or the third option could be to implement a HEMS that does not only monitor but also manages the energy of a household. It is claimed to have a positive influence on the users, but still feedback is essential to make sure people stay aware of the amount of energy they use.

Besides focusing on the different variables, the personas should be in the starting point of designing a HEMS. HEMS are mainly successful if they are targeted at specific users (Dam, 2013, p.122). As we take the personas from chapter 5, we need to design HEMS for five different user profiles;

1. The “*EASY COMFORTABLES*”

The “easy comfortables” are often people who have certain habits according to their comfort and energy consumption. These habits are not easy to change, but could be changed over a longer timespan (Dam, 2013, p.111). The type of feedback shouldn’t be too detailed, but should give social comparative results. In this way the occupants are easier to convince to change their behavior habits (Dam, 2013, p.107).

2. The “*ALL TIME SAVERS*”

“All time savers” often don’t need to save money and be frugal, but still they maintain this lifestyle and don’t want to spend money unnecessarily (Dam, 2013, p.164). For them a HEMS which can be used to find out and how to save money works best (Dam, 2013, p.165).

3. The “*SPENDERS*”

The “spenders” enjoy living to the full. “Spenders” usually need a frame of reference to compare their energy consumption with. They are not interested in numbers, but the use of colours is more understandable for them (Dam, 2013, p.165). Their motivation to use HEMS lies in the certain amount of mistrust they have towards their energy suppliers and energy bills. A working application for the “spenders” would be a ‘suspicion checker’, that shows the users what the cause of energy peaks is (Dam, 2013, p.165).

4. The “*MOBILITY SUFFERERS*”

The raising question for the “mobility sufferers” is the architecture of the HEMS. Should the HEMS be portable or fixed and where should it be placed? Elderly suffer most from mobility and reaching disorders. The HEMS should therefore be placed on a spot which is reachable when sitting down.

5. The “*SIGHT SUFFERERS*”

The “sight sufferers” have glasses to read, but while ageing also contrast between colors becomes more important. So, HEMS for the “sight sufferers” should be designed with suitable contrast patterns for elderly. Also the size of the letters and figures should be adjustable.

As we can conclude from discussing these different personas according to the use of HEMS, there isn’t a ‘one-size-fits-all’ approach for home energy management systems (Dam, 2013, p.122). While designing HEMS for these different personas, focus points should be:

- Creating the right triggers at the right moments;
- Increasing simplicity;
- Comparing their energy consumption with the consumption of other households (Dam, 2013, p.113).

Still we see enough households with different reasons for the non-use of HEMS. A lot of reasons for the non-use of HEMS are very technical (errors in the software, technical problems that led to confusion, feedback not functioning well, daily transmissions of information not correct, etc.) (Dam, 2013, p.168). But of course there were also enough non-technical problems that still have to be solved;

- The loss of interest over time;
- Disinterest in numbers and figures;
- The desire for comfort and seeing energy as a necessity to achieve that;
- The money that can be saved does not warrant the effort needed to save (Dam, 2013, p.168).

To find out in what way these problems could be solved, Sonja van Dam did different case studies. From these case studies she composed various ‘design related guidelines’. These guidelines, the variables of the HEMS and the different personas combined should lead to different useful HEMS for the 2nd skin project.

The most relevant and important ‘design related guidelines’ are listed below;

- HEMS should be integrated in an overarching change strategy, they should not be installed as standalone interventions (Dam, 2013, p.265);
- The HEMS should be aimed at different user types in order to ensure the goal of using the HEMS right will be reached (Dam, 2013, p.265). The designer should use a user-centered design approach, using for example different types of feedback (Dam, 2013, p.272);
- The designer of a HEMS should consider how to create positive dialogues between household members, for example through social games (Dam, 2013, p.267);
- The HEMS should be designed to make energy reduction easy (Dam, 2013, p.272);
- HEMS should also support users who have little knowledge about energy consumption and the technical installations around them (Dam, 2013, p.272);
- HEMS should focus on creating daily habits for users, for example a ritual of checking the HEMS (Dam, 2013, p.272);
- Solar panels and solar collectors should also be implemented in the feedback information of the HEMS and in this way be promoted (Dam, 2013, p.272).

7.3 DESIRED BEHAVIOR

Besides reducing the energy consumption, this research focuses on the healthy life of elderly. The endeavor is to let elderly age in place longer in a healthy and energy efficient way.

The best method for designing for behavior change depends on the goal of your design. When starting to design for behavior change, three steps should be clear before choosing the method:

1. Select the desired target behavior for your design;
2. Make sure the desired behavior is easy to do;
3. Ensure a trigger will encourage the desired behavior (BehavioralStrategies, 2012).

In this thesis different behavior endeavors have been researched and discussed. The most important desired behavioral aspects that have to be achieved are listed below:

- Trigger the occupants to ventilate more (to make sure their indoor climate stays healthy);
- Trigger elderly to sit outside more (to make them more exposed to the sun, which provides them vitamin D);
- Trigger the occupants to ventilate by mechanical ventilation (especially in winter when they avoid opening windows);
- Trigger the occupants to be more aware of their energy consumption and reduce it, trigger them to habits (as seen in the research about pre-programmed thermostats, we should trigger people to stay alert and be aware of their energy consumption instead of programming their device ones);
- Trigger the occupants to not use the heating system at the same time as opening the windows (but mechanical ventilation with heat recovery simultaneously with heating system on is OK);
- Trigger the occupants to not use the mechanical ventilation system at the same time as opening the windows (this confuses the mechanical ventilation system).

The next steps which should be made, are to make sure the desired behavior is easy to do and ensure a trigger will encourage the desired behavior. These will be elaborated in the design chapter.

7.4 CONCLUSION

The final design for the 2nd skin project will technically be much more energy efficient than the skins that these apartments have now. The new skins will not independently achieve the goal of energy neutral buildings in 2020, the occupants are on influence too. Therefore smart systems have to be designed which trigger the occupants to behave energy efficient and thereby reduce energy.

As we saw in the research from this chapter, there are already a lot of devices developed to trigger occupants to reduce their energy consumption. Still we have to take in mind that different users interact different with these devices, so different designs of these devices should be provided to ensure all different user profiles will act right. Hereby the six different variables of the HEMS should help to design for these different personas. The 'design related guidelines' that Sonja van Dam has drafted after several case studies will help to design better HEMS.

Besides saving energy, the focus should also be aimed at the healthy life of elderly as discussed in the previous paragraph. This means that a HEMS as they now exist would not fit to the assumptions we want to reach. There is much more to answer. The design chapter will elaborate this further.

III. DESIGN DIRECTIONS

This section provides a translation of the research part into design requirements. Firstly a vision will be given on the outcome of the research and a direction in which the problem statement can be (partly) solved. Chapter 9 will specify the design requirements. Chapter 10 will show these design requirements translated into different design concepts.

8. VISION

In this chapter the research part is translated into a vision. The vision does not provide specific design requirements yet, but gives a long-term perspective on what to achieve in future. This vision will help to define the design requirements which are elaborated in the next chapter.

8.1 VISION

To achieve the goal of energy neutral buildings in 2020, we have to live much more energy efficient than we do now. New technologies will be implemented to achieve this goal. These technologies should also improve the independent and healthy life of elderly. The question is how to achieve these goals in future perspective. 'How will elderly be taken care of in future?', 'Which technologies are they able to use?', 'Which technologies should be implemented in their lives and which shouldn't?', 'What technologies will be implemented in the façade in future?', etc. This chapter will give a future perspective of the energy neutral façade and healthy life of elderly according to the facade.

1. VISION ON WELL-BEING OF ELDERLY

In future much more elderly have to age in place, and often they have to grow old on their own. Houses have to be arranged in a way that elderly are able to live independently as long as possible. Deteriorations shouldn't give problems or should be prevented or postponed. New technologies and smart solutions should stimulate elderly to undertake actions which benefit to their mental and physical health.

The most common deterioration factors elderly face are mobility disorders (reaching and walking) and sight disorders. Their environment should stimulate them to go/ sit outside more to make sure elderly catch more sunlight and thereby create vitamin D (which benefits the strength of their bones and muscles). Besides that daylight is good for their mental health and their vision. Elderly need more light while ageing, so enough (day) light is necessary to do their daily activities. A transparent façade is therefore desirable. In future more focus will be targetted on the transparency of the facade and the connection with the environment according to elderly.

While technologies change over time, elderly do too. The generation of elderly of today are already much more into technologies than the generation of 10 years ago. A lot of elderly are already used to smart phones, laptops, etc. Especially the future generations won't

have problems using these devices. However, it must be taken into account that with certain deteriorations (like sight disorders) technical devices should be designed especially for elderly (they need more contrast between colors, bigger letters, etc.).

Contact with the environment is not only desirable to make sure the elderly catch enough sunlight, but it also contributes to their mental health. An outdoor area is therefore preferable. The area should be adjustable to many comfort aspects (wind, sunlight, rain, cleanability, insects, privacy, etc.). Therefore more focus will be directed to the comfort and health preferences of elderly to stimulate them to go outside.

Another question that could be raised is how we could make sure elderly are not too far deteriorated to live independently. How can we make sure they are taken care of in time?

Of course family and neighbours play an important role in this situation, but not all elderly have the ability to count on family or neighbours. Installing cameras could prevent elderly to be found days later in their home, but it also causes privacy issues. Other technologies should be implemented to improve the independent life of elderly. For example sensors in the floor/ ceiling/ wall could provide information on where occupants walk and sit during the daytime. If they stay on a certain place for a very long time, a camera could be switched on to see if the person is being fine or not.

So in future elderly should live more independently while new technologies try to make their lives healthier and easier. Monitoring technologies will provide control over their deteriorating lives.

2. VISION ON LIVING ENERGY NEUTRAL

The final goal is to achieve the target of energy neutral buildings in 2020. While in the end the energy consumption always depends on the habits of the occupants, this habits should be guided to an energy neutral mode.

As we see now, a lot of devices already inform occupants about their energy consumption. Smart meters and home energy management systems are implemented in their homes to show them their energy consumption. These devices are mainly meant to convince occupants to save energy, but often these devices get into the background after some time. Research shows

that different user profiles require different information on such devices. Some occupants want to know in detail where their energy is going, while others just want to know if they are being more energy efficient than their neighbours or not. It should be possible to set your home energy management system to your personal preferences of information output.

Besides that, these home energy management systems now only focus on the amount of energy you consume, while the health of the indoor climate is also very important (especially for elderly). Elderly tend to ventilate too little, they should be stimulated to ventilate more and thereby improve their physical health. An extra feature on these home energy management systems could improve their behavior towards ventilating. Occupants prefer to ventilate by opening windows instead of using a mechanical ventilation system. They often have the idea that ventilating by opening windows is much more efficient than using a mechanical system, because ventilating by opening windows gives a much 'fresher' feeling of ventilating your room. By making people aware of the efficiency of mechanical ventilation, occupants could be triggered to use the mechanical system (with heat recovery) more (especially in winter) and thereby reduce their energy consumption.

On the other hand occupants have to be triggered to overcome over-ventilation. Many households lose a lot of energy by keeping their windows or grids open all day (simultaneously with their heating system on) while this isn't necessary. People should get a better perception of the amount of ventilation hours per day they need (compared with the amount of hours they spend at home). This could also be implemented in the home energy management system.

Home energy management systems monitor and/or manage the energy consumption of occupants. In future more and more the energy consumption of households will be managed by these devices, but still people prefer to have control over their own comfort. Besides that, people are much more aware of their energy consumption when they have to control systems manually. We only have to trigger them to undertake the certain actions regularly to save energy. So devices should be designed partly with automated features, but should still trigger to be aware of their energy consumption.

3. FUTURE FAÇADE DEVELOPMENT

The home energy management systems will be more and more integrated with the facade element itself, as the NEXT active facade concept shows. In future these devices will be integrated optimally. Still occupants and buildings demand different compositions and contents of these NEXT active facade elements, therefore these elements should be flexible in shape and in context.

Besides that, new strategies will be presented to give occupants more opportunities to realize their preferences according to the composition of facade elements. Many research is done now in for example 'leasing facades'. People get more options in designing their own customized façade.

These options can differ in replacing the whole façade or adding just elements of their preferences.

The different user profiles of elderly also have different preferences, they should have the opportunity to go for different façade aspects to create a façade which benefits to their personal comfort. These options will not only be determined by the occupants themselves, but advice will be given to show the occupants which options work best for their facade (according to the wind direction, incoming sunlight, ventilation, etc.).

To generate these different replacable facade elements new strategies will be used to reduce the costs. Nowadays strategies are developed to lease facades. The different replacable facade elements will also be leased more and more in future.

8.2 CONCLUSION

As my vision already explained we need to take into account that the future will bring a lot more and new technologies and strategies.

Elderly will be able to use new technologies until a certain level, but we should keep in mind that not everything should be automated to prevent fast deterioration. The technologies should not only provide energy efficiency, but also comfort. Otherwise the occupants won't be interested enough and won't use the devices in the desired way.

The same goes for the energy neutral use of a facade. Some actions or systems could or should be automated, while others shouldn't. New strategies should be developed to make sure occupants behave in energy efficient ways. Besides that strategies should be developed to integrate energy efficiency elements in the facade which could be controlled manually and automatically.

The design directions in the next chapter will go more into detail about what the design should look like and how it should operate.

9. DESIGN REQUIREMENTS

Paragraph 9.1 shows which different interaction levels between occupants and facades, based on observations, research and interviews. The second paragraph provides a narrative of the design requirements on the interaction between elderly and the facade, according to energy consumption, deterioration and health of the elderly.

The design requirements are listed into three categories; 'predetermined requirements', 'requirements according to the energy neutral use of the facade' and 'requirements according to the well-being of elderly'. These requirements are listed in paragraph 9.3. Paragraph 9.4 provides more necessary information on some of these requirements. Paragraph 9.5 presents a list of these determined requirements in short.

9.1 INTERACTION LEVELS FACADE

There are many different interaction levels between facade and user. The picture of *figure 69* shows some of these interactions.

The most important functions of the facade and therefore the most important interaction levels for elderly are:

- watching what happens outside;
- ventilate, by
 - opening a window
 - using the ventilation system;
- heating the room by keeping the windows closed and the heating system on;
- letting daylight enter the room;
- close the sunshade (glare protection);
- keeping the noise outside;
- listening to the birds outside;
- getting in contact with people outside;
- keep the insects outside (closing an insect protection screen);
- open/close the curtains;
- letting sunlight inside (they need vitamine D);
- feel safe inside (burglarly protection);
- watering the plants outside;
- drying laundry;
- sitting on the balcony (vitamin D);
- using the windowsill for objects.

These different facade functions and interactions should all be taken in mind when designing a new facade. The next paragraph will explain why some interactions are more important than others for this research graduation.



Figure 69; Different interaction levels (own illustration)

9.2 INTERACTION ELDERLY AND FACADE

The BAM 2nd skin project wants to answer the energy neutral goal by renovating porch apartments in Rotterdam. In 2020 new buildings have to operate 'energy neutral', but the renovation of existing buildings also contributes to the 'energy neutral' purpose. Simultaneously elderly have to age in place, because of the restricted care rules. The final goal is to trigger elderly to independently live healthy and safe, with an energy neutral approach. To reach this goal we need to know what the optimal conditions are for an energy neutral, healthy and safe life for elderly.

THE GERIATRIC GIANTS

As mentioned in the research part elderly deteriorate. One of the most common disorders is mobility disorders (the most common ones are reaching and walking). Therefore it is important to stimulate movement of elderly. On the other hand designing a facade to overcome mobility problems seems not to be the most effective way to prevent mobility problems. In fact activities and meetings organized especially for elderly would have much more effect on keeping elderly active and postpone mobility disorders. In case of designing an elderly proof facade according to mobility disorders, it is best to design a facade which still stimulates elderly to actively stand up to open a window for example, but give the occupants the opportunity to change their system to a more automated system if necessary. Of course with this you don't overcome all mobility disorders.

Design driver: All operations should be reachable for elderly (from a point of view that they are sitting). Operations which are hard to reach, should be motor driven. (The reachability of cleaning windows should also be taken in mind).

Not only movement contributes to prevention of mobility disorders, also daylight has a great impact. Vitamin D helps to keep bones and muscles healthy. Our body creates vitamin D under the influence of direct sunlight. Normally 2/3 of the vitamin D we need is created due to direct sunlight, the rest should be replenished by vitamin D supplements or food with vitamin D. So encouraging elderly to go outside or open windows to catch daylight should be supported.

Design driver: Support elderly to go/ sit outside and stimulate them to open windows. And besides that give the occupants the opportunity to sit outside to catch sunlight.

The second most common deterioration factors for elderly are sensory disorders, most difficulties are found in hearing and vision disorders. Elderly suffer from certain noise levels and frequencies. For example some elderly suffer from surrounding noises which seem very soft, but are in their perception very loud. Therefore they are retained to open a window. Noise insulation could in this case be a solvent.

Design driver: A noise insulation screen that still ventilates would support these elderly to open windows more.

As shown in the research part there are four main vision disorders. There cannot be given a solution to most of these disorders through the façade, mostly devices or surgery is needed to postpone or recover these problems. But what could be solved through the façade is the amount of (day)light elderly need. Elderly need more light than others because of the deterioration of their eyes. With enough (day)light elderly stay more aware, more active and get less cognitive problems. The transparency of the façade should in this case be as large as possible, but it should be possible to prevent overexposure.

Design driver: The transparency of the facade should be large, but elderly should have the option to regulate the amount of daylight that is coming in.

The third disorder of the four geriatric giants is related to the brain, cognitive disorders. Elderly living in porch apartments won't be elderly suffering from a far stage of dementia. In the end those patients will go to care institutions. But most elderly in the end will suffer from cognitive problems. Therefore interactions and operations should be understandable and easy for elderly. They have to be simple, not too detailed and effective. An interaction should provide comfort, otherwise elderly won't perform the way we want them to. By implementing an action/ interaction/ element in time, elderly are used to the action and are more able to use a design in the right way.

Design driver: New interactions should be implemented in an early stage. These interactions need to be tested to the different personas.

Incontinence, the fourth geriatric giant, is a disorder caused by several other problems. We cannot directly prevent incontinence by a façade design, but we can try to prevent or postpone the other geriatric giants which also have an influence on incontinence.

HEALTHY LIFE OF ELDERLY

To try to extend the independent life of elderly all discussed geriatric giants are important, but what in this case is a healthy life for elderly actually? This can be split in the physical and mental health of elderly. Physically elderly should be stimulated to keep moving till a certain degree. The accessibility and force should be tailored to their abilities. Besides that their physical health also contains a healthy indoor climate. The CO₂-level and humidity should be healthy, aligned with a comfortable indoor climate. From research we saw that elderly are not ventilating enough, we should encourage them to ventilate.

Design driver: Elderly should be triggered to ventilate enough, which contributes to a healthier indoor climate.

Their physical health could also be improved when they catch more sunlight (vitamin D), this is important for their bones and muscles but also for their awareness and activeness. A façade which provides large openings or gives the opportunity to sit outside is therefore desirable. Still the outside area has to be comfortable for elderly, an area protected against wind is therefore preferable.

Design driver: A facade which provides an outside area or big window openings, but the option of blocking the wind is desirable.

The mental health of elderly could be improved by expanding their environmental contact. This not only provides more social contacts (and prevents social isolation) but also helps to contribute to recovery of disorders. A transparent façade in this case generates contact with the environment. Because elderly mostly spend more time at home than others, they also sit in the living room more. From their chairs they should be able to look outside. A transparent balustrade would be preferable for the view of elderly, but a secure feeling at night should also be taken in mind. Contact with the outside environment also stimulates to go outside.

Design driver: Transparent balustrade, but give the occupants the option in the degree of transparency.

HEATING AND VENTILATION

Elderly have a higher temperature preference than other households. They are not willing to change their comfort level. What could be possible is to use colours to increase their perceived temperature and thereby reduce their energy consumption. Also in summer a different colour could perceive a lower temperature.

Design driver: Use of different colours could increase the perceived temperature of the occupants.

Elderly tend to ventilate less than others, while elderly need a healthy indoor climate most. In summer night cooling should be stimulated to improve their indoor climate. The CO₂ level and humidity level should be measured automatically to make them aware of the health of their indoor climate. Ventilating a room should be done fast to keep the preferred comfort of the occupants. The ventilation system and the action of opening a window should be linked to make sure the ventilation is efficient.

Design driver: Give occupants a better view in the health of the indoor climate and thereby stimulate them to ventilate more, but make sure they don't use the mechanical ventilation and natural ventilation at the same time.

The reason why occupants don't ventilate enough does not only lay in the reason that they have a higher temperature preference. They also want to avoid insects from flying in.

Design driver: An insect screen should be implemented to stimulate natural ventilation.

FAÇADE ASPECTS

When designing the façade different aspects have to be taken into account; maintenance, accessibility to plants, orientation of the façade, noise isolation, insect screens, safety, functions behind the façade, rainfall, etc. Different functions behind the façade demand different façade abilities. Balconies orientated to the south demand more space to sit outside, while balconies orientated to other sides demand space to for example dry laundry. Different zones for one apartment can demand different façade types, that have to be developed. Occupants should have the options to choose for different facade elements to add to their facade.

Design driver: A standard 2nd skin element should be designed, occupants can choose for extra options to add to this facade element.

OPERATION OF THE SYSTEM

The operation of the façade should stimulate elderly to keep moving at a certain level, not everything should be automated. Elderly should be triggered to take action in ventilating their room enough and be more aware of their energy consumption. A sensor which indicates the health of their indoor climate could trigger them to open/close a window. This sensor could be linked to the existing home energy management systems that already exist and are still being improved.

Design driver: Make elderly more aware of their energy consumption by implementing home energy management systems, but also make them more aware of the importance of ventilation according to their health.

9.3 DESIGN REQUIREMENTS IN 3 CATEGORIES

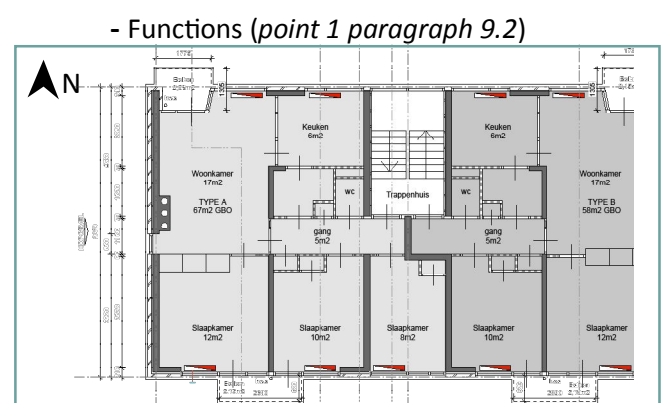
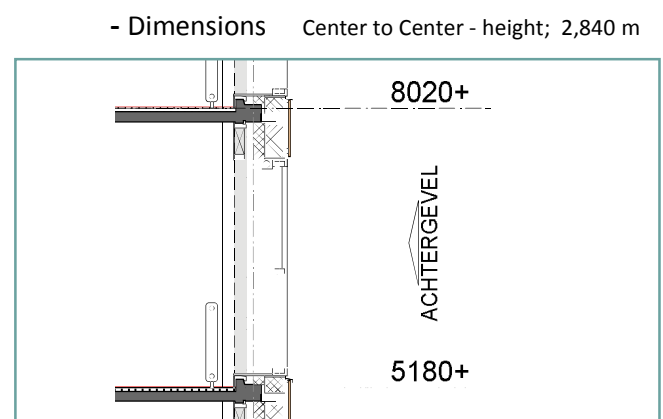
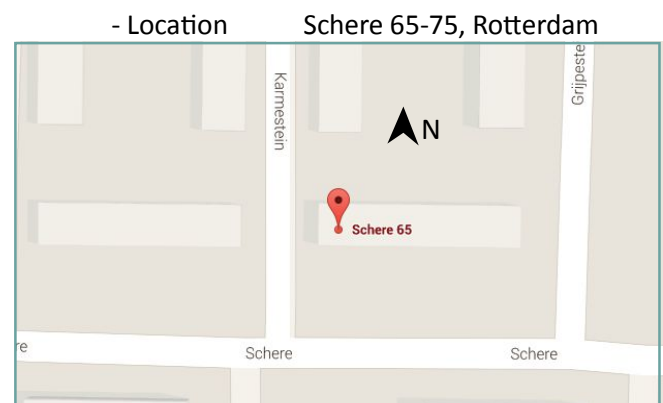
The design drivers that are formulated in the previous paragraph, were a step into defining the design requirements.

In this paragraph the design requirements are listed into three categories; 'predetermined requirements', 'requirements according to the energy neutral use of the facade' and 'requirements according to the well-being of elderly'.

9.3.1 DESIGN REQUIREMENTS ACCORDING TO PREDETERMINED REQUIREMENTS

A1. Applicable in the BAM 2nd Skin project

The facade element that will be designed should be applicable to porch apartments in the Netherlands. The BAM 2nd Skin project in Rotterdam is taken as a reference, because most of these porch apartments are quite the same. While designing the orientation, the dimensions and the inside functions should be taken into account.



A2. 'Energy neutral' facade

The facade element that will be designed should be energy neutral (and meet the stricter regulations). There are several requirements set about the facade:

- R_c facade 6,5
- Windowtype Aluminium, $U = 1,0$
- Glasstype HR++, Climaplus Saint Gobain ($ZTA = 0,38$)
- Ventilation Mechanical ventilation system with heat recovery system
- Energylabel A

A3. Aluminium window frames

I started this project on behalf of the company ALCOA, later BAM became involved too. ALCOA Harderwijk provides Architectural systems out of aluminium. Besides that BAM prefers to use an aluminium window type (see *previous requirement*), so the design should be developed and detailed in aluminium.

9.3.2 DESIGN REQUIREMENTS ACCORDING TO ENERGY NEUTRAL USE OF THE FACADE

B1. Opening windows linked with heating system

We waste a lot of energy by keeping the heating system switched on and the windows open at the same time, therefore these systems should be linked.

When a window in a room is opened by someone the heating system should automatically be switched off in that room.

B2. Opening windows linked with ventilation system

We waste a lot of energy by having the mechanical ventilation system switched on and the windows open at the same time, therefore these systems should be linked.

When a window in a room is opened by someone the mechanical ventilation system should automatically be switched off in that room.

B3. Natural ventilation system

While natural ventilation in some situations costs less energy than using air conditioning or a mechanical ventilation system, it should be stimulated in that situations. Paragraph 9.4 point 2 elaborates different natural ventilation possibilities and their effectiveness.

B4. Implementation of an insect protection screen to stimulate natural ventilation

Occupants also tend to naturally ventilate less because of incoming insects. Especially in summer, ventilation at night should be stimulated. In summer the temperature decreases at night and your rooms can simply be cooled by opening your windows at night. An insect protection screen contributes to stimulating occupants to naturally ventilate.

B5. Implementation of trigger that makes occupants aware of the health of their indoor climate

Especially elderly tend to ventilate too little. Mostly occupants are not aware of the health of their indoor climate. A trigger should be implemented in the facade to make the occupants aware if their indoor climate is healthy or not. If the indoor climate is not healthy, they should open a window or put on the ventilation system. When the indoor climate is healthy again, the sign changes in a 'healthy sign'. (Point 3 paragraph 9.4)

9.3.3 DESIGN REQUIREMENTS ACCORDING TO THE WELL-BEING OF ELDERLY

C1. Transparent facade

The facade should be transparent for the largest part. In this way the connection with the environment is bigger, which is better for elderly. In addition more daylight can enter the room, which is also favourable for elderly because their sight becomes worse while ageing. See also point 4 paragraph 9.4.

C2. Large openings facade

The facade should have the ability to be opened for a large part. In this way elderly have a better connection with the environment (and become less socially isolated), but it is also better for their health. When they catch direct sunlight, more vitamin D will be created in their body.

C3. Transparent balustrade

During the daytime elderly sit in front of their windows a lot. While large openings are required (*point C2*), they sit in front of a transparent facade with large opening (balcony) a lot. While it is hard for them to watch outside over a balustrade from their inside chair, a transparent balustrade is required (*also see point 5 paragraph 9.4*).

C4. Safe feeling with transparent facade

Occupants with a transparent facade want to feel safe too (especially at night). Therefore they should have the ability to make their facade (partly) non-transparent (for example by implementing curtains or more sophisticated windows).

C5. Increasing perceived temperature

Elderly have a higher temperature preference than other households. We don't just want to decrease the temperature and thereby reduce their comfort, but we can try to increase their perceived temperature. Point 6 in paragraph 9.2 goes more into detail on this topic.

C6. Noise protection

Elderly suffer from certain noises (low frequency noises and very loud noises). Surrounding noises can be very annoying too. The floors and walls have strict

rules to avoid these problems. Still elderly can suffer from outside noises when opening windows.

A noise protection screen could be implemented when a window is open, but not all elderly prefer such a screen. Therefore it is required that these noises should be protected by the closed facade, but when occupants open a window, this noise is not filtered anymore.

C7. Triggering movement

As discussed in the research part, movement is very important for elderly's health. We cannot prevent all mobility problems by a facade design, but we could still stimulate elderly to stand up and actively take part in opening a window or look outside for example.



Figure 70; Reachability and operation facades for elderly (CompleteCare, 2015)

C8. Prevention of overexposure

Daylight is important to elderly's mental and physical health and to improve their vision. On the other hand overexposure should be prevented to make sure elderly are able to do their activities (like watching tv) with optimal daylighting conditions. A sunshading system should therefore also be implemented in the system. This sunshading system should give the occupants the opportunity let daylight enter the room, but avoid overexposure on different times of the day. This will be elaborated in paragraph 9.4 point 4.

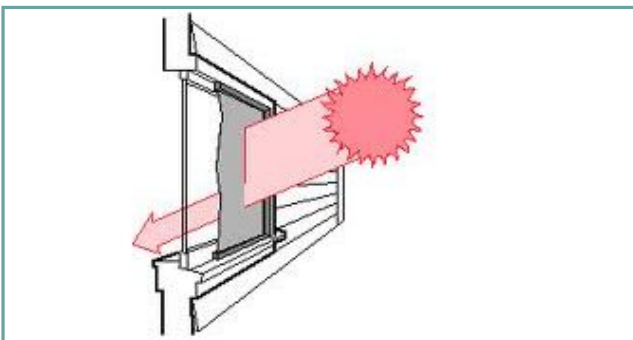


Figure 71; Prevention overexposure (Oikos, 1994)

C9. Opportunity to keep plants

The facade should give the ability to elderly to keep plants (in- and outside). Plants are not only part of their daily life, but also contribute to the health of the indoor air.

C10. Opportunity to hang curtains

Occupants should have the ability to hang curtains inside in front of their facade. Not only from a privacy point of view, but also to contribute to keep the cold in winter outside.

C11. Cleanability facade

The importance of a transparent facade is clear now, but these windows should be reachable for elderly to clean by themselves. Otherwise the transparency of the facade becomes less and the function of the transparent facade is undone.

9.4 ELABORATED DESIGN REQUIREMENTS

This paragraph explains and elaborates some design requirements that were stated in the previous paragraph.

1. DIVISION OF DIFFERENT ZONES (according to design requirement A1.)

As figure 72 shows, the porch apartments in Rotterdam can be divided in 3 different function zones;

- the bedrooms (faced to the South)
- the living room (faced to the North)
- the kitchen (faced to the North)

These three different function zones are located at one of the facades. The kitchen and living room are both faced to the north, so will be treated as one zone. The two zones have different demands according to the facade;

ZONE 1: THE BEDROOMS

The bedrooms require a (partly) transparent facade, but the sense of security is also essential. Occupants mostly get dressed in the bedroom so prefer a non-transparent facade at that time, but waking up is

easier when daylight enters the room. The bedrooms are faced to the south, so sunshades/ curtains should be implemented that are adjustable to the preferences of the users.

Besides that night-ventilation is very important for bedrooms. Most occupants prefer to sleep with an open window during the night. Especially in summer ventilating during the night provides comfort.

ZONE 2: THE LIVING ROOM/ KITCHEN

The living room requires a lot of transparency. Elderly spend most of their time in the living room. They should have the ability to watch outside from their chairs. On the other hand overexposure should be avoided so elderly can still do their daily activities with a transparent facade, like watching tv. The living room is faced to the north, so we should try to let daylight enter the room as much as possible. Point 4 of this paragraph will go more into detail about the transparency of the facade.

Because elderly spend a lot of time in their living room, ventilation is very important. Ventilation could be done naturally by opening windows or using mechanical ventilation with heat recovery. Point 2 of this paragraph will go more into detail about ventilation.



Figure 72; Floorplan porch apartments Rotterdam, divided in zones of different functions and orientation (own illustration)

2. NATURAL VENTILATION

(according to design requirement B3.)

“Why using natural ventilation as there already is a mechanical ventilation system with heat recovery system implemented in the façade?”

Occupants prefer to control their own comfort. You can trigger them to use a mechanical ventilation system instead of opening a window, but most occupants feel much happier when they are aware of controlling their own comfort. Opening a window gives occupants the feeling of a direct result, while using a mechanical ventilation system doesn't.

Besides that natural ventilation contributes to low maintenance (no hygiene problems with ducts and filters) and low running costs (Baker, 2014). Natural ventilation also has a psychological benefit; it connects with the outside and gives people a natural feeling (Baker, 2014). And as Guerra-Santin and Tweed (2013) showed in their research the use of air conditioning has a bad influence on the health of occupants, strong variations in temperature are not healthy.

The goal is to achieve a healthy indoor climate for elderly which also provides comfort. Baker (2014) shows the three main purposes of ventilation in buildings:

1. Maintain a minimum air quality (1-2 air changes/h)
2. Remove heat (and other pollutants) (2-15 air changes/h)
3. Provide perceptible air movement to enhance thermal comfort (0.5-2 m/s)

The air changes per hour express the rate at which the ventilation system actually dilutes and removes the air contaminants present in the space.

Different options are possible to naturally ventilate a building:

1. Single sided ventilation
2. Cross ventilation
3. Stack effect
4. Reverse stack effect

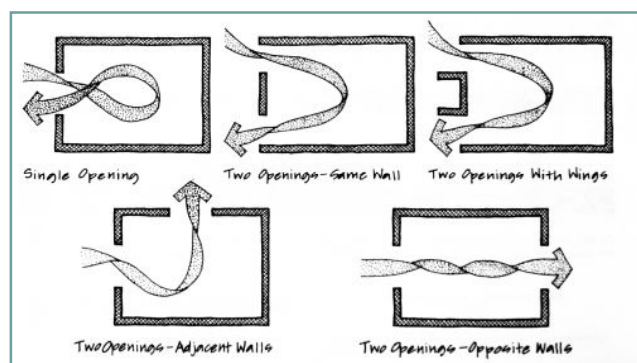


Figure 73; Different ventilation openings and flows (Brown & DeKay, 2013)

In case of the porch apartments of the BAM 2nd skin project, not all natural ventilation options are possible. Stack effect ventilation is not only harder to implement for the different levels, but can also give problems with noise control. In this case 'single sided ventilation' and 'cross ventilation' are the best possibilities. Looking at the floorplans of the porch apartments, cross ventilation in most cases is not possible either.

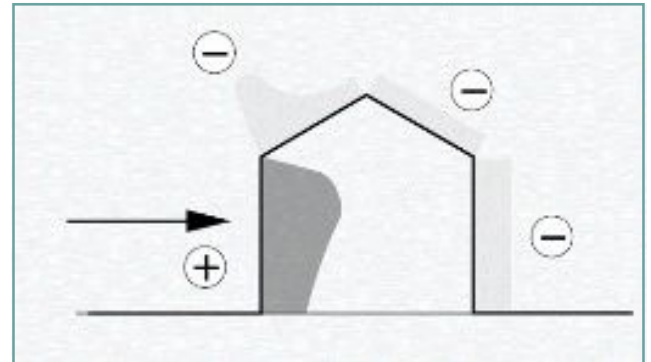


Figure 74; Positive wind pressure on the windward side of the building and negative on the roof and leeward side (Baker, 2014).

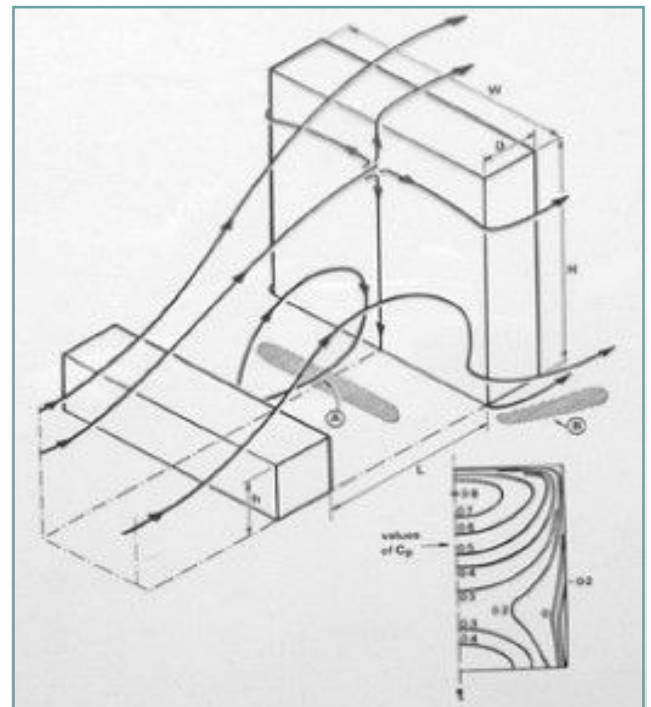


Figure 75; Wind pressure distributions are complex in urban areas (Baker, 2014).

When making use of natural ventilation, the wind flow should be clear. Generally the wind pressure is positive on the windward side and negative on the roof and leeward side (Baker, 2014). As we place the wind rose of Rotterdam on the google maps card of the case study, this is the result (figure 75).

Obviously the wind will not act the same daily, but on average we can say that the wind direction is mainly South-West. The monthly wind directions from June 2014 till May 2015 are shown in the appendix (KNMI, 2015). As the graphs in the appendix show, wind (speed and direction) is very variable. Therefore open-

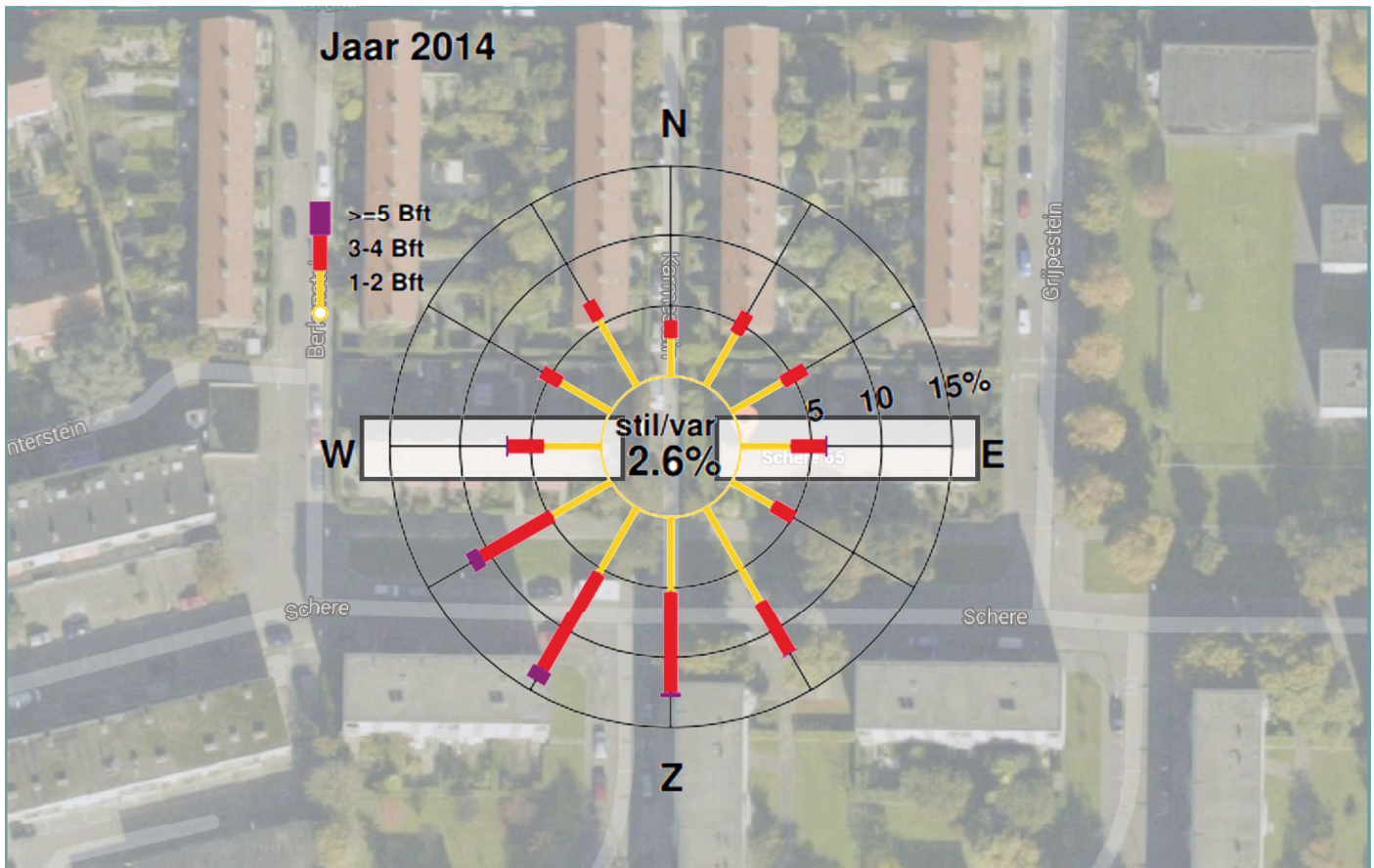


Figure 94; Wind rose pasted on the google maps card of Rotterdam (Schere 65), the white buildings represent the BAM 2nd Skin porch apartments. The wind rose shows that the annual main wind direction is South-West (own illustration).

ings in a façade should be variable too, the façade should be able to cover the wide range of required ventilation rates and the wide range of wind speeds (Baker, 2014). Many small openings contribute to faster ventilation more than one large opening. With more small openings it will be more likely that there will be a pressure difference between the openings to drive the flow as Baker says (2014).

For ‘single-sided ventilation’ openings should be well distributed horizontally and vertically to improve the pressure difference and to improve the distribution within a room (Baker, 2014).

To calculate if ‘single-sided ventilation’ provides enough fresh air, the following rule of thumb may be used (Baker, 2014). (The depth of the floorplan is specified in terms of floor to ceiling height.) ;

Ventilation config.	Depth to floor/ceiling ht H.
single sided, single opening	1.5 H
single sided, multiple opening	2.5 H
cross ventilation	5 H

Figure 76; Rule of thumb to calculate if the ventilation rate is enough (Baker, 2014)

The floor to ceiling height is 2,700m.

- Single sided (single opening): $1.5 \times 2,700 = 4,050$ m
- Single sided (multiple opening): $2.5 \times 2,700 = 6,750$ m
- Cross ventilation: $5.0 \times 2,700 = 13,50$ m

The floorplan depth of the bedrooms is 3,920m, the depth of the living room is 5,400m and the depth of the kitchen is 2,260m.

So the bedrooms and kitchen can be ventilated by single sided ventilation with a single opening, while the living room has to be ventilated by double openings.

In winter much smaller openings are required to maintain the air quality and prevent heat loss. The mechanical ventilation system with heat recovery should in this case often better be used.

The ventilation of the building or room could be done under intelligent control. Whereas in summer a parameter is needed to measure the temperature and remove the heat, during both summer and winter a parameter is needed to control the air quality (CO_2 level).

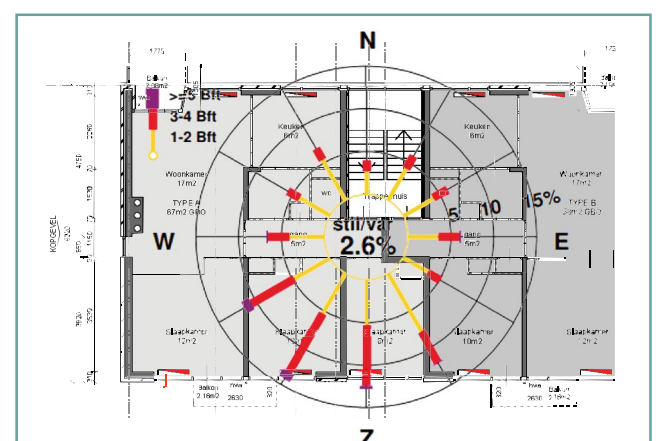


Figure 77; Floorplan with wind rose pasted on it to show which functions lay behind which wind direction (own illustration)



Figure 78; Know your window styles: Sliding, awning, single-hung, double-hung, casement, fixed and hopper (Oregonian, 2012).

The most effective way to naturally ventilate the porch apartments is by ventilating “single sided”.

The openings should be controllable over different sizes to cover different wind directions and wind speeds. A double hung system (figure 78, third picture) is most effective to ventilate the room as fast. In ‘double-hung’ systems both the top and bottom sashes can move (Oregonian, 2012).

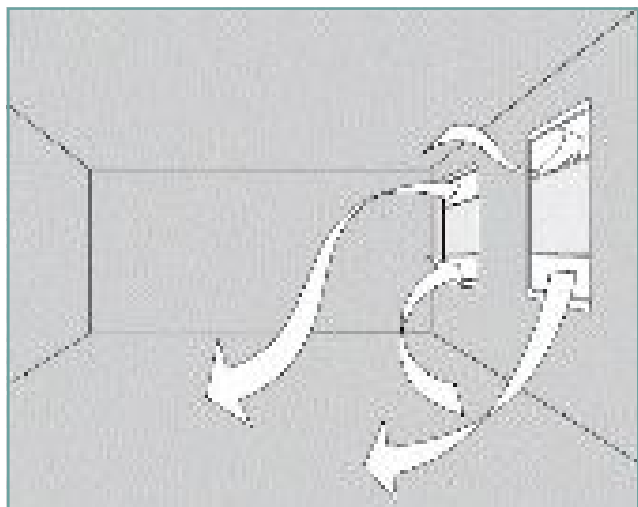


Figure 79; Ventilation is improved when openings are well distributed horizontally and vertically (Baker, 2014).

The implementation of windows with a ‘double-hung system’ doesn’t naturally provide better and faster ventilation of the indoor air. Still users have to open both windows to ventilate best. As mentioned in figure 78 it can be hard to reach the upper window. It would be much easier and effective if both windows would open at the same time by using one handle.

An example of a ‘double-hung’ window is presented in figure 80, followed by a figure of the operation of a ‘double-hung’ window (figure 81).

During the design phase it should be analyzed if the ‘double hung’ ventilation system could be a suitable option to naturally ventilate for elderly.



Figure 80; ‘Double-hung’ window (Acahomes, 2014)

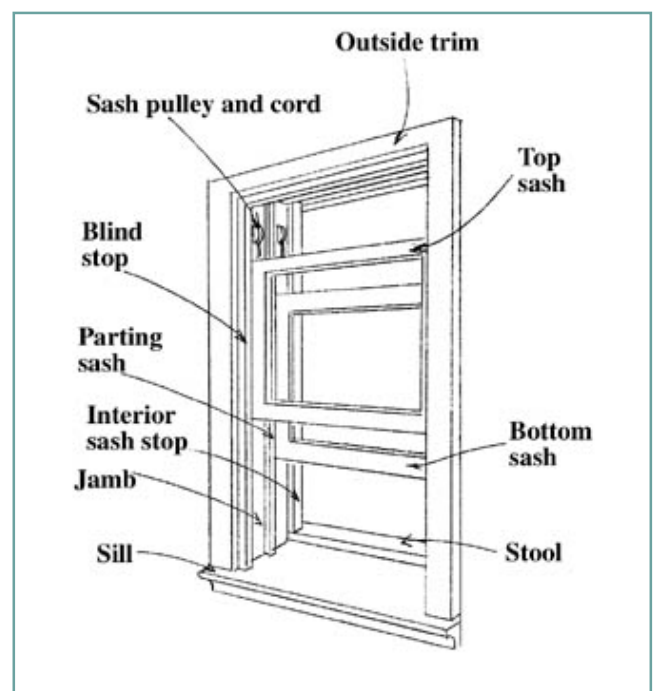


Figure 81; Operation ‘double-hung’ window (Acahomes, 2014)

3. IMPLEMENTATION OF TRIGGER THAT MAKES OCCUPANTS AWARE OF THE HEALTH OF THEIR INDOOR CLIMATE (according to design requirement B5.)

Before triggering elderly to be aware of the health of their indoor climate, we should know what a healthy indoor climate is.

HUMIDITY

One important factor of the indoor climate is the humidity. The humidity should be between 40 en 60 %.

When the humidity falls below 40 %, occupants can suffer from health problems (dry eyes, dry skin, decreased resistance, headache, concentration problems, tiredness, etc.) (Cornelissens, 2012).

A too low humidity can easily be improved by keeping plants inside. Some plants are known for their air purifying function (for example Aloe Vera) (Cornelissens, 2012).

When the humidity rises above 60 % it doesn't smell fresh inside longer, it causes allergic reactions to acarions and it can cause moisture (Cornelissens, 2012).

By ventilating enough a too high humidity rate can be prevented (Cornelissens, 2012).

Ventilating can be done by opening windows or using mechanical ventilation. Heat recovery systems are more and more implemented in dwellings to regulate the refreshment of the air. A heat recovery system mostly only works well when all doors and windows stay closed. When occupants open doors and windows in summer, the whole system is disrupted (Cornelissens, 2012). Besides that the filter of heat recovery systems should be replaced regularly, otherwise the indoor air becomes unhealthy (Cornelissens, 2012).

CO₂-LEVEL

When we exhale, Carbon Dioxide (CO₂) is released. CO₂ is only toxic in high concentrations. Logically the concentration of CO₂ in a room increases when there are more people in the room.

For residences a level of 800 ppm CO₂ is fine. The level is too high when it rises over 1200 ppm.

The CO₂ level can be kept low by ventilating enough (mechanically or naturally). Logically occupants should ventilate more when there are more occupants in the room.

NO₂-LEVEL

Exposure to NO₂ can potentially cause or worsen respiratory symptoms and morbidity (Rijksinstituut Volksgezondheid, 2015). Ventilating enough is therefore required.

FINER PARTICLES (*fijnstof*)

Fine dust (or finer particles) is a term for particulate air pollution, which is small enough to be inhaled. The main source of fine dust is tobacco smoke. Besides that an indoor open fireplace, cooking, vacuum cleaning and outside sources are important sources (Rijksinstituut Volksgezondheid, 2015).

The consequences of too much fine dust in your indoor air are mainly health problems; coughing, chest tightness and worsening of respiratory symptoms (Rijksinstituut Volksgezondheid, 2015).

There is no norm on which the amount of fine dust can be measured yet. Regularly ventilating helps best.

Stof/probleem	Geschat percentage in Nederlandse woningen	
Vochtproblemen	6-16% van woningen, afhankelijk van bouwjaar woning	← Humidity
Zichtbare schimmel	9% van woningen, afhankelijk van bouwjaar	
Huisdierallergenen	33% van woningen	← Finer particles
Tabaksrook	Ongeveer 40-49% van woningen	
Meeroken door niet-rokers in woningen	18-40% van woningen	
Concentratie PM _{2,5} binnen naar buiten	25% bij niet-rokers, 95% bij rokers	
Afvoerloze geisers waarbij verbrandingsproducten niet direct afgevoerd worden	12% van de geisers	← CO ₂ - level
Vluchtige organische stoffen (VOS)	In 0-8 % van woningen is som van VOS > advieswaarde Gezondheidsraad van 200 µg/m ³	
Formaldehyde	In 60% van woningen wordt het MTR voor langdurige blootstelling overschreden (10 µg/m ³)	
Radon	Aanwezig in 100% van woningen 0% boven Europese aanbeveling van 200 Bq/m ³	
CO ₂ -concentratie meer dan 1.200 ppm	59% van verblijfsruimten, 47% van slaapruidten	
Te hoge temperatuur in zomer	17% van woningen	

Figure 82; Table of dust/ air problems in Dutch dwellings (Rijksinstituut Volksgezondheid, 2015)

4. TRANSPARENT FACADE (according to design requirement C1.)

Elderly's sight becomes worse while ageing, they need more light to have a good view. Besides that, connection with the environment is important for elderly's health. A transparent facade is therefore favourable. The question is how large the transparencies should be and on which level. In the appendix different scenarios for the facades of the porch apartments are attached. These studies were done to find out how much transparency would be preferable for different times of the day during the year.

Light has an influence on the day- and night rhythm of people, on how active people are and on people's mental health (Starremans, 2011, p.12). Especially for elderly, it is harder to switch between light and dark spaces, so the difference between a light outdoor space and a dark indoor space should be avoided (Starremans, 2011, p.12). By making the difference in light intensity between indoor and outdoor spaces small, elderly stay brighter. Besides that from different research sources it is proved that people sleep better at night when they are exposed to a light intensity of 1000 lux for at least one hour a day (Starremans, 2011, p.13).

During the daytime it is therefore preferable to expose elderly under a light intensity of 1000 lux with peaks of 2000 lux (Starremans, 2011, p.13). In the appendix a light intensity study of the living room and one of the bedrooms of the first floor is shown. The study is done with the largest possible window openings.

Obviously different activities require different light intensities. *Figure 83* presents light intensities for different activities for dwellings and *figure 84* presents light intensities for different activities for elderly.

The living room of the porch apartments in Rotterdam will be used as a multifunctional room; it will be used as workspace, dining room, living room, etc. The required light intensity varies between 300 en 2500 lux.

The required light intensity for bedrooms is 100-300 lux. If elderly want to read in their beds, the required light intensity is 500-1000 lux.

DIALUX CALCULATIONS - LIVING ROOM

The largest window of the living room is faced to the north. As the figures show in the appendix, the largest light intensity that reaches the room is 5000 lux (in summer). Only a small part of the room (directly behind the window) has this large light intensity. The rest of the figures show smaller light intensities.

The maximum required light intensity for the multifunctional room is 2500 lux. This light intensity should not only be provided by direct daylight. With a light in-

Ruimte	Basisverlichting in lux	Extra verlichting
Woonkamer	200-300	Sfeerverlichting
Boven de tafel	500-1.500	Te gebruiken voor een lichtstimulus tijdens de maaltijd
Leeslamp bij een luie stoel		1.000-2.500 lux om goed te kunnen lezen, maar ook voor biologische stimulatie (bij voorkeur blauwig/koel licht)
Hobby-/werkruimte	500-1.000	
Kantoor	500-1.000	
Keuken	300-500	Werkverlichting boven het aanrecht: 1.000 lux, en eventueel verlichting in de keukenkastjes
Badkamer en toilet	200	
Slaapkamer	100-300	Bedlampje: 1.000 lux Lichtwekker: geeft in plaats van geluid een steeds feller wordend licht: 0-700 lux Verlichting in de kledingkast: 100 lux
Gang en berging	100	
Trap	200	

Figure 83; Light intensity in lux that is required per room in a dwelling on work- or eye level (van Hoof, Schoutens et al. 2007,

Ruimte	Basisverlichting in lux	Extra verlichting
Ingang	50	
Entree	200	
Balie	500-1.000	
Werkruimten	500-1.000	
Woonruimten of slaapkamers	100-300	Leeslamp bij leesstoel: 500-1.000 lux Lampen boven eettafels te gebruiken voor een lichtstimulus tijdens de maaltijd
Medisch onderzoek	500-2.000	
's Nachts bij observatie door verzorgenden	5	
Badkamer en toilet	200	
Gang	200	
Trappen	200	
Multifunctionele ruimte	300-1.500	Tijdens maaltijden: 500 lux Activiteiten (o.a. lezen, zang en samenzijn): tot 1.000 lux Mogelijkheid om licht te dimmen
Gezamenlijke woonruimten	300-2.500	Mogelijkheid voor biologische stimulatie 1.000-2.500 lux (blauwig licht)
Sport- en revalidatieruimten	500	

Figure 84; Light intensity in lux that is required per room in a care or nursing home on work- or eye level (van Hoof, Schoutens et al. 2007, p.27).

tensity between 1000 and 2500 lux the biological clock of your body will be stimulated, preferably the colour of this light should be bluish (van Hoof, Schoutens et al., 2007). Therefore the light intensity should be reached by use of daylight and artificial light.

In summer, autumn and spring the light intensity rises above the required light intensity (only when you are sitting directly behind the window), the transparency is too large. While in winter the light intensity is smaller than required.

Maximal transparency for the living room is therefore preferable in winter and only partly in the other seasons.

As the living room is most used during the daytime and connection with the environment is important especially for elderly, the transparency of the facade

of the living room should be maximal. In summer, autumn and spring the overexposure can be prevented by adding sunshadings.

DIALUX CALCULATIONS - BEDROOM

The light intensity outcomes of the bedroom show a lot of overexposure (see appendix). In fact the room should only be lightened in the morning (while waking up) and the evening (when going to bed). The light intensity should be between 100 and 300 lux (van Hoof, Schoutens et al., 2007).

But, often bedrooms function also as study or playing rooms. In that case these rooms require much more light intensity. The bedrooms therefor should also be provided with maximum facade transparency, but the occupants should have the option to adjust sun shadings for privacy and overexposure.

TRANSPARENCY- SUNSHADING

The transparency of the facade is very important for elderly as mentioned before. To make sure enough daylight can enter the room, a smart sun shading should be implemented on the facade.

It should be possible to make the facade fully transparent, but it should also be possible to block overexposure on parts of the facade. Besides that occupants sometimes want to block the bottom part of their windows. The sunshading should therefore be adjustable over the whole window.

5. BALUSTRADE

(according to design requirement C3.)

Because the need for environmental connection and vitamin D is important for elderly, a transparent balustrade is required. The minimum height of the balustrade of a balcony is 1 meter (Bouwbesluit, 2012). If the balcony is situated on a height of 13 meter or higher, the balustrade has to be at least 1,2 meter (Bouwbesluit, 2012). The height of the porch apartments is 11 meter, so the balustrade has to be 1 meter high at least.

The height-to-height distance between two floors is 2,840 meter. Inbetween one facade element needs to be placed. *Figure 85* shows one of the design options of Spee Architecten. In the design options of Spee Architecten the balcony is removed and is replaced by a flat facade element. In this option the transparent facade part of the element has a height of 2,160 meter.

The balustrade is preferred to be transparent to make sure occupants sitting inside can easily see what happens outside. There are different ways of making balustrades transparent (glass, vertical or horizontal fence, etc.). These options should be tested in the final design.

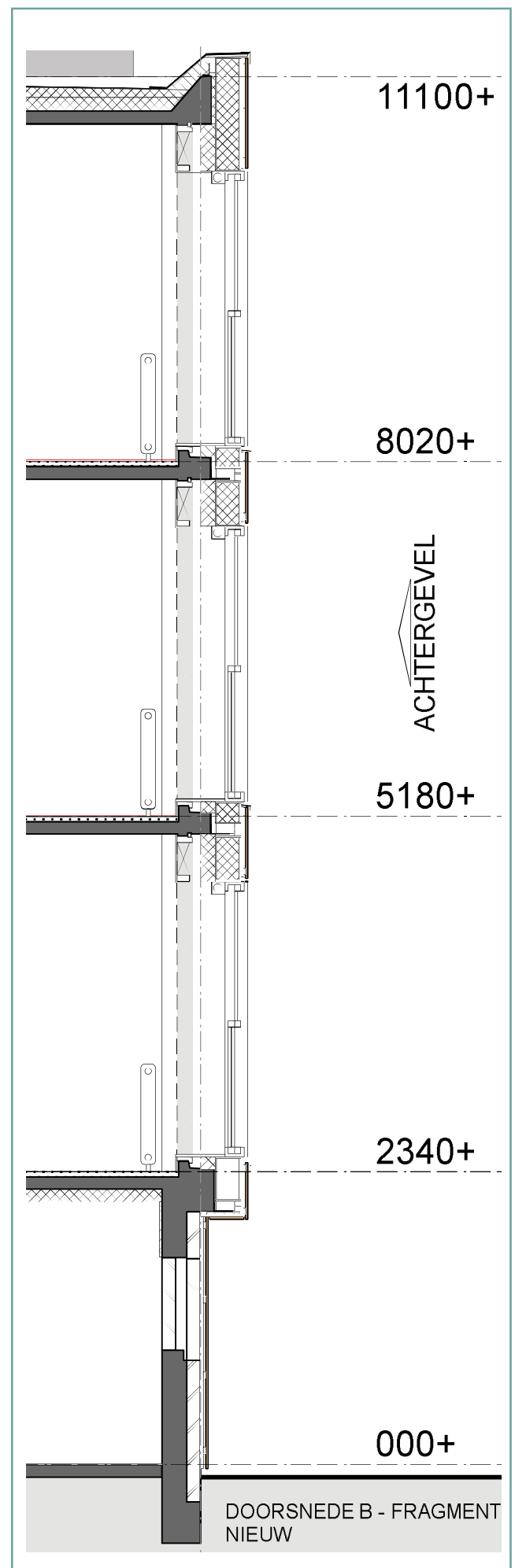


Figure 85; Design option Spee Architecten, balcony replaced by facade element (SpeeArchitecten, 2014).

6. PERCEIVED TEMPERATURE

(according to design requirement C5.)

Elderly have a higher temperature preference than other households. Elderly's greatest demand is to feel comfortable in their own home. They want to save energy, but only if their comfort stays the same. Setting the temperature to a lower setting is therefore no solution for them.

The question is how we can have an influence on the perceived temperature. Could we set the temperature to a lower setting but let the occupants perceive the space the same as before?

The relative humidity, airspeed, air temperature and radiant temperature all influence the perceived temperature.

By applying weatherstrips to prevent trek and insulation on the floor to prevent cold floors, you can already influence the perceived temperature a lot.

Another way to influence the perceived temperature is by using certain colors. Colours can create feelings of well-being, unease, activity or passivity for example (Neufert, 2000). *Figure 86* shows different colours and their influence on human.

As the figure shows, blue gives people a cold feeling while orange gives people a warm feeling. An experiment with a blind man proves this. In the experiment they placed a blind man first in a blue room and later in a red room. In both situations the environmental temperature was the same, but when they measured his body temperature it seemed his body temperature was higher in the red room than in the blue room (Stenvert, 2015).

Colours could be given at materials, but using different light colours could also play a big role in giving people a certain temperature perception.

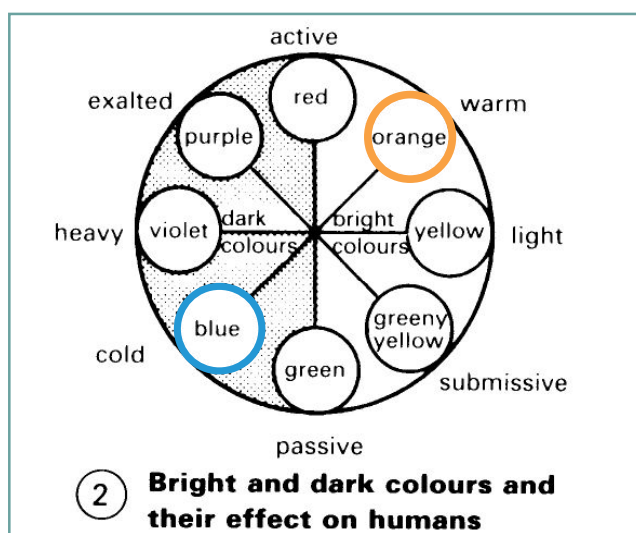


Figure 86; Colors and the influence they have on humans (Neufert, 2000).

9.5 LISTED DESIGN REQUIREMENTS

In this paragraph all previous discussed requirements are listed in short design requirements sentences. Again they are divided in the three different categories: 'design requirements according to predetermined requirements', 'design requirements according to the energy neutral use of the facade' and 'design requirements according to the well-being of elderly'.

Later on these design requirements will be used to evaluate the design(s) along with the evaluation of the different elderly which had been interviewed before and after setting these requirements.

A. DESIGN REQUIREMENTS ACCORDING TO PREDETERMINED REQUIREMENTS

A1. Applicable in the BAM 2nd Skin project

- Location Schere 65-75, Rotterdam
- Dimensions Center to Center - height; 2,840 m

A2. 'Energy neutral' facade

- R_c facade 6,5
- Windowtype Aluminium, $U = 1,0$
- Glasstype HR++, Climaplust Saint Gobain ($ZTA = 0,38$)
- Ventilation Mechanical ventilation system with heat recovery system
- Energylabel A

A3. Aluminium window frames

B. DESIGN REQUIREMENTS ACCORDING TO ENERGY NEUTRAL USE OF THE FACADE

B1. Opening windows linked with heating system

B2. Opening windows linked with ventilation system

B3. Natural ventilation system - 'double hung'

B4. Implementation of a protection screen for safety and insects to stimulate natural ventilation at night (in summer)

B5. Implementation of trigger that makes occupants aware of the health of their indoor climate

- Humidity 40-60%
- CO_2 -level 800 ppm
- NO_2 -level
- Finer particles

C. DESIGN REQUIREMENTS ACCORDING TO THE WELL-BEING OF ELDERLY

C1. Transparent facade

Maximum transparency for living room and bedrooms.

C2. Large openings facade

- The windows should be able to be opened to the height of the balustrade (1 meter), so above 1 meter the windows should be able to open totally.

C3. Transparent balustrade which can be changed to an non-transparent balustrade.

The balustrade transparency should be adjustable.

C5. Increasing perceived temperature by implementing blue lights in winter which provide more light for elderly but also give a higher temperature feeling.

C6. Noise protection when the facade is closed

C7. Movements should be reachable for deteriorating elderly from a sitting point of view

All possible movements should be reachable for elderly while they are in a sitting position. Other movements have to be motor driven.

C8. Implementation of sun shading

The sunshading should be adjustable over the length of the whole window. It should be possible to just block parts of the sunlight.

C9. Opportunity to keep plants (in- and outside)

An additional element should be provided which occupants can choose to buy or rent. This element should be placed on the railing of the balcony.

9.6 CONCLUSION

The main goal was to provide an environment that contributes to the well-being of elderly and simultaneously contributes to an energy efficient use of the facade.

Not all requirements are equally important, but by trying to implement all of the requirements in a facade design the best results could be reached according to the well-being of elderly and the energy neutral use of the facade.

Because the requirements aim mainly at the behavior of the occupants and the quality of the facade elements, the requirements can be divided in two groups (*figure 87*). This division will help to design for the desired behavior and the quality of the facade element, but still these division should be translated into an integrated design. The next chapter will provide the translation of these design requirements into design concepts.

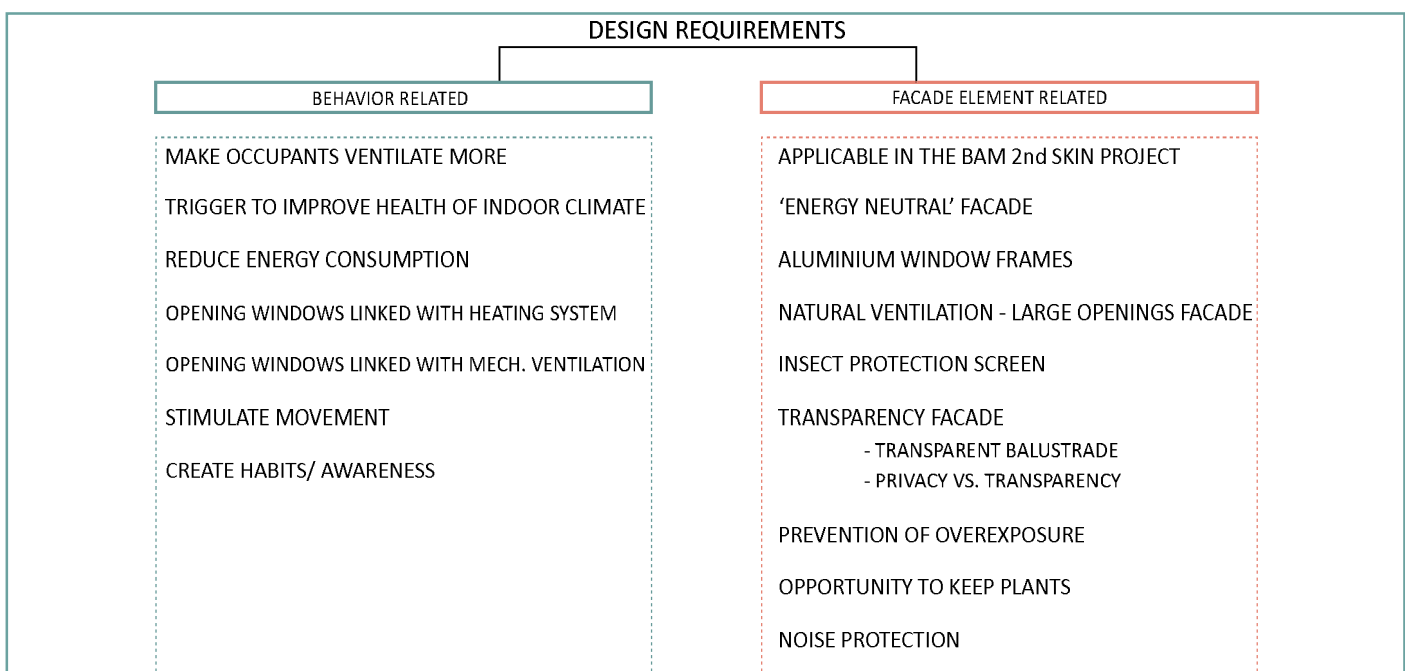


Figure 87; Design requirements divided in 'behavior related requirements' and 'facade element related requirements' (own illustration)

10. CONCEPT IDEAS

After the first two interviews, I made several concept designs which were later on evaluated by the participants again. These first concept designs were presented at my first P4 presentation in May. After my tutors and I decided to postpone the P5 date, I took a step back on developing these designs. We decided that a second face-to-face chat with the participants would help to redevelop the final design(s).

These concept designs of my first P4 presentation are attached in the appendix (appendix A.5.). Now the designs changed a lot due to the second face-to-face interview with the participants. In this interview the focus was set more on the comfort preferences of the occupants rather than looking at their energy consumption behavior.

As the design requirements showed in previous chapters, the design for the 2nd skin approach should be divided in two parts to achieve all requirements; a conceptual design for the 'Home Energy Management System' (HEMS) and a façade element design. Still these two designs have to be integrated.

Chapter 7 showed possibilities in how to design for the desired behavior. Sonja van Dam presented a lot of 'design related guidelines' for future designs. The first paragraph of this chapter will discuss which design requirements should be implemented in a HEMS and how this should be designed. Different designs for HEMS will be presented and discussed. The second paragraph presents different design concepts for the 2nd skin façade element. These designs will be checked with the design requirements.

The conclusion will give answer on the question which design fits best for the approach of the 2nd skin project and all the defined design requirements.

10.1 CONCEPTUAL DESIGN HEMS

The goal of the 2nd skin project is to develop a methodology for a zero energy approach in renovation projects. To achieve this, this part of the strategy consists of monitoring and evaluating the right feedback to the users to decrease their energy consumption. This could be done with home energy management systems (HEMS) as explained in chapter 7. HEMS have six variables to try to meet people's different preferences. As five different personas are defined and these personas demand different designs to change their mind set to an energy neutral behavior, five different concepts for HEMS have to be designed.

To remind, the six different variables of HEMS are:

1. The type of energy measured
(gas and/or electricity);
2. The level of feedback
(feedback on overall household consumption, information for separate appliances, feedback to just one appliance);
3. The type of feedback
(factual, social or comparative, figure 68);
4. Strategies to influence energy consumption
(Do they only monitor or also manage the energy consumption?);
5. The architecture of the HEMS
(touch screens, online web applications, standby-killers, etc.);
6. The intended purpose
(energy saving or peak shaving) (Dam, 2013, p.107).

1. THE TYPE OF ENERGY MEASURED

If occupants want to know their gas or electricity consumption of course depends on their interest, but in case of the 2nd skin project we try to achieve overall energy reduction. In case of space heating the gas consumption is most important. As *figure 88* shows, the CO₂ emissions of gas are much bigger than the CO₂ emissions of electricity.

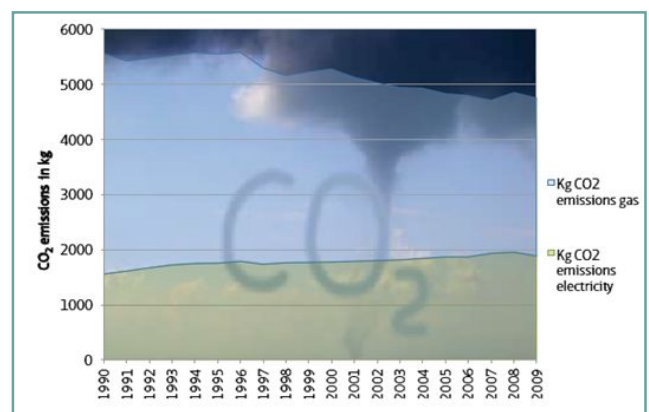


Figure 88; CO₂-emissions per households during the past 20 years in the Netherlands (EnergieNed, 2009)

But, in case of electricity we see a raise of electronic devices (also with elderly, see *figure 89*), so the electricity consumption becomes more and more important.

The different personas should be aware of both their electricity consumption and gas consumption. Both should therefore be implemented in the HEMS.

2. THE LEVEL OF FEEDBACK

The level of feedback differs per persona. Some just want to know if they are more energy efficient than their neighbours while others want to know what the cause is of the peak in their energy consumption.

	Total	Kitchen, washing, cleaning and personal care appliances	Visual/audiovisual equipment	Computers and ICT appliances
Total	51	30	14	7
Young singles	37	21	11	6
Middle-aged singles	42	24	13	6
Elderly singles	38	24	9	4
Young couples	52	29	15	8
Middle-aged couples	61	34	18	9
Elderly couples	52	33	13	6
Families with young children	59	33	18	9
Families with older children	69	37	22	11

Figure 89; Number of appliances per household in the Netherlands (Dam, 2013, p.67)

This variable should therefore be discussed per person.

3. THE TYPE OF FEEDBACK

Also the type of feedback depends on the occupant. Some just want to know if they are doing well or not, while others want to know the exact amount of energy they spend.

This variable should therefore be discussed per person.

4. THE STRATEGY TO INFLUENCE ENERGY CONSUMPTION

The strategy to influence energy consumption can differ in monitoring the energy consumption or managing the energy consumption, or do both.

As was concluded from occupants with pre-programmed thermostats, not every action should be automated. Otherwise the occupants will lose their awareness in reducing energy consumption. But, some actions which benefit to reducing the energy consumption could be managed though.

As one of the goals is to make elderly ventilate more, a sensor should be placed to measure the health of the indoor climate (CO_2 -level, humidity, NO_2 -level and the finer particles). When this sensor measures an unhealthy indoor climate, two actions could be triggered:

- turn on the mechanical ventilation system, or;
- open one or more windows.

As visualized in figure 90.

When occupants (especially in winter) ventilate too little, the action of turning on the mechanical ventilation system (with heat recovery), could be managed by the HEMS. When the indoor climate is healthy again, the HEMS will switch off the mechanical ventilation system.

system.

Besides that it should be avoided to use mechanical ventilation and natural ventilation at the same time. When occupants open doors and/or windows simultaneously with using the mechanical ventilation system, the mechanical ventilation system gets disrupted (Cornelissens, 2012). Therefore the action of opening a window should be linked with turning off the mechanical ventilation system (figure 91).

And lastly when the sensor indicates that the indoor climate is unhealthy and simultaneously the heating system is on, it should be stimulated to turn on the mechanical ventilation (with heat recovery) and keep the windows closed (figure 92).

Figure 93 shows the existing HEMS system and the additional three aspects that should be implemented.

5. ARCHITECTURE OF HEMS

The differences in architecture of HEMS lay in the way people are able to use technology and how much they are into it, but also in the degree of interest to reduce the energy consumption.

This variable should therefore be discussed per person.

6. THE INTENDED PURPOSE

Occupants are interested in different strategies to reduce their energy consumption. Some want to reduce the overall energy consumption, and some just want to know the causes of peak energy consumption.

This variable should therefore be discussed per person.

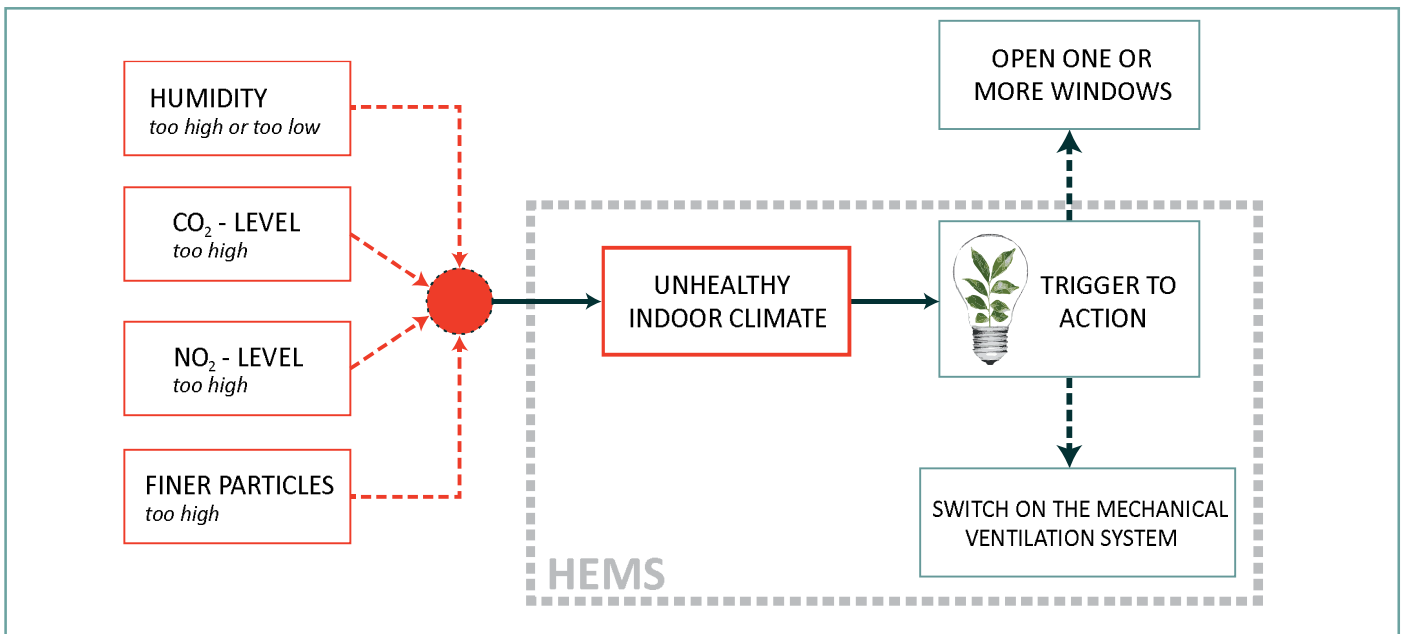


Figure 90; Strategy to influence energy consumption 1 (own illustration)

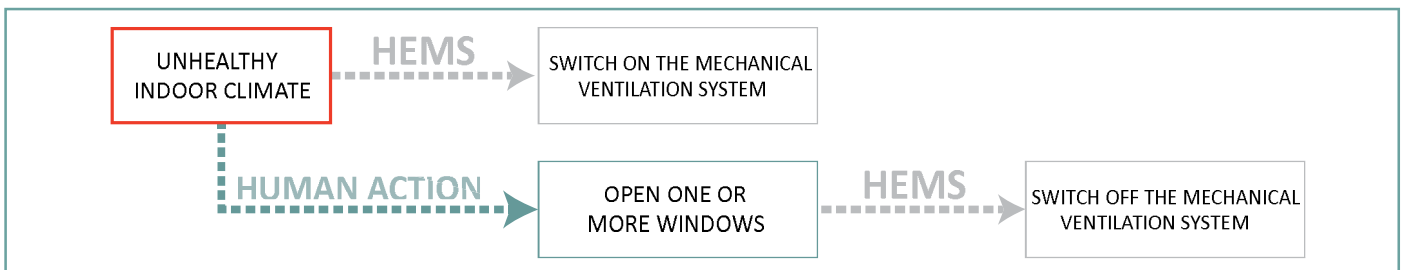


Figure 91; Strategy to influence energy consumption 2 (own illustration)

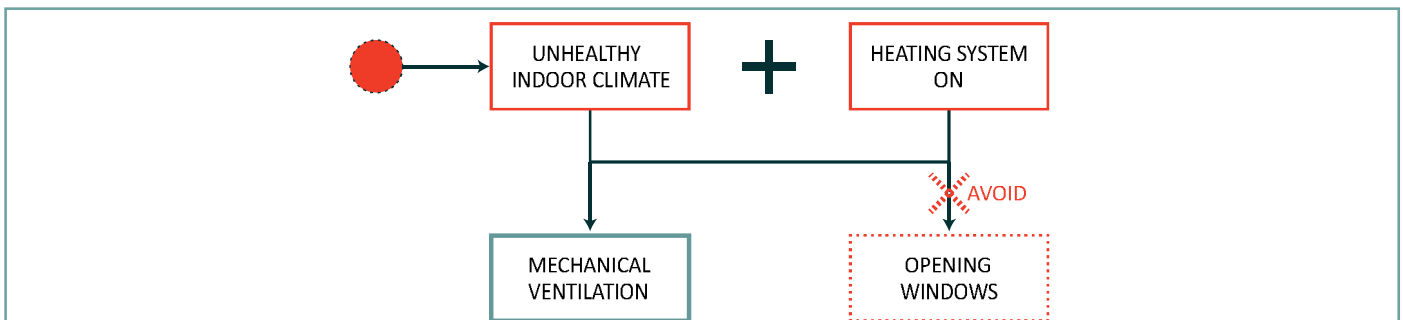


Figure 92; Strategy to influence energy consumption 3 (own illustration)

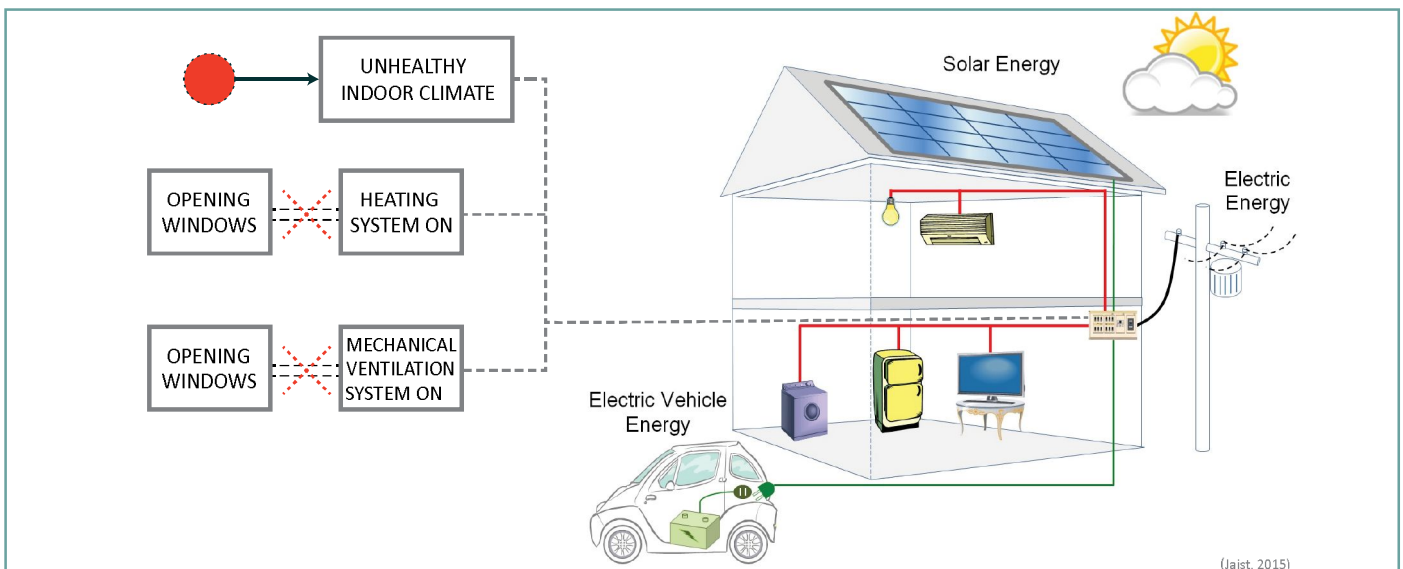


Figure 93; HEMS (Jaist, 2015) + the missing points (own illustration)

As discussed, variable 1 'the type of energy measured' and variable 4 'the strategy to influence energy consumption' have quite the same approach for the different personas.

The rest of the variables are checked with the different personas and design requirements and thereby translated into concept designs for HEMS. The concept designs for these HEMS are elaborated per persona below.

1. The "EASY COMFORTABLES" (figure 94)

- LEVEL OF FEEDBACK

The level of feedback shouldn't be too detailed, but should give social comparative results.

- TYPE OF FEEDBACK

They would like to know if they are consuming more energy than their neighbours for example. They would like to get tips on how to reduce their energy consumption, but they don't want to put a lot of effort in finding out how to reduce their energy consumption by themselves.

- ARCHITECTURE OF HEMS

They are interested in reducing the energy consumption, but they don't want to be confronted with it everywhere and all day. A device that is placed somewhere in the living room is therefore enough for them.

- INTENDED PURPOSE

The intention of the 'easy comfortables' is to reduce the overall energy consumption, they are not interested in peaks and a lot of details.

With the 'easy comfortables' mostly a longer time-span (longer than 4 months) is necessary to create (daily) habits (Dam, 2013, p.111).

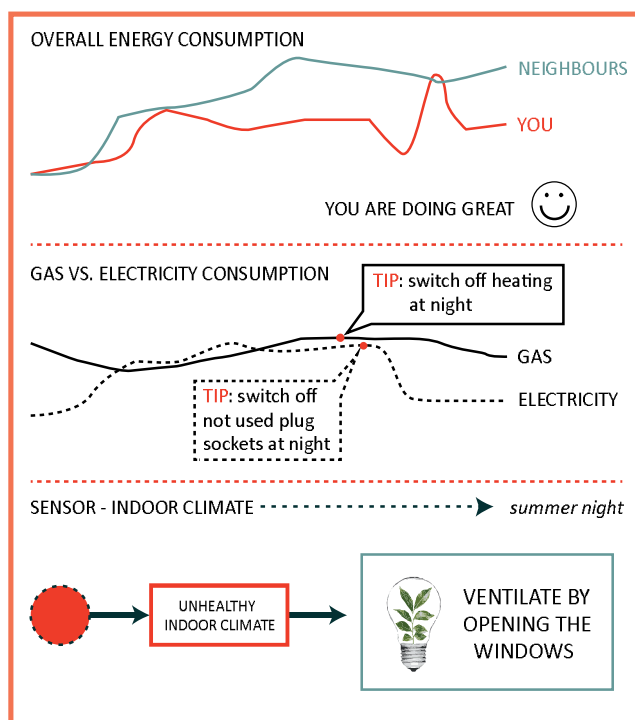


Figure 94; Visualization HEMS for the 'easy comfortables' (own illustration)

2. The "ALL TIME SAVERS" (figure 95)

- LEVEL OF FEEDBACK

The level of feedback should be detailed. Figures and numbers should explain their energy consumption. There should be different levels of detail according to the feedback that is provided.

- TYPE OF FEEDBACK

They are very into saving. The cause of a peak in their energy consumption should therefore be explained in the feedback. They are more into figures and numbers than other personas.

- ARCHITECTURE OF HEMS

They are interested in reducing the energy consumption and they would like to have the ability to check it everywhere and all day. A device that is easy to take along is therefore preferable.

- INTENDED PURPOSE

The intention of the 'all time savers' is to seek for peaks in the energy consumption of their households, they are less interested in the overall energy consumption.

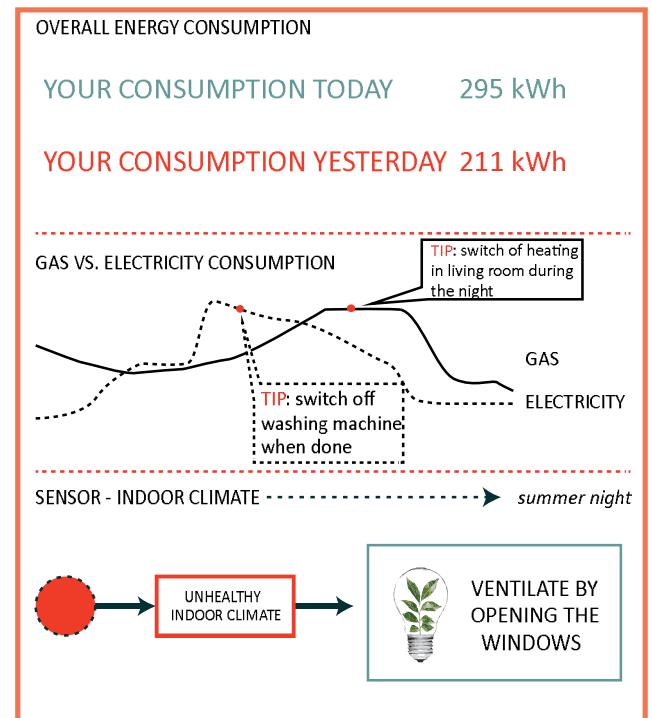


Figure 95; Visualization HEMS for the 'all time savers' (own illustration)

3. The "SPENDERS" (figure 96)

- LEVEL OF FEEDBACK

The 'spenders' need a frame of reference to compare their consumption with. The level of feedback shouldn't be detailed, but should give social comparative results. They are not interested in numbers, colours work better.

- TYPE OF FEEDBACK

They are not really interested in their overall energy consumption, they just want to live their lives comfortably. But, what they do want to know, is what the causes of peaks are according to their energy use.

- ARCHITECTURE OF HEMS

They don't want to be confronted with their energy consumption all the time, but they should stay aware of their consumption daily. A device that is placed on a spot where they spend a lot of time is therefore a must.

- INTENDED PURPOSE

They are more interested in knowing the causes of energy peaks than in the overall energy consumption.

The fourth and fifth persona are more an addition to the first three personas than 'stand-alone' personas. Not all HEMS variables are therefore elaborated with these personas.

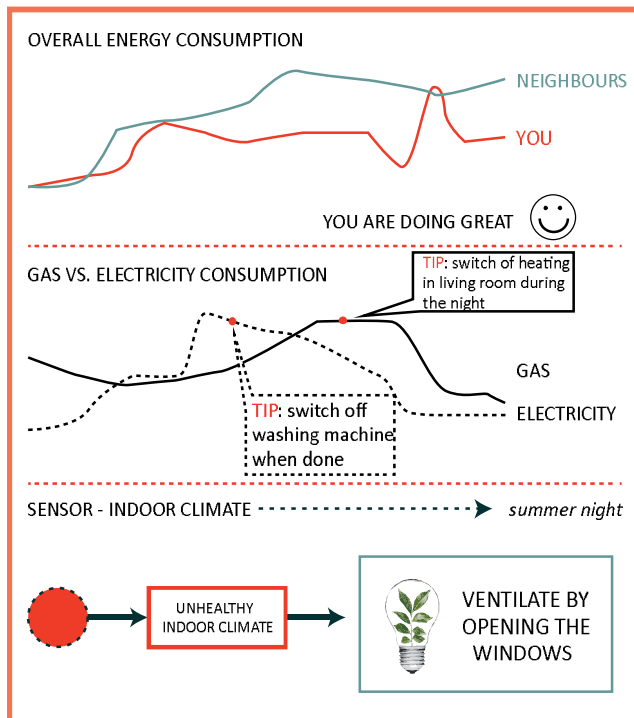


Figure 96; Visualization HEMS for the 'spenders' (own illustration)

4. The "MOBILITY SUFFERERS"

- ARCHITECTURE OF HEMS

The mobility of these personas is not optimal anymore. Therefore a fixed HEMS should be placed at a spot that is reachable for them while they are sitting. A portable HEMS could also be a solution.

5. The "SIGHT SUFFERERS"

- LEVEL OF FEEDBACK/ ARCHITECTURE OF HEMS

The feedback should be presented in suitable contrast patterns and big enough letter/number sizes.

To realise all these intended aspects, the HEMS system and the facade element should be integrated. The facade element should contain different functions: insulation, heating, ventilation, cooling and sunlight admission. All these functions should be aligned with each other.

A project that focuses on this integration in the facade is the NEXT active facade concept. The NEXT active facade concept can be seen as one sustainable solution that reduces energy consumption and provides individual comfort for the occupants (ALCOA, Somfy, TROX, 2015).

The facade is the most important element in the energy efficiency of a building. The facade can provide comfort and sustainability. The NEXT active facade offers one integrated facade solution which can provide 20% energy reduction while the individual comfort increases, the concept is shown in figure 97. The NEXT active facade elements filter and condition the indrawn outside air and bring these draft free into the inside area. This decentral ventilation method is energy efficient and takes little space. A heat exchanger regenerates the exhaust air, while night ventilation and automatic sun shading use the natural resources. In the facades of the NEXT active facade 7 climate functions can be implemented: sun- and heat regulation, air supply, air supply and exhaust, heat exchange, ventilation, heating, and cooling (ALCOA, Somfy, TROX, 2015).

One big advantage is that everything is regulated by one operating system. Generally climate services are realized by different parties. Each party is responsible for their achievements, but they don't really align the climate services with each other. The NEXT facade element takes the overall responsibility and aligns the climate services with each other (ALCOA, Somfy, TROX, 2015).

The system has different optimal solutions and can be switched from energy-modus to comfort-modus for example. One example of an optimal operating system: in winter the occupant opens the sun shading. When the room becomes warmer due to the heat of the sun, the system decreases the heating system temperature (ALCOA, Somfy, TROX, 2015).

Optimal comfort and maximum energy performance are realizable by combining different climate functions, combining them all or choosing for several ones. In this way you can upgrade your building to energylabel A. Figure 98 shows different combinations to upgrade your home to the desired energylabel (ALCOA, Somfy, TROX, 2015).

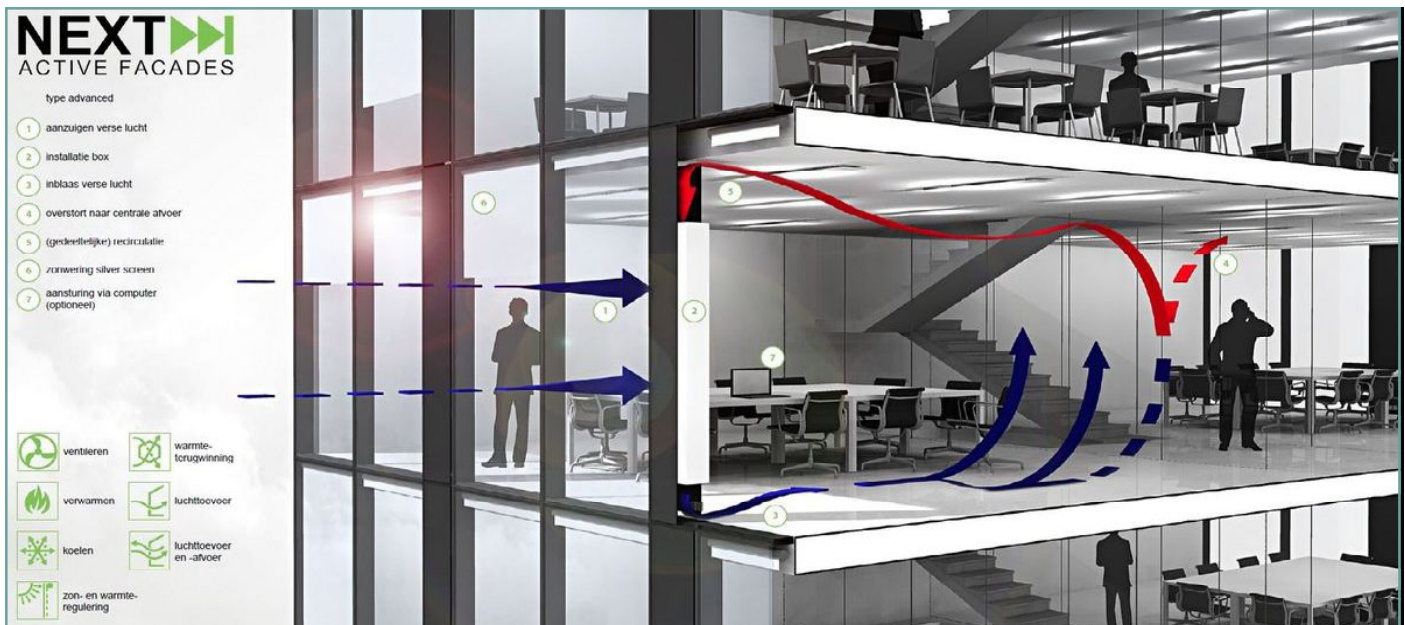


Figure 97; Concept NEXT active facade (ALCOA, Somfy, TROX, 2015)

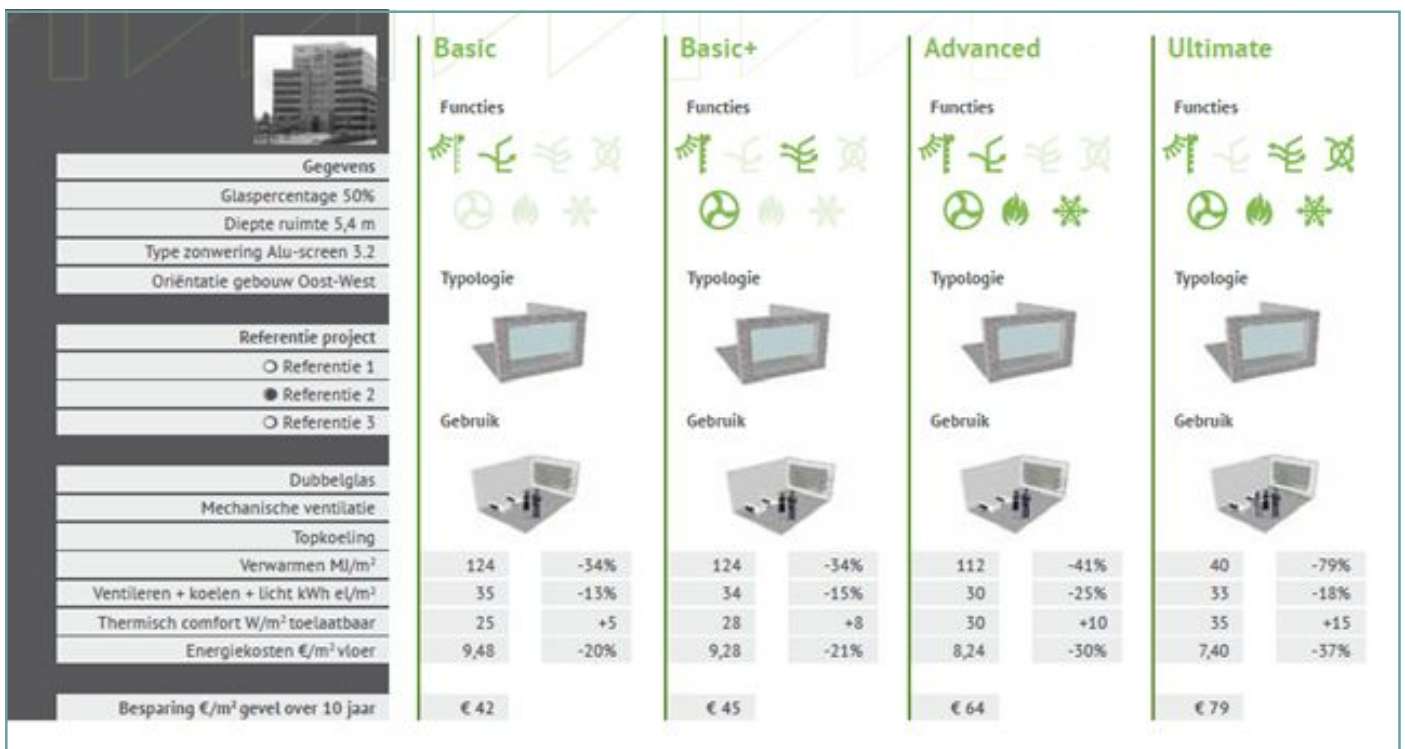


Figure 98; Upgrading to the desired energylabel (ALCOA, Somfy, TROX, 2015)

The NEXT façade element can be customized to the desired size. The façade has a flexible layout. The units can be placed in the façade, but also in the floor or the ceiling (ALCOA, Somfy, TROX, 2015). Therefore the NEXT facade system is very flexible and could be placed in many different facades.

The NEXT active façade provides comfort by ventilating, cooling or heating when necessary and an extra option is a managed sun shading system. These are all managed in one plug and play box. Still this active element has to be further developed.

To regulate the ventilation the health of the indoor climate should be measured. The humidity, the CO₂-level, the NO₂-level and the level of finer particles should

be measured with this element and should trigger the occupant to ventilate or manage the ventilation system itself.

Another aspect that could be implemented in this active façade element is the outside noise. By applying a noise filter into the element the system can manage the ventilation to be natural or mechanical. In this way the elderly will be protected from disturbing noises.

The last aspect that also could be implemented in this system is the use of different colours. By managing different colours, occupants feel different. Colours can make you feel warm or cold, but also active or sleepy. This could be managed by using a light sources with different colours.

10.2 FACADE ELEMENT DESIGNS

The previous paragraph was more focusing on designing for the right behaviors towards energy reduction, while this paragraph more focuses on designing for a healthy and comfortable life of the occupants (elderly) in a facade element.

The BAM 2nd skin project in Rotterdam is used as a reference for the different designs. The first part of this paragraph shows the dimensions of the apartments where we are designing for. The second part of this paragraph shows a table which will be used to check the quality of each design. After that three different design options are presented and reviewed by the quality table.

10.2.1. BAM 2ND SKIN PROJECT

As figure 99 shows, each existing apartment of the BAM 2nd skin project has two balconies, one partly indoor-partly outdoor and one outdoor balcony. In this situation the kitchen has no balcony. All facades will be renovated, so the facades which have windows already but no balcony yet, could be designed into facades with balconies.

The facades have different dimensions. These dimensions of the facades of the different rooms are shown in figure 101.

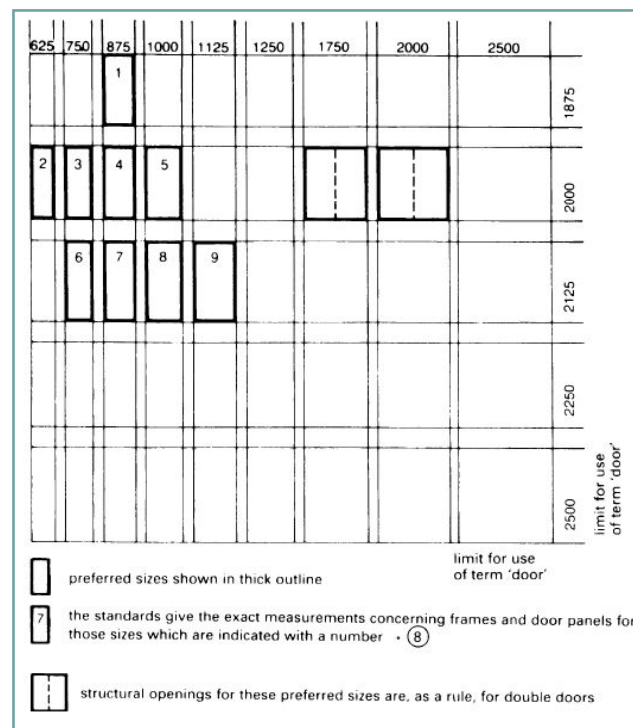


Figure 100; Typical structural opening sizes to DIN 4172 (Neufert, 2000)

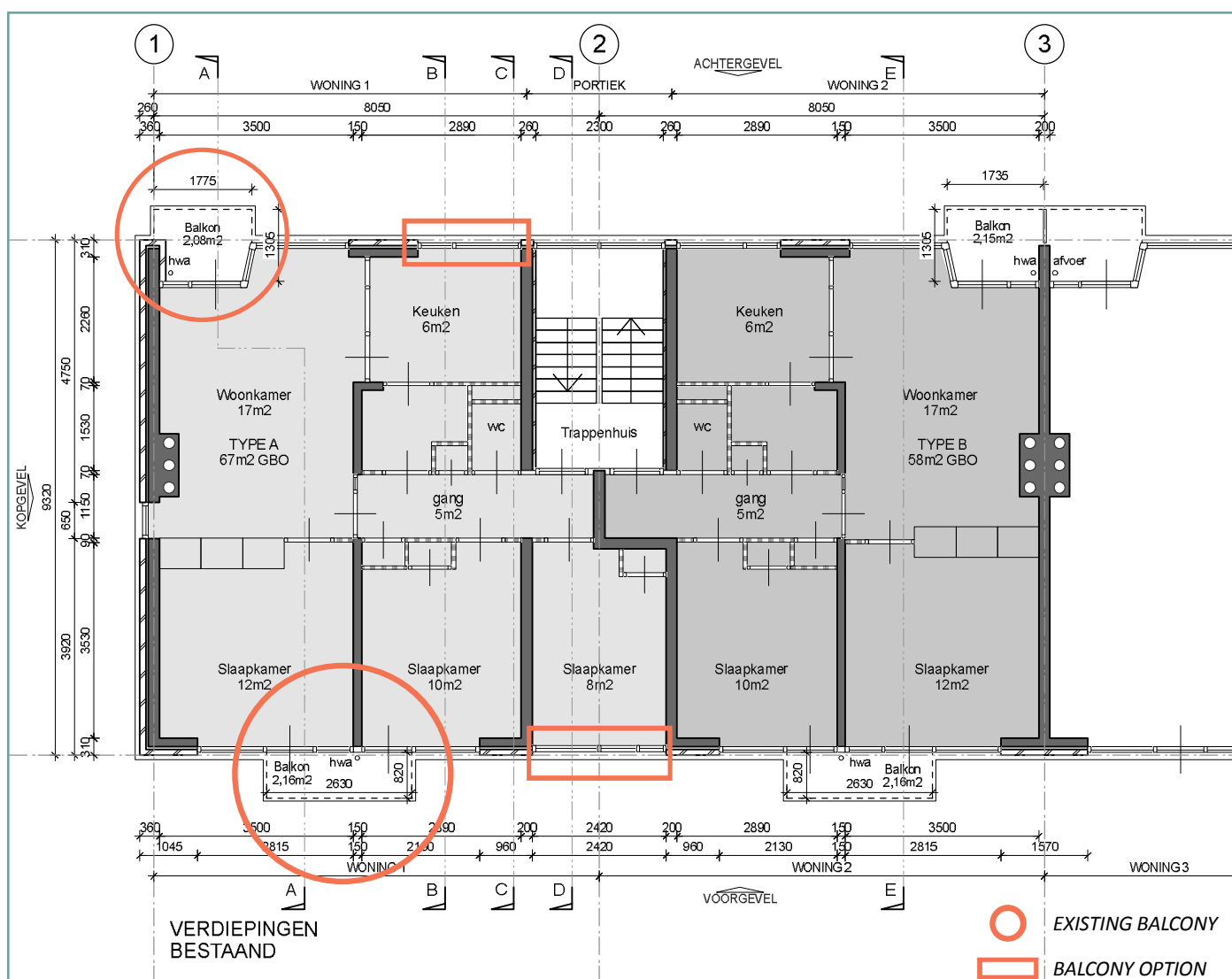


Figure 99; Floorplan BAM 2nd skin project, Rotterdam (SpeeArchitecten, 2014)

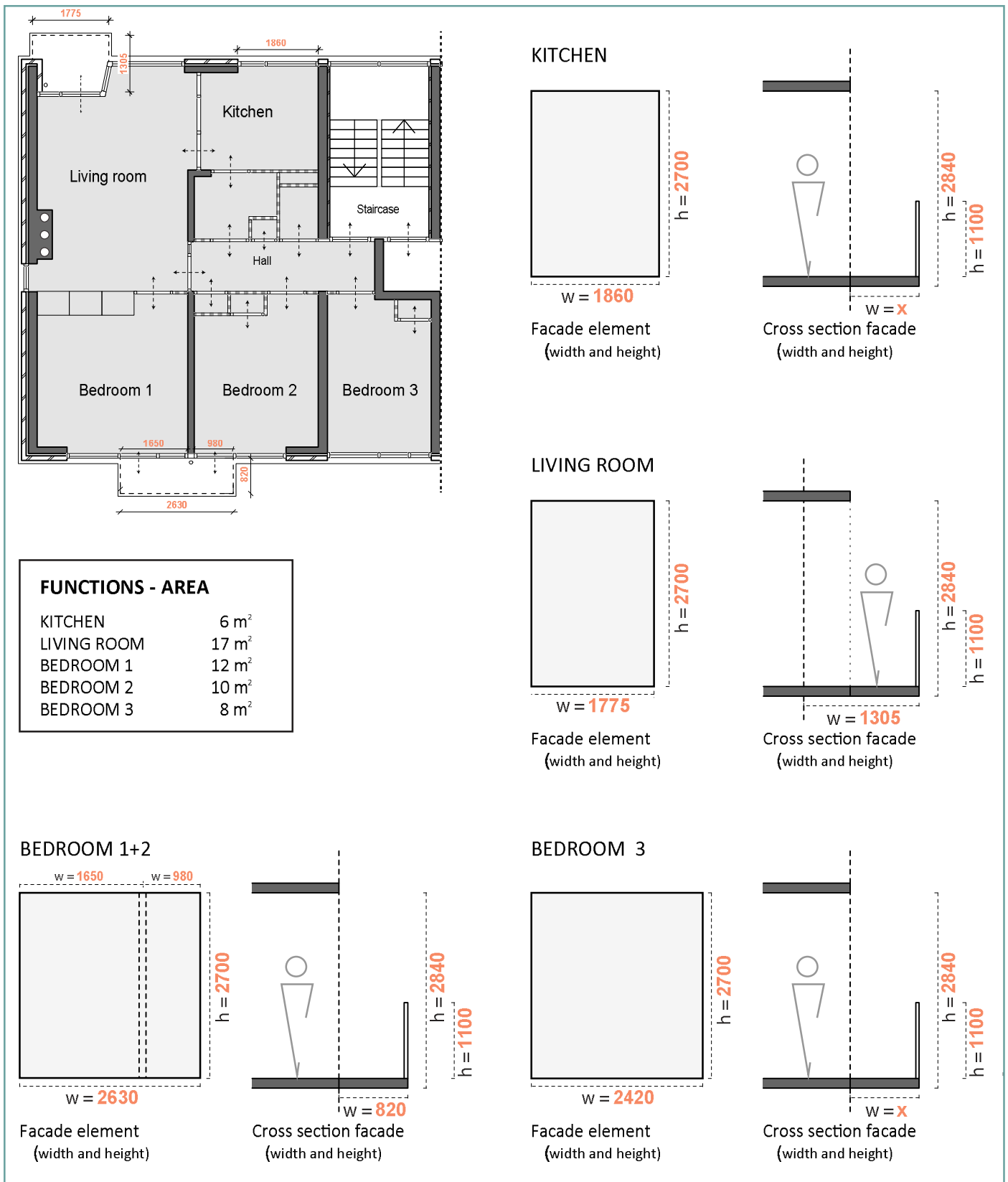


Figure 101; Dimensions of the different facades of the BAM 2nd skin project, Rotterdam (own illustration)

As shown in the figure, the kitchen and bedroom 3 don't have a balcony at the moment. Therefore the width of these balconies is accorded to x . The existing balconies of the living room and bedroom 1 and 2 have a width of 1305 mm and 820mm. Because the facades will be replaced by new skins and therefore the balconies will be replaced too, these dimensions do not have to be maintained.

Some new facades could be replaced by balconies with single or double doors. By designing for the facade of bedroom 1 and 2, the wall which splits the room has to be taken into account.

Figure 100 shows different opening sizes for single and double doors.

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY					
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)	INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	VIEW / TRANSPARENCY (VIEW/ PRIVACY)	OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)	ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY, HEAT/COOL)	WINDOWS/ILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
CONCEPT X		SMALL BIG					VIEW PRIVACY					IN OUT	IN OUT					

Figure 102; Requirement checklist for the different facade element designs (own illustration)

10.2.2. REQUIREMENT CHECKLIST

As a lot of design requirements has been defined, the goal is to try to integrate as much as possible requirements into the facade element designs. All different design concepts, which are all attached in appendix A.6., will be checked with a design requirement checklist. This checklist is divided into different main categories; ventilation, elderly, comfort and functionality (figure 102). The checklist will be marked with pluses and minuses to regard the requirements for a design as respectively positive or negative.

10.2.3. THE CONCEPT DESIGNS

In appendix A.6, all different concept designs for the BAM 2nd skin project will be presented and discussed. The concept designs that I made are concept designs for the kitchen and bedroom 1 and 2.

The living room has a partly indoor and partly outdoor balcony and should therefore be approached differently. Adding a new skin (and balcony) is therefore in this case harder. Therefore this facade is disregarded for the concept designs.

Not all apartments have a third bedroom, that's why also this room is disregarded.

The concept designs are mainly to test which operations and aspects are most important to design for. The concept designs can also be used as a starting point for the new 2nd skin designs for the living room and the third bedroom.

In appendix A.6. the different concepts are discussed, clarified with pictures of the models. The requirement checklist will rate the concepts. Some suggestions are given to improve the concept.

The models are mainly made to test the shape of the balconies and the different facade element compositions and their operations.

Not all requirements will therefore be visible in the pictures of the models. The requirement checklist will therefore be rated positive if it is possible to add for example 'an insect screen'. If it is not very clear why a design requirement is ranked positive, this will be explained by visualization or text.

Some of the additions to the models can be observed as equal. These will be explained below.

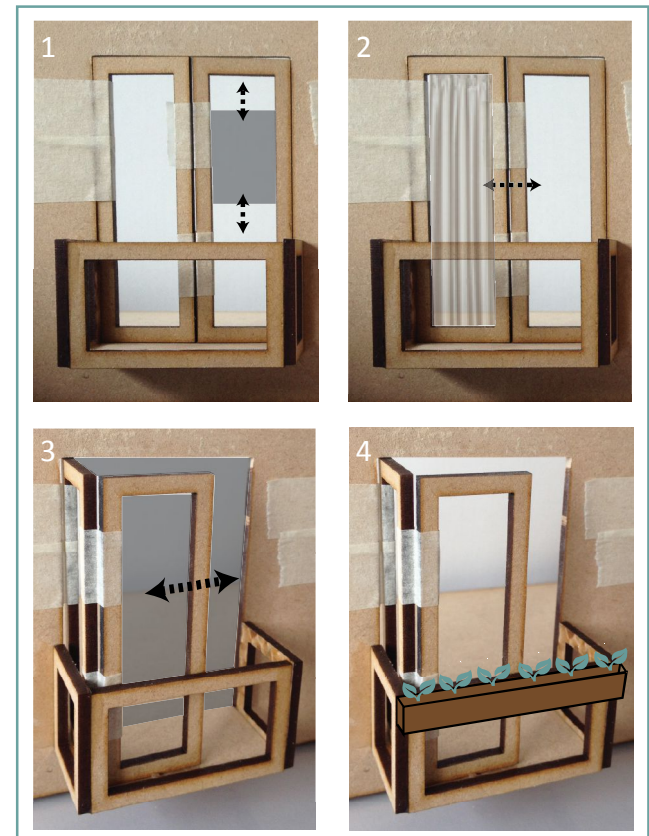


Figure 103; Model additions (own illustration)

1. ADJUSTABLE SUNSHADING - INSIDE

The inside adjustable sunshading can be placed on the height the occupant wants. In this way overexposure can be blocked.

2. CURTAINS

Curtains can be placed behind the facade for privacy, but also to keep the cold outside.

3. INSECT PROTECTION

When the facade elements are opened, an insect screen can be closed to keep the insects outside.

4. KEEPING PLANTS OUTSIDE

The occupants have the opportunity to keep plants outside by hanging them on the railing of the balustrade.

The different concept designs show a lot of different options and operations. The requirement checklist gives the design a quite positive or negative rate according to designing for elderly and energy efficiency. Not all requirements are of equal weight. For example, it is much more important that elderly can sit outside comfortably (and catch sunlight/ create vitamin D) than having a noise protected façade (not all elderly have the same hearing disorder, so this requires different noise protections).

Some of the requirements are rated mainly negative as the ratings show. For example the requirements 'rain protection' shows mainly negative ratings, but this seems worse than it is. The porch apartments all have their balconies above each other, most of the occupants therefore have an overhang of the balcony above them and suffer less from rain. Only the occupants living on the upper floor will be troubled by the rainfall. The same applies to the sun, the upper floor will be troubled most by overheating and overexposure. So, only for the upper floor a sun-/ rainprotection screen has to be designed.

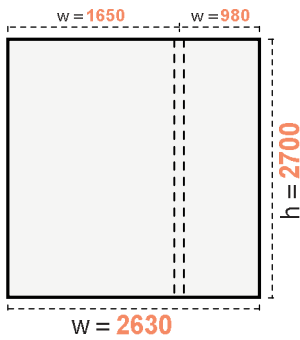
One of the most important requirements from the interviews is having an outdoor space/ area. A balcony is therefore desirable. Not in all situations a balcony will be possible. Concept design 12 gives an idea of what a flat design element could look like and how it could operate. The requirement checklist shows a lot of negative results, but for a flat design a lot of these requirements cannot be achieved.

The three most promising design concepts according to the requirement checklist, the evaluation by the elderly and the comments of the tutors are; concept 3, concept 5 and concept 7. These three concepts are shown on the next pages and will be further developed in the next chapter.

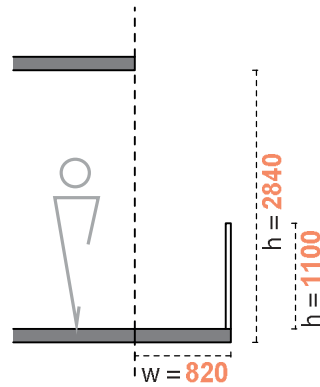
All three concepts are concepts for the connection between the two bedrooms, but this concept could also be used for separate rooms. The pictures of the models on the next pages show the idea for implementing the concepts in individual rooms.

CONCEPT 3 - BEDROOMS 1 & 2

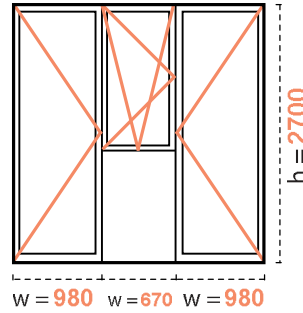
BEDROOM 1+2



Facade element
(width and height)



Cross section facade
(width and height)



Facade-door design
(concept 3)

- Two doors, one window
- Opening to the outside
- Window also able to tilt

Specifications
(concept 3)

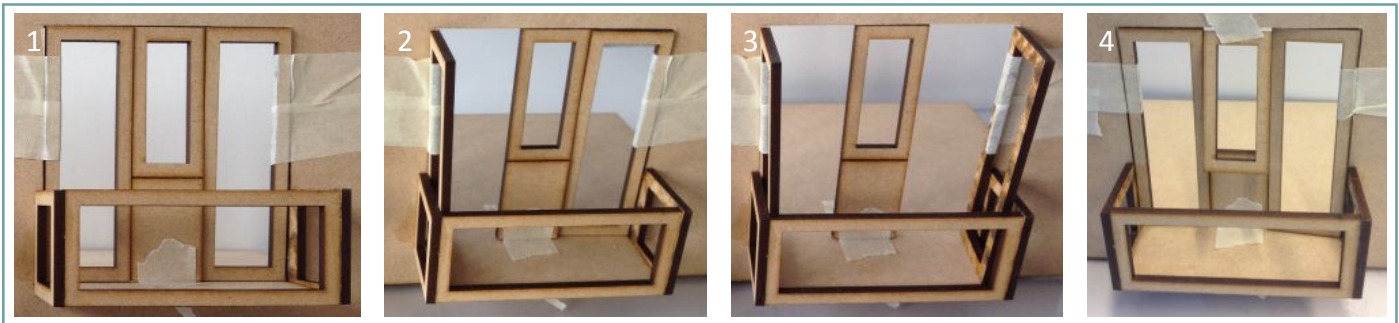


Figure 104; Models concept 3 - bedroom 1 & 2 (own illustration)

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY					
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)	INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	VIEW TRANSPARENCY (VIEW/ PRIVACY)	OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)	ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY/ HEAT/ COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
CONCEPT 3	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+

Concept 3 consists of 2 doors and inbetween one window. The doors both open to the outside and can function as wind protection screens. The window can be tilted or opened outwards.

The wall underneath the window allows the occupants to have a windowsill and keep plants both in and outside. A folding table could be added to the wall outside to provide flexibility to the occupants.

The big doors allow occupants to ventilate with large openings. The window allows the occupants to ventilate with a small opening.

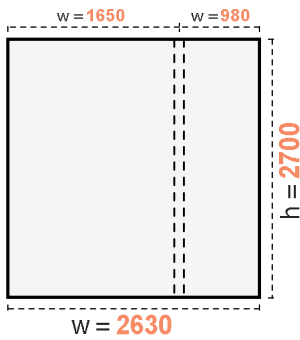
The balustrade of the balcony is transparent and allows the occupants to have a view to the outside.

Most requirements are rated positive or semi-positive and semi-negative. The privacy requirement could be achieved by adding a printing on the glass balustrade for example (same as concept 1).

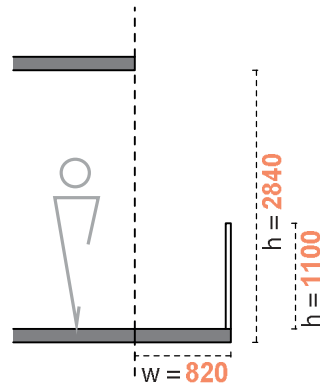
For the upper floor of the porch apartments a sun-screen should be added to the design.

CONCEPT 5 - BEDROOMS 1 & 2

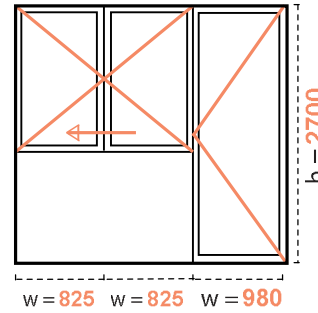
BEDROOM 1+2



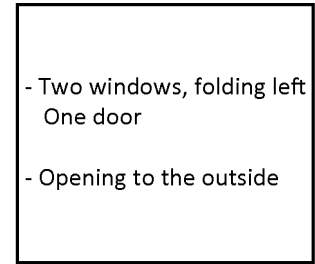
Facade element
(width and height)



Cross section facade
(width and height)



Facade-door design
(concept 5)



Specifications
(concept 5)

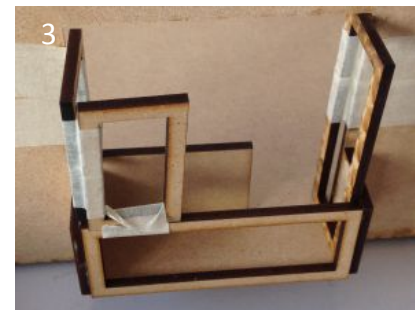
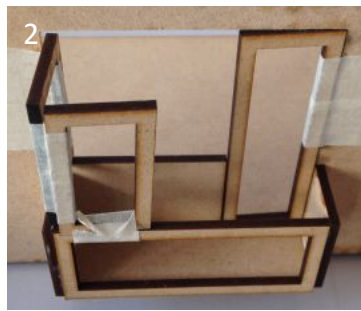
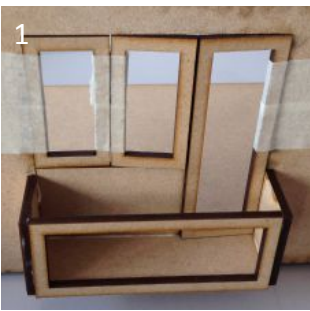


Figure 105; Models concept 5 - bedroom 1 & 2 (own illustration)

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY					
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)	INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	VIEW TRANSPARENCY (VIEW/ PRIVACY)	OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)	ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY, HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
CONCEPT 5	+	+	+	+	-	+	+	+	-	+	+	+	-	+	+	+	+	+



Concept 5 consists of 2 folding windows to the left and one door. All opening outwards. The right window can be disconnected from the frame and connected to the balcony railing to provide a wind protection screen. The door opens also outwards and can therefore also function as a wind protection screen.

To open the windows first the door should be opened. In this way the facade can be designed without an intermediate frame. In this way the border between in and outside minimal and the connection with the environment gets better.

The windows allow the occupants to have a window-sill inside and keep plants both in and outside.

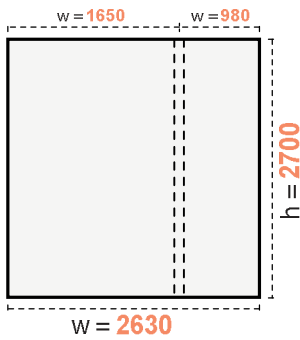
The balustrade of the balcony is transparent and allows the occupants to have a view to the outside.

Most requirements are rated positive or semi-positive and semi-negative. The privacy requirement could be achieved by adding a printing on the glass balustrade for example (same as concept 1).

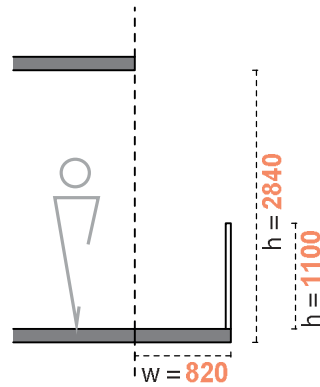
For the upper floor of the porch apartments a sun-screen should be added to the design.

CONCEPT 7 - BEDROOMS 1 & 2

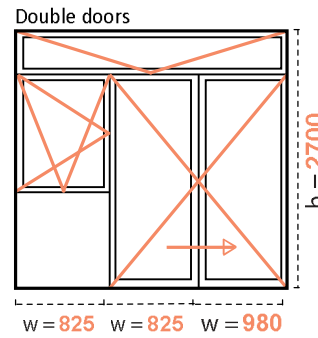
BEDROOM 1+2



Facade element
(width and height)



Cross section facade
(width and height)



Facade-door design
(concept 7)

- Two doors, folding left
- Two window
- Opening to the outside
- Windows able to tilt

Specifications
(concept 7)



Figure 106; Models concept 7 - bedroom 1 & 2 (own illustration)

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY								
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)		INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	TRANSPARENCY (VIEW/ PRIVACY)		OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)		ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY; HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
		SMALL	BIG					VIEW	PRIVACY					IN	OUT						
CONCEPT 7	+	+	+	+	+	+	+	+	-	+	-	+	+	+	-	+	+	+	+	-	-



Concept 7 consists of two folding door which can again be used as wind protection screen. Besides that the design consists of two windows. The upper window is able to be tilted outwards. In this way occupants can easily ventilate their home naturally when they are absent.

The other window can also be used as a wind protection screen by opening it outwards and connecting it to the railing of the balustrade.

Most requirements are rated positive. The privacy requirement could be achieved by adding a printing on the glass balustrade for example (same as concept 1).

For the upper floor of the porch apartments a sun-screen should be added to the design.

The upper tilting window is too large in length now. This window should be divided in at least two parts.

10.3 CONCLUSION

All three concepts have advantages and disadvantages. Therefore all three concepts will be developed. In this way the homeowners and housing cooperations still have their say in what their preferences for a facade element are. The advantages and disadvantages of the three concepts are listed below.

CONCEPT 3

The mainly advantage of the design of concept 3 is the easy operation of the elements. The doors can just be opened outwards or closed and have the ability to be attached to the balcony and be used as wind protection screens.

A second advantage is the fixed element in the middle. In this way the occupants can enter the balcony from both of the bedrooms and place a foldable table in front of the fixed element.

The main disadvantage is the limited space on the balcony. By opening the doors outwards, the occupants only have the middle space in front fixed element to store their balcony furniture.

CONCEPT 5

A big advantage of the concept 5 is the foldable window that can also be used as a wind protection screen in two compositions.

Another big advantage is the wide open space that can be created by opening the door and the folding windows. The border between in- and outside becomes less hard.

The right door is opening inwards, therefore it is essential to analyze the orientation of the specific building to make sure the wind protection screen is orientated right.

The movement of the folding windows is more complex than the operation of concept 3, but still everything is reachable.

CONCEPT 7

Concept 7 is quite the same as concept 5, but in this concept all elements are opening outwards. So wind disturbance from more directions can be avoided.

One big advantage of concept 7 are the tilting windows on top. The occupants can easily ventilate their rooms while they are absent. The disadvantage of the tilting windows is the reachability (they have to be motor driven) and the complexity of the movements (same as in concept 5).

Another big advantage is the wide open space that can be created by opening the door and the folding windows. The border between in- and outside becomes less hard.

As you can see the different designs have different advantages and disadvantages. Therefore all three designs will be further developed in the final design chapter.

IV. FINAL DESIGN

The last section shows the results of the research translated into three different designs. The first chapter explains the design in drawings, visualizations and details. Chapter 12 includes different evaluation methods that were used to rate the final designs. And the last chapter gives an answer on the research question, a reflection on the whole graduation process and recommendations for future research.

11. DESIGN

This chapter will show the final facade element designs for concept 3, 5 and 7 of the previous chapter 'Concept ideas'. The concepts are first evaluated and improved and later on developed into detail.

The first paragraph will discuss the tactical approach for selling the facade elements to the homeowners and housing cooperations, while having in mind that still the occupants should have their own preference input. Later on the three concepts will be elaborated into final designs in paragraph 11.2. Paragraph 11.3 will elaborate the extra facade element options, followed by the assembly of the whole facade elements to the 2nd skin project in paragraph 11.4.

11.1 TACTICAL APPROACH

The different occupants have different preferences as the previous research chapters show. Not all preferences are equal for the occupants, as we saw in designing a Home Energy Management System (HEMS) for the different personas. To make sure all occupants are satisfied and willing to energy efficiently use the new facade (2nd skin), they should still have the opportunity to have a say in what they want. Of course they will be limited in their say, therefore a tactical approach is necessary.

PHASE 1 - THE ELEMENT

Three concepts for a facade element are developed and detailed in this chapter. The advantages and disadvantages of the different designs depend on many different local factors (e.g. winddirection, orientation, etc). Homeowners or housing cooperations should have the opportunity to get insight in the advantages and disadvantages of each design for their apartment(block).

Of course the look of the entire facade should in the end give one facade appearance. Therefore this decision should be made by the architects in consultation with the homeowners/ housing cooperations.

PHASE 2 - THE EXTRA OPTIONS

Cause not all defined requirements are implemented in the standard design elements, occupants should have the opportunity to choose for different extra elements. By providing the option to choose for these elements, the appearance of the whole facade stays

quite equal.

The different options which the occupants can choose, are:

- an insect protection screen;
- an inside sunshading system;
- flower boxes to hang on the balustrade;
- curtains inside;
- the transparency of their balustrade;
- implementation of motor driven windows instead of manually operating windows.

These different element will be elaborated in paragraph 11.3.

PHASE 3 - HEMS

As discussed in chapter 10.1 three different Home Energy Management System designs are required in order to meet the habits of the different personas. To find out which HEMS the occupants need, different questions (according to the interest and knowledge in energy and the willingness to reduce energy) should be answered and concluded into which HEMS works best for that household.

With this approach the occupants still have enough participation in their personal comfort and facade design, while still energy efficiency and the health of the occupants are most important.

As mentioned, the three different concepts are further developed and will be discussed and detailed in the next paragraph.

11.2 FROM CONCEPTS TO FINAL DESIGNS

As the previous chapter of the concept ideas showed, the designs consist of two main parts. These two design objects seem to be two separate designs, but can only function together. *Figure 107* shows the vision on the integration of the two main design parts. This vision is translated in a design strategy (*figure 108*), which shows the integration of the Home Energy Management System design and the Facade element design.

Paragraph 10.1 showed three different design concepts for the HEMS and how this HEMS should be extended with extra connections to reduce the energy consumption. The NEXT facade element (as discussed in the previous chapter) will be implemented in the

facade element and connected to the HEMS system. In this research the NEXT facade element will not be developed further, but the concept of the NEXT active facade will be used. Therefore the NEXT element will also be placed in facade element in concept.

The next pages will show the translation of the three concept facade element designs into final designs.

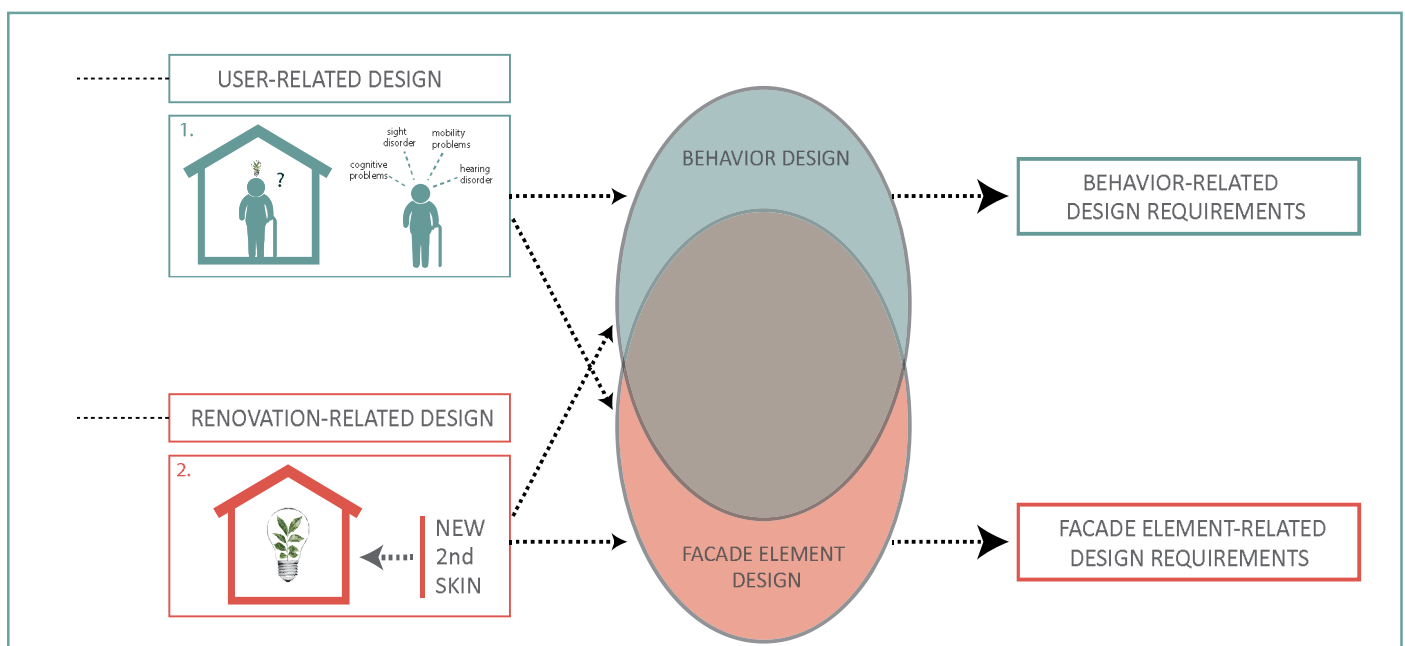


Figure 107; Vision on the integration of the two main design parts (own illustration)

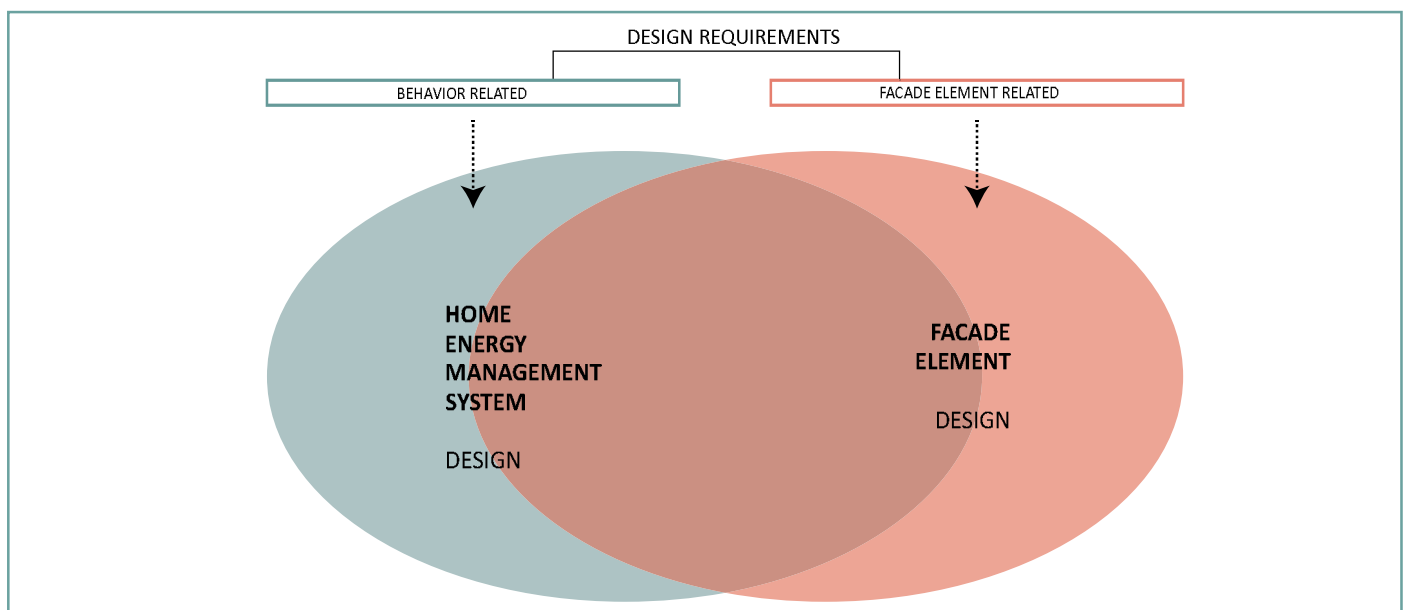


Figure 108; Vision translated into design strategy (own illustration)

DESIGN 1 - concept 3

Figure 109 and figure 110 show two impressions of the implementation of design 1 in the BAM 2nd skin apartments in Rotterdam. On the next few pages the operation of design 1 will be discussed, clarified by drawings and details. The design will also be checked on the determined design requirements.



Figure 109; Visualization design 1 (concept 3) on the BAM 2nd skin project in Rotterdam (own illustration)



Figure 110; Visualization design 1 (concept 3) on the BAM 2nd skin project in Rotterdam, balcony texture (own illustration)

OPERATION

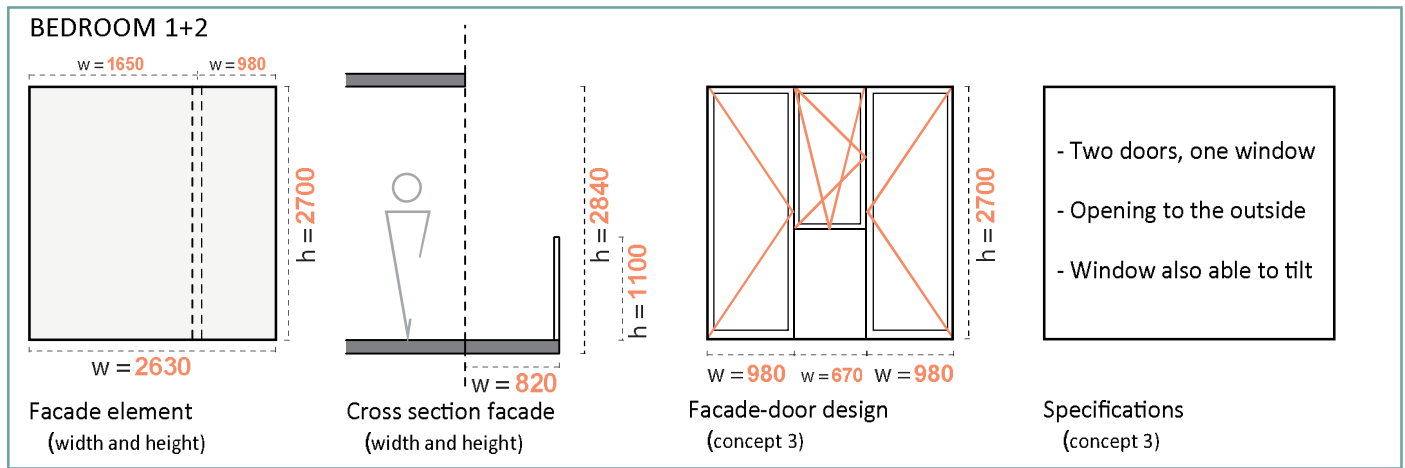


Figure 111; Concept design 3 (own illustration)

Figure 111 shows the concept design of concept 3. The final design for concept 3 is shown in figure 112.

The two doors open outwards and can be fixed to the balcony by turning the door handle downwards. Both doors can function as wind protection screens in this way.

Because the dimensions of the 2nd skin project are fixed, the doors in the design don't have the same dimensions. This problem can be solved in two ways;

- change the shape of the balcony;
- minimize the dimensions of the middle window.

Both options are possible, in this design the first option is chosen.

The big advantage of this design is that the balcony can be used by two rooms and the composition al-

lows the occupants to implement a folding table underneath the window. In this way the occupants still have enough space to store their furniture.

Two cross sections of the facade, as figure 112 shows, will be presented in detail on the next pages. First the vertical section AA' will be shown, followed by the horizontal section BB'.

The space marked in green in figure 112 will provide space for the NEXT facade element (which is connected to the HEMS inside).

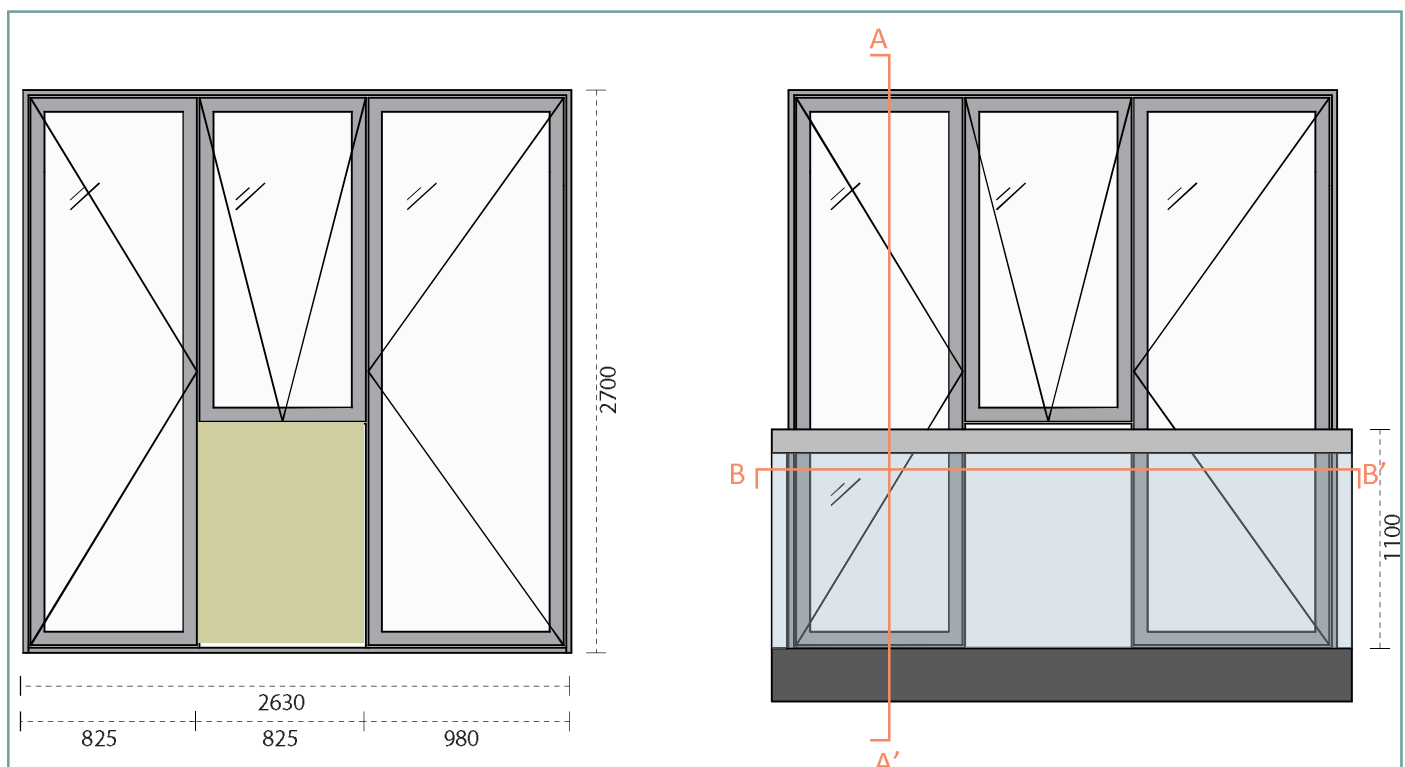
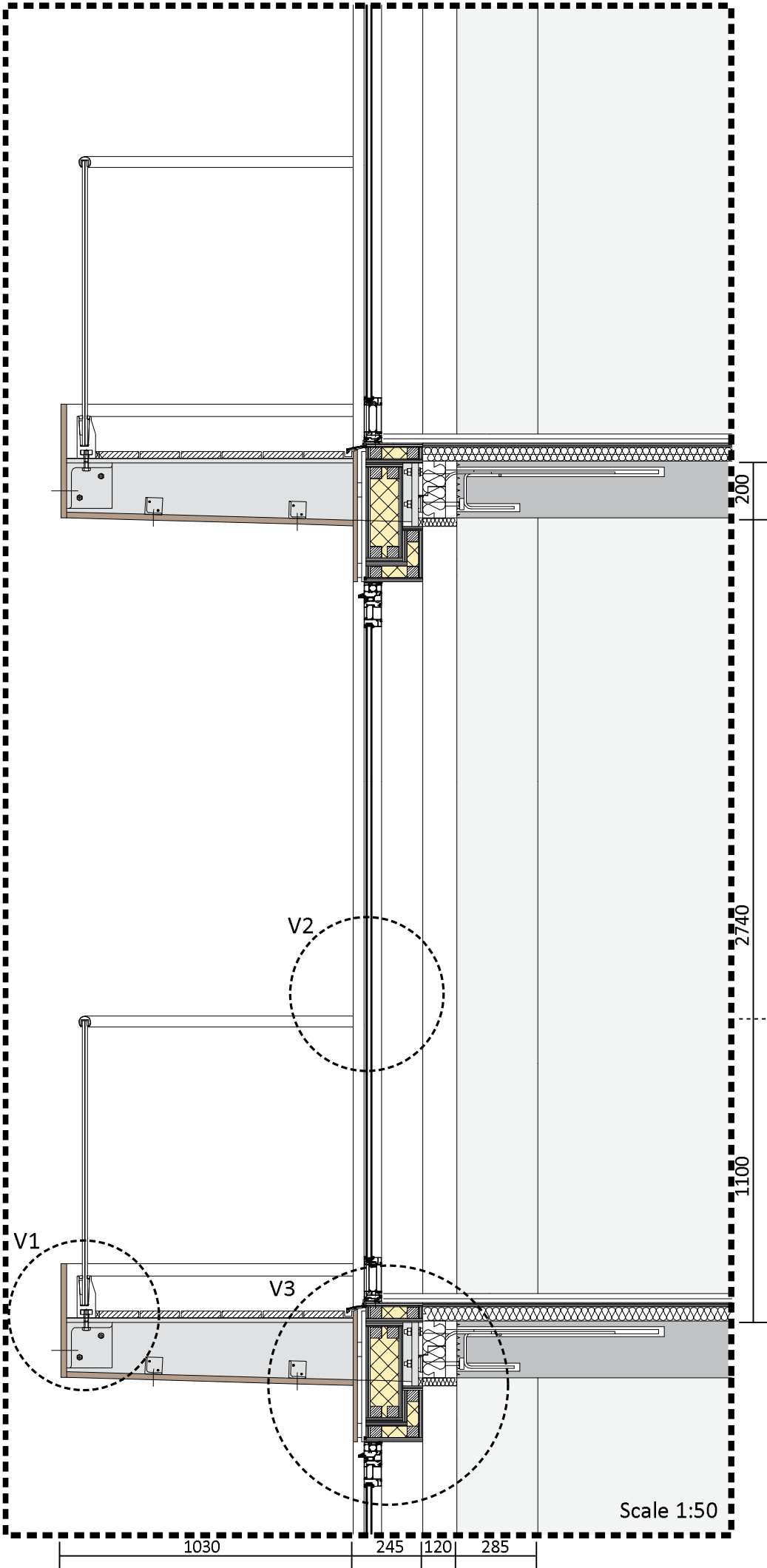
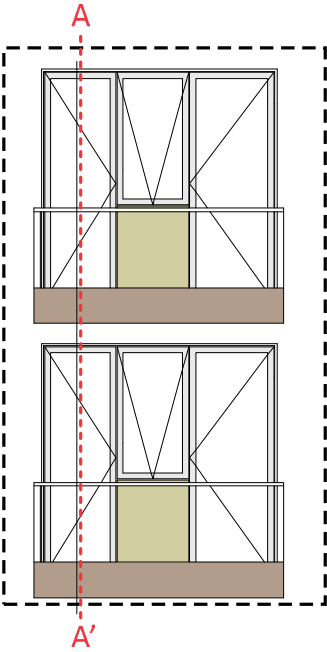
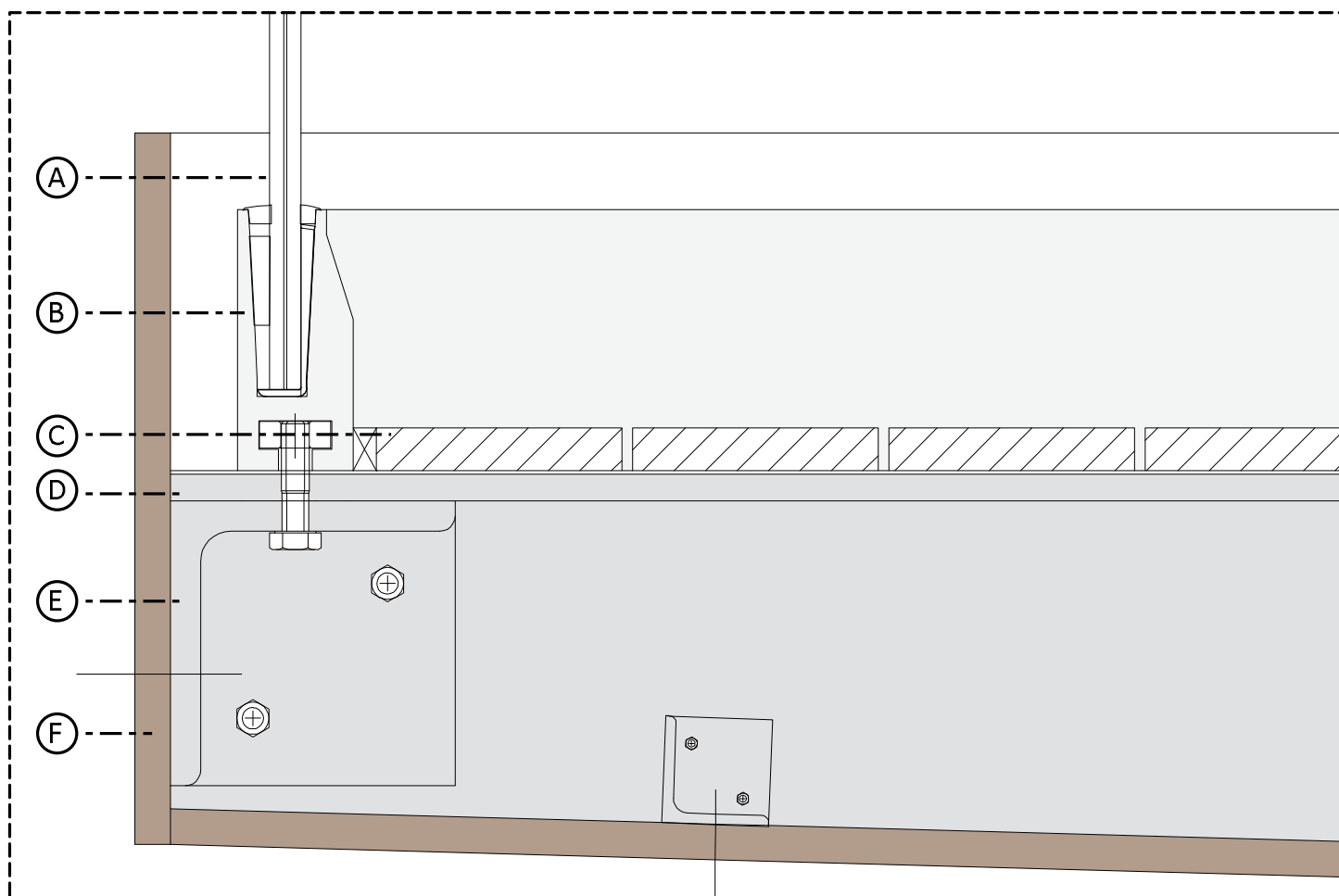


Figure 112; Final design - concept 5 (own illustration)

SECTION AA'



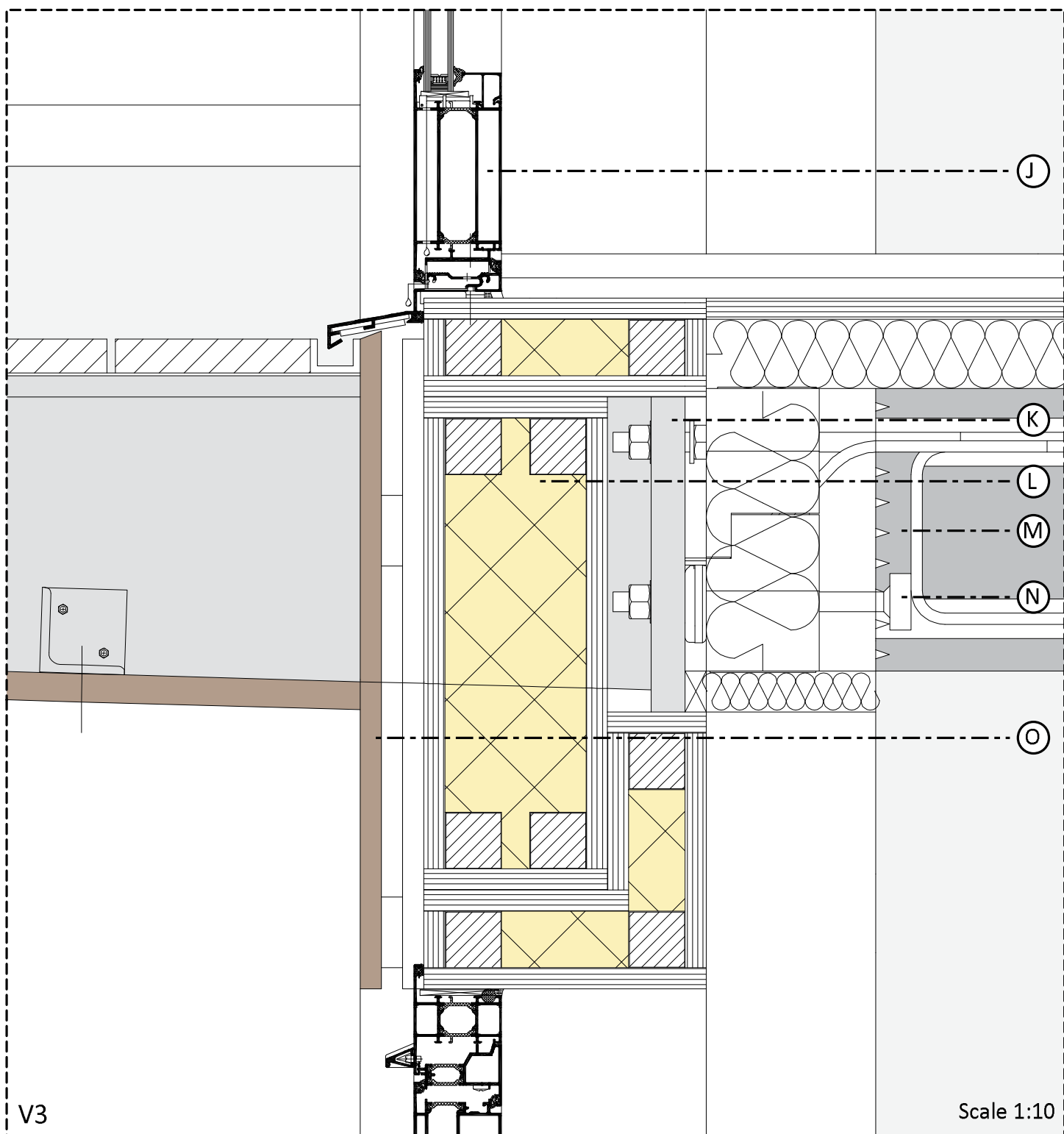
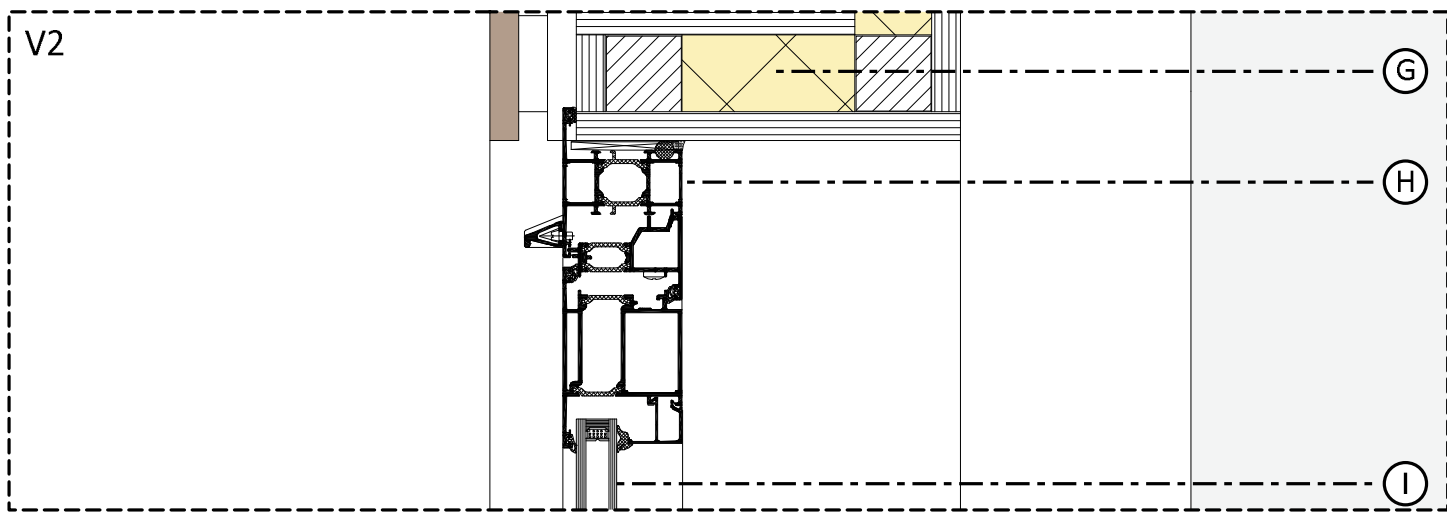


A - glasspanels balustrade
 B - base of the balustrade
 C - wooden balcony terrace
 D - cantiliver beam (connected to isokorf)
 E - hook profile
 F - balcony cladding
 G - insulation ($R_c = 3,5$)
 H - aluminium profile, outwards opening door

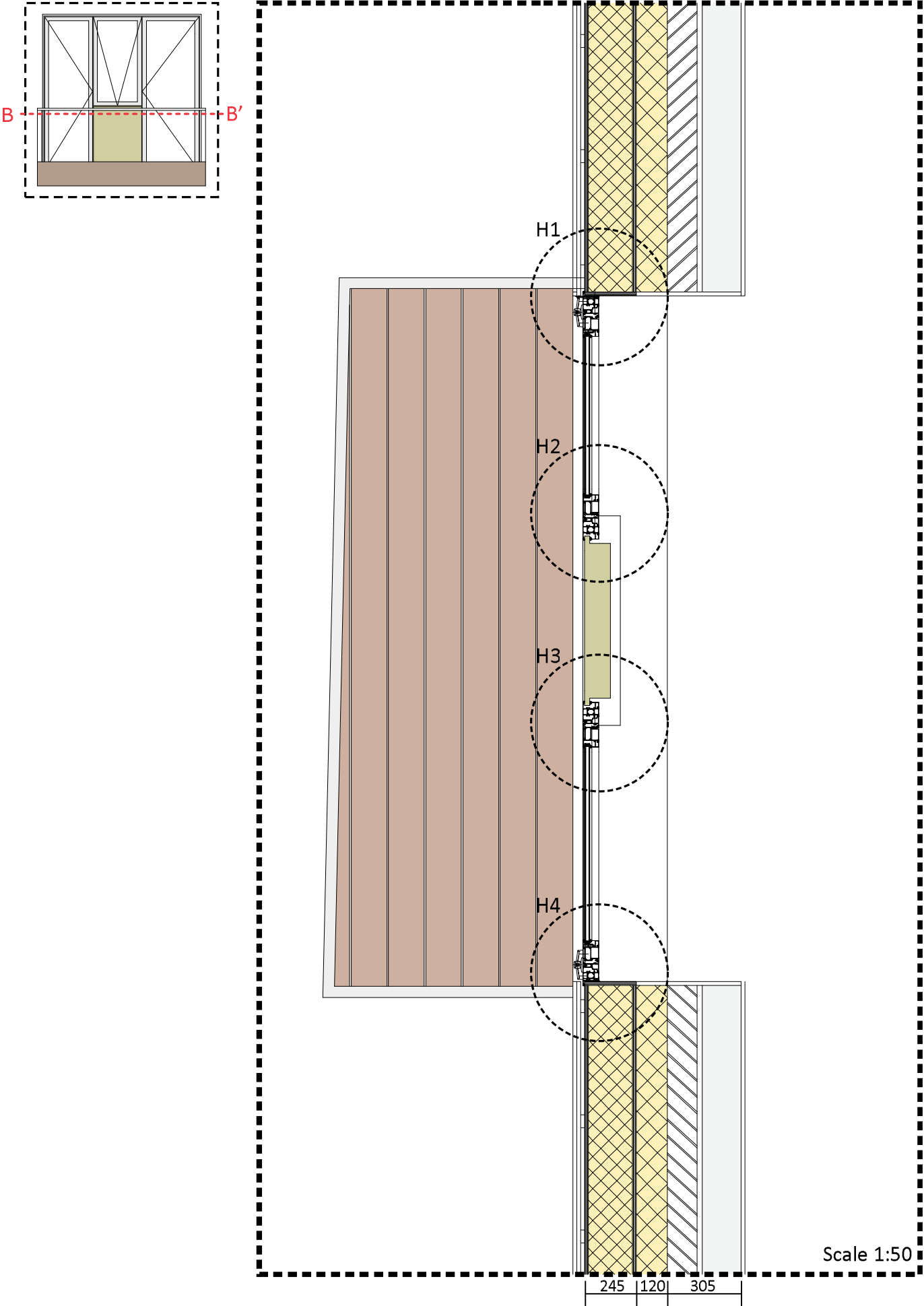
I - glass (door)
 J - bottom door profile (aluminium)
 K - cantiliver beam (connected to isokorf)
 L - 2nd skin element (insulated)
 M - existing concrete floor
 N - isokorf system
 O - facade cladding

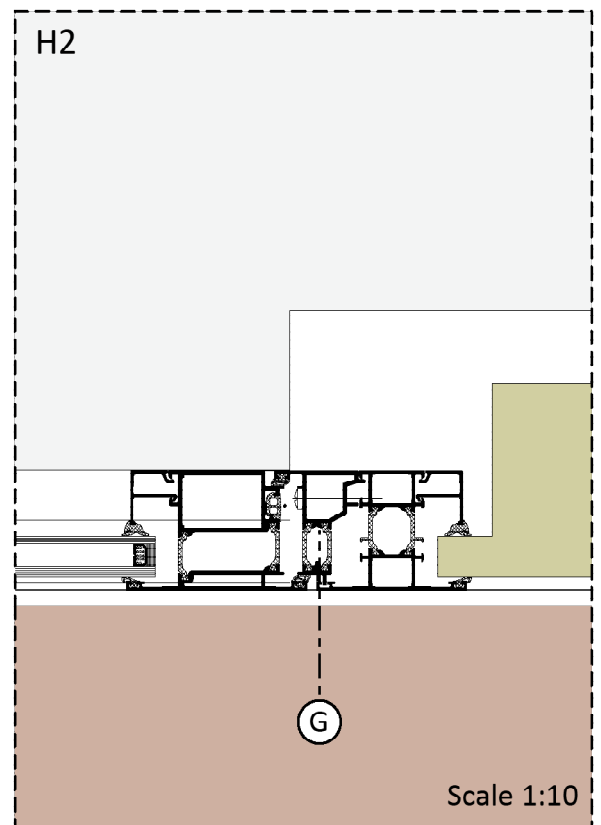
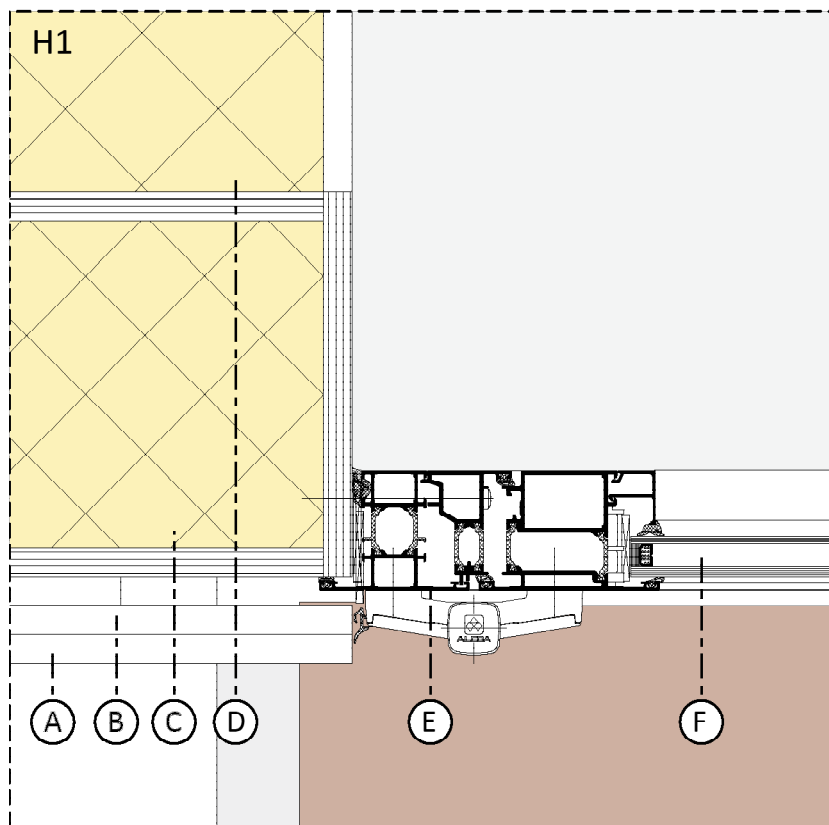
V1

Scale 1:10



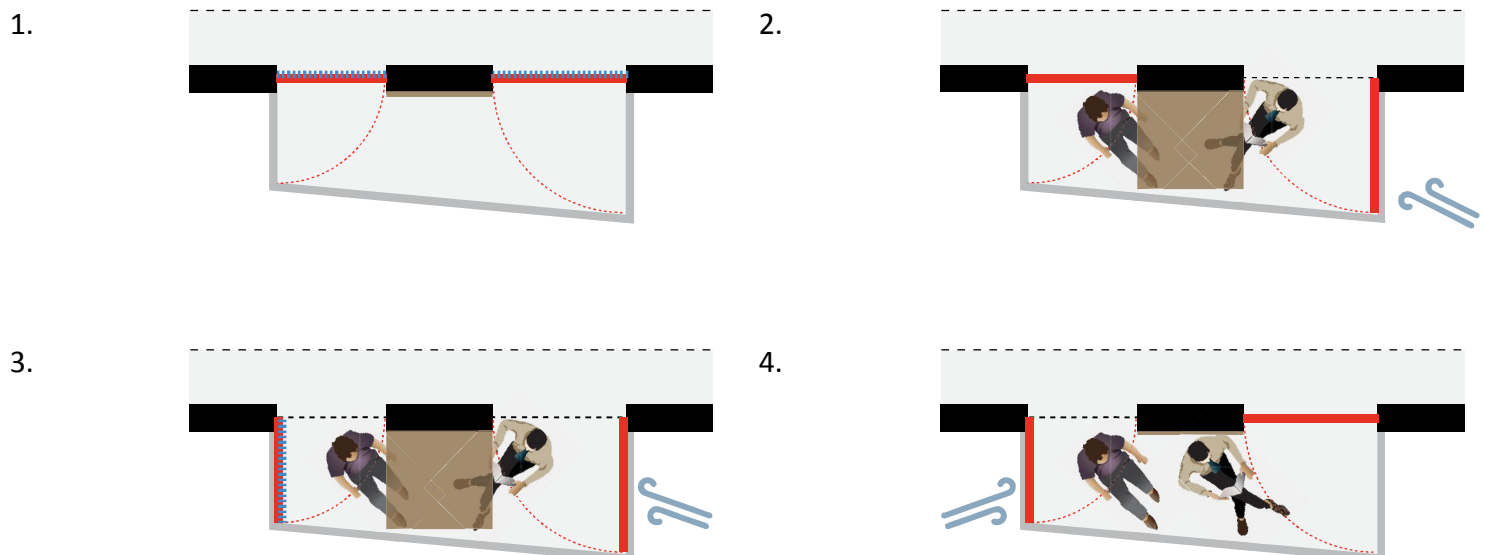
SECTION BB'

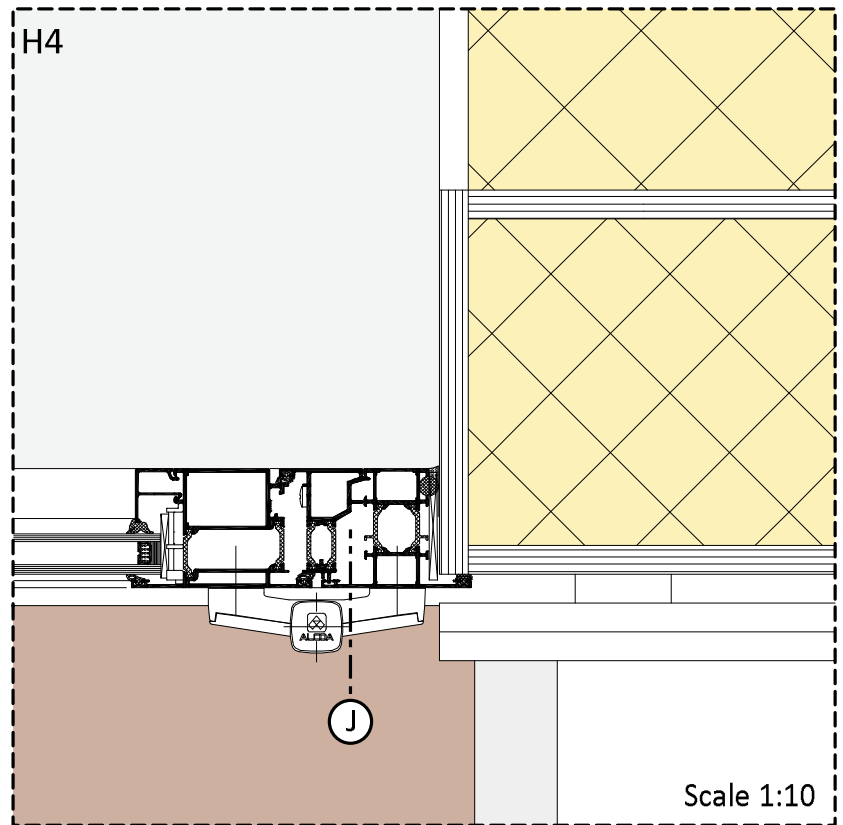
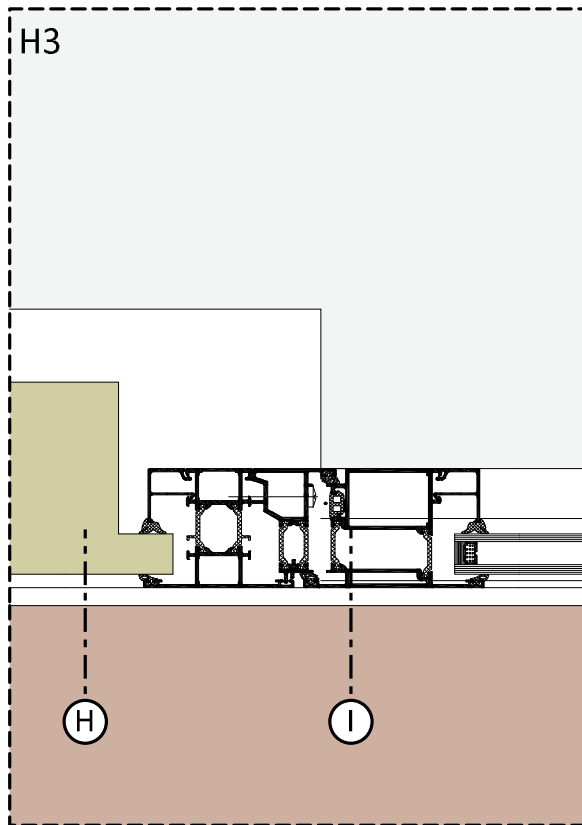




- A - facade cladding
- B - wooden styles and battens
- C - insulation (EPS, $R_c = 3,5$)
- D - insulation ($R_c = 3,0$)
- E - outward opening door profile (aluminium)
- F - door glass
- G - connection outward opening door and NEXT element (aluminium)
- H - NEXT active facade element
- I - connection outward opening door and NEXT element (aluminium)
- J - outward opening door profile attached to wall (aluminium)

DIFFERENT SCENARIOS (topview)





DIFFERENT SCENARIOS (visualizations)

1.



- planter boxes
- extra cladding to make the balustrade semi-transparent

2.



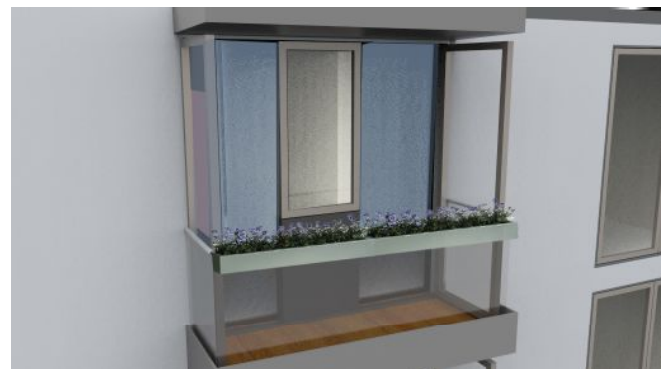
- adjustable sun shading system
- foldable table

3.



- print on transparent balustrade to make it semi-transparent

4.



- adjustable sun shading system
- adjustable insect protection screen

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY								
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)		INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	TRANSPARENCY (VIEW/ PRIVACY)		OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)		ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY, HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
		SMALL	BIG					VIEW	PRIVACY					IN	OUT						
CONCEPT 3	+	+	+	+	+	+	+	+	-	+	-	+	+	+	-	+	+	+	+	+	

As the requirement checklist of design 1 (concept 3) shows, not all requirements are marked with a plus. All requirements that are not marked with a plus will be discussed below.

- RAIN PROTECTION

The design didn't mainly focus on rain protection, but because of the positioned balconies above each other the occupants are already partly rain protected. The upper balcony is also provided with an overhang. Besides that the windows, which function as rain wind protection screens, can also be partly used as rain protection screens.

- TRANSPARENCY - VIEW

Because of the partly solid part of the facade element (the NEXT element), the view from inside to outside is partly blocked. The occupants cannot look outside from every position.

- TRANSPARENCY - PRIVACY

In the original design the balustrade is fully transparent. Not all occupants prefer a fully transparent balustrade all the time. Therefore this transparency should be adjustable or partly blocked. Different options to solve this problem are shown in the figure on the next page.

The first option is a print that can be attached to the glass. The print is partly transparent.

The second option is an extra structure in front of the balustrade which still provides transparency, but makes the view for passers less direct.

The third option is a shading system that is attached to the inside of the balcony and can be adjusted to the preferable place.

- NOISE PROTECTION

The facade protects against several noises when closed, but not all noises will be avoided. When the facade is (partly) open, the occupants won't be protected from any noises. This research didn't focus on developing a noise protection screen, but as the recommendations say there should be done more research into this topic.

- ADJUSTABLE SUN SHADING - OUTSIDE

The facade is provided with an indoor sun shading system, but no extra outdoor sun shading is added. Because the balconies have an overhang, the occupants are already partly protected against the sun. Besides that, the wind protection screens can also function as sun protection by closing the indoor sun shading when the door/ windows are opened.

- SPACE AREA ON BALCONY

By keeping the windows closed, the space area is quite good. But when the windows have to be opened, the higher furniture (and people) have to move partly. There is space to store stuff on the balcony, but there is a possibility that this stuff has to be moved when opening the windows.

Additionally a foldable table inbetween the two doors can be provided. By making the table foldable, the storage space can still be remained. In this case there should be thought of the direction to fold the table to, the NEXT element won't function optimally if a table is folded in front of it.

- WINDOW CLEANABILITY

All windows are quite easy to clean, except the glass of the balustrade. The glass should be cleaned by a company regularly, or the occupants should use an easy tool to clean the glass by themselves.



Figure 113; Final design 1 (concept 3), balustrade option 1 (own illustration)



Figure 114; Final design 1 (concept 3), balustrade option 2 (own illustration)



Figure 115; Final design 1 (concept 3), balustrade option 3 (own illustration)

DESIGN 2 - concept 5

Figure 116 and figure 117 show two impressions of the implementation of design 2 in the BAM 2nd skin apartments in Rotterdam. On the next few pages the operation of design 2 will be discussed, clarified by drawings and details. The design will also be checked on the determined design requirements.



Figure 116; Visualization design 2 (concept 5) on the BAM 2nd skin project in Rotterdam (own illustration)



Figure 117; Visualization design 2 (concept 5) on the BAM 2nd skin project in Rotterdam, wooden cladding (own illustration)

OPERATION

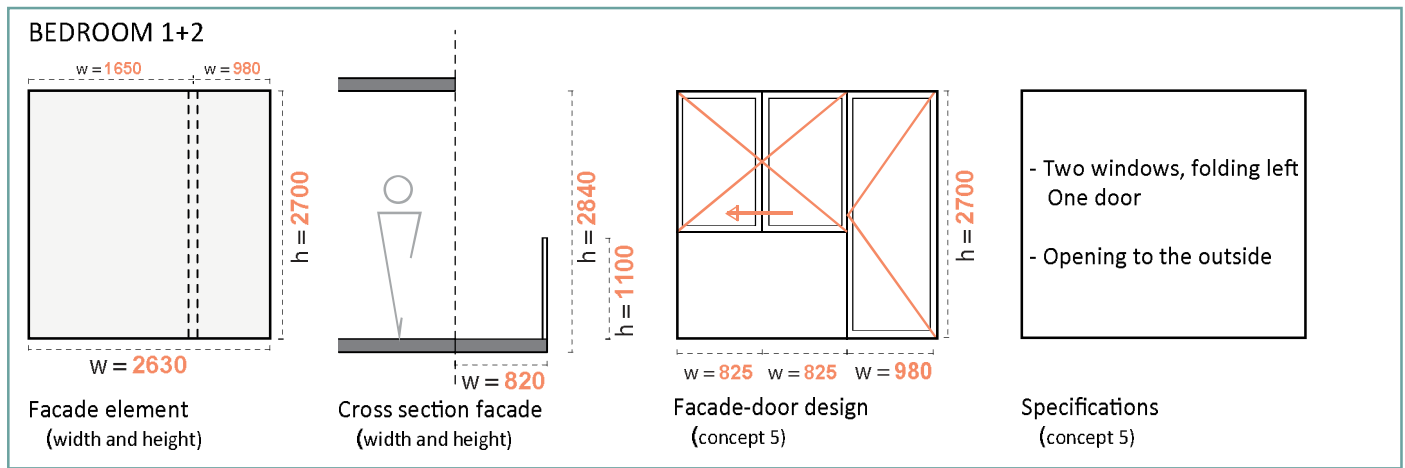


Figure 118; Concept design 5 (own illustration)

Figure 118 shows the concept design of concept 5. The final design for concept 5 has changed a bit (figure 119). The door at the right side is a bit wider than the windows and is therefore changed into an inwards opening door. In this way the occupants also have more space to keep furniture on their balconies.

The two windows fold outwards and can be connected to the railing of the balustrade. In this way a wind protection screen can be constituted.

The main wind direction in the Netherlands is South-West. The designs for different renovation apartments should therefore be aligned with the wind direction.

The balustrade fully consists out of glass. By connecting the folding windows as windscreens a comfortable outside area can be created for the occupants.

The door opens inwards now and this also means the windows can be opened without opening the door first.

Two cross sections of the facade, as figure 119 shows, will be presented in detail on the next pages. First the vertical section AA' will be shown, followed by the horizontal section.

The space marked in green in figure 119 will provide space for the NEXT facade element (which is connected to the HEMS inside).

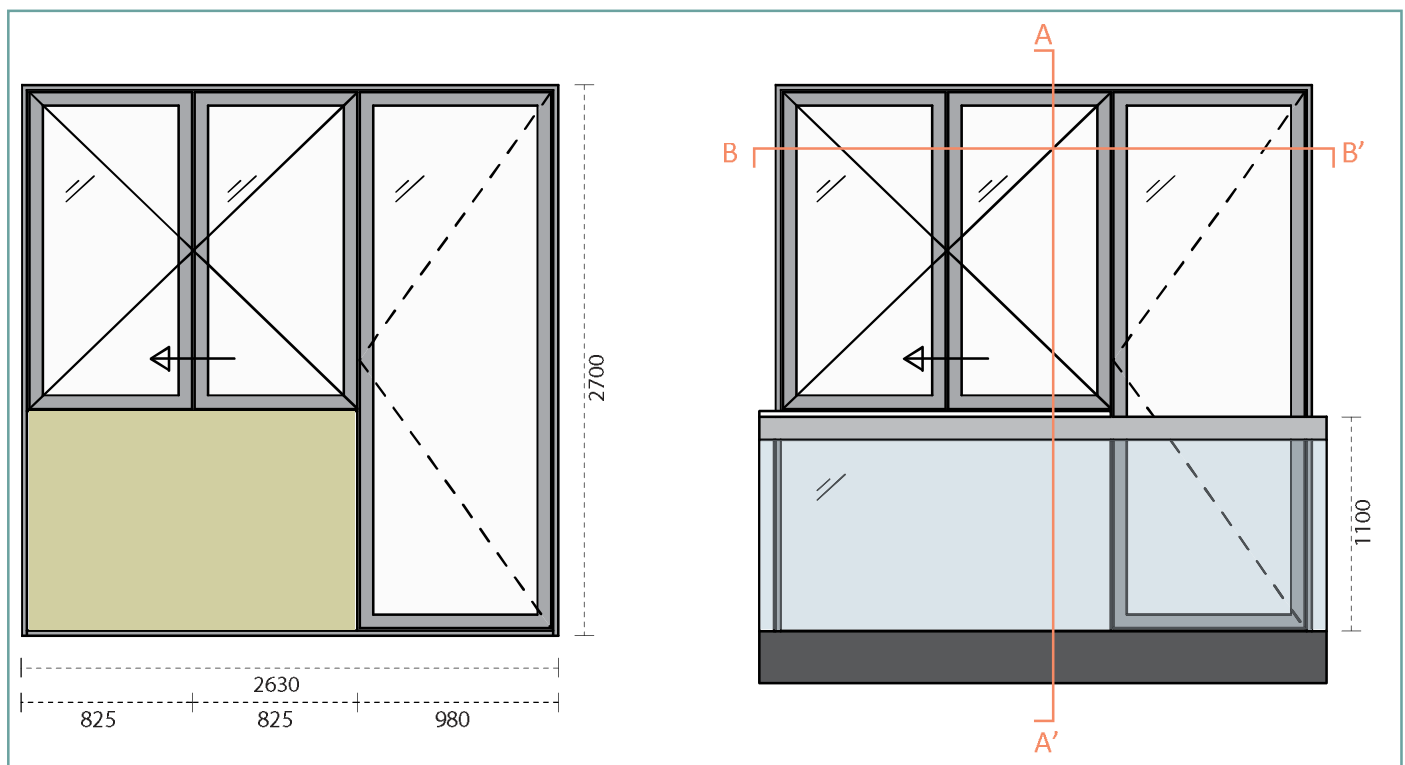
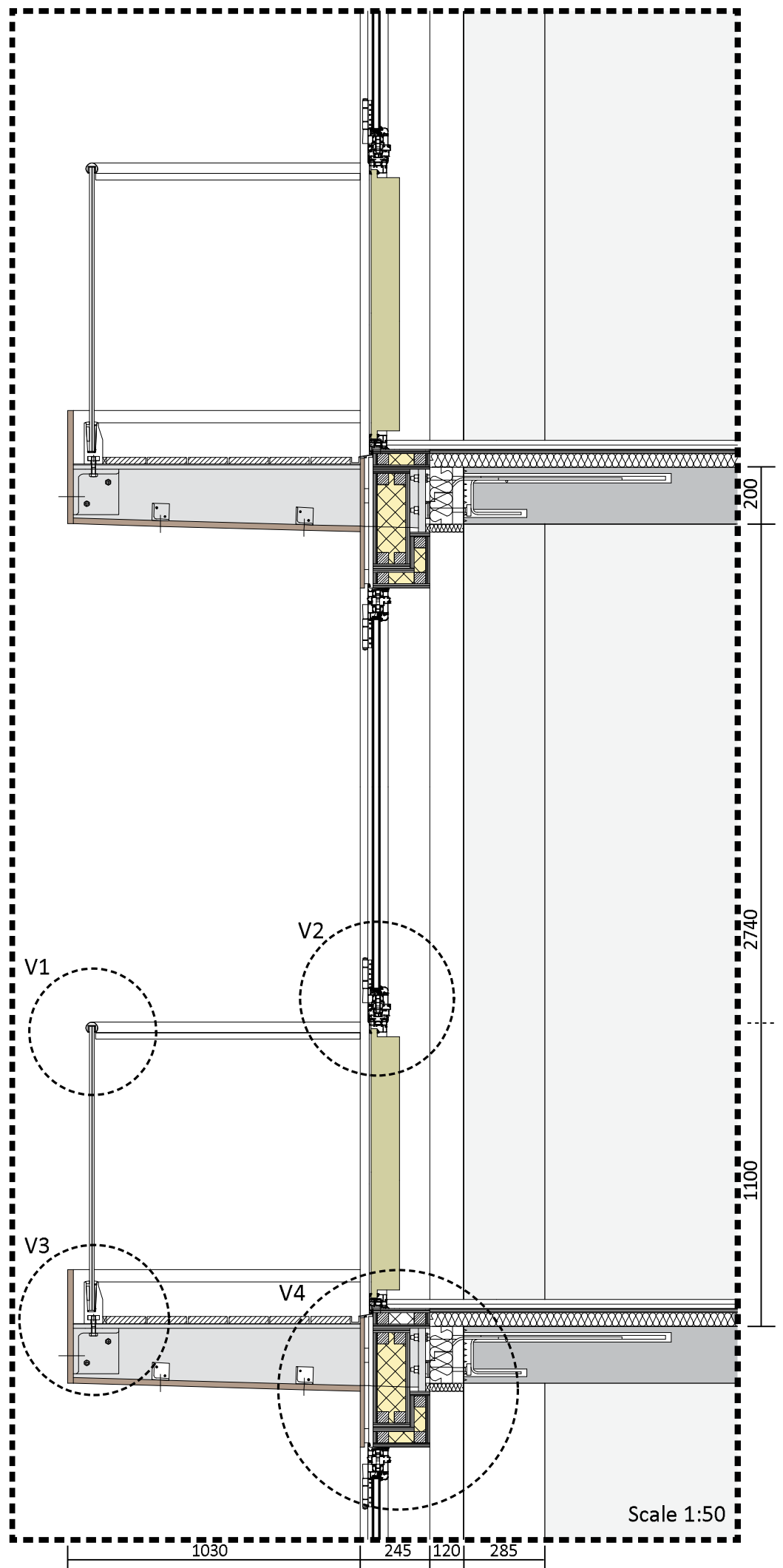
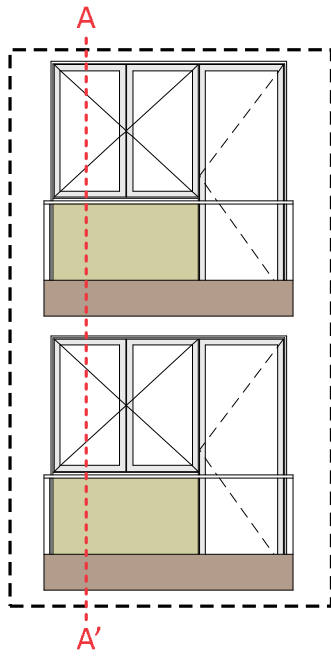
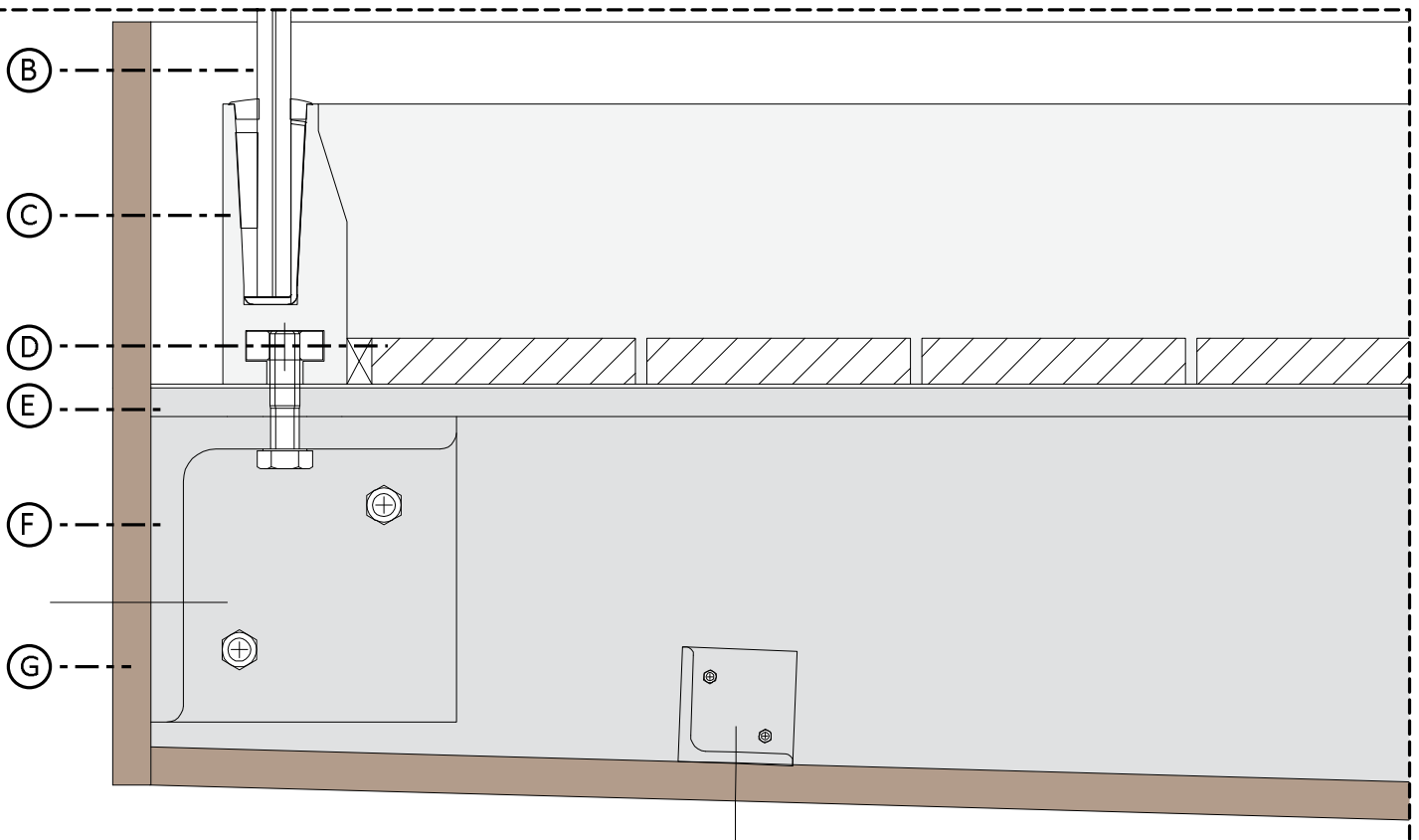
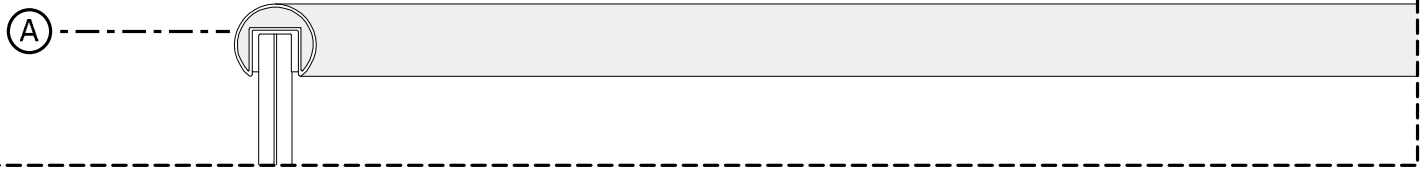


Figure 119; Final design - concept 5 (own illustration)

SECTION AA'



V1

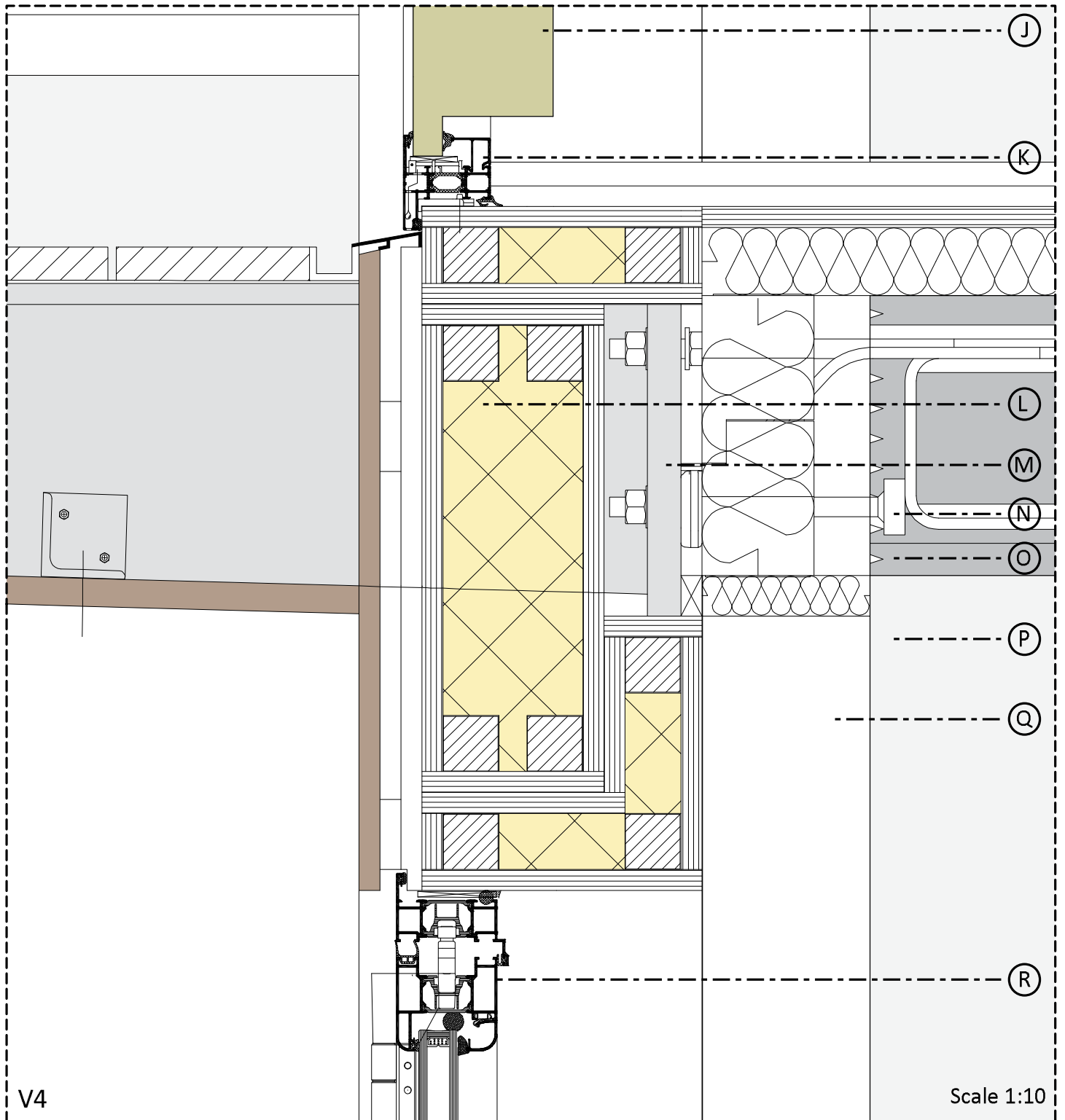
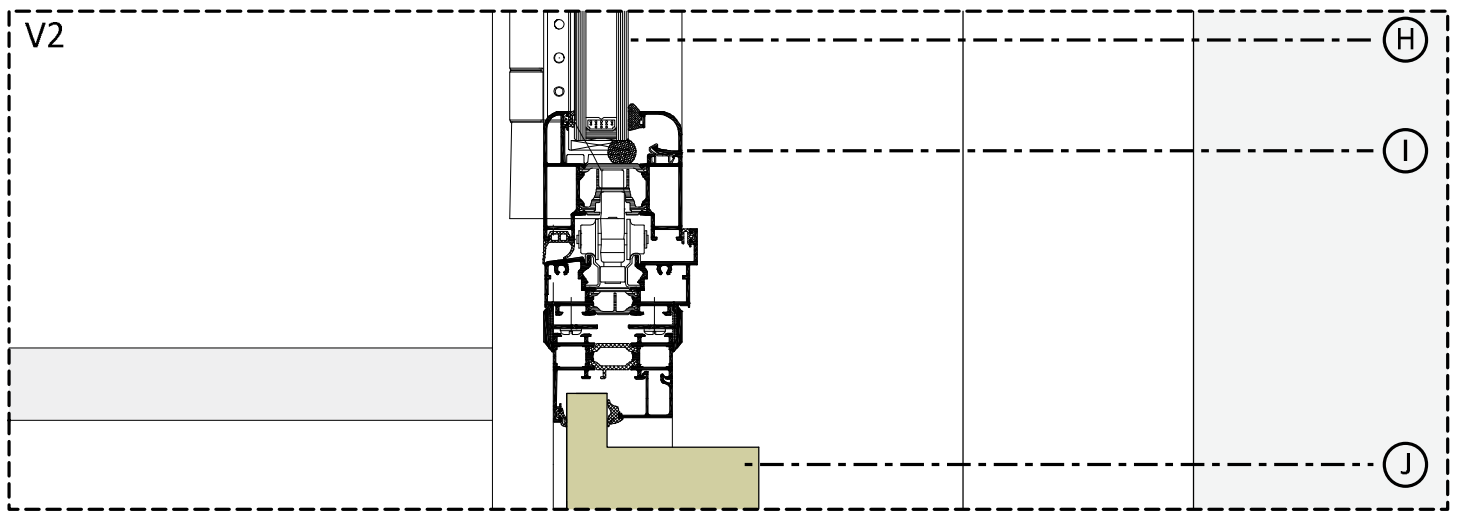


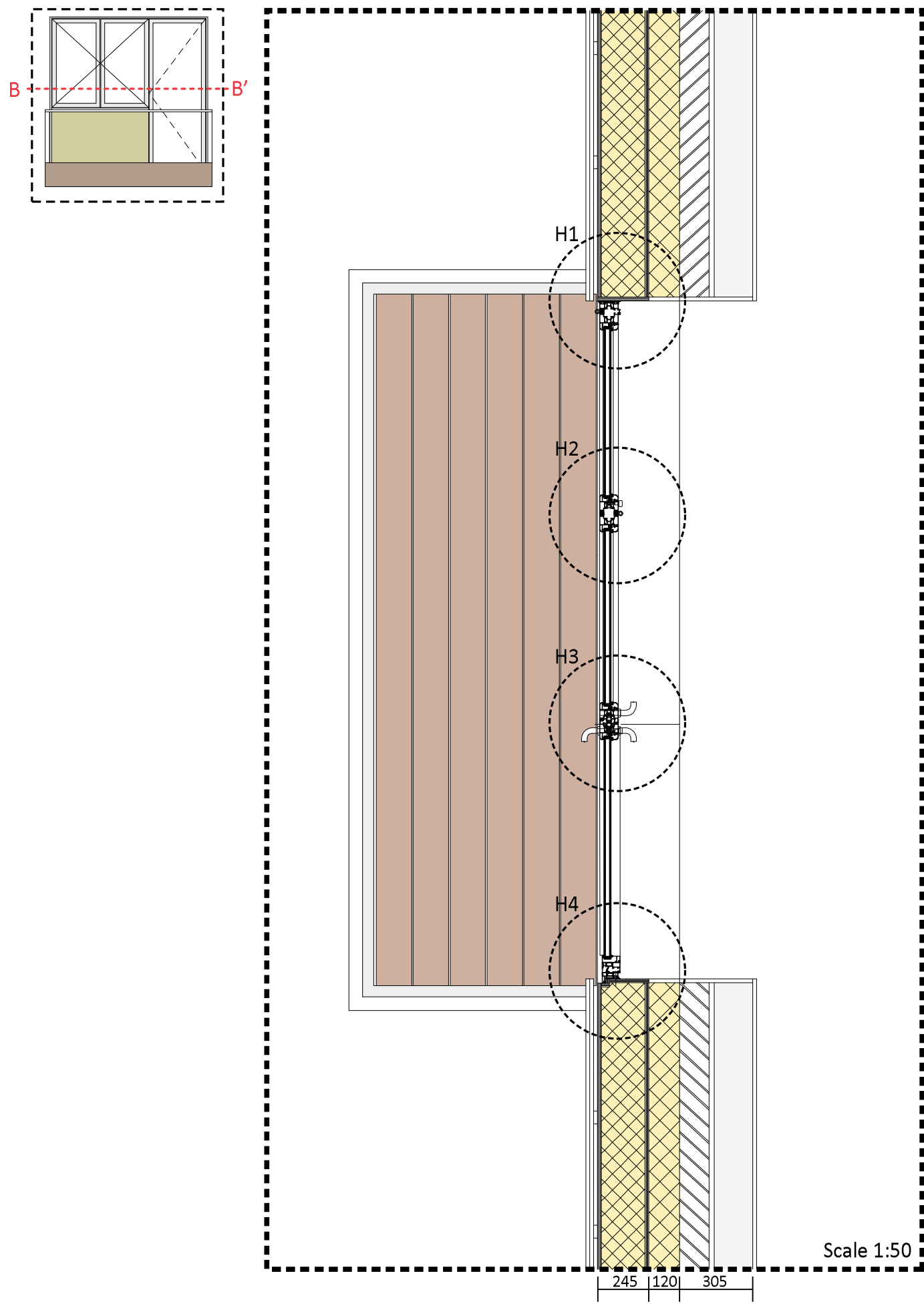
- A - handrail balustrade (aluminium)
- B - glasspanels balustrade
- C - base of the balustrade
- D - wooden balcony terrace
- E - cantiliver beam (connected to isokorf)
- F - hook profile
- G - balcony cladding
- H - glass folding window
- I - outfolding aluminium profile

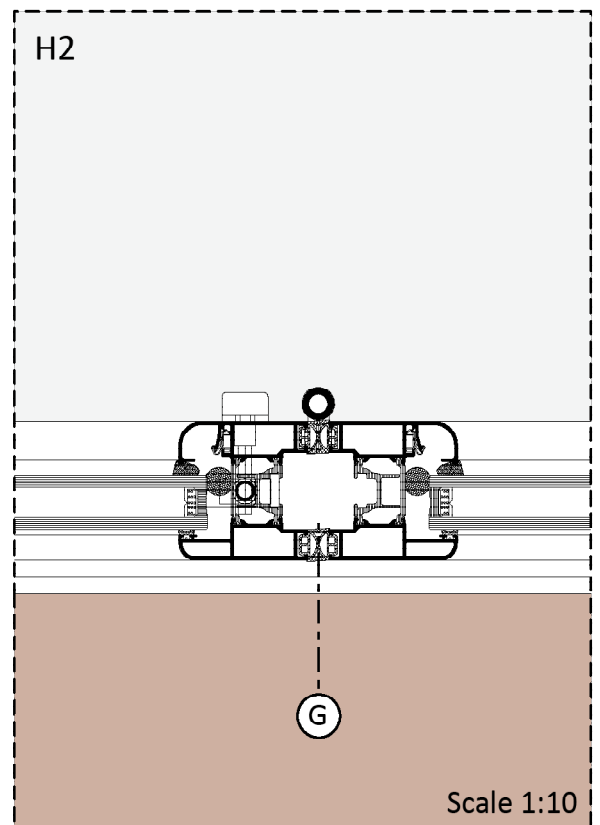
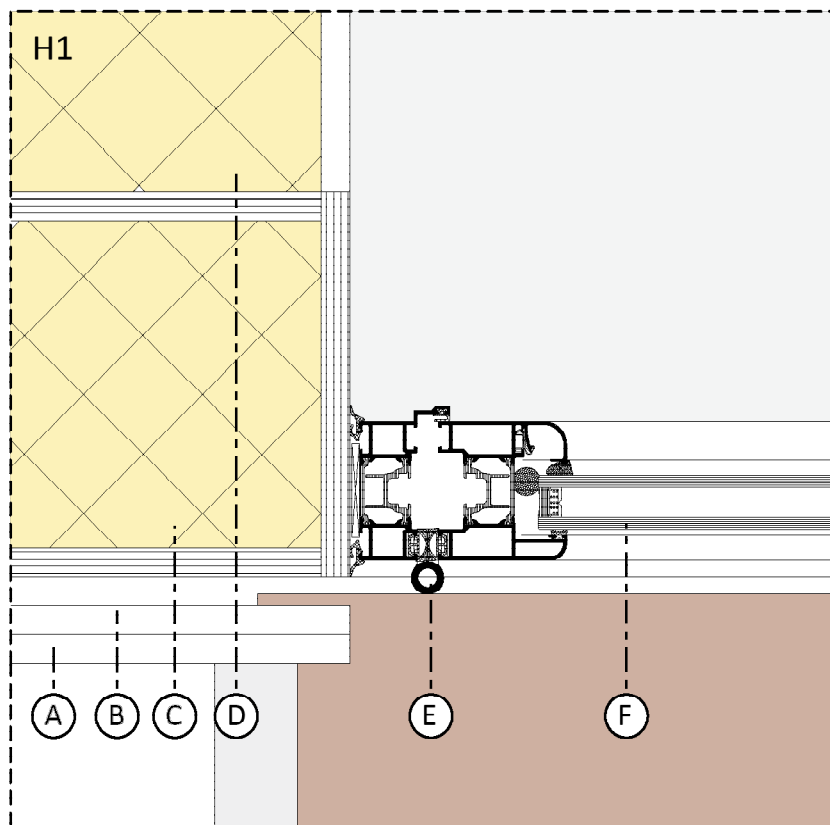
- J - NEXT facade element
- K - aluminium profile
- L - 2nd skin element (insulated)
- M - cantiliver beam (connected to isokorf)
- N - isokorf system
- O - existing concrete floor
- P - existing concrete wall
- Q - existing covering wall
- R - upper aluminium folding window profile

V3

Scale 1:10



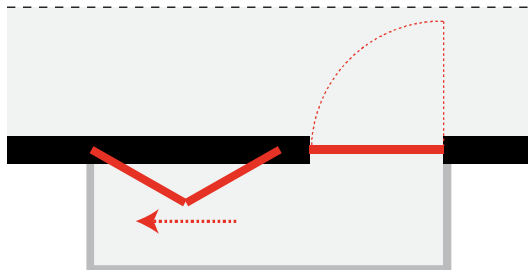




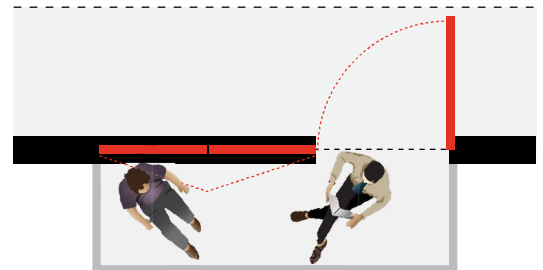
- A - facade cladding
- B - wooden styles and battens
- C - insulation (EPS, $R_c = 3,5$)
- D - insulation ($R_c = 3,0$)
- E - outward folding window profile (aluminium)
- F - window glass
- G - middle outward folding window profile (aluminium)
- H - outward folding window profile (aluminium)
- I - inward opening door profile (aluminium)
- J - inward opening door profile attached to wall (aluminium)

DIFFERENT SCENARIOS (topview)

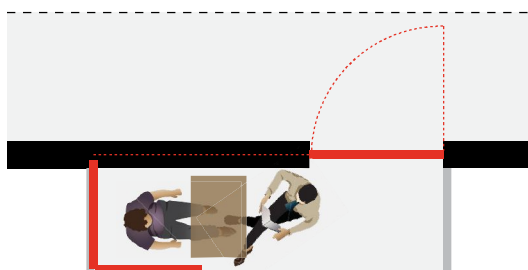
1.



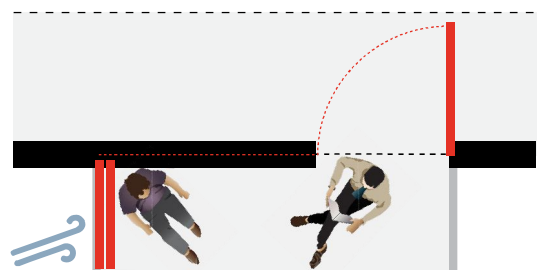
2.

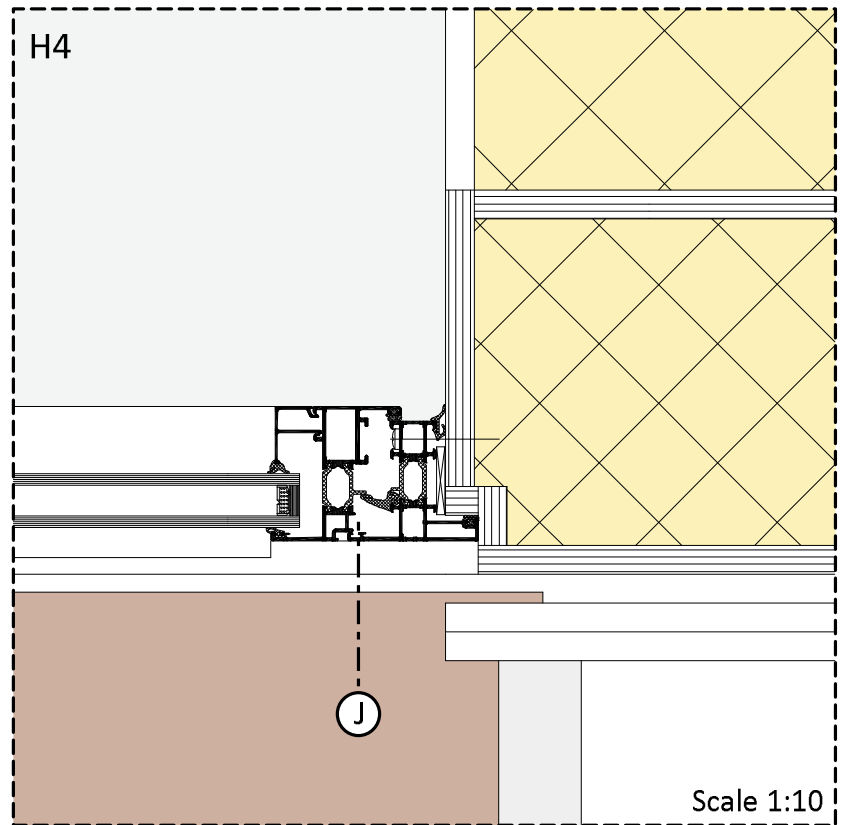
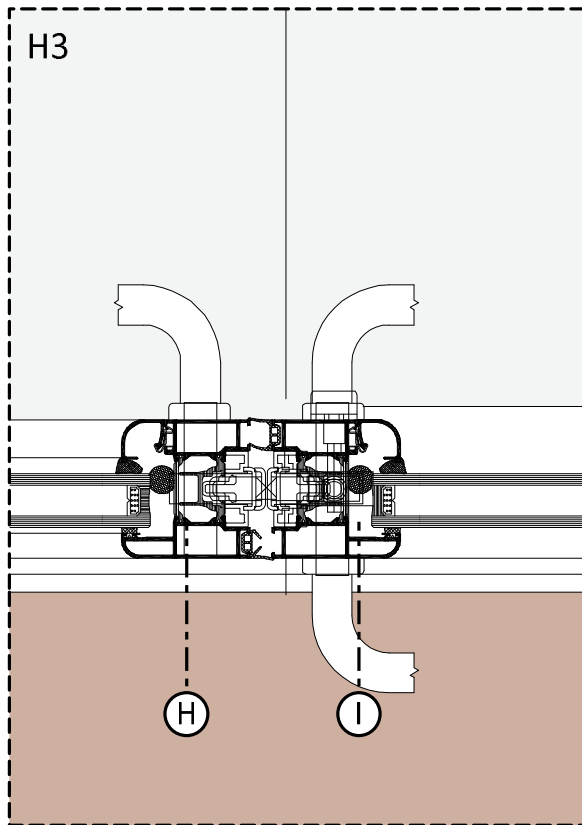


3.



4.





DIFFERENT SCENARIOS (visualizations)

1.



- adjustable sunshading system
- extra cladding to make the balustrade semi-transparent

2.



- adjustable sun shading system
- planter boxes

3.



- adjustable insect protection screen
- planter boxes

4.



- adjustable transparency of the balustrade

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY								
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)		INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	TRANSPARENCY (VIEW/ PRIVACY)		OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)		ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY, HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
		SMALL	BIG					IN	OUT					VIEW	PRIVACY						
CONCEPT 5	+	+	+	+	-	+	+	+	-	+	-	+	+	+	-	+	+	+	+	+	+



As the requirement checklist of design 2 (concept 5) shows, not all requirements are marked with a plus. All requirements that are not marked with a plus will be discussed below.

- RAIN PROTECTION

The design didn't mainly focus on rain protection, but because the balconies are all positioned above each other the occupants are already partly rain protected. The upper balcony is also provided with an overhang. Besides that the windows ,which function as rain wind protection screens, can also be partly used as rain protection screens.

- TRANSPARENCY - VIEW

Because of the partly solid part of the facade element (the NEXT element), the view from inside to outside is partly blocked. The occupants cannot look outside from every position.

- TRANSPARENCY - PRIVACY

In the original design the balustrade is fully transparent. Not all occupants prefer a fully transparent balustrade all the time. Therefore this transparency should be adjustable or partly blocked. Different options to solve this problem are shown in the figure on the next page.

The first option is a print that can be attached to the glass. The print is partly transparent.

The second option is an extra structure in front of the balustrade which still provides transparency, but makes the view for passers less direct.

The third option is a shading system that is attached to the inside of the balcony and can be adjusted to the preferable place.

- NOISE PROTECTION

The facade protects against several noises when closed, but not all noises will be avoided. When the facade is (partly) open, the occupants won't be protected from any noises. This research didn't focus on developing an noise protection screen, but as the recommendations say there should be done more research into this topic.

- ADJUSTABLE SUN SHADING - OUTSIDE

The facade is provided with an indoor sun shading system, but no extra outdoor sun shading is added. Because the balconies have an overhang, the occupants are already partly protected against the sun. Besides that, the wind protection screens can also function as sun protection by closing the indoor sun shading when the door/ windows are opened.

- SPACE AREA ON BALCONY

By keeping the windows closed, the space area is quite good. But when the windows have to be opened, the higher furniture (and people) have to move partly. There is space to store stuff on the balcony, but there is a possibility that this stuff has to be moved when opening the windows.

- WINDOW CLEANABILITY

All windows are quite easy to clean, except the glass of the balustrade. The glass should be cleaned by a company regularly, or the occupants should use an easy tool to clean the glass by themselves.

- COMPLEXITY MOVEMENTS

The movement of the folding window could be quite complex for elderly, but by implementing the system early in their lives they will know how to use the system.



Figure 120; Final design 2 (concept 5), balustrade option 1 (own illustration)



Figure 121; Final design 2 (concept 5), balustrade option 2 (own illustration)



Figure 122; Final design 2 (concept 5), balustrade option 3 (own illustration)

DESIGN 3 - concept 7

Figure 123 and figure 124 show two impressions of the implementation of design 3 in the BAM 2nd skin apartments in Rotterdam. On the next few pages the operation of design 3 will be discussed, clarified by drawings and details. The design will also be checked on the determined design requirements.



Figure 123; Visualization design 3 (concept 7) on the BAM 2nd skin project in Rotterdam (own illustration)



Figure 124; Visualization design 3 (concept 7) on the BAM 2nd skin project in Rotterdam, balcony print (own illustration)

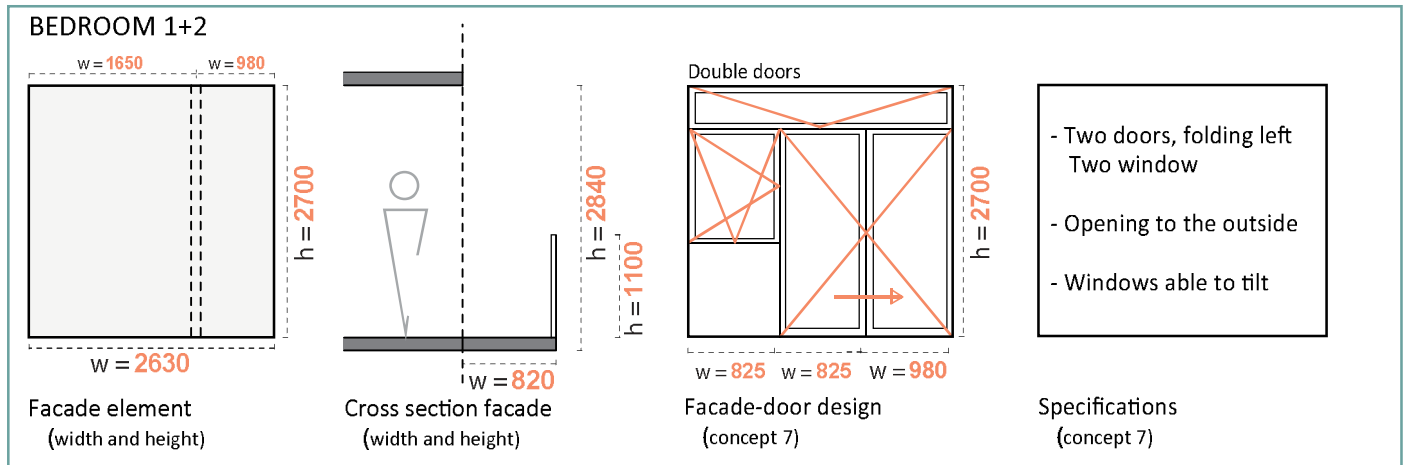


Figure 125; Concept design 7 (own illustration)

Figure 125 shows the concept design of concept 7. The final design for concept 7 changed a little (figure 126).

As you can see the composition of the different windows and doors changed. Besides that, the tilting window at the top is divided in two. This is done because one tilting window would be too wide and the movement would cost too much power.

The window opens outwards and can be connected to the railing of the balustrade. In this way a wind protection screen can be constituted.

Also the folding doors can be deformed to a wind protection screen, these can be fixed to the balcony by turning the door handle downwards.

The width of the folding doors is smaller than the

width of the window. This can be solved by three options:

- change the shape of the balcony;
 - minimize the dimensions of right window (in this case the facade element becomes smaller);
 - change the window in an inwards opening window.
- All options are possible, in this design the first option is chosen.

Two cross sections of the facade, as figure 126 shows, will be presented in detail on the next pages. First the vertical section AA' will be shown, followed by the horizontal section BB'.

The space marked in green in figure 126 will provide space for the NEXT facade element (which is connected to the HEMS inside).

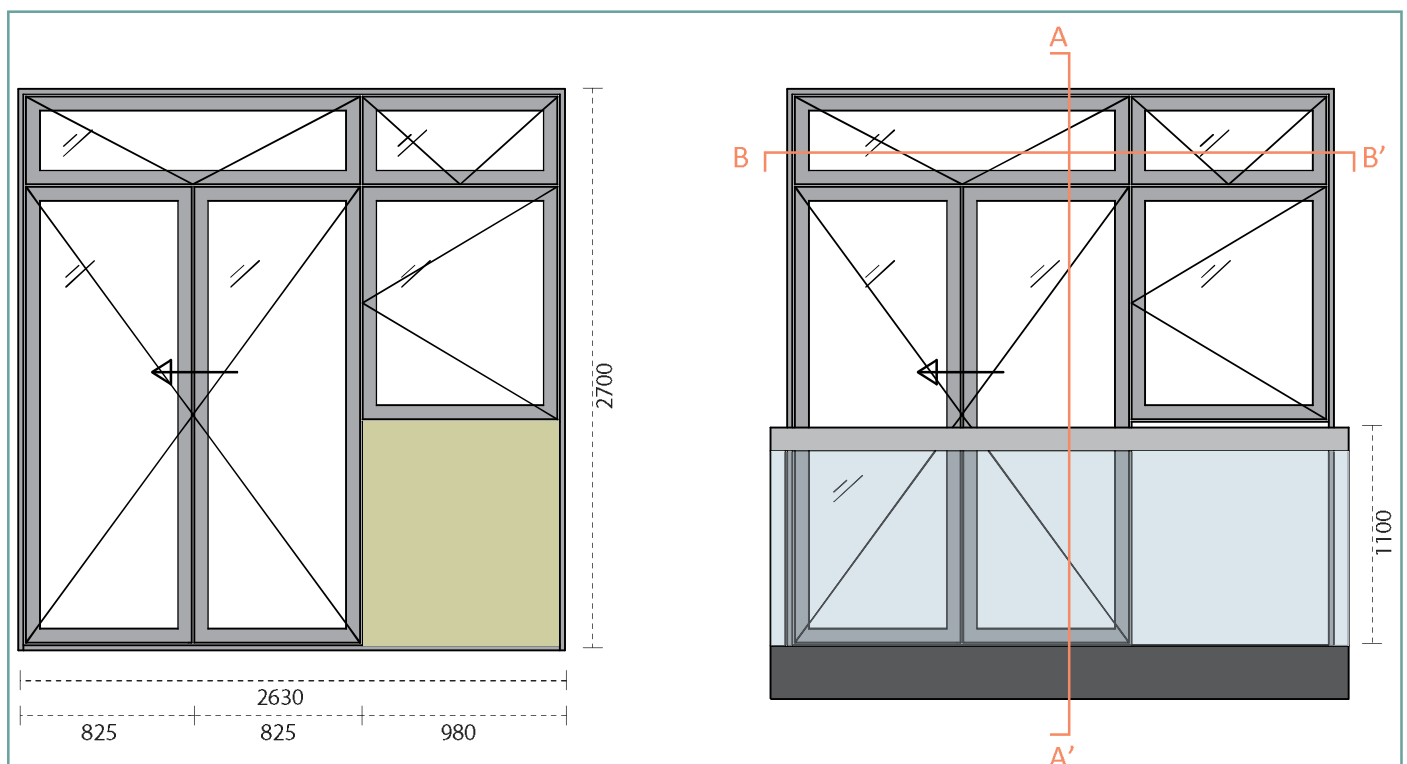
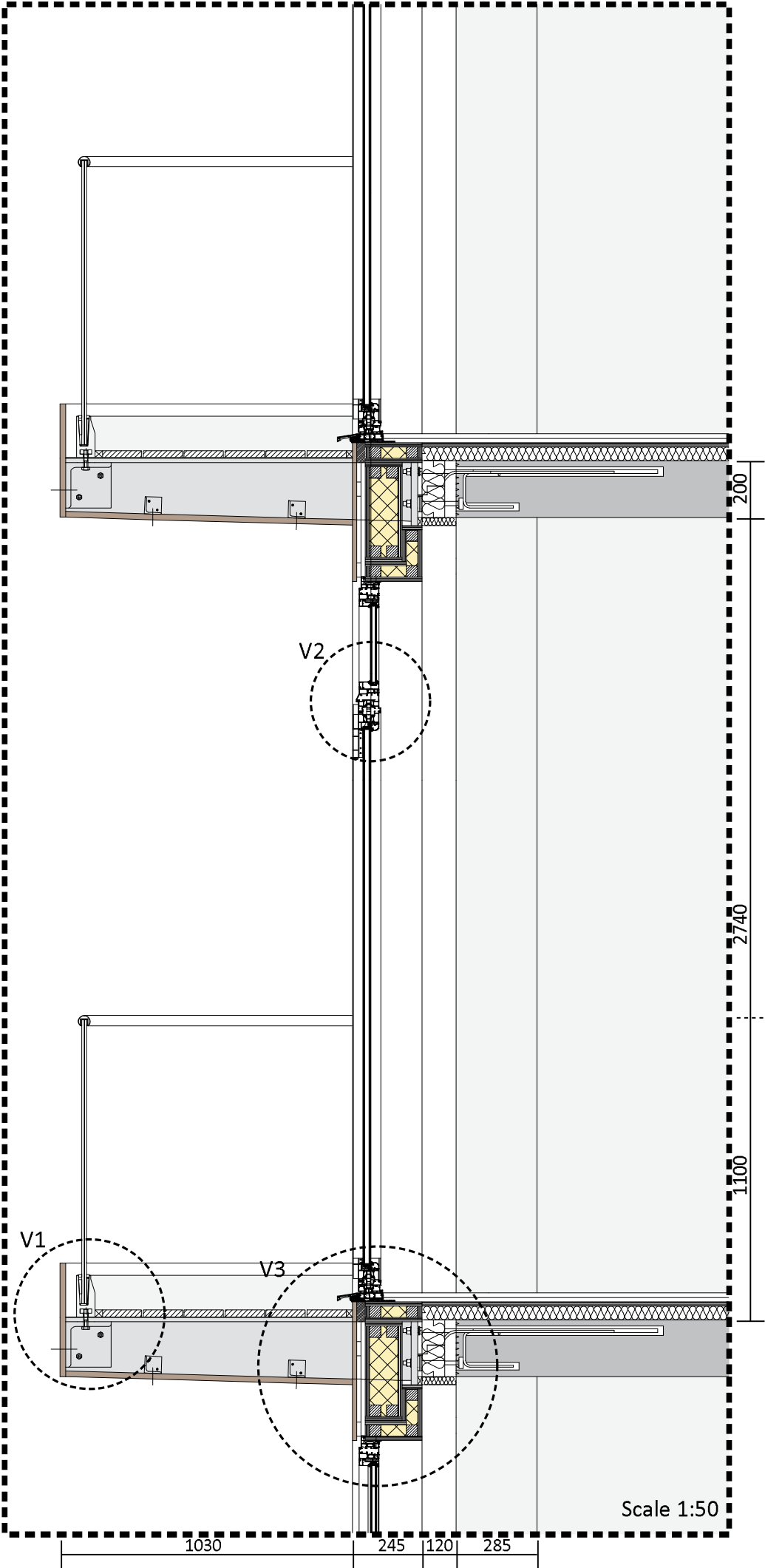
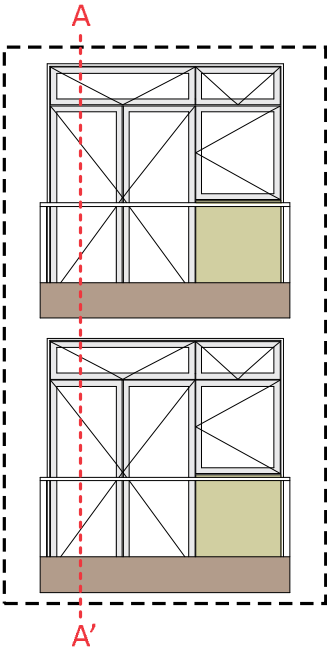
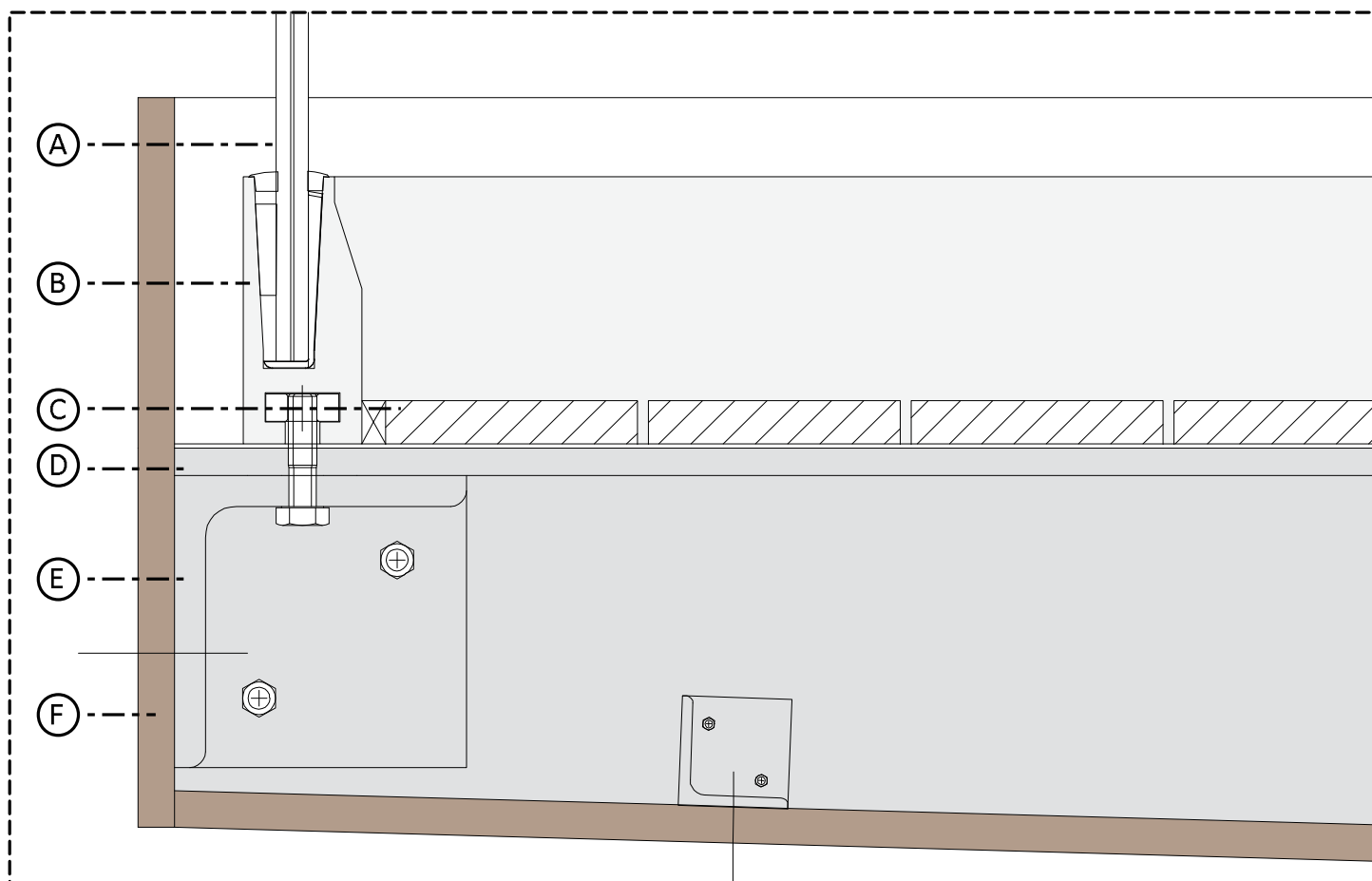


Figure 126; Final design - concept 7 (own illustration)

SECTION AA'



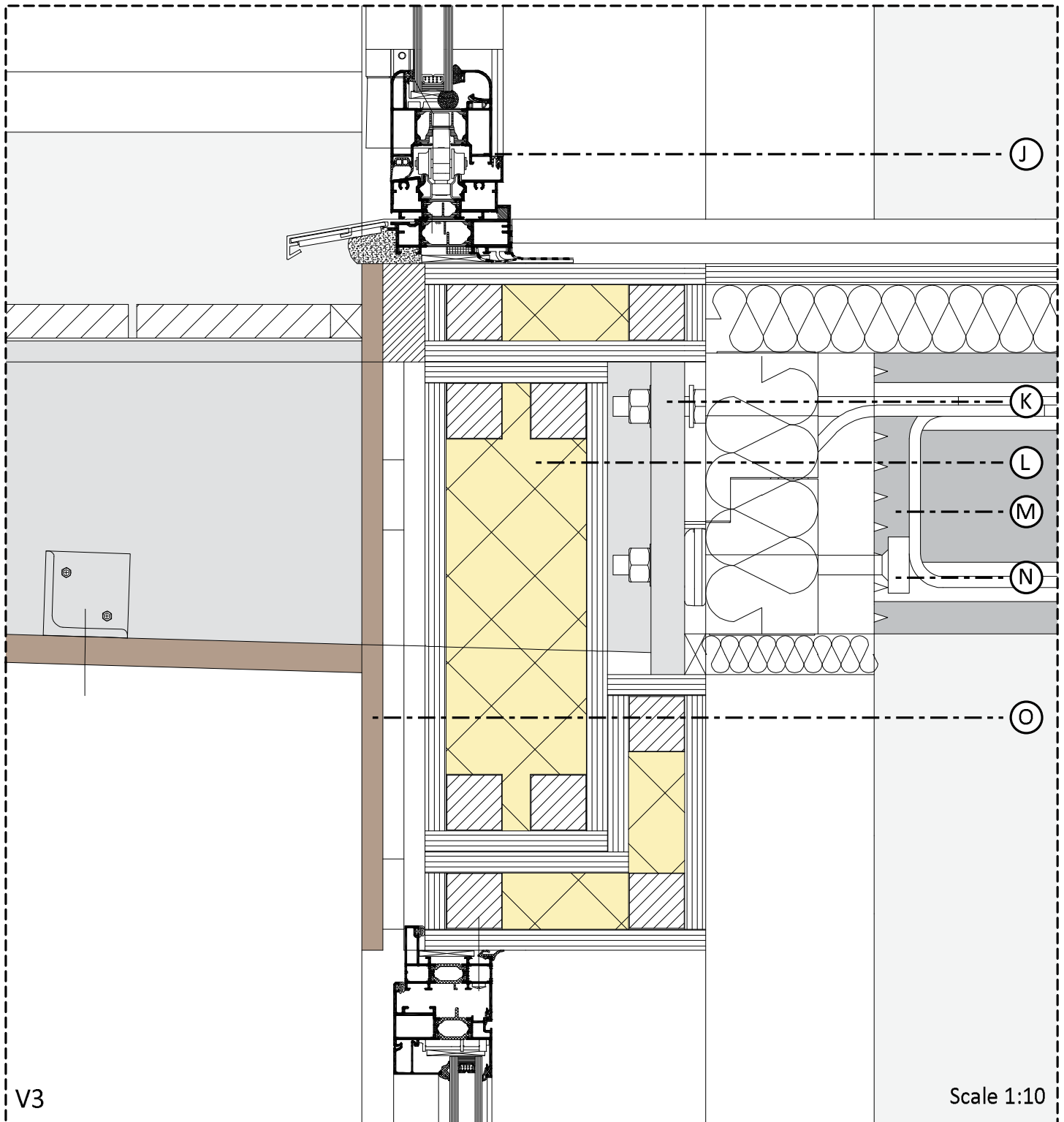
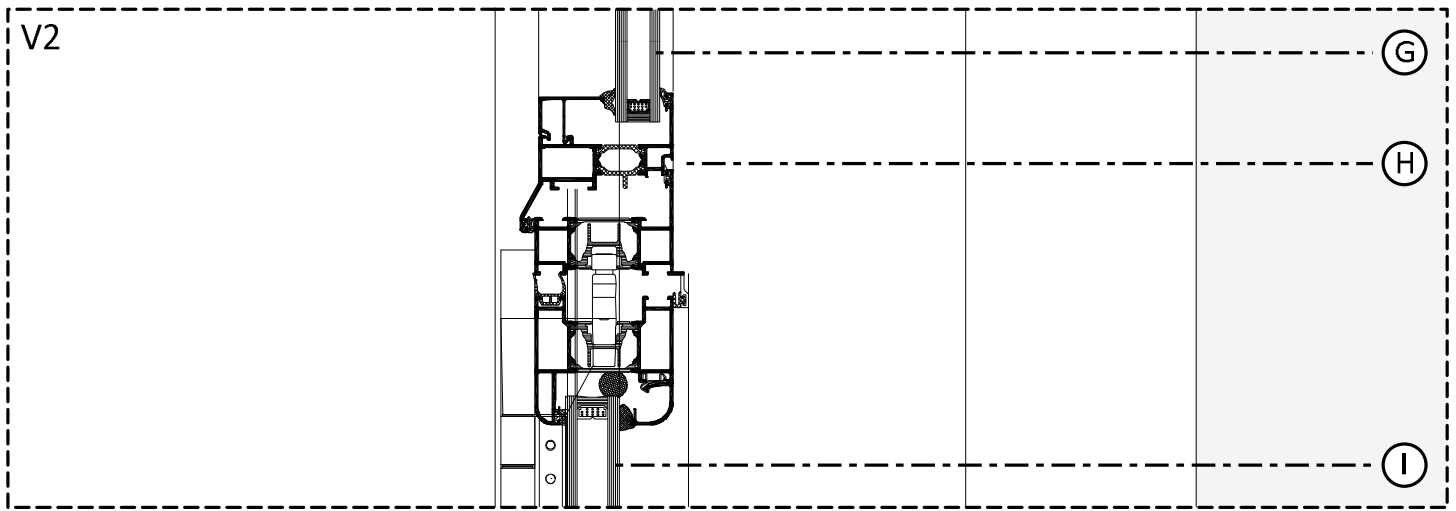


- A - glasspanels balustrade
- B - base of the balustrade
- C - wooden balcony terrace
- D - cantiliver beam (connected to isokorf)
- E - hook profile
- F - balcony cladding
- G - glass tilting window
- H - aluminium profile, outwards tilting window

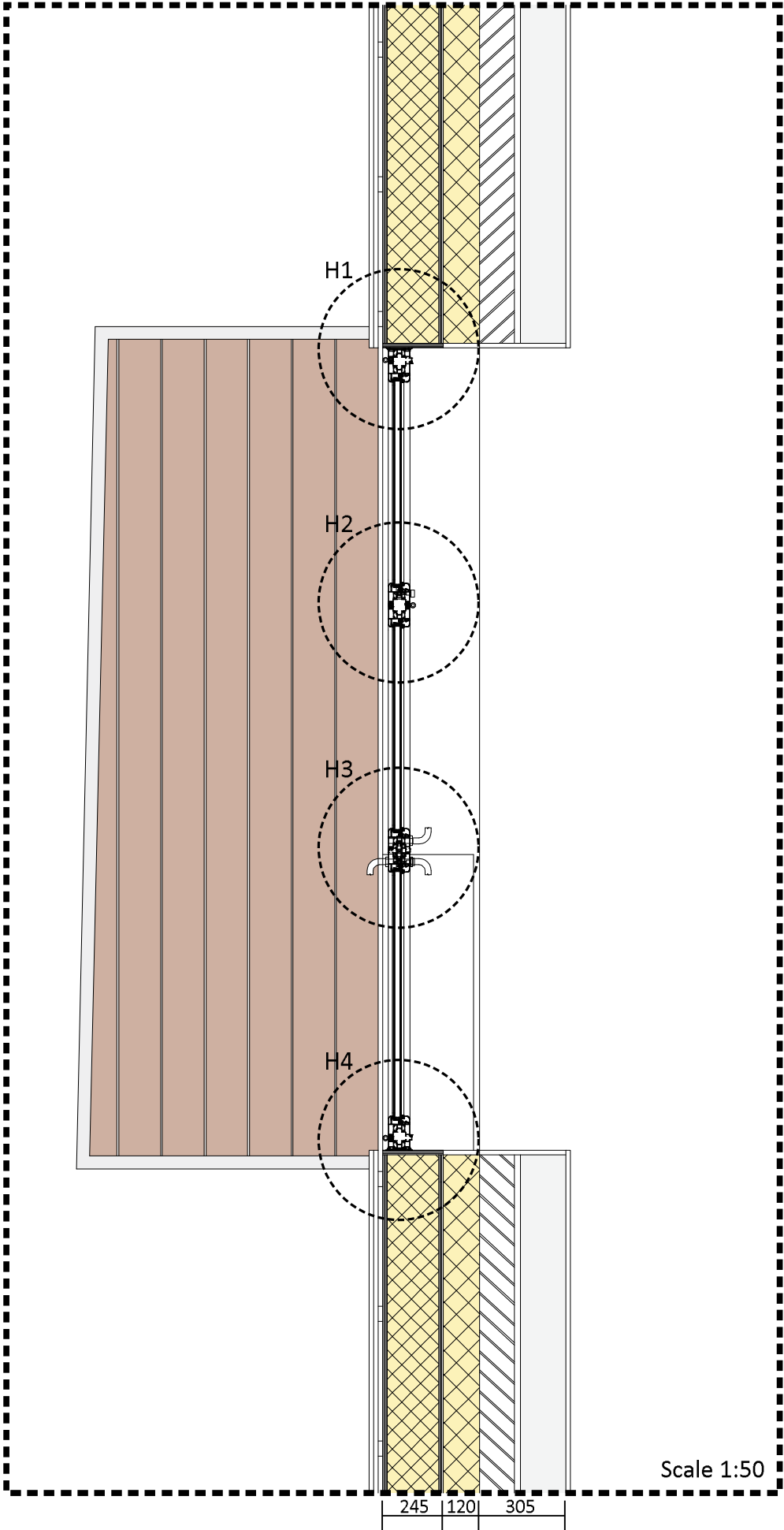
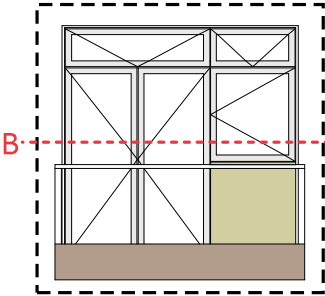
- I - glass (folding door)
- J - bottom folding door profile (aluminium)
- K - cantiliver beam (connected to isokorf)
- L - 2nd skin element (insulated)
- M - existing concrete floor
- N - isokorf system
- O - facade cladding

V1

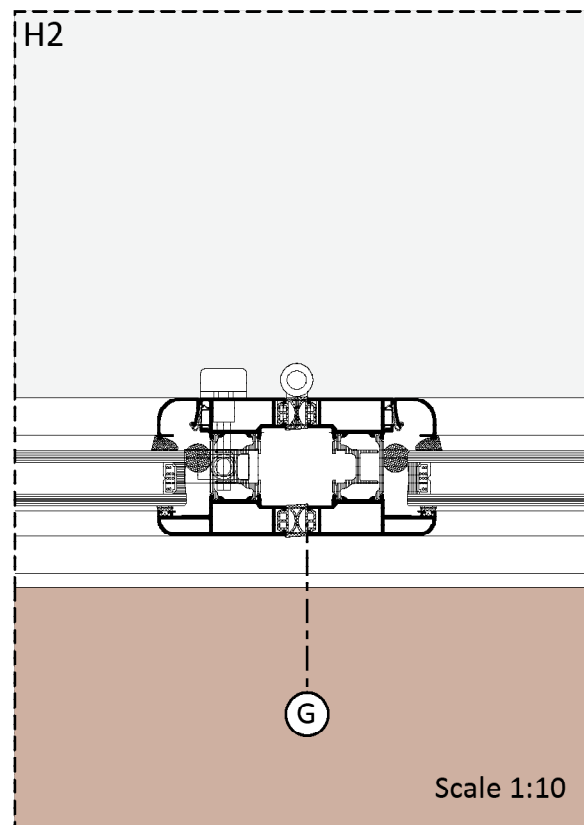
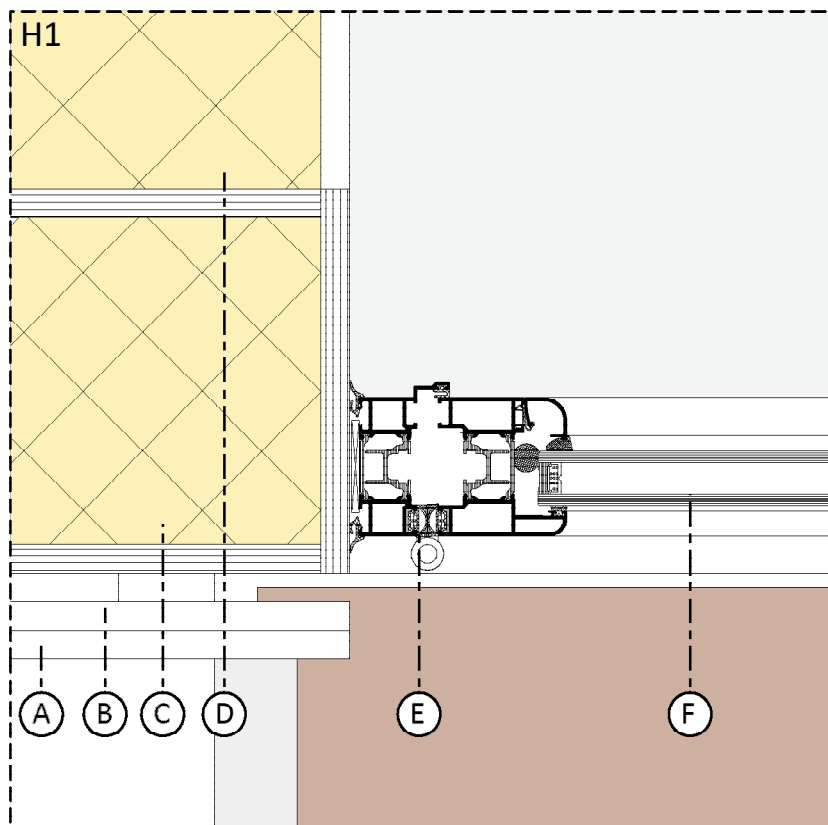
Scale 1:10



SECTION BB'



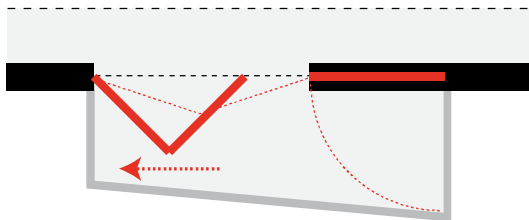
Scale 1:50



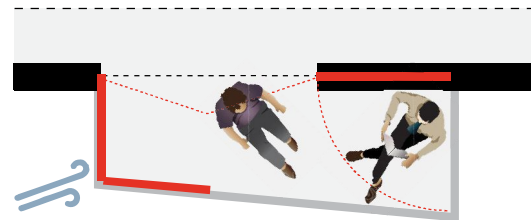
- A - facade cladding
- B - wooden styles and battens
- C - insulation (EPS, $R_c = 3,5$)
- D - insulation ($R_c = 3,0$)
- E - outward folding door profile (aluminium)
- F - door glass
- G - middle outward folding door profile (aluminium)
- H - connection between outward folding door and outward opening door (aluminium)
- I - connection outward opening door to the wall (aluminium)

DIFFERENT SCENARIOS (topview)

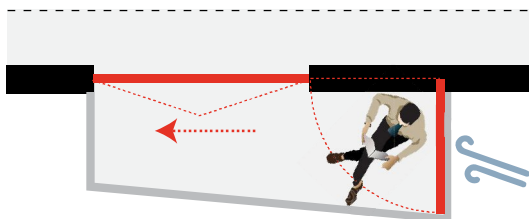
1.



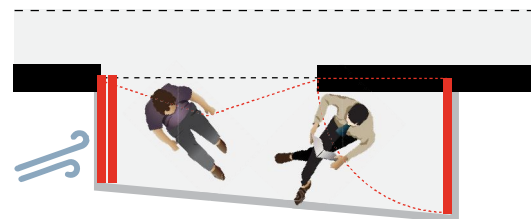
2.

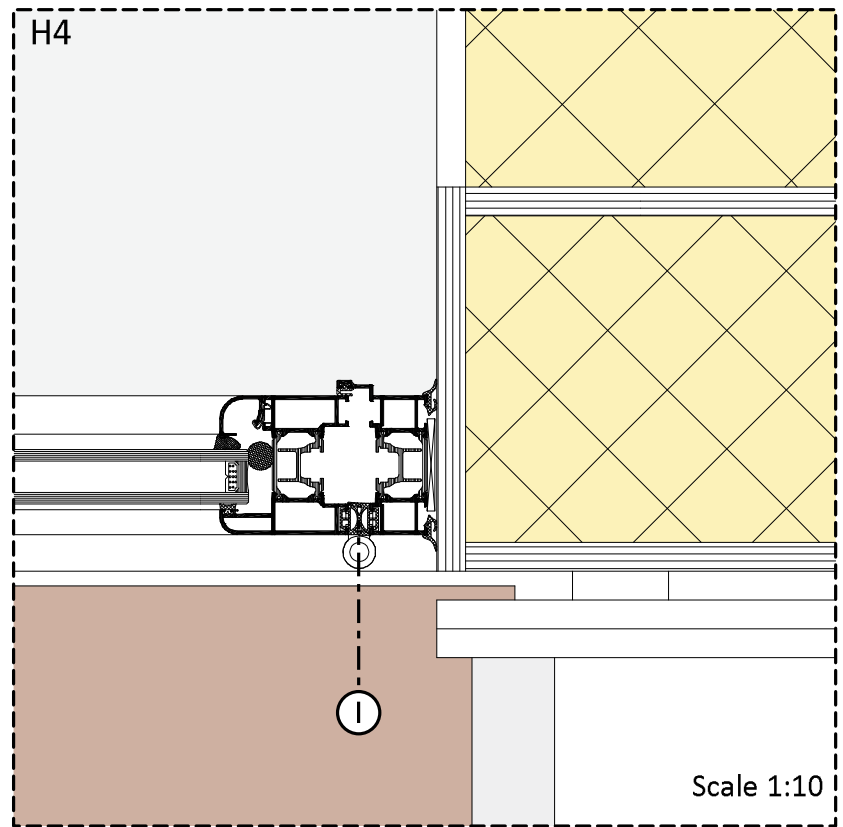
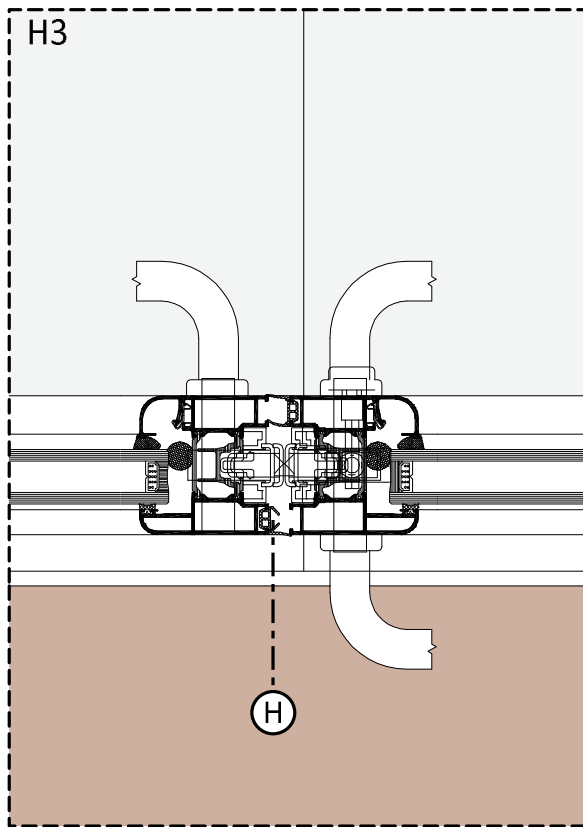


3.



4.





DIFFERENT SCENARIOS (visualizations)

1.



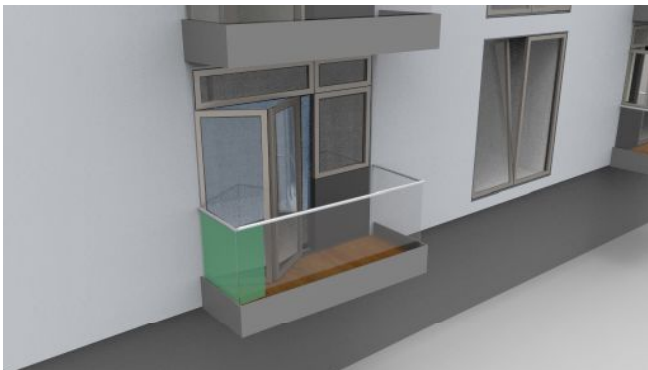
- print on transparent balustrade to make it semi-transparent

2.



- adjustable insect protection screen
- extra cladding on balustrade to make it semi-transparent

3.



- adjustable transparency of the balustrade
- adjustable insect protection screen

4.



- adjustable sun shading system

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY								
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)		INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	TRANSPARENCY (VIEW/ PRIVACY)		OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)		ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY, HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
		SMALL	BIG					VIEW	PRIVACY					IN	OUT						
CONCEPT 7	+	+	+	+	+	+	+	+	-	+	-	+	+	+	-	+	+	+	+	-	-



As the requirement checklist of design 3 (concept 7) shows, not all requirements are marked with a plus. All requirements that are not marked with a plus will be discussed below.

- RAIN PROTECTION

The design didn't mainly focus on rain protection, but because the balconies are all positioned above each other the occupants are already partly rain protected. The upper balcony is also provided with an overhang. Besides that the doors and window, which function as rain wind protection screens, can also be partly used as rain protection screens.

- TRANSPARENCY - PRIVACY

In the original design the balustrade is fully transparent. Not all occupants prefer a fully transparent balustrade all the time. Therefore this transparency should be adjustable or partly blocked. Different options to solve this problem are shown in the figure on the next page.

The first option is a print that can be attached to the glass. The print is partly transparent.

The second option is an extra structure in front of the balustrade which still provides transparency, but makes the view for passers less direct.

The third option is a shading system that is attached to the inside of the balcony and can be adjusted to the preferable place.

- NOISE PROTECTION

The facade protects against several noises when closed, but not all noises will be avoided. When the facade is (partly) open, the occupants won't be protected from any noises. This research didn't focus on developing an noise protection screen, but as the recommendations say there should be done more research into this topic.

- ADJUSTABLE SUN SHADING - OUTSIDE

The facade is provided with an indoor sun shading system, but no extra outdoor sun shading is added. Because the balconies have an overhang, the occupants are already partly protected against the sun. Besides that, the wind protection screens can also function as sun protection by closing the indoor sun shading when the doors/ window are opened.

- SPACE AREA ON BALCONY

By keeping the windows closed, the space area is quite good. But when the windows have to be opened, the higher furniture (and people) have to move partly. There is space to store stuff on the balcony, but there is a possibility that this stuff has to be moved when opening the doors.

- WINDOW CLEANABILITY

All windows are quite easy to clean, except the glass of the balustrade. The glass should be cleaned by a company regularly, or the occupants should use an easy tool to clean the glass by themselves.

- COMPLEXITY MOVEMENTS

The movement of the folding doors could be quite complex for elderly, but by implementing the system early in their lives they will know how to use the system.



Figure 127; Final design 3 (concept 7), balustrade option 1 (own illustration)



Figure 128; Final design 3 (concept 7), balustrade option 2 (own illustration)



Figure 129; Final design 3 (concept 7), balustrade option 3 (own illustration)

11.3 THE EXTRA OPTIONS

Cause not all defined requirements are implemented in the standard design elements, homeowners, housing cooperations and occupants should have the opportunity to choose for different extra elements as mentioned in the first paragraph of this chapter. By providing the option to choose for these elements, the appearance of the whole facade stays quite equal. In this paragraph these options will be discussed.

1. AN INSECT PROTECTION SCREEN;

There are different options for implementing insect protection screens. The most integrated option is to choose for a 'pleated flyscreen'. This is an insectscreen that can be folded and unfolded and therefore occupies little space. The screen can be implemented on the outside or the inside of your facade, depending on your window operation (turning outwards or inwards).

Figure 130 and 131 show the operation and the assembly of this insectscreen system. More operation and assembly details are attached in appendix A.7.1.

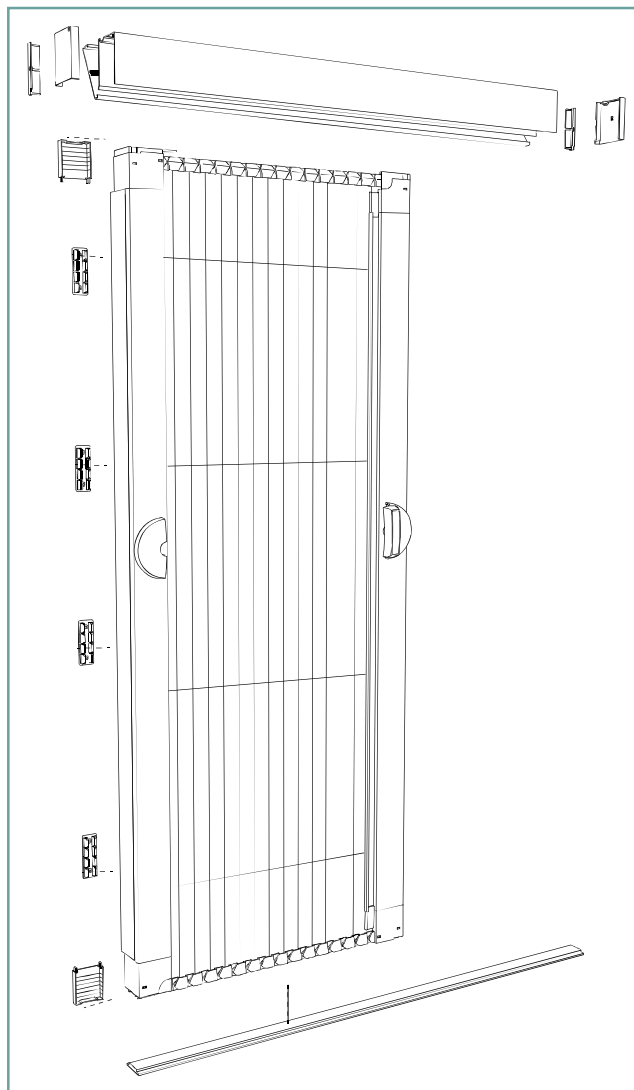


Figure 130; Pleated flyscreen (Unilux, 2015)

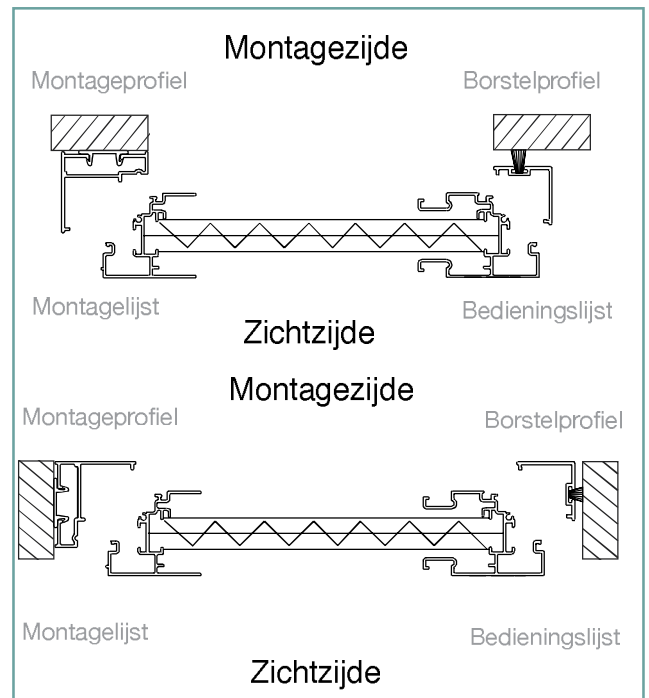


Figure 131; Pleated flyscreen, assembly (Unilux, 2015)

Of course there are also other suitable options. For example a rolling insect screen. This system is less suitable for elderly because of the extension height (as you can see in figure 132).

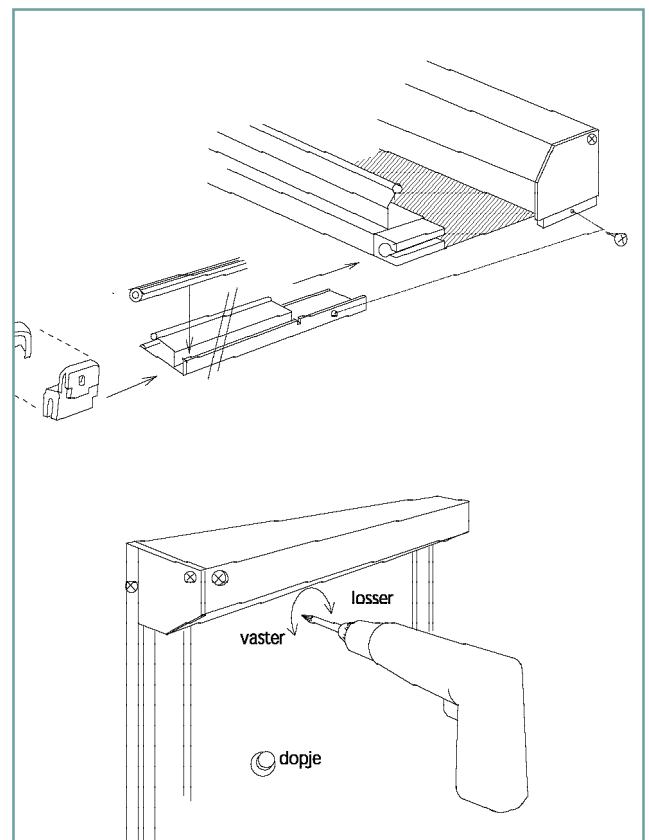


Figure 132; Roller flyscreen (Unilux, 2015)

Another last option would be a fixed insect screen door, but this has more disadvantages than the other options. A fixed door occupies a lot of space and blocks the view (also if you're not using your door as an insectscreen at that moment).

2. AN INSIDE SUNSHADING SYSTEM;

An adjustable sun shading system should be implemented to improve the indoor light intensity for the occupants. This system should allow the occupants to block only part of their windows from entering sunlight. In this way they can overcome overexposure, but still let daylight enter the room.

A sun shading system does not only controls the lighting levels, but can also create comfort according to heating and ventilation. By properly aligning sun control devices with (natural) light, temperature and cooling in relation to each other, optimal comfort and energy solutions can be created (HunterDouglas, 2015). By connecting the sun shading control to the building management system (HEMS), sun control systems can be controlled in combination with cooling, heating and even the lighting levels (HunterDouglas, 2015). In this way energy can be saved in summer by overcoming overheating and in winter by overcoming heat loss.

Hunter Douglas says that energy-efficient buildings can only be realized by integrating ventilation, cooling, heating, lighting and climate systems with window coverings and sun shading systems (2015). They designed a building management system which can communicate with every other building management system (as figure 133 and 135 show).

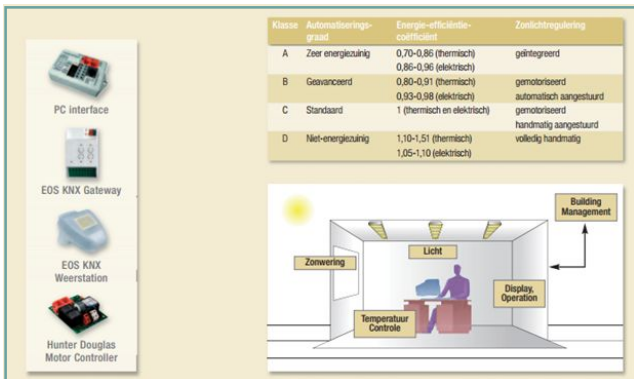


Figure 133; Building management system sun shading (Hunter-Douglas, 2015)

The sun shading system should be adjustable in a way that the occupants are able to position the sun shading on the height they prefer. So the shading should be adjustable from the bottom and from the top (as figure 134 shows). This is a system that already exists (figure 136) and is shown in detail in the appendix A.7.2.

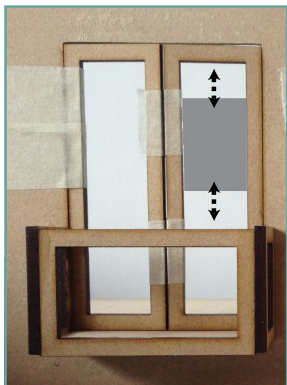


Figure 134; Adjustable inside sunshading system (own illustration)

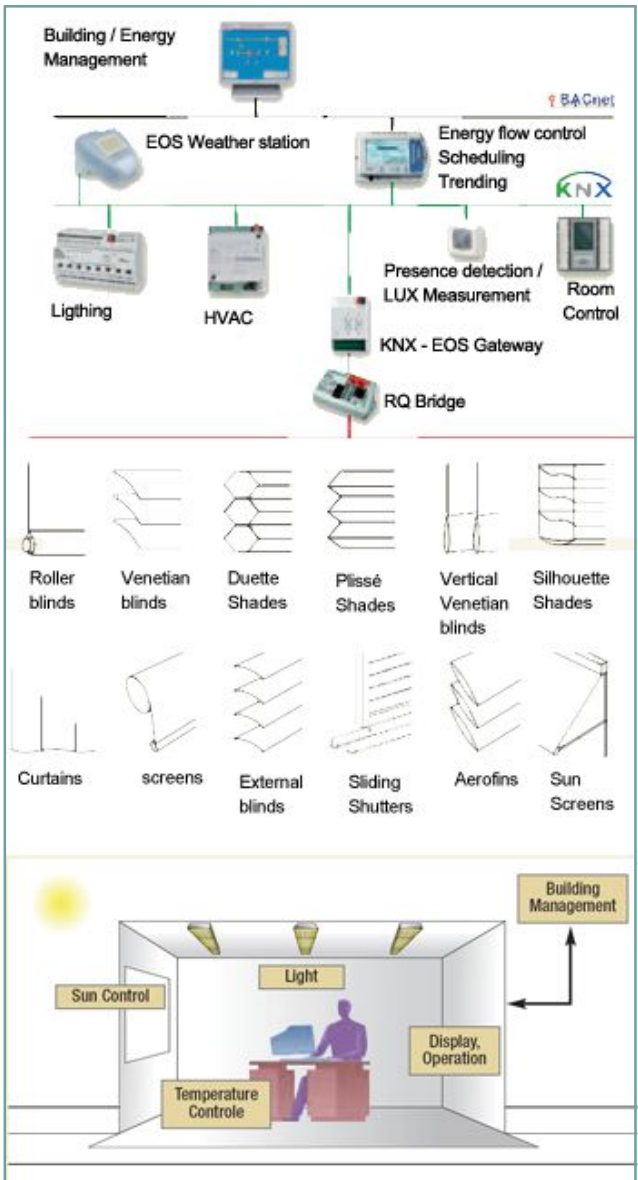


Figure 135; Building management system sun shading (Hunter-Douglas, 2015)



Figure 136; Adjustable inside sunshading system (BRON)

3. FLOWER BOXES TO HANG ON THE BALUSTRADE;
To give the facade an uniform look, an unified system is needed to hang flower boxes on the balustrade. As the examples below show, it is possible to design a system that is easy to attach/ hang on the railing of the balustrade.



Figure 137; Different flower box options (Fennel, 2015)

The designs above are possible options for the balustrade of the 2nd skin project, an detailed option for the 2nd skin project is shown in the drawing below. The final look of the planter boxes should be discussed with the architect and housing cooperations/ home owners.

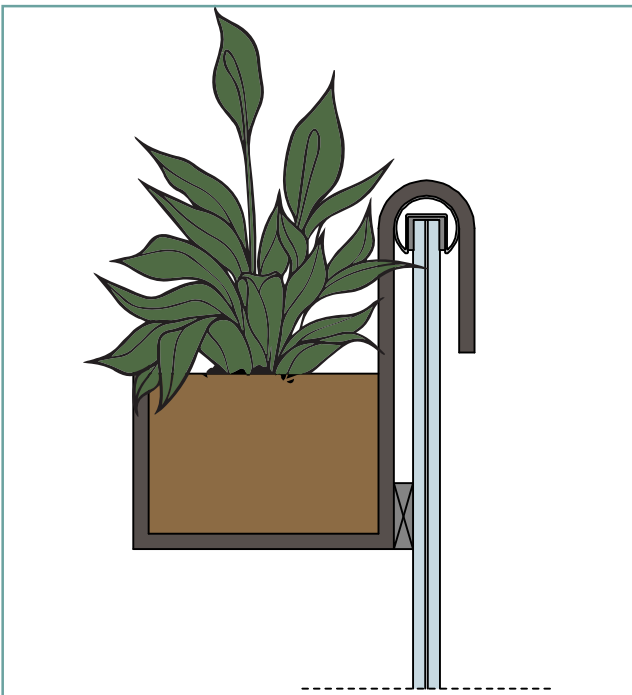


Figure 138; Design planter boxes for the design (own illustration)

4. CURTAINS INSIDE;
Occupants just have the opportunity for a curtain rail. They won't be forced into 2 types of curtains for example.

5. THE TRANSPARENCY OF THEIR BALUSTRADE.
The transparency of the facade has a double sided approach; on the one hand the balustrade has to be transparent to allow occupants to look outside from every perspective. On the other hand occupants don't want to be watched by strangers all the time.

One solution is to paste a print layer on the balustrade as shown in figure 139.

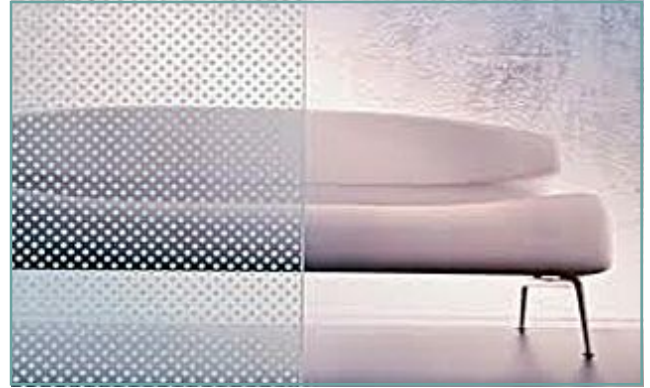


Figure 139; Print layer on glass (BRON)

Another solution is to go for a balustrade that isn't made out of glass, but another (less transparent) material. Figure 140 shows an example.



Figure 140; Grid on iron balustrade (BRON)

This option isn't an option that every occupant can choose for himself, the facade appearance of the building in the end has to look uniform. Therefore this decision has to be made in group context. Some examples were already shown in the previous chapter of the different designs.

6. MOTOR DRIVEN WINDOWS

Not all windows are easy to reach, therefore the occupants should have the option to choose for windows that open by pressing a button to open the motor driven window.

11.4 ASSEMBLY 2ND SKIN FACADE

The 2nd skin project also aims for fast and easy implementation, limiting the nuisance for the occupants, and thus allowing them to remain in their houses during the installation process. Keeping occupants in their homes is needed to decrease the costs of the renovating process related to the relocation of occupants, and it will facilitate the acceptance of the occupants to take part in renovation processes (Guerra-Santin, 2015). Therefore it is relevant to explain and show the assembly method for the 2nd skin designs. This paragraph will elaborate the assembly process in detail.

THE BALCONY

Firstly there should be discussed whether the existing balcony structure should be kept or should be removed and replaced.

The existing balconies cause cold bridges and should therefore be wrapped with insulation to overcome this thermal problem. By wrapping the balconies, you can lose space and there are less possibilities according to the dimensions of the new balcony.

Therefore Schoeck came up with a Isokorf thermal-supporting element. Schoeck Isokorf type RKS is a thermal bridge-supporting element for connecting steel balconies to existing reinforced concrete floors. It transfers negative moments, positive shear forces and horizontal forces (Schoeck, 2015, p.23). *Figure 141* shows what such an isokorf element looks like. The center-to-center distance between two of these elements should be 0,7m at maximum (*figure 142*).

The existing balcony should be removed first and later on these isokorf elements can easily be placed into the concrete floor structure. As *figure 144* shows, steel profiles can easily be connected to the isokorf elements.

While in the new 2nd skin designs the dimensions of the existing balconies are preserved, still the tech-

nique of the isokorf elements are implemented in the new designs. Not only because these elements save space, but also because in future designs much more is possible by implementing these isokorf elements. The designs become much more flexible.

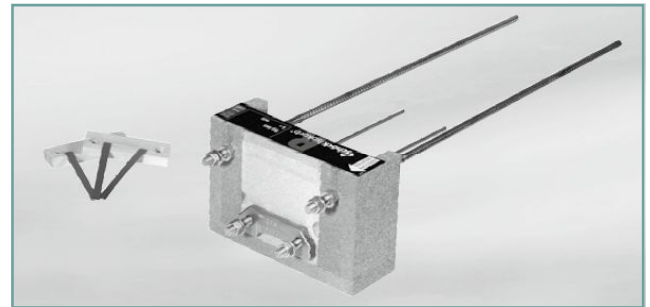


Figure 141; Schöck Isokorf, type RKS (Schoeck, 2015, p.23)

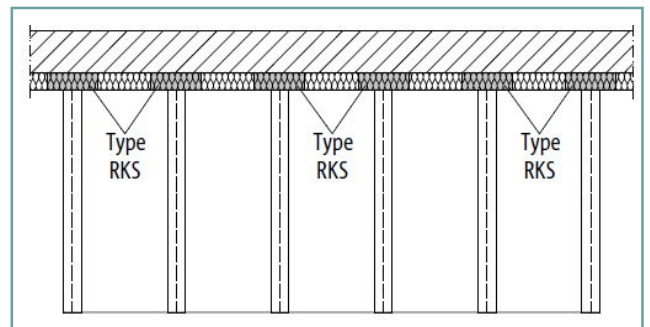


Figure 142; Renovation of an existing balcony type RKS14, free cantilevered (Schoeck, 2015, p.25)



Figure 143; Implementation Isokorf element (Schoeck, 2015)

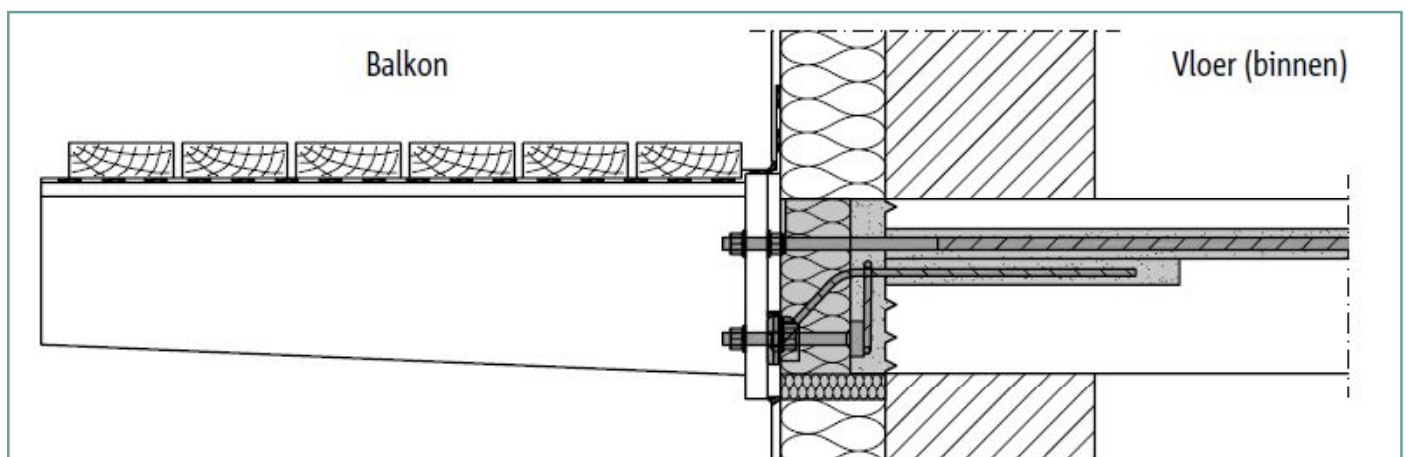
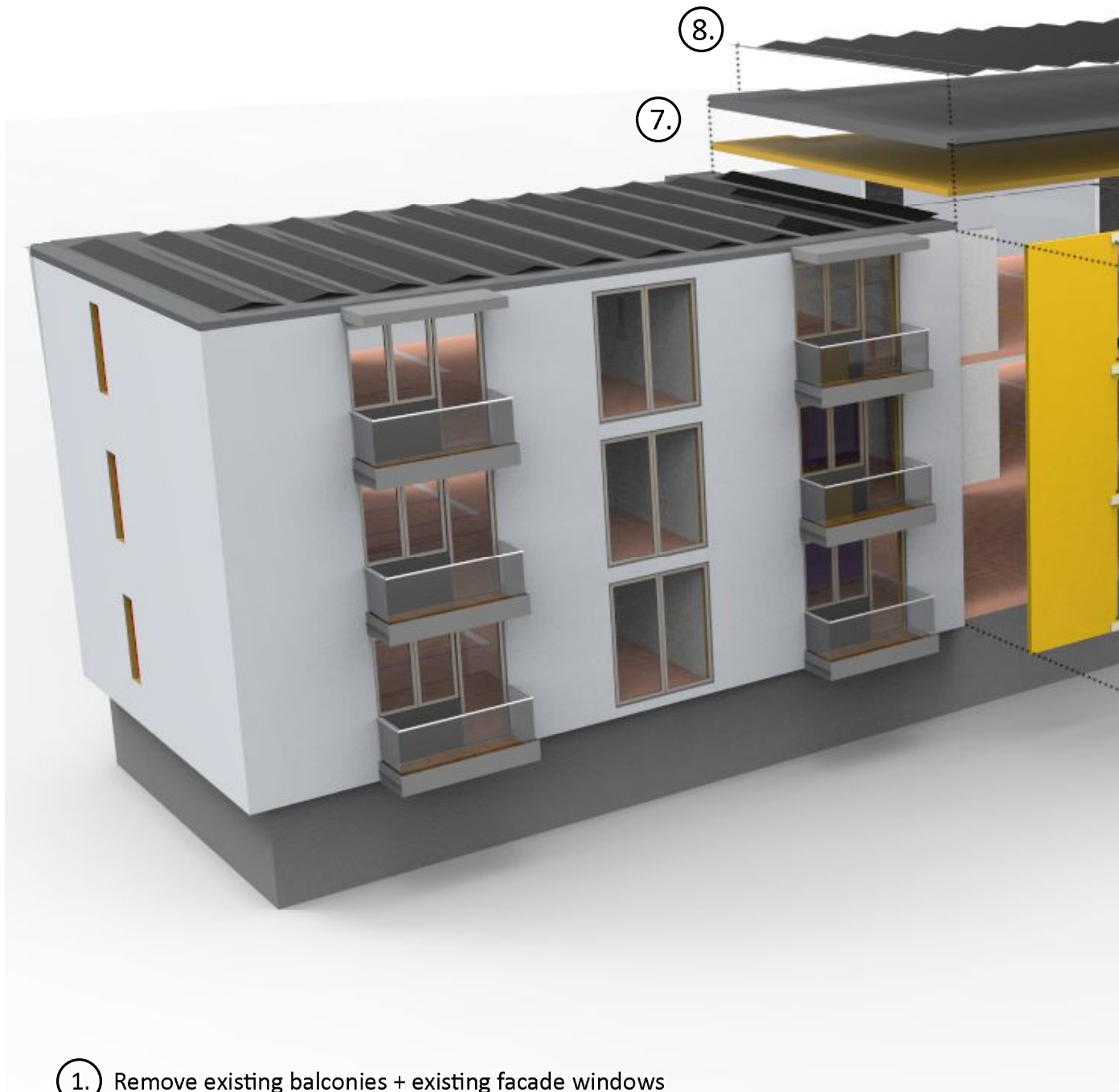
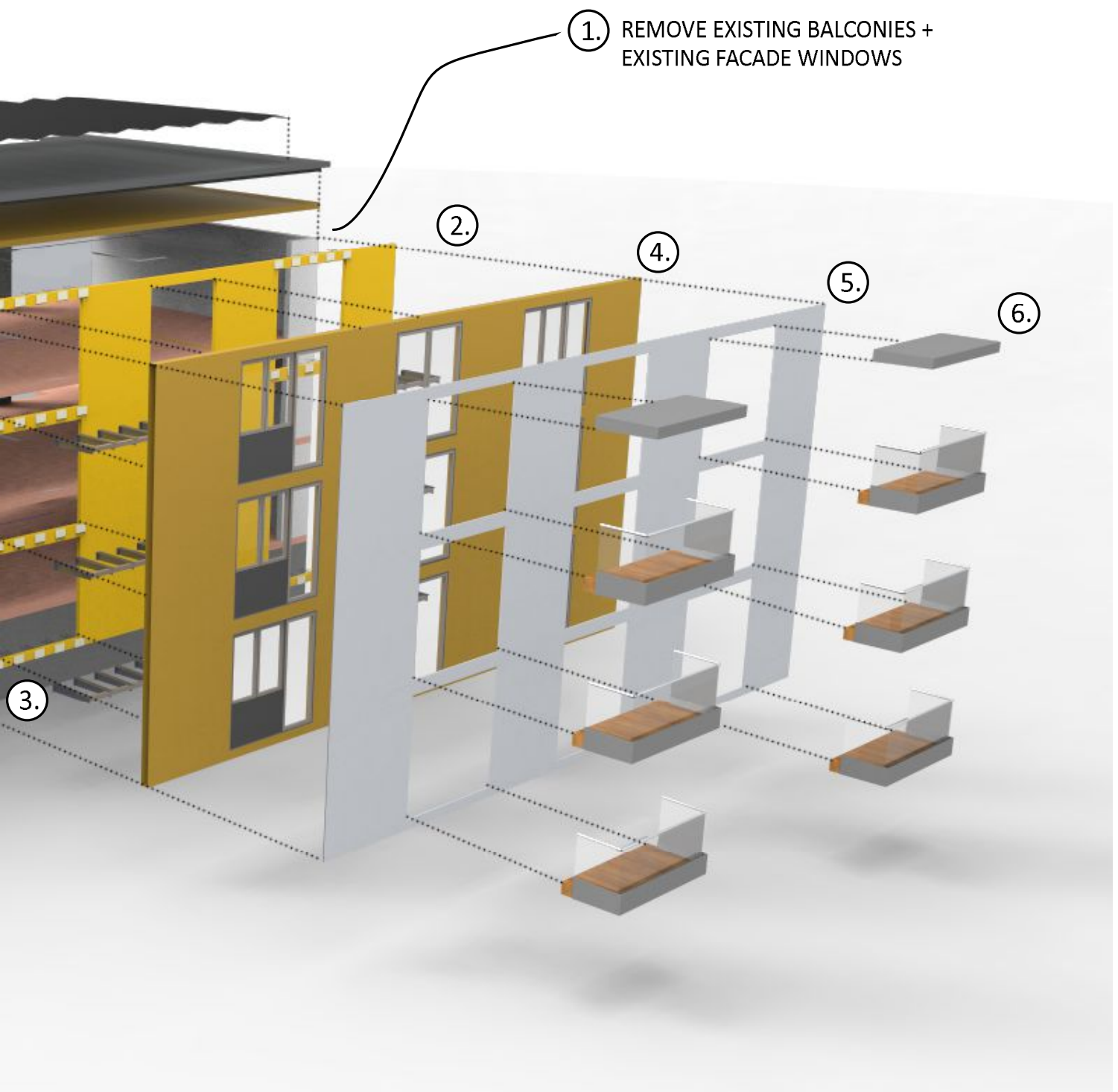


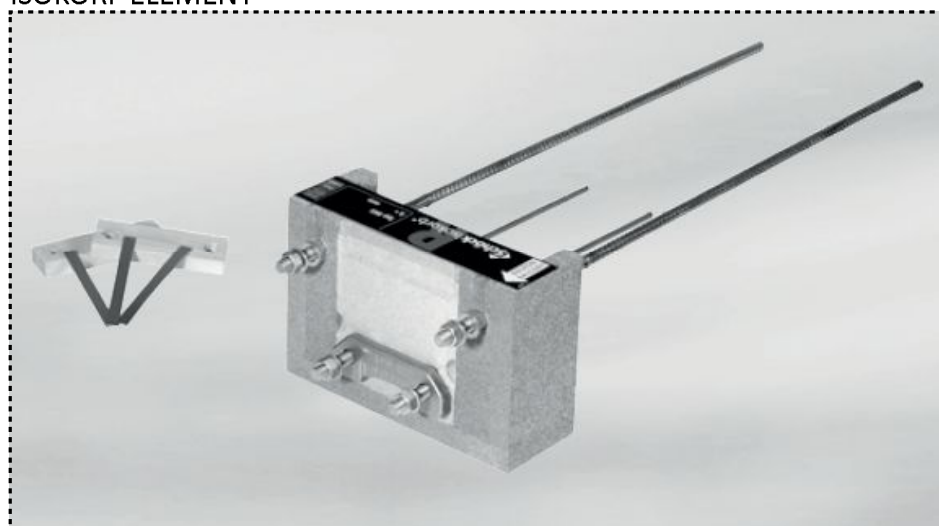
Figure 144; Cantilevered balcony type RKS14, a renovation of an existing balcony (Schoeck, 2015, p.25)



- ① Remove existing balconies + existing facade windows
- ② Attach Isokorf elements + first insulation layer
- ③ attach balcony profiles to isokorf construction
- ④ prefab isolated panels (including facade windows)
- ⑤ cladding
- ⑥ attach balcony finishings
- ⑦ roof insulation + roof covering
- ⑧ PV panels + solar collectors



ISOKORF ELEMENT



As the exploded view on the previous pages shows, the 2nd skin facade will be applied in several steps:

1. The existing balconies and windows have to be removed;
2. Several isokorf elements have to be attached to the existing floors and the first insulation layer has to be applied too;
3. Steel profiles have to be attached to the isokorf elements for the construction of the balconies later on;
4. The prefab isolated panels should then be attached to the facade, including the new facade window elements);
5. The final cladding has to be added then (different claddings are possible to attach);
6. Now all the extra elements of the balcony can be attached to the steel profiles (wooden floor, glass balustrades, cladding, handrails, etc.)
7. The roof insulation and final covering should be attached then;
8. And finally the PV panels and solar collectors will be placed on the roof.

As the exploded view shows, all elements are quite easy to add to the existing facade. The work that will cost most of the time is removing the balconies and existing facade elements (windows). All elements that are added after that, can be attached from outside and won't cause a lot of disturbance for the occupants.

11.5 CONCLUSION

The three different facade elements require different aluminium profile systems as shown in the details.

By giving the occupants the opportunity to partly design/ choose their own facade, they are much more willing to use their new facade in the desired way. Because the occupants change over time, there could be thought of leasing part of these extra facade element options.

And as paragraph 11.4 showed, with the right assembly method, the 2nd skin can be applied quite fast and easy.

In the next chapter the different designs will be evaluated by the personas, the interviews and the design requirements.

12. EVALUATION

In this chapter the designs will be evaluated. Firstly design 1 (of the first P4) will be evaluated shortly, in the second paragraph the final designs will be evaluated. The designs will be evaluated by three different components; the participants of the interviews, the defined personas, and the defined requirement checklist.

12.1 EVALUATION DESIGN 1

The first evaluation was done just before my first P4 presentation (in May 2015). The 'final' design was much different than the designs are now (see appendix A.5 for the first designs). The evaluation of the design was done by email (appendix A.3.2). The most important conclusions are listed below.

VENTILATION

Most occupants were not aware of the health of their indoor climate (and the importance of ventilation). They were interested in having more insight in the health of their indoor climate and getting tips to improve it, but they were not really convinced that the new design would improve that.

DAYLIGHT

All occupants prefer doing their daily activities in daylight rather than using artificial light. They therefore agreed with the maximum transparency of the façade, but they were curious how this incoming daylight would be optimally adjustable.

'DOUBLE HUNG' SYSTEM

They were enthusiastic about the idea of implementing a 'double hung' system into their façade system, especially in combination with an insect screen. But they were doubting about the easiness of the operation of this 'double hung' system. Some occupants were afraid of getting cold feet by using this window as an effective ventilation system, others were afraid of the safety of their stuff that could fall outwards. So they were enthusiastic about ventilating faster and the ease of an implemented insect screen, but there were still some doubts about the easiness and safety of the operation.

As the evaluation of the first design shows, there were still quite some important remarks on the design. Therefore my tutors and I decided to postpone my P5 presentation. After my first P4 presentation I took a step back and did a second face-to-face interview, which focused more the comfort preferences of

elderly according to their home instead of their energy efficiency behavior.

12.2 EVALUATION DESIGN 2 (final design)

The second designs, which were made after my first P4 presentation, are much more detailed and extensive than design 1. The final does not only exist of 2 main parts (the HEMS and the façade element), but these two main parts both consist of more than one design. The evaluation of design 2 is therefore more extensive too. Firstly the designs will be evaluated by the participants of the interviews, followed by an evaluation by the different defined personas and finally the requirement checklist will rate the designs.

A. THE INTERVIEWS

After my first P4 presentation I did a new face-to-face interview with the same participants as mentioned before. This interview gave me much more inside in the preferences of the occupants according to comfort. With the feedback from my P4 presentation, the new outcomes of the interviews and the evaluation of design 1, I re-started the design part of my research. The new 12 design concepts were again evaluated by the participants by email. The outcome will be discussed below. These comments are all incorporated in the final design part.

All occupants were more much enthusiastic about the second (final) designs than they were about the first design. They still had some questions according to the operation of the different designs.

BALCONY

All occupants were very happy with the fixed balcony (the outside area). Also the windscreen felt like a big advantage for them. One of the occupants commented that he hoped the balcony would be faced to the south, of course this depends on the location and the orientation of the façade. For each situation there should be looked at the different optimal scenarios according to wind, sunlight, ventilation, etc.

TRANSPARENCY

Most occupants were happy with the transparency of the balustrade. One of them commented to prefer a small solid bottom part of the balustrade (50 cm from the bottom should be non-transparent) to have a little bit more privacy. The appearance of the façade should be equal, so different scenarios should be designed to meet the preferences of the different

occupants.

OPERATION

Most designs are easily operable (and most actions are reachable), but some questions are marked on the simplicity of the system (is it only manually operable or also electric?). Therefore non-reachable operations should be electric. Besides that occupants should have the opportunity to go for an electric operating system.

Home Energy Management System (HEMS)

All occupants were happy with the new insights of designing HEMS for different user profiles and the new strategy for saving energy and providing a healthy indoor climate. They were curious if this would be a good working system for a longer time span.

In the end only one of them gave the preference for concept 7 (design 3), the others were happy with all three concept designs.

B. THE PERSONAS

In chapter 5 five types of personas were defined; the 'easy comfortables', the 'all time savers', the 'spenders', the 'mobility sufferers' and the 'sight sufferers'. Below the final designs of this research will be evaluated with the defined personas.

1. THE 'EASY COMFORTABLES'

- According to the HEMS design

The 'easy comfortables' are elderly who are willing to save energy, but only if this would benefit their comfort. They don't spend time on ventilating enough and do not have an idea of the health of their indoor climate.

With the design of the HEMS that is specified to their habits, they are much more into saving energy easily. They are triggered to be more aware of the health of their indoor climate. The HEMS system shows which action on a specific moment costs the least energy (ventilating mechanically or naturally).

- According to the façade element design

The façade element should provide comfort to make sure the 'easy comfortables' will use the façade element in the desired way. The system can be a little complex for the occupants, but provides a lot of comfort according to wind and sunlight, therefore most occupants will use the façade in the desired way.

2. THE 'ALL TIME SAVERS'

- According to the HEMS design

The 'all time savers' are elderly who are very aware of possible deterioration and energy costs. They are willing to save as much energy as possible, but their health should be taken into account too.

The new design focusses on the well-being of elderly

and simultaneously on an energy efficient use of the facade. The HEMS system that is designed for these occupants allows them to have a sight in where most energy consumption is spend in their household. In this way they are able to change their habits.

- According to the façade element design

The integration of the façade element and the HEMS system gives the users insight in how to use their façade in the right way. The 'all time savers' will therefore use their façade in the desired way and will simultaneously profit from the comfortable spot they can create on their balcony.

3. THE 'SPENDERS'

- According to the HEMS design

The 'spenders' are elderly who want to enjoy the last years of their life and don't want to spend time or energy in saving energy.

The new HEMS design for the 'spenders' focusses on peaks and compares their energy consumption with neighbours. In this way these occupants stay focused on their consumption and get tips on how to reduce these.

- According to the façade element design

The most important thing for the 'spenders' is the level of comfort the new design provides. If you compare the new design with the existing situation, it can provide comfort in many ways.

4. THE 'MOBILITY SUFFERERS'

For this persona the focus is aimed at the facade element more than at the HEMS. The facade element should be easy to use and reachable from a sitting perspective. The extra option of having a facade which can be driven by a motor can be a solution for this group.

5. THE 'SIGHT SUFFERERS'

Also for this persona the focus is more aimed at the facade than at the HEMS. The facade element should give the occupants the ability to let in daylight as much as possible, but limit the overexposure. Therefore the option of implementing an adjustable inside sunshade system should be chosen by this group.

C. THE REQUIREMENT CHECKLIST

In the chapter of the final designs, the designs were already evaluated and discussed by the requirement checklist. *Figure 145* on the next page gives a quick overview on the three checklists.

As the comparison of the checklists of the three concepts shows, they do not differ a lot in their rating, as was already concluded and discussed in the chapter of the final design.

The main missing requirements in the three concepts were the missing rain protection, the missing privacy

	VENTILATION					ELDERLY					COMFORT					FUNCTIONALITY						
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)		INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	TRANSPARENCY (VIEW/ PRIVACY)		OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)		ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)		CURTAINS (PRIVACY, HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
		SMALL	BIG					VIEW	PRIVACY					IN	OUT	IN	OUT					
CONCEPT 3	+	+	+	+	+	+	+	+	-	+	-	+	+	+	-	+	+	+	+	+	+	
CONCEPT 5	+	+	+	+	-	+	+	+	-	+	-	+	+	+	-	+	+	+	+	-	+	
CONCEPT 7	+	+	+	+	+	+	+	+	-	+	-	+	+	+	-	+	+	+	+	-	-	

Figure 145; Requirement checklist comparison between concept 3, 5 and 7 (own illustration)

according to the transparent balustrade, the missing noise protection, the missing outside sun shading, the limited space on the balcony, the window cleanability of the balustrade and the complexity of some of the designs.

As already shown in the final design chapter, most of these missing requirements do not have to be seen as problems. They could be easily solved, or are not that important to solve in this design.

12.3 CONCLUSIONS

As the evaluation shows, the postponing of my P5 was relevant. The participating occupants were much more happy and satisfied with the new designs.

The different evaluation methods gave me more insight in the different angles of criticizing a design. What we can conclude from the different evaluation methods and outcomes, is that some requirements are more important in ranking than others. For example having an outdoor area was much more important than implementing a noise protection screen.

By dividing the final design in two main (integrated) parts (the HEMS and the facade element), the designs could be evaluated much better. The occupants were also much more convinced of the operation of the designs and the comfort and energy reduction it would deliver.

The three designs for the facade element are quite equally evaluated by the checklist, but also by the occupants and the personas. Therefore all three designs should be considered when renovating the facade of a porch apartment.

The layout of the HEMS system should be chosen per household while the different personas show that there is no universal approach for all different users.

13. DISCUSSION

13.1 CONCLUSIONS

To give answer to the research question “How can elderly be triggered to an energy neutral and healthy use of the facade?”, two design directions are important. These two directions are ‘the technical direction’ (according to the energy neutral facade) and ‘the user-centered direction’ (according to the behavior and habits of the occupants). Besides that the approach is to make sure the housing cooperations/ home owners/ occupants are willing to buy and use the product(s) that triggers the occupants to an energy neutral and healthy use of the facade.

As the design shows, to achieve these goals, the design is divided in two parts: a design part of a HEMS, and a design part of a facade element. Which are in the end integrated with each other.

While elderly suffer from different and various deterioration problems, the designs should also be adjustable for these different deteriorations. The most important and common deterioration factors are vision and mobility. Although these disorders can not be prevented, a smart facade design could help to postpone these disorders or it could make elderly suffer less from these problems.

A clever facade design regarding to the let in of daylight can improve the vision of elderly, but it can also increase their body temperature, improve their biological clock and keep up their vitamin D level.

Besides preventing or postponing the deteriorations of elderly, the quality of their environment is very important to their mental and physical health. The quality doesn't only point to the health of the air, but also the mental connection with the environment. The more interaction with the environment, the less elderly get socially isolated (which also stimulates elderly's mobility). The more elderly catch direct daylight, the more vitamin D will be created in their body (which benefits to their health and mobility). The design is not only directed to the improvement of the quality of life for elderly according to their deteriorations, but it is also directed to their comfort preferences and habits. In this way much more occupants are willing to use a facade element in the desired way.

Regarding to the quality of the indoor air, it seems that elderly ventilate too little, which also contributes to their health deterioration. Therefore elderly should be stimulated to ventilate their rooms more. This is harder to achieve than it sounds, while elderly place their comfort (high temperature) on a high value. Elderly also prefer a higher temperature setting than others. Stimulating elderly to ventilate more there-

fore only works if they have more insight in the health of their indoor climate and if it benefits to their comfort.

Different designs of HEMS systems for the different personas provide a possible solution to this problem. These still should be tested in a long timespan in order to conclude if this system will work in long terms or not. The HEMS does not only provide information about the energy consumption of the occupants, but also provides information on the health of the indoor climate and connects certain actions with each other to reduce unnecessary energy consumption.

Space heating seems to be the biggest energy consumer. The more occupants get in touch with their equipment, the more they are aware of the operation, costs and the energy consumption of it. The HEMS should therefore become part of their daily lives.

The final design stimulates elderly to be energy efficient and live healthy simultaneously. Partly actions are automated and partly elderly are triggered to undertake certain actions.

The final design also gives the occupants the freedom to design their own facade according to their preferences and comfort by giving them different additional options.

So to give answer to the research question “*How can elderly be triggered to an energy neutral and healthy use of the facade?*”:

- We should give them more insight and awareness in a healthy way of life by providing a personalized home energy management system (which gives the occupants feedback and advice on their behavior according to energy efficiency and living healthy);
- We should provide them comfort, a facade that not only focuses on energy efficiency but also has an added value by optimizing the connection with the environment (in which the deterioration factors are considered);
- The facade elements should be designed for different scenarios (according to location, orientation, etc.), which will be chosen by the housing cooperation or home owners. The occupants should have a choice in several extra facade options to personalize and optimize their own comfortable facade.

13.2 REFLECTION

For my graduation topic I did research on the energy neutral use of the façade and simultaneously the well-being of elderly and their abilities in living energy neutral, healthy and safe. When I started my graduation in November the topic was totally different.

The initial idea was to design an 'intelligent door handle' on behalf of the company ALCOA Architecture systems. There was no problem statement or assignment formulated which this 'intelligent door handle' had to meet. So I started with analyzing the different interaction levels between façade and user, which is very broad. Therefore the launch of the project took a little bit longer than expected.

A few weeks before my P2 presentation it became clear that both of my tutors would appreciate it if I combined this project from ALCOA with the BAM 2nd skin project (a renovation project of porch apartments in Rotterdam). As this was not very clear to me from the beginning, the launch of my graduation project took a little bit more time than planned. The change of the main research question shows the research direction completely changed during the time. While these changes in research direction first were

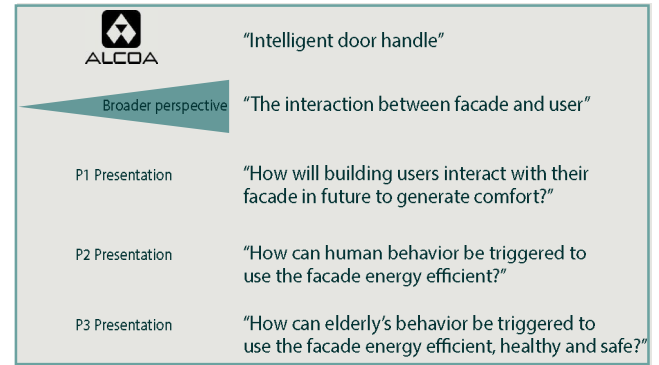


Figure 146; Change of the main research question during the process (own illustration)

a bit confusing to me, in the end the subject made much more sense. The relevance of the project not only became clear by the different recent (newspaper) articles I read, but also by discussing the research topic with others. A lot of people became interested in the outcome and asked me to stay in touch. Also the switch from designing a 'door handle' to designing a 'façade element' made more sense for the framework of my graduation studio.

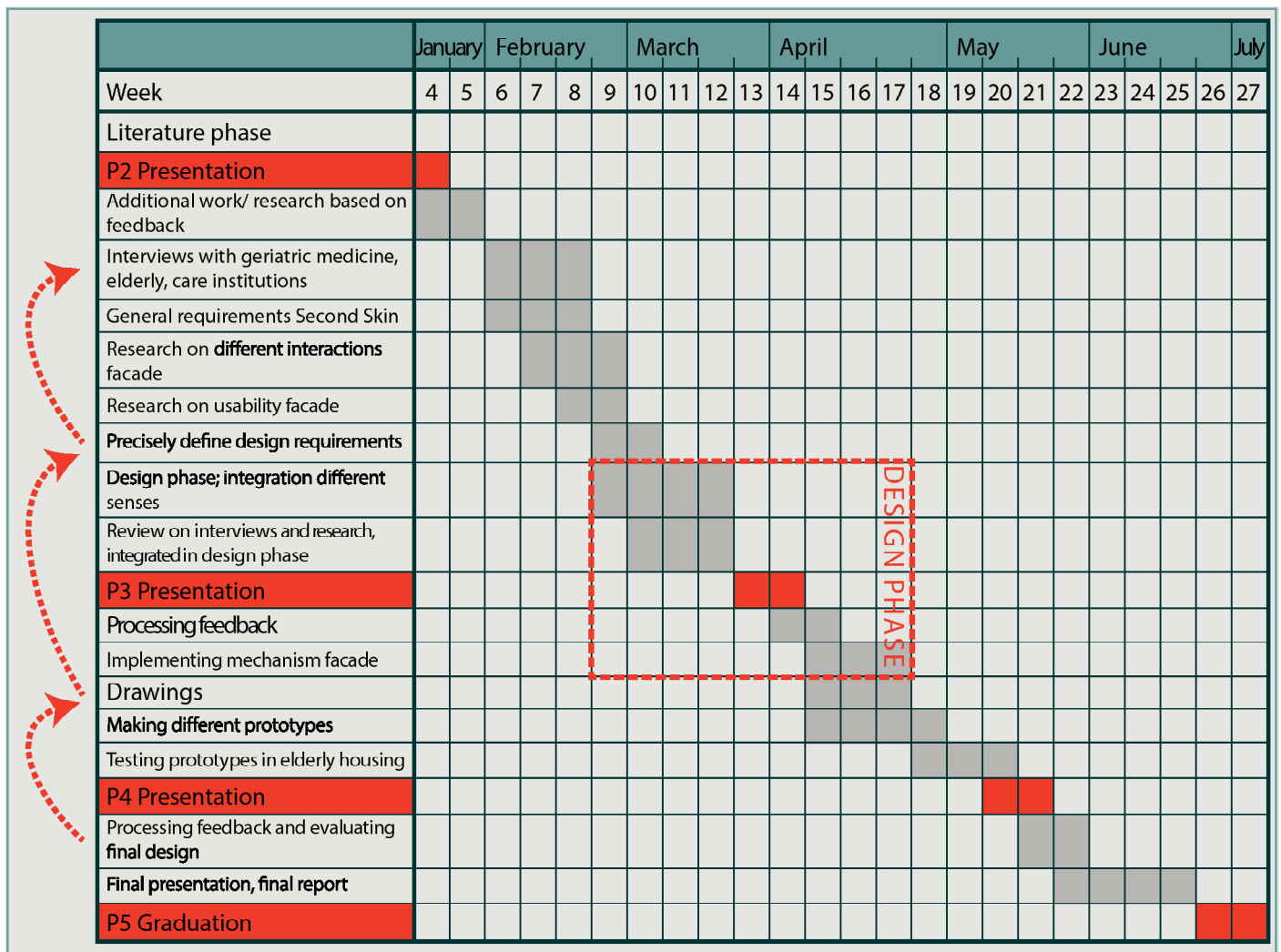


Figure 147; Planning made before P2 presentation (own illustration)

The main part of my graduation project consists of research, which is in the end translated into strict design requirements and a final design. It was new for me to go deeper into the well-being of elderly and take their well-being into account while designing for an energy neutral use of the façade. The final design is mainly based on literature, feedback from interviews, making models, simulations from Dialux, reference material from ALCOA and feedback from my tutors.

My first planning shows that I wanted to finish the final design in nine weeks and after that prototype the design and test it. Unfortunately the process to define the strict final design requirements took much more time than planned. In the end 12 concept designs were made, from which three designs were chosen to develop.

I noticed that defining the final design requirements was much more important than quickly defining the design requirements and starting on designing the final product. By formulating the design requirement much stricter, the design possibilities became much smaller and made more sense.

My planning and the research methods were valuable guidelines during the research process. Although I couldn't live up to my initial planning, it functioned as a handhold during my process. The research method consisted mainly of literature, but I also learned a lot from talking to the target group. Also interviews with professionals provided me new insights. *Figure 147* shows the initial planning which I made before my P2 presentation. This planning changed a lot as *figure 22* in chapter 3 showed.

My graduation research allowed me to focus on topics I had never done research in before. It didn't only taught me a lot about the life and deteriorations of elderly, but also on how to deal with designing for interactions, a graduation direction from the faculty of Industrial Engineering. I never really designed for interactions between people and products before, so in the beginning this didn't felt as important as I know it is now. The different knowledge fields of my tutors and my mentor from ALCOA helped me to think and design from different angles.

When looking back at the entire process, I learned that talking to my tutors regularly contributes to a faster process. Especially when feeling stuck, they can help you to clear up your mind settings. I am sure a second big research project like this will have a faster progress because of all the things I learned from this project.

The original plan was to graduate before summer. Due to personal reasons and the feeling that I wasn't done yet, my tutors and I decided to postpone the gradua-

tion date. My student advisor from the TU Delft advised me to take a break and go on holidays during the summer and get back with a fresh mind. So I did and, having done the P4 presentation for the second time, I felt much more satisfied.

13.3 RECOMMENDATIONS

During the research and design process additional questions appeared. Some of these questions were answered in this thesis, others should still be answered in new research projects.

PERCEIVED TEMPERATURE

One of the first topics that seemed very interesting to me is saving energy by increasing the perceived temperature by the use of colours. As mentioned in my research the perceived temperature could be increased by using for example blue light, it was tested on one blind man in that research example. I think it would be very interesting to see if this really works and if the perceived temperature could also be increased by colouring the floor, the facade or ceiling for example.

HOME ENERGY MANAGEMENT SYSTEMS

A few of the formulated design requirements point to the design of a home energy management system. The effectiveness of HEMS is not optimal yet, some research on HEMS is still missing:

- There isn't done enough research in the long-term effectiveness of HEMS. This research is needed to find out whether routine use can contribute to increased effectiveness;
- HEMS are now mostly used to monitor energy consumption of households. More research is needed to develop and test HEMS that can also manage the energy consumption;
- Strategies should be developed to give every household the opportunity to find out if a HEMS works for them. For example by leasing/renting a HEMS for a short period;
- New insights for HEMS are given in this thesis. These are not factually tested (such a HEMS isn't developed for this project), these tests are needed to find out if these new insights work for the occupants.
- There should be done research on linking the HEMS system with the NEXT active facade element. These are both in a conceptual form now and should be developed and tested in future.

MECHANICAL VENTILATION FILTERS

Another part that could be further developed is replacing the filter of the mechanical ventilation system. When occupants don't change the filter in time their indoor air becomes polluted. Strategies should be developed to overcome these problems, for example by:

- Designing a system in which the filter changes itself when necessary;
- Designing a system in which a filter isn't necessary anymore;
- Let an external party change the filters regularly from outside, so the occupants won't suffer from them;
- Integration of the filter function in the NEXT active facade element which will be checked regularly

by one party.

HEARING DISORDER

One of the deterioration factors of elderly is hearing disorders. For some elderly environmental sounds are very annoying and therefore they don't go outside or open windows. A sound protection screen could be designed which can still ventilate.

FURTHER DETERIORATED ELDERLY

This research focuses on porch apartments (without elevators), therefore far deteriorated elderly are excluded in this research. It would be very interesting to see if we could improve the lives of elderly with dementia with a healthy and energy neutral indoor climate. Therefore other dwellings (for example with elevators) should be researched.

FURTHER DEVELOPMENT NEXT FACADE

The NEXT active facade concept fits well in the outcomes of this research. But the NEXT active facade is still in a concept phase and should be further developed. During the development the new additions (measuring the humidity etc.) could be integrated too.

RESEARCH INTO KEEPING THE EXISTING BALCONIES

In my final design the existing balconies will be replaced by new ones. This is not only because in this way the balconies can be developed in different sizes, but also because of the coldbridge of the existing situation. Further research should be done in keeping the existing balconies and prevent this coldbridge in an efficient (space saving) way.

LEASING FACADE ELEMENTS

While the occupants of an apartment change over time, the facade preferences change too. In this situation it could happen that the facade should change regularly which costs a lot of money. By leasing these extra facade element options, the costs can be reduced. Further research should be done in the life span of these different elements and how these could be leased.

DIMENSIONS BALCONIES

In this thesis the dimensions of the existing balconies of the bedrooms are taken as a starting point. By looking at the possibilities of the isokorf system, much more options arise. Balconies can be placed at many more positions on the facade and the dimensions of the balconies are flexible. More study should be done into the optimal place and dimensions of the balconies.

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A. 1. Spee Architecten - Design options 2nd Skin

A.1.1. Floorplans, elevations and sections BAM 2nd skin project;

A.1.2. Visualizations BAM 2nd skin project;

A. 2. Elderly - Vision with different sight disorders

A. 3. Interviews elderly

A.3.1. Face-to-face interview according to their perception of energy consumption;

A.3.2. Interview by email according to research results and design concepts (evaluation);

A.3.3. Face-to-face interview according to their perception of comfort;

A.3.4. Interview by email according to research results and design concepts (evaluation).

A. 4. Orientation analyses, Rotterdam

A.4.1. Windroses Rotterdam 2014-2015;

A.4.2. Dialux daylight study, Rotterdam.

A. 5. Concept ideas 1 (after interviews A.3.1. and A.3.2.)

A. 6. Concept ideas 2 (after interviews A.3.3. and A.3.4.)

A. 7. Nano double blind sun shading system

A. 1. SPEE ARCHITECTEN - DESIGN OPTIONS 2ND SKIN

A.1.1. Floorplans, elevations and sections BAM 2nd skin project

The first two floorplans (figure A.1 and A.2) at the right show the existing situation of the porch apartments in Rotterdam.

To improve the energy efficiency of these buildings, better insulation is attached to the buildings, but also solar panels and collectors are placed on the roof (figure A.3).

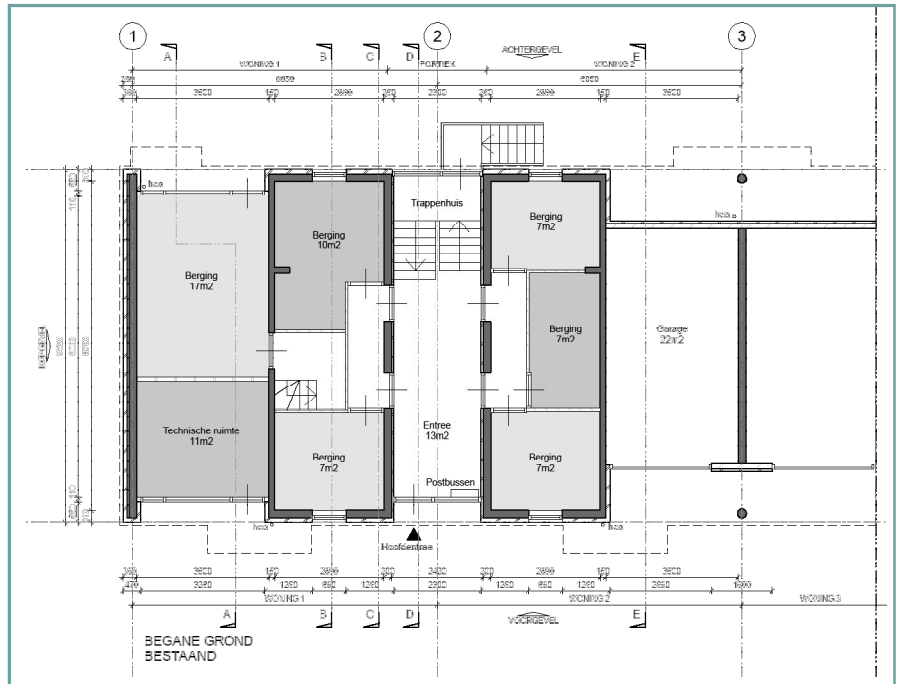


Figure A.1; Plan - Ground floor porch apartments BAM 2nd Skin (SpeeArchitecten, 2014)

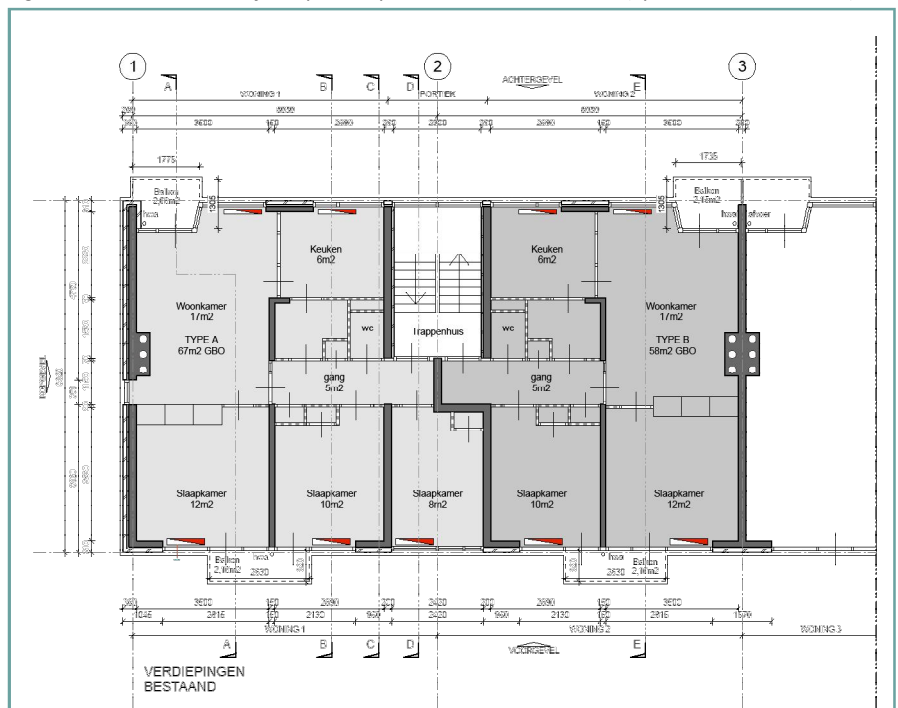


Figure A.2; Plan - First floor porch apartments BAM 2nd Skin (SpeeArchitecten, 2014)

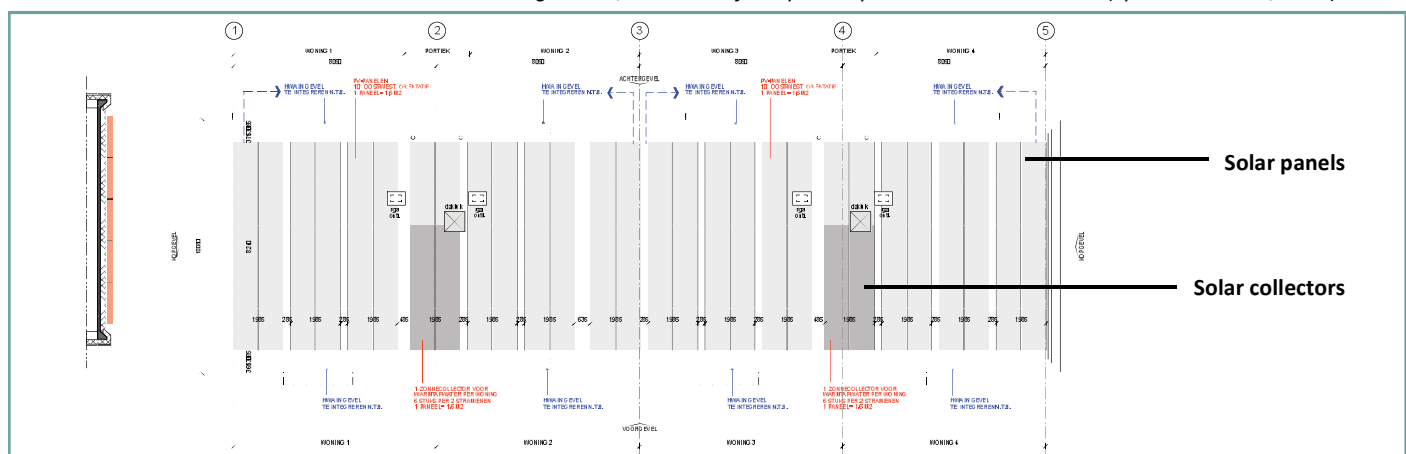


Figure A.3; View - Rooftop porch apartments BAM 2nd Skin (SpeeArchitecten, 2014)

Figure A.4 and A.5 show two options of Spee Architects.

- In the *first option* they interrupt the cold bridges of the balcony by wrapping up the balconies with thermal insulation. New insulated facade elements are attached to the old ones and the balconies are provided with new balustrades.

- In the *second option* they also attach new better insulated panels to the old facades, but these panels go around the existing balconies.

In both of the options the balconies of the bedrooms are removed and replaced by big glass facades.

Both of the options and the existing situation are shown in elevations and sections on the next page (figure A.6, A.7 and A.8).

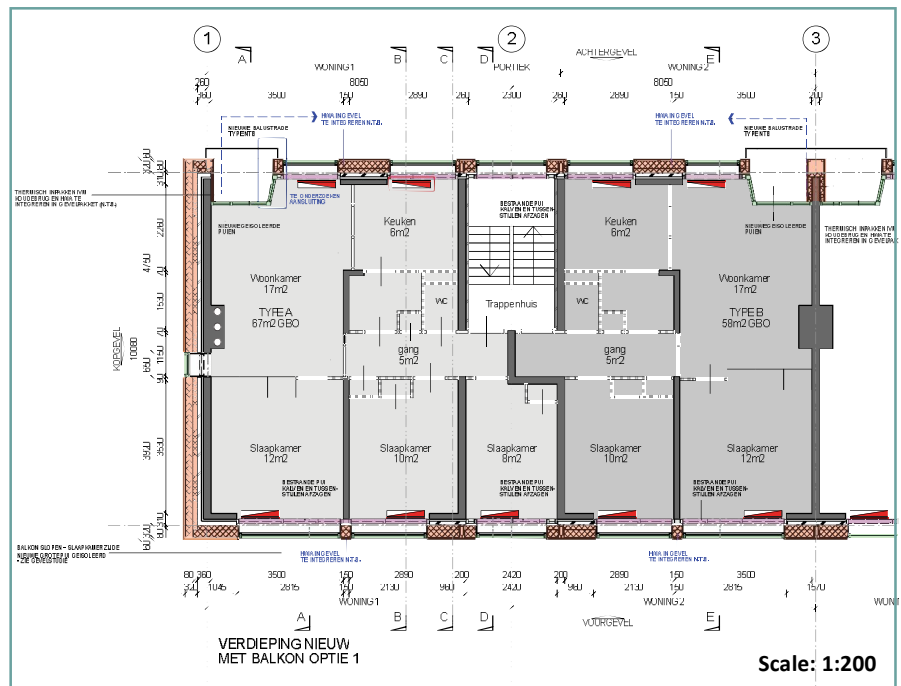


Figure A.4; Plan - First floor porch apartments BAM 2nd Skin, new design option 1 (SpeeArchitecten, 2014)

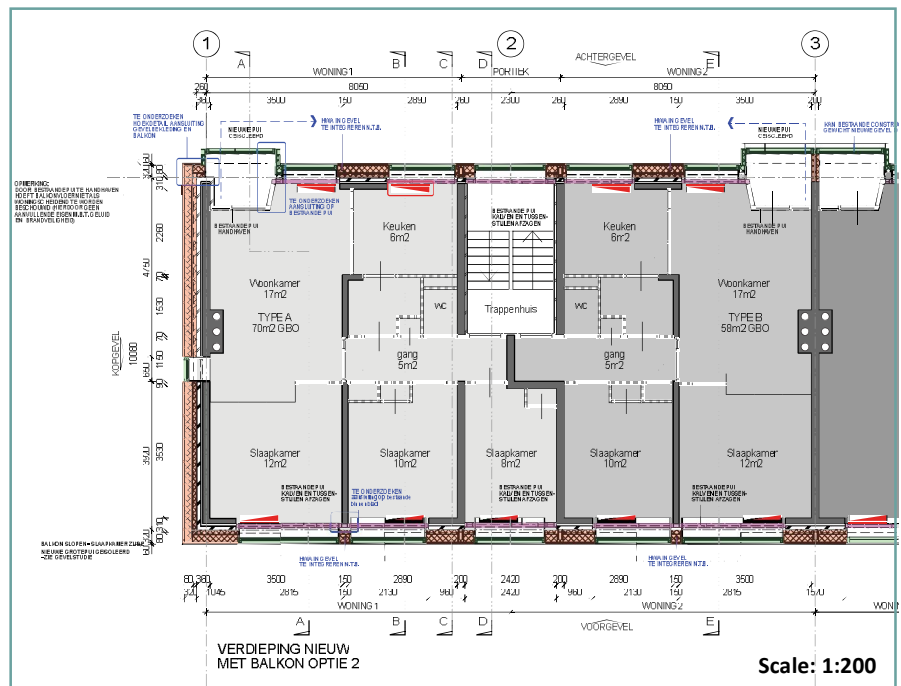
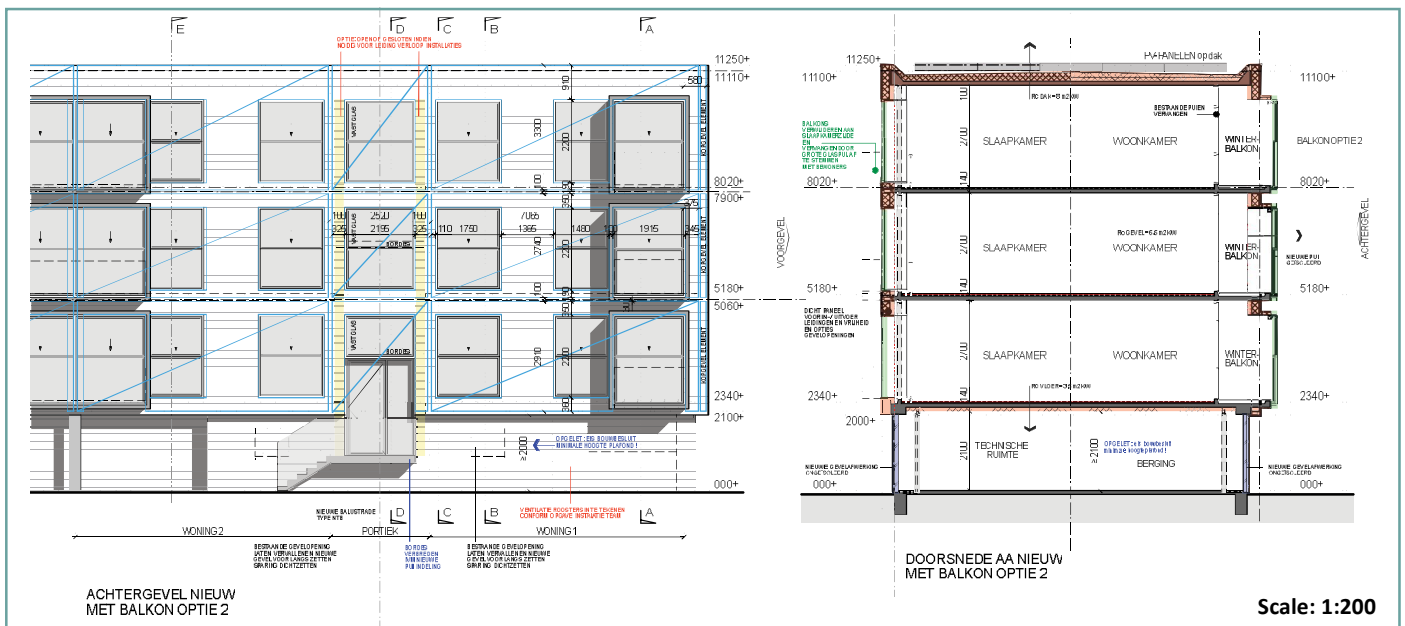
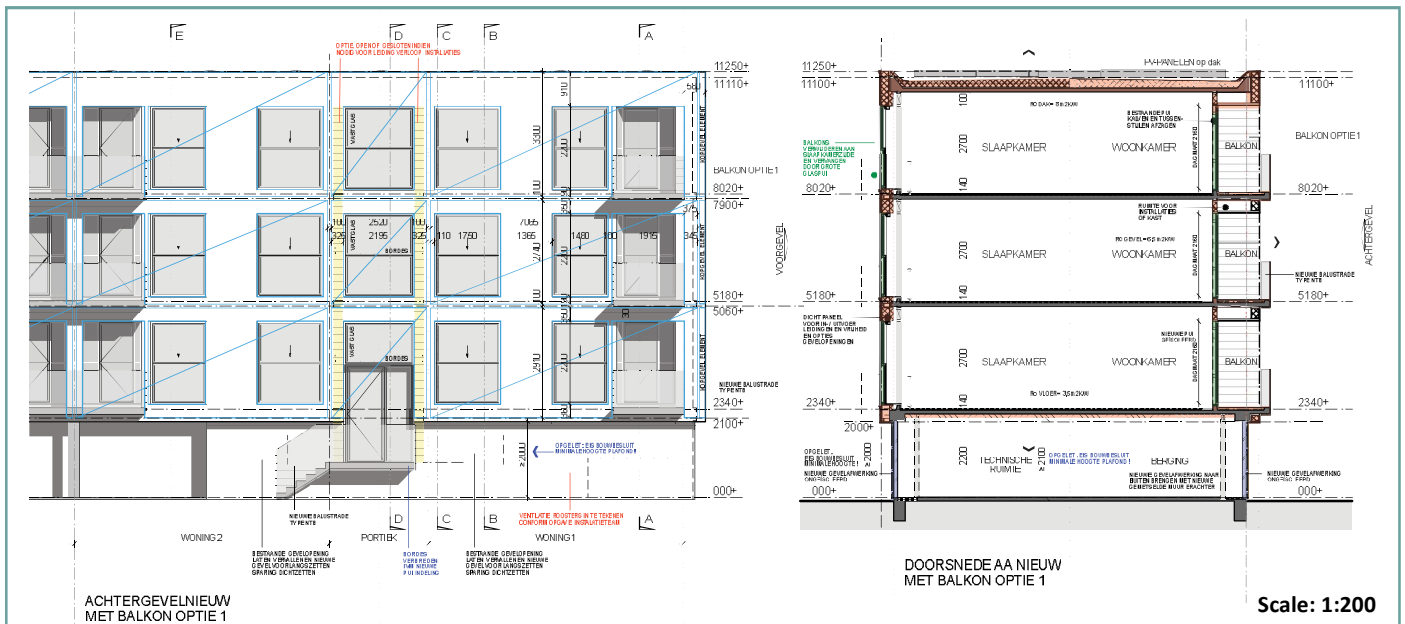
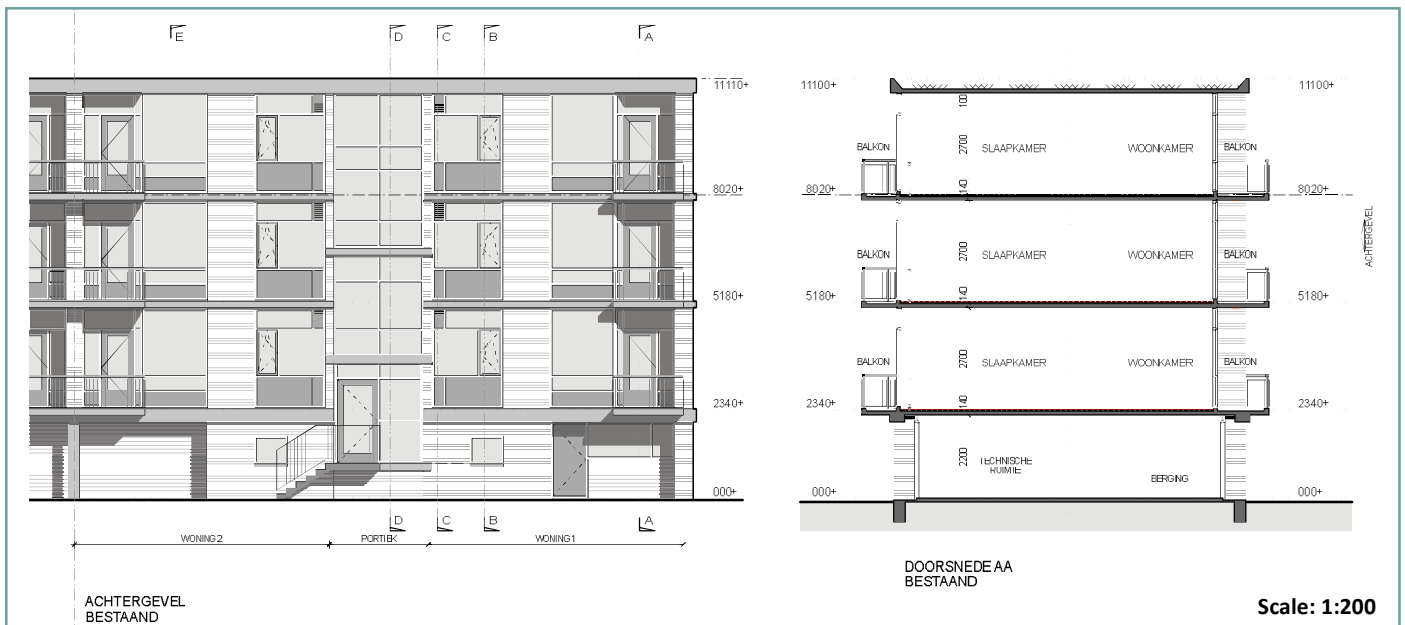


Figure A.5; Plan - First floor porch apartments BAM 2nd Skin, new design option 2 (SpeeArchitecten, 2014)



A.1.2. Visualizations BAM 2nd skin project

These design options for the porch apartments in Rotterdam are made by Spee Architecten. They present different cladding options and different window operations.



Figure A.9; Different cladding and window operation options (SpeeArchitecten, 2014)



Figure A.10; Different cladding and window operation options (SpeeArchitecten, 2014)



Figure A.11; Different cladding and window operation options (SpeeArchitecten, 2014)

A. 2. ELDERLY - VISION WITH DIFFERENT SIGHT DISORDERS

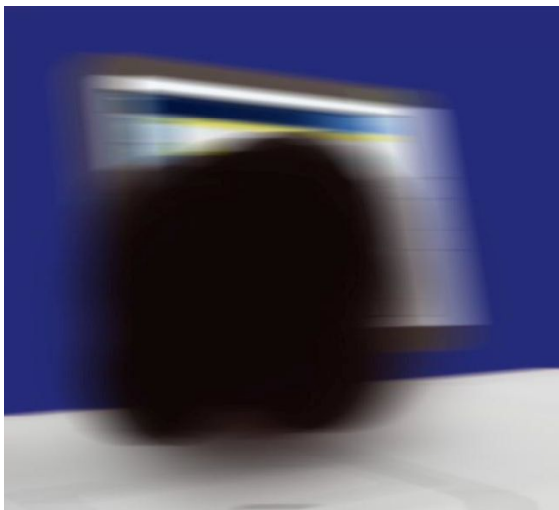
The pictures show the vision people have with different sight disorders.



NORMAL VISION



ACHROMATOPSIA



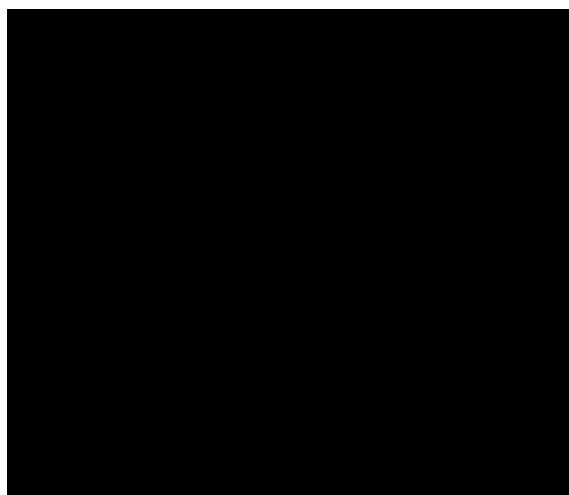
MACULA DEGENERATION



CATARACT



GLAUCOMA



NO VISION: BLIND

Figure A.12; Vision with different sight disorders

A.3. INTERVIEWS ELDERLY

Four interviews are done to get enough results. These different interviews are attached here in the following order;

- A.3.1.** Face-to-face interview according to their perception of energy consumption;
- A.3.2.** Interview by email according to research results and design concepts (evaluation);
- A.3.3.** Face-to-face interview according to their perception of comfort;
- A.3.4.** Interview by email according to research results and design concepts (evaluation).

All interviews are first presented in a list of questions, followed by an elaborated part of the different participants.

A.3.1. Face-to-face interview according to their perception of energy consumption

The first interview consisted of two main parts. The first part was more an introduction of the person who was sitting in front of me, the second part was more about the habits of this person.

PART 1

1. *What is the gender?*
2. *What is the age?*
3. *Living alone/ with partner?*
4. *Since when do you live in this dwelling?*
5. *Are you planning to stay here for the rest of your life or do you prefer to go to a care institution when necessary?*
6. *What are your daily activities?*
7. *What kind of job/ occupation did you have before you retired?*
8. *Do you suffer from elderly disorders? (mobility problems/ sensory disorders/ cognitive problems)?*

PART 2

1. *In what kind of dwelling do you live at the moment (flat, detached house, ...)?*
2. *In what kind of dwelling did you live before this dwelling?*
3. *How many hours per day do you spend at home inside?*
4. *Which rooms do you mostly use in the daytime?*
5. *What do you use your facade most for (ventilation, keeping the warmth inside, looking outside, listen to the birds, light accession, keeping insects outside, etc.)?*
6. *How many times do you open a window per day per room? How often do you change the setting of your heating system per day?*
7. *What kind of heating system do you have (thermostat)? Do you know how the thermostat works? How do you use it? Can you show it to me? What do you do when it is too hot inside (do you open a window?)?*
8. *What kind of ventilation system do you have? How do you ventilate your bedroom (is the window open all day)?*
9. *Are you actively trying to save energy? Yes, how?*
10. *Do you switch off your heating system in rooms you are not using/ at night?*
11. *Would you like to save more energy?*
12. *Is it hard for you to control the heating and/ or ventilation system?*
13. *Observing if elderly have new technology devices and if they are able to control these devices.*

A.3.1. - Interview 1; Magda Wolthoorn - Emmapark 89, Pijnacker

PART 1

1. What is the gender? *Female*
2. What is the age? *90 years*
3. Living alone/ with partner? *Alone*
4. Since when do you live in this dwelling? *14 years, since the beginning*
5. Are you planning to stay here for the rest of your life or do you prefer to go to an care institution when necessary? *I hope I can stay here all my life.*
6. What are your daily activities? *I read a lot at home and I watch tv a lot, sometimes I send emails from my computer and sometimes I go outside to go to the supermarket.*
7. What kind of job/ occupation did you have before you retired? *I was working in a library.*
8. Do you suffer from elderly disorders? (mobility problems/ sensory disorders/ cognitive problems)?
*I broke my hip a few months ago, therefor I walk with a walker.
I also have special glasses (double focused) to read and use the computer.*

PART 2

1. In what kind of dwelling do you live at the moment (flat, detached house, ...)?
Apartment on the first floor with roof garden and balcony (energy label B).
2. In what kind of dwelling did you live before this dwelling?
A single family house in Pijnacker North.
3. How many hours per day do you spend at home inside?
Mostly all day. I only leave the house if the weather is good and if I have to go outside to buy things.
4. Which rooms do you mostly use in the daytime?
The living room, but when the weather is good I use the balcony often.
5. What do you use your facade most for (ventilation, keeping the warmth inside, looking outside, listen to the birds, light accession, keeping insects outside, etc.)?
I mainly use the facade to regulate my comfort or to ventilate, but I miss an insect screen protection.
6. How many times do you open a window per day per room? How often do you change the setting of your heating system per day?
In the winter I always leave my bedroom window open (and I close my bedroom door). And when I cook I always open a window (because there is lack of cooking ventilation). In summer I open my windows a lot.
7. What kind of heating system do you have (thermostat)? Do you know how the thermostat works? How do you use it? Can you show it to me? What do you do when it is too hot inside (do you open a window)?
I have a programmed thermostat, which is set on 22 degrees always. In the living room and bathroom the heater is always on, in my bedroom the heater is always off.
8. What kind of ventilation system do you have? How do you ventilate your bedroom (is the window open all day)?
I have a mechanical ventilation system which is always set on 1 (in the kitchen and bathroom).
9. Are you actively trying to save energy? Yes, how?
No, but I am not consuming actively either.
10. Do you switch of your heating system in rooms you are not using/ at night?
The thermostat is set on 16 degrees when I leave the house or when I sleep.
11. Would you like to save more energy?
I would like to get a smart meter to save more energy, but only if I am able to understand the operation of it.
12. Is it hard for you to control the heating and/ or ventilation system?
No, but I have difficulties with reading the manual of a device.
13. Observing if elderly have new technology devices and if they are able to control these devices.
She has a computer, mobile phone and is thinking about buying a tablet.

A.3.1. - Interview 2; Lida Bergenhenegouwen - Van Houtenlaan 1, Pijnacker

PART 1

1. What is the gender? **Female**
2. What is the age? **67 years**
3. Living alone/ with partner? **Alone**
4. Since when do you live in this dwelling? **Since 2000.**
5. Are you planning to stay here for the rest of your life or do you prefer to go to an care institution when necessary? **I hope I can stay here all my life.**
6. What are your daily activities? **I am babysitting the kids of my daughter a lot.**
7. What kind of job/ occupation did you have before you retired? **I was working in an interior store.**
8. Do you suffer from elderly disorders? (mobility problems/ sensory disorders/ cognitive problems)?
No, I use glasses but that's all.

PART 2

1. In what kind of dwelling do you live at the moment (flat, detached house, ...)?
Apartment on the first floor. The apartment is built in 1960, but renovated (doubleglass everywhere).
2. In what kind of dwelling did you live before this dwelling?
A single family house.
3. How many hours per day do you spend at home inside?
On average I am at home 3 hours a day.
4. Which rooms do you mostly use in the daytime?
Mostly in the kitchen (kitchen and living room are attached), I can catch the most daylight in the kitchen.
5. What do you use your facade most for (ventilation, keeping the warmth inside, looking outside, listen to the birds, light accession, keeping insects outside, etc.)?
Only a small part of the windows can be opened, so I use the facade most to catch daylight.
6. How many times do you open a window per day per room? How often do you change the setting of your heating system per day?
In my bedroom I keep the window always open, except in winter. When cooking I open an extra window.
7. What kind of heating system do you have (thermostat)? Do you know how the thermostat works? How do you use it? Can you show it to me? What do you do when it is too hot inside (do you open a window)?
I have a manual thermostat, I try to use the heating system as less as possible.
8. What kind of ventilation system do you have? How do you ventilate your bedroom (is the window open all day)?
I have a mechanical ventilation system in the kitchen, for the other rooms I use the windows to ventilate.
9. Are you actively trying to save energy? Yes, how?
No, but I am not consuming actively either.
10. Do you switch of your heating system in rooms you are not using/ at night?
I switch of the heating system.
11. Would you like to save more energy?
Yes, but my comfort is also important.
12. Is it hard for you to control the heating and/ or ventilation system?
No.
13. Observing if elderly have new technology devices and if they are able to control these devices.
She has a computer, mobile phone. She is still quite young for an elderly.

A.3.1. - Interview 3; Guus Maiburg - Ridderspoor 108, Nootdorp

PART 1

1. What is the gender? **Male**
2. What is the age? **70 years**
3. Living alone/ with partner? **With partner**
4. Since when do you live in this dwelling? **September 2012**
5. Are you planning to stay here for the rest of your life or do you prefer to go to an care institution when necessary? **I hope I can stay here all my life.**
6. What are your daily activities? **Volunteering work (organizing activities for elderly)**
7. What kind of job/ occupation did you have before you retired?
I set up a test center for cash machines. I worked as facility manager.
8. Do you suffer from elderly disorders? (mobility problems/ sensory disorders/ cognitive problems)?
No, we moved here to foresee deterioration, so we were able to move ourselves.

PART 2

1. In what kind of dwelling do you live at the moment (flat, detached house, ...)?
Apartment on the first floor with a balcony.
2. In what kind of dwelling did you live before this dwelling?
A detached dwelling with a garden, built by myself in 1994.
3. How many hours per day do you spend at home inside?
Half of the week we are outside.
4. Which rooms do you mostly use in the daytime?
Mostly in the living room or study room.
5. What do you use your facade most for (ventilation, keeping the warmth inside, looking outside, listen to the birds, light accession, keeping insects outside, etc.)?
Let in daylight and ventilate.
6. How many times do you open a window per day per room? How often do you change the setting of your heating system per day?
I am not at home so often, so mostly when I get at home, or not.
7. What kind of heating system do you have (thermostat)? Do you know how the thermostat works? How do you use it? Can you show it to me? What do you do when it is too hot inside (do you open a window)?
I have a manual thermostat, I use it every day.
8. What kind of ventilation system do you have? How do you ventilate your bedroom (is the window open all day)?
I have a mechanical ventilation system and I use the windows to ventilate.
9. Are you actively trying to save energy? Yes, how?
Yes, I write down the energy settings weekly.
10. Do you switch of your heating system in rooms you are not using/ at night?
The thermostat is set on 16 degrees when I leave the house or when I sleep.
11. Would you like to save more energy?
Yes.
12. Is it hard for you to control the heating and/ or ventilation system?
No.
13. Observing if elderly have new technology devices and if they are able to control these devices.
They are very in to new technologies.

A.3.1. - Interview 4; Johannes Greven - Tijdemanhove 5, Delfgauw

PART 1

1. What is the gender? **Male**
2. What is the age? **90 years**
3. Living alone/ with partner? **With partner**
4. Since when do you live in this dwelling? **Since 1994.**
5. Are you planning to stay here for the rest of your life or do you prefer to go to an care institution when necessary? **I hope I can stay here all my life.**
6. What are your daily activities? **We go on holidays a lot, I still drive a car.**
7. What kind of job/ occupation did you have before you retired? **I studied engineering and I worked for the ministry.**
8. Do you suffer from elderly disorders? (mobility problems/ sensory disorders/ cognitive problems)?
We both wear glasses and I have a hearing device. My wife struggles from her knee.

PART 2

1. In what kind of dwelling do you live at the moment (flat, detached house, ...)?
Terraced house, built in 1998.
2. In what kind of dwelling did you live before this dwelling?
A detached house which I built myself.
3. How many hours per day do you spend at home inside?
When we are not on holidays, we spend most of our time at home.
4. Which rooms do you mostly use in the daytime?
The living room.
5. What do you use your facade most for (ventilation, keeping the warmth inside, looking outside, listen to the birds, light accession, keeping insects outside, etc.)?
Daylight and ventilation.
6. How many times do you open a window per day per room? How often do you change the setting of your heating system per day?
Comfort is very important, we only open a window when necessary.
7. What kind of heating system do you have (thermostat)? Do you know how the thermostat works? How do you use it? Can you show it to me? What do you do when it is too hot inside (do you open a window)?
I have a programmed thermostat, which is set on 23 degrees always (day and night).
8. What kind of ventilation system do you have? How do you ventilate your bedroom (is the window open all day)?
We use windows to ventilate.
9. Are you actively trying to save energy? Yes, how?
No, we want to be comfortable in our ageing years.
10. Do you switch of your heating system in rooms you are not using/ at night?
No, the thermostat is always set on 23 degrees.
11. Would you like to save more energy?
If it's easy and provides comfort, yes.
12. Is it hard for you to control the heating and/ or ventilation system?
We only use the windows to ventilate.
13. Observing if elderly have new technology devices and if they are able to control these devices.
They have a computer (apple), iPad, iPhone, ...

1. MAGDA WOLTHOORN

Name	Magda Wolthoorn
Age	90 years
Gender	Female
Address	Emmapark 89, Pijnacker
Type of dwelling	Apartment, 1st floor
Living alone/ partner	Alone
Type of temperature control	Programmable thermostat



Figure A.13; Magda Wolthoorn's apartment (first floor) in Pijnacker (own picture)

Magda Wolthorn is a 90-year old woman who lives alone in her apartment since her man died one and a half year ago. She is living in this apartment for 14 years now, since it was built.

She hopes to live in the apartment all her life, she prefers to not go to a care institution. She uses a walker if she goes outside, but inside she doesn't use the walker.

Recently she broke her hip, but she can already walk again. She uses double focus glasses to read. She reads and watches tv a lot and uses the computer to send emails, but has trouble with overexposure while doing these activities. She is thinking of buying a tablet.

Most of the time she is at home, in the summer she tries to leave the house and goes outside most of the time. When she is at home she is in the living room most of the time (figure A.16).

The house has an energylabel B. The house is equipped with a programmable thermostat. The thermostat is set on a temperature of 22 degrees. At night the thermostat is set at 18 degrees. When she leaves the house for vacation she sets the thermostat on 16 degrees. The radiators in the livingroom and bathroom are always on, in her bedroom the radiator is never on.

The ventilation system is very poor. When she cooks she mostly opens a window. In her bedroom the windows are always open. The only thing she misses is an insect screen in her bedroom.

She has no difficulties with understanding the ventilation- and/ or heating system, but she has difficulties reading the manual instructions of new devices.

She is not actively saving energy, but she would like to save more energy.



Figure A.14; Front door on roof garden (own picture)



Figure A.15; Roof garden, front doors apartments (own picture)



Figure A.16; Living room inside (own picture)

2. LIDA BERGENHENEGOUWEN

Name	Lida Bergenhenegouwen
Age	67 years
Gender	Female
Address	Van Houtenlaan 1, Pijnacker
Type of dwelling	Appartment, 1st floor
Living alone/ partner	Alone
Type of temperature control	Radiator with manual valves



Figure A.17; Lida Bergenhenegouwens apartment (first floor) in Pijnacker (own picture)

Lida Bergenhenegouwen is an 67-year old woman who lives alone in her apartment since she divorced. She is living in this apartment for 15 years now, it was built in 1960.

She hopes to live in the apartment all her life, she prefers to not go to a care institution. She has no mobility problems.

She uses glasses. She babysits her grandchildren a lot and she does a lot of activities outside. She is at home approximately three hours per day in the daytime. When she is at home she is in the living room or kitchen most of the time (figure A.18). The living room and kitchen are one room.

The house has an energylabel D. The house is equipped with radiators with manual valves. She uses the radiators in the living room and the kitchen when she is cold. At night these radiators are off.

She has a small ventilation system in the kitchen. In the rest of the house she opens and closes the windows. When she cooks she mostly opens a window. In her bedroom the windows are always open at night. There are no abilities to open big windows, only small windows on top of the facade. She doesn't like the fact that she can't open a window on eye level.

She has no difficulties with understanding the ventilation- and/ or heating system.

She wants to be energy efficient, but doesn't want to be cold in her own house.

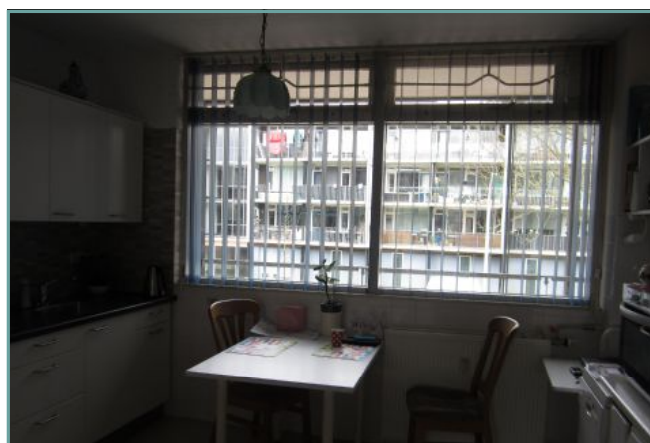


Figure A.18; Kitchen, windows can be opened on top (own picture)

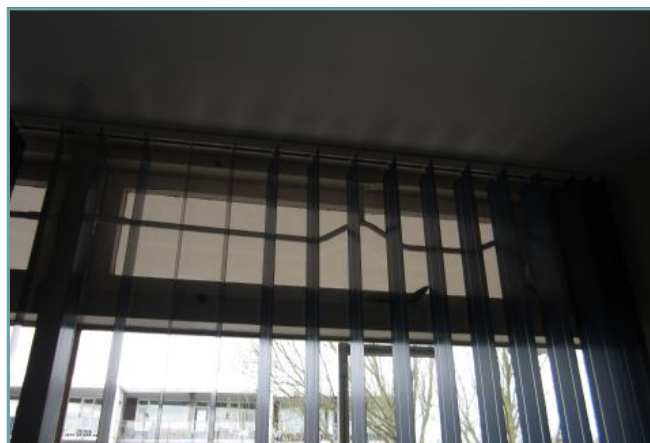


Figure A.19; Windows can only be opened on top(own picture)

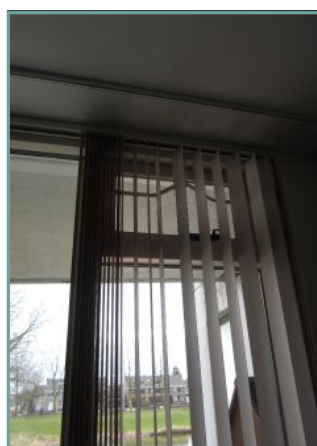


Figure A.20; Small window in bedroom on top (left), gas meter per apartment (right) (own pictures)

3. GUUS MAIBURG

Name	Guus Maiburg
Age	70 years
Gender	Male
Address	Ridderspoor 108, Nootdorp
Type of dwelling	Apartment, 2nd floor
Living alone/ partner	with partner
Type of temperature control	Manual thermostat



Figure A.21; Guus Maiburgs apartment (second floor) in Nootdorp (own picture)

Guus Maiburg lives with his partner in this apartment since 2012, the building is built in 1997. They decided to move because of their age and they still had the abilities to move themselves. They don't have children.

They moved this early to make sure they understand all devices in their new home. He says recognition is very important when you grow older. He also says that the force in our hands decreases, grip is very important.

They hope to live in the apartment all their life, he prefers not to go to a care institution. They do not have mobility problems.

They use glasses to see. They do a lot of voluntary work, organizing activities for elderly for example. Because of their big contribution in voluntary work, they are outside their house half of the week. When they are at home they use their working room and living room most. They also have a big balcony with wind separation of glass (figure A.22 and figure A.23).

Their apartment has an energylabel C. The house is equipped with a manual thermostat. They use the manual thermostat everyday.

They are very active in being energy efficient. He writes down the energymeter readings every week. When there is a peak, he tries to find out where it comes from.



Figure A.22; Balcony with windows (own picture)



Figure A.23; Balcony with panels of glass (own picture)



Figure A.24; Living room inside (own picture)

4. JOHANNES GREVEN

Name	Johannes Greven
Age	90 years
Gender	Male
Address	Tijdemanhove 5, Delfgauw
Type of dwelling	Terraced house
Living alone/ partner	with partner
Type of temperature control	Programmable thermostat



Figure A.25; Johannes Greven's terraced house in Delfgauw (own picture)

Johannes Greven is a 90 year old man who lives with his wife in Delfgauw. They are living in this terraced house since it was built in 1997. They don't have children.

They hope to live in the house all their life, they prefer not to go to a care institution. She has problems with her knee, he does not walk very smooth anymore.

They both use glasses and he has two hearing devices. Most of the day they are at home. He has a mechanical hobby on the first floor in the house. Most of the time they use the living room or working room when they are at home.

The house has an energylabel B. The house is equipped with a programmable thermostat. The thermostat is always set on 22 degrees in the living room and bathroom. In the rest of the house the radiators are off. They don't lower or turn of the thermostat at night.

She has a small ventilation system in the kitchen. In the rest of the house she opens and closes the windows. When she cooks she mostly opens a window. In her bedroom the windows are always open at night. Half of the year they are on holidays, during this time they put off the thermostat.

He bought his first computer 10 years ago and now has an iMac, iPhone and an iPad. He controls his hearing device with his iPhone.

They don't want to put effort in being energy efficient. They don't want to save money, they just want to enjoy the last part of their life.

A.3.2. Interview by email according to research results and design concepts (evaluation)

Het doel voor Nederland is om vanaf 2020 alleen nog maar energie neutrale woningen te realiseren, ook moeten er veel bestaande woningen gerenoveerd worden. In Rotterdam worden momenteel portiekwoningen gerenoveerd van een energielabel E naar een energielabel A. Om dit te bereiken worden de gevel, vloeren en het dak van deze portiekwoningen energietechnisch verbeterd. Uit onderzoek blijkt dat het energieverbruik van een woning uiteindelijk toch altijd afhangt van de gebruikers en hun gewoonten. Het energieverbruik van 1 dezelfde woning kan met een factor 2 verschillen (ookal is het aantal gebruikers hetzelfde). In mijn onderzoek focus ik mij dus vooral op het energie neutrale gebruik van de gevel van de portiekflats in Rotterdam.

Door de nieuwe zorgwet moeten steeds meer ouderen langer zelfstandig thuis blijven wonen. Ook zij worden geacht te weten hoe zij hun woning energieneutraal kunnen en behoren te gebruiken. Daarnaast is het belangrijk te zorgen dat zij zo lang mogelijk zelfstandig thuis kunnen blijven wonen in deze portiekflat. Er moet rekening gehouden worden met ouderdoms achteruitgang, maar juist ook te zorgen dat deze achteruitgang zo lang mogelijk uitgesteld wordt. Ouderen moeten kunnen begrijpen hoe zij tegelijkertijd hun woning energieneutraal gebruiken en daarnaast dit hun gezondheid ten goede komt.

Uit mijn onderzoek zijn een aantal conclusies gekomen die ik hieronder als stellingen of vragen heb uitgeschreven. Graag ontvang ik op deze stellingen en vragen van u feedback of een antwoord over hoe u hierover denkt.

1. Een van de ouderdomsfactoren die bij ouderen veel voorkomt is de achteruitgang van de ogen. Een bril kan al veel verbeteren, maar daarnaast is voldoende licht heel belangrijk. Voldoende licht is niet alleen belangrijk voor beter zicht, maar ook voor de actievere houding die ouderen hierdoor aannemen (men wordt minder snel moe).

- Merkt u zelf dat u meer licht nodig heeft dan vroeger?
- Als u in een appartement van een portiekflat zou wonen, zou u dan liever dicht bij het raam zitten om een boek te lezen met meer licht of liever gebruik maken van kunstmatig licht?

2. Ouderen brengen gemiddeld meer thuis door dan anderen. Hierdoor hebben zij minder contact met de omgeving, terwijl juist voor hun het sociale contact zo belangrijk is (omdat ze anders sneller sociaal geïsoleerd raken). Vooral in portiekflats komt het daarom veel voor dat ouderen veel voor het raam zitten en naar buiten kijken. Uit onderzoek is gebleken dat ouderen vanuit hun stoel vaak niet over de balustrade van hun balkon kunnen kijken, waardoor hun contact met de omgeving verstoord wordt. Een transparante balustrade/balkonrailing zou voor hun daarom wenselijk zijn.

- Hoe staat u hiertegenover?

3. Ouderen hebben een hogere temperatuur voorkeur dan andere huishoudens. Hierdoor hebben zij ook de neiging hun binnenruimtes minder te ventileren. Dit heeft vaak tot gevolg dat de woning binnen eigenlijk niet gezond is (CO₂-gehalte te hoog, luchtvochtigheid te hoog of te laag, etc.). Ouderen zouden daarom aangespoord moeten worden hun woning beter te ventileren.

- Heeft u enig idee of uw binnenklimaat gezond is?
- Wat zou u ervan vinden als een lampje in uw woning bijvoorbeeld aangeeft dat u moet ventileren om te zorgen dat uw binnenklimaat gezond blijft? (dit lampje is bijvoorbeeld rood wanneer de lucht niet gezond is en groen wanneer u niets hoeft te doen)
- Ventileert u liever door een raam open te doen of door een mechanisch ventilatie systeem te gebruiken?
- Ventileert u de ene ruimte meer dan de ander? Zo ja, welke?

4. Er gaat veel energie verloren doordat bewoners tegelijkertijd hun verwarming aan hebben staan en een raam in dezelfde ruimte open hebben staan.

- Wat zou u ervan vinden als het openen van een raam gekoppeld is met verwarmingssysteem? (wanneer het raam geopend wordt, wordt automatisch het verwarmingssysteem uitgeschakeld)

5. De meest voorkomende achteruitgangsfactoren bij ouderen zijn problemen bij zien, horen en mobiliteit. Die mobiliteit heeft niet alleen met te weinig beweging te maken, maar ook met vitamine D tekort. Vitamine D is belangrijk voor de sterkte van je botten en spieren. Tweederde van de benodigde vitamine D kan door genoeg zonlicht in je lichaam aangemaakt worden. Het is daarom belangrijk dat vooral ouderen genoeg buiten komen of in ieder geval in de zon zitten.

- Hoeveel zit u in de zon of bezig met het activiteiten doen in het zonlicht?
- Vult u uw vitamine D bij met supplementen?

- Als u in een portiekflat zou wonen, zou u dan veel in de zon gaan zitten als u een balkon had of een gevel die voor een groot deel open kan?
6. Bewoners die veel thuis zijn hebben vaak veel behoefte aan groen in of buiten huis. Vooral bij het wonen in een portiekflat kan groen voor ouderen veel betekenen. Daarnaast zijn planten ook gezond voor het binnenklimaat van uw woning.
- Hoe denkt u hierover? Heeft u zelf veel planten binnen of buiten huis?
 - Hecht u er veel waarde aan planten te hebben in/ buiten huis?
7. Ouderen hebben vaak ook last achteruitgang van het gehoor. Hierdoor kunnen niet alleen harde geluiden, maar ook omgevingsgeluiden erg vervelend zijn.
- Heeft u zelf gehoorproblemen? Zo ja, heeft u last van omgevingsgeluiden of andere geluiden?
8. Natuurlijke ventilatie is goedkoper dan mechanisch ventileren. Hoewel bij natuurlijk ventileren (een raam openen) wel meer warmte verlies op kan treden dan bij mechanisch ventileren met warmte terugwinning (in de winter). In de zomer is het energie zuiniger om natuurlijk te ventileren, het implementeren van een speciaal raam dat zorgt voor een snelle ventilatie flow is daarom gewenst. De volgende visualisatie weergeeft een beeld van een gevel idee (volgende blz).
- De ventilatieflow gaat het snelst door vanaf de onderkant van het raam verse lucht binnen te laten komen en bovenin de lucht de woning te laten verlaten. De eerste stand van het raam is hiermee het openen van het raam waarbij een kier beneden en een kier boven ontstaat (zie plaatje, situatie rechts boven)
 - Ter veiligheid en ter protectie van insecten gaat bij de opening van het raam automatisch een scherm mee dat veiligheid en insectenprotectie biedt voor ouderen. Dit scherm is handmatig ook los te koppelen. (zie plaatje, situatie rechts onder)
 - Stand 3 van de gevel is de 2 raamdelen volledig naar beneden schuiven, hierdoor ontstaat er een soort balkon idee (hierdoor is contact met de omgeving groter en krijgen ouderen meer vitamine D binnen). (zie plaatje, links boven)
 - Als laatste moet er ook nog een zonnescherm en eventueel scherm ter geborgenheid van de bewoners geplaatst worden. Het zonnescherm staat haaks op het raam zodat het zicht naar buiten er nog steeds is. Ter geborgenheid van de bewoners is er de mogelijkheid de transparante balustrade af te schermen zodat niet iedereen direct naar binnen kan kijken. (zie plaatje, links onder)
- Hoe denkt u over de 4 verschillende situaties? Ziet u uzelf dit gebruiken als u in een portiekflat zou wonen?
 - Zou u vaker natuurlijk ventileren met dit systeem?

FEEDBACK INTERVIEWS

1. Alle ouderen merken dat ze meer licht nodig hebben dan vroeger. Ze zitten om 2 redenen graag dicht bij het raam: er is meer licht, en ze zien graag beweging op straat.
2. De meeste ouderen staan heel positief tegenover het hebben van een transparante balustrade omdat het contact met de omgeving en de grond heel belangrijk is. Enkelen geven aan wel graag hun privacy te behouden.
3. De meeste ouderen hebben geen idee van de gezondheid van hun binnenklimaat, enkelen wel. Ze vinden het een goed idee een sensor te implementeren in de woning die aangeeft of er geventileerd moet worden of niet. Op het moment ventileren de meeste ouderen meer door het openen van een raam dan door het gebruik van mechanische ventilatie. Afhankelijk van het systeem moeten periodiek filters worden vervangen en ouderen hebben niet altijd in de gaten of het systeem defect is. De ruimtes die ze het meest ventileren zijn de woonkamer en de slaapkamer.
4. Het openen van een raam koppelen aan het gebruik van het verwarmingssysteem vinden ze een goed idee.
5. De ouderen hebben allemaal een balkon en zitten hier regelmatig op in de zomer (in de zon). De meesten vullen hun vitamine D gehalte aan met supplementen. Allen hechten veel waarde aan hun balkon en een vaste buitenruimte.
6. Voor de meeste ouderen zijn planten een must, ze brengen een beetje leven in huis. Het houden van planten binnen en buiten is daarom heel belangrijk voor hun.
7. Enkele ouderen geven aan gehoorproblemen te hebben, sommigen hebben hier aangepaste apparatuur voor. Ze geven aan niet veel last te hebben van omgevingsgeluid. De reclames van TV reclame zijn harder dan het gewone geluid. Harde tonen vallen vaak weg.
8. Extra opmerkingen die de geïnterviewden gaven:
 - Het is een goed idee als er een raam open gaat en er is een hor tegen insecten;
 - Vervangen van filters wordt op oudere leeftijd lastiger bij mechanische ventilatie, zeker als men gaat dementeren.

A.3.3. Face-to-face interview according to their perception of comfort;

Hoofdvraag: Wat is voor ouderen het belangrijkste aan de gevel met betrekking tot hun 'well-being'?

THEMA 0; ALGEMEEN/ INLEIDING

1. Wat is belangrijk in uw leven?
2. Waarvan wordt u blij van?
3. Welke activiteiten zijn belangrijk in uw leven?
Waar vinden deze activiteiten voornamelijk plaats?

THEMA 1; WAT/WAAR/WANNEER

1. Is er iets aan de indeling van uw woning veranderd (de afgelopen jaren)?
(bijvoorbeeld gebruiken ze de slaapkamer nu als hobby ruimte?)
2. Wanneer (welke delen van de dag) bent u in de woonkamer?
3. Welke plekken in de woonkamer zijn fijn? Waarom?
Hebben deze plekken specifieke karakteristieken?
4. Welke verschillende activiteiten doet u in de woonkamer?
Kunt u mij dit aanwijzen/ voordoen?
5. Wanneer bent u in de buurt van het raam?
Wat doet u daar?
6. Zijn er ook activiteiten/ dingen wanneer u liever niet in de buurt van het raam bent?
Hoe komt dat dan (te warm/ te koud)?

THEMA 2; SOORTEN ACTIVITEITEN

1. Welke activiteiten vindt u bijzonder fijn/ leuk om te doen in de woonkamer? Waarom?
2. Ondervindt u hinder bij het doen van bepaalde activiteiten in de woonkamer?
Welke activiteiten zijn dit?
Ondervindt u hinder bij schoonmaken of laat u dit doen?
3. Is dit altijd al zo geweest of is er iets veranderd de afgelopen tijd (jaar/ Jaren)?
4. Hoe droogt u de was? (buiten/ droger/ in de ruimte) Wat doet u om het vocht binnen op pijl te houden?

THEMA 3; INTERACTIE MET DE RAAMPARTIJ

1. Bij het doen van welke activiteiten maakt u gebruik van de gevel/ het raam?
Kunt u dit voordoen?
2. Welke handelingen verricht u om te zorgen dat u zich comfortabel voelt met betrekking tot de gevel in de woonkamer? Kunt u dit voordoen?
Wat is het verschil in deze handelingen voor comfort tussen zomer en winter?
3. Heeft u moeite (of juist geen moeite) bij bepaalde handelingen/interacties met betrekking tot de gevel?
4. Mist u iets aan uw gevel (wat u voorheen wel had in een vorige woning)?
5. Bij welke activiteiten opent u uw raam/ ramen?

THEMA 4; CONTACT MET DE OMGEVING

1. Observatie: is er een balkon/ buitenruimte? (in pandig/ uitpandig balkon?)
Wat staat er allemaal op het balkon?
2. Wat is uw uitzicht? Waar kijkt u graag naar?
3. Heeft u via uw gevel contact met de omgeving?
Kunt u dit laten zien?
Heeft u contact met de buren (sociaal contact) via het balkon?
4. Waar gebruikt u uw balkon/ buitenruimte voornamelijk voor?
Kunt u dit voordoen?

- Wanneer (welke dagdelen) gebruikt u uw balkon/ buitenruimte voornamelijk?
5. Heeft u een vensterbank? Waar gebruikt u deze voor?
 6. Houdt u planten (binnen/buiten)? Hoe verzorgt u deze?
Kunt u dit laten zien?
 7. Heeft u last van geluid van de omgeving (buren/ buiten/ ...)?
Is door bijvoorbeeld renovatie de geluidservaring veranderd?

THEMA 5; DAGLICHT

1. Observatie: staat er een stoel bij het raam? Hoe dichtbij?
2. Bij welke activiteiten zit u graag dichtbij het raam/ daglicht?
3. U gaf aan liever te lezen/ leven bij daglicht. Hoe dicht bij het raam zit u dan?
Kunt u dit laten zien?
4. Opent u uw raam/ramen ook vaak tijdens deze activiteiten?
5. Waarvoor gebruikt u uw gordijnen/ zonwering (warmte/ daglicht regulering/...)?

THEMA 6; GEBORGENHEID/ONDERHOUD/ VEILIGHEID

1. Voelt u uw veilig in huis?
Waarom niet/ wel?
2. Doet u 's avonds/ 's nachts uw gordijnen dicht?
3. Wat doet u als u langdurig weggaat (qua ventilatie en gordijnen)?
4. Op welke manier(en) onderhoudt u uw gevel (of laat u dit doen)?
Heeft u hier moeite mee?

1. MAGDA WOLTHOORN

Name	Magda Wolthoorn
Age	90 years
Gender	Female
Address	Emmapark 89, Pijnacker
Type of dwelling	Apartment, 1st floor
Living alone/ partner	Alone
Type of temperature control	Programmable thermostat

DAYLIGHT

She reads a lot and prefers to read with natural daylight. She needs (a lot) more light than she was used to. If necessary she uses an extra lightsource to read. She lives in an apartment with a balcony. The balustrade of the balcony is not transparent, but she is very happy with the solid balustrade. She cares about her privacy, but she sits at the balustrade a lot to look outside.

In summer she sits outside a lot (in the sun), but she also takes medicines to complete the amount of vitamin D.

VENTILATION

She is not sure if her indoor climate is healthy. She uses her mechanical ventilation system in the kitchen and bathroom, because there are no windows. She ventilates the rest of the rooms by opening windows, but she has no idea if she ventilates enough.

The window in her bedroom is almost always open, she only closes it when it is very cold. So the heating system can be working while the windows are open too.

Plants are very important to her. She was not aware of the contribution of plants to the health of the indoor climate, but she is very fond of plants.

NOISE

Her apartment is insulated very well, but she can still suffer from activities of the square in front of her dwelling, but she won't complain about it.

'DOUBLE HUNG' SYSTEM

She can't really imagine how the 'double hung' system would work. She thinks she will get cold feet by implementing this system.

An insect screen is desirable, but not if it blocks your whole view.

2. LIDA BERGENHENEGOUWEN

Name	Lida Bergenhenegouwen
Age	67 years
Gender	Female
Address	Van Houtenlaan 1, Pijnacker
Type of dwelling	Apartment, 1st floor
Living alone/ partner	Alone
Type of temperature control	Radiator with manual valves

DAYLIGHT

She prefers doing her daily activities in daylight rather than doing it in artificial light.

To take advantage of the light as much as possible she does her activities in front of the windows most.

She uses her balcony a lot when there is enough sunlight, but she also takes supplements to complete the amount of vitamin D that she needs.

VENTILATION

She has no idea of the health of her indoor climate. She would therefore be happy with a device that warns her when her indoor climate is not healthy.

She ventilates her kitchen and bedroom most. When she has to choose between her mechanical ventilation system or naturally ventilating her rooms, she prefers natural ventilation. Not only because natural ventilation feels better, but it also works better than her mechanical ventilation system.

She would like to implement a system in her house with a link between the action of opening a window and the elimination of the heating system and ventilation system.

NOISE

She doesn't have hearing disorders, so no recommendation on that.

'DOUBLE HUNG' SYSTEM

She is enthusiastic about the idea of the double hung system in combination with the balcony. She is also very excited about the implementation of an insect screen.

3. GUUS MAIBURG

Name	Guus Maiburg
Age	70 years
Gender	Male
Address	Ridderspoor 108, Nootdorp
Type of dwelling	Appartment, 2nd floor
Living alone/ partner	with partner
Type of temperature control	Manual thermostat

DAYLIGHT

He noticed that he needs more light than before. He prefers to sit in front of a window to catch light, not only because he prefers daylight but also because he prefers to have a view on the activities on the streets. In summer he spends a lot of time in the sun on his balcony. He also takes vitamin D supplements. He is very positive about the transparency of the balustrade of a balcony. He thinks contact with the ground and environment is very important for elderly.

VENTILATION

He is very much into technology and therefor knows a lot about the health of his indoor climate. He is also aware of the fact that most occupants have no idea of the health of their indoor climate. Therefore he supports the idea of implementing a system that warns occupants when their indoor climate is unhealthy. He also warns for the difficulties of mechanical ventilation. A lot of users have hardly no idea that they have to change the filters of the ventilation systems ones in a while. He thinks natural ventilation is better, much easier and much more effective.

He thinks linking the ventilation & heating system with the action of opening a window is a good idea. But it could cost less energy by instead of turning off the heating system, putting the temperature setting 5 degrees lower. Ofcourse this depends on the duration of having the window open.

NOISE

He has troubles hearing high tones and advertisements sound very loud to him.

'DOUBLE HUNG' SYSTEM

He is enthusiastic about the idea of the double hung system in combination with the balcony. The implementation of an insect screen is a plus.

An interview with Magda Wolthoorn



Figure A.26; Magda's frontdoor at the courtyard.

What are the most important things for you in your daily life now?

'The most important thing for me is contact with people. They always keep telling me that I am very autonomous, but please don't get help when it's not necessary. Assistance of technique is necessary, but please keep stimulating real human contact! I don't want to talk to a screen with robots!'

To keep up her contacts she uses also her mobile phone. Once her phone was broken, she got another mobile phone and she noticed that it was much harder for her to read from her cellphone screen while the screen and letters were bigger. She noticed that the colour contrast of the letters and the background was chosen wrong (brown letters and an orange background colour). So her old mobile phone with much smaller letters was easier for her to use.

You mentioned that reading gets harder for you. which actions do you undertake to make reading easier?

'I always sit in my chair at the win-

dow. But because reading gets harder, I am extra happy with my television. It is easier to read from the television than from a book. And next to that I am very happy with the service center in my neighbourhood (SWOP). This is a service center which organizes lectures, excursions, holidays, etc. for elderly. Last year I did an English course for example, but also a course about history of art and gymnastics with my walker.'

A year ago she broke her hip and thereby lost her balance a little bit more. Therefore she takes a walk with her walker twice a day. If it is very windy she prefers to stay inside because the wind can blow the walker from her hands. She is aware of the importance of moving, when she doesn't move enough she gets stiff.



Figure A.27; Magda and her walker that she only uses inside.

Name	Magda Wolthoorn
Age	90 years
Gender	Female
Address	Emmapark 89, Pijnacker
Type of dwelling	Apartment, 1st floor
Living alone/ partner	Alone
Type of temperature control	Programmable thermostat

So, you are very aware of your deteriorations. Did you change anything in your house to make your daily life more comfortable?

'The interior of my apartment didn't change a lot, I got a chair in the shower. The apartments are built life-proof; there are no thresholds, wide doors, enough space in the bathroom, etc.). Not a lot has changed so far.'

Magda spends a lot of her time in the living room. She prefers to sit in her chair in front of the television. The chair has the ability to rotate, so when she is reading she can rotate her chair to the window. She reads a lot of literature and magazines in her chair. In front of the chair she placed a bicycle seat, to keep up her moving.



Figure A.28; Magda's rotatable chair in front of the window

Magda's biggest struggles are the deterioration of her eyes, the functioning of her hands and the ability to walk and move.



Figure A.29; Magda shows how she uses her bicycle seat in front of her window.

Magda, you mentioned that you have some problems with the deterioration of your body. Which activities are harder for you due to these deteriorations?

'I struggle with reading as I mentioned, but thereby I am also not going outside anymore at night. Another example is a button I tried to sew to a jacket last week. Normally it costs me an hour, but because of the deterioration of my eyes and hands it cost me a whole day. Pressing buttons with my hands is also harder, regularly I think I press a button but in the end it seems that I didn't press hard enough (a doorbell for example). I also struggle with carrying objects, but I always try to think up smart solutions. I use my walker now to move my plants from inside to the balcony for example.'



Figure A.30; By turning a button, Magda can regulate the sunshading system. The button is easier than a press button she mentioned.

And after you broke your hip, did any activities become harder?

'Yes indeed some activities became harder. Next to the deteriorations that I already mentioned, I have problems with reaching. I cannot reach the upper shelf in my kitchen anymore. And with my age I don't want to climb a chair or something.'

Magda has a spot in front of one of her windows where she always uses her computer. She uses her computer a lot to look up things.



Figure A.31; Magda shows that she struggles with reaching, she cannot place the insectscreen on her own.

Magda, when you use your computer, do you ever have problems with overexposure or overheating?

'Yes I do, during the daytime I close the curtains to prevent overexposure. And in summer it can become very hot, then I use an extra ventilator to prevent overheating.'

'It is not that easy to refresh the air in my apartment, to do that I have to open my frontdoor and the door or windows at the balcony side. And if I do that, the doors and windows start to bang.'

You mentioned that it is harder for you to walk, how do you handle to for example clean your apartment?

'Weekly I have a helper who cleans my apartment. But there is one struggle; one of my windows cannot be opened and cannot be reached from the balcony. Thereby it is impossible to clean the window and we have no external party which cleans these windows.'



Oh, how do you handle with this then?

'I sometimes throw a bucket of water against the window. And once in a while they clean the windows of the building in front of my apartment and then I ask them to clean my single window too.'

And what do you do to dry your cloths?

'I dry them in my drycleaner or I hang them in the bathroom. I never hang them outside actually. My washing machine is also a drycleaner so that is very easy.'

Magda has an indoor balcony with a lot of plants, a table and chairs. The balcony faces the square with several shops.

Which actions do you undertake to feel comfortable according to the facade?

'In summer the door of the balcony is almost always open. In front of the opening I place an insects curtain. I cannot place the curtain myself anymore, because reaching became harder for me, but someone else does it for me. I am really happy with the amount of sunlight that reaches my facade, but when I sit at the balcony I always sit with my back to the sun because of the eyes disorders. I also have a sunscreen, or I use the curtains to block the sun. In winter I keep most windows closed and I still try to enjoy the sunlight inside.'

Do you have difficulties with certain actions according to the facade?

'The sunscreen is electric, so I do not have difficulties with that, but for example I cannot reach the top of the curtains anymore so I am not able to wash them myself.'

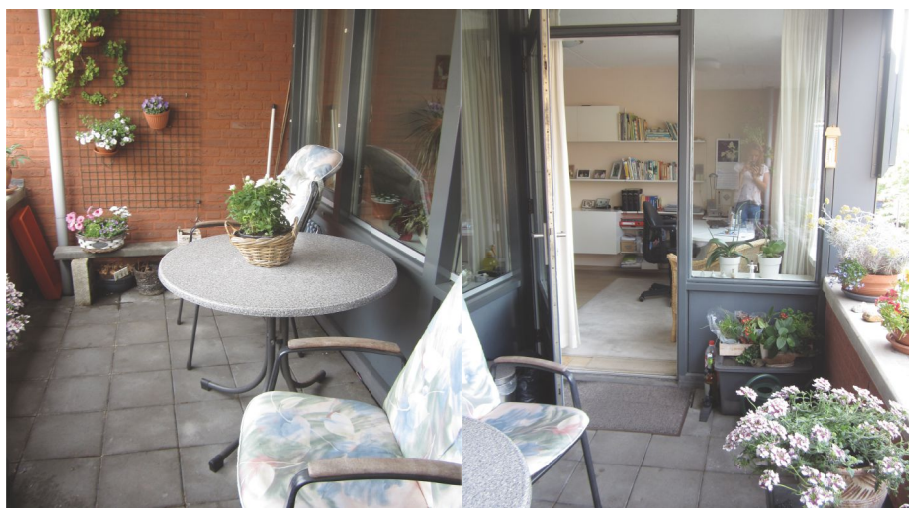


Figure A.32; The balcony (mainly used for her plants and a private spot to sit and have dinner).

I do not have difficulties with opening windows, I mostly use the door of the balcony to refresh the indoor air.'

Magda does not have social contact with neighbours through her balcony, because the balcony is indoor and she has a communal courtyard at her front door. The balcony functions as a private spot to her.

You mentioned that you use your balcony as a private spot. Where do you mainly use your balcony for?

'I mainly use it for my plants and to sit outside in summer. In summer I regularly eat outside. The balustrade is low enough to watch outside and still feel secluded.'

And during wintertime, do you move your plants inside?

'Some of them. I increased the width of my windowsills, because the windowsills were so small that I couldn't place plants on them and otherwise the plants wouldn't get enough daylight.'

The balcony is faced to the square. Do you ever suffer from noise caused by activities on the square?

'During concerts I sometimes suffer from noise, but within daily activities I don't. Heavy music is a problem with my indoor balcony, it sometimes sounds as a sound-box. The sound of the church clocks can also sound very loud.'

Do you feel safe inside?

'Yes I feel very safe, much safer than when my apartment would be connected to the groundfloor. There are security camera's at the entrance and in the elevator.'

And do you close your curtains at night and during holidays?

'I mainly use my curtains to protect against sunlight. During holidays I close the luxaflex and curtains partly, also to protect against sunlight.'



Figure A.33; Magda closing the luxaflex sunshade.

An interview with Guus Maiburg



Figure x; Guus' building entrance.

What are the most important things for you in your daily life now?

'Contact is the most important thing in life to me, to make sure that we are not feeling lonely. We have to make sure that people stay in touch, especially elderly loose a lot of nearby people while they get older. Liaising contacts is therefor very important.'

'At the moment I am working on a project about loneliness. I am trying to represent loneliness with a lot of pictures in a book.'

Guus and his wife are still in good health. They do a lot of voluntary work and try to help elderly to keep in touch with others.

Guus and his wife renovated their home to an elderly proof home before moving into it.

Where are your decisions based on while renovating your apartment?

'It is important to consider where to situate the lounge area. It depends on the tv collector, the fire place, etc. Not everything is wireless in every home.'

'We placed our lounge area near several windows. Not only to ob-

tain more daylight while reading, but moreover to have the best outside view, a connection with the environment. Therefor transparency is very important, the balustrade should be transparent too.'

Which difficulties do you face with doing activities close to a window?

'It is always complicated to watch TV near a window, because of overexposure and reflectivity. Besides that we are very happy with our insectscreen. It works very easy and provides a lot of comfort.

Against overexposure we have a sunscreen. The sunscreen doesn't block all the light, it still provides direct daylight.'

Which actions do you undertake to feel comfortable according to the facade?

'During the wintertime we close the curtains early. We have too layers of curtains: one against cold and draft, a second one to provide privacy (this one is more transparent).

And if you are on holidays, do you open or close the curtains?

'We keep our curtains open. If they want to know if we are at

Name	Guus Maiburg
Age	70 years
Gender	Male
Address	Ridderspoor 108, Nootdorp
Type of dwelling	Apartment, 2nd floor
Living alone/ partner	with partner
Type of temperature control	Manual thermostat



Figure A.34; Insect screen of Guus' home



Figure A.35; Insect screen of Guus' home

home they will find out in the end. If we are on holidays we close our doors with a 3-lock. If we are at home we close the curtains during the night.'

Guus and his wife have a large balcony. It is an indoor balcony, so they don't have contact with their neighbours through their balcony which they like. They added extra glass panels on the balustrade to block the wind. As the pictures show, they took in to account how they were able to clean these windows.

Your balcony is quite big, where do you use it mainly for?

'We mainly use our balcony to have dinner and to relax. Besides that we sometimes use it to dry our laundry in summer.'

If we get back to the facade, what is the difference between the actions you undertake during summer and winter?

'It really depends on the outside temperature. If the temperature is very low we close the curtains and the ventilation system. The filters of the ventilation have to be replaced every now and then, most people don't know how or when to do that. We do it yearly, a fixed schedule to replace these filters works best for us.'

'Elderly die by feeling too cold, but also by feeling too hot. Wrong use of the airconditioning has a bad influence on the health of elderly. The temperature difference between in and outside should have a maximum of 5 degrees.'

And how do you handle the maintenance of your facade?

'We have to clean the windows by ourselves, but water battles on the facade are cleaned by a company. Every 2 years, the gutter is



Figure A.36; windows on Guus' balcony



Figure A.37; sliding windows on Guus' balcony

checked, the facade is repainted, etc.'

Some of the windows of the apartment are featured with ventilation grids.

Do you often use the ventilation grids?

'No, they don't work really well. To open them, you have to rotate a stick. It is hard to rotate the stick and the grid doesn't ventilate really well. Therefore we do not often use the system, we prefer to open a whole window or door and use the insect screen.



Figure A.38; ventilation grid, from inside



Figure A.39; ventilation grid, from outside

You have special curtains in front of your windows I see. What is the function of them?

'These are double layered curtains with an aluminium film layer inbetween. So they protect against the cold, but also against the heat.'



Figure A.40; double layered curtains

Are there any other things you want to add to this interview?

'It is really important to make sure users can clean their windows. The most modern glass panels should be used for energy efficiency (better insulation and sunprotected). It is very important to make sure that the windows can be cleaned. Not only to have a better view, but also to make sure the window doesn't loose it's strength. If windows aren't regularly cleaned, it looses it's film layer.'

An interview with Lida Bergenhenegouwen



Figure A.41; Lida's apartment

What are the most important things for you in your daily life now?

'The most important things for me are to stay healthy, keep seeing my children and grandchildren (3 children and 7 grandchildren), to keep going on cultural trips and to keep reading.'

Lida lives alone in her apartment. Not a lot has changed in the apartment since she lives there. She spends most of her time in the kitchen and living room near the windows.

You spend a lot of time in the living room near your window. Do you ever face trouble with overexposure while you're watching TV?

'Yes, during the daytime I have to turn the TV or close the curtains to watch TV.'

Are there any other problems you face according to your facade?

'Yes, I can only open a small upper part of the window, that makes ventilating very hard for me. And I can only reach these windows

by climbing a chair.

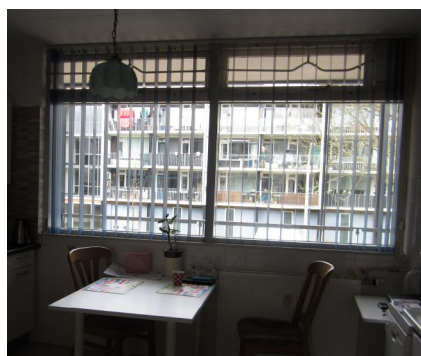


Figure A.42; windows in Lida's house

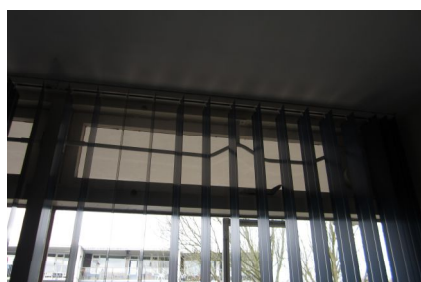


Figure A.43; burglary protection windows

The rod in front of these small windows is to protect against burglary.

Do you have any other burglary protection in your home?

'Yes, my front and backdoor are provided with extra locks (3 locks per door) but I only use these when I am on holidays. During the night I use an extra clamp.

Name	Lida Bergenhenegouwen
Age	67 years
Gender	Female
Address	Van Houtenlaan 1, Pijnacker
Type of dwelling	Apartment, 1st floor
Living alone/ partner	Alone
Type of temperature control	Radiator with manual valves

If I go to bed, I close the lamellae and the curtains in my bedroom. I also close the lamellae in my living room, but I keep the curtains opened.'

What do you do to feel comfortable in summer and winter?

'In the wintertime I put on the heater and I use blankets when I am a little bit cold. In the summertime I open the windows and my balcony door in my bedroom.'

A few years ago they started renovating the apartments in her block. She suffered a lot from the renovation work, there were many problems. She got a new balcony, but the workers constructed it wrong so she couldn't open her balcony door anymore.



Figure A.44; balcony after renovation

Is the renovation of the balcony an improvement?

'Yes, they made the balcony bigger so that is really an improvement. And the noise disturbance has also become less. But there are still a few struggles I face.

At one side of the balcony they placed a transparent glass panel against the wind. I am not able to clean the panel myself, so it hasn't been cleaned ever since. Therefore I pasted an adhesive film on the glass panel, but my view thereby disappeared.

The glass panel is also not fully connected to the wall, this causes a cold airflow, which is also a disadvantage. I solved it by adding an extra strip to overcome the airflow.'



Figure A.45; balcony after renovation, glass panel

Do you often use your balcony?

'Yes, I use my balcony a lot; to dry clothes, to have dinner, to watch my grandchildren playing downstairs, to keep plants.'

And your balustrade is quite transparent, are you happy with that?

'Yes, I wouldn't want a massive balustrade. In this way I can easily watch the grandchildren playing, even if I sit inside. And via the balcony I keep in touch with other people outside.'

Are there any other things you want to add to this interview?

'Yes, I would like to show you how I open my window in my bedroom. I made a stick with a rod on top to open and close the window. It is still hard, but in this way I don't have to climb a chair all the time. I get older now, so in this way I don't fall of the chair.'



Figure A.46; stick to open the window



Figure A.47; stick to open the window

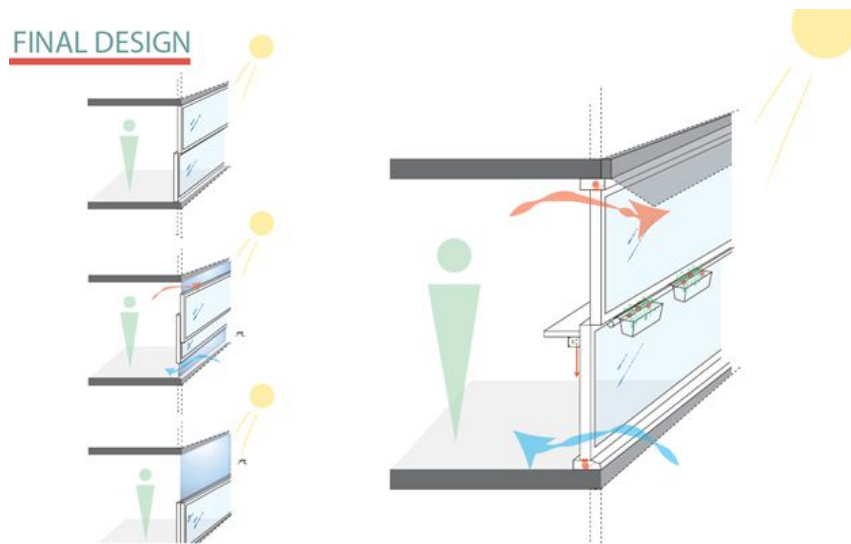
A.3.4. Interview by email according to second design concepts (evaluation)

Beste deelnemer aan mijn onderzoek,

Afgelopen half jaar heb ik verschillende interviews bij u afgenomen met betrekking tot energie efficientie en comfort van de gevel en het balkon (en het gebruik hiervan).

Komende jaren worden er van veel portiek woningen gevels gerenoveerd, hierbij wordt getracht zo veel mogelijk aan te sluiten op de behoeftes van de bewoners, maar ook te zorgen dat bewoners hun gevel en energie efficiënt gebruiken.

Bij een eerdere evaluatie liet ik enkele ontwerpen zien en heb ik hier uw commentaar op gevraagd. (zie hieronder, dit is dus een oud ontwerp)



Uiteindelijk kwam bij het tweede interview naar voren dat een vaste buitenruimte wel een van de grootste vereisten is. Ook kwamen uit het tweede interview andere belangrijke comfort vereisten naar voren:

- Natuurlijke ventilatie wordt fijner ervaren als mechanische ventilatie
- Wanneer een raam open staat is het fijn als er een insectenscherm dichtgemaakt kan worden
- Een vaste buitenruimte is belangrijk, maar men moet wel windvrij kunnen zitten
- Daglicht/ zon moet reguleerbaar zijn
- Planten houden moet binnen en buiten mogelijk zijn
- Gordijnen moeten dichtgemaakt kunnen worden met betrekking tot privacy, maar ook met betrekking tot hitte/kou
- Een vensterbank binnen voor planten en andere spullen wordt ook belangrijk geacht.
- Alle handelingen moeten bereikbaar zijn, reiken naar hoge handelingen moeten vermeden worden
- De gevel moet zo transparant mogelijk zijn (ook de balustrade), zodat je vanuit je stoel binnen ook naar buiten kan kijken
- Ramen moeten bereikbaar zijn om ze te kunnen wassen.

Vanuit deze uitgangspunten en eerdere uitgangspunten uit mijn onderzoek ben ik ontwerpen gaan maken. Deze ontwerpen zijn qua maatgeving toegepast op de maatgeving van een referentie portiekflat in Rotterdam.

De eerste 2 concepten zijn gericht op het kleinste (uitpandig) balkon (1,85m bij 1,00m vloeroppervlak).

CONCEPT 1

Bij dit eerste concept schuiven de deuren open naar 1 kant. Hierbij kan de deur gebruikt worden als windscherm. De grote opening die hiermee gecreeerd wordt kan door middel van een insectenscherm afgesloten worden. De balustrade is van glas en daardoor volledig transparant. De 2 grote deuren zijn voor-

zien van zonwering die vanaf boven en vanaf beneden gedicht kan worden en zo op de hoogte gezet kan worden die fijn is voor degene die binnen zit.

CONCEPT 1



CONCEPT 2

Bij het tweede concept kan de deur opengezet worden als windscherm, maar ook het raam kan aangesloten worden op het balkon en daardoor als windscherm werken. Voor de rest heeft dit concept dezelfde specificaties als concept 1.

CONCEPT 2



De rest van de concepten zijn gericht op het grootste (uitpandig) balkon (1,63m bij 1,00m vloeroppervlak). (niet alle concepten zijn toegevoegd, ik heb er een paar gekozen, dus de nummering zal niet helemaal kloppen)

CONCEPT 4

Bij dit concept bestaat de gevel uit 3 delen, 2 deuren en 1 raam. De deuren kunnen allebei naar buiten opengeklapt worden en werken daardoor als windschermen. Het middelste raam kan als klappraam naar buiten gebruikt worden of als raam naar de zijkant scharnierend. Het balkon is transparant (glas). De ramen kunnen eveneens als in de vorige concepten voorzien worden van zonwering aan de binnenkant.

CONCEPT 4



CONCEPT 5

Bij dit concept bestaat de gevel uit 3 delen, 2 ramen en 1 deur. De deur en de ramen kunnen naar buiten opengeklapt worden en werken daardoor als windschermen, de ramen sluiten precies aan op het balkon. Het balkon is transparant (glas). De ramen kunnen eveneens als in de vorige concepten voorzien worden van zonwering aan de binnenkant.

CONCEPT 5



CONCEPT 7

Bij dit concept bestaat de gevel uit 4 delen, 2 deuren 1 groot raam en een klampaam bovenin. De deuren en het raam kunnen naar buiten opengeklapt worden en werken daardoor als windschermen, het raam sluit precies aan op het balkon. Het balkon is transparant (glas). De ramen kunnen eveneens als in de vorige concepten voorzien worden van zonwering aan de binnenkant. Het klampaam bovenin kan gebruikt worden voor ventilatie wanneer het regent of in de winter.

CONCEPT 7



CONCEPT 9

Bij dit concept bestaat de gevel uit 4 delen, 1 deur, 2 grote schuiframen die gebruikt kunnen worden zoals te zien is op de foto's en 1 klampaam. De deur kan naar buiten opengeklapt worden en werkt daardoor als windscherm. Het balkon is transparant (glas). De ramen kunnen eveneens als in de vorige concepten voorzien worden van zonwering aan de binnenkant. Het klampaam bovenin kan gebruikt worden voor ventilatie wanneer het regent of in de winter.

Het voordeel van het raamsysteem met schuiven is zoals in het oude ontwerp de manier om snel te ventileren (beneden komt verse lucht naar binnen, boven gaat warme lucht naar buiten).

CONCEPT 9



Hierbij de vraag of u even de tijd wil nemen naar de 6 verschillende concepten te kijken en hier eventueel positief en negatief commentaar op te geven.

Alvast bedankt!

FEEDBACK DEELNEMERS

COMMENTAAR GUUS MAIBURG

- hoe simpel is de bediening voor ouderen (handmatig of ook elektrisch)
- bij renovatie gaat het ook om kosten. C(hoe meer elementen hoe meer kosten?)
- wat zijn de onderhoudsaspecten. (bv. smeren draaipunten)
- houd altijd rekening met de zijde waar het balkon komt (op het zuiden)

Al met al mijn compliment wat je er uiteindelijk van gemaakt hebt.

COMMENTAAR LIDA BERGENHENEGOUWEN

je bent er druk mee geweest en het ziet er allemaal goed uit.

ik heb het vanuit mijn standpunt als volgt beoordeeld:

uitgegaan van een makkelijke doorgang, b.v. blad met kopjes , stoelen en evt. rollator of rolstoel.
ook het gebruik van de deuren als windscherm is een goed idee.

1, is goed, brede doorgang .

2, is beter omdat het raam apart open kan en toch n brede doorgang.

4, vind ik niet handig door de 2 smalle doorgangen

5, groter balkon dus meer mogelijkheden brede doorgang is prima.

7, ideaal omdat het raam ook apart open kan en brede doorgang

9, vind ik niet zo praktisch door smalle doorgang.

kortom

voor het kleine balkon kies ik voor optie 2

voor het grotere balkon ga ik voor optie 7

als je nog iets wil weten hoor ik het wel, succes met de afronding!

COMMENTAAR MAGDA WOLTHOORN

Het ziet er heel goed uit, ik ben benieuwd naar de verdere uitwerking!

Het enige waar ik nog echt mee zit is de transparante balustrade. Zou het niet mogelijk zijn om de balustrade boven 50 cm transparant te laten zijn en daaronder niet transparant?

A.4. ORIENTATION ANALYSES, ROTTERDAM

A.4.1. Windroses Rotterdam 2014-2015

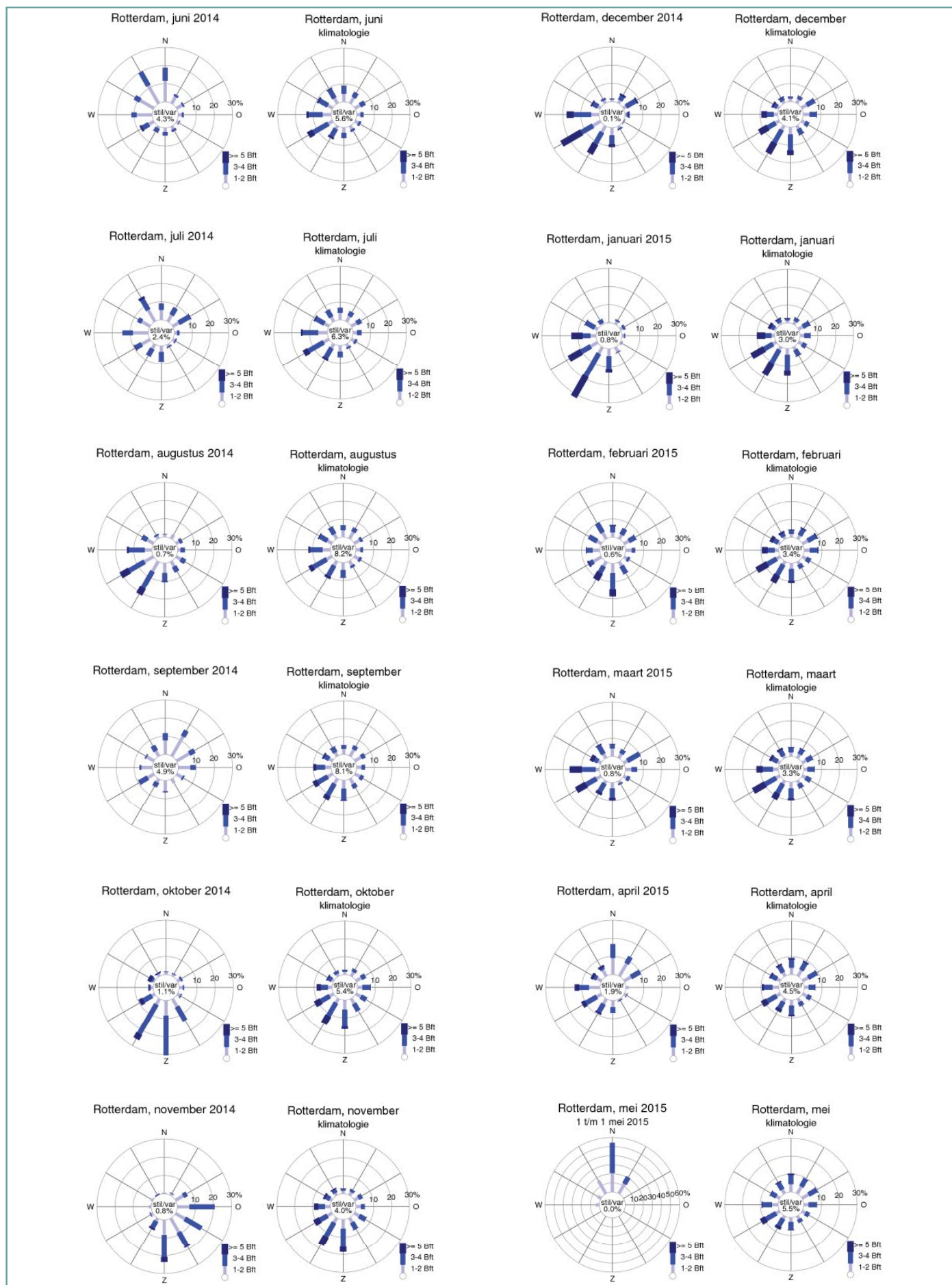


Figure A.48; Windroses Rotterdam

A.4.2. Dialux daylight study, Rotterdam

To examine the height and width of the transparent facade elements, several Dialux (daylight) studies were done. The two facades (figure A.49 and A.50) were imported in the Dialux program to find out more about the amount of lux that enters the different rooms. Two of these outcomes are shown on the next two pages.

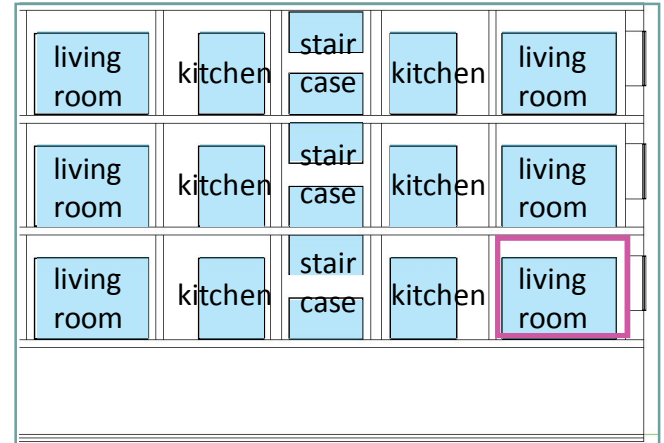


Figure A.49; Elevation North side Rotterdam porch apartments, windows in blue colour (own illustration)

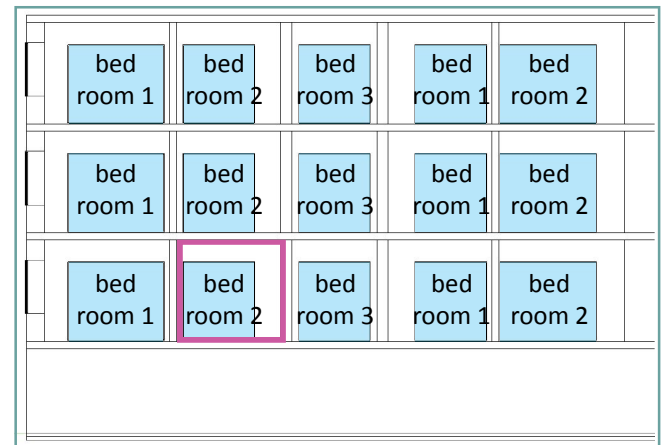


Figure A.50; Elevation South side Rotterdam porch apartments, windows in blue colour (own illustration)

-	JAN	FEB	MRT	APR	MEI	JUN	JUL	AUG	SEP	OKT	NOV	DEC
1	08:47 - 16:39	08:19 - 17:27	07:25 - 18:19	07:14 - 20:13	06:09 - 21:04	05:25 - 21:50	05:24 - 22:03	06:02 - 21:30	06:52 - 20:27	07:41 - 19:18	07:35 - 17:11	08:25 - 16:32
2	08:47 - 16:40	08:17 - 17:29	07:22 - 18:21	07:11 - 20:15	06:07 - 21:06	05:24 - 21:51	05:25 - 22:02	06:03 - 21:28	06:53 - 20:25	07:42 - 19:15	07:36 - 17:10	08:27 - 16:31
3	08:47 - 16:41	08:16 - 17:31	07:20 - 18:23	07:09 - 20:16	06:05 - 21:07	05:24 - 21:52	05:25 - 22:02	06:05 - 21:27	06:55 - 20:23	07:44 - 19:13	07:38 - 17:08	08:28 - 16:31
4	08:47 - 16:42	08:14 - 17:33	07:18 - 18:24	07:07 - 20:18	06:04 - 21:09	05:23 - 21:53	05:26 - 22:02	06:06 - 21:25	06:56 - 20:21	07:46 - 19:11	07:40 - 17:06	08:29 - 16:30
5	08:46 - 16:44	08:12 - 17:35	07:16 - 18:26	07:05 - 20:20	06:02 - 21:11	05:22 - 21:54	05:27 - 22:01	06:08 - 21:23	06:58 - 20:18	07:47 - 19:08	07:42 - 17:04	08:31 - 16:30
6	08:46 - 16:45	08:11 - 17:37	07:13 - 18:28	07:02 - 20:22	06:00 - 21:12	05:22 - 21:55	05:28 - 22:01	06:09 - 21:21	07:00 - 20:16	07:49 - 19:06	07:44 - 17:03	08:32 - 16:29
7	08:46 - 16:46	08:09 - 17:38	07:11 - 18:30	07:00 - 20:23	05:58 - 21:14	05:21 - 21:56	05:29 - 22:00	06:11 - 21:19	07:01 - 20:14	07:51 - 19:04	07:45 - 17:01	08:33 - 16:29
8	08:45 - 16:47	08:07 - 17:40	07:09 - 18:32	06:58 - 20:25	05:56 - 21:16	05:21 - 21:56	05:30 - 21:59	06:13 - 21:18	07:03 - 20:11	07:52 - 19:02	07:47 - 16:59	08:34 - 16:29
9	08:45 - 16:49	08:05 - 17:42	07:07 - 18:33	06:55 - 20:27	05:55 - 21:17	05:20 - 21:57	05:31 - 21:59	06:14 - 21:16	07:05 - 20:09	07:54 - 18:59	07:49 - 16:58	08:35 - 16:28
10	08:44 - 16:50	08:03 - 17:44	07:04 - 18:35	06:53 - 20:28	05:53 - 21:19	05:20 - 21:58	05:32 - 21:58	06:16 - 21:14	07:06 - 20:07	07:56 - 18:57	07:51 - 16:56	08:36 - 16:28
11	08:43 - 16:52	08:02 - 17:46	07:02 - 18:37	06:51 - 20:30	05:51 - 21:20	05:20 - 21:59	05:33 - 21:57	06:17 - 21:12	07:08 - 20:04	07:58 - 18:55	07:53 - 16:54	08:38 - 16:28
12	08:43 - 16:53	08:00 - 17:48	07:00 - 18:39	06:49 - 20:32	05:50 - 21:22	05:19 - 21:59	05:34 - 21:56	06:19 - 21:10	07:09 - 20:02	07:59 - 18:53	07:54 - 16:53	08:39 - 16:28
13	08:42 - 16:55	07:58 - 17:50	06:58 - 18:40	06:47 - 20:33	05:48 - 21:24	05:19 - 22:00	05:35 - 21:55	06:21 - 21:08	07:11 - 20:00	08:01 - 18:50	07:56 - 16:51	08:39 - 16:28
14	08:41 - 16:56	07:56 - 17:52	06:55 - 18:42	06:44 - 20:35	05:47 - 21:25	05:19 - 22:01	05:37 - 21:54	06:22 - 21:06	07:13 - 19:57	08:03 - 18:48	07:58 - 16:50	08:40 - 16:28
15	08:40 - 16:58	07:54 - 17:53	06:53 - 18:44	06:42 - 20:37	05:45 - 21:27	05:19 - 22:01	05:38 - 21:53	06:24 - 21:04	07:14 - 19:55	08:04 - 18:46	08:00 - 16:49	08:41 - 16:28
16	08:39 - 16:59	07:52 - 17:55	06:51 - 18:46	06:40 - 20:39	05:44 - 21:28	05:19 - 22:02	05:39 - 21:52	06:26 - 21:02	07:16 - 19:53	08:06 - 18:44	08:01 - 16:47	08:42 - 16:28
17	08:38 - 17:01	07:50 - 17:57	06:48 - 18:47	06:38 - 20:40	05:42 - 21:30	05:19 - 22:02	05:40 - 21:51	06:27 - 21:00	07:18 - 19:50	08:08 - 18:42	08:03 - 16:46	08:43 - 16:29
18	08:37 - 17:03	07:48 - 17:59	06:46 - 18:49	06:36 - 20:42	05:41 - 21:31	05:19 - 22:03	05:42 - 21:50	06:29 - 20:58	07:19 - 19:48	08:10 - 18:40	08:05 - 16:45	08:43 - 16:29
19	08:36 - 17:04	07:46 - 18:01	06:44 - 18:51	06:33 - 20:44	05:39 - 21:33	05:19 - 22:03	05:43 - 21:49	06:30 - 20:56	07:21 - 19:46	08:11 - 18:37	08:06 - 16:43	08:44 - 16:29
20	08:35 - 17:06	07:44 - 18:03	06:41 - 18:52	06:31 - 20:45	05:38 - 21:34	05:19 - 22:03	05:44 - 21:48	06:32 - 20:54	07:23 - 19:43	08:13 - 18:35	08:08 - 16:42	08:45 - 16:30
21	08:34 - 17:08	07:42 - 18:04	06:39 - 18:54	06:29 - 20:47	05:37 - 21:36	05:19 - 22:03	05:46 - 21:46	06:34 - 20:52	07:24 - 19:41	08:15 - 18:33	08:10 - 16:41	08:45 - 16:30
22	08:33 - 17:09	07:40 - 18:06	06:37 - 18:56	06:27 - 20:49	05:35 - 21:37	05:19 - 22:04	05:47 - 21:45	06:35 - 20:49	07:26 - 19:39	08:17 - 18:31	08:11 - 16:40	08:46 - 16:31
23	08:32 - 17:11	07:38 - 18:08	06:34 - 18:58	06:25 - 20:51	05:34 - 21:38	05:20 - 22:04	05:48 - 21:44	06:37 - 20:47	07:27 - 19:36	08:19 - 18:29	08:13 - 16:39	08:46 - 16:31
24	08:30 - 17:13	07:35 - 18:10	06:32 - 18:59	06:23 - 20:52	05:33 - 21:40	05:20 - 22:04	05:50 - 21:42	06:39 - 20:45	07:29 - 19:34	08:20 - 18:27	08:15 - 16:38	08:47 - 16:32
25	08:29 - 17:15	07:33 - 18:12	06:30 - 19:01	06:21 - 20:54	05:32 - 21:41	05:21 - 22:04	05:51 - 21:41	06:40 - 20:43	07:31 - 19:32	07:22 - 17:25	08:16 - 16:37	08:47 - 16:32
26	08:28 - 17:16	07:31 - 18:14	06:27 - 19:03	06:19 - 20:56	05:31 - 21:42	05:21 - 22:04	05:53 - 21:39	06:42 - 20:41	07:32 - 19:29	07:24 - 17:23	08:18 - 16:36	08:47 - 16:33
27	08:26 - 17:18	07:29 - 18:15	06:25 - 19:05	06:17 - 20:57	05:30 - 21:44	05:22 - 22:04	05:54 - 21:38	06:43 - 20:39	07:34 - 19:27	07:26 - 17:21	08:19 - 16:35	08:47 - 16:34
28	08:25 - 17:20	07:27 - 18:17	06:23 - 19:06	06:15 - 20:59	05:29 - 21:45	05:22 - 22:04	05:56 - 21:36	06:45 - 20:36	07:36 - 19:25	07:28 - 17:19	08:21 - 16:34	08:47 - 16:35
29	08:23 - 17:22		07:21 - 20:08	06:13 - 21:01	05:28 - 21:46	05:23 - 22:03	05:57 - 21:35	06:47 - 20:34	07:37 - 19:22	07:29 - 17:17	08:22 - 16:33	08:48 - 16:36
30	08:22 - 17:24		07:18 - 20:10	06:11 - 21:02	05:27 - 21:47	05:23 - 22:03	05:59 - 21:33	06:48 - 20:32	07:39 - 19:20	07:31 - 17:15	08:24 - 16:33	08:48 - 16:37
31	08:20 - 17:25		07:16 - 20:11		05:26 - 21:49		06:00 - 21:32	06:50 - 20:30		07:33 - 17:13		08:48 - 16:38

Figure A.51; Sunrise and sunset table

LIVING ROOM

First floor

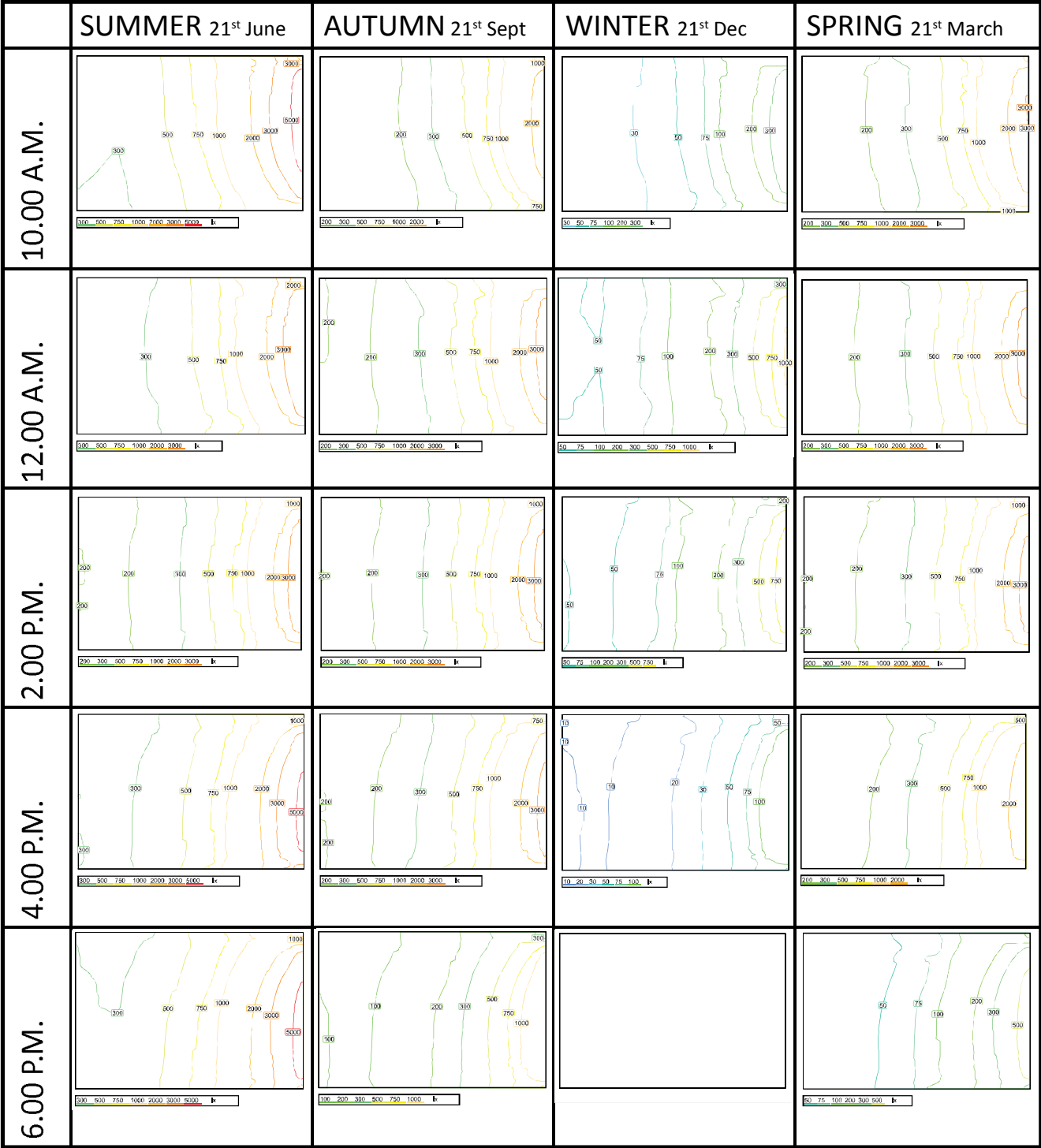
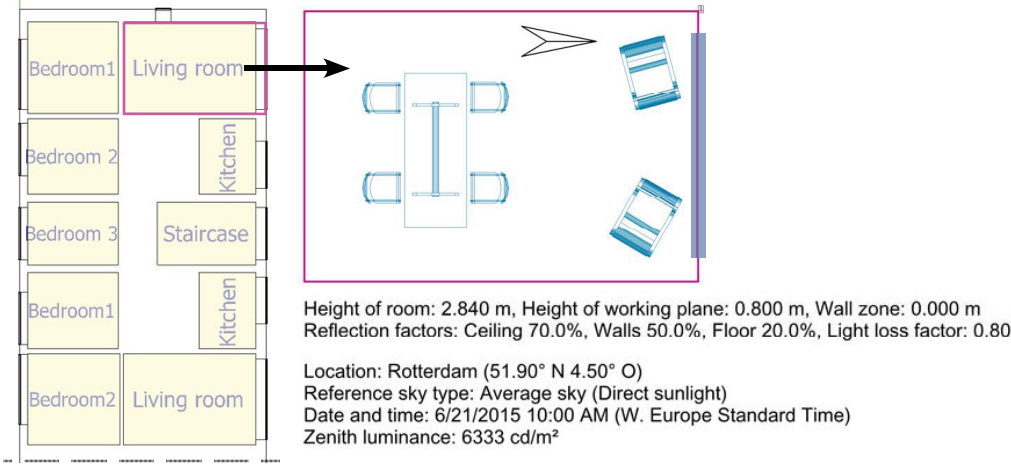


Figure A.52; Dialux outcome Living room

BEDROOM

First floor

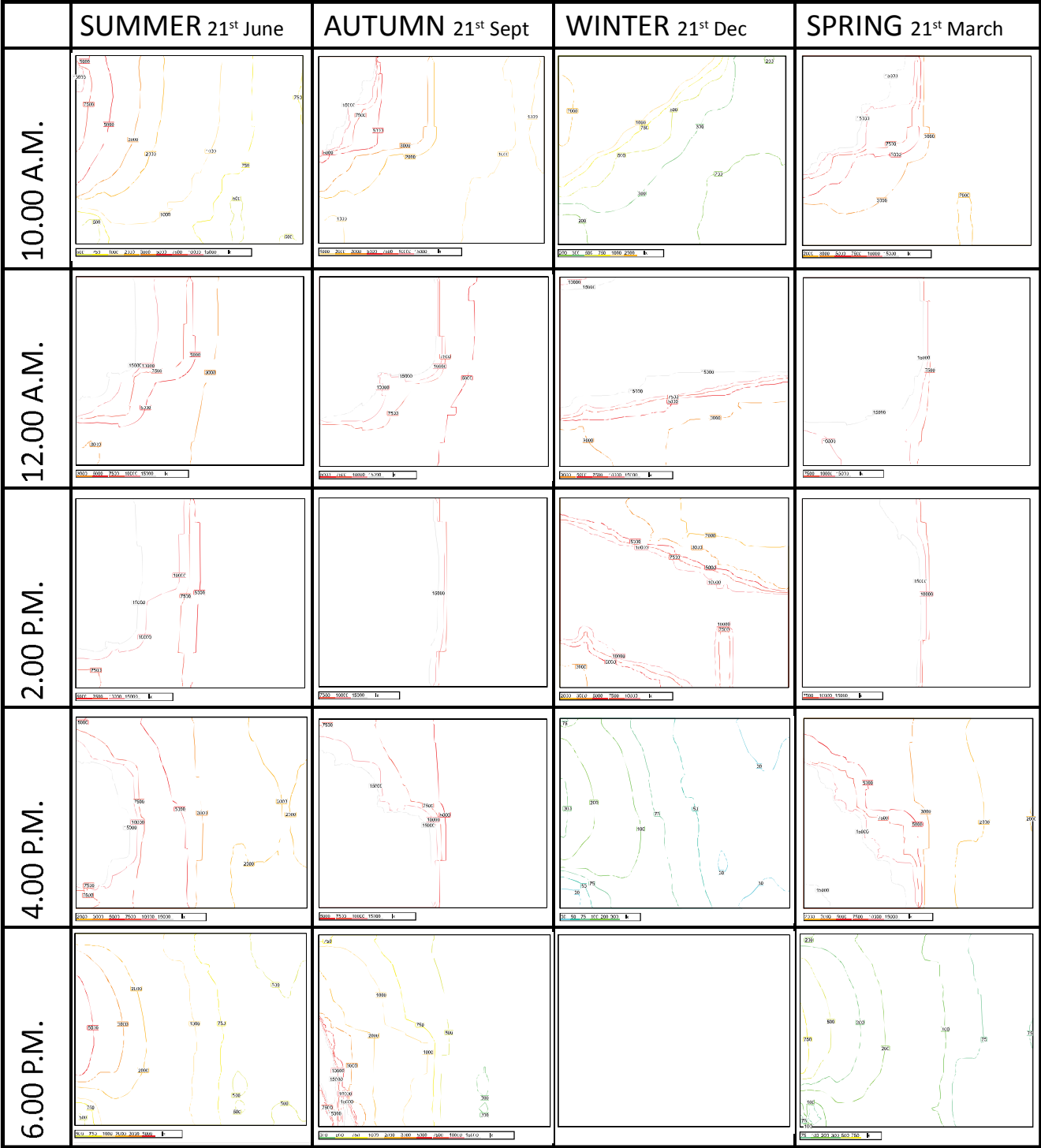
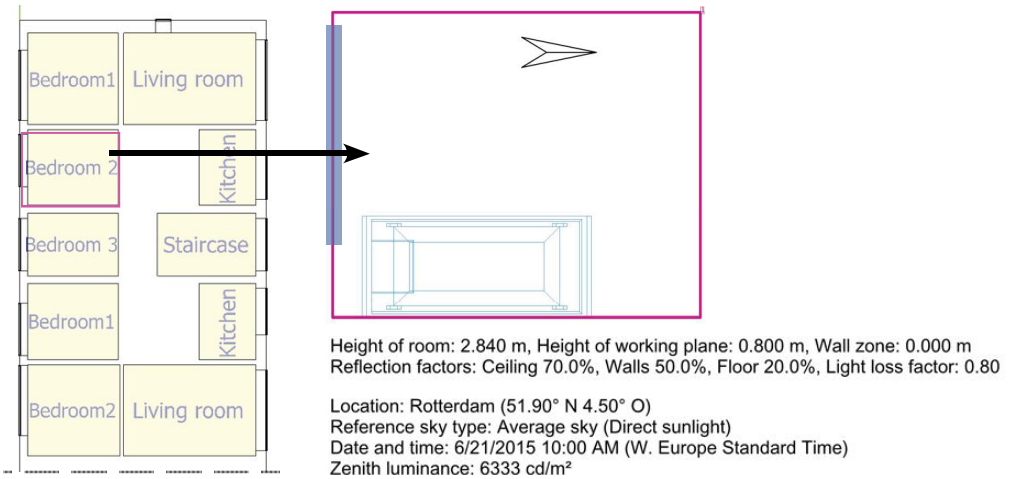


Figure A.53; Dialux outcome Bedroom

A.5. CONCEPT IDEAS (after interviews A.3.1. and A.3.2.)

In the phase of my first P4 presentation I made several designs according to the research and interview outcomes. In the end this 'final' design isn't further developed in detail, but it still seems clarifying to show the steps I made between my first P4 and my second P4 presentation.

The first paragraph will give an overview of different concepts which are made for the facade of the living room of the porch apartments in Rotterdam. These design concepts mainly focus on the operation of the facade and how to ventilate naturally. Paragraph 2 will explain which concept will be developed in detail.

A.5.1 THE DIFFERENT CONCEPT IDEAS

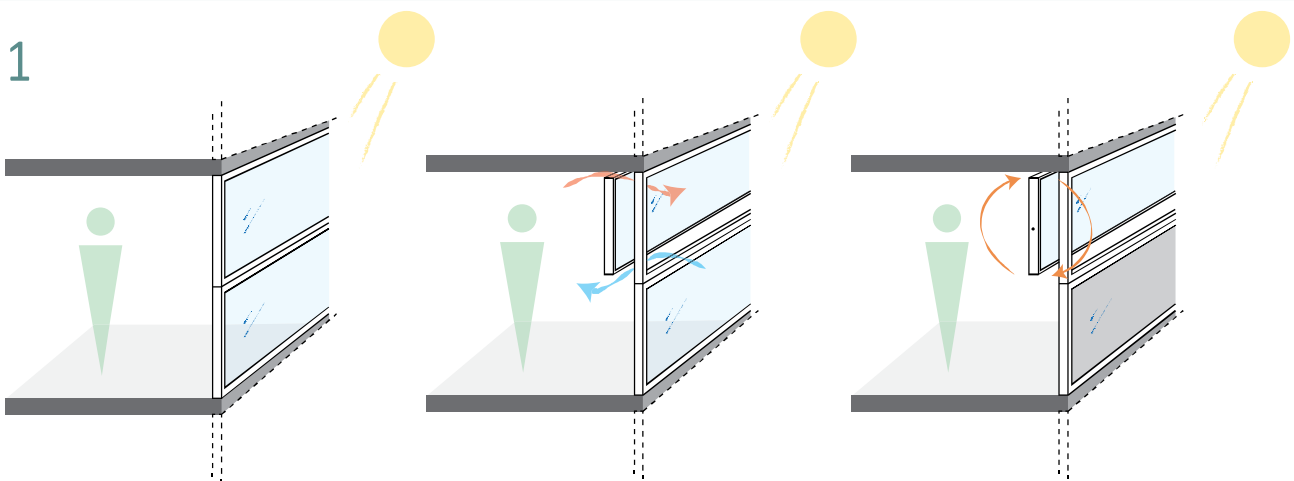
This paragraph presents 8 design concepts in which several design requirements are translated into a design. Each design concept will be explained by drawings and text.

In the design concept I did not focus on all design requirements. For example I did not focus on the implementation of a sunshading, while this is still an important design requirement. For this requirement I would use an existing system that can easily be implemented in the design concepts.

Another example is the possibility to hold plants. Most of the design requirements have movable windows on which planters can't be attached. Therefore the easiest solution is to attach a rod to the solid facade on which the planters can be attached.

From the visualization on the previous page it is quite clear which design requirements are strict and which can be translated into other designs.

1



DESIGNCONCEPT 1

In this design concept the facade is horizontally divided in two windows. The transparency of the facade is maximal.

Both of the windows can be displaced (parallel) to the inside. In this way a natural ventilation flow occurs (as the second visualisation shows).

Secondly these windows can be turned. By turning the windows the transparency of the facade changes to a non-transparent facade (as the third visualisation shows).

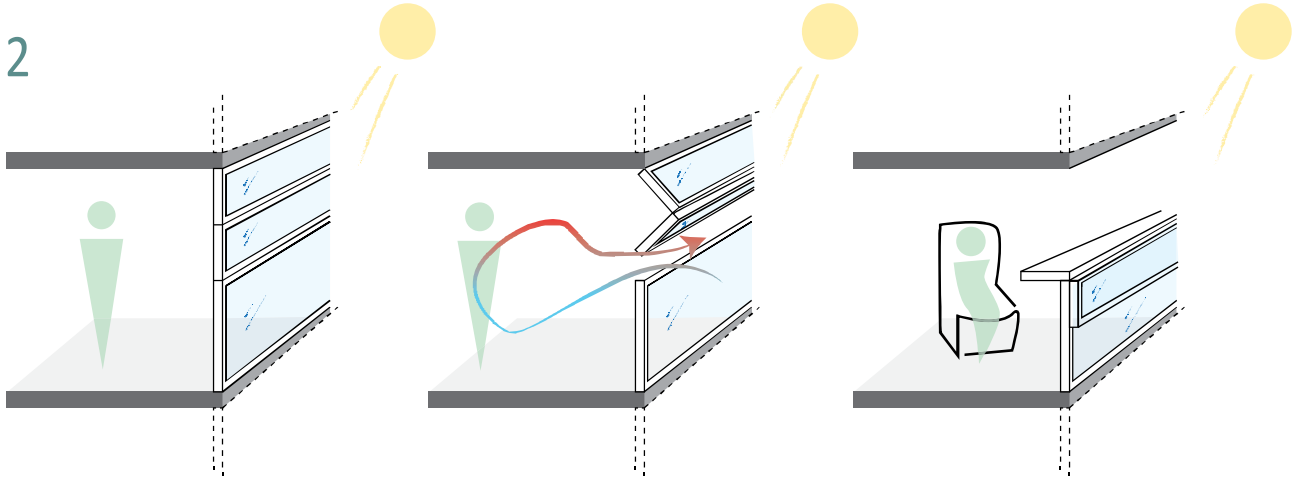
ADVANTAGES

- Natural ventilation
- Maximal transparency
- Secure feeling at night/ transparent balustrade
- Connection environment

DISADVANTAGES

- No possible to open large part of the facade
- No stimulant to generate vitamin D
- No insect protection

2



DESIGNCONCEPT 2

In this design concept the facade is horizontally divided in three windows. The transparency of the facade is maximal.

The two smaller smaller windows can move, while the bigger bottom window can't. The smaller windows can slide to stimulate natural ventilation.

Secondly these windows can be turned into a windowsill. In this way the occupants are also stimulated to sit in the sun (generation of vitamin D).

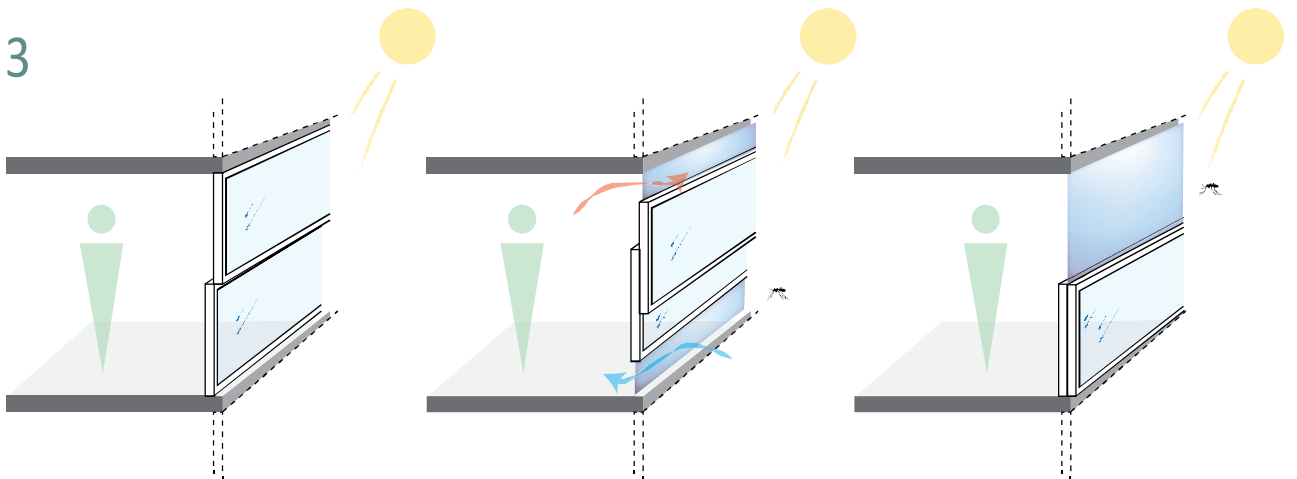
ADVANTAGES

- Natural ventilation
- Maximal transparency
- Transparent balustrade
- Connection environment
- Possibility to open large part of the facade
- Stimulant to generate vitamin D
- Windowsill

DISADVANTAGES

- No secure feeling at night
- No insect protection

3



DESIGNCONCEPT 3

In this design concept the facade is horizontally divided in two windows. The transparency of the facade is maximal.

The system works as a 'double hung' system. When the windows slide, automatically an insect screen occurs to protect occupants from insects entering the room. The insect screens can be detached manually.

Secondly these windows can be turned into a balcony. Both of the windows are slided down in this situation.

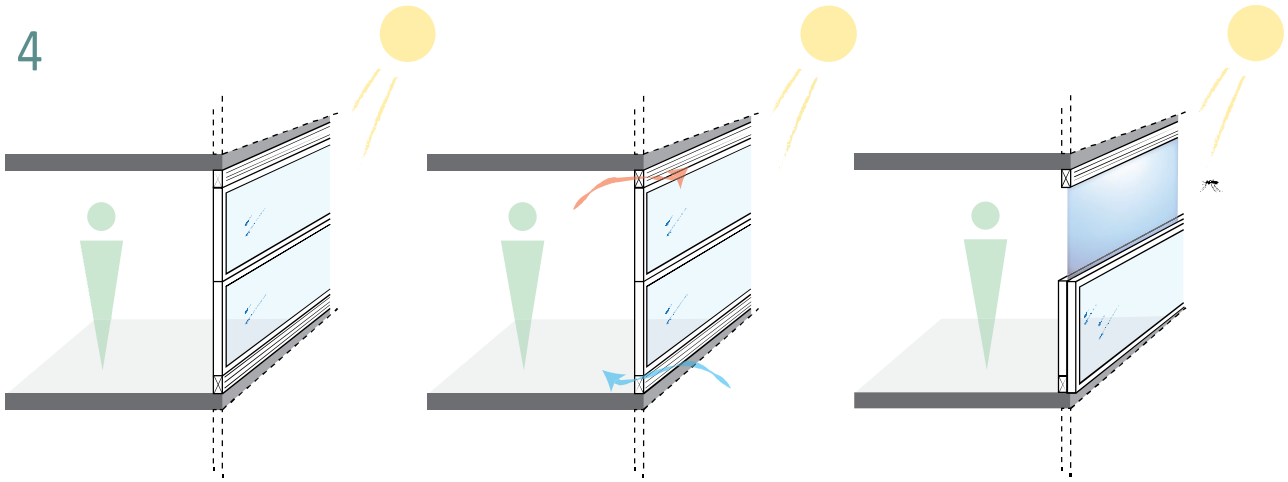
ADVANTAGES

- Natural ventilation ('double hung')
- Maximal transparency
- Transparent balustrade
- Connection environment
- Possibility to open large part of the facade
- Stimulant to generate vitamin D
- Insect protection

DISADVANTAGES

- No secure feeling at night

4



DESIGNCONCEPT 4

In this design concept the facade is horizontally divided in two windows. The transparency of the facade is almost maximal.

On top and bottom of the facade two grids are situated. These grids can be opened to provide natural ventilation.

Secondly the upper windows can be slid down. In this way a balcony is created (provided with an insect screen).

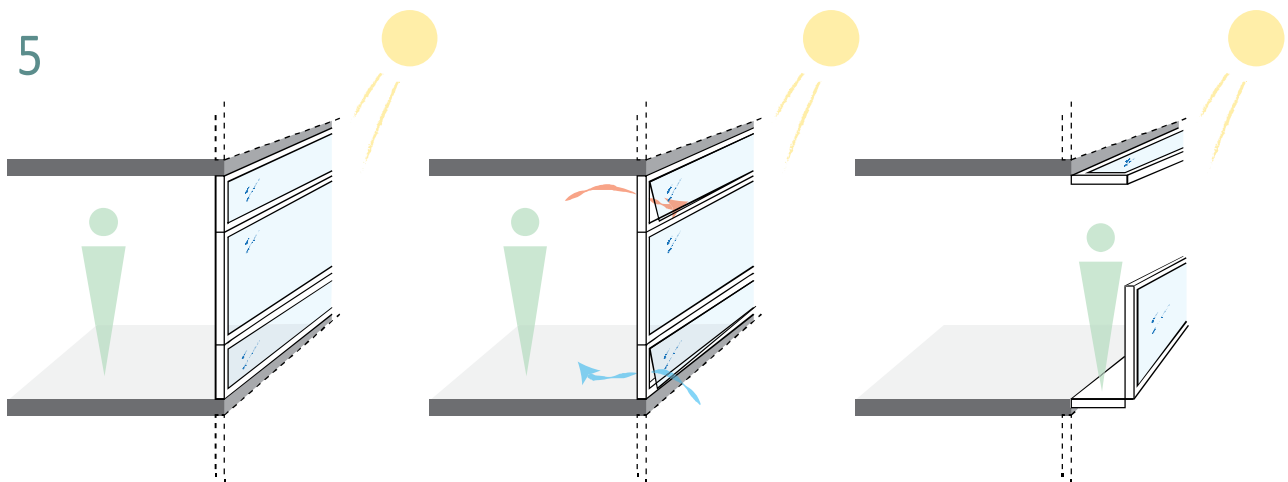
ADVANTAGES

- Natural ventilation
- Almost maximal transparency
- Transparent balustrade
- Connection environment
- Possibility to open large part of the facade
- Stimulant to generate vitamin D
- Insect screen

DISADVANTAGES

- No secure feeling at night

5



DESIGNCONCEPT 5

In this design concept the facade is horizontally divided in three windows. The transparency of the facade is maximal.

On top and bottom of the facade two small windows are situated, with inbetween these windows a larger one. Both small windows can be opened to generate a ventilation flow.

Secondly the facade can be turned into an balcony as presented in the visualization.

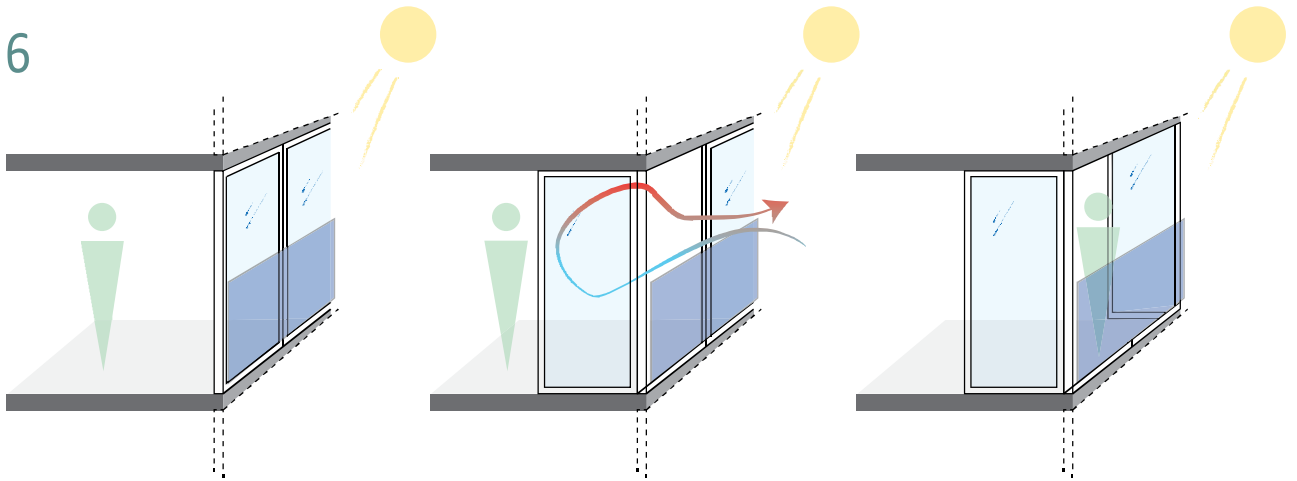
ADVANTAGES

- Natural ventilation
- Maximal transparency
- Transparent balustrade
- Connection environment
- Possibility to open large part of the facade
- Stimulant to generate vitamin D

DISADVANTAGES

- No secure feeling at night
- Insect screen

6



DESIGNCONCEPT 6

In this design concept the facade is vertically divided in two windows. The transparency of the facade is maximal.

In front of the two large vertical windows a french balcony is attached to the facade. By opening the doors a natural ventilation flow occurs.

Secondly the facade can be fully opened to create a balcony for the occupants.

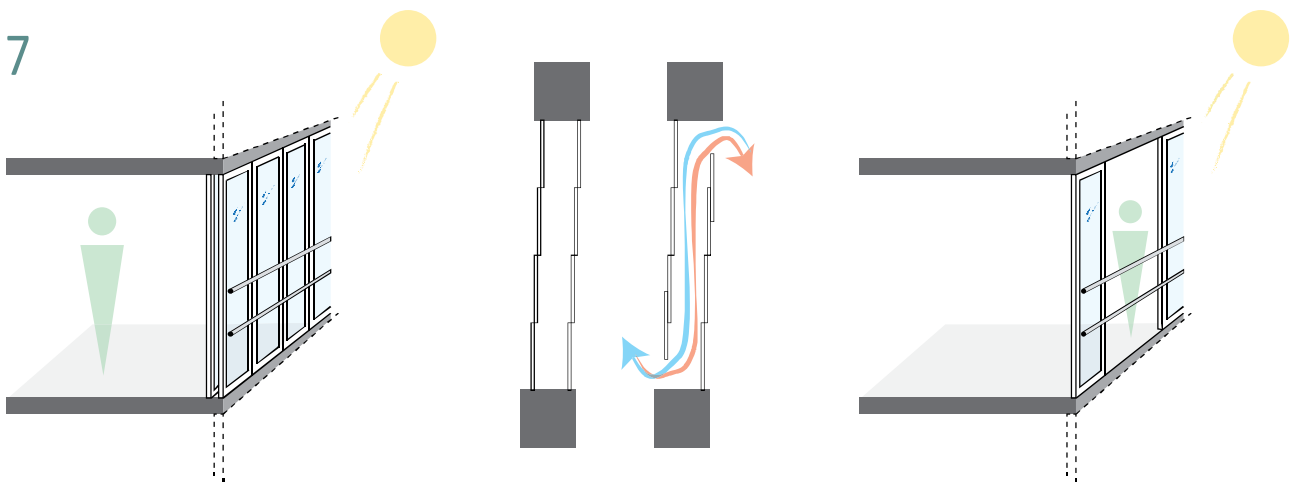
ADVANTAGES

- Natural ventilation
- Maximal transparency
- Transparent balustrade
- Connection environment
- Possibility to open large part of the facade
- Stimulant to generate vitamin D

DISADVANTAGES

- No secure feeling at night
- Insect screen

7



DESIGNCONCEPT 7

In this design concept the facade is vertically divided in two layers of four windows. The transparency of the facade is almost maximal.

By sliding the first layer from the right and the second layer from the left, a ventilation flow occurs which does not give a cold feeling.

Secondly the windows can be slideed open for a large part, in this way a balcony is created.

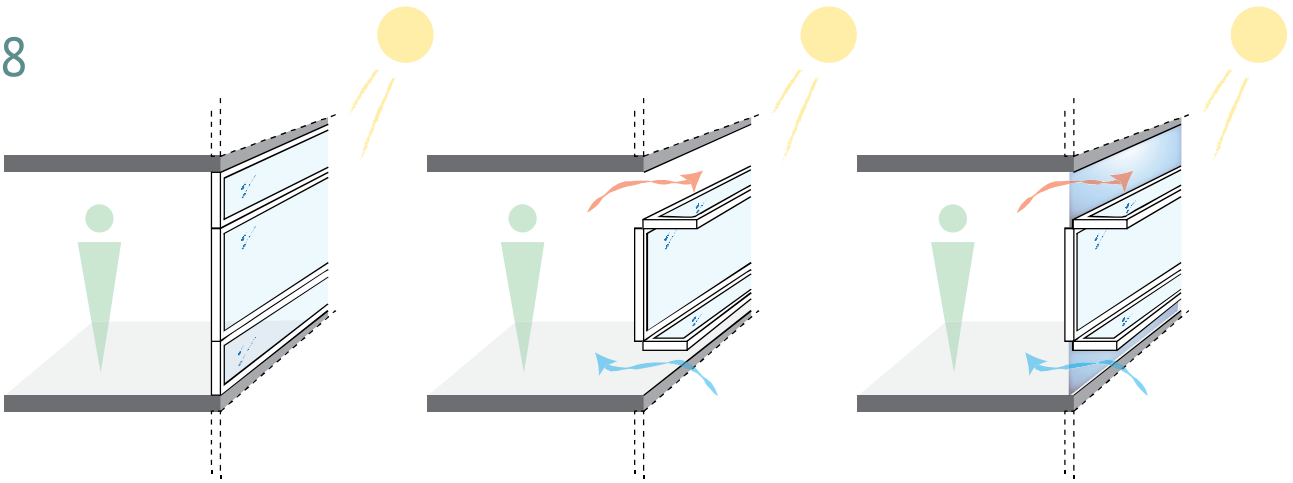
ADVANTAGES

- Natural ventilation
- Almost maximal transparency
- Transparent balustrade
- Connection environment
- Possibility to open large part of the facade
- Stimulant to generate vitamin D

DISADVANTAGES

- No secure feeling at night
- Costs a lot of space
- Insect screen

8



DESIGNCONCEPT 8

In this design concept the facade is horizontally divided in three windows. The transparency of the facade is maximal.

By opening the upper and bottom window to the outside, a fast ventilation flow occurs.

Secondly insect screen protect the occupants from insects entering the room.

ADVANTAGES

- Natural ventilation
- Maximal transparency
- Transparent balustrade
- Connection environment
- Possibility to open large part of the facade
- Insect screen

DISADVANTAGES

- No secure feeling at night
- Stimulant to generate vitamin D

A.5.2 THE CONCEPT TO BE DEVELOPED

By combining several ideas a facade can be developed with an energy neutral, healthy and safe perspective. All design concept have different interesting parts that could be developed.

As we look back to the design requirements, some design requirements are obvious in development others aren't.

The concept design is made for the facade of the living room of the 2nd skin project. The maximum height of the facade is 2,84 m. The windows of the facade will be developed with aluminium windowframes.

The action of opening a window is linked with the mechanical ventilation system and the heating system. If a window is opened, the ventilation system and heating system automatically turn off.

At the inside of the facade a flashing light indicates that the indoor climate of the room is not healthy. The occupants are warned that they have to ventilate the room.

The facade of the living room is required to be as transparent as possible, but should be provided with a sunshading to prevent overexposure.

Large openings in the facade are preferable because of the well-being and health of the elderly. Also a transparent balustrade is preferable, but it should be able to change the balustrade to a non-transparent balustrade.

There is not enough time to develop all design requirements in one design in detail. Therefore we should look back at the original goal of this research; Triggering elderly to an energy neutral and healthy use of the facade. We want to trigger elderly to ventilate more to provide a healthier life to them. Therefore the operation of the window system is most important to develop, especially because of the deterioration factors of elderly.

The design concepts show different operations of ventilating. The question is which system operation works best for elderly and which system provides the best conditions for the well-being of elderly.

Idea 2, 3 and 4 show most advantages in well-being of elderly. The operation of one of these ideas should be developed in the final design.

Chapter A.5.1 showed different design concepts. These concepts were not specified on all design requirements, but mainly on the ventilation flow, the transparency of the facade, the operation of the facade and the insect screen.

Figure A.54 shows the three design concepts that suit best according to the well-being of elderly and the energy neutral use of the facade.

Figure A.55 presents most of the design requirements of chapter 9 in one visualization. Most of these requirements are numbered in the figure.

As mentioned in the previous chapter, some requirements are already quite strict (for example linking the heating system with the action of opening a window). These requirements will only be developed to a concept, not in detail. Other requirements will be developed much more into detail.

Because some of the design requirements will be automated actions, it will be most important to detail the actions that should be done manually. These actions should be tested mainly.

Figure A.56 on the next page shows the final design in concept, the most important design requirements are implemented in the design.

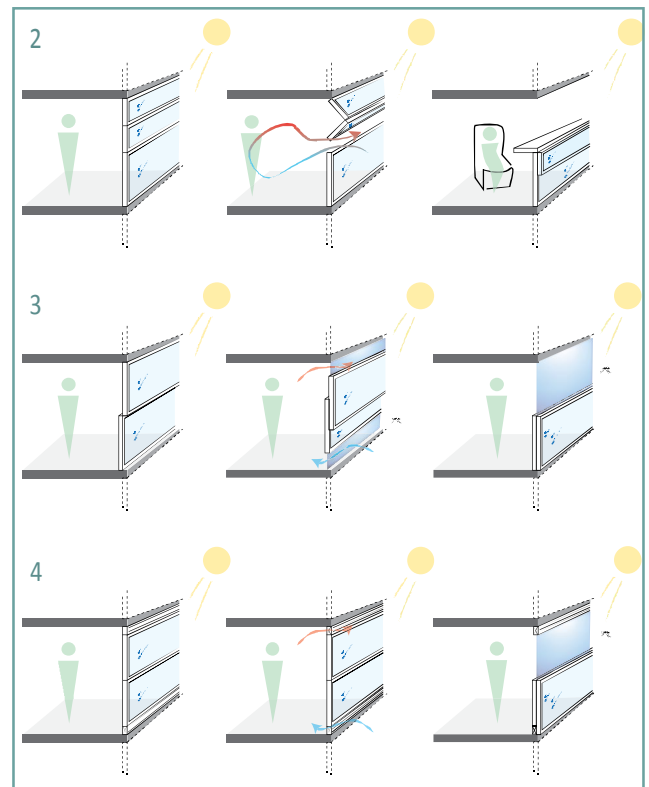


Figure A.54; Three of the eight design concepts from the previous chapter (own illustration).

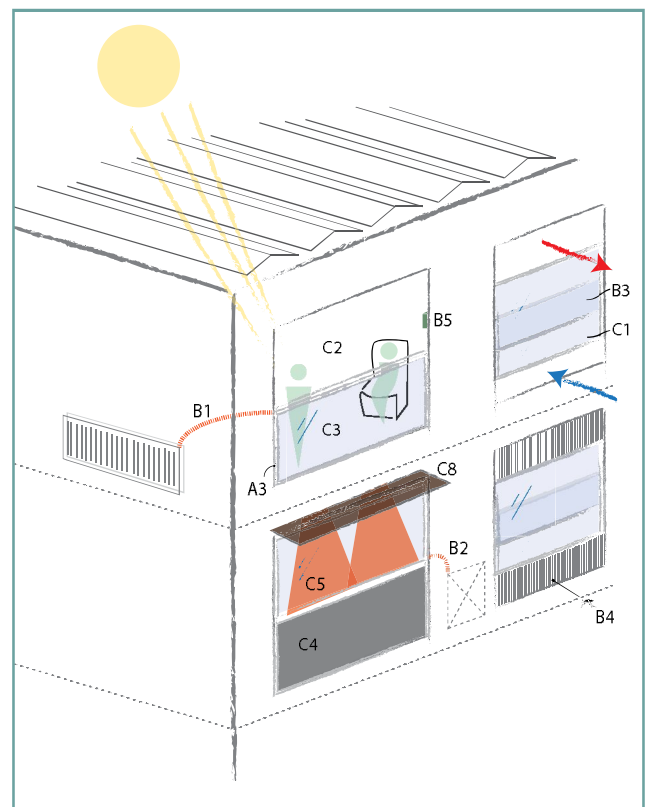


Figure A.55; Visualization which shows most of the design requirements in a concept drawing (own illustration)

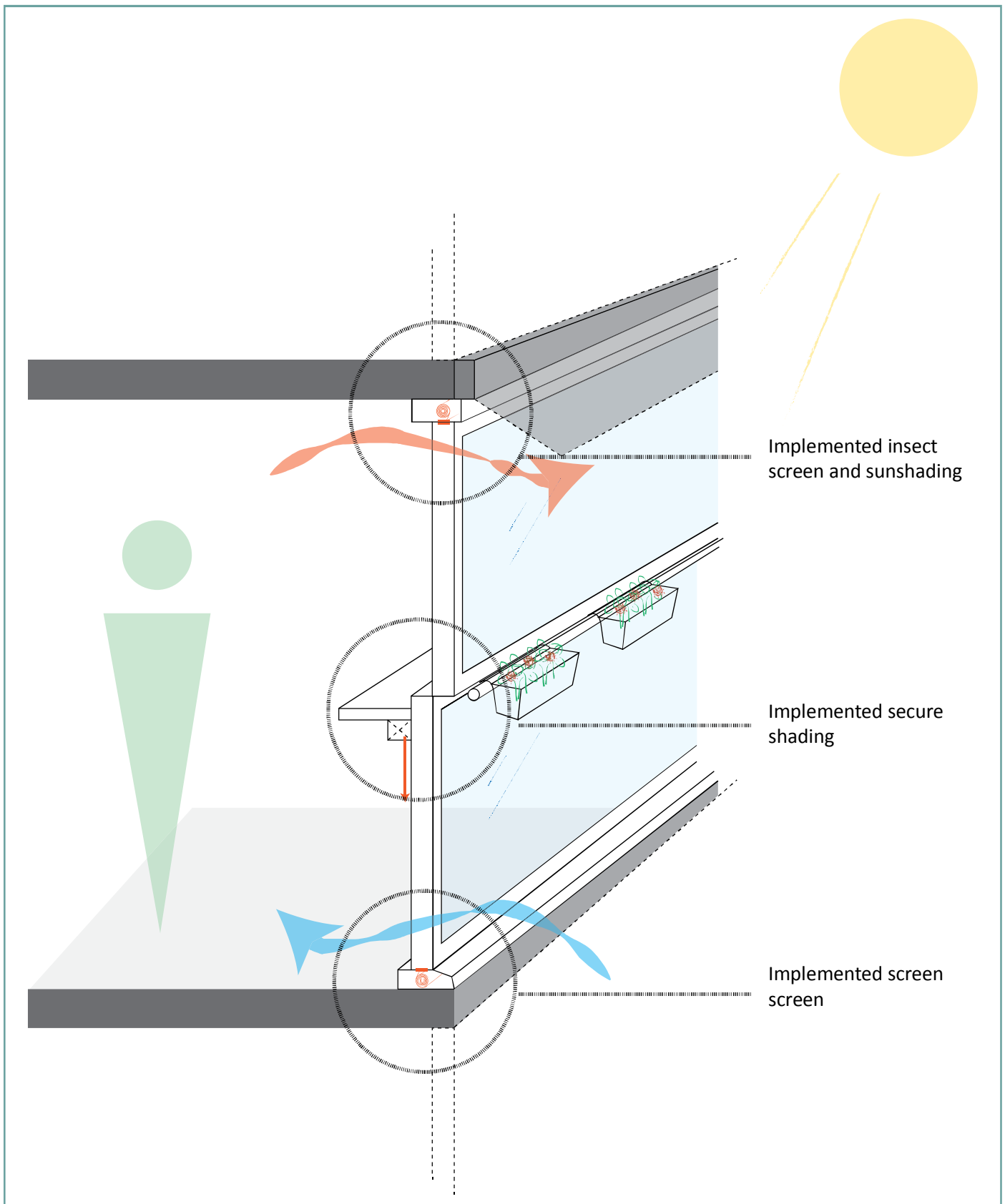


Figure 111; Visualization final design concept (own illustration)

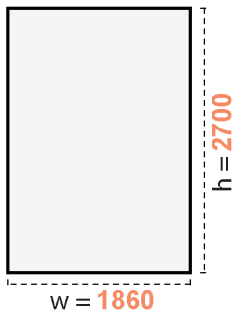
A.6. CONCEPT IDEAS 2 (after interviews A.3.3. and A.3.4.)

On the next few pages different design ideas will be shown. All the designs are checked with the different requirements and the provided text will discuss the advantages and disadvantages.

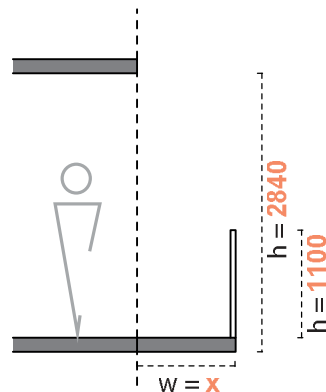
Three of these designs are chosen for further development. These are shown in the chapter of the concept ideas and developed in the final design chapter.

CONCEPT 1 - KITCHEN FACADE

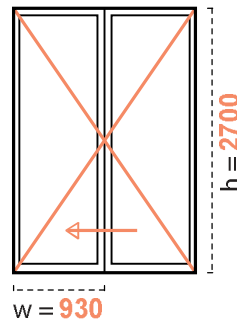
KITCHEN



Facade element
(width and height)



Cross section facade
(width and height)



Facade-door design
(concept 1)

- Folding to the left
- Folding to the outside
- Right folding door disconnectable from frame

Specifications
(concept 1)

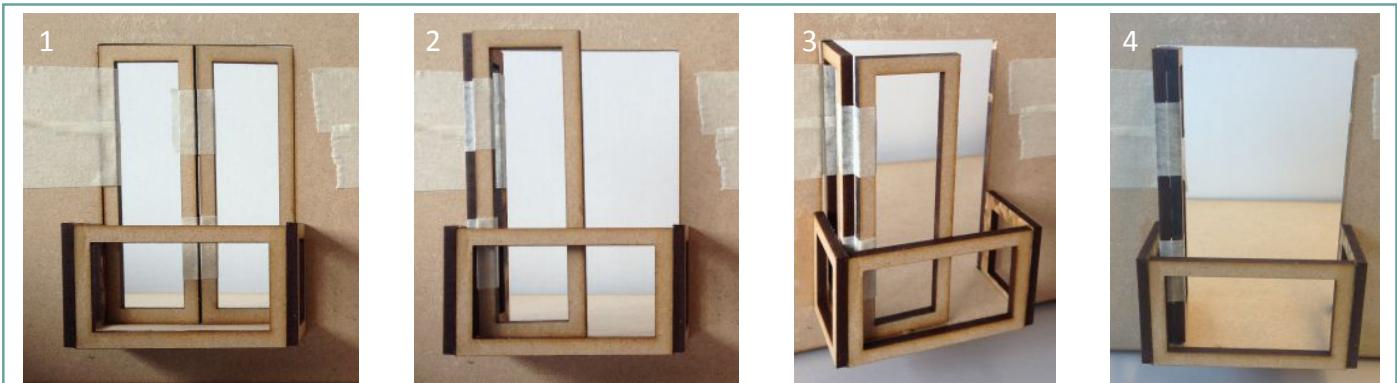


Figure A.57; Models concept 1 - kitchen (own illustration)

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY					
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)	INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	TRANSPARENCY (VIEW/ PRIVACY)	OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)	ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY, HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
		SMALL ----- BIG					VIEW ----- PRIVACY					IN ----- OUT	IN ----- OUT					
CONCEPT 1	+	-----+	+	+	+	+	-----+	+	-	+	+	-----+	-----+	+	-	-	-----+	-----+
		↑					↑											

The first design is a concept for the facade in front of the kitchen. In the existing situation it doesn't have a balcony, but in the new design it does. The folding doors can fold outside to the left. In this way a wind screen can be created and the occupants can sit outside comfortably. The balustrade of the balcony is transparent and allows the occupants to have a view to the outside.

The doors can be opened in two ways; The doors can be fully folded to the left side, or; opened as in picture 2 and 3 of figure A.57. Thereby the ventilation opening can become very wide.

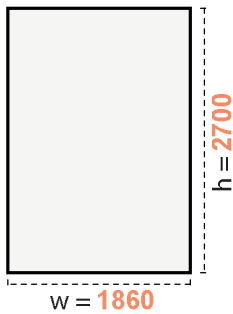
The space area isn't very efficient because the doors fold open to the outside, in this way it is hard to keep furniture outside.

As the requirement checklist of concept 1 shows, not all requirements are marked as positive. The two appointed requirements with arrows are easy to change into a positive direction. By adding small windows in the doors at the top, the occupants are able to open small window parts. The privacy requirement could be achieved by adding a printing on the glass balustrade for example.

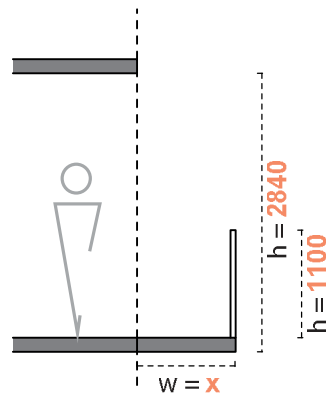
Other requirements are harder or not achievable. For example the ability to keep plants inside on a windowsill isn't possible in this design.

CONCEPT 2 - KITCHEN FACADE

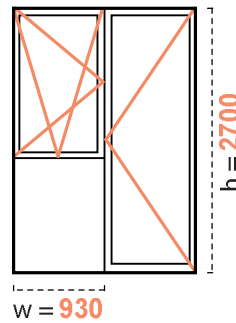
KITCHEN



Facade element
(width and height)



Cross section facade
(width and height)



Facade-door design
(concept 2)

- One door, one window
- Opening both outside
- Window also able to tilt

Specifications
(concept 2)

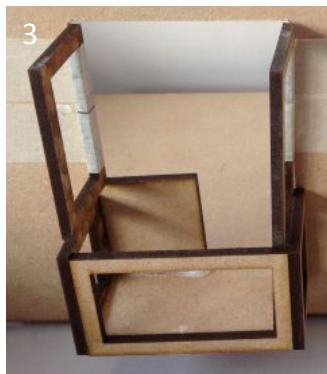
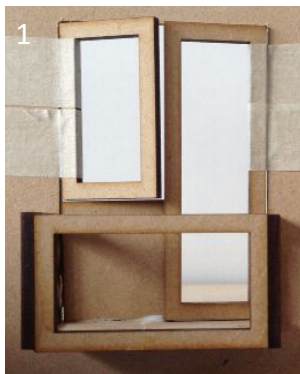


Figure A.58; Models concept 2 - kitchen (own illustration)

	VENTILATION				ELDERLY					COMFORT					FUNCTIONALITY			
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)	INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	VIEW TRANSPARENCY (VIEW/ PRIVACY)	OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)	ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY, HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
CONCEPT 2	+	++	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+



This concept design for the facade of the kitchen consists of an outdoor opening door and window which both can be used as wind protection screens. The window can also be tilted, in this way the room can still be ventilated but will be protected against rain (picture 4). The balustrade of the balcony is transparent and allows the occupants to have a view to the outside.

The wall underneath the window allows the occupants to have a windowsill and keep plants both in and outside.

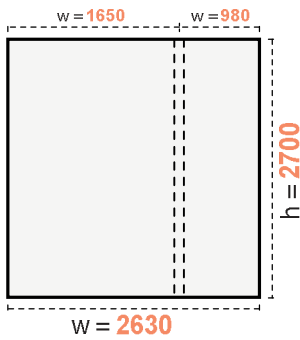
The space area isn't very efficient because the door and window fold open to the outside, so not all furniture is easy to be kept outside.

As the requirement checklist of concept 2 shows, a lot of the requirements are marked as positive. The privacy requirement could be achieved by adding a printing on the glass balustrade for example (same as concept 1).

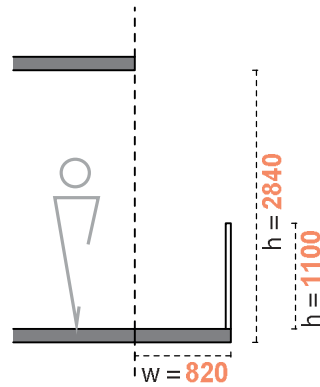
For the upper floor of the porch apartments a sun-screen should be added to the design.

CONCEPT 3 - BEDROOMS 1 & 2

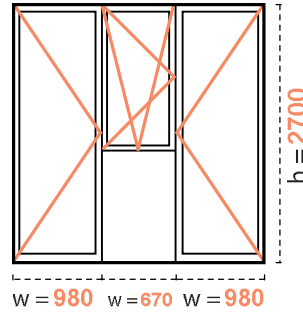
BEDROOM 1+2



Facade element
(width and height)



Cross section facade
(width and height)



Facade-door design
(concept 3)

- Two doors, one window
- Opening to the outside
- Window also able to tilt

Specifications
(concept 3)

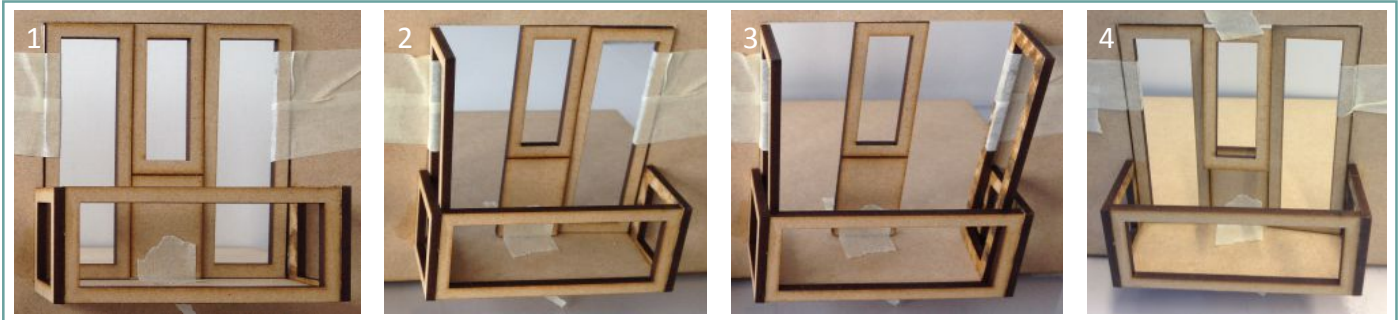


Figure A.59; Models concept 3 - bedroom 1 & 2 (own illustration)

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY					
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)	INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	VIEW TRANSPARENCY (VIEW/ PRIVACY)	OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)	ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY/ HEAT/ COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
CONCEPT 3	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+

Concept 3 consists of 2 doors and inbetween one window. The doors both open to the outside and can function as wind protection screens. The window can be tilted or opened outwards.

The wall underneath the window allows the occupants to have a windowsill and keep plants both in and outside. A folding table could be added to the wall outside to provide flexibility to the occupants.

The big doors allow occupants to ventilate with large openings. The window allows the occupants to ventilate with a small opening.

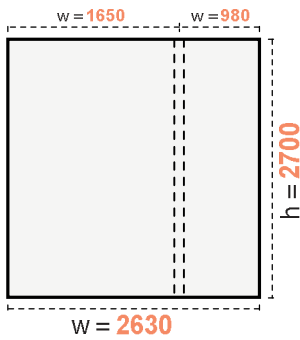
The balustrade of the balcony is transparent and allows the occupants to have a view to the outside.

Most requirements are rated positive or semi-positive and semi-negative. The privacy requirement could be achieved by adding a printing on the glass balustrade for example (same as concept 1).

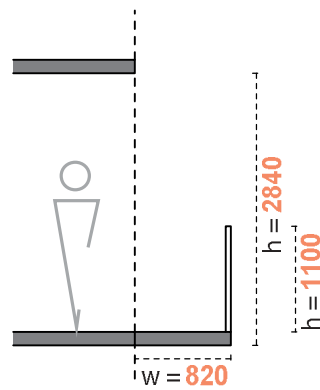
For the upper floor of the porch apartments a sun-screen should be added to the design.

CONCEPT 4 - BEDROOMS 1 & 2

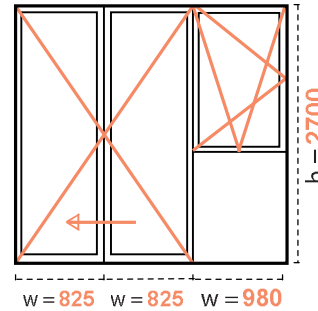
BEDROOM 1+2



Facade element
(width and height)



Cross section facade
(width and height)



Facade-door design
(concept 4)

- Two doors, folding left
- One window
- Opening to the outside
- Window also able to tilt

Specifications
(concept 4)



Figure A.60; Models concept 4 - bedroom 1 & 2 (own illustration)

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)		INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	TRANSPARENCY (VIEW// PRIVACY)		OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)		ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY; HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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Concept 4 consists of 2 folding doors and one window. The doors fold to the left and are able to fully fold or be disconnected to function as a wider wind protection screen.

There is experimented with different shapes to find out which shape functions best for the different requirements. The advantage of this shape is that the depth of the balcony can be larger because the wind-screen makes an angle.

The window can be used as a wind protection screen for the other side of the balcony.

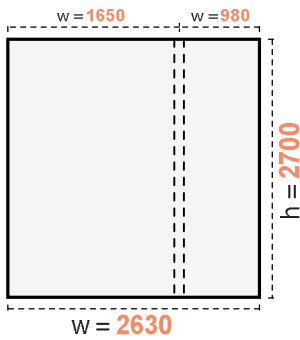
The balustrade of the balcony is transparent and allows the occupants to have a view to the outside.

Most requirements are rated positive. The privacy requirement could be achieved by adding a printing on the glass balustrade for example (same as concept 1).

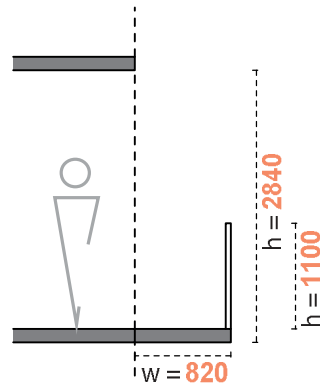
For the upper floor of the porch apartments a sun-screen should be added to the design.

CONCEPT 5 - BEDROOMS 1 & 2

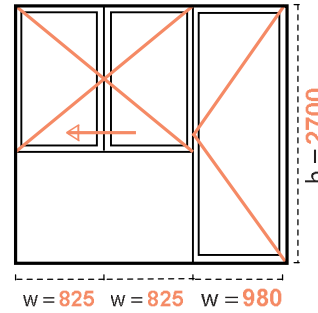
BEDROOM 1+2



Facade element
(width and height)



Cross section facade
(width and height)



Facade-door design
(concept 5)

- Two windows, folding left
One door
- Opening to the outside

Specifications
(concept 5)

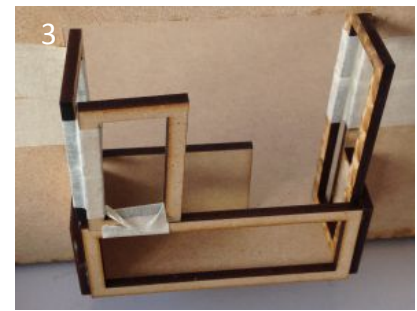
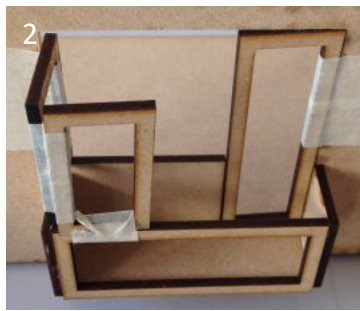
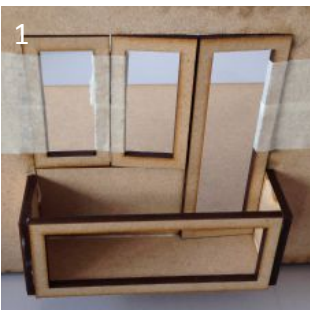


Figure A.61; Models concept 5 - bedroom 1 & 2 (own illustration)

	VENTILATION				ELDERLY					COMFORT					FUNCTIONALITY			
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)	INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	VIEW TRANSPARENCY (VIEW/ PRIVACY)	OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)	ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY, HEAT/COOL)	WINDOW/ SILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
CONCEPT 5	+	++	+	-	+	+	+	+	-	+	+	+	+	+	+	+	+	+



Concept 5 consists of 2 folding windows to the left and one door. All opening outwards. The right window can be disconnected from the frame and connected to the balcony railing to provide a wind protection screen. The door opens also outwards and can therefore also function as a wind protection screen.

To open the windows first the door should be opened. In this way the facade can be designed without an intermediate frame. In this way the border between in and outside minimal and the connection with the environment gets better.

The windows allow the occupants to have a window-sill inside and keep plants both in and outside.

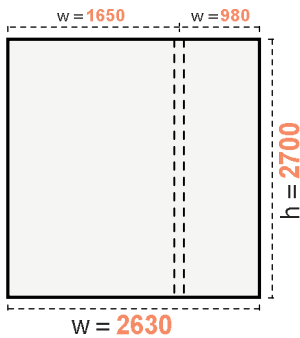
The balustrade of the balcony is transparent and allows the occupants to have a view to the outside.

Most requirements are rated positive or semi-positive and semi-negative. The privacy requirement could be achieved by adding a printing on the glass balustrade for example (same as concept 1).

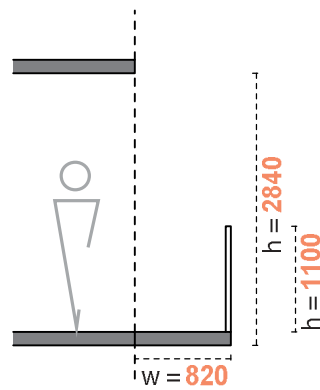
For the upper floor of the porch apartments a sun-screen should be added to the design.

CONCEPT 6 - BEDROOMS 1 & 2

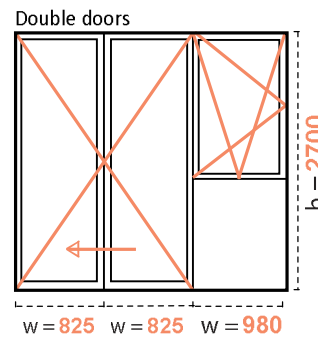
BEDROOM 1+2



Facade element
(width and height)



Cross section facade
(width and height)



Facade-door design
(concept 6)

- Two doors, folding left
One window
- Double doors
- Opening to the outside
- Window also able to tilt

Specifications
(concept 6)

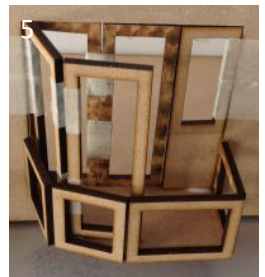
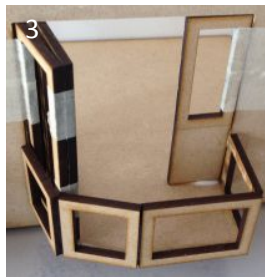
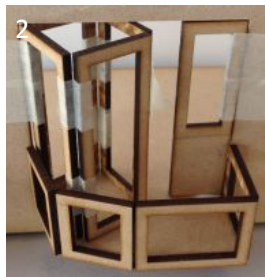


Figure A.62; Models concept 6 - bedroom 1 & 2 (own illustration)

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY									
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)		INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	VIEW	TRANSPARENCY (VIEW/ PRIVACY)	OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	IN	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)	IN	ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY; HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
		SMALL	BIG					PRIVACY	OUT					OUT								
CONCEPT 6	+	+	+	+	+	+	+	+	-	+	-	+	+	+	-	+	+	+	+	+	+	-



Concept 6 consists of two double folding doors and one window. The outer folding doors fold outwards, the inner folding doors fold inwards. In this way a wind protection screen can be constituted while the inner folding doors can close the facade again.

The window can be used as a wind protection screen for the other side of the balcony. The window also allows for small ventilation openings.

The balustrade of the balcony is transparent and allows the occupants to have a view to the outside.

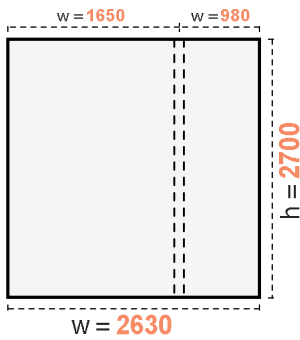
Most requirements are rated positive. The privacy requirement could be achieved by adding a printing on the glass balustrade for example (same as concept 1).

The most negative part of this concept is that the movements are very complex. Especially for elderly these operations are hard.

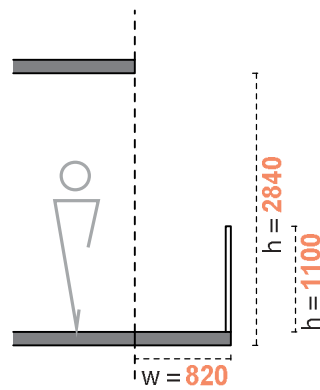
For the upper floor of the porch apartments a sun-screen should be added to the design.

CONCEPT 7 - BEDROOMS 1 & 2

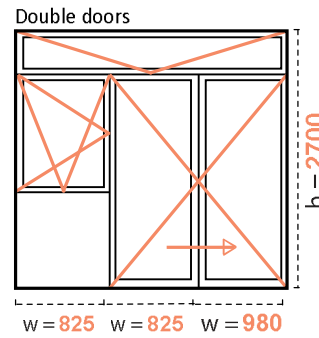
BEDROOM 1+2



Facade element
(width and height)



Cross section facade
(width and height)



Facade-door design
(concept 7)

- Two doors, folding left
- Two window
- Opening to the outside
- Windows able to tilt

Specifications
(concept 7)



Figure A.63; Models concept 7 - bedroom 1 & 2 (own illustration)

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY								
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)		INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	TRANSPARENCY (VIEW// PRIVACY)		OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)		ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY; HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
		SMALL	BIG					VIEW	PRIVACY												
CONCEPT 7	+	+	+	+	+	+	+	+	-	+	-	+	+	+	-	+	+	+	+	-	



Concept 7 consists of two folding door which can again be used as wind protection screen. Besides that the design consists of two windows. The upper window is able to be tilted outwards. In this way occupants can easily ventilate their home naturally when they are absent.

The other window can also be used as a wind protection screen by opening it outwards and connecting it to the railing of the balustrade.

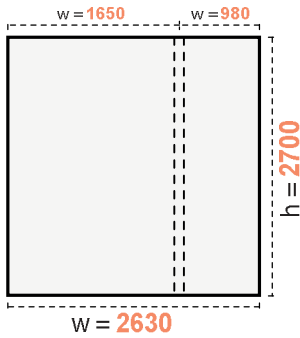
Most requirements are rated positive. The privacy requirement could be achieved by adding a printing on the glass balustrade for example (same as concept 1).

For the upper floor of the porch apartments a sun-screen should be added to the design.

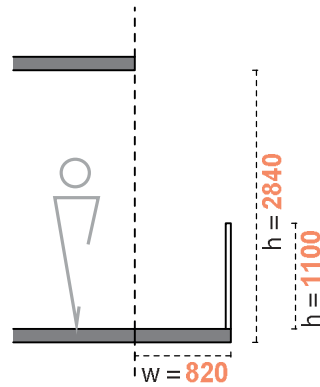
The upper tilting window is too large in length now. This window should be divided in at least two parts.

CONCEPT 8 - BEDROOMS 1 & 2

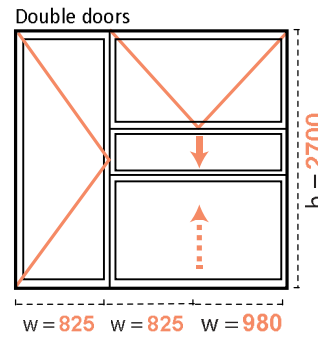
BEDROOM 1+2



Facade element
(width and height)



Cross section facade
(width and height)



Facade-door design
(concept 8)

- One door,
2 sliding windows,
One tilting window
- Opening to the outside

Specifications
(concept 8)



Figure A.64; Models concept 8 - bedroom 1 & 2 (own illustration)

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY					
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)	INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	VIEW TRANSPARENCY (VIEW/ PRIVACY)	OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)	ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY, HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
CONCEPT 8	++	++	+	+	+	+	+	+	-	+	+	+	+	+	-	+	+	-



Concept 8 consists of a door that opens outwards and can be used as a wind protection screen. The other part of the facade consists of 3 windows. Two sliding windows which can function as a double hung system (to make ventilation very efficient). The upper window is a tilting window which can also function as a sun-/rainprotection screen.

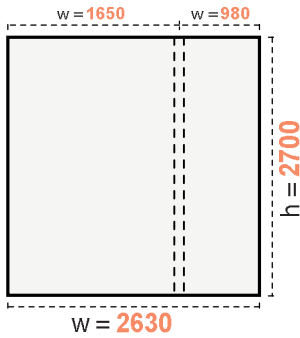
The balustrade of the balcony is transparent and allows the occupants to have a view to the outside.

Most requirements are rated positive. The privacy requirement could be achieved by adding a printing on the glass balustrade for example (same as concept 1).

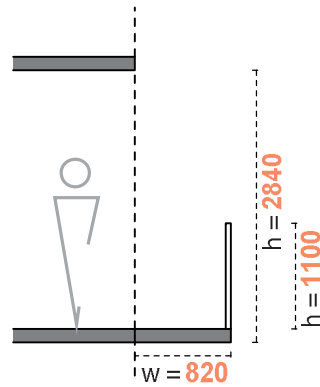
The most negative part of this concept is that the movements are very complex. Especially for elderly these operations are hard. Besides that the upper tilting window is quite large and heavy to function as a sun-/rain protection screen.

CONCEPT 9 - BEDROOMS 1 & 2

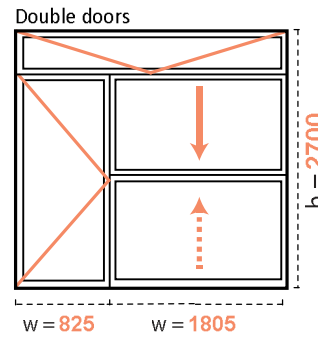
BEDROOM 1+2



Facade element
(width and height)



Cross section facade
(width and height)



Facade-door design
(concept 9)

- One door,
2 sliding windows,
One tilting window
- Opening to the outside

Specifications
(concept 9)

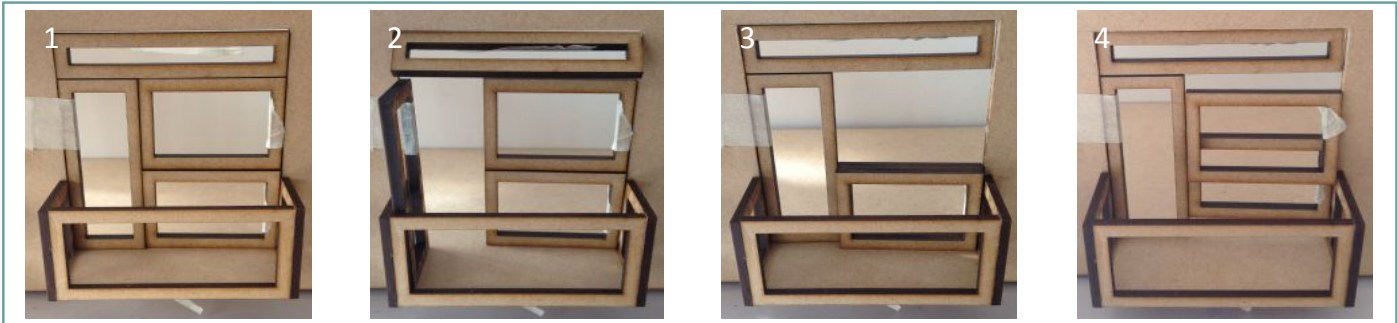


Figure A.65; Models concept 9 - bedroom 1 & 2 (own illustration)

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY					
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)	INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	VIEW TRANSPARENCY (VIEW/ PRIVACY)	OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)	ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY, HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
CONCEPT 9	++	++	+	+	+	+	+	+	-	+	+	+	+	+	-	+	+	-



Concept 9 consists of a door which opens outwards and can function as a wind protection screen. The two windows next to the door are sliding windows which function as a double hung system (to make ventilation very efficient). Besides that at the top a tilting window can provide natural ventilation when the occupants are absent.

The balustrade of the balcony is transparent and allows the occupants to have a view to the outside.

Most requirements are rated positive. The privacy requirement could be achieved by adding a printing on the glass balustrade for example (same as concept 1).

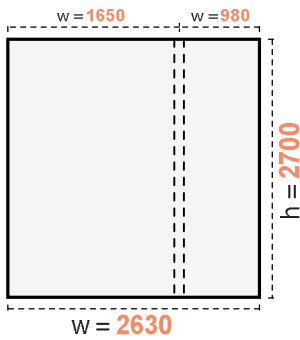
The most negative part of this concept is that the movements are very complex. Especially for elderly these operations are hard.

For the upper floor of the porch apartments a sun-screen should be added to the design.

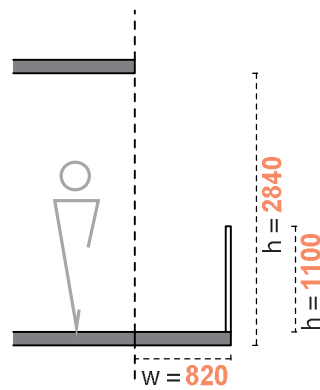
The upper tilting window is too large in length now. This window should be divided in at least two parts.

CONCEPT 10 - BEDROOMS 1 & 2

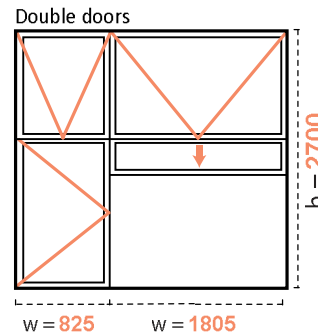
BEDROOM 1+2



Facade element
(width and height)



Cross section facade
(width and height)



Facade-door design
(concept 10)

- One door (half),
One sliding window,
Two tilting window
- Opening to the outside

Specifications
(concept 10)

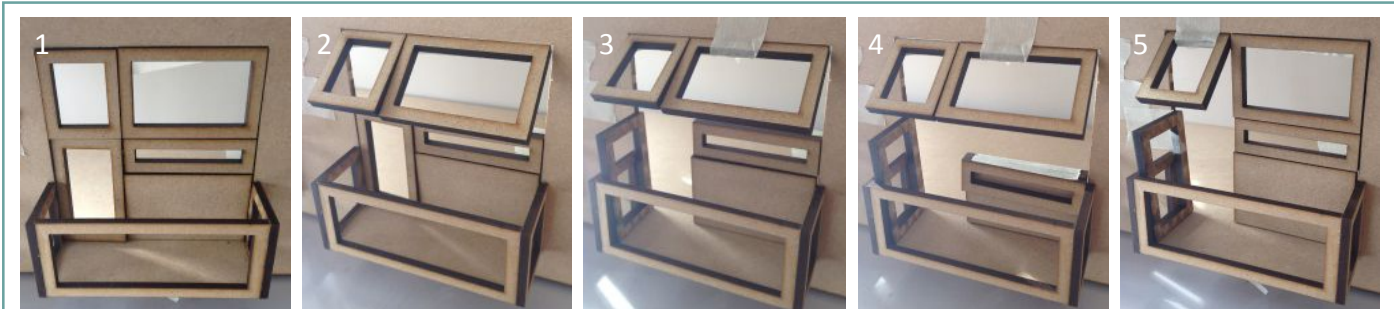


Figure A.66; Models concept 10 - bedroom 1 & 2 (own illustration)

	VENTILATION				ELDERLY				COMFORT				FUNCTIONALITY								
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)		INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	TRANSPARENCY (VIEW/ PRIVACY)		OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)		ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY, HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
		SMALL	BIG					VIEW	PRIVACY					IN	OUT						
CONCEPT 10	+	+	+	+	+	+	+	+	-	+	-	+	+	+	-	+	+	+	+	-	



Concept 10 consists of two upper outwards tilting windows which also function as rain-/sunprotection screens. The small upper window should operate together with the action of opening the door (as the third picture shows). The small window can be slid down the wall, so small ventilation is also possible.

The wall allows the occupants to have a windowsill and keep plants in- and outside.

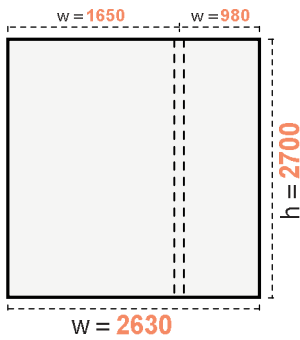
The balustrade of the balcony is transparent and allows the occupants to have a view to the outside.

Most requirements are rated positive. The privacy requirement could be achieved by adding a printing on the glass balustrade for example (same as concept 1).

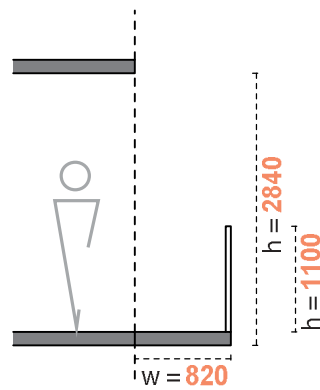
The most negative part of this concept is that the movements are very complex. Especially for elderly these operations are hard. Besides that the upper tilting window is quite large and heavy to function as a sun-/rain protection screen. It is also quite complex to design a door with a tilting window, this action will also be quite hard for elderly.

CONCEPT 11 - BEDROOMS 1 & 2

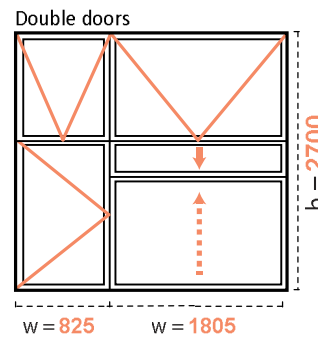
BEDROOM 1+2



Facade element
(width and height)



Cross section facade
(width and height)



Facade-door design
(concept 11)

- One door (half),
Two sliding windows,
Two tilting window
- Opening to the outside

Specifications
(concept 11)



Figure A.67; Models concept 11 - bedroom 1 & 2 (own illustration)

	VENTILATION					ELDERLY					COMFORT					FUNCTIONALITY					
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)		INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	TRANSPARENCY (VIEW// PRIVACY)		OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)		ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY, HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
		SMALL	BIG					VIEW	PRIVACY					IN	OUT						
CONCEPT 11	++	+	+	+	+	+	+	+	-	+	-	+	+	+	-	-	+	-	+	+	-



Concept 11 is quite the same as concept 10, but more transparent.

Concept 11 consists of two upper outwards tilting windows which also function as rain-/sunprotection screens. The small upper window should operate together with the action of opening the door (as the third picture shows). The small window can be slid down the wall, so small ventilation is also possible.

The balustrade of the balcony is transparent and allows the occupants to have a view to the outside.

Most requirements are rated positive. The privacy requirement could be achieved by adding a printing on the glass balustrade for example (same as concept 1).

The most negative part of this concept is that the movements are very complex. Especially for elderly these operations are hard. Besides that the upper tilting window is quite large and heavy to function as a sun-/rain protection screen. It is also quite complex to design a door with a tilting window, this action will also be quite hard for elderly.

CONCEPT 12 - ANY FACADE

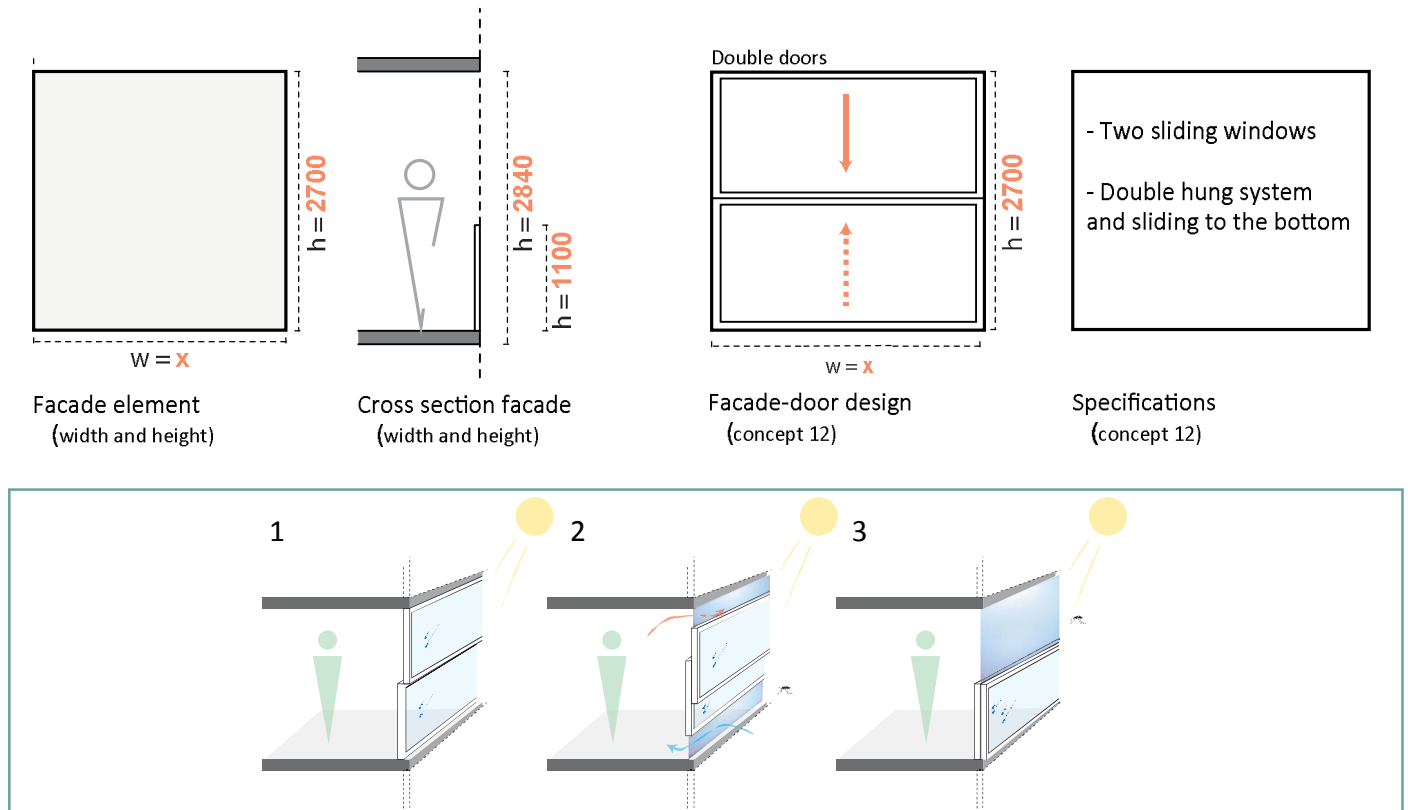


Figure A.68; Models concept 12 - any facade (own illustration)

	VENTILATION				ELDERLY					COMFORT					FUNCTIONALITY			
	STIMULATION TO VENTILATE MORE	NATURAL VENTILATION (SMALL AND BIG OPENINGS)	INSECT PROTECTION	RAIN PROTECTION	TAKE ALL DETERIORATION FACTORS INTO ACCOUNT	REACHABILITY	VIEW TRANSPARENCY (VIEW/ PRIVACY)	OVERALL COMFORT (ADDED VALUE)	NOISE PROTECTION	OUTSIDE AREA/ BALCONY	WIND PROTECTION	ADJUSTABLE SUN PROTECTION (IN- AND OUTSIDE)	ABILITY TO KEEP PLANTS (IN- AND OUTSIDE)	CURTAINS (PRIVACY, HEAT/COOL)	WINDOWSILL (INSIDE)	SPACE AREA ON BALCONY (FURNITURE ETC.)	WINDOW CLEANABILITY	COMPLEXITY MOVEMENTS (SYSTEM OPERATION)
CONCEPT 12	++	++	+	-	+	+	+	+	-	-	-	+	-	+	-	-	-	+-

Concept 12 is a design for any facade in a project that doesn't allow balconies. The facade consists of a double hung system with an attached insect/safety protection screen that automatically rolls out when opening the window.

The facade element can also be changed into a balustrade. Hereby the occupants can have a kind of feeling that they are outside instead of inside.

The whole facade is transparent and allows the occupants to have a view to the outside.

The requirement checklist shows a lot of minuses. Of course the cause is the miss of the outside area. Although there is tried to create a kind of inside-outside area, it isn't the same. But, it can be a solutions in situations where it isn't possible to add an outside spade to the facade.

A.7. EXTRA OPTIONS

A.7.1. Unilux plisse insect screen;

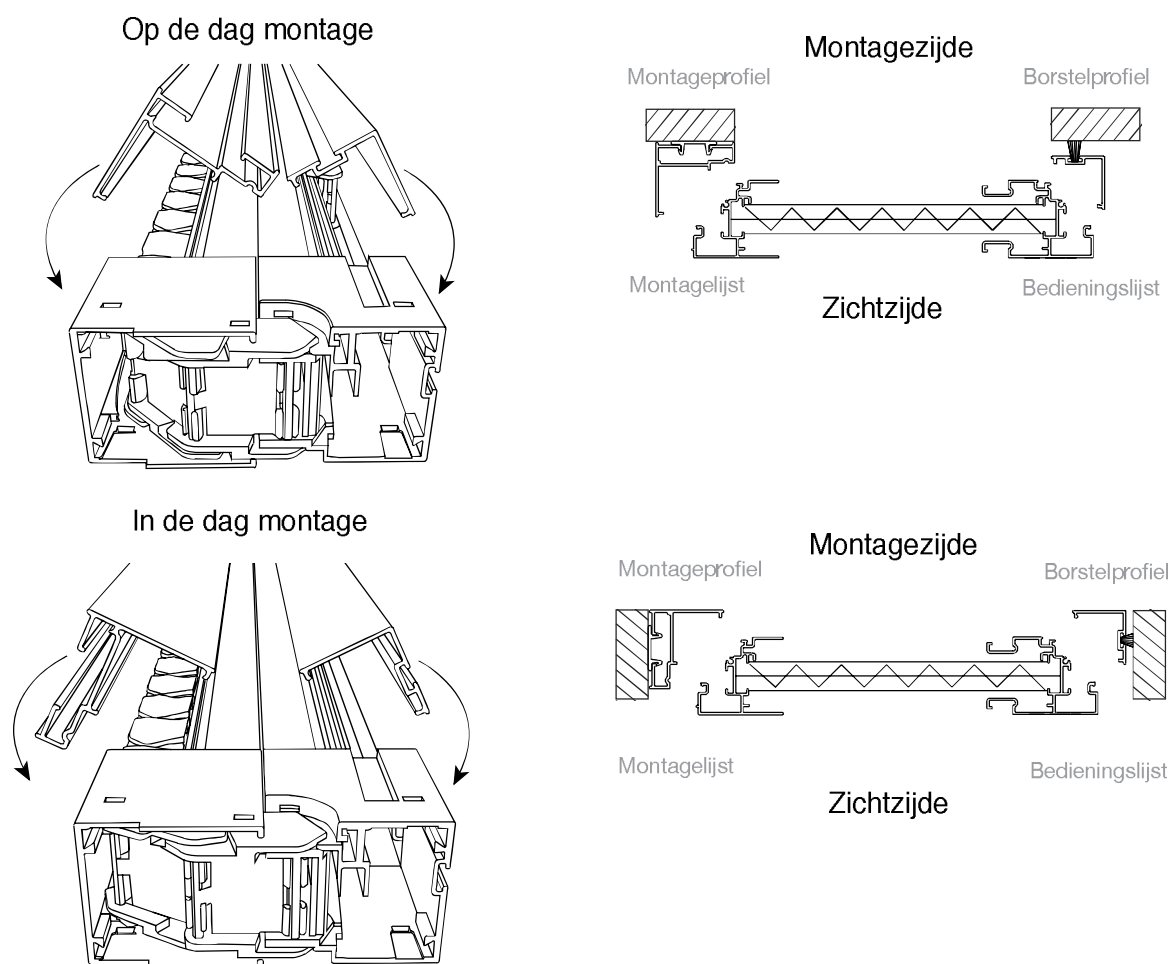
unilux

Screening Pioneers

Plisséhordeur PLISSÉFIT Standaard

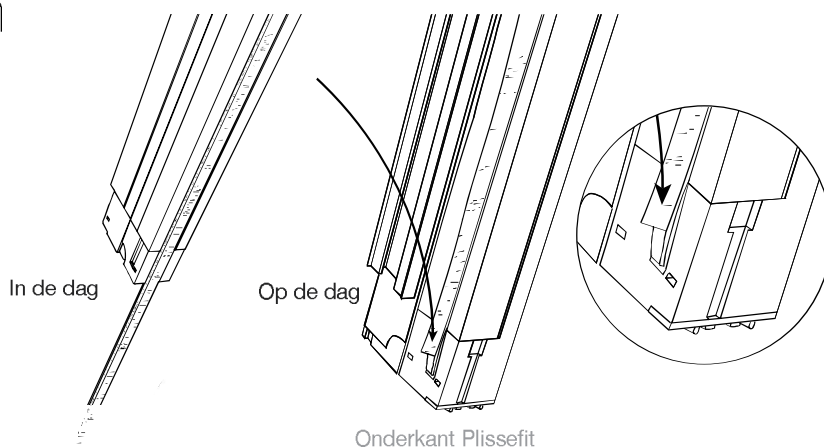
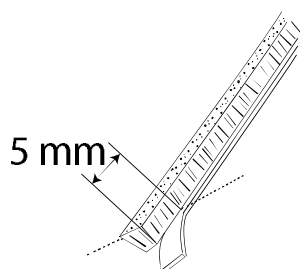
Vorbereiding: montagelijsten monteren

Let erop dat de koorden niet tussen de profielen vast komen te zitten.



Borstel monteren

Knip de borstel af en schuif de borstel in de kraal van het borstelprofiel.



Versie PF2015-0709

Figure A.69; Plisse insect screen (Unilux, 2015)



Unilux B.V.
i: www.unilux.nl

Op de dag

Montage links

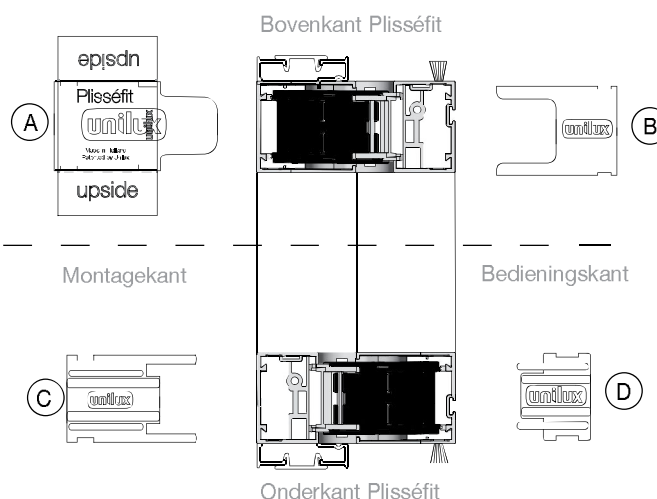
Klik deksel A boven in de montagelijst en
fixeer de montagekap met de sticker. Klik
deksel B in de bedieningslijst

Klik deksel C onder in de montagelijst en
deksel D in de bedieningslijst

Op de dag

Montage rechts

Verwissel de deksels met boven en onder.



In de dag

Montage links

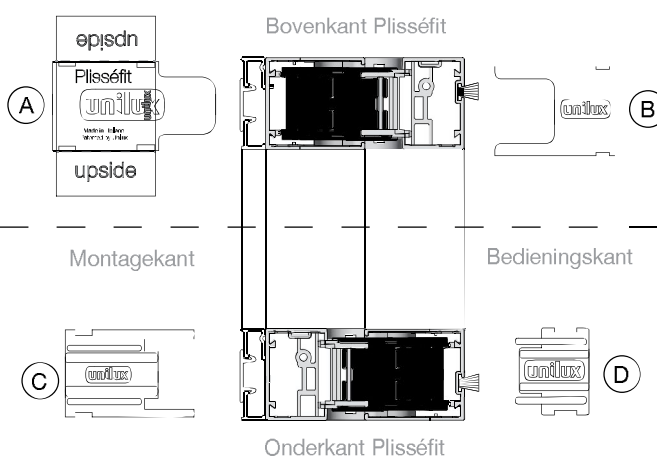
Klik deksel A boven in de montagelijst en
fixeer de montagekap met de sticker. Klik
deksel B in de bedieningslijst

Klik deksel C onder in de montagelijst en
deksel D in de bedieningslijst

In de dag

Montage rechts

Verwissel de deksels met boven en onder.



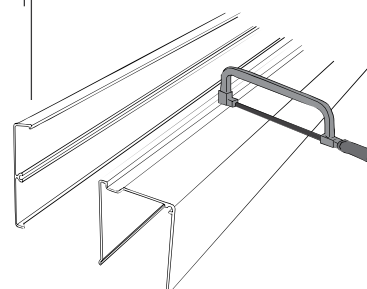
Montage op de dag:

Maak de ondergeleider en de
bovengeleiders op de juiste maat
(dagmaatbreedte plus 80 mm)

Montage in de dag:

Maak de ondergeleider en bovengeleider
op maat. Als u gebruik wil maken van de
afdekkapjes -5 mm i.v.m. speling.

De Plissefit is nu klaar voor montage,
ga verder met de handleiding Plisséfit.



Plisséhordeur PLISSÉFIT Easy

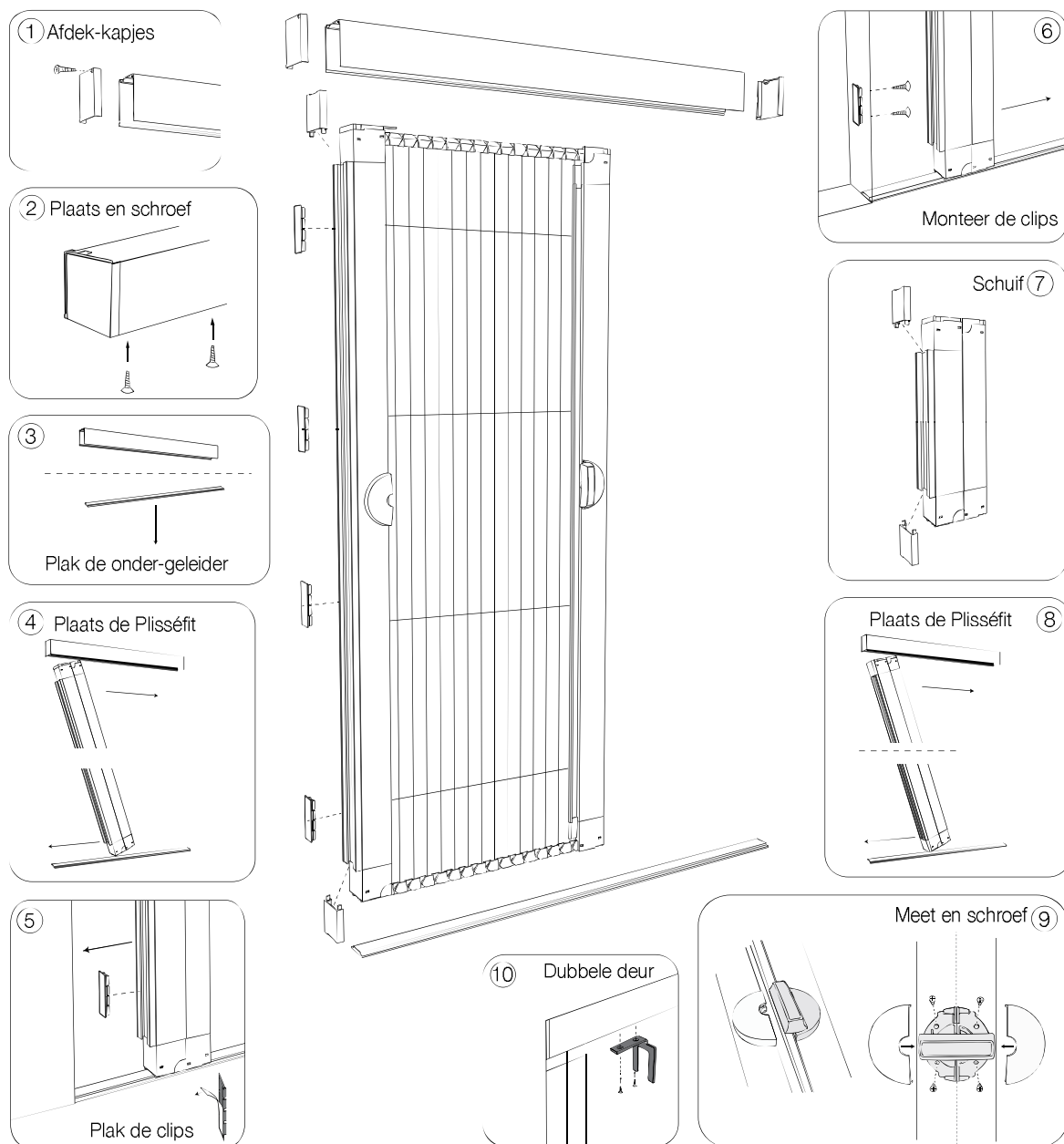
Handleiding Op de dag



Versie PF2015-0709

Figure A.71; Plisse insect screen (Unilux, 2015)

Handleiding In de dag



Unilux B.V.
i: www.unilux.nl

Fijnafstelling (Voor probleemoplossingen zie: [youtube.com/UniluxBV](https://www.youtube.com/UniluxBV))

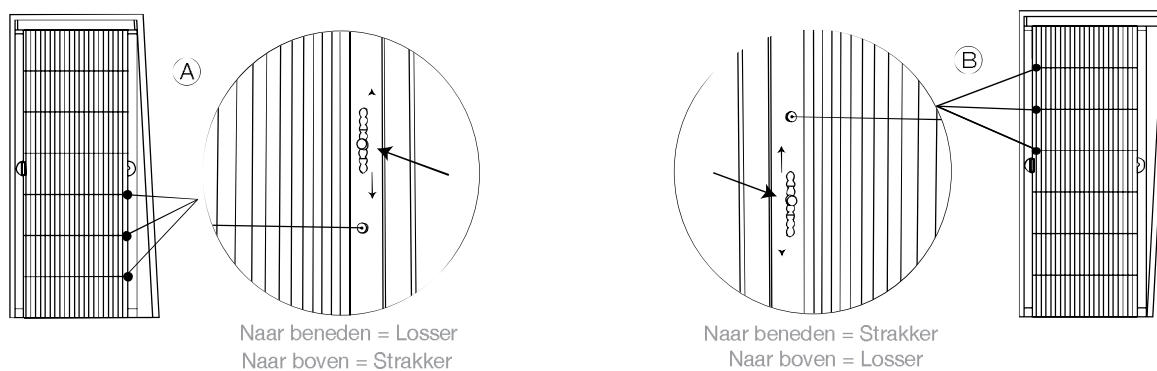
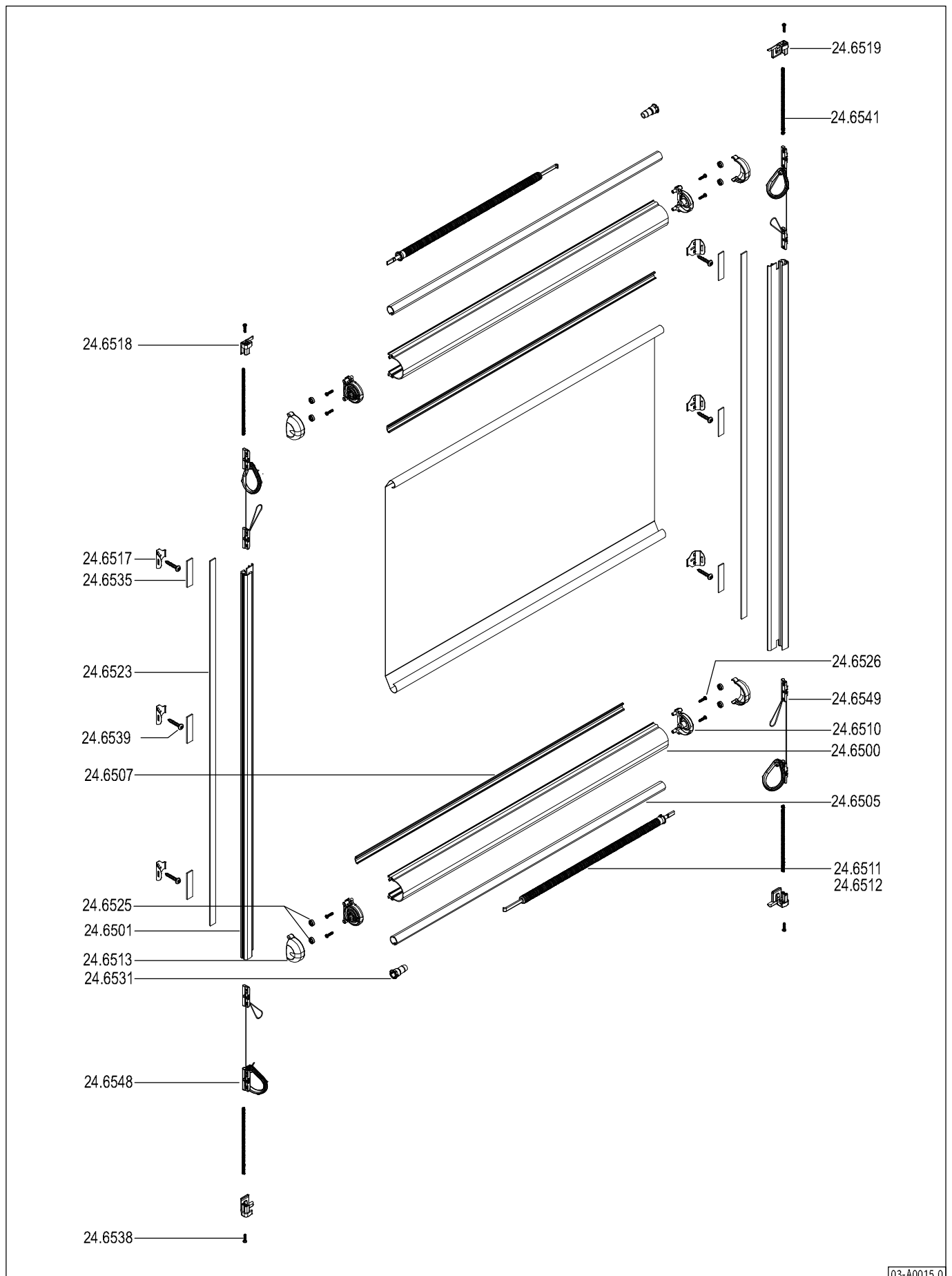


Figure A.72; Plisse insect screen (Unilux, 2015)

1.2 DOUBLE NANO ROLLER BLIND



03-A0015.0

Figure A.73; Nano double blind sun shading (HunterDouglas, 2015)

HUNTER DOUGLAS - NANO DOUBLE BLIND SUN SHADING

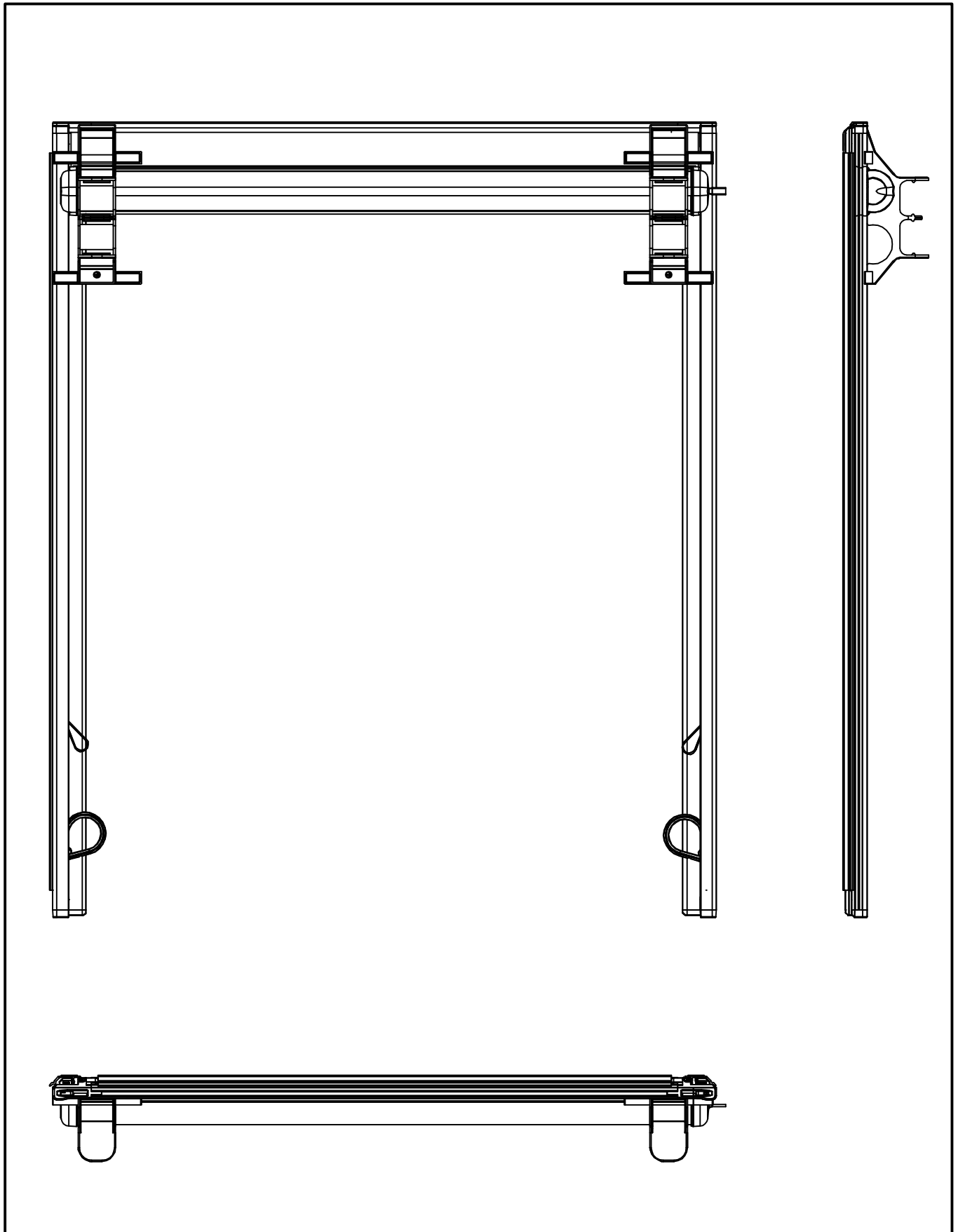


Figure A.74; Nano double blind sun shading (HunterDouglas, 2015)