MEMORY LANE **NURSING HOME**

- A DEMENTIA CARE FACILITY

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ABSTRACT

Dementia describes several various conditions in which the cognitive abilities are weakened by illness and is a disease that can cause personality changes, memory loss, and decreased motivation. Moreover, it is the main reason for elderly in Denmark to move into a nursing home. The aim for this master's thesis is to clarify the challenges that people with dementia encounter on a daily basis and examine possible design principles that can solve or minimize these challenges. Furthermore, to provide a practical workspace for caregivers, and comfortable spaces that enhance the interaction between residents and their relatives.

This thesis will present an architectural design solution for a nursing home that accommodates the needs for elderly diagnosed with dementia through spatial layout, wayfinding, and atmospheres to strengthen the feeling of home and belonging. There will be a focus on how to create a healthy indoor environment that stimulates senses and provides visual, acoustic, atmospheric, and thermal comfort.

The overall design method is inspired by the Integrated Design Process marked by iterations throughout the process. Moreover, the thesis involves a combination of primary research that involves a collection of original data from interviews, observations, and visits at chosen case studies, and secondary research that involves the processing of existing data collected by architects, academics etc.

The result is a dementia nursing home that connects the residents to the agricultural history of their past and strengthens their sense of belonging by drawing inspiration from the traditional 'four winged farm' in the building structure and layout. Furthermore, the tendency for wandering by people with dementia is accommodated through spatial organization consisting of four connected continuous loops with functions, such as a dining room and a gathering hall open for the local community to carry out events, along the route as well as glass walls with a view of the activities in the courtyards to distract the sometimes endless wandering. Way-finding is strengthened by implementing landmarks at decision points and creating a clear difference between the courtyards through the facades and activities characterizing each courtyard.

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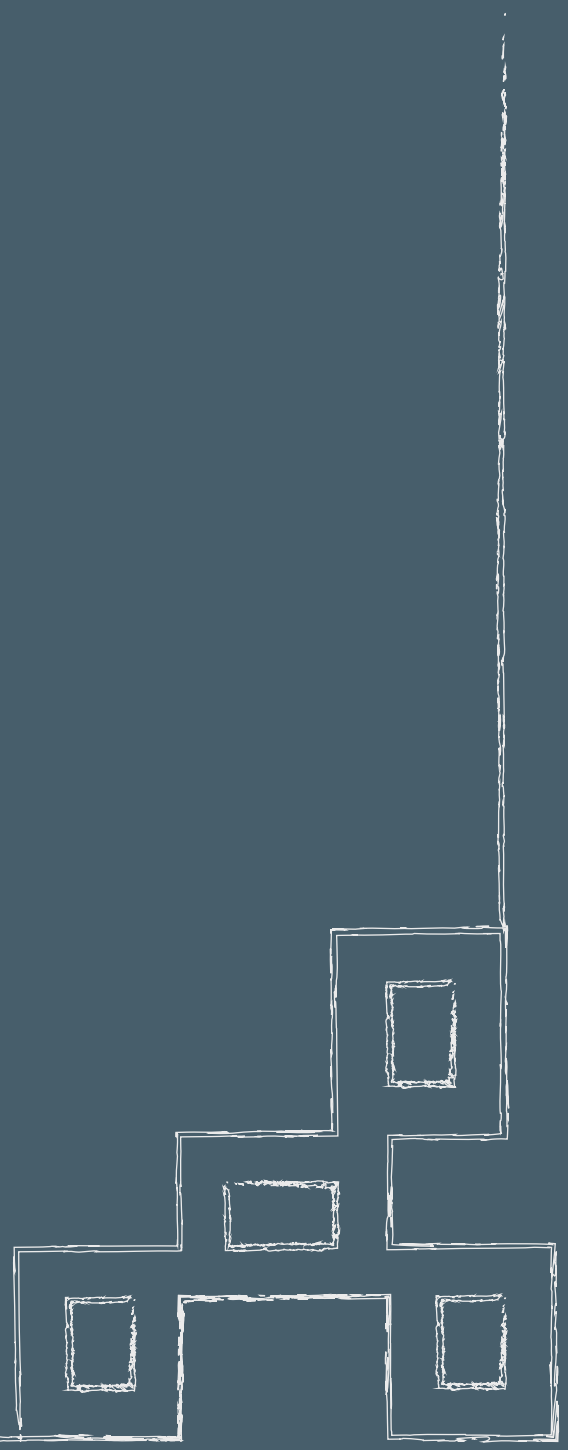
INTRO



INTRODUCTION

In the following paragraphs, an introduction to the thesis is given through an elaboration of the motivations for the chosen topic in regards to designing a 'Dementia Nursing Home'. This includes facts supplemented by personal experiences as well as reflections and statements from a relative to a person diagnosed with dementia.

Moreover, the overall method and sub-methods used to examine the identified problem that is chosen to be investigated, is presented. This includes the challenges that occur when communicating with people with dementia, and the reservations that are to be taken with the primary user group.

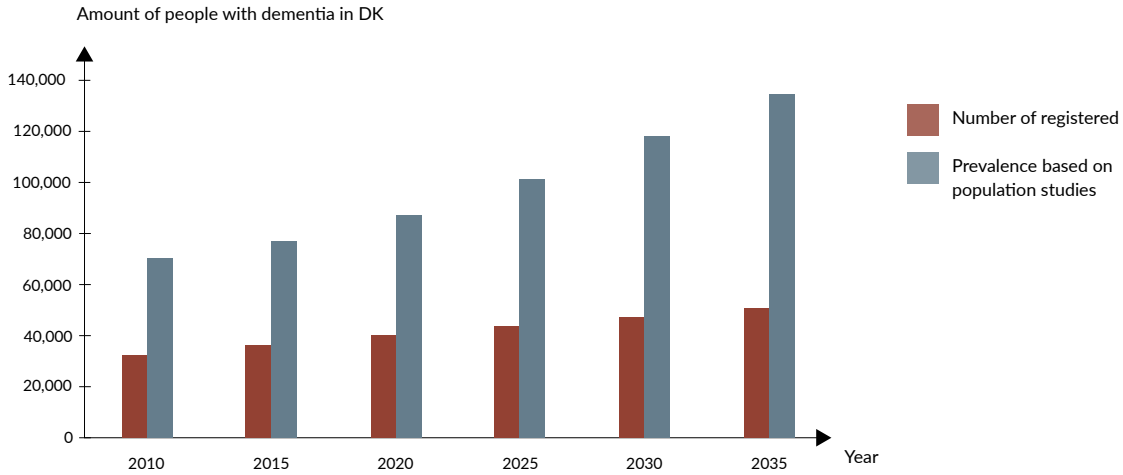
INTRODUCTION

DEFINING THE PROBLEM

The global population aged 80 years or older is expected to triple from 2019 to 2050 and reach 426 mil., meaning that the number of elderly people is growing at record speed and faster than the population as a whole (United Nations, 2020, p. 1-2). Likewise, the Danish population above 80 years is projected to increase 59 % from 2020 to 2030, leading this age group to make up over 7 % of the Danish population (Danmarks Statistik, 2020). Simultaneously, the number of people diagnosed with dementia is rising both globally and nationally. And even though dementia is not directly caused by aging, the probability of developing a dementia disease increases when people age (Graham et al., 2009). Internationally 46.8 mil. people are living with dementia, which is expected to rise to 131.5 mil. people in 2050 (Martin et al., 2015), while it is estimated that around 134.000 people above 65 years in Denmark will have dementia in 2035, a development of 47,000 since 2022 (Nationalt Videnscenter for Demens, 2023a).

This development has created a demand for more nursing homes designed for people with dementia, as this is the main cause for the 40,000 people above 65 years, who are living in a nursing home in Denmark in 2022, to move into a nursing home. The majority of these people are deeply dependent on getting help to get through everyday tasks such as eating, putting on clothes, and getting into or out of bed (Ældresagen, 2023a).

The aim for this master thesis is to design a nursing home that accommodates the needs of people with dementia through design strategies based on theory, research, observations, interviews etc. To design a nursing home that makes the residents feel at home, encourages community, and an environment that stimulates senses and creates a meaningful life for people with dementia. A building and spatial layout that accommodate the needs from both residents and staff members in regards to practical and logistical conditions, while still providing the residents with a sense of freedom and opportunity to leave their housing. Moreover, there will be focus on designing a healthy indoor environment in relation to acoustic, thermal, visual, and atmospheric comfort, and the effect it has on the residents well-being. Lastly, to design a welcoming environment where relatives can spend time with their loved ones and be part of their everyday life when visiting.



Illu. 1 - The expected prevalence of dementia in Denmark based on the current development (Nationalt Videnscenter, 2023b).

MOTIVATION

In Denmark 39,000 people were registered with a dementia disease in 2021 (Nationalt Videnscenter for Demens, 2023a). One of these people is my grandmother, who got the diagnosis in 2021 a few months after her husband passed, following years of battling illness. In these years my grandmother experienced stress and concern for her husband, as she was taking care of him in their home. She started to change behavior and became more and more forgetful, which the formal caregivers, who came several times a day, described as symptoms of stress from taking care of her husband as she had trouble handing over what she considered being her tasks to the caregivers and continued doing them as well.

When a family member is diagnosed with dementia, it affects the entire family. It can be a long, stressful and emotional journey for everybody involved, and in most cases lead to the big decision regarding when to move to a nursing home as the symptoms progress.

My grandmothers symptoms of Alzheimer's is to me very obvious through small acts, such as when she tries to turn of her computer with a remote control as she mistake it for a TV, or when I find food in the microwave from the day before as she have forgotten putting it in there, or when she is eating dinner three times, as she cannot remember that she already ate. However, more serious symptoms also appear when she does not recognize or confuse her great grandchildren and grandchildren with each other, or days when she asks me 20-30 times where my grandfather is or that we need to go visit him at the hospital. Then I have to tell her that he has died 20-30 times that day. To me he died one time 1,5 years ago, but in her mind he dies over and over again each day.

This is the reality that the 400,000 dementia relatives in Denmark go through (Ældresagen, 2023b). Slowly your father, mother, or grandparents who you have known your entire life are slipping away even though they physically are standing right in front of you. What are core memories to you, the person now cannot even recall, and in the late stages the person might not even remember you. Conversations or events suddenly seem meaningless as the person cannot remember it shortly after, and good memories start to fade as the stress from taking care of the person or worrying for their health and well-being overshadows them.

In general relatives do not have the same conditions as professional caregivers, as they are available day and night. A relative to my grandmother describes the course of the disease as experiencing a change in the child-parent relationship, where she has become a parent for her own mom, as she visits her daily to provide care that the municipal home care staff are not providing, such as buying groceries, washing clothes, and checking if the dog has been fed.

"As long as she is living at home, I feel like I need to carry on as if she does not have Alzheimer's and maintain the facade that nothing has changed, because these are my memories of her [...] The day I found out that she has Alzheimer's I became my mom's mom. I knew that everyday life would not be the same ever again [...] I feel like everything depends on me. I have become more stressed and walk around with my phone all the time in case the home care staff is calling. I am the contact person - the one they are always calling."
- Charlotte, 2023.

The transition from living at home to moving to a nursing center is not something that most people want to go through, but in Denmark that is what 40,000 people need, because the disease acquires care and treatment to live a meaningful life as much as possible both for the demented person and their relatives. Often the decision is made together with relatives, as they are affected by the disease too (Alzheimerforeningen, 2020). It is a big adjustment, when leaving your home to build another, and even more so when you have dementia, as it can be difficult to understand and remember why you need to move to get help with everyday tasks. New surroundings and people, especially caregivers, who will be a huge part of your life and the place you call home takes getting used to.

In my grandmother's case, she cannot remember having agreed to move to a nursing home nor having spoken with a dementia consultant from the municipality when the pre admission assessment was done. Leaving what has been home to you for more than six decades, a house with memories from your entire life, is deeply difficult. Therefore, when designing a nursing home for people with dementia, it has tremendous meaning for the resident that the best conditions are created for them to feel a sense of home.

METHODOLOGY

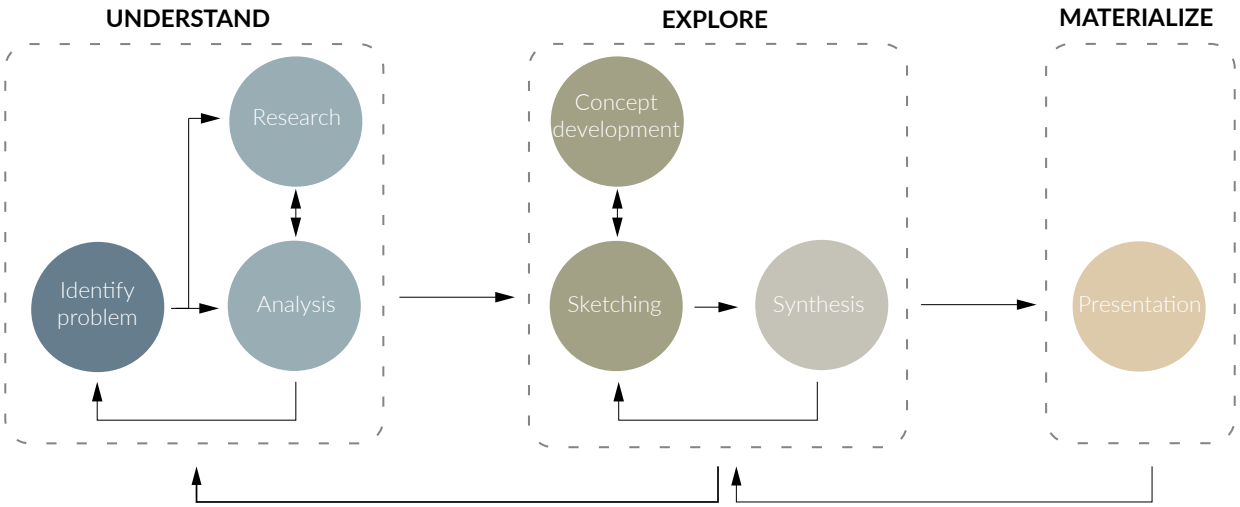
DESIGN PROCESS

The overall method used in this master's thesis consists of an iterative developing process with inspiration from 'The Integrated Design Process' (IDP), which is a holistic and iterative method with focus on combining architectural and technical knowledge through an integrated building design, where form, function, and aesthetics is integrated with technical parameters such as indoor climate, building energy, and construction. The aim is to provide the designer with an overview of the many aspects that must be considered in order to achieve better sustainable solutions and be implemented during the IDP (Hansen et al., 2005).

A simplified model of the IDP inspired method that shows the different phases as well as the order and connection between the phases, is seen in illu. 2. Divided into three overall stages of development: 'Understand', 'Explore', 'Materialize', each of the three sections of the thesis: 'Program', 'Design process', and 'Presentation', is represented respectively. An iterative approach has been applied to ensure a deeper integration of the two fields, architecture and engineering, with the aim to create sustainable design solutions. This resulted in a dynamic progression in the work process, where newly acquired knowledge from later stages were integrated in the design by revisiting earlier phases with new insights and experiences.

First stage includes three phases that together form the knowledge-based foundation of the project about the chosen problem to investigate.

The first phase, 'Problem', an idea generation of different topics and approaches was made to identify the problem that would be examined in the thesis, which led to an initial problem that established the foundation for the 'Research' and 'Analysis'



Illu. 2 - Visualization of the overall design process consisting of an iterative approach, divided into three overall stages.

phase.

In the 'Research' phase, relevant literature about the subject was researched to expand my knowledge about the topic and find reliable sources to support my statements or unfold a given subject through state-of-the art examples, research papers, and case studies. This phase involves a combination of primary research in the field that involved a collection of original data from interviews, observations, and visits at chosen case studies, and secondary research from desk studies that involved the processing of existing data collected by others.

The collected data was then analyzed, compared, and interpreted in the 'Analysis' phase, e.g. knowledge from an architectural guide for how to build in close relation to the landscape made by the Municipality of Hjørring was used to analyze the landscape through a phenomenological approach when visiting farms and walking around the building site.

The second stage aimed to explore design solutions to the chosen problem that meet the design criterias made in the first stage, and end with a final building design.

In the 'Sketching' phase, design ideas were developed through 2D and 3D visualizations by exploring various forms, layouts, principles of passive house design etc. Due to the iterations between the two first stages, the initial design sketches do not meet all of the design criterias presented in the first stage, as new research and analyses was added during the iterations, which resulted in new design criterias.

Simultaneous with the 'Sketching' phase was the 'Concept Development', where several ideas from the 'Sketching' phase were developed into a concept to bring clarity and coherence to the design. The concept was then further evolved in the 'Sketching' phase, hence the alternation between the two phases.

The 'Synthesis' phase describes the merging of the architectural and technical parameters considered in the 'Sketching' phase, e.g. designing the windows entailed a combination of considerations involving facade design, indoor thermal comfort, daylight, view, atmosphere, building energy consumption etc. The result of this phase was the final building design.

The third and last stage did not entail as many iterations as the two prior stages, as the design became finished in the 'Synthesis' phase, with the exception of minor corrections. Moreover, the 'Presentation' phase provides a visual and verbal presentation of the final design of the nursing home through both architectural and technical aspects, e.g. plans, sections, building energy consumption, indoor climate, and renderings.

Furthermore, several sub-methods have been used in the 'Research', 'Analysis', and 'Sketching' phases. These are as follows:

INTERVIEW

A series of interviews have been made to provide a better understanding of the user group based on their experiences and statements. All interviews were made at the start of the design process.

A formal, semi-structured interview was made with a caregiver at Pleje- og Omsorgscenter Banebo in Viborg and with a woman who is a relative to a person diagnosed with dementia. The semi-structured approach gave me, as the interviewer, control over the interviews, while the interviewee freely could answer the questions. Moreover, the order of the prepared questions depended on the conversation, and unprepared follow up questions were added to elaborate a specific theme or answer. For both interviews permission to record was given, and afterwards the questions and answers were written down, which gave a more precise representation of the interview when analyzing the answers.

Additionally, two separate unstructured interviews were made with two assistant leaders at Tornhøjhaven nursing home and with a caregiver at Lundgården nursing home, while touring the nursing homes. This is a good approach when wanting the interviewee to open up and express themself with their own words, and it helped with the conversation flow. In both cases, the unstructured interview was supplemented by a semi-structured interview at the start or end of the visits depending on the circumstances. This provided either a well-informed foundation or helped answering unanswered questions. These interviews were not given permission to be recorded, which made it more difficult to participate in the conversation, while simultaneously writing down the answers. Therefore, the majority of these interviews are based on memory from written down key words or important statements, which can be a disadvantage in relation to

the accuracy of the content when analyzing.

As dementia diseases affect the brain, it can change the person's memories and perception of time and space. Therefore, it can be challenging to interview a person with dementia, and is important to make certain reservations when interviewing. Due to difficulties interviewing the primary target group, as interviewing residents at the visited nursing homes was not an option, formal interviews made by an active member of the Scottish Dementia Working Group and former vice chair of the European Working Group Person with Dementia were included. The interviewer was diagnosed with early Alzheimers in 2006 herself and through these interviews, she aims to spread awareness about the disease. This contributes to questions with a deep understanding of the subject, but it can also provide subjectivity to questions.

In addition, I was able to perform an informal interview with a person with dementia to get insight into the mind of a person with a dementia disease. Only a few quotes and key words were written down as the person easily got distracted due to her diagnosis. Still, it is of significance to underline the uncertainty in regards to the answers as the mind of a demented person is challenging to truly comprehend and is different for each individual.

PERSONA

Three fictional characters representing a resident with dementia, a caregiver, and a relative were made based on a composition of empirical data obtained through interviews, observations when visiting nursing homes, research papers, and personal experiences. Each persona is presented through social, physical, and physiological characteristics that are a compilation of the aforementioned methods. The purpose of this method is to provide a tangible and realistic representation of the user group when designing.

SCENARIOS

Three different scenarios were made for each of the three personas through storyboards consisting of a number of drawn illustrations that visualize some of the challenges that follows from being diagnosed with dementia, working with demented people, or being in close relation to a person with dementia. This method is based on empirical data collected through interviews, observations when visiting nursing homes, research papers, and personal experiences to visually present a deeper understanding of some of the challenges that the user group experiences on a daily basis.

OBSERVATION

Personal observation was used as a method to gain knowledge about caregivers' and residents' actions when visiting the two nursing homes. By observing how they acted and reacted in their surroundings, design challenges that the residents and caregivers were not aware of or able to express verbally in the interviews were obtained. The observations were made in authentic surroundings at the nursing home during a conducted tour by a caregiver in one instance and in another by two assistant leaders, and the observation was written down as it occurred to provide an accurate representation when mentioning or illustrating the action or reaction, and to prevent false memories. However, recording the conversation was not an option at either nursing homes, but this could have been beneficial to supplement the observations and make sure to prevent a fault analysis. Lastly, at Tornhøjhaven permission to take pictures of my observations was given, which strengthened the method.

CASE STUDIES

An in depth examination of two separate nursing home buildings, Lundgården and Tornhøjhaven, was analyzed through plans and photos supplemented by the aforementioned interviews with a caregiver and two assistant leaders, respectively. The aim was to understand the context and design approach of each case as well as the functionality of spaces, building layout, and design principles used for wayfinding. A combination of primary and secondary research was used to provide a much broader and higher-quality analysis of the cases by integrating field studies consisting of original data from interviews and observations, with desk studies involving existing data collected by, for instance, the architecture firm who designed the nursing home.

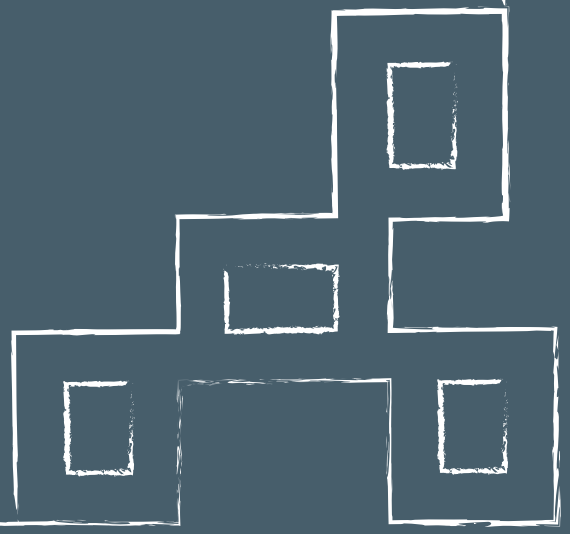
THE PROBLEM STATEMENT

OBJECTIVES

By utilizing the aforementioned methods, the aim is to design a nursing home that answers the following question, which presents the identified and chosen problem to investigate in this thesis:

How to design a nursing home for elderly diagnosed with a dementia disease, with a healthy indoor environment that stimulates senses, enhances the elderlies' sense of home, and improves wayfinding through spatial layout, as well as a building that reflects the site's context and open landscape?

02 PROGRAM



USER UNDERSTANDING

Over the years, there has been an increasing focus on health care and healing architecture to improve the environment and well-being for demented people as well as research regarding this topic. In this paragraph some of the research will be presented and reflected upon with the intention to present the state of the art in relation to sensory challenges and wayfinding in regards to dementia. Additionally, a formal semi-structured interview with a caregiver is conducted to get an insight into the everyday life of a caregiver and the challenges that come with it. Lastly, three personas and storyboards are created to represent the characteristics and challenges of the user group.

UNDERSTANDING DEMENTIA

PHYSICAL CHANGES AND INFLUENCE ON MEMORY

The following describes the four main types of dementia diseases and the symptoms that can appear in different stages of the disease. In addition, the statistical development of dementia, both globally and nationally, is presented to shed light on the rapidly rising need for nursing centers with focus on dementia design solutions.

WHAT IS DEMENTIA?

Dementia is not a specific disease but a term used to describe several various conditions in which the cognitive abilities are weakened by illness. The symptoms are many and vary from individual to individual, but can include personality changes, difficulty planning, decreased motivation, memory and judgment. Often complex thinking as well as trouble remembering actions or experiences that have happened a few days or even a few hours ago are the first symptoms of dementia (Graham et al., 2009).

In continuation, there exist many different types of dementia, whereof the four main diseases that cause the condition is Alzheimer's disease, Vascular dementia, Lewy Body dementia, and Frontotemporal dementia. Each disease has its own characteristic symptoms that can appear different in each individual, and sometimes overlap, making the cause of dementia difficult to tell apart (Graham et al., 2009).

Alzheimer's disease is the most common type of dementia with around 62 % of all cases (Alzheimerforeningen, 2023a). In the early stages the symptoms often include mild memory loss and confusion that gradually progress over time to more severe symptoms that may eventually make it necessary for help day and night. The brain consists of millions of nerve cells that make us able to think and remember. When having Alzheimer's these nerve cells are damaged by a protein in the brain called Beta-amyloid, which is present in all brains, but in individuals with Alzheimer's they behave unusually by clumping together. This affects the neurons that contain the protein Tau to produce an abnormal amount of this protein that has influence on the shape of the nerve cells. This results in nerve cells dying or collapsing, which makes the brain shrink in some areas (Graham et al., 2009).

Moreover, the three main functions of the hippocampus involve creating new memories, wayfinding, and stress control (Fich et al., 2017). The cerebral cortex is the outermost layer of the brain that consists of nerve cells that involve memory, thinking, learning, problem-solving, emotions, and senses. Within the cerebral cortex a region called hippocampus is located in the brain's limbic system in each of the brain's two hemispheres. Often Alzheimer disease starts in the hippocampus before spreading to other regions of the brain, which explains why decreased memory is one of the first symptoms experienced (Alzheimer's Society, 2019).

Illu. 3 - Prevalence of the most prominent dementia diseases stated in procentages (Alzheimersforeningen,2023b).

Furthermore, the hippocampus decreases in size when experiencing long-term stress, which can be defined as an unbalanced homeostasis, where all systems in the body are in an unbalance. This affects the stress response system as the release of cortisol increases rapidly, which causes an overload on the hippocampus that can lead to an acceleration in the disease (Fich et al., 2017).

Vascular dementia is the second most common dementia disease with around 17 % of all cases (Alzheimerforeningen, 2023a). It is a disease in the brain caused by disturbances in the brain's blood supply due to e.g. a stroke or fat starting to accumulate on the inside of the blood vessels, which narrows the vessels and thereby restricts the blood flow. In relation to which parts of the brain that are affected by this reduced blood flow, different symptoms appear. In the early phases, it is especially memory, language, and personality that can be affected. In comparison to Alzheimer's disease, Vascular dementia begins more suddenly and worses in phases rather than gradually (Graham et al., 2009).

Lewy Body dementia represents around 4 % of all cases (Alzheimerforeningen, 2023a), and differs considerably from Alzheimer and Vascular dementia, as the symptoms in the early stages often are similar to Parkinson's disease, including shaking, stiffness, and reduced mobility. In addition, it is also common to experience hallucinations. However, reduced memory and difficulties in thinking are similar to the aforementioned dementia diseases, but can vary from hour to hour. In an individual with Lewy Body dementia, a special protein is accumulated inside the nerve cells in the brain and forms Lewy bodies, which disrupt the normal functioning of the nerve cells (Graham et al., 2009).

Lastly, Frontotemporal dementia is the fourth most common cause for dementia and makes up around 2 % of all cases (Alzheimerforeningen, 2023a). The main part of the brain that is affected is the frontal lobe, which often causes major changes in the personality with behavioral disturbances and the ability to speak or find the right words. Often the situational awareness gradually disappears and the individual becomes impulsive and reckless. Contrary to Alzheimer's disease, the areas of the brain involved in memory are often not affected until relatively late into the course of the disease (Graham et al., 2009).

DIFFERENT TYPES OF MEMORY

According to which parts of the brain that have been damaged, different types of dementia can result in different kinds of memory problems. 'Working memory' involves when a person stores information only for a few seconds in their conscious thought to e.g. remember an address until you are able to write it down. When experiencing problems with this memory type, it can be difficult to comprehend the meaning of long sentences. Contrary to other types of memory, 'Working memory' does not need the hippocampus, but relies on other parts of the brain (Alzheimer's Society, 2019).

'Semantic memory' refers to more general knowledge, e.g. memory of objects and the meaning of words. If the disease damages the left temporal lobe, it can affect the ability to understand language, which often is the case in the early stages of Alzheimer's through difficulties with finding the right words (Alzheimer's Society, 2019).

'Episodic memory', is the memories of past events and experiences, which are created in the hippocampus, where they are stored for a short period of time. However, selected memories are moved to the cerebral cortex, which is the reason why it can be easier for people with dementia to remember experiences from years ago than something that happened last week. Sometimes it happens that older memories can be triggered through senses, e.g. when hearing a specific song or smelling a specific odor. In some Alzeimer's cases the disease can in the later stages be spread to the cerebral cortex, causing these long-term memories to disappear as well (Alzheimer's Society, 2019).

'Procedural memory' refers to remembering skills that a person has acquired throughout their life such as using a computer or riding a bike. In comparison with 'semantic memory' and 'episodic memory' this type of memory is often quite well-preserved (Alzheimer's Society, 2019).

SENSORY CHALLENGES AND INDOOR CLIMATE

HEALTH AND WELL-BEING

As a result of the increasing amount of dead nerve cells, the impact of the disease becomes more and more problematic for the individual, as the brain cannot process the same amount of information anymore. This expresses itself in the gradual worsening of sensory skills in the form of hearing, vision, touch, taste, and smell (James et al., 2017), which is elaborated in the following, complemented by statements from people with dementia to get insight into the lived experiences of sensory challenges when having dementia. Additionally, the connection between sensory challenges and the indoor environment is elaborated through inclusion of relevant studies.

HEARING AND ACOUSTIC INDOOR ENVIRONMENT

The three stages of hearing include: 1) Detection of the sound, 2) Resolution, which involves localizing where the sound is coming from, and 3) Identification through naming and understanding the sound. Over 70 % of people aged 70 and over have some sort of hearing loss, and when having dementia the hearing process can be particularly compromised (Feddersen et al., 2014). Some people with dementia can be affected by difficulties when processing auditory information, which includes problems with filtering sounds. They may be overwhelmed in environments with several sound sources and be unable to differentiate the sounds from each other, which can lead to a hypersensitivity to auditory stimulation (James et al., 2017). Hearing aids can increase background noise, which is the reason why it is important to eliminate meaningless background noise (Hoff et al., 2008). Likewise, they can get easily overstimulated when hearing loud sounds or unexpected noise (James et al., 2017).

"'In noisy environments I just can't think... my brain shuts down..."
- Agnes (Houston, 2015, p. 6, l.17-18)

This sensitivity to sound can especially occur in large rooms with reflective surfaces where the reverberation times are long. Therefore, it is important to consider surface area and the implementation of absorptive materials when designing the indoor acoustic environment, to reduce the amount of bounces sound waves make on the surfaces. The size, function, and placement of common areas where multiple residents stay at the same time and a TV or music is playing, is also important to consider due to the many overlapping sound sources. External sounds from traffic or other noise sources from the site context should also be considered when designing the building, as well as the construction of floating floors or walls that through insulation can control absorption and transmission of sound.

Not only can the communication among residents be affected, but also between the caretaker and resident, as the auditory impressions are distracting, which can be isolating for the resident (Houston, 2015).

Research finds that music therapy can help develop verbal and non-verbal communication in people in advanced stages of dementia. A study was conducted on eight adults with dementia who participated in an eight hour long music session once a week for eight weeks together with their caregivers and profes-

sional musicians. Based on observable data of the participants behavior, 10 communicative actions such as laughing, pointing, body positioning, and playing an instrument were categorized. Due to the communication difficulties that people with dementia often experience, it can be hard to form connections with other people or get the feeling of belonging in a group. However, in this study it was experienced that social interaction responses through mirroring, turn taking, and humor with the other participants led to positive interactions. Moreover, the setting in which the study was conducted consisted of a multisensory experience as it entailed visual, auditory, tactile, and physical components as the participants could see, hear, and feel the textures of the instruments. This made it possible for the participants to utilize different senses that appealed to them when interacting, and indicated that multisensory environments can improve the communication between people with dementia and their caregivers (Clare et al., 2020).

VISION AND VISUAL INDOOR ENVIRONMENT

Visual impairment can be experienced through a loss of depth and the speed of perception, where the brain's capacity to process information is reduced (James et al., 2017), also described as 'brain blindness', where the eyes see, but there is a delayed interpretation in the brain of what is seen (Houston, 2015). When implementing a mechanical ventilation system, it therefore can be beneficial to make sure that fittings with supply air are not directed towards e.g. curtains as it can result in movement, which may cause the demented person to think someone or something is in room with them (Hoff et al., 2008). Other experiences involve a narrowing of the visual field, where the individual has difficulties with seeing objects in the periphery of their visual field. Likewise, there can occur a difficulty with recognizing patterns, e.g. stripes or dots can appear to be moving or misinterpreted as something completely different (James et al., 2017).

"In shops they always have a big black mat and that looks like a hole, so it is perception and a leap of faith to actually step on to it..."
- Tommy (Houston, 2015, p. 4, l.14-16)

Furthermore, lighting can have a great impact on the biological clocks of people with dementia, as their circadian rhythm can be more disturbed than in elderly without dementia. A study with 13 demented patients at a psychiatric hospital shows that their sleeping patterns improved when being exposed to three biodynamic lighting armatures, which were placed in the common room with an illuminance level, color temperature, and intensity corresponding to a real daylight curve. This resulted in a decrease in the amount of wandering during the night and napping during the day, as well as a significantly prolonged sleep during the night time (Dahl et al., 2019).

Therefore, daylight considerations are important when designing for people with dementia. Not only are the placement and size of windows determining the amount of natural daylight that penetrates through the room, but it also allows the elderly to have a connection to the outside world and follow the surroundings as the day progresses.

TASTE, SMELL AND ATMOSPHERIC INDOOR ENVIRONMENT

In elderly people with dementia the olfactory sense is affected, as it may influence the perception of different smells due to the decrease and shrinkage of olfactory cells in the forebrain. When Implementing a ventilation system it will be beneficial not to have it manually operated, as people may not be aware of a smell that needs ventilation (Hoff et al., 2008).

"I often ask my wife to show me the packet (because I don't believe it's what I asked for)... It's (the smell) just not right..." - Ross (Houston, 2015, p.9, l.7-9)

Often dementia diseases are associated with feeding difficulties, as some people experience a decrease in appetite. However, research studies conclude that when exposing people with dementia to food related smells from an adjacent kitchen, it can improve their appetite. A study where 32 elderly aged above 75 years from three different Alzeimer's disease units participated in two control lunches and two primed lunches, where a large scent diffuser sprayed food odors into the room related to the food they were going to eat 15 min. before the meal was served. Afterwards, two measures regarding food intake and behavioral assessment were conducted for each participant. The result was that the participants consumed more food during the primed lunch than during the control lunch with an increase of 25 %, while behavioral measurements indicated that the resident showed an increase in interest toward the food (Sulmont-Rossé et al., 2018).

Therefore, it can be beneficial to program the spatial layout between common areas or rooms where the residents are staying prior to mealtimes in such a way that the odor from the kitchen can spread throughout the rooms. However, it is important that loud and sudden sounds from the kitchen stay shielded.

TOUCH AND THERMAL INDOOR ENVIRONMENT

Sometimes sensitivity to touch also appears among people with dementia, who can develop hypersensitivity or hyposensitivity in different parts of the body due to the decreased processing in the brain. While parts such as hands, feet, and mouth can become heightened in sensitivity, other parts such as legs and arms can become less sensitive to touch. These kinds of changes when being touched can therefore have great impact on individuals, who need help with brushing teeth or showering, which require physical contact (James et al., 2017).

In general, elderly have a lower activity level than younger people, resulting in a decrease in the ability to regulate body temperature and therefore have a need for higher ambient temperatures. It may not be clear for people with dementia that a room is too cold or too warm, and they do not associate the room temperature with the discomfort that they are experiencing. Instead they feel uncomfortable and frustrated without being able to verbalize it. Radiators and manual heating systems should be avoided or covered up as people often forget if they have adjusted the temperature and may get the impression that the system is malfunc-

tioning. Likewise, the thermal comfort in the bedroom needs to provide reasonable temperatures to prevent the individual from leaving their beds during the night, and thereby decrease the risk of them falling (Hoff et al., 2008).

To sum up, the connection between the indoor environment and senses have a great impact on the health and well-being of elderly with dementia. When designing it is significant to consider reverberation times in common rooms to avoid distractions and confusion as well as room programming to increase appetite through food odors. Additionally, window sizes and placement should strengthen the circadian rhythm to decrease wandering at night, and automatic systems should be implemented, as people with dementia have difficulties remembering having adjusted the systems or are unaware of an unhealthy indoor environment. Likewise, manually controlled systems can cause a higher energy consumption.

WAYFINDING
STATE OF THE ART

WANDERING

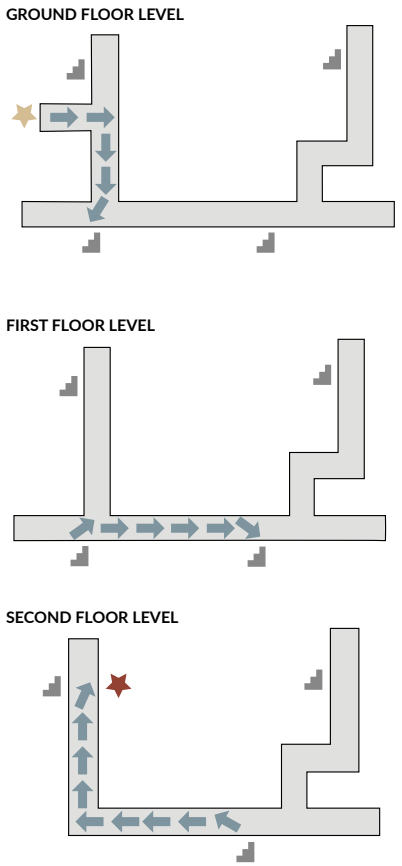
Alzeimer's disease causes some people to lose their sense of direction and ability to recognize places due to an impairment of cognitive spatial skills, resulting in a struggle to build a mental map of the living environment, making them feel uncertain and disoriented even in familiar environments. Often they feel compelled to walk around without having any place to go and do not realize what direction they are heading (Alzheimer Association, 2023). Wandering can be triggered by various reasons, including a changed environment, e.g. when moving to a nursing home and leaving their well-known home behind. People with dementia might wanna escape an overstimulated environment, e.g. due to loud noises or blinding sunlight. Moreover, it can be caused by boredom as wandering might be a way of feeling occupied, or due to a loss of short-term memory where the person forgets where they were going and why. Another reason for wandering can be explained by a searching for the past, where the person is looking for someone or something in relation to their past, e.g. a partner who has died or a childhood home (Dementia Australia, 2020).

This wandering behavior occurs among all dementia diseases, even in the early stages, and as the disease progresses, the risk for wandering increases (Alzheimer Association, 2023). It can be problematic as it increases the risk of fatigue and injuries, but it can also be potentially life-threatening, and leaves the relatives and caregivers in distress. In Denmark, it is estimated that around 1,500 people with dementia leave their home each year, of which more than half of them disappear during autumn and winter (Alzheimerforeningen, 2022). Therefore, when designing a dementia nursing center it is important to provide spaces for managed wandering in a safe environment, as it can have a great impact on the health and well-being of people with dementia and potentially save lives.

INDOOR WAYFINDING

A research study that aims to examine elderly's experience when navigating in an unfamiliar environment shows which strategies are used when learning a new route and possible causes for disorientation. The study was conducted at a retirement development with independent living and shared common areas, where 32 elderly over 65 years were guided through the building in a specific route once. The participants had never been in the building, and therefore were unfamiliar with the space. They had to memorize the route to their best ability and afterwards repeat the route by themselves. If any error occurred, they were instructed to return to the starting point and repeat the route until it was done successfully. The route consisted of seven 'decision points' as shown on illu. 4, where landmarks such as paintings or objects were placed at some of these. After all participants completed the route, they were asked four questions that focused on the strategies that were used to memorize the route and the causes for possible disorientation as well as their design preferences (O'Malley et al., 2020a).

It was discovered that the most used orientation strategies included verbalizing the route and visual cues through e.g.



Illu. 4 - The route that the participants walked during the experiement. The yellow star indicates the starting point, and the red star indicates the end point (O'Malley et al., 2020b).

landmarks, signage, and door numbers. Participants stated that landmarks helped them when deciding when to change direction during the route and differentiate the different floors from each other. A few also reported that structural cues influenced their navigation, as the floor plan guided them through shifts between long corridors and corners (O'Malley et al., 2020a).

26 of the participants stated that they experienced disorientation within the development through the lack of environmental cues such as windows (O'Malley et al., 2020a), which creates a connection to the outside and provides navigation information through the position of the sun and the outside view. However, repetitive design and long corridors was the leading cause for disorientation among the participants:

"Corridors were long so you could lose sense of position – no windows with views." - Alice (O'Malley et al., 2020a, p. 11, l.14-15)

Even though none of the participants were diagnosed with a dementia disease, this study gives an indication of some of the orientational challenges that people with Dementia experience. Moreover, it shows the importance of placing landmarks at decision points to help with orientation and wayfinding in unfamiliar environments. However, too many landmarks can cause information clutter and deteriorate the ability to navigate (O'Malley et al., 2020a).

Similarly, another study concludes that the number of decision points have a significant impact on wayfinding, and needs to be reduced on the routes. 14 design criteria that support wayfinding and spatial orientation were evaluated on 14 different floor plan layouts of existing inpatient care facilities for people with dementia. The design criteria involve moments of decisions on the route, location of living room and entrance, and visual access between living room, corridor, and entrance among others. It was concluded that the different layouts have both advantages and disadvantages. However, it is assessed that floor plans consisting of one straight corridor or one continuous loop corridor provides the most optimal surroundings for people with dementia, while a spatial layout consisting of two corridors that are separated by other functions seems to have a negative impact on wayfinding skills. Likewise, corridors with one or multiple corners as well as corridors combined with other functions have a negative effect (van Buuren et al., 2022).

Additionally, the residents should be able to adapt to different environments quicker through a gentle transition between private rooms and public common area spaces. Closed and inaccessible space at the end of a corridor often leads to frustration for people with dementia. Therefore, dead-ends must be avoided, either by placing a common function at the end of the corridor or by designing a continuous loop corridor. Lastly, visual accessibility between spaces increases the ability to make decisions and strengthen their cognitive map (van Buuren et al., 2022).

In conclusion, it is important that the spatial layout allows spaces for managed wandering in a safe environment through a continuous route with no dead-ends or one straight, short corridor with a common function at the end. The implementation of activities or 'way stoppers' along the route can also be beneficial, as having a reason to stop wandering and engage in an activity can create a sense of purpose to their wandering. Moreover, decreasing the amount of 'decision points' and implementing landmarks at 'decision points' can help improve the cognitive map for people with dementia and strengthen their wayfinding skills.

CAREGIVER
INTERVIEW

Nathalie Galfe Østergaard is an educated SOSU Assistent, who has worked at four different nursing centers throughout her career since 2010. Currently she works as a SOSU Helper at Pleje- og Omsorgscenter Banebo in Viborg Municipality, where she has been working for the past 3 years. The nursing center is not specifically targeted towards people with dementia, but among the residents there are people with a dementia diagnosis, and for the past 13 years Nathalie has been taking care of elderly with dementia. Therefore, she has gained experience and seen how it can affect both the demented person and their relatives. She has also felt first hand the impact it has on professional caregivers through her own work. In this section some of the challenging aspects of working as a caregiver and the tasks they perform will be presented from a caregivers point of view. For an extended version of the interview, see appendix 1.

TASKS

Nathalie works strictly on evening duties from 3 pm to 11 pm. In this time span her tasks are various and involve both taking care of the residents, administrative work, and talking with relatives. Throughout her shift she is equipped with an Ipad that entails a list of tasks that need to be accomplished for each of the residents at a given time. For example, when distributing medicine she has to make sure that it is dosed correctly, give the medication, and then sign off that the resident has taken it. When making an unusual observation regarding a resident, or if a resident needs extra care, she also registers it in the Ipad to pass on information that the night watch needs to be aware of, e.g. that a resident needs his or her blood pressure or heart rate measured.

"We sometimes wish there wasn't so much documentation, and you could actually spend your time doing something good for the residents. [...] So sometimes it's a bit tiresome that it takes up so much time, but it does. There must always be documentation of what is being done, even if it is a short visit to the toilet..." - Nathalie Galfe Østergaard, 2023.

The first task Nathalie does when showing up for work is change into uniform and get a short brief from the day watch about the 17 residents that she and her coworker are going to take care of. Then she is ready to greet the residents that are awake in the common area, where they are drinking coffee, and wake up those who are still taking an afternoon nap, help them to the toilet, and make sure they get something to drink. Afterwards she is distributing medicine before gathering the residents for dinner around 5.30 pm, where she serves the food and sits as much as possible with the residents. This is called a pedagogical meal, where the caregiver is present to improve the residents' experience. Some need a little help with cutting out their food, while others cannot eat by themselves, which Nathalie helps with. After the meal, she sits down with them, engaging in conversations, and occasionally sings with them, or a helper reads to them. Thereafter, she takes a short break, before serving the evening coffee at 07.30 pm in the common room, for those who want to participate, and enjoy what is currently on TV. As the evening progresses she and her coworker start helping those who want to go to bed from around 08.30 pm. She helps some residents through guidance in relation to brushing their teeth or with toilet visits. Others need complete help getting into bed with a lift, putting on nightwear, and brushing their teeth. At the end of her shift, around 10:00 pm, she starts cleaning up the common room and writes some journal notes before giving a short brief to the night watch.

" [...] we don't spend a lot of time in the offices. We are out in the field, providing care for the elderly. [...] I can say that nurses and similar professionals might use our offices for certain tasks. [...] Precision is crucial when dosing medication, so it's important to have a quiet environment where you can concentrate without any distractions." - Nathalie Galfe Østergaard, 2023.

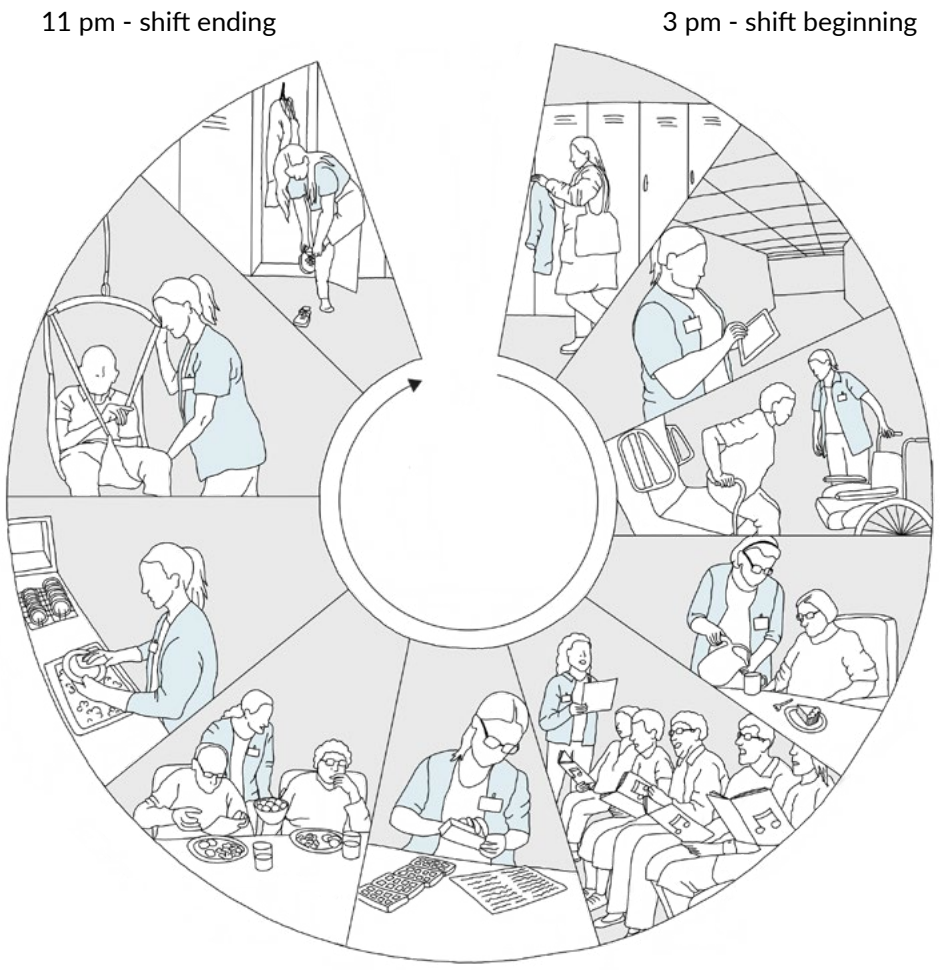
Another vital aspect of the caregiver role is the communication with the residents' relatives, providing essential information and offering reassurance either in person or over the phone. Family and friends visit primarily during the day, and the visits take place in the resident's apartment, in the common living room, or smaller excursions are made to e.g. the local supermarket or just a walk in the neighborhood. Including the relatives in the residents' life after moving to a nursing home is important, not only for the residents' sense of familiarity and home, but also for the relatives to connect with their loved ones and enjoy the time they spend together.

"Relatives are always welcome. If we have someone who is dying, we actually have a guest bed that we offer to set up in the resident's room. [...] So, the relatives are sometimes offered the option to stay overnight with their mother, father, or grandmother." - Nathalie Galfe Østergaard, 2023.

BREAKS

When working with elderly at a nursing center, you have to be prepared for a dynamic work environment, where each day is different, and as Nathalie describes it: "You never really know what you are showing up for". It can be both physically and psychologically challenging, making a break much needed at times, but it is not always possible. On certain days, the pace can be extremely hectic, leaving no room for even a 5 min. break, while the workload on other days is more calm, making longer breaks possible. However, it all depends on the residents health and well-being.

Usually Nathalie spends her breaks in an adjacent room to the large common room for the residents, where she and her colleague meet up to relax, get a cup of coffee, and talk when it is possible. Here they can confide with each other about the residents, e.g. if they need help with a task or just need someone to talk with. However, it can be difficult to take a break, not only due to the dynamic work environment, but also because of the necessary short distance between the residents common room and the nursing home's break room, which gives her visual and audible contact to the residents.



Illu. 5 - Visual representation of the tasks made by a caregiver during an evening shift.

"Even if we are having a break, the residents can still contact us on our community alarm. So it is not like they cannot get in touch with us, and they can also see us, so we are not that far away. [...] So we are actually more or less on all the time." - Nathalie Galfre Østergaard, 2023.

WORKLOAD

When asking Nathalie, if she feels like it can be stressful to take care of 7-9 residents at the same time, she expressed that it can be in some periods. Especially during the corona lockdowns, where she had to dress in protective clothing each time she entered a residents apartment, or when residents get any other contagious illness, where they need to be isolated and require extra care. Currently the nursing center that she is working at has two empty apartments.

"This means that you suddenly have a little bit of time to give some 'Star moments' to people who are there. It also means that it is a little bit quieter, because you have two fewer residents." - Nathalie Galfre Østergaard, 2023.

It can be both physically and psychologically challenging to work with demented people, particularly when the same conversations are repeated numerous times throughout the day each day. After years working in close relation with people with dementia, Nathalie has learned how to interact in such situations with repetitive behavior and conversations in a way that is the most beneficial to both of them.

"Patience is a virtue, I can tell you that. [...] They can also become aggressive, and in reality it is because they lose their identity a little bit. It is a bit scary to them. They know that something is happening, but they can not figure out what it is, but they can sense that something is happening." - Nathalie Galfre Østergaard, 2023.

"Often people with dementia feel and see much, much more than you think. They see your facial expressions and your irritation more than you think." - Nathalie Galfre Østergaard, 2023.

Sometimes it happens that Nathalie and her colleagues switch the residents that they are caregivers for to relieve each other when necessary. It can be hard to take care of the same residents each day when they have dementia due to repetitive behavior. Likewise, it can be physically hard to take care of some of the residents, especially when putting them into or out of bed. Despite the presence of two caregivers and the use of a lift, the physical strain when transferring the residents into the lift is significant, especially those who are unable to help with e.g. lifting their legs.

"It can sometimes be a bit heavy if it is a very heavy citizen, then it is nice that there are two of us so I do not have to stand and use so much effort. You can feel it in your shoulders and other places, if you have had a lot of lifting like that. If I have to stand for five shifts and lift some heavy legs and stand and move legs that never really help me, then I can feel it in my shoulders and in my body." - Nathalie Galfre Østergaard, 2023.

To sum up, the role of a professional caregiver entails various tasks, including helping the residents get out, writing journals, and communicating with the relatives. It can be physically and mentally hard at times, when the nursing home houses many residents with special needs or illnesses. However, for Nathalie it is rewarding work to bring meaning to others' lives and create 'star moments' that bring joy to their lives.

USER GROUPS

” I will probably forget myself in the end.

Jytte Sørensen, 2023, diagnosed with dementia

” Often people with dementia feel and see much much more than you think. They see your facial expressions and your irritation more than you think.

Nathalie Galfre Østergaard, 2023, caregiver

” The day I found out that she has Alzheimer’s I became my mom’s mom. I knew that everyday life would not be the same ever again.

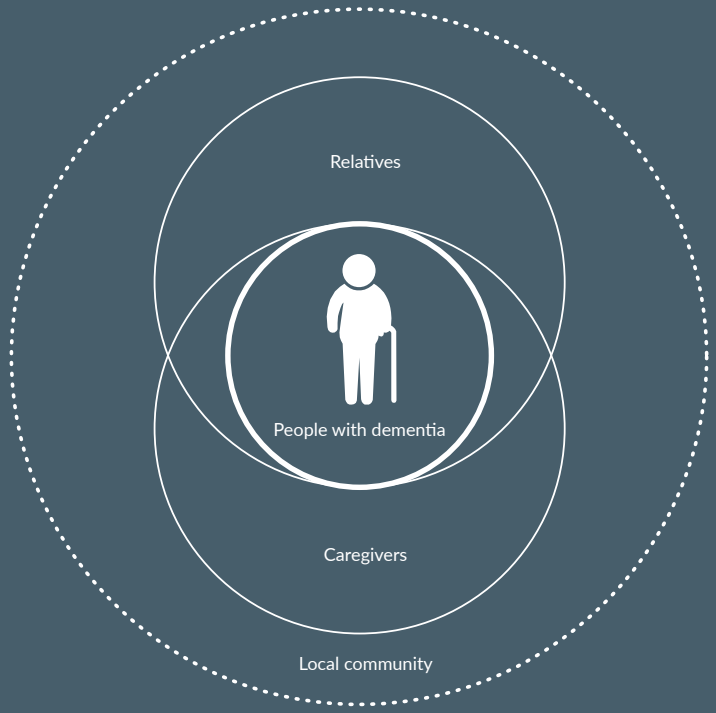
Charlotte Sørensen, 2023, relative

It affects the entire family when a family member is diagnosed with a dementia disease, as it can be a long, stressful, and emotional journey for everybody involved. Often there is a need for the demented person to move to a nursing home to get help with everyday tasks, and relieve the family of some of the stress from taking on the role as an informal caregiver.

It is a big adjustment, when the elderly leave the place that they call home to move to a nursing home with a different environment and many new people, and even more so when you have dementia. It can be difficult to get a sense of home as well as understand and remember why you need to move to get help with everyday tasks.

Professional caregivers become a big part of the elderly’s everyday life and provide care that can be challenging both physically and psychologically when working with demented people. Moreover, the nursing home needs to accommodate the needs from both residents and staff members, hence it needs to be a practical workspace, while still providing the residents with a sense of home.

Therefore, three main users appear when designing a nursing home for elderly diagnosed with dementia, which includes elderly with dementia, their relatives, and professional caregivers. In addition, creating a connection between the nursing home and the local community is of great significance for the residents' sense of belonging.



Illu. 6 - User groups.

SUB-CONCLUSION

DESIGN PRINCIPLES

The following points summarize the design principles concluded in the ‘User Understanding’ section:

- Avoid overlapping sound sources.
- Separate residents’ rooms from common areas or other noisy activity spaces.
- Avoid manually controlled systems.
- The kitchen and common dining room should be connected to offer sensory cues that encourage residents to eat through sightlines into the kitchen and/or by smelling food being prepared.
- Provide for sensory stimulation through a variety of meaningful activities to meet each resident’s individual needs.
- Place landmarks at ‘decision points’ to improve wayfinding.
- Interior layouts should be legible with either one continuous pathway or one straight corridor.
- Avoid corridors with corners or combined with other functions.
- Walking loops should be included both indoors and outdoors and provide opportunities for meaningful engagement along the way.
- Controlled multisensory environments for therapy should be included when programming.
- Allow for personalization and/or provide distinctive landmarks at each resident’s entrance to enhance spatial recognition.
- Spaces should be distinct, both in appearance and overall layout.

CASE STUDIES

The following paragraph examines how to create a sense of home in an institutional environment. In addition, two case studies are included to get an insight into best practice examples and to reflect upon the spatial layout, functions, and atmosphere experienced at the nursing homes. These are based on my own observations from visiting the facilities and through formal as well as informal, semi-structured interviews with a caregiver at Lundgården about her experience and observations from working at the nursing home, and two assistant leaders at Tornhøjhaven.

SENSE OF HOME

A nursing home provides safety and care for the elderly, ensuring their well-being and comfort. However, their privacy also gets compromised, as they are living closely together with people, whom they do not know or might not remember. Likewise, their home also functions as a work place for caregivers, who have to enter the residents' private rooms to provide care. It can feel invasive and deeply affect the residents' sense of home, as they in some ways lose their control over when they want to be by themselves and when they want to join the community or be around other people. Home is often perceived as your own territory, a safe space for you to live your life on your own terms, and a place where you are in control. However, when living at a nursing center, the line between private and public can be blurred, and it can be difficult to establish a familiar, homely atmosphere.

In the following, the influence of atmosphere and senses on the perception of home will be described, as well as how to create a sense of home in an institutional environment through habits.

ATMOSPHERE

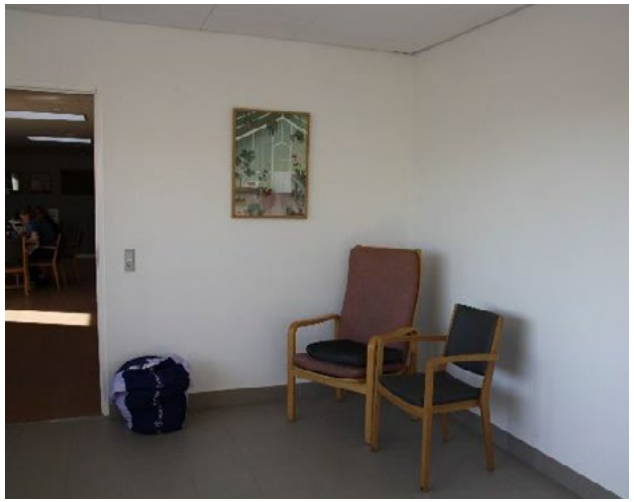
When entering a room we make a judgement of the environmental character based on numerous factors, which results in an overall feeling of an atmosphere and an assessment of whether or not a room feels homely. This experience is, according to Juhani Pallasmaa, multisensory and is not only influenced by vision, hearing, touch, smell, and taste, but also by orientation, scale, and illumination among others (Böhme, 2014).

"Every significant experience of architecture is multisensory; qualities of matter, space and scale are measured by the eye, ear, nose, skin, tongue, skeleton, and muscle. Ultimately, we sense works of art and architecture through our senses of self and existence." - Juhani Pallasmaa, 2014 (Böhme et al., 2014, p. 34)

Before we are able to describe the details of a room and its characteristics, we get an impression of the room's atmosphere from emotions based on external stimuli that leads to an internal feeling of the atmosphere. This emotive perception is determined unconsciously and instinctively, and it can be difficult to change the first impression once the room has been judged (Böhme et al., 2014).

BODILY HABIT AND RHYTHMIC FIT

The 'feeling of home' is subjective and has a different meaning for each individual, but often home is related to feelings of attachment to a place or space. However, fundamentally it refers to the process of integrating people and place after a relocation, and is not solely based on physical surroundings. Bodily habits such as previous daily tasks, habitual behaviors or routines can be helpful to people with dementia in the early stage of the move and can be a vital part in feeling at home (Chen et al., 2021). By providing the residents with the opportunity to watch or proceed with everyday tasks that have been part of their entire life, e.g. watering plants, putting plates in the dishwasher, or participating in cooking, it can create a sense of purpose and relation to prior experiences (Høyland et al., 2015). Simultaneously, it can help



Illu. 7 - Before "Projekt Hjemlighed" initiatives was made in a common room at the nursing home Tornhøjhaven, Aalborg Øst (Aalborg Kommune, 2021).

the resident to adapt to the new surroundings more easily and to be less resistant to the new environment, as they are bringing previous habits into their new environment (Chen et al., 2021).

After a longer stay at a care center, the bodily habits will gradually start to form a rhythmic fit to the surroundings, which means that the body becomes familiar with space, both in relation to physical objects, time and space as well as people (Chen et al., 2021). Therefore, objects such as personal belongings and furniture that the residents have formed a relationship with throughout their lives, also have a great influence on their perception of home. It is important that they can leave their personal mark and take ownership over their private rooms. Moreover, it is essential to communicate the identity of each individual resident and differentiate their private spaces from each other (Høyland et al., 2015). For example, by personalizing the entrance to each apartment, it enhances the residents' individuality and simultaneously improves their wayfinding skills when navigating at the nursing home.

Additionally, a rhythmic fit in relation to people also happens, which reflects the integration on a more social level through physical interactions that occur with caregivers and relatives through daily habits. Together, this physical and social integration in the new environment will hopefully result in a psychological integration with time and create a sense of home.

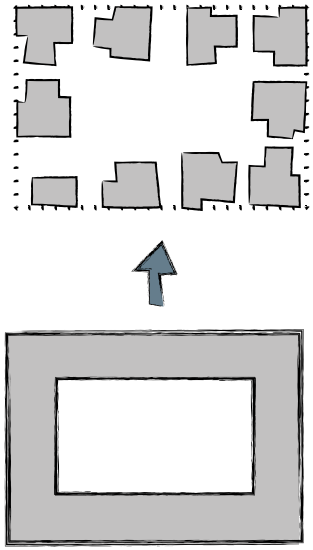
Overall, the sense of home that people living with dementia develop after moving to a nursing home can be explained by the integration of their past habits, activities, and routines, with their new environment in relation to physical, social, and psychological aspects. Moreover, to establish a feeling of home, it requires not only continuing previous habitual activities, but it also involves turning these habits into new routines and integrating social interactions into these habitual activities, which can provide a psychological connection to the new space.

Illu. 8 - After "Projekt Hjemlighed" initiatives was made in a common room at the nursing home Tornhøjhaven, Aalborg Øst (Aalborg Kommune, 2021).

TORNHØJHAVEN

A CASE STUDY

Area: 6500 m²
Building Type: Municipal Nursing Center
Location: Aalborg Øst, Denmark
Architects: Friis & Moltke, Lytt, Moe
Building owner: Aalborg Municipality and Domea
Build: 2015-2018
Residences: 72 apartments



Illu. 9 - Similar to a village, the buildings are perceived as tower blocks (Friis & Moltke Architects, 2016a).

This case study examines the effect of the building structure at a nursing center for people with late-stage dementia, and how it influences both the staff and residents' everyday life. In addition, there will be a focus on spatial layout and made considerations in regards to the final design of the thesis.

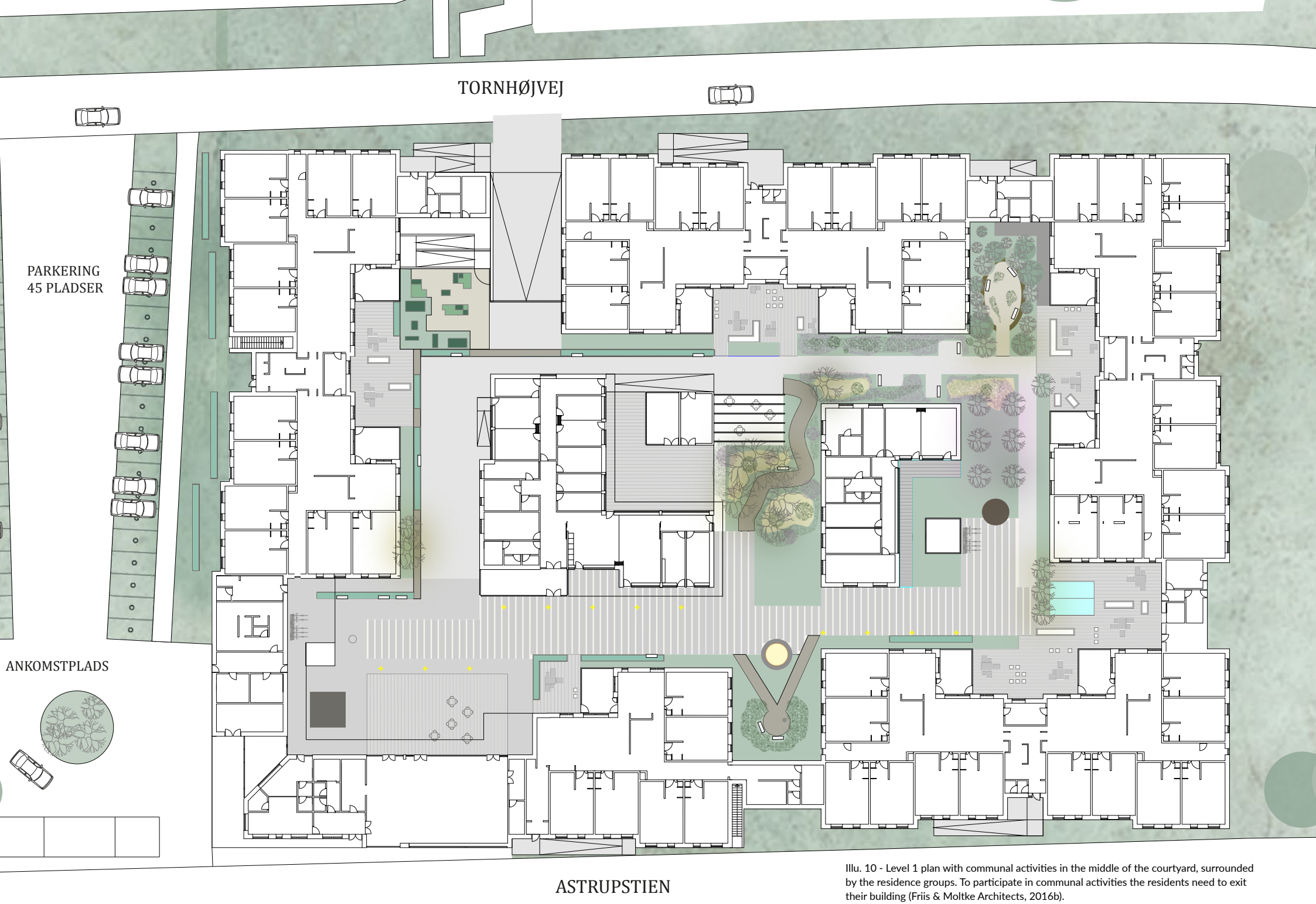
Tornhøjhaven is a municipal nursing center that opened in 2018 and is therefore considered the first dementia nursing center in Denmark. A lot of inspiration was taken from Hogewey, which is a nursing center for people with dementia located in Holland. During the design process, a visit was made to Hogewey and a consultant from the Dutch nursing center also took part in the design process when developing Tornhøjhaven (Aalborg Kommune, 2021).

BUILDING STRUCTURE AND CIRCULATION

The building structure consists of a block that is divided into smaller volumes with the intent to create a small village. In the middle, a common courtyard is created by the surrounding building volumes. The 72 residences are divided into 12 groups with six residences in each, where each group is accessed through the common courtyard (Aalborg Kommune, 2021). Similar to a village, all circulation between the groups is placed outside in the courtyard, which creates a close connection between inside and outside as well as a safe space for the residents to wander. However, during my visit I observed that a resident was walking in a continuous loop around the two separate buildings that are placed in the middle of the courtyard from the moment I came to the moment I left. The two leaders expressed that sometimes it happens that a caregiver needs to interfere and stop the resident's endless wandering. This might be caused by the repetitive building volumes and yellow bricks that makes the yard environment very difficult to navigate in, as every building looks the same. Moreover, the route does not lead to anything that can stop this behavior, but there are a few areas along the route that differ the spaces from each other through physical objects, such as a sensory garden, a bright red mailbox, signs for the shop and hairdressing salon, and an orangery. These can be seen as landmarks, but they are all placed along the route and not at 'decision points', which is reduced due to the continuous loop, but still appear as the two building volumes in the middle divide the path and offer a shortcut.

A part of the observed resident's wandering consisted of repeatedly stopping at the same transparent door to an activity room that is placed in the outer building volume. The transparent door has a direct view to the outside of the nursing center, to a moderately busy path with cyclists and pedestrians. This door was compelling to the resident, who over and over tried to leave through what he thought was an exit. When asking what they would change in the physical environment if they had the opportunity, this was mentioned by one of the assistant leaders, as residents often try to leave the premises through the transparent emergency doors.

This building structure gives the residents a greater sense of freedom, as they can leave their housing easily and wander in the



Illu. 10 - Level 1 plan with communal activities in the middle of the courtyard, surrounded by the residence groups. To participate in communal activities the residents need to exit their building (Friis & Moltke Architects, 2016b).

yard or sit on the terrace that is placed outside each residential group. This way, they have the opportunity to participate in different activities and communities. However, this structure also provides some challenges. During cold seasons, it can be slippery outside, potentially causing a risk for both staff members and residents as common functions are located outside their housing, which can be isolating. I was told by one of the assistant leaders that the majority of residents are quite late in the course of their disease, which means that the activity rooms are not used particularly often, and the activities are moved to each of the residential groups instead. The residents also participate in cooking, dishwashing etc. to continue with tasks that have been part of most of their lives and to get a feeling of ownership over the space, but according to the assistant leaders, the activity itself does not mean anything, it is the human interaction that is caused by the activity that matters.

Sometimes it happens that a resident sees it as a hassle to take shoes on to go to these activities and thereby withdraw from the situation, making the caregiver lose the interaction with the resident and the resident to isolate themselves. Therefore, initiatives such as a shop and a hairdressing salon, which is placed in the middle of the court, is not being used. Furthermore, it was estimated that only around 1/4 of the residents participate in activities in the common activity room, where weekly music therapy is held, besides church services, visits from the local day-care, bingo, and visits from a visitor dog etc. Mostly in the summer, the activities are moved outdoors in the courtyard, where the music is spread for everyone to hear, and the children from the day-care run around in the court, bringing life to the outdoor area and invite the residents, who are able to, to join.

Illu. 11 - Plandrawing of one housing unit with six residential apartments (Friis & Moltke Architects, 2016c).

In addition, by placing the circulation between the residences and other functions outside, it also creates practical problems for the staff as the courtyard creates longer distances and makes it more difficult to e.g. distribute food, which are delivered to the nursing center. Another challenge that occurs through this scattered building volume, is the limited visual connection between the residences. It can be difficult for the staff to follow what is happening in each group, and to communicate with each other, in comparison to one building volume with a corridor where you can see where help is needed, which was expressed by one of the assistant leaders. It is not possible for staff members that are responsible for residents in different residential groups to see where there is a need for their help, and for relatives or visitors, it can be hard to find the staff if they have questions or need help with something.

HOUSING

In each residential group, a common area that connects the apartments is divided into smaller areas with the intent to create intimacy and a feeling of home. At the same time, it creates the opportunity for multiple activities at once without any of them interfering, but it is experienced that the residents often sit by themselves. Moreover, these common areas are often very empty with a few modern pieces of furniture (Høj, 2022).

Somehow the common room seems very divided and with consideration to the size of the residential group, consisting of only six residents, there are too many activities happening at once, which do not strengthen the community between the residents. The common room needs to be an extension of their room and feel just as much like home as their room, so they do not isolate themselves.

FURTHER INITIATIVES

When Friis og Moltke won the competition, the vision was to create a diverse environment that provides different experiences for the residents in the courtyard. The intention was to create a transition between an open urban landscape with trees, lakes, and hills, and a town square with streets and shops. However, due to budget cuts the final building did not meet these expectations, nor a great many other planned design strategies (Høj, 2022). The courtyard felt empty and primarily dominated by yellow bricks and gray tiles with limited greenery, which made it difficult to differentiate the residential group units from each other. Therefore, in 2019 the municipality of Aalborg chose to make some changes, as it was experienced that the building had a negative influence on the residents, who were not stimulated enough. This project got the name “Projekt Hjemlighed” and involved many initiatives in both indoor and outdoor environments (Aalborg Kommune, 2021).

In the courtyard, more trees and plants were planted, but during my visit I had a hard time discovering these changes, which primarily is caused by me visiting during winter, but the assistant leaders both expressed that the outdoor spaces are much more inviting in the summer, while being dominated by bricks and tiles in winter, which are giving a less welcoming atmosphere. Moreover, plant boxes were added to the terraces, which have distinguished the semi-private terraces from the semi-public courtyards and create a more stimulating environment in summer than prior to the initiatives. Furthermore, in each residential group the walls in the common room have been painted, new furniture, pictures, rugs, and lamps have been added, which have created a more inviting environment with various textures and colors to stimulate the residents (illu. 7, p. 25, and illu. 8, p. 26). The common room in each residential group is decorated differently and in relation to the residents living there. I had the opportunity to briefly see parts of a common room, while the majority of the residents were taking a nap. The small space felt very intimate, but one of the assistant leaders voiced the problems of the few square meters, as it is difficult to provide care at times. An example was given that if a resident is aggressive and has externalizing behavior the caregivers cannot see them coming, as the door to their private room opens directly to the common area with no buffer space for the caregivers to see them coming.

In conclusion, it is important that the building volume and spatial layout accommodate the needs from both residents and staff members in regards to practical and logistical conditions, while still providing the residents with a sense of freedom and opportunity to leave their housing. Common functions need to be easily accessible to enhance the involvement of residents, and focus on atmospheres and interior is vital to stimulate the residents’ senses and strengthen their feeling of home.

Illu. 12 - The courtyard during summer months (Friis og Moltke Architects, 2016d).

Illu. 13 - The common room with the pedestrian and biking path right outside the windows.

Illu. 14 - The courtyard during summer months (Friis og Moltke Architects, 2016e).

Illu. 15 - The sensory garden during winter months.

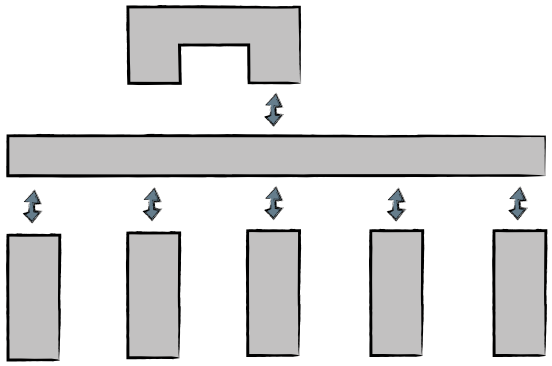
Illu. 16 - Activities stored in the corner of the common room.

Illu. 17 - The courtyard with the shop and hairdressing salon in the building to the left.

LUNDGÅRDEN

A CASE STUDY

Building Type: Municipal Nursing Center
Location: Vrå, Denmark
Architects: unknown
Building owner: unknown
Build: 1974
Residences: 48 apartments



Illu. 18 - Spatial layout of Lundgården.

In this case study, the spatial layout will be examined in relation to circulation and wayfinding at a nursing home for people with all stages of dementia and reductions in physical functions. Furthermore, there will be a focus on the effects of the interior and physical environment in relation to the sense of home as well as the activities provided at the nursing home.

LAYOUT AND WAYFINDING

Lundgården is a municipal nursing center with 48 apartments that are distributed in four wings, which are connected through a common corridor (illu. 18). The building was built in 1974, but an extension was added in 2006-2007 through a new wing. In 2017-2018 a 'Dementia Village' department, inspired by Hogewey, was established at the nursing center as well as a day center for elderly in Hjørring Municipality, which is in use daily (Hjørring Kommune, n.d.).

When walking through the long, bright, and warm corridor that is blinded by the sun, I experienced the poor visual and thermal indoor environment that was also expressed by one of the caregivers. However, the large windows give a close connection to the outdoor areas and open up the corridor, so it does not feel cramped. The long corridor also provides the caregivers with an overview of each of the wings, and it is easier for staff members to communicate, in comparison to the conditions at Tornhøjhaven. Moreover, there are benches and small sitting areas along the corridor, providing resting space for the residents to sit and talk with each other, while one of the residents' kittens is running down the corridor, making residents and staff members smile. Only a few, large, and very heavy paintings are mounted to the walls, as it is experienced that the residents take them down, hence several murals that are painted on to the walls is a great technique to add color to the room and create a more homelike atmosphere, which is not possible for the residents to take down.

In contrast, when passing each of the four wings, I was met by a long, dark corridor with only one window placed at the end covered by protective film, limiting the view to the outside. There is no indication of which of the residents each room belongs to, just a plain, white door surrounded by white walls. The atmosphere does not invite the resident into their home, but it feels rather impersonal and disorienting, as there is no indication of which wing you are located in through e.g. landmarks, view to the outdoors, or personalized entrances. When asking the caregiver if she experienced any wayfinding problems among the residents when trying to find their rooms, she stated that it was not her impression that wayfinding initiatives, such as personalized entrances, would help. In her opinion, the residents who have difficulties finding their apartment would need help from the staff either way.

Furthermore, along the corridor the main kitchen and eating area is located in separate rooms to protect the residents from loud, sudden noises. However, when I walked past the common eating area that is combined with a small kitchen, I observed that while several residents were sitting at the table after finishing lunch, a caregiver was putting dishes in the dishwasher. This produced a lot of loud, sudden noises, which made it difficult for the resi-

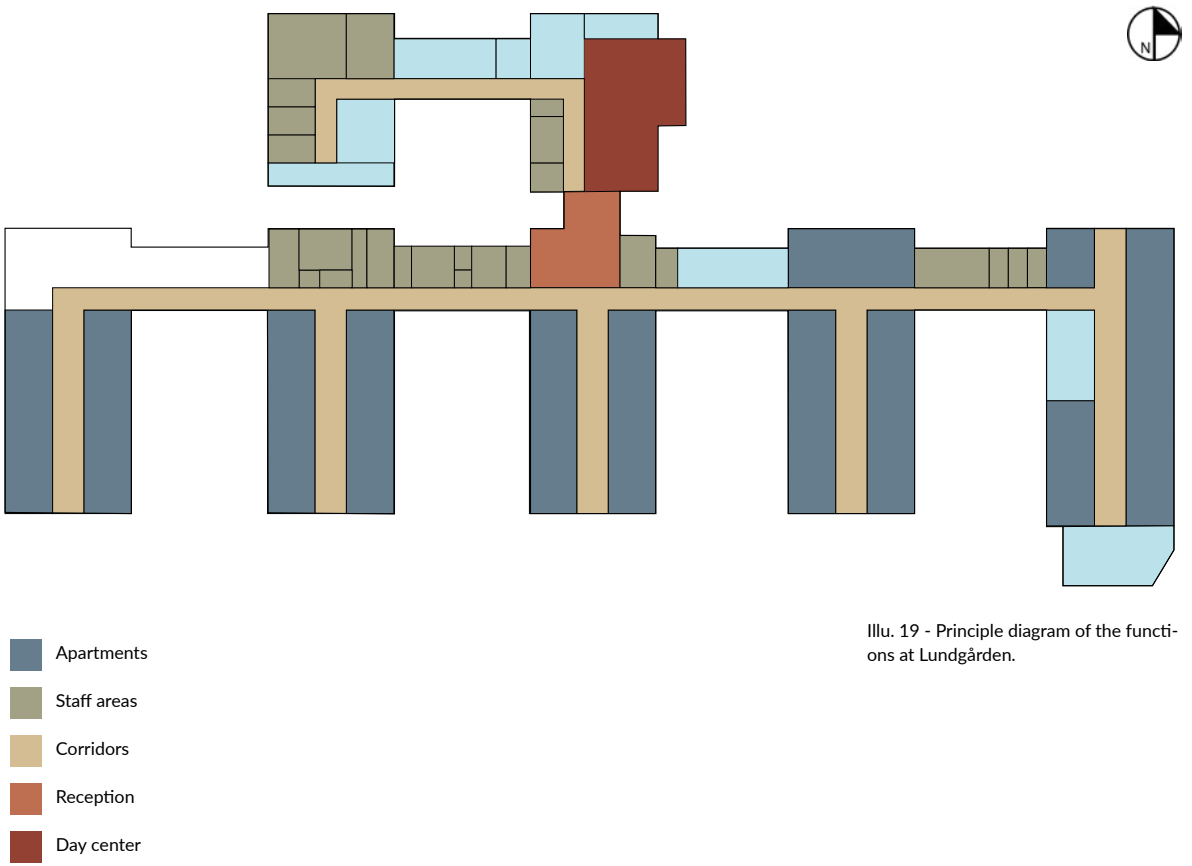
dents to hear each other when talking.

STAFF FACILITIES

The 'Dementia Village' department consists of staff functions such as a changing room, storage room, and one of several laundries that are placed around the building. These functions are strictly for the staff to use, hence the door is provided with a double door handle system to keep the residents out. Simultaneously, the doors and walls are painted over with a large mural of a landscape with a blue sky to conceal these entrances and prevent the resident from seaking towards exits.

When showing the changing room, the caregiver expressed her discomfort when being in there, and that she quickly changes clothes to leave the room as fast as possible, as it is not a pleasant nor inviting environment to be in. I noted that the room had a poor atmospheric and visual indoor environment, and that the several rows of lockers prevented daylight from the few windows to penetrate that far into the room, leaving the majority of the space dark and excluded from the outdoors.

Likewise, the combined laundry and cleaning supply room was described as 'the worst place on earth' due to insufficient logistics. The space is small compared to the amount of equipment that the space needs to store, and the path from the door to the washing machine is blocked by several cleaning carts, which altogether makes the room feel crammed with stuff and unmanageable for the staff members.



Illu. 19 - Principle diagram of the functions at Lundgården.

ACTIVITY ROOMS

In the 'Dementia Village' department, several initiatives have also been established to entertain and stimulate the residents through activity rooms. Some turned out to be very successful, while others did not receive the desired effect.

A store with primarily clothes is one of the initiatives that succeeded. The purpose of the shop is not for the residents to buy the donated articles from privates and Rødekors, but it is described as an 'experience shop' by one of the volunteers working there. She says that the residents together with their relatives walk down to the shop to get a change of scenery, and to change the subject of conversation as these often are repetitive and can be tiring for the relatives. Articles are changed regularly, providing the perfect environment for the relatives to have new topics to talk with their loved ones about.

When standing in the corridor in front of the shop, my perception of the atmosphere was characterized by a sense of warmth and coziness produced by the painted bricks on the wall, the hung streetlamps, plants, and exhibition cases placed along the corridor. The large windows brightens up the space, and the openings in the wall gives an open and welcoming atmosphere that invites you in when passing by. However, I also got the sense of it being quite narrow as one of the volunteers was standing in the corridor and hanging clothes from a trolley onto a dressing rail. As a resident was walking by, everybody was moving out of the way to make room for her to pass, as the path was narrowed by the trolley as well as the many wide exhibition cases hung on the wall. These contain black and white pictures, old books, and knick-knacks that the residents can relate to their early lives to further strengthen their sense of home at the nursing home.

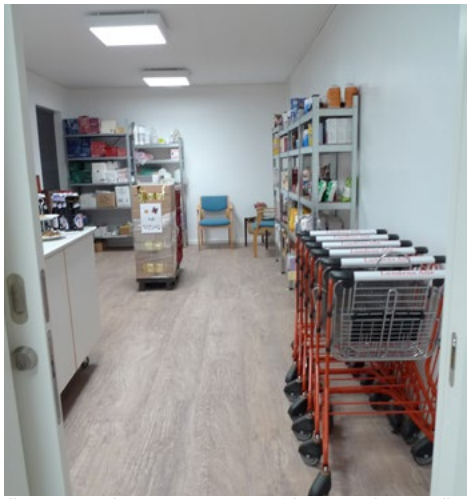
The resident passed the store with no interest and continued her wandering. The volunteer said that it was because she had not turned on the music, as this is the indication to the residents that the store is open. When the resident reached the end of the corridor, she turned around and continued wandering back the same route. This time, when she reached the store, the music was on and she entered the rooms with clothes, jewelry, games, paintings etc. to look at, before resuming the wandering.

Additionally, a bar room at the end of the corridor turned out to be very popular among the residents and is used regularly. Here it is possible for them to watch TV, play some darts, or get a drink in the bar, which is managed by volunteers. It is a space that strengthens the community as residents meet and talk with each other about past events. Also the hairdressing salon where a hairdresser visits sometimes, has turned out to be a success. It is a space that many residents enjoy, as it gives them a sense of normality to take care of themself and be presentable. This area is comparatively small, as it is placed in the same room as a movie theater only divided by a black, retractable partition wall, which can be seen as an obstacle by demented people with an decreased speed of visual perception, which can make the salon less inviting as it is partially covered by a black wall.

One of the activity rooms that did not turn out as expected is a food store, as it was experienced that the majority of the residents have difficulties with the perception of money. In the store they do not pay with physical money, but it is written down what they take and then paid later. This does not work for the residents, as they do not like the idea of 'owing money' the caregiver expressed. Therefore, the function is not used often, and the residents do not get a particular use out of it.

A caregiver expresses that the distance between this department and the residents' apartments can be problematic, as the facilities are not used often enough by the residents. Moreover, the overall layout of the building causes the staff and residents' movement patterns to collide, making the caregiver wishing for a more natural spatial layout that leads people. Moreover, the many dead-ends that occur in the building layout can cause frustration for people with dementia, and make it more difficult to navigate in the space.

In conclusion, it is important to implement activity rooms that attract attention from the residents, decrease wandering, and stimulate them, to create meaning in their lives. The functions provided at the nursing center have to be well thought through, and it is better to have a few activities that the elderly show interest in and want to participate in, than many various activities that do not catch nor stimulate them. Likewise, it is of significant meaning that their relatives can participate in the activities to strengthen their relationship and communication. Lastly, it is important that these functions are an integrated part of the spatial layout for easy accessibility and to decrease wandering.



Illu. 23 - In the grocery store, residents can buy smaller obejcts, food, snacks, and drinks (Venderby, 2017).

Illu. 24 - At the store, residents can buy clothes or just look through the many products and objects together with relatives to start new conversations (Hjørring Kommune, 2019c).

Illu. 25 - In the bar 'Rottehullet' residents meet to get a drink in the bar, play darts, or have a conversation with other residents (Hjørring Kommune, 2019d).

Illu. 20 - In the courtyard a pavillion acts as the gathering place during summer. Here residents and caregivers spend time drinking afternoon coffee or enjoy ice cream from the blue ice-cream booth (Hjørring Kommune, 2019a).

Illu. 21 - In the outdoor areas of the nursing home is a caravan with appurtenant garden funiture, where residents can spend time away from the nursing home and relax in nature (Hjørring Kommune, 2019b).

Illu. 22 - Elderlies, attending the Day Center at the nursing home, waint besides the phone booth at the indoor bus stop to be picked up (Hansen, 2017).

SUB-CONCLUSION
DESIGN PRINCIPLES

The following points summarize the design principles concluded in the 'Case Studies' section:

- Include past habits, activities, and routines in the design through accessible functions.
- Make space for residents to personalize their apartments and entrances.
- The local community should be involved in the design to enhance the residents' sense of belonging and strengthen their social interactions.
- Common functions need to be easily accessible and in near distance to the residents' apartments.
- Staff entrances should be disguised from the residents.
- Residents must have unrestricted access to a secure outdoor space.
- Outdoor areas should have a single exit/entrance.
- Outdoor spaces should be surrounded by the building volume and/or camouflaged fencing.
- All rooms should have clear views of the outdoors.
- Avoid multi purpose rooms as they can become overwhelming.
- Various activities should be provided and encourage residents to participate in the community.
- There must be orienting views through spaces and between destinations.
- Visual cues for important activities should be provided.
- Staff should be able to monitor residents throughout the interior and exterior.

PERSONAS

Based on observations, research, personal experience, interviews with caregivers, statements from people with dementia, and visits to two nursing homes, three personas are created to represent people with dementia, caregivers, and relatives respectively. Each persona is presented through social, physical, and physiological characteristics that are a compilation of the aforementioned methods to give a tangible picture of the user group when designing.

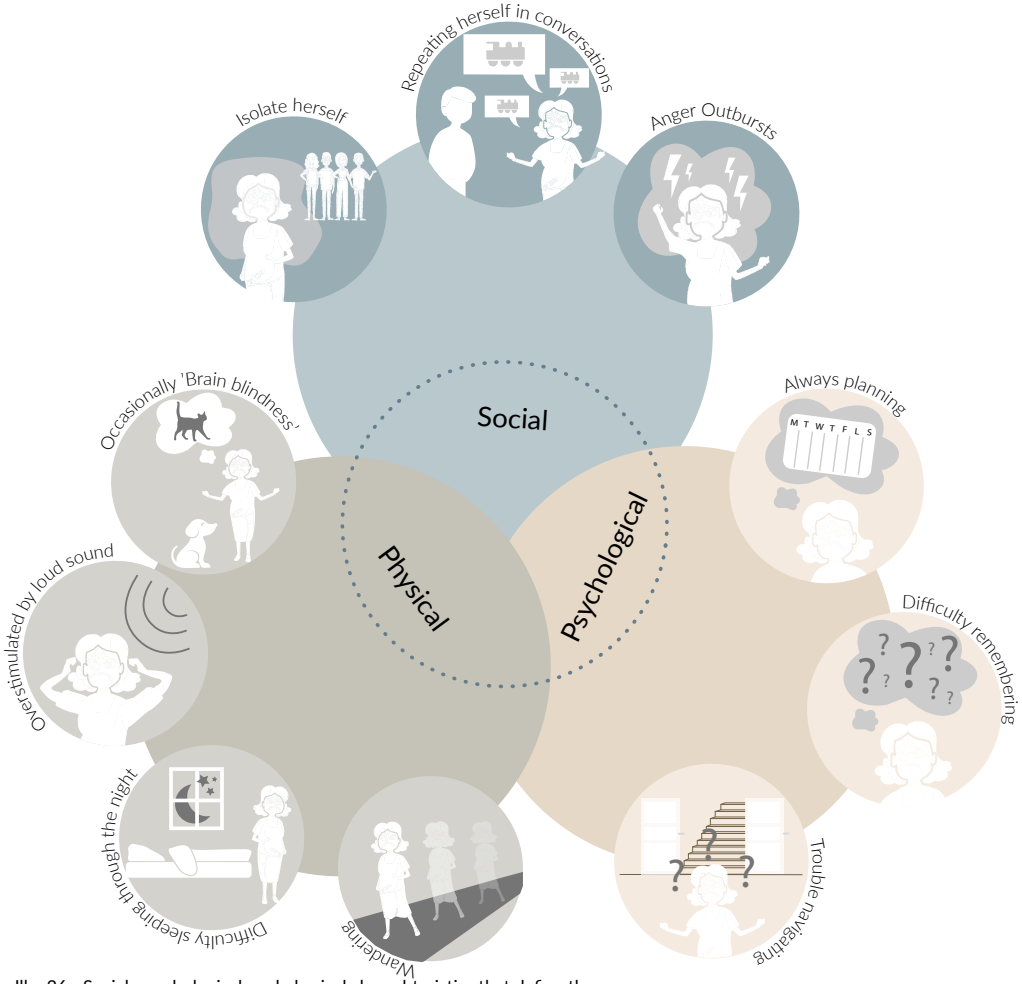
It is important to make certain reservations when working with people with dementia, as dementia diseases affect the brain and therefore change the perception of space and environment as well as memories. Hence, there occurs an uncertainty in regards to the characteristics presented through this persona, as the mind of a demented person is challenging to truly comprehend and is different for each individual.

PERSONA

PERSON WITH DEMENTIA

Sophie is 73 years old and was diagnosed with Alzheimer's disease three years ago. The first two years she spent at home with her spouse, Jacob, in the house that they built together at their farm and have lived in for the past 45 years. Sophie's symptoms concerned mild forgetfulness and occasionally confusion, but slowly they developed, and she started to experience new and more serious symptoms, such as trouble with wayfinding and poor judgement. Sophie started to need help with simple everyday tasks, leaving much of the housekeeping to her husband, whom she often became angry at for insignificant matters. Her personality started to change and she found herself declining invitations from her friends and only leaving the house to walk their dog. One day Sophie was out for a walk and could not find her way home in the neighborhood she had lived in for decades. After several hours her husband found her sitting at a bus stop at the end of the road. This incident led to the common decision about applying for an apartment at the local nursing home, so Sophie could get help from professional caregivers in a safe environment, to take away some of the stress that her husband experienced daily.

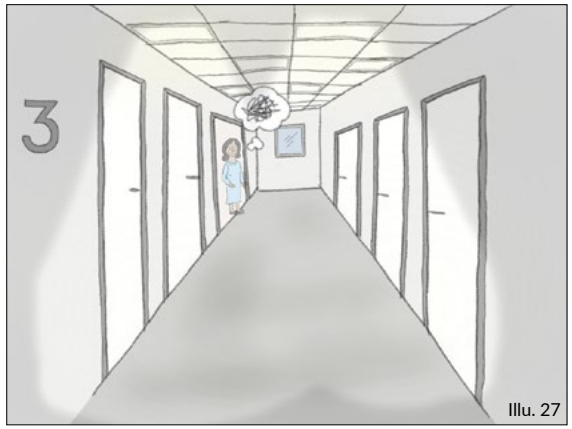
At the nursing center, Sophie participates in activities together with the other residents and feels like a part of the community. However, her apartment is smaller than the house she is used to, and there is not much room for her to take more than a few pieces of her own furniture with her. Moreover, she gets lost sometimes when wandering through the long corridors and cannot find the way back to her apartment, which feels frustrating and confusing.



Illu. 26 - Social, psychological, and physical charachteristics that define the persona of the person with dementia.

STORYBOARD

A DAY IN THE LIFE WITH DEMENTIA



Illu. 27

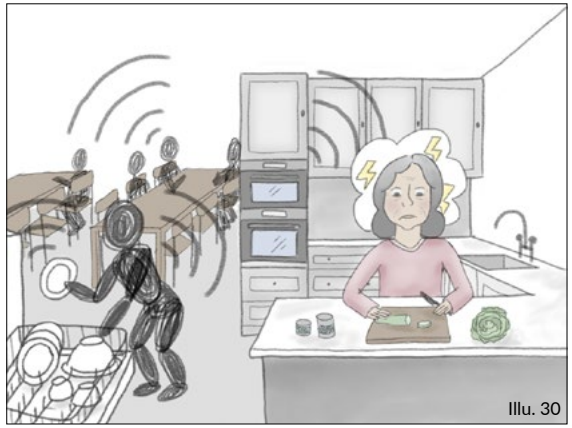
1. It is early morning, and Sophie is trying to get to her mailbox, but she gets disoriented, as her front door leads to a long corridor, and confused about where all the other doors lead to.


Illu. 28

2. Getting help from a caregiver that Sophies has trouble recognizing makes her frustrated, since she believes that it is evening and time for her to go to bed.


Illu. 29

3. Sophies is wandering around the corridors in the nursing home, going over the same schedule over and over again in her head.


Illu. 30

4. At dinner she helps cook, which reminds her of the daily life in her and Jacob's home, but she gets distracted by the many sounds from people chatting, the oven's beeping, and a caregiver trying to unload the dishwasher.


Illu. 31

5. Sophie continues to wander. Everything looks the same, and she quickly forgets that she already has walked past the same door 10 times in her search for her apartment.

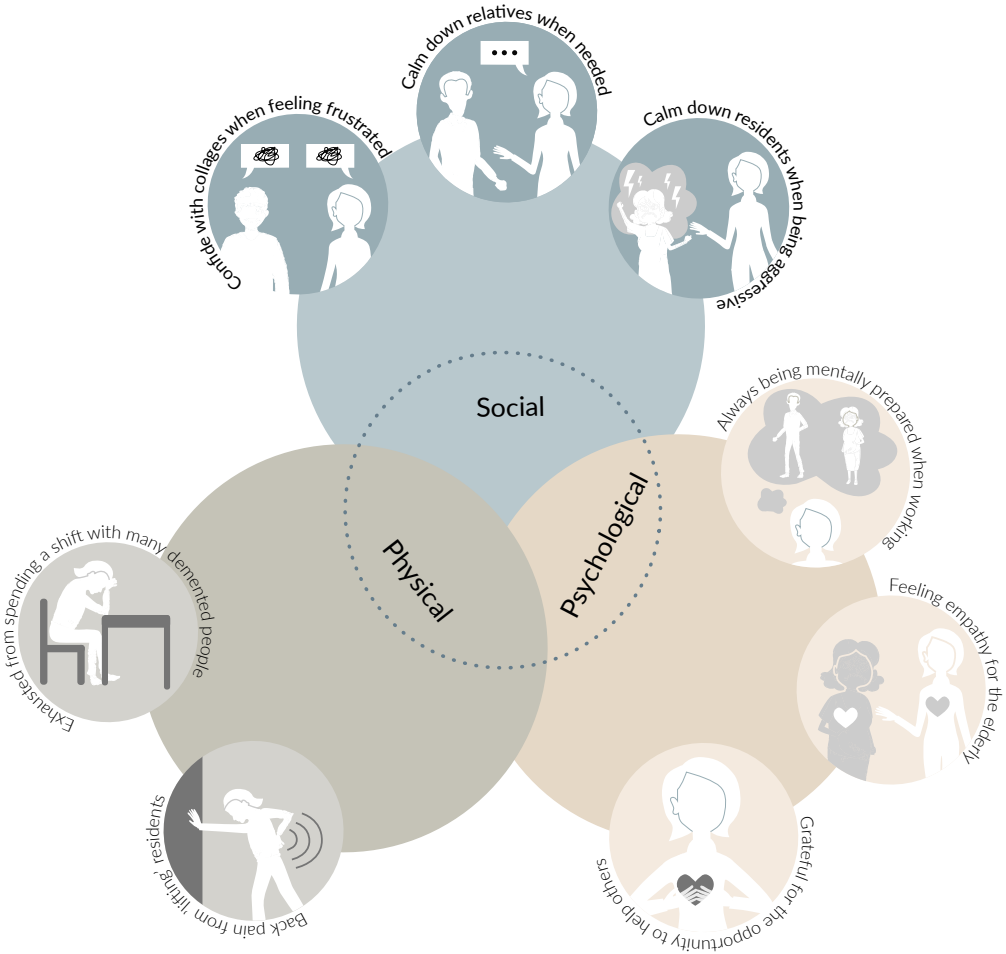

Illu. 32

6. It is in the middle of the night, and Sophie has trouble sleeping. She can't find the bathroom since the room is dark, unfamiliar, and does not look like her and Jacob's bedroom.

PERSONA
CAREGIVER

When Ava left primary school, she decided to become a caregiver after being an activity volunteer at a day center, where she read to the elderly once a week. She felt a sense of purpose, and it was very rewarding to get so close to the residents and their relatives and feel that her efforts made a difference in their lives. She wished to continue helping elderly and create a meaningful life for them when they decide to move to a nursing home, hence she chose this career path.

Through her carriere she has worked at several nursing homes and experienced how dementia can affect a family first-hand. At work she helps the elderly with everyday tasks from the moment they wake up to the moment they are put into bed, as well as during the night when some of them tend to wander. It is rewarding work, but it can be hard at times, as no one in Sophie's family has dementia and she feels like they do not understand how exhausting it can be after working for five continuous days with the same demented residents, having the same conversations over and over again. Together with her colleagues at work, she feels understood and a part of a community that can relate to the same challenges that she experiences.



Illu. 33 - Social, psychological, and physical charachteristics that define the persona of the caregiver.

STORYBOARD

A DAY IN THE LIFE OF A CARETAKER


Illu. 34

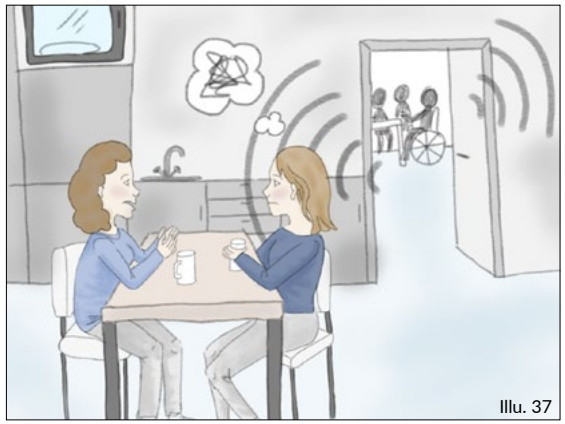
1. When Ava arrives at work, she quickly changes into her uniform as the changing room is dark, stuffy, and an unpleasant space to be in.


Illu. 35

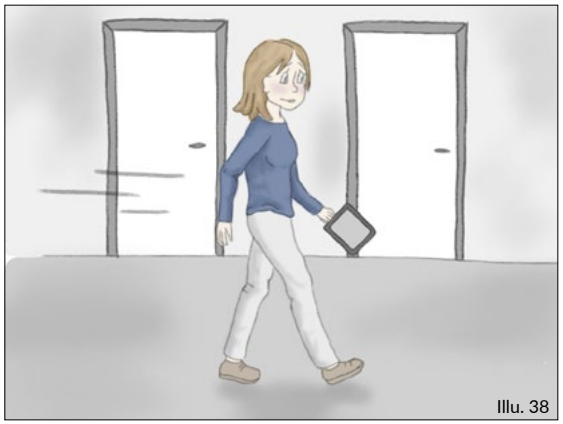
2. A coworker passes on the status of each of the residents to Sophie, and she receives the news that a resident has passed away during the night. She processes the news and prepares for the day, before getting back to work.


Illu. 36

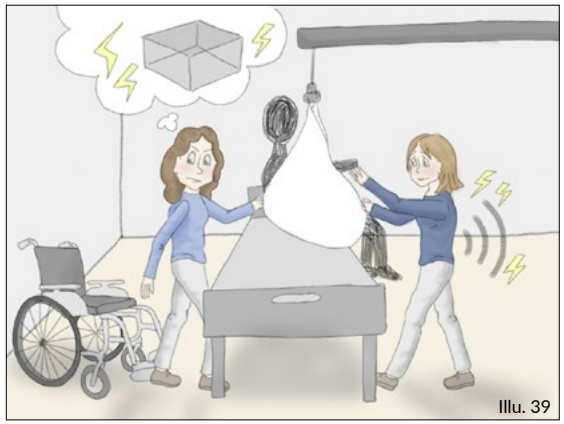
3. Ava would rather spend time with the residents, exchange stories, and do activities with them, but a lot of her time is spent on filling out monotonous journals on her Ipad when checking each resident.


Illu. 37

4. In the break room, Ava and her colleague try to take a break, but they have to keep the door open to see and hear if the residents need help, which distracts their conversation.


Illu. 38

5. It is busy at the nursing home, and Ava is responsible for many residents at the same time, but the distances between them are long, and she cannot be everywhere at once.


Illu. 39

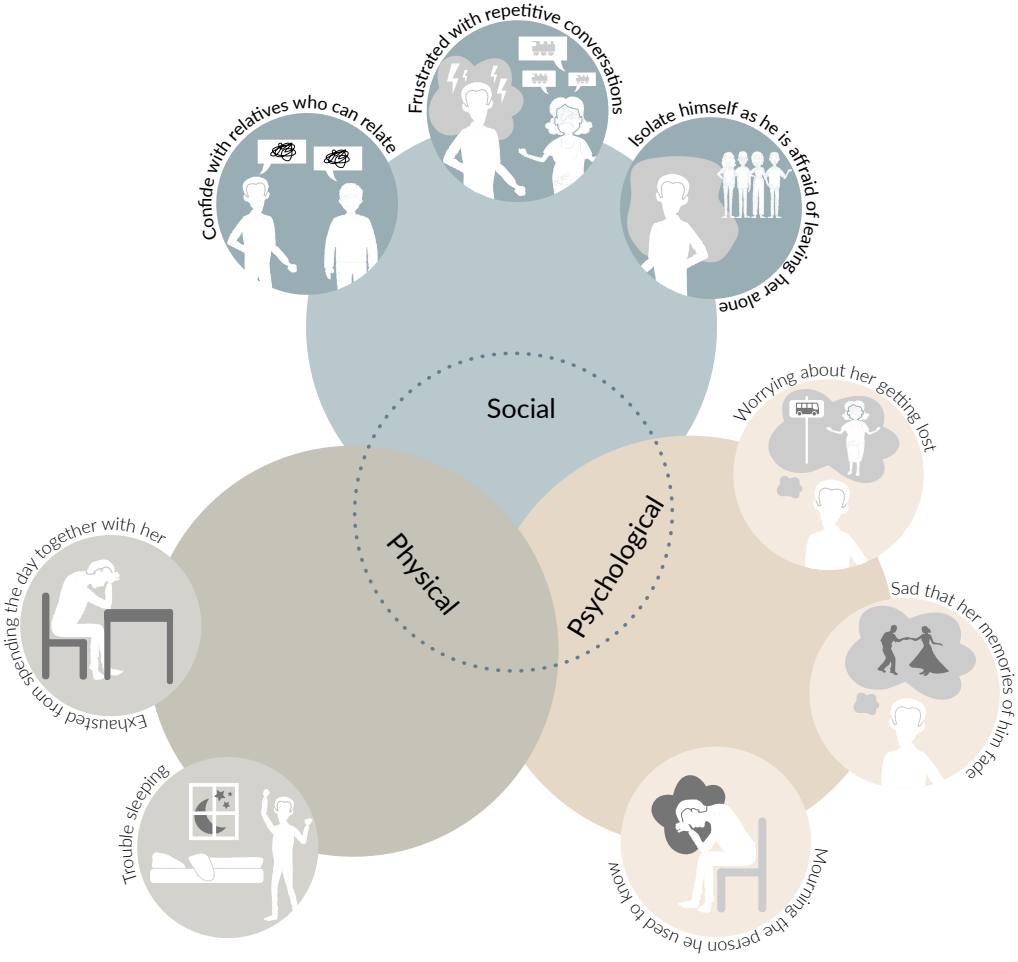
6. Together with her coworker, Ava is putting a resident into his bed with help from a lift. She experiences pain in her back, and the space around the bed is limited, making the task difficult for them to do.

PERSONA

RELATIVE

When Sophies's husband received the news that his wife had Alzeimer's disease, he became confused and unsure as it was his first encounter with the disease, and he did not know what meaning it would have on their lives. Slowly he saw his wife slipping away, not remembering what they had been talking and laughing about just a few hours earlier. After a few years she started to forget their prior anniversaries and memories that were more important to him. He felt like he was grieving the Sophie he knew from just a few years ago, and at the same time very alone in his grief, as he was spending most of his days alone together with his wife. This made him feel exhausted from constantly repeating himself and experiencing her rising aggressive behavior towards him. Time Jacob did not spend with his wife, he spent worrying about her wandering in the streets with no memory of how to find back home, which led to the decision that Sophie needed to move to a nursing center.

After the move, Jacob visits his wife twice a week to play cards or participate in music therapy with Sophie, other residents, and their relatives. Sometimes he brings their dog and they walk around the neighborhood and enjoy the fresh air, away from the nursing home. However, Jacob is told by the caregivers that when he leaves, Sophie can not remember him ever being there, which makes him feel sad about the situation, but he tries to appreciate the time they are spending together, even if the memories are only for him to keep.



Illu. 40 - Social, psychological, and physical charachteristics that define the persona of the relative to a person with dementia.

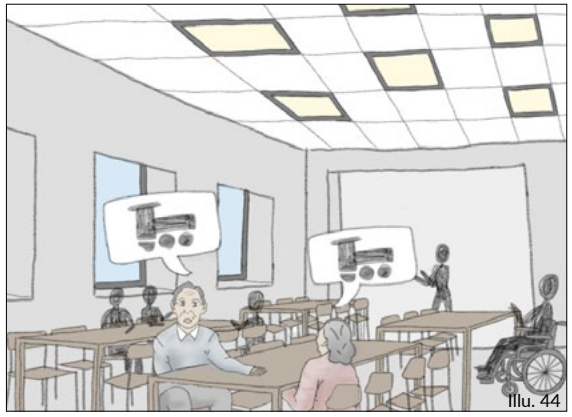
STORYBOARD

A DAY IN THE LIFE OF A RELATIVE

1. Jacob visits his wife at the nursing home, but he has difficulties orienting the corridors as the space is plain and has no landmarks or indication of where his wife lives or where to find the staff.

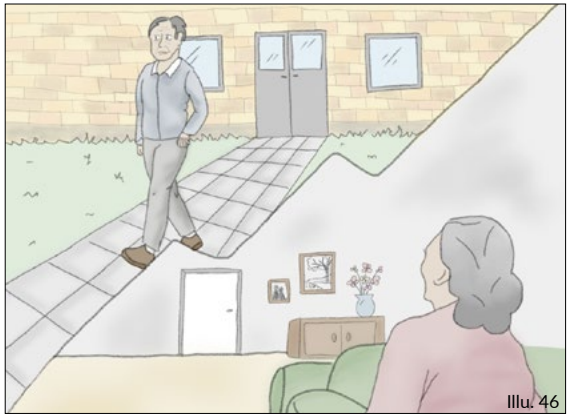
2. Together they play a card game and talk about past events, but Sophie starts to repeat herself.

3. They decide to go for a walk around the nursing home to connect with other residents. Along the long and poorly illuminated corridors, Jacob feels disconnected from the outside and reminisces about their time together at their farm.



4. In the dining room with the other residents, they have their afternoon coffee, but the topic of conversation is repeating itself, and it is difficult for Jacob to remain focussed.

5. They participate in music therapy with the other residents to experience something new together, instead of having the same conversation over and over again, and he feels like Sophie is her old self and briefly forgets their situation.



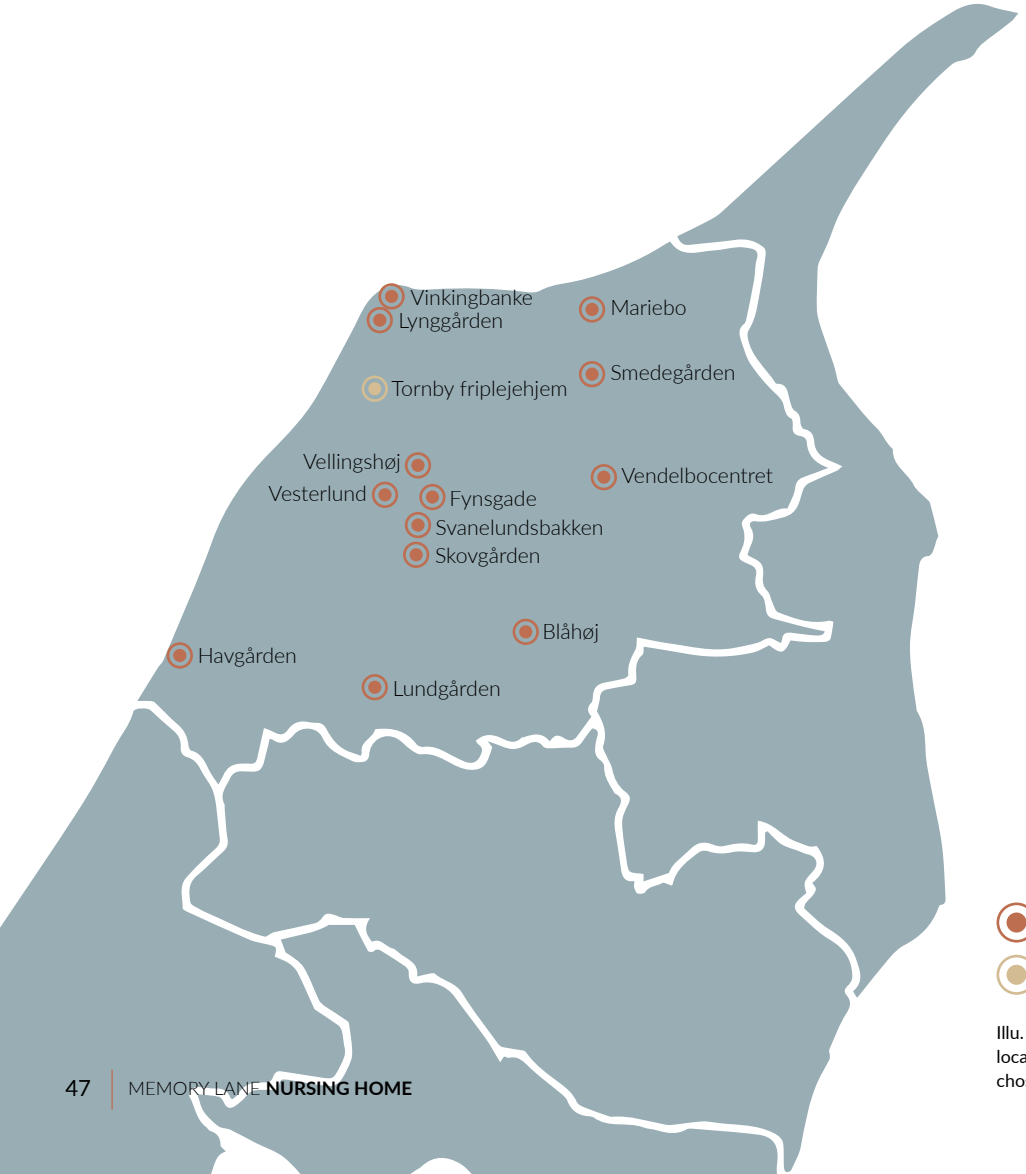
6. When it is time for Jacob to leave, he feels guilty for leaving his wife as he knows that she cannot remember him ever visiting.

SITE INTRODUCTION

In the following, the site will be presented through analysis based on desktop and field studies. The town is chosen based on a problem regarding the closure of the only nursing home in Tornby, and through a phenomenological approach, by visiting the town, a site has been chosen in regards to the knowledge obtained from the 'User Understanding' section. Each analysis is complemented by a strollology method, where pictures of the site and its surrounding environment are taken to get an understanding of the different atmospheres and views. All pictures presented are taken during winter, in late February 2023.

SITE INTRODUCTION

NURSING HOMES



Municipal nursing homes

Site

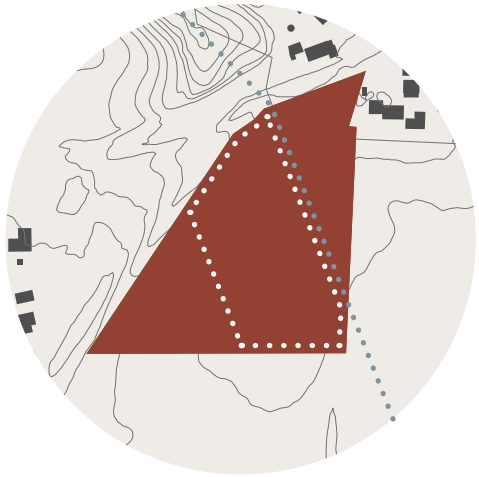
Illu. 47 - Mapping of the 13 nursing homes located in Hjørring municipality and the chosen site for the thesis.

In Denmark, 950 nursing centers are owned by the Municipality, whereof 13 are located in the Municipality of Hjørring (Sundhedsministeriet, 2022). In 2007 new legislations regarding independent nursing centers were approved, which has resulted in an increase in the number of independent nursing center places from 311 in 2009 to 1,618 in 2020. Independent nursing centers give the elderly, who chose to move to a nursing center, a great choice when it comes to deciding the conditions at their last home. These kinds of centers do not have an operational agreement with the Municipality, which gives the center a greater liberty when it comes to meeting the individual resident's needs. In addition, many Municipalities choose to shut down municipal nursing centers in smaller towns in favor of larger and fewer nursing centers (Ældresagen, 2023c).

This is the case in Hjørring where the Municipality chose to close the municipal nursing center, Havbakken, in Tornby in 2019, which left the local population frustrated. The same year, an independent committee as well as a support organization was formed with the intention to build an independent nursing center to replace the former municipal nursing center (Tornby Friplejehjem, n.d.).

A proposal for a district plan has been developed for the site with the intention to change the allowed building use from industry to residence. The plan concerns the plot number 1ø (marked with red in illu. 48-49), an area of 2 hectares localized in the southern part of Tornby, which is bound by residences towards north and northeast and arable land towards east and south. The building site is further bound (marked with a gray dotted line) due to a buried sewer (marked with a blue dotted line) in the northeastern part of the site and with an open space in the southwestern part that ensures distance to the few residences toward north and east. Moreover, it is expected that the upcoming project will entail around 30 residences (Hjørring Kommune Teknik- & Miljøområdet, 2022).

This Master Thesis will take point of departure from the presented problem and present a design proposal for an independent nursing center in Tornby. The proposal for the district plan and building site restrictions will act as a guideline for the design, and will be changed if needed to accommodate the design principles concluded in the Program.



Illu. 48 - Location of the chosen site in 1:5000.

Illu. 49 - Location of the chosen site in 1:25000.

Building site

Butied sewer

Site

LOCAL COMMUNITY

BUILDING USE

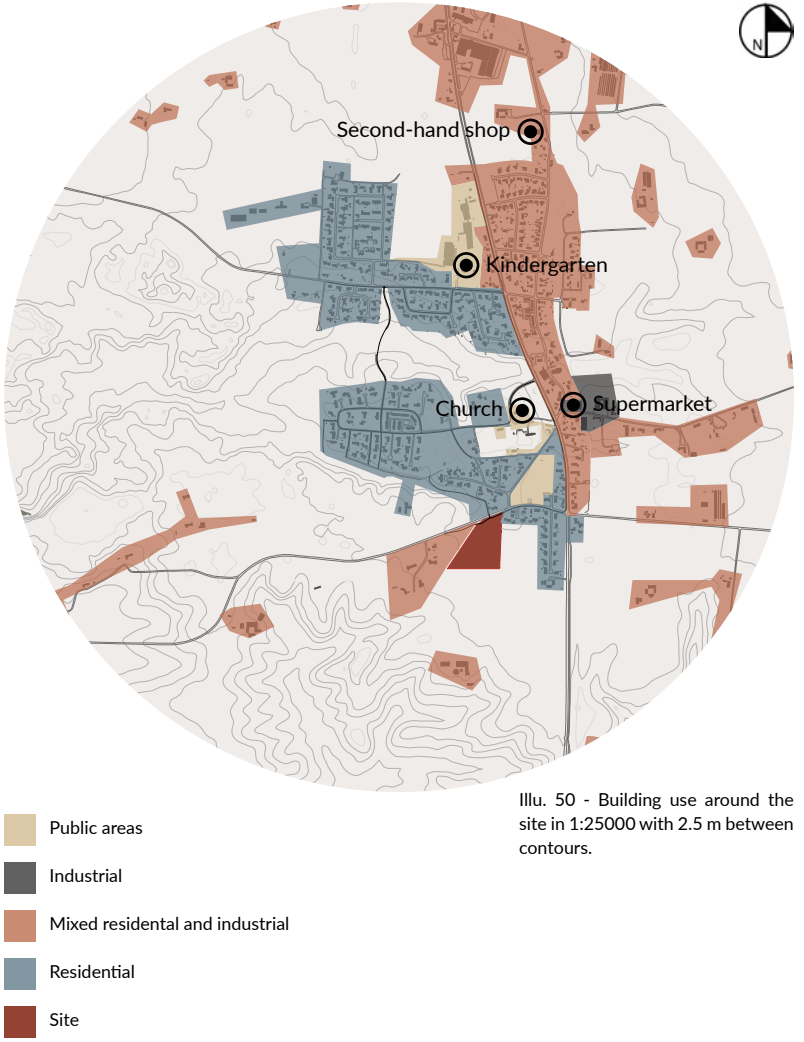
The site is located in the northern part of Denmark, in Tornby, in the outskirts of the town, close to nature, a forest, and open fields. It has been decided not to change the location of the site based on the following analysis in relation to flow patterns, vegetation, and distance to local functions as well as statements from caregivers at Lundgården, Tornhøjhaven, and Banebo. Likewise, observations from visiting the site have had an influence on the decision, which will be described in the following paragraphs.

At Lundgården, the local community plays a significant part in the residents' life, as the nursing home schedules weekly excursions to e.g. a public swimming pool, walks, church services, and games at the local village hall so they continue to be involved in the community and are not isolating themself at the nursing home.

Likewise, Tornhøjhaven makes occasional excursions for the residents that are able to participate, for example to one of the residents' hometown, but the majority of the residents are not in any condition to participate on these excursions, hence the connection to the local community are made through different initiatives. For example, a local day-care is regularly visiting the nursing center to strengthen the understanding and bonds between people from different life situations and generations. By opening up the two institutions and joining them together, it can help to create an increased openness for each other and for people in other life situations. Together they play and make music, sounds that will spread throughout the courtyard when the activities are moved outdoors.

At Banebo, where caregiver Nathalie works, excursions also have a significant influence on the residents' connection to society. When relatives visit, they often go for a walk to e.g. the local supermarket to buy some snacks, but it does not have to be with a specific purpose in mind. It is the walk itself and experiencing nature and stimulating the residents' senses that is the main reason.

The site is located close to a kindergarten, hence the conditions for a potential collaboration between the two institutions, like at Tornhøjhaven, is favorable. Furthermore, another possible collaboration could be with the local second-hand shop in relation to implementing an 'experience store' like at Lundgården. In addition, the site is within walking distance to a supermarket and a church.



Illu. 50 - Building use around the site in 1:25000 with 2.5 m between contours.

Illu. 51 - The bridge that connects the two residential areas, marked with blue on illu. 50.

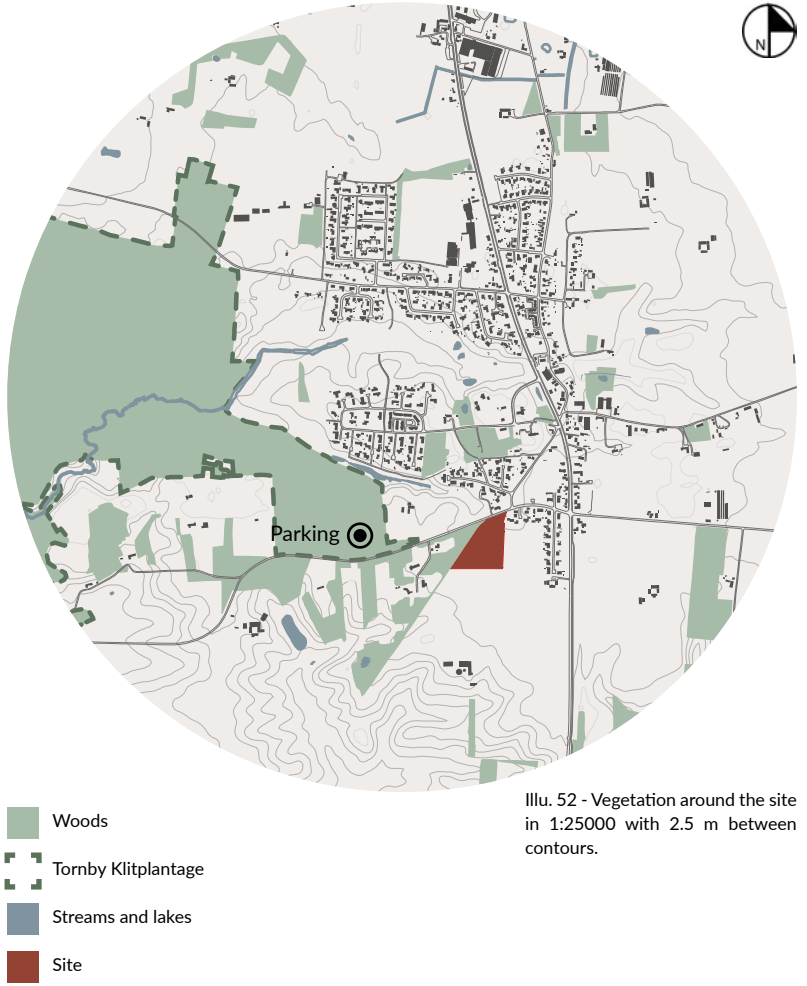
VEGETATION
THE WOODS

Another reason behind choosing the site location, is the close distance to Tornby Klitplantage, where activities such as MTB paths, shelters, a dog park, a Viking village, and Live Action RolePlays can be experienced. The forest offers great opportunities for the residents to connect with nature to improve their quality of life by activating their senses, and give them experiences away from the nursing home as well as improve their sleeping patterns. In my design, I aim to create a close interaction between indoors and outdoors, and to make use of the surrounding nature through materials, views, flow patterns etc.

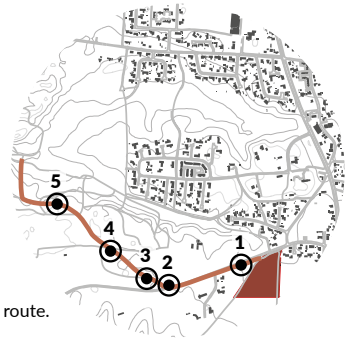
The nursing home, Banebo, is located in the middle of Viborg city, making it less integrated with nature. Therefore, a trip to a summer house outside the city for a weekend is one example of the initiatives made to connect the residents with nature.

During my visit to the site and by walking around the town of Tornby, I met a group of 7 residents and 2 caregivers from a municipal nursing center in Hjørring Municipality, who had driven with a minibus to the forest and parked at the parking space at the southern entrance. Together the elderly and caregivers walked into the forest, while talking to each other about the surroundings, until a few of the residents felt tired and the caregivers decided to turn around and walk back to the parking space. Some of the elderly sat down on the benches to rest, while the rest walked through the more difficult terrain with no paths, while helping one another to cross the road to a field with cows, whom they could hear in the forest. The elderly seemed very content and happy, as they were smiling and laughing while taking in the surroundings, which provided the perfect conditions for the elderly in relation to stimulating all their senses, and giving a sense of community when meeting and interacting with other people, like myself.

The main walking paths in the forest are wide and even, making it accessible for people with walking-impairments and wheelchair users to move through the landscape. Some of the residents that I met had crutches or a walker, and did not have trouble walking in the terrain.



Illu. 52 - Vegetation around the site in 1:25000 with 2.5 m between contours.



Illu. 54 - The route.

Illu. 53 - Pictures capturing the atmospheres and observations taken on a route, starting at the site and ending in the nearby woods, which is marked on illu. 54.

FLOW
MOVEMENT PATTERNS

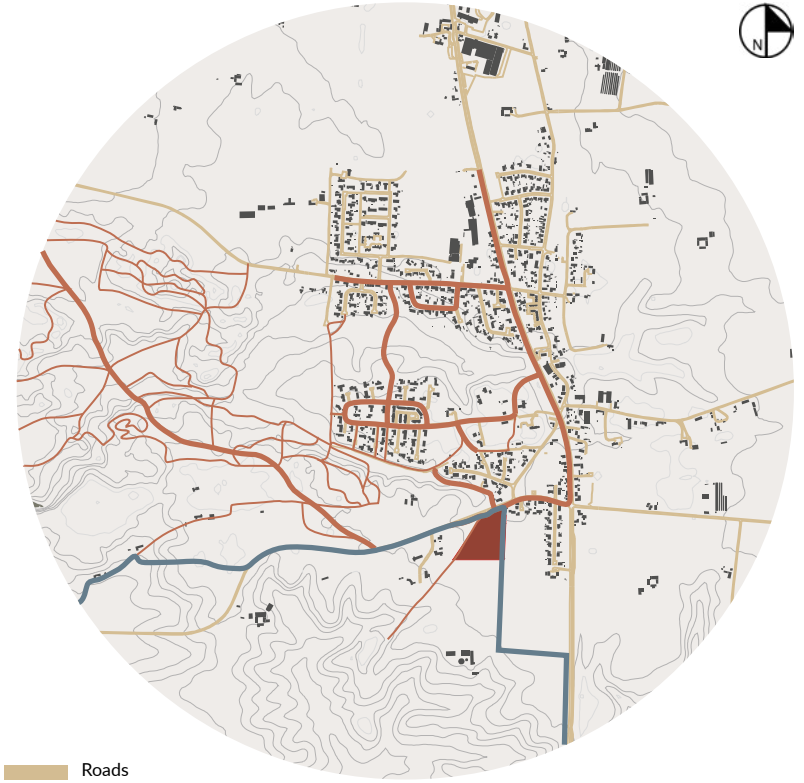
The site is connected to numerous, intertwined walking paths that bind the town and forest together. The paths are established as 'tramp paths', which means that the paths lead you over and along fields as well as along private roads and existing forest roads. The course of the paths is planned so that you experience both the beautiful landscape and are introduced to cultural monuments through information boards that tell stories for locals and for guests.

In the middle of the town, a wavy path with lampposts and overhanging trees led me up the terrain to the church that is visible from the site, and further to an enclosed playground next to a busy road. The terrain was relatively steep, and when reaching the bench at the highest point of the area, I had a view to the supermarket and the church.

Moreover, I was led through dense residential areas packed with trees and greenery as I walked between the houses, until I was met by an open landscape with horses that guided me down the undulating landscape to a stream. On one side I was standing with residences in the background, while admiring the forest on the other side, to which a small bridge was leading me towards (illu. 1-8).

Another path led me through an open landscape with a long, curved bridge that brought me over a wetland from one residential area to another. In contrast to the more dense residential area, this path gave a sense of break through the open, panorama view of nature and the quiet environment, before reaching the other residential area and walking past the school and kindergarten, where I was met by the sounds of children playing. As I approached the end of the road, the noise from cars driving by became gradually louder from the main road that leads through the town (illu. 9-12).

At Lundgården, Tornhøjhaven, and Banebo, it was mentioned that the activity itself does not always matter, but it is the human interaction and surrounding environment which influences the residents' senses that has an effect on their well-being. Through these walking paths it is possible for caregivers and relatives to walk with the residents and experience the town and nature, while not having a specific place to go. It is possible just to wander and converse with one another, away from the nursing home.



Illu. 55 - Movement patterns around the site in 1:25000 with 2.5 m between contours.

Illu. 57 - The route.

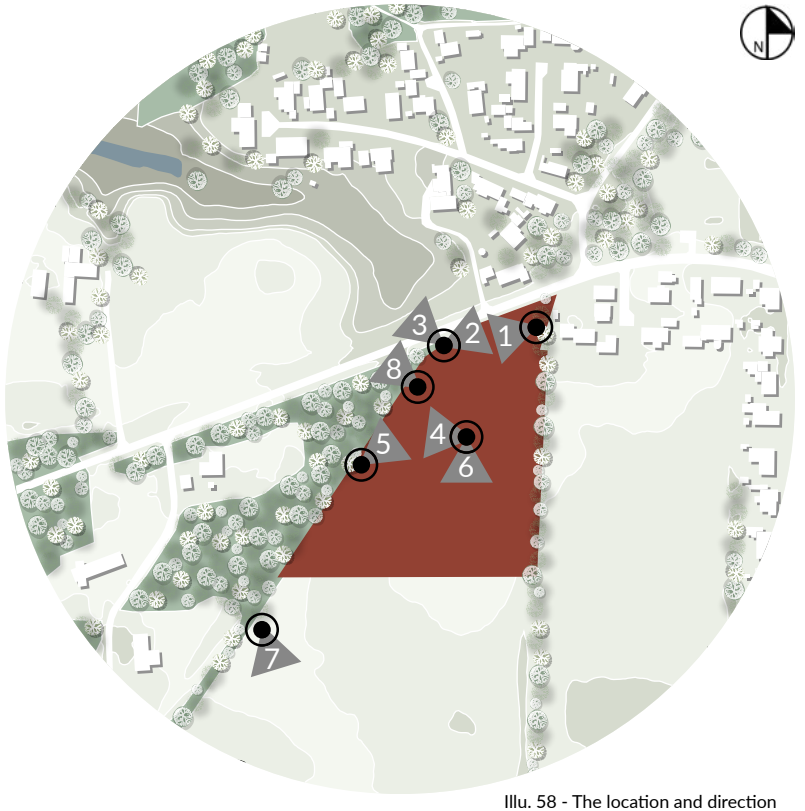
Illu. 56 - Pictures capturing the atmospheres, observations, and sensory experiences in the town, Tårnby, taken on two different routes. The first starts at the church and ends at the woods (nr. 1-8), and the second starts at the nearest residence area and ends at the busy main road (nr. 9-12), which is marked on illu. 57.

THE SITE

STROLLOLOGY

The overall atmosphere at the site is very idyllic and calm. It is peaceful and quiet with only occasional noise from a car passing by on the main road. However, when visiting, the sounds primarily consisted of birds chirping, church bells ringing, and horses neighing in the distance. It is a site that is integrated in the walking paths connected to the rest of the town and forest, as a riding trail is made along the northern and eastern site border, which brings horses and riders by the site. Likewise, a walking path is made along the trees at the western site border.

The following pictures and appurtenant descriptions will capture the views from and around the site in relation to terrain, atmosphere, vegetation, paths etc.



Illu. 58 - The location and direction of the pictures in illu. 59, in 1:5000 with 0.5 m between contours.

The site is located in the outskirts of the town with a view to the forest, which is seen in the background. Along the main road, a riding trail that borders most of the site boundary is found.

A slightly busy main road with a couple of houses built on each side is located alongside the site, which indicates the beginning of the town border.

A view of the undulating landscape, fields, and horses, which can be heard from the site.

Currently, the site is used for growing corn and is therefore a large, open area with no exciting building volumes. West of the site, a small woods is planted to block the view to an adjacent residential plot.

The town is visible in the background, with a view to the church. When standing at the site, the sounds of church bells in the distance provides an audible connection to the town. Moreover, the terrain is predominantly flat.

In the distance, towards south, several windmills are placed in the horizon, and a row of trees are blocking the view to an adjacent residential plot.

South of the site, the terrain changes from the very flat and even terrain, experienced at the site, and becomes a more undulating landscape.

In the Northwest corner of the site, a small opening in the woods is made as a part of the riding route.

Illu. 59 - Pictures capturing the atmospheres, observations, and sensory experiences at the site. The location and direction od which the photographs are taken is marked on illu. 58.

PLACEMENT IN THE LANDSCAPE

BUILDING AND LANDSCAPE

The experienced value of a landscape is highly influenced by the scenic qualities. By working consciously with the atmospheres and experiences in the different landscape types when placing new buildings, a harmony with or a contrast to the existing landscape can be created to either amplify or break with the surroundings.

The municipality of Hjørring has in collaboration with NIRAS made a 'Visual Architecture Guide for the Open Country' containing a number of recommendations regarding the interaction between building and landscape to provide an overview of the various landscape types, their qualities, and their experiential values to create a positive synthesis between building and landscape. Experiential values are described as simplified images of the overall impression of the landscape, and it is these values that must be taken into consideration when building in any landscape (Hjørring Kommune, 2012).

In the municipality of Hjørring, the variation in landscape provides an unique experience, as all landscape types are represented, which creates special visual experiences through the many contrasts where different landscapes meet. Moreover, a great number of large agricultural areas is also characteristic for the Municipality and the landscape that most of the citizens experience on a daily basis, when commuting to and from work or school. The vast landscape evokes a sense of freedom and humbleness merely based on the sheer scale of its dimensions, which is a quality that is seen less of. Therefore, it is important to thoughtfully take a stance on how a building is situated within its surroundings and consider the dynamic interplay between building and landscape (Hjørring Kommune, 2012).

Based on the descriptions of each of the six different landscape types that are presented in the guide, it is assessed that the chosen site for the nursing home is located in 'The Open Simple' landscape that is characterized by its vast expanses with few facilities and vegetation as well as an insignificant variation in the terrain. Through long views you are able to see as far the eye can see at the open landscape with an uninterrupted horizon line. This landscape type can be vulnerable to both large buildings that can be too dominant in the space, and to many small elements that fill up the open space (Hjørring Kommune, 2012). To analyze and reflect upon the interaction between building and landscape, I drove around the Municipality of Hjørring to take pictures of farm buildings that illustrate this correlation. Specifically, pictures were taken of farms placed in 'The Modest' landscape type, which is reminiscent of 'The Open Simpel', except 'The Modest' describes a scenery where slightly larger buildings and facilities subordinate to the landscape and discreetly is fitted into the surroundings (Hjørring Kommune, 2012). Therefore, the site will become a 'Modest' landscape after implementing the nursing home.

To reduce the visual impact on the surrounding landscape, connecting plantings around the construction can be established. By planting vegetation in front, behind, or between of the building a connected mass from several smaller building volumes can be

Illu. 60 - Open, nearly uncovered farm building with a unifying "back".

Illu. 61 - Open farm building placed in front of a raised horizon line.

created and make the building less dominant in the landscape.

As seen on illu. 60 the building is nearly completely open and uncovered by trees on the flat terrain, but the farm does not overtake the scenery or seem out of place. It discreetly submits to the landscape, because of the trees and rising horizon line in the background, which forms a unifying "back" that makes the building fit more harmoniously in the landscape. Similarly, the farm in illustration 61 is an example of how to melt the harsh lines and geometric forms of the farm with the organic shapes of the landscape. It is more challenging to see where the farm ends and the landscape begins by placing the left side of the farm in front of a raised horizon line, and trees and vegetation on the right side of the building slightly overlapping the facade, which provides a soft transition.

Large installations such as the mast on illustration 62 can seem dominating in the landscape due to the height and material choice, which is in contrast to the low-rise building. Likewise, the windmills on illustration 63 is conspicuous even though it is placed behind the building, as the height of the trees in front of the windmills does not cover them up, nor are there trees in the background to form a cohesive background. In both cases, the tall installations draw attention to the farm, making it more prominent.

A clear contrast is seen between illustration 64 and 65, where vegetation in front of the building of the first picture creates a connected mass from several smaller building volumes. Subtly, the trees almost hide the building, as if nature has draped a veil over the structure. However, by placing trees in front of the entire building facade, it can also blur the characteristics of the farm structure. In contrast, the facade on illustration 65 is entirely visible and the building's structure communicates an open expression. Even though the farm is characterized by several extensions and renovations that has resulted in a great many smaller buildings and facades with different materials, the vegetation placed in between, behind, and a few trees in front of the building contribute to a more cohesive interplay between the buildings and the landscape. Likewise, the many gables that exceed the trees in the background, creates a rhythmic connection to the tree crowns.

Moreover, the compact building mass with several floors and a large composition of materials in illustration 66, seems much more dominating in the landscape despite trying to subordinate to landscape by melting the farm into the background with vegetation. The difference between the two examples is that illustration 65 shows a farm where the buildings are more spread out in the landscape and do not vary in height. Even though the farm has more buildings, it manages to create a stronger mutual influence between building and landscape where the farm moves with the landscape.

Much like illustration 61, illustration 67 is a great example of a farm that is subordinate to the landscape, but instead of being placed in the terrain, the building is placed on top of the lands-

Illu. 62 - Large installations seem dominating in the landscape.

Illu. 63 - The building subordinates to the landscape, while the uncovered windmills seem dominating.

Illu. 64 - Vegetation in front of the building creates a connected mass, hides the farm, and blures the characteristics of the farm structure.

Illu. 65 - The many gables create a rhythmic connection to and continuation of the tree crowns in the background.

cape. With its long facades and horizontal lines parallel to the horizon line, it creates a harmonious expression, strengthening the openness that is characteristic in the Municipality of Hjørring, while showcasing the strong characteristic of the farm building.

Furthermore, in the guide, it is advised to find and maintain important sight lines when designing a new building in 'The Open Simple' landscape to avoid that any buildings or installations are preventing a view to the horizon line in order to preserve the view (Hjørring Kommune, 2012). Therefore, it is in the design important to maintain the sight lines along the eastern and northwestern site limit where a riding rute and a hiking trail is established.

In regards to placement in the landscape and the interplay between building and landscape, it is according to landscape architect, Sven-Ingvar Andersson, important to have a balanced approach between mass and void:

"The city's physiognomy is delineated just as much by the absence of buildings as it is by the solitary monuments. The interspace is one of the urban building's most important elements. Utilized in a conscious way, it has the potential to articulate the diffuse mass."
- Sven-Ingvar Andersson, 2002 (Andersson, 2002, p. 44, l.24-27)

By pulling the nursing home away from the excessing road and creating a distance to the residential houses located north of the site, and thereby making an intentional pause between the buildings, the relation to the landscape is used to support the conceptual expression. Furthermore, it is important to create identifiable buildings with clear identity associations to be perceived as sympathetic for the human experience (Andersson, 2002). When driving around and analyzing the surrounding farm building, it was observed that they often are built in a distance from the main road, surrounded by open fields, and accessed through a private gravel road. By creating a distance between the building and the road, it can also strengthen the concept and enhance the overall expression of the building, which is characteristic in the 'The Open Simple' landscape and highly associated with farms.

In conclusion, a harmonious interaction with the landscape can be attained by considering the placement of vegetation, the placement of the building in relation to the horizon line or background, and not by making a compact building mass or a significant variation in the height of the buildings. Furthermore, not only are a one-storey building accommodating the need for accessibility in the nursing home for both staff and residents, but a low-rise building can also contribute to a harmonizing interaction with the landscape. Lastly, vegetation should contribute to connecting buildings and installations, and not to cover them up.

Illu. 66 - The many materials and shapes as well as the compact mass seems dominating.

Illu. 67 - A farm building that subordinate to the landscape through horizontal lines parallel to the horizon line.

THE DEVELOPMENT OF FARM BUILDINGS

The farm's architectural structure can play a significant role in strengthening the sense of belonging for older individuals with their surroundings. For many of the residents, farms often hold nostalgic memories of their youth or experiences tied to rural living. The familiar layout of the farmstead as described in the following section, can evoke a comforting feeling of continuity and connection to the past. When diagnosed with dementia and moving to a nursing home, the sense of belonging becomes essential for your safety, health, and well-being. Therefore, the farm's physical design, with its traditional elements, can act as a powerful anchor, providing a tangible link to their personal history and cultural heritage.

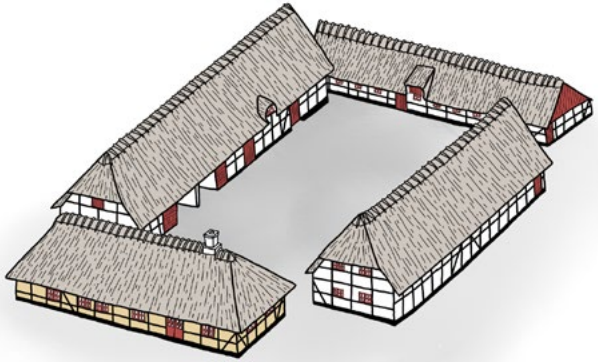
By delving into the history of the farms, a more profound understanding of their previous uses, the significance they had for the local community, and the role they have played in the development of the area. This knowledge helps making informed decisions on how best to preserve and integrate the characteristics of the farm building into the new context.

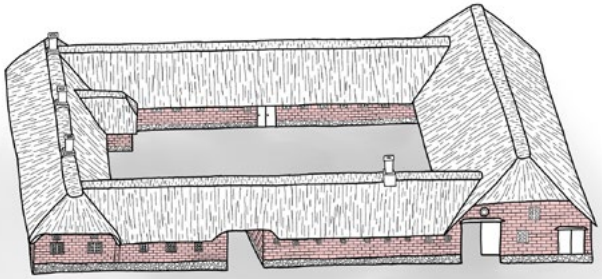
Even though Denmark is a relatively small country, the architectural style differs for each region, resulting in many different farm structures characterized by the surrounding landscape and climatic conditions (Kulturstyrelsen, 2012). Throughout the country, a number of well-preserved agricultural properties can still be found in the Danish landscape. These structures not only show the regional diversity within the landscape but they also stand as proof of the craftsmanship traditions of the past as well as Denmark's history as a peasant society. They are a reminder of an era when agriculture framed everyday life, but the farms also face the threat of modernization and changing demands, potentially erasing these valuable cultural treasures.

However, the structures did share overall tendencies in the architectural style on a national basis, which will be presented on the following pages through a historic timeline of the structural development, characteristics, and architectural design, starting from the 1750s.

> A meaningful architectural experience is not simply a series of retinal images. The 'elements' of architecture are not visual units or gestalt; they are encounters, confrontations that interact with memory.
>
> **- Juhani Pallasma, 2005, p.63, l.12-14**

Illu. 68 - A 'four-winged farm' building and christmas tree farm located in Hjørring Municipality, showcasing the traditional expression of the farm structure, influenced by the Industrialization.





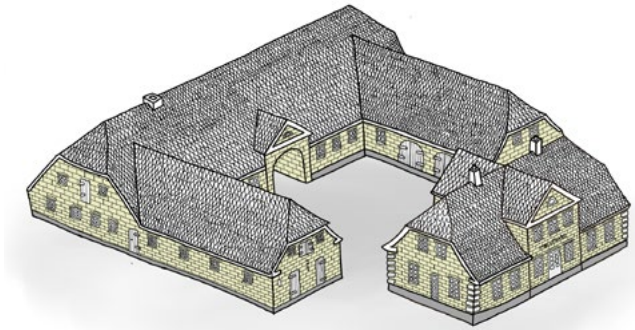
Illu. 69 - The development of farm buildings.

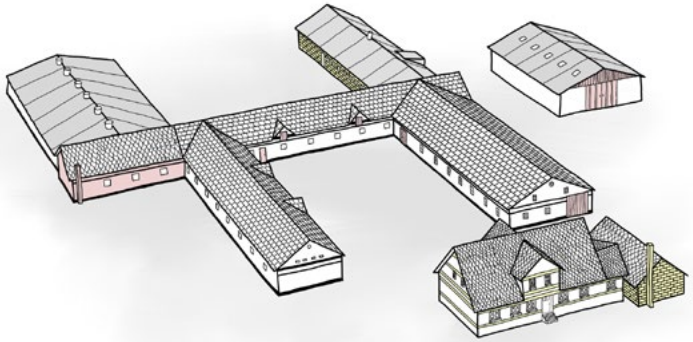
1750-1850

During the mid-18th century, significant agricultural reforms were implemented, leading to an exchange of land between the farms. Originally, farmland was divided into small scattered plots for individual farms. However, through the land exchange process, these farms were consolidated into more substantial, contiguous units. This transformation brought about a whole new agricultural landscape and resulted in the emergence of new farms (Realdania, 2016).

The prevailing architectural style during this period was the longhouse, which typically spanned six to eight meters in depth and included a pitched roof. The longhouse represented a pragmatic and widely acknowledged architectural style, characterized by its short gables and elongated facades. As the development in agriculture led to a rising demand for storage, a significant transformation in farm structures followed. The ' four-winged farm' became dominant in new constructions as well as pre-existing 'angle farms' and 'parallel farms', as it offered expansion possibilities without the need for constructing entirely new buildings. By extending and connecting the wings, the courtyard became more private and defined (Realdania, 2016). The courtyard served as the central space of the farm, allowing access to the farmhouse, the barn, and the stables. It was a multifunctional space where horses were watered and chickens and piglets were running around, as well as a space that contained a dunghill, firewood, and tools (Kulturarvsstyrelsen et al., 2002).

Until the 1840s, most farm buildings were constructed using half-timbering, a technique where the open spaces of the frame were filled with a mixture of timber posts and twigs, which was coated with clay. This method was predominant well into the 1800s, but during the early decades of the 1900s the technique was replaced by mud brick and fired brick. The roof structure consisted of trusses made of wood, which were covered with reed thatch and long straw that formed overhanging eaves. Windows were not numerous, and the few that were incorporated were small with narrow mullion, half-rounded upper doorhead, and unable to be opened (Realdania, 2016).





1850-1900

During this period, the dominant farm type was the brick-built 'four winged farm', usually consisting of three connected wings for agricultural purposes and one detached farmhouse. While half-timbering constricted the flexibility of the building size, the use of brick made it possible to build more freely as well as larger buildings. The aim was to create symmetry and regularity in the facade and often an emphasized entrance in the center of the facade was implemented (Realdania, 2016). Moreover, the roof still consisted of wood trusses, which primarily were hipped or half-hipped along the west coast due to the strong winds, while the east coasts mainly had a gable end (Kulturstyrelsen, 2012). Roof tiles made of clay and slate started to replace the thatch roof after the 1860s. Around 1870 to 1910, the architectural style was influenced by Historicism, where characteristics from earlier architectural styles were mixed and implemented, often through historic inspired decorative details with a National Romanticism expression (Realdania, 2016).

1900-1950

The 'four winged farm' remained as the ideal, but after World War II an incipient rationalization and industrialization of buildings changed the traditional farm land. The farm buildings of this period were especially influenced by Bedre Byggeskik, which is a Danish architectural style developed by Landsforeningen Bedre Byggeskik consisting of architects, craftsmens, and building owners with the intent to develop Danish architectural tradition. This era favored a minimalist approach and became an end to Historicism, which expressed itself through the decrease in decorative details, such as cornices, quoinings, and door frames. There were no excess decorations and the facade expression became more calm and harmonious with its simple buildings with uniform windows (Realdania, 2016).

1950-1965

The increasing focus on production related conditions, resulted in a decrease in new farm buildings and only a few farmsteads were built during this period. However, new demands in relation to the mechanization of work processes lead to many extensions and renovations of existing buildings. At the same time, a detachment from the traditional 'four winged farm' started to appear, as it was of most importance that the farms could adapt to the changing needs as well as the increasing awareness of climatic conditions such as daylight and wind. Moreover, less attention was given to aesthetics and the farm's overall impression, while the technical development of the farm became the focuspoint (Realdania, 2016).

Illu. 70 - Photographs of farm buildings built in different time periods and some marked by renovations and additions. These buildings are located in Hjørring municipality and taken in spring 2023.

When driving through the Municipality of Hjørring, it was my experience that the traditional 'four winged farm' building style with its simplistic expression and clean lines often is blurred by the many additions. The decreasing focus on the aesthetics of farm buildings was a prevailing theme based on my personal encounters when visiting farms. As seen on illustration 70, nr. 2 the many extensions and renovations have influenced the facade expression significantly through its many gables, varying materials, and diverse window types, which contributes to a more complex facade in comparison to the farm in illustration 70, nr. 3 and 5. It was my impression that the facades have become messy and unorganized, and that the strong architectural style of the past has been lost.

For more photographs of farm buildings from the field study, see appendix 1.

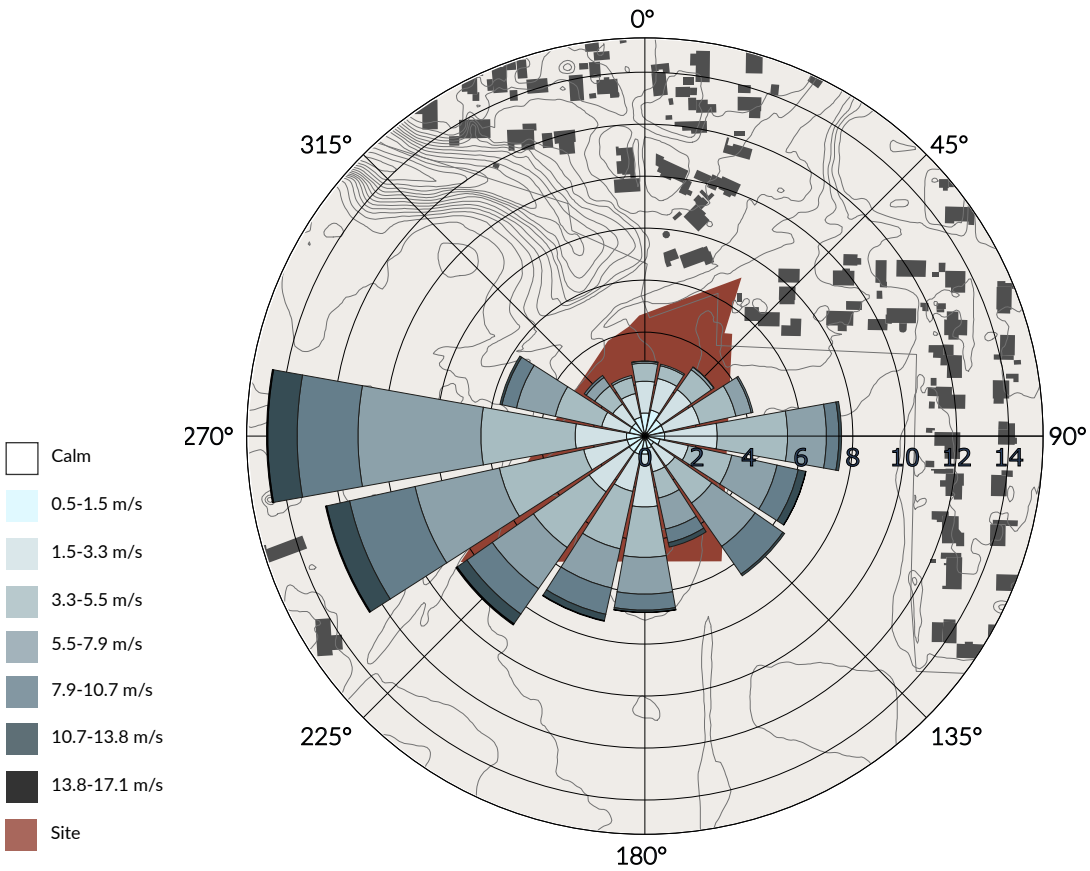
My aspiration is that the final design connects the residents to the agricultural history of their past, which had a substantial impact on their life whether they grew up on or around farms, and thereby strengthen their sense of belonging at the nursing home. This can be achieved through inspiration from the evolutionary progression of farm structures by preserving the simple and uncluttered essence of the 'four winged farm' and convey its impact on the historic development of farm buildings. Hence, the design process will prioritize the examination of this building style.

MICRO CLIMATE

ANNUAL WIND ROSE

Based on data from a weather observing station in Sindal, which is the closest station to the site, a large amount of wind is measured from west and southwest with a velocity between 3.3-10.7 m/s for the majority of the wind. However, strong winds with a speed up to 17.1 m/s are also experienced from the same directions. The woods and line of trees along the west side of the site border are to some extent shielding the site from these winds. However, as the site is located on a large, open field with an open landscape towards south, the site is exposed to much wind.

Therefore, when designing the nursing home, outdoor spaces should prevent the residents from discomfort in relation to wind. It is important to incorporate shielded outdoor areas for the residents to enjoy nature without the risk of falling due to strong winds or having additional difficulties hearing and communicating due to the noise that follows. Safe spaces that encourage the residents to spend time outdoors and engage in the community at the nursing home should be provided.



Illu. 71 - Annual wind rose based on data from an weather observing station in Sindal (Betti G. et al., 2022).

SUB-CONCLUSION

DESIGN PRINCIPLES

The following points summarize the design principles concluded in the ‘Site Introduction’ section:

- Surrounding walking paths should be an integrated part of the flow patterns on the site.
- Existing sightlines to the open landscape should be maintained.
- The building should be in a harmonious interaction with the open, simple landscape type.
- Vegetation should be used to connect building masses or subordinate to the landscape.
- The building height should not exceed the existing tree height.
- A distance between the building and the main road should be implemented to strengthen the conceptual expression.
- The building structure should reflect the principles of the ‘four-winged farm’ to strengthen the residents' connection to the agricultural history of their past.
- The local community should be involved in the design through collaborations with local institutions and stores.
- Comfortable outdoor areas that are shielded from wind from west and southwest should be provided.

03

DESIGN
PROCESS

DESIGN PROCESS

The following chapter presents some of the many design iterations made in the ‘Sketching’, ‘Concept development’, and ‘Synthesis’ phase, relevant to the final concept and building design. Both architectural and technical parameters are considered, and design ideas are presented through 2D and 3D visualizations by exploring various forms, layouts, principles of passive house design, indoor climate optimization etc., including appurtenant calculations and explorations enclosed in the Appendix, offering a more in-depth analysis of the quantitative aspects that have guided the design decisions.

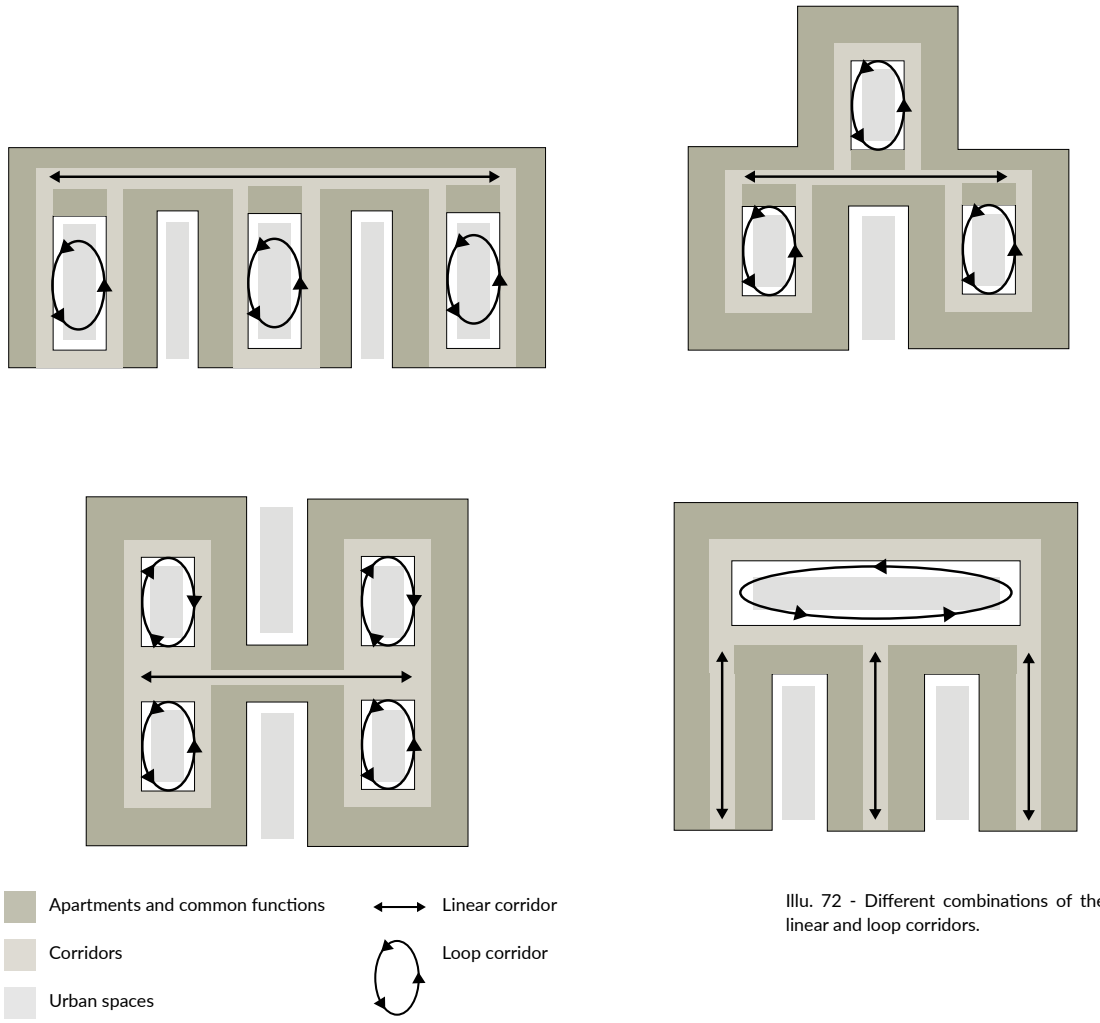
This chapter provides an insight into the creative and iterative journey undertaken to the final building design through selected iterations, critical design choices, and considerations that have shaped the architectural vision and are essential to understand how the final design has come to be.

SPATIAL LAYOUT AND CIRCULATION

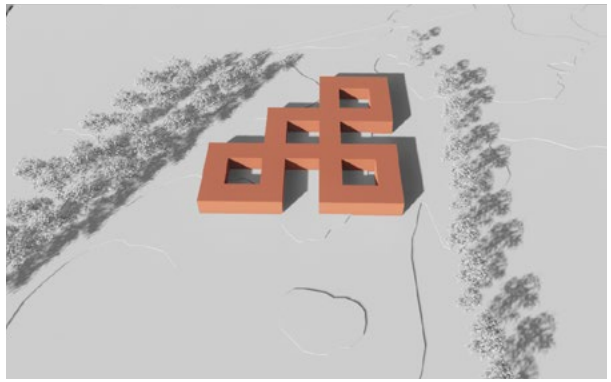
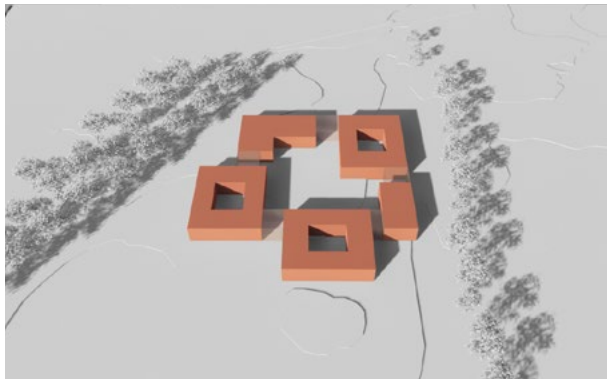
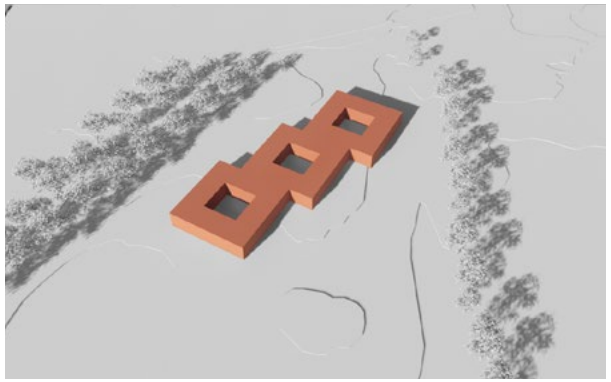
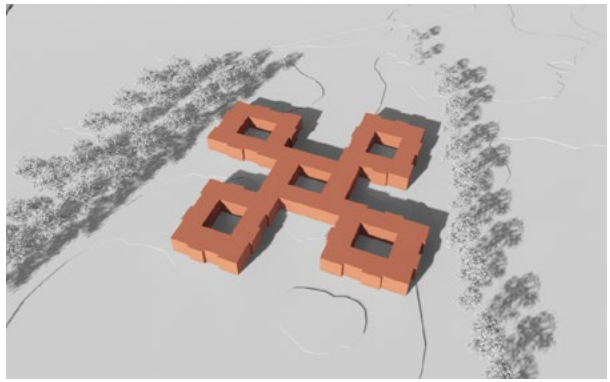
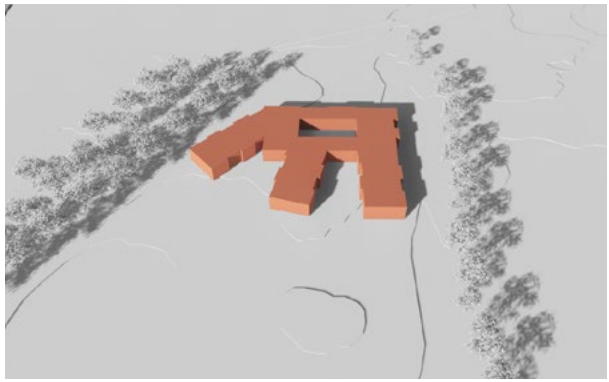
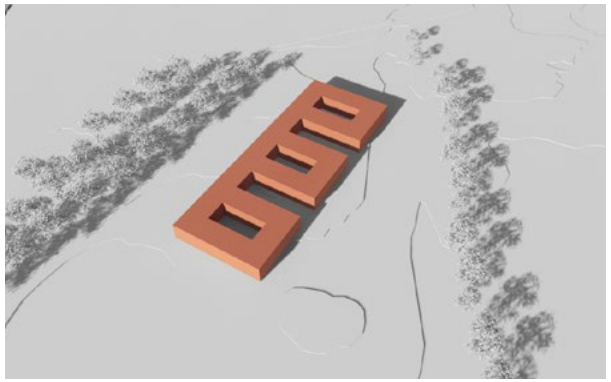
CIRCULATION

The initial design process consisted of hand sketching and sketch modeling (see appendix 3) of different forms and typologies with various spatial layouts in regard to circulation. After several design iterations, the design explorations became very focused on loops and linear corridors (illu. 72 and 73) due to the acquired knowledge about wandering and wayfinding (pp. 17-18). Additionally, a series of form studies was made to get a spatial understanding of the examined spatial layouts in relation to the context (see appendix 4).

A spatial layout consisting only of linear corridors provides a visual overview for the caregivers, as they have a clear view of each residential department when working in the connecting linear corridor as seen at Lundgården (illu. 19, p. 33) and expressed by the caregivers working at the nursing home. However, the many dead ends can become frustrating for the residents when wandering and lead to a feeling of being imprisoned.
In contrast, designing a spatial layout consisting solely of continuous loops creates a fluent circulation throughout the building and provides a space for managed wandering in a safe environment. However, it can also increase wandering if there are no 'way stoppers' or activities placed along the route to stop the wandering and distract the residents. Moreover, several enclosed courtyards are provided as a safe urban space for the residents, but the caregivers do not have a clear visual view of the entire residential department. Implementing large windows and/or glass walls can improve the caregivers overview by creating sightlines across the courtyards.



Illu. 72 - Different combinations of the linear and loop corridors.

Illu. 73 - 3D sketches of different spatial layouts in relation to form, and how they fit in the context.

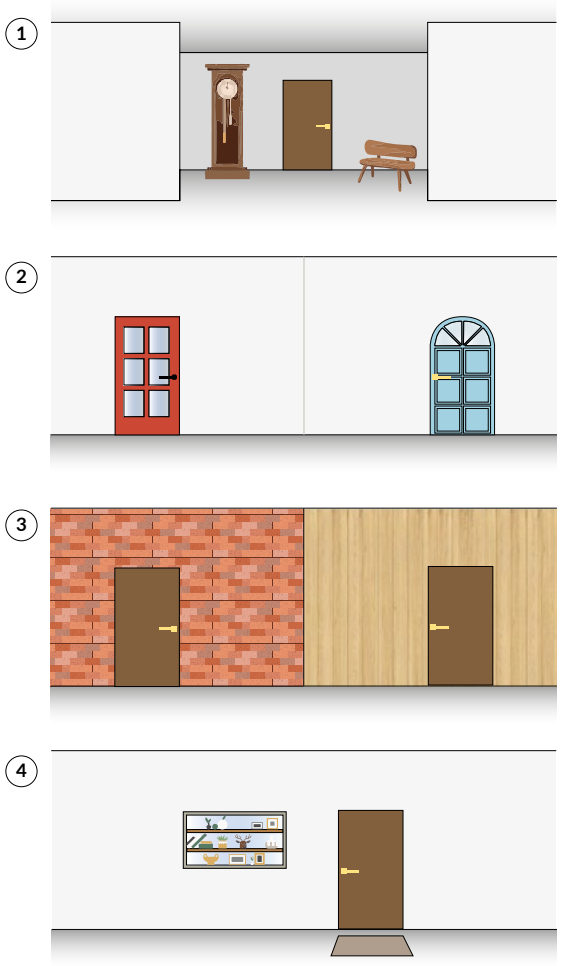
THE APARTMENTS

LAYOUT AND ENTRANCE

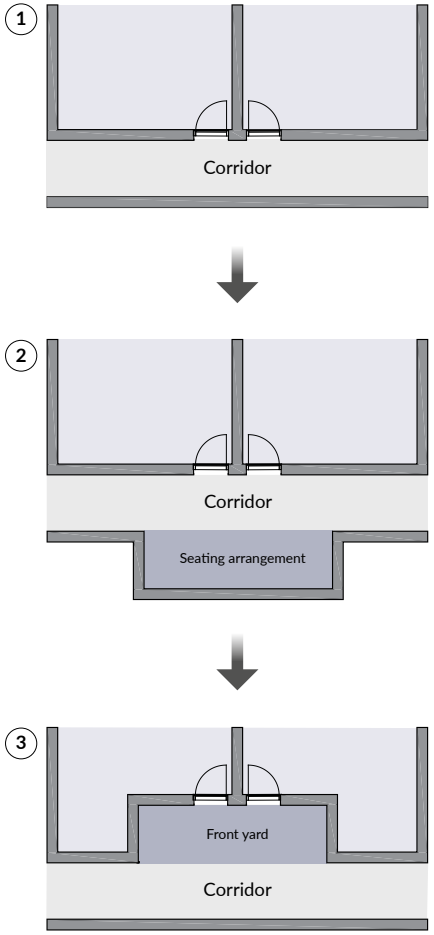
Different design principles with focus on improving the residents' wayfinding skills and recognition of the entrance to their own apartment was considered. Personalizing the entrance by placing benches, mailboxes, tables or other kinds of furniture (illu. 74, nr. 1), a recognizable difference between each apartment is created through objects that spark memory and add an individual touch to the apartments' entrance. Furthermore, a variation in front doors through color and/or shape (illu. 74, nr. 2) as well as different wall materials for each apartment (illu. 74, nr. 3), can enhance the individuality. Moreover, placing a window with a view from the apartment to the corridor, lets more daylight into the apartment and creates another space to put personal mementos on the window sill or shelves to spark memory (illu. 74, nr. 4).

Furthermore, a couple of different corridor layouts have been tested. By adding niches to the corridors (illu. 75, nr. 2), there is space for seating arrangement to rest when wandering, while creating a 'front yard' as an extension of the apartments (illu. 75, nr. 3) provides a space for them to personalize as they are used to in their previous homes, and it prevents the resident from walking directly into the sometimes busy corridor when opening their front door.

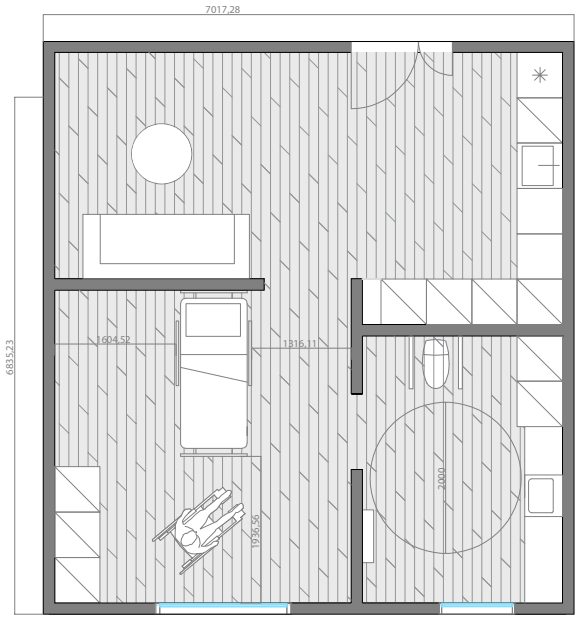
Creating distinct zones: bedroom, bathroom, and living room, within the apartment was important during the design development to provide a sense of familiarity and enhance the feeling of a true home environment. Different layouts, apartment sizes, and composition of zones were explored (illu. 76, 77, and 78). An entrance was later added to not having the front door opening



Illu. 74 - Four different design principles to personalize the entrances.

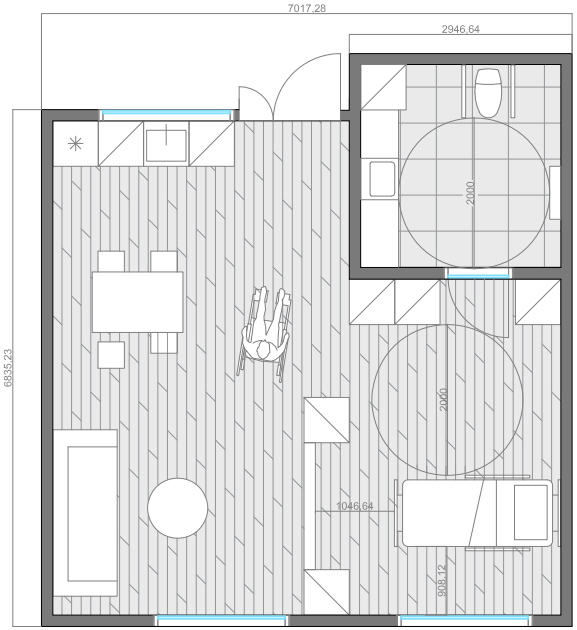


Illu. 75 - Three different principles in relation to the layout of the corridor.



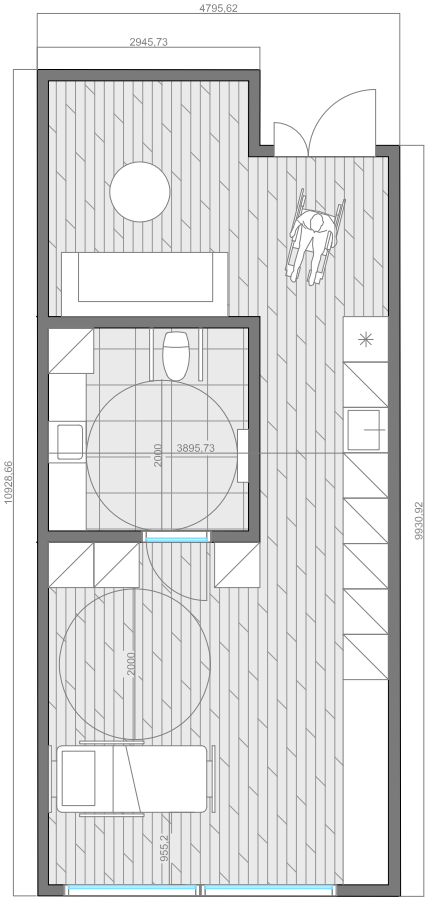
53 m²

Illu. 76 - Layout of a residential apartment in 1:100.



49 m²

Illu. 77 - Layout of a residential apartment in 1:100.



49 m²

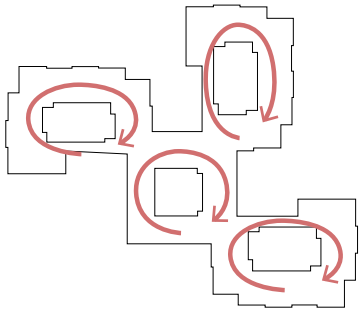
Illu. 78 - Layout of a residential apartment in 1:100.

directly into the kitchen or living room.

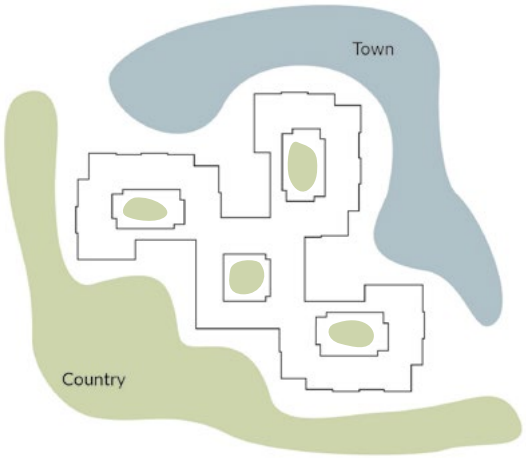
Based on statements made by caregivers at both Tornhøjhaven and Lundgården, it was expressed that the residential apartments often are designed too small, which creates problems for the nursing staff when helping the elderly in or out of bed, to the bathroom etc. Moreover, in the interview with the caregiver at Banebo, she described how they made room for an extra bed for relatives in the apartments in case the resident becomes sick or is dying and a relative needs to be close to the resident. Therefore, a spatial apartment with flexibility in relation to relatives without compromising the necessary space for essential work tasks provided by caregivers, is an important factor that was incorporated when designing.

CONCEPT DEVELOPMENT

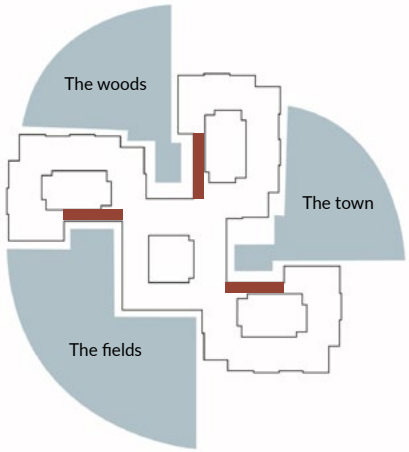
YARDS AND LOOPS



Illu. 79 - Circulation consisting of four continuous and connected loops.



Illu. 80 - The transition from town to country through the building form.



Illu. 81 - The corridor in each residential department is characterized by three different views to navigation.

CIRCULATION

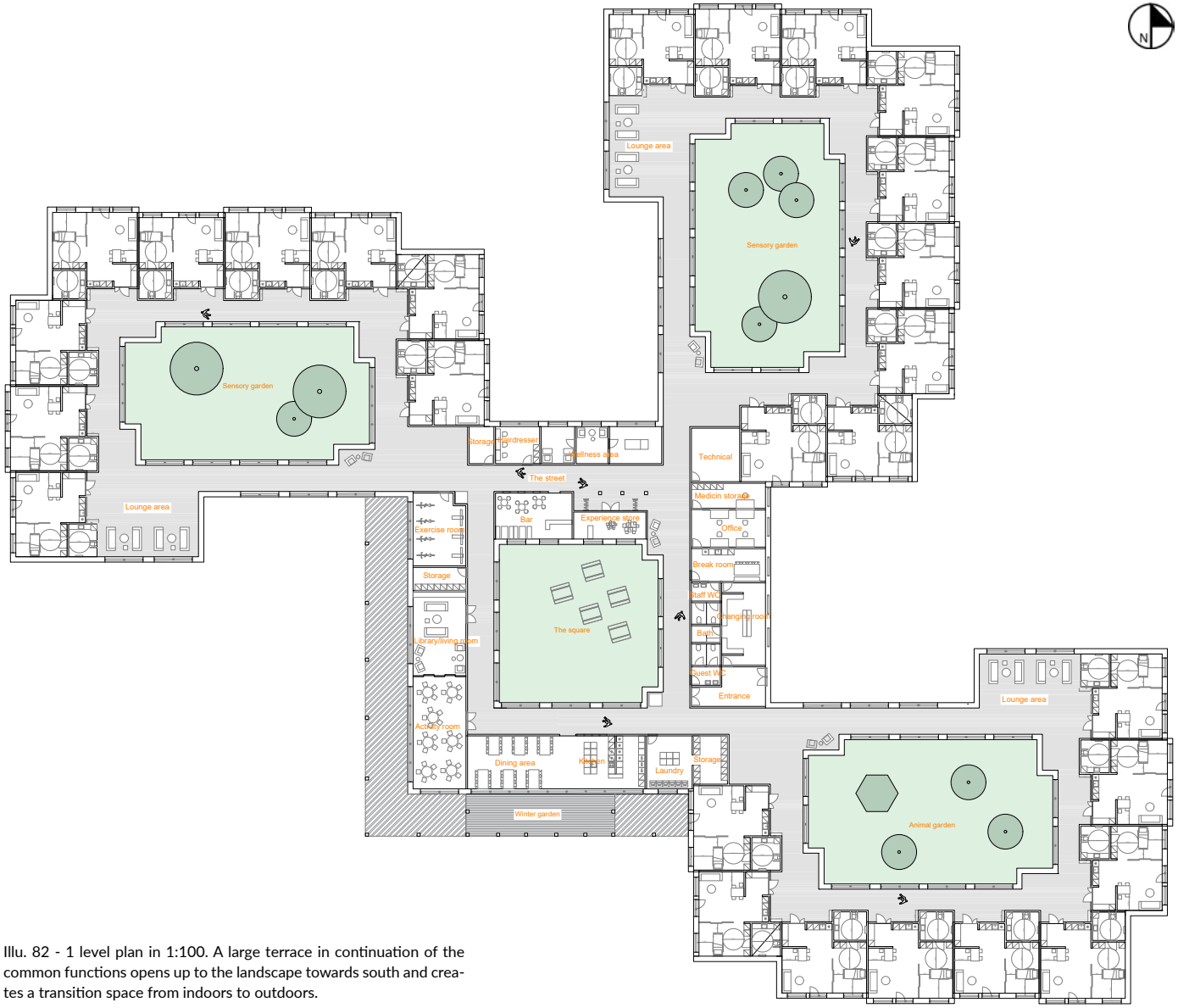
The decision was made to further develop the layout consisting of four continuous loops, based on the included research regarding how to improve wayfinding, as well as the intention to connect the residents to the agricultural history of their past through the building structure. Drawing inspiration from the momentous 'four winged farm' that has impacted the building structures of farms to this day, the concept started to take shape.

TRANSITION

The residential apartments were positioned towards the town, while the communal facilities were oriented towards the woods and open fields, allowing views of 'The Open Simple' landscape from the common areas. The building structure opened up towards the south and embraced the open landscape, while creating a graduating transition between the town and the rural areas by bringing elements from the countryside into the courtyards. Additionally, the transition was expressed in the facade design, and how it opened towards the woods and fields, while appearing more private towards the town (illu. 87, p. 78).

VISUAL FIELD

Each residential loop was provided with a corridor with a direct view to the outdoors, outside the building, to improve wayfinding by creating three significantly different views. The first was characterized by the dense woods, the second captured the bustling of the main road and town, and the third view showcased the serene expanses of the fields and open landscape.

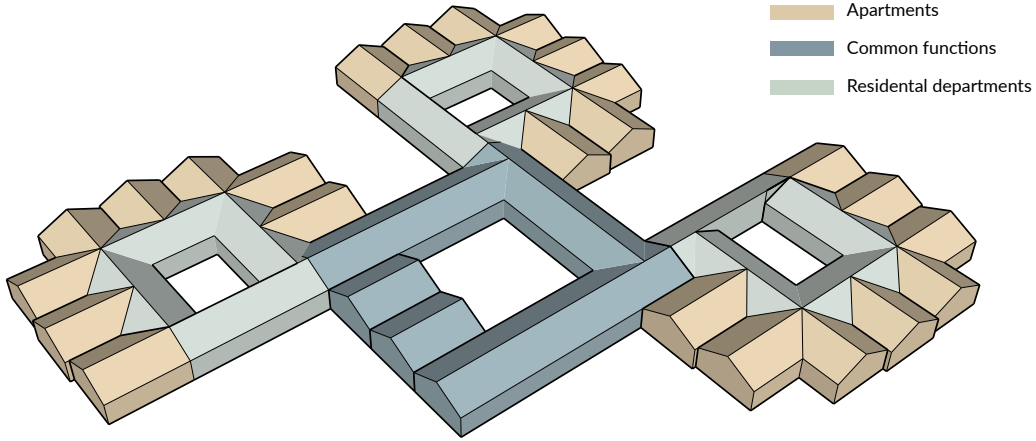


Illu. 82 - 1 level plan in 1:100. A large terrace in continuation of the common functions opens up to the landscape towards south and creates a transition space from indoors to outdoors.

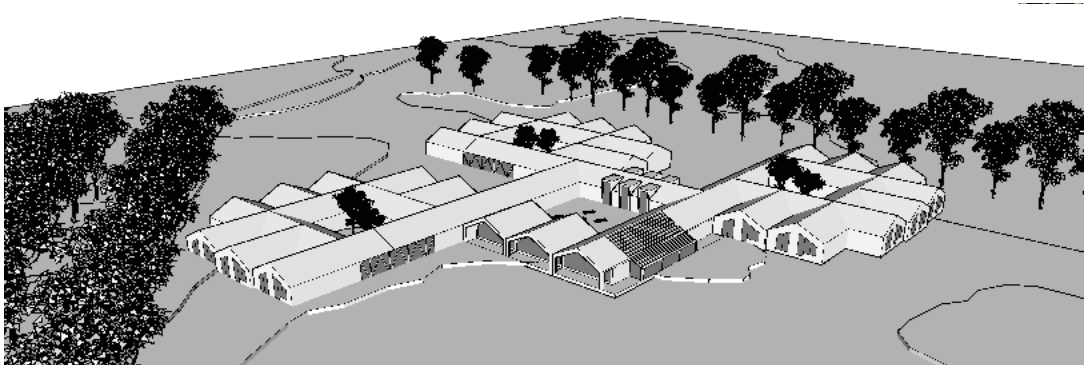
INDIVIDUALITY
PRINCIPLES

An important aspect of the design development was to enhance the resident's sense of individuality. To achieve this, several initiatives were taken. The volume of each residential apartment was added perpendicular to the main structure (illu. 83) to create a visible distinctiveness and strengthen the feeling of home as well as ownership by creating the appearance of separate units while still being attached. The volume of each apartment was then shifted in relation to each other (illu. 82, p. 76) and different facade materials added (illu. 87), creating a more dynamic facade. Lastly, a difference in height between the connecting loop with all common functions and the three residential loops was made (illu. 85). This created a hierarchy between the communal and residential departments through a visual distinction.

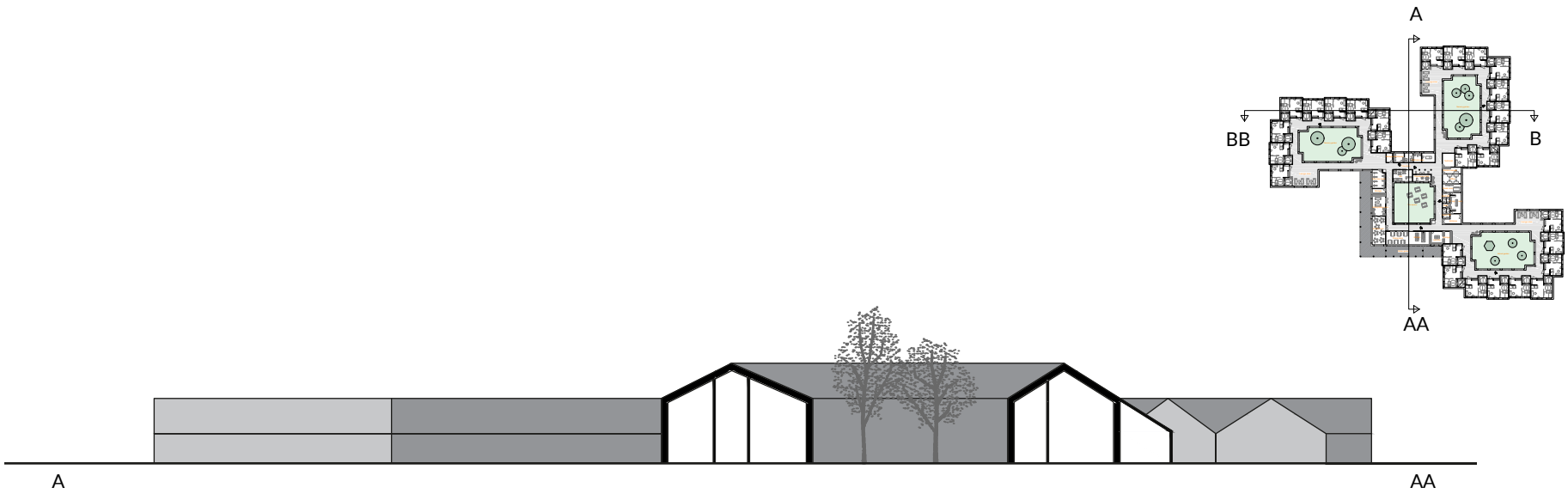
However, as the design evolved, a concern arose. The composition began to feel cluttered with numerous elements trying to get attention simultaneously. The abundance of gables and various facade materials reminded a lot of the messy and unorganized expression that marked farm buildings from the 1950s up till now, due to the many extensions and renovations. The shifts in the facade, the different facade materials, the added on residential volumes, and the difference in building height was too much going on at once. In continuation, all four initiatives strengthen individuality on the outside of the building, when it really is on the inside, where the residents spend the majority of their time, that the need for visual distinction between the apartments to improve wayfinding is most important. Therefore, a new-found focus and prioritization of the need for individually on the inside overshadowed the rest of the design process.



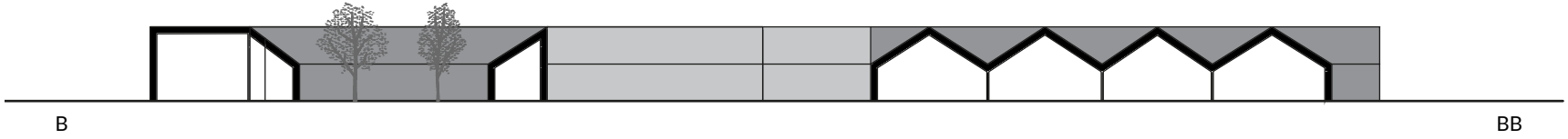
Illu. 83 - Placement of the overall functions.



Illu. 84 - 3D sketching of the building. Several design principles are implemented in the facades to experiment with different facade expressions in the apartments, corridors, and in connection to the large terrace. Therefore, the expression appears quite messy.



Illu. 85 - A-AA section in 1:500 that shows a difference in building height between the three residential departments and the common function department that connects them to create hierarchy in the building and enhance the communal areas.



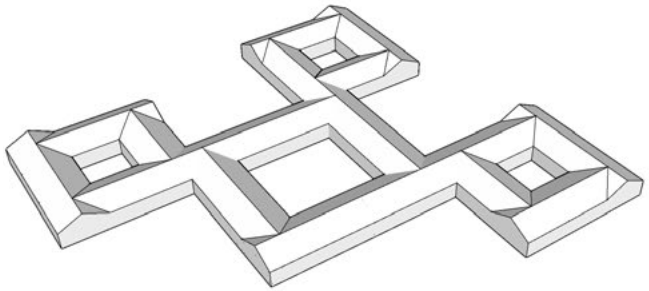
Illu. 86 - B-BB section in 1:500 that shows the residential apartments, where the volume is placed orthogonal on the corridors to enhance individuality in the building form.

Illu. 87 - South facade in 1:500 that shows the many design initiatives made in the volume and facade to enhance individuality and create a clear differentiation of the different departments and corridors.

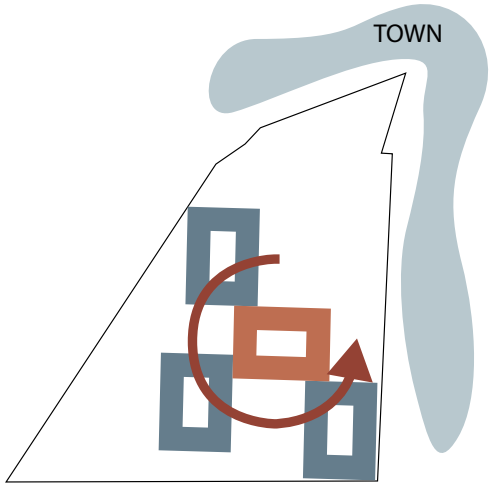
FORM AND LANDSCAPE

EXPRESSION AND PLANS

The building became less cluttered by removing the many individualization initiatives that ended up blurring the conceptual design. Instead, the simple expression of the traditional 'four winged farm' with connected wings, combined with the minimalistic approach influenced by Bedre Byggeskik in the 1950s-1965s (illu. 88), was preserved. By subtracting the many added volumes and gables, the facades became more clean and harmonious with the landscape, not taking away attention from the open fields and flat terrain. Moreover, the layout of the building involved several indentations in the facade due to the connection between the four departments, which created some complexity to the facade. The many added volumes, shifts in the facade etc., only contributed to further complicate the expression, making the building disharmonious with the landscape.



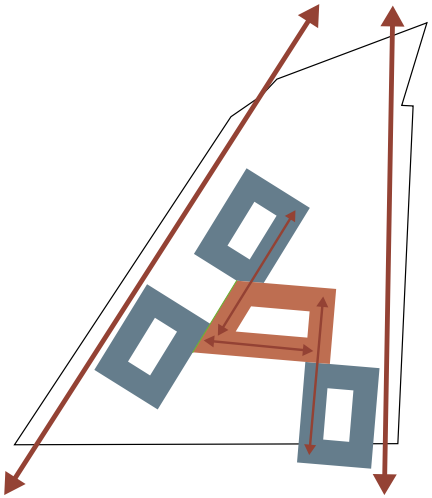
Illu. 88 - The building form is made more simple to create a stronger conceptual expression and a more harmonious interaction with the landscape.



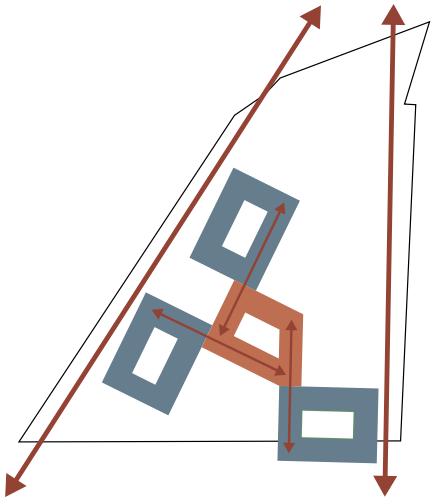
Illu. 89 - The building is rotated 180 degrees to appear more open and to invite the local community in.

180 DEGREE ROTATION

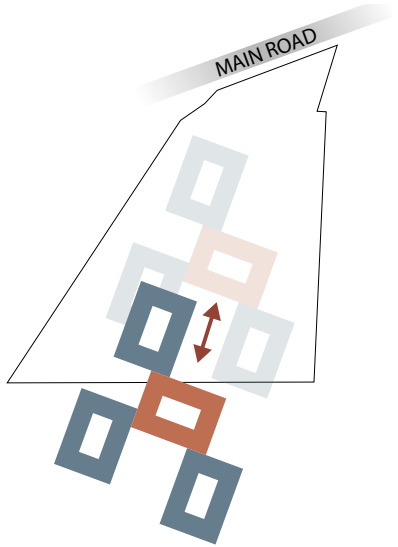
It became very important to design a nursing home not merely for the residents, caregivers, and relatives, but a home that allows the local community to become a part of everyday life at the nursing home, bringing social interactions, activities, sensory stimulation, joy, and a feeling of belonging in the town and community for the residents. Therefore, the building was rotated 180 degrees, allowing the connecting courtyard that entails common functions for both the residents and the local community to be facing the town and the accessing road. Subsequently, opening the building up to the town and becoming more inviting compared to the former plan design.



Illu. 90 - Important sight lines are preserved by altering the connecting loop, ex. 1.



Illu. 91 - Important sight lines are preserved by altering the connecting loop, ex. 2.



Illu. 92 - The site limit is exceeded to create distance to the main road.

SIGHTLINES

Important sight lines, including the walking path and riding trail along the northwestern and eastern site boundary, were preserved by rotating three of the four volumes, making the facades facing each sightline parallel with the line to enhance it. Beyond the external perspectives, an equal emphasis was placed on securing the internal sight lines. It was important that the morphing of the shapes did not compromise the inner sight lines that connect the department with all common functions with the residential departments to provide an overview of each unit for the caregivers when staying in the connecting loop. As seen in illu. 90 this was not the case. Another attempt that did maintain the inner sight lines was made (illu. 91), but after further experimentation with the shapes, it was decided to preserve the simple and rectangular shapes of the 'four winged farm' to communicate the concept more clearly.

EXCEED THE SITE LIMIT

The building was pulled back from the road to support the conceptual expression by creating a 'pause' in the landscape as described in the section 'The Placement in the Landscape' (p. 57-60). This deliberate spatial distance served to establish a harmonious interplay between the architectural structure and the surrounding landscape by making the building subordinate to the landscape with its long facades and horizontal lines parallel to the flat terrain.

VISUAL AND THERMAL INDOOR CLIMATE

TEMPERATURES

AIMS AND REGULATIONS

Two rooms have been selected as the most critical in terms of thermal indoor climate and subsequently examined in BSim, which is a dynamic building simulation program. By setting up systems involving venting, mechanical ventilation, heating, equipment, and lighting according to the occupancy day profile, a better representation of reality is given, as the data change over time (see appendix 8, table 8.1). The aim with each of the models is to examine the indoor operative mean temperature above 27°C and 28°C according to the requirements in BR18 regarding a maximum of 100 hours above 27°C and 25 hours above 28°C (Bygningsreglementet, 2018a, §385-§392, 1.0). In addition, it will be examined whether the operative temperatures comply with the limits in category 2 concerning a Predicted Percentage Dissatisfied (PPD) of <10% and Predicted Mean Vote (PMV) of -0.2<PMV<+0.2 in regards to maintaining 20°C<t_o<24°C within the heating season (15th of September-15th of May) and 23°C<t_o<26°C outside the heating season (15th of May-15th of September) (Dansk Standard, 2019, p. 5).

As elderly have a lower activity level than younger people, they often experience a decrease in the ability to regulate body temperature and therefore have a need for higher ambient temperatures (Hoff et al., 2008). Hence, the aim is to maintain a high operative temperature of 23°C during the heating season and 25°C outside the heating season, while still complying with the regulations.

Simultaneously, the amount of daylight that each design allows to enter the room is examined in relation to the requirements in BR18 regarding a glazing area that correspond to minimum 10% of the relevant floor area, and by documenting that the interior illuminance from daylight is 300 lux or more on minimum 50% of the relevant floor area for at least half of the daylight hours (Bygningsreglementet, 2018b, §379, stk. 2). Daylight considerations are important when designing for people with dementia, as lighting can have a great impact on the biological clocks of people with dementia, as their circadian rhythm can be more disturbed than in elderly without dementia (Dahl, 2019). In addition, elderly require more light to see clearly than younger people. Therefore, the aim is to attain an illuminance of minimum 400 lux on at least 50% of the relevant floor area.

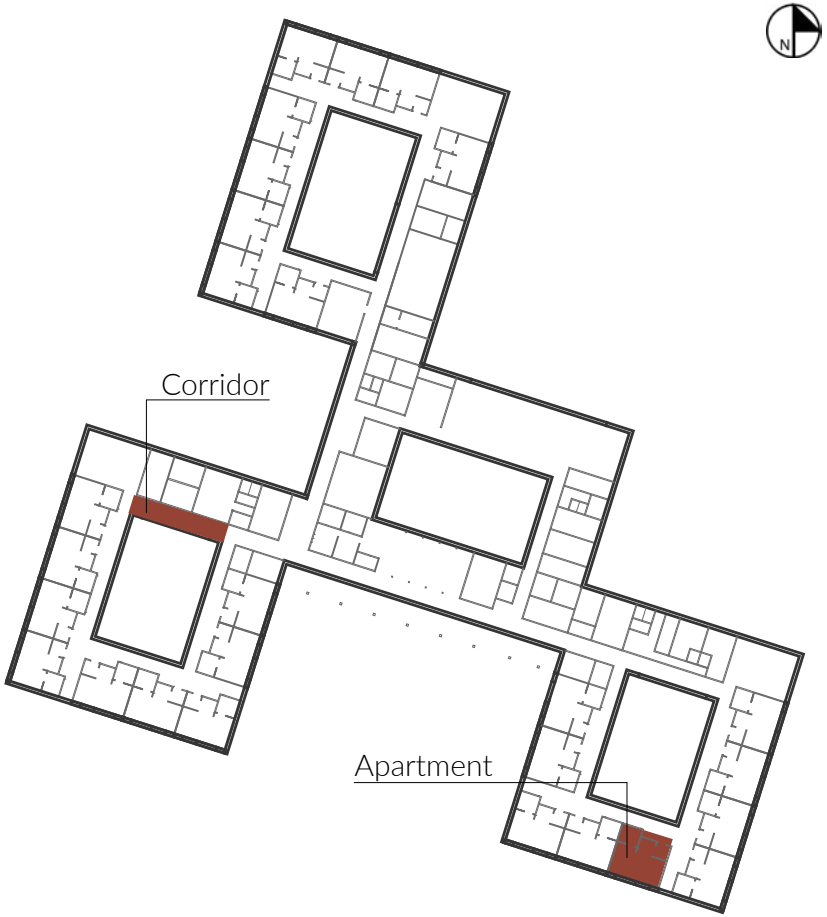
SYSTEM CONTROL

When setting up the systems (see appendix 8, table 8.2), it was important that the control did not rely on user interaction as people with dementia may not understand if a room is too hot or too cold, causing discomfort without being able to express it. Therefore, manual heating and ventilation systems often are not suitable for them, as they often forget that they have adjusted the temperatures or may not be aware of a smell that needs ventilation due to a decrease in smell. By creating a smart home where temperatures, air quality, and glare prevention is regulated by automatic control and sensors, thermal, atmospheric, and visual indoor comfort can be attained without the necessity of a resident or a caregiver to control the indoor climate. However,

the residents are still able to manually open the windows in their apartment for additional venting due to safety.

Moreover, to prevent glare, a shading control system is implemented. This type of shielding is designed to respond to external light levels. If the illuminance measured on the facade where the window is placed exceeds a certain lux value, integrated venetian blinds between the layers of glazing are activated. The shading remains closed until the external light levels drop below the activation threshold.

Lastly, the required air change rate for all rooms has been calculated (see appendix 5, table 5.4) with the aim to comply with the requirement in BR18 regarding a maximum concentration of 1000 ppm CO2-pollution in the room during dimensioned conditions, meaning the normal operation of the building (Byggningsreglementet, 2018c, §420-§452, 1.7). A hybrid ventilation system consisting of mechanical ventilation with an 80 % heat recovery during the heating season (week 1-18 and week 37-53) and natural ventilation in the cooling season (week 19-36), is implemented. Furthermore, all rooms have a Variable Air Volume (VAV) control system, where the air volume is adapted to the current ventilation needs to save energy for heating, as the rooms are used to varying extents throughout the day and fluctuate in the number of occupants. Moreover, based on the calculated needed air change rate, the necessary effective opening area for natural ventilation in each of the two rooms is calculated. Stack ventilation based on thermal buoyancy is used in the apartment, and cross ventilation based on wind is used in the activity room (see appendix 6).

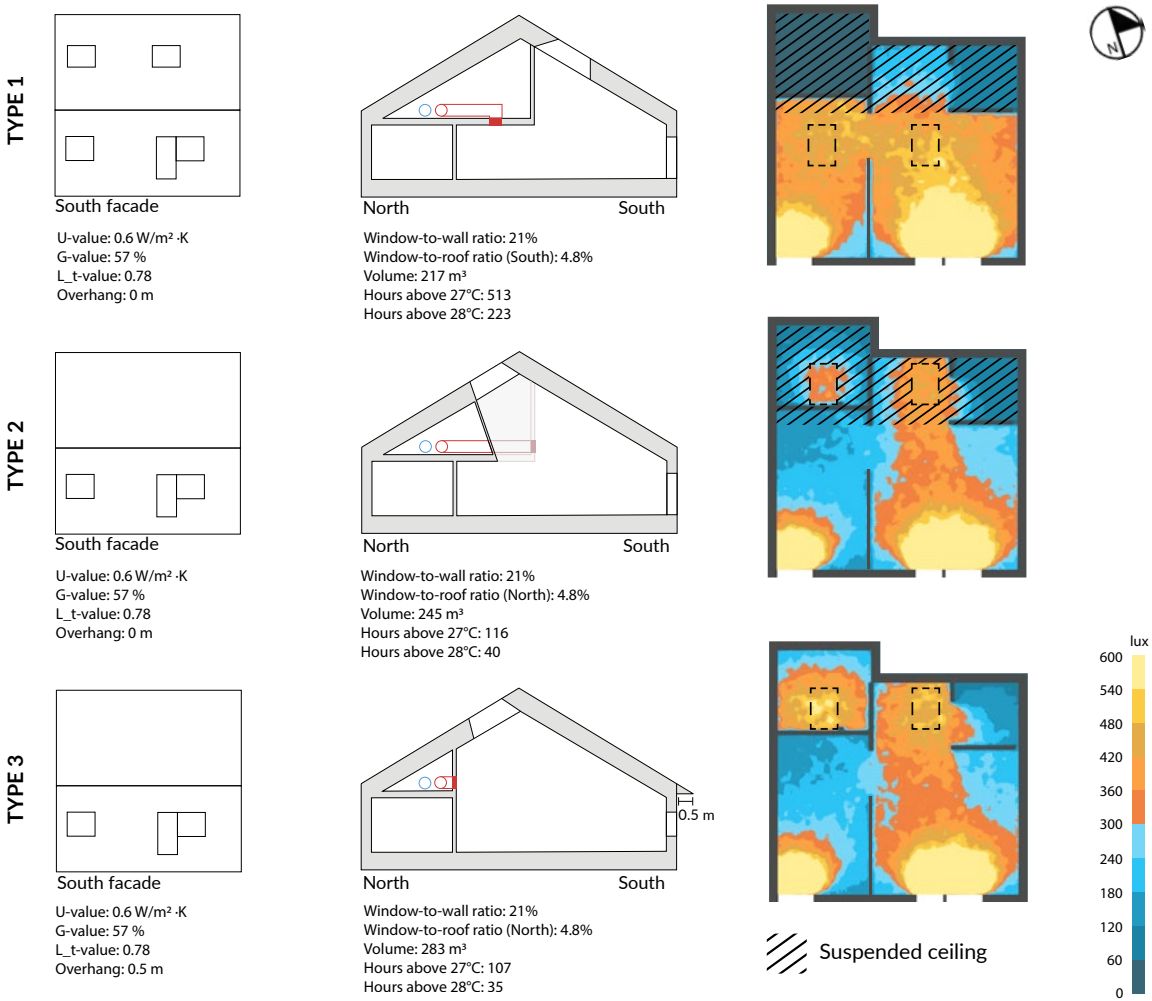


Illu. 93 - Location of the two critical rooms examined in relation to the visual and thermal indoor environment.

APARTMENT

The first room is a residential apartment with an exterior wall towards southwest and no shading from buildings or trees, which results in the highest solar heat gain in any of the apartments. Likewise, the examined scenario involves a high peopleload with a resident who is bedridden and therefore is staying in the apartment at all times. Two caregivers come and go during the day to feed, turn, and help the resident to the bathroom with a lift. Two relatives also visit the resident for a few hours during the day.

Several iterations were made in relation to volume, glazing values, window placement, overhang, and window-to-wall ratio to get an understanding of how each parameter affects the operative temperature in the room. In type 1, the ceiling height in the entrance, kitchen and bathroom is lowered to gradually open up the space from the relatively small entrance to the living room with a cathedral ceiling. Additionally, it creates more space for the mechanical ventilation system, but it also decreases the volume in the apartment. In type 2, the roof windows that allow stack ventilation are moved from facing south to facing north to provide daylight in the bathroom and increase the daylight in the kitchen as well as to lower the solar heat gain, which results in a larger volume and subsequently lower the hours above 27°C and 28°C significantly. To allow more daylight to enter the bathroom and kitchen, type 3 has no lowered ceiling, which results in slightly lower operative temperatures due to the increase in volume as well as the addition of an overhang with a depth of 0.5 m towards south to reduce solar heat gain. The window-to-wall ratio was

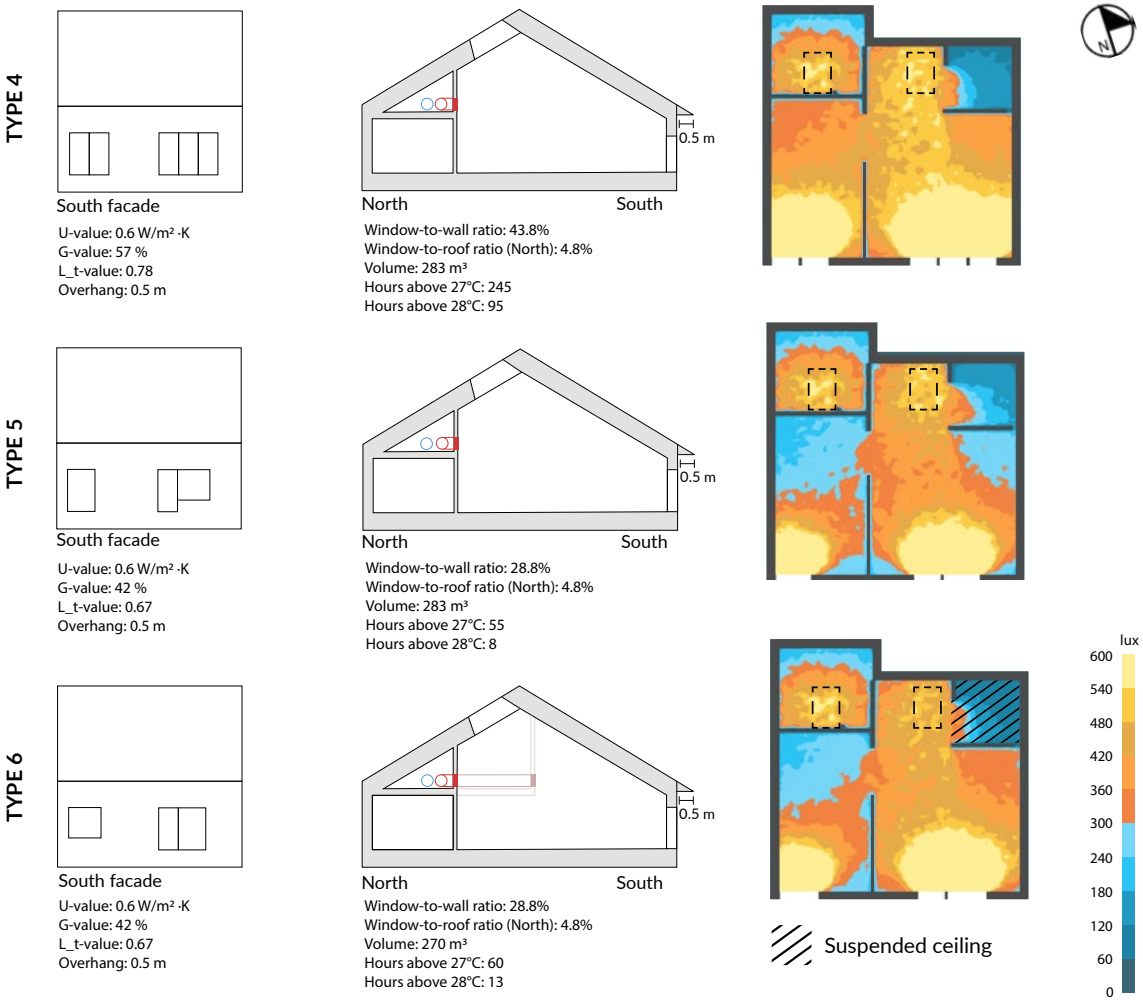


Illu. 94 - The examined conditions for three different apartment types.

Illu. 95 - Experienced illuminance distribution in each apartment types.

then doubled type 4, which provided a high illuminance in all rooms of the apartment. However, the operative temperatures needed to be reduced substantially. Hence, type 5 is designed with a reduction of around 15% in window-to-wall-ratio, and glazing values with a higher L_T value and thereby a higher g value was implemented, while still providing illuminance values that comply with the requirements. Lastly, a lowered ceiling in the entrance is implemented in type 6 to attain the aforementioned gesture and still maintain operative temperatures that do not exceed the requirements.

Based on the results, it is possible to increase the window-to-wall ratio a little to improve the view and the experienced atmosphere in the room, which is seen in the final design.



Illu. 96 - The examined conditions for three different apartment type.

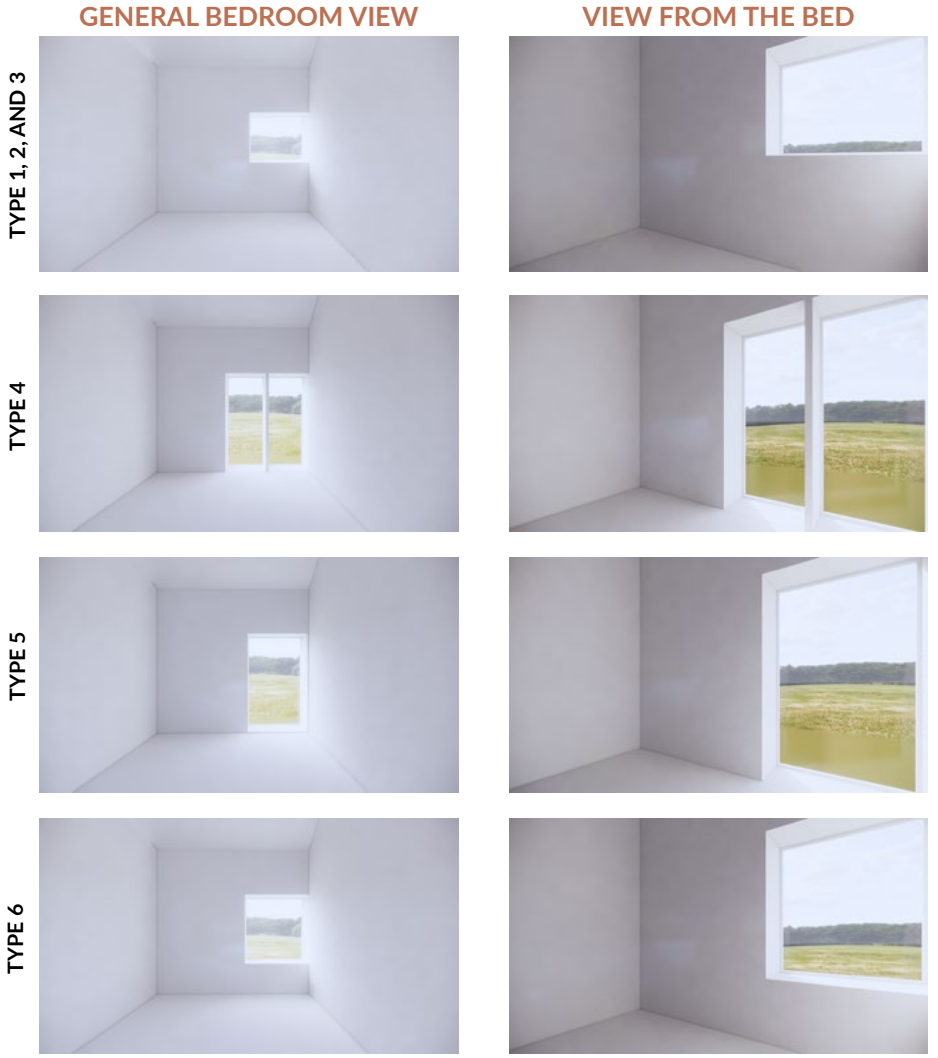
Illu. 97 - Experienced illuminance distribution in each apartment types.

BEDROOM VIEWS

Not only are the placement and size of windows determining daylight access, operative temperatures, and facade expression, but it also provides a view of the outside world. A view of the ever changing landscape and surroundings as the days and seasons progresses, which gives the occupants a sense of connection with nature and the local community. Moreover, windows play a significant part in regard to the residents' circadian rhythm and subsequently their sleep patterns, health and well-being.

When dimensioning windows for the residential apartments, several sizes and placements were examined in relation to the thermal comfort and illuminance requirement iterations in the former section, and with focus on view and connection to the outside.

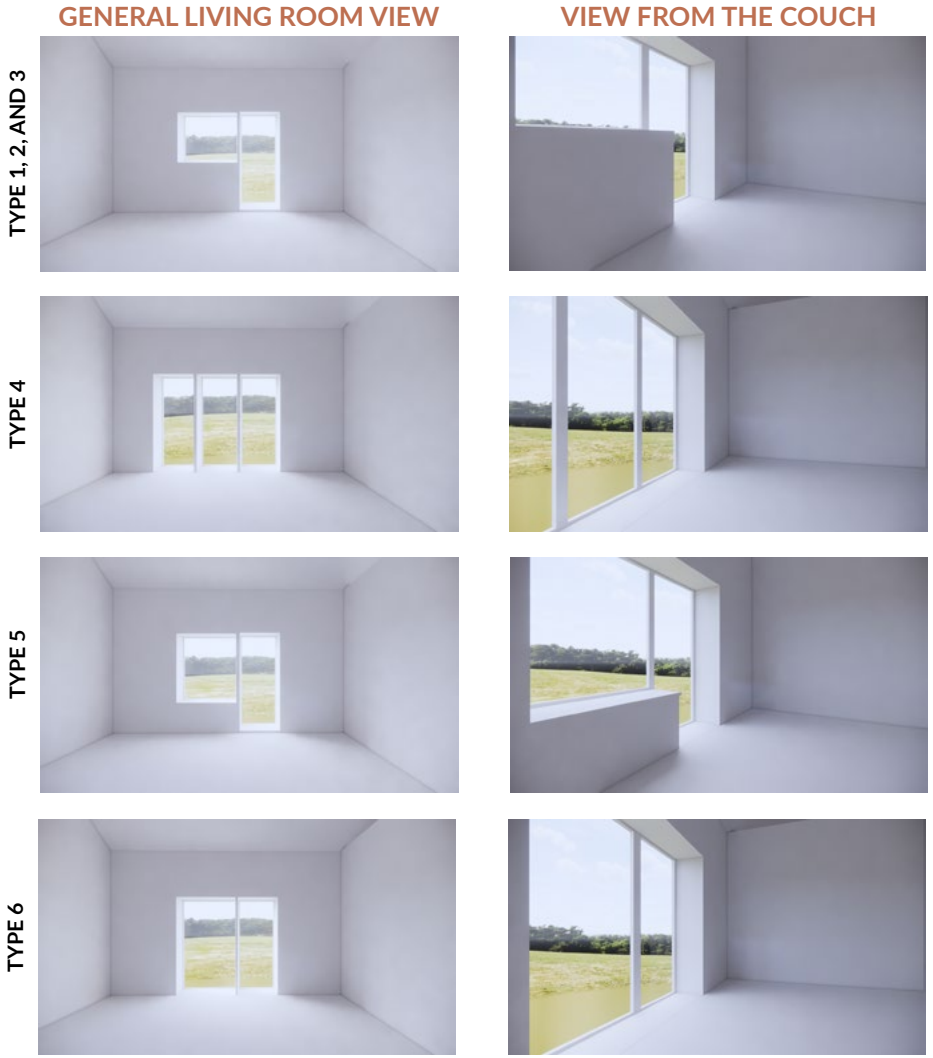
A low sill height (type 4, 5, and 6) is preferable as it increases the vertical field of view for the residents when laying in bed. Additionally, a window sill that is leveled with the floor (type 4 and 5) melts the room and landscape together and creates a fluent transition between inside and outside. In contrast, a higher sill height (type 1, 2, and 3) feels like a barrier between inside and outside, especially the view when laying in bed is very limited and only provides a view of the sky. By placing the window along the wall, daylight will naturally reflect more diffuse light into the rest of the room, resulting in softer shadows and contrasts. At the same time, it opens up the space by creating a brighter and more uplifting atmosphere.



Illu. 98 - The views of the landscape in the bedroom for each of the examined apartment types.

LIVING ROOM AND KITCHEN VIEWS

Likewise, a low sill height in the living room (type 5, 6, and 4) is preferable as it increases the vertical field of view when sitting on the couch or at a table. A window with a higher sill height (type 1, 2, 3, and 5) can create a clear transition between inside and outside, which is beneficial when designing for people with dementia as large glass surfaces can be interpreted as if nothing is there and may be difficult to understand. In addition, it is possible to place plants or personal belongings on the sill to make the space more personal and increase the feeling of home. However, a sill height that is leveled with the floor (type 4 and 6) maximizes the view of the open fields and trees on the horizon as well as creating a welcoming atmosphere where the room is in close connection with the landscape. To avoid confusion, windows with mullions as seen on illu. 70, nr. 1 on p. 65, which is characteristic for old farm buildings, will be an excellent design solution to define the windows, while maintaining the connection to the landscape as well as the association to the architectural style of farm building from the past.



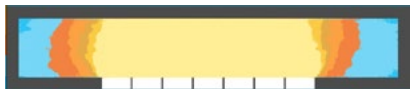
Illu. 99 - The views of the landscape in the living room for each of the examined apartment types.

CORRIDOR

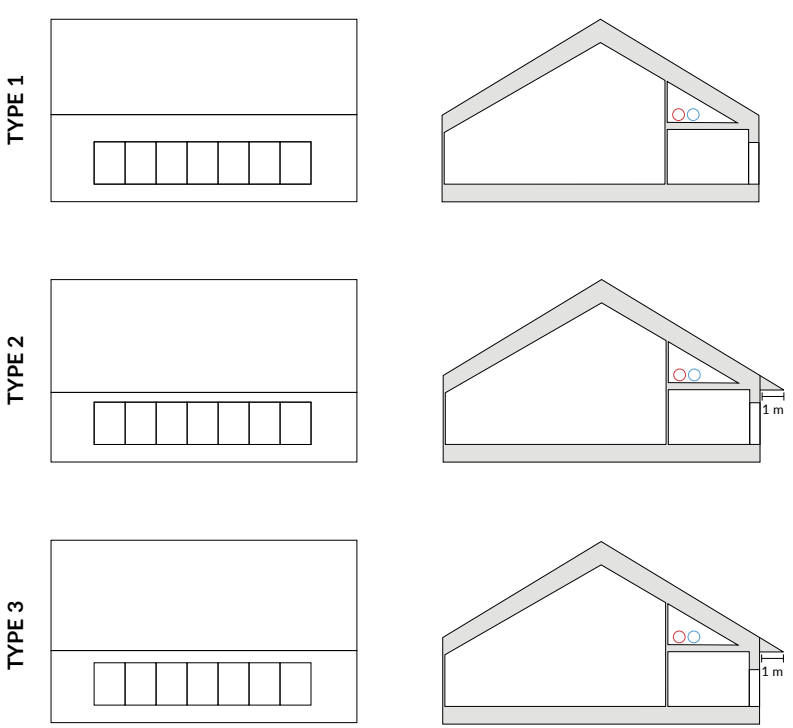
The second room is a corridor in one of the loops with an exterior wall towards south, which has a relatively small volume and a high window-to-wall ratio, because of the intention to improve wayfinding in the wandering corridors. By creating different characteristics to residential wings through the courtyard and its activity, the wandering corridor in each of the three blocks becomes more recognisable. Hence, the glass wall plays an important role in opening up the space, breaking down the barrier between the corridor and courtyard, and bringing the activity and nature into the wandering area.

Additionally, when walking through the corridor at Lundgården, which have very similar conditions to the selected critical room, the poor thermal indoor environment that was also expressed by one of the caregivers, was experienced. However, the benefits that the large windows provide to the experience in the corridor, initiated the examination of the room by changing parameters in relation to providing thermal comfort in the corridor.

As seen in type 1 the combination of the large window-to-wall ratio, small volume, and direction of the windows, result in a number of hours above 27°C and 28°C that do not comply with the requirements. To reduce the hours, the windows are replaced in type 2 with windows that have a lower g-value, which decrease the transmittance of solar heat gain through the glazing. In addition, an overhang with a depth of 1 m was added, which reduced the hours by half. To further bring down the operative temperatures, mechanical ventilation was then added outside the heating



Illu. 100 - Experienced illuminance distribution in all three of the corridor types.



U-value: 0.6 W/m² ·K
G-value: 57 %
L_t-value: 0.78
Overhang: 0 m

Window-to-wall ratio: 22.4%
Volume: 141 m³
Hours above 27°C: 377
Hours above 28°C: 205

U-value: 0.7 W/m² ·K
G-value: 42 %
L_t-value: 0.67
Overhang: 0 m

Window-to-wall ratio: 12.6%
Volume: 141 m³
Hours above 27°C: 148
Hours above 28°C: 76

U-value: 0.7 W/m² ·K
G-value: 42 %
L_t-value: 0.67
Overhang: 0.5 m

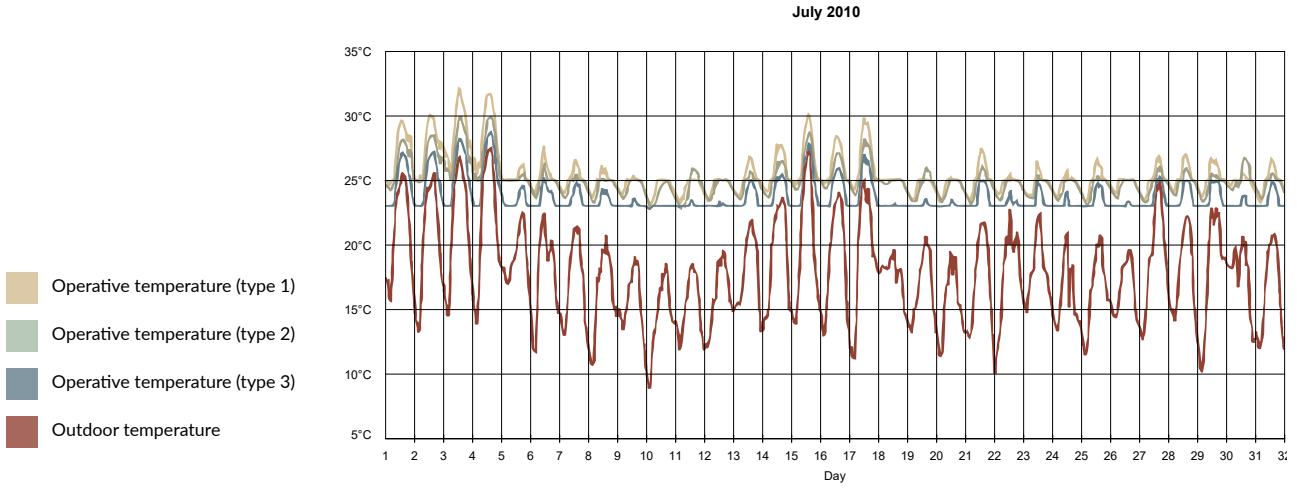
Window-to-wall ratio: 13.8%
Volume: 141 m³
Hours above 27°C: 77
Hours above 28°C: 23

Illu. 101 - The examined conditions for three different corridor types.

period in type 3.

As the highest operative temperatures are experienced in July, the graph (illu. 103) shows how each of the three initiatives affe-cts the temperature. Moreover, it is experienced that type 1 and 2 both exceed the required 23°C<t_o<26°C, while type 3 does comply with the requirement with exception of two days where the outdoor temperature is 27°C. As the mechanical ventilation system does not have cooling, it is not possible to mechanically nor naturally ventilate the room to a lower temperature than the outdoor temperature.

Illu. 102 - The view of the courtyard from the corridor, when entering the residential department.

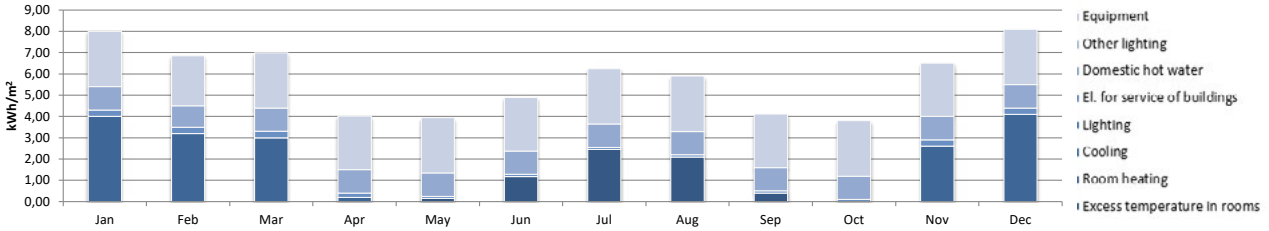


Illu. 103 - The experienced operative temperatures in each of the examined corridor types and the expected outdoor temperatures in July, which is the month where the highest temperatures are measured in the corridor for all three examinations.

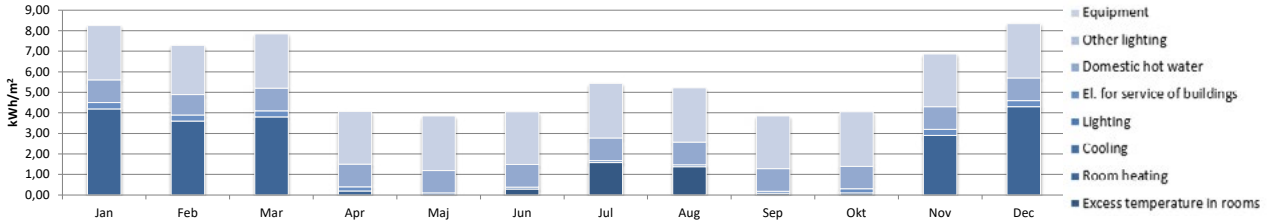
EXCESS TEMPERATURES

Simultaneous with the explorations of thermal comfort, it is discovered that excess temperatures are experienced for the whole building in June, July, August and September (illu. 104) through the program BE18.

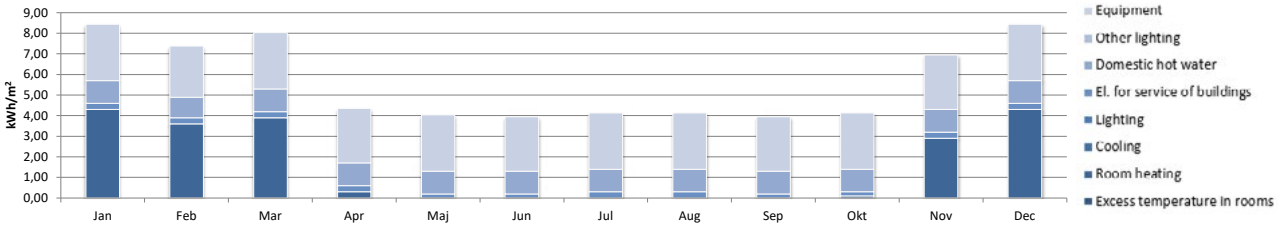
It is attempted to reduce the excess temperatures by implementing a passive strategy consisting of an 0.5 m overhang on facades with windows directed towards southeast and southwest, which do eliminate any excess temperatures in September and reduce the amount in June, July and August, but it is not removed completely (illu. 105). To eliminate the excess temperatures for all months, mechanical ventilation during summer is implemented (illu. 106). The following diagrams show the impact of each of the two initiatives.



Illu. 104 - Energy consumption with no overhang.



Illu. 105 - Energy consumption with an overhang of 0.5 m and facades with windows directed towards southeast and southwest.

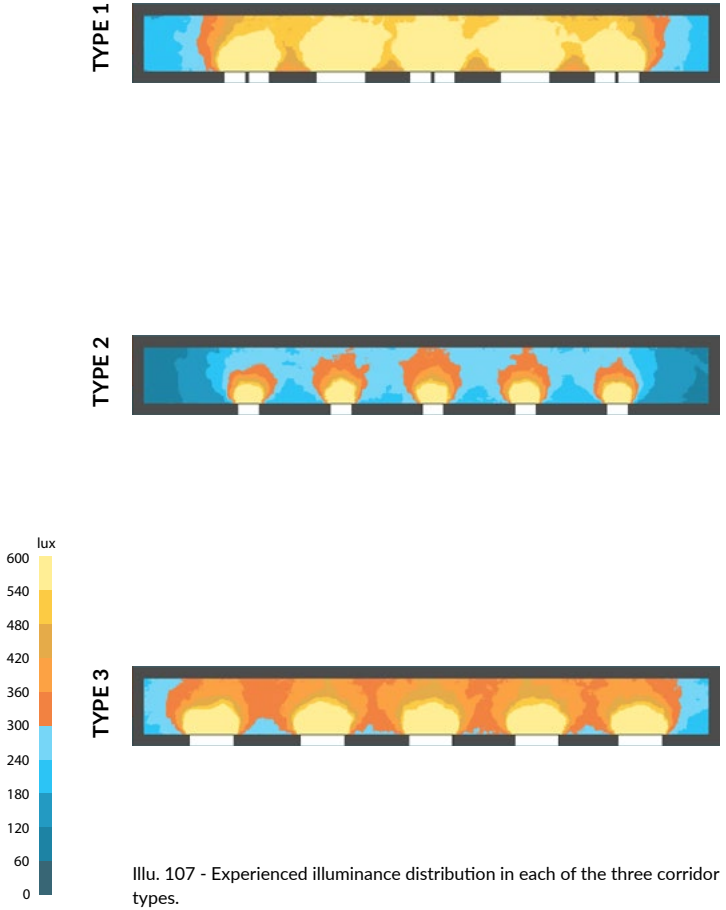


Illu. 106 - Energy consumption with an overhang of 0.5 m and facades with windows directed towards southeast and southwest and mechanical ventilation during outside the heating season.

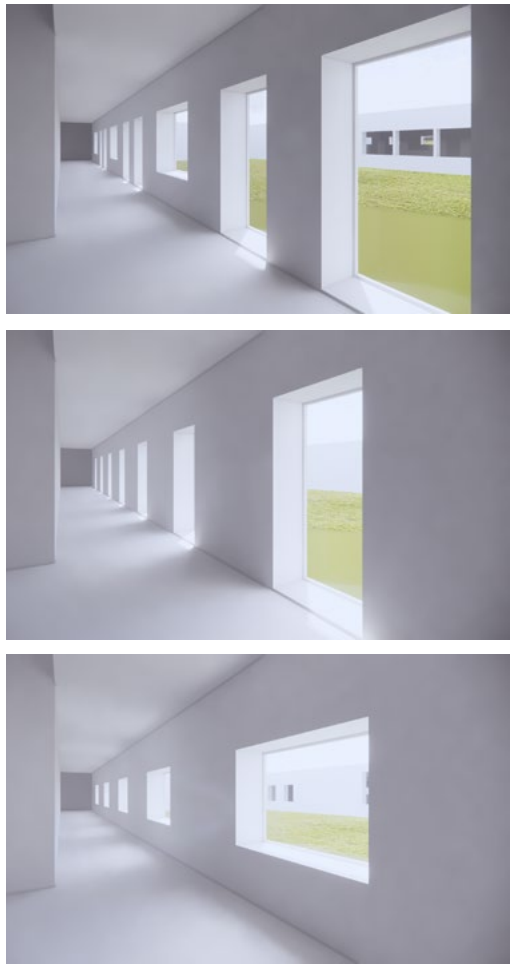
FACADES

Inspiration from the characteristic small farm windows with narrow mullion and half-rounded upper doorhead is drawn to strengthen the association with farm buildings, and avoid confusion as people with dementia often have visual impairment e.g. through a loss of depth and the speed of perception. Therefore, it is possible that the residents do not interpret the window as a window and instead a hole in the wall. Windows with mullions is a design solution to define the windows and associate them with the architectural style of farm buildings at the same time.

The daylight efficiency and view of a few different combinations of window dimensions was examined. The first option, type 1, with a mixture of windows offering both horizontal and vertical fields of vision, is quite overdimensioned, as the illuminance values are higher than 600 lux on the majority of the floor area, and the rhythmic combination of windows comes off cluttering. Type 2 connects the corridor with the landscape, but it is on the verge of not meeting the daylight requirements. It is decided to continue with the type 3, as it provides sufficient daylight and a wider horizontal visual field, enhancing the caregivers' overview of the courtyards, while the lowered sill height serves as seating along the corridor for the residents to rest when wandering. Additionally, the thermal requirements are met (see appendix 9).



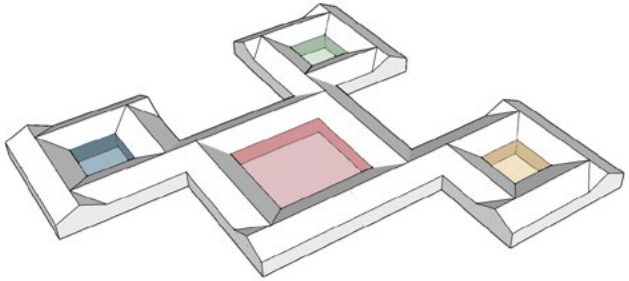
Illu. 107 - Experienced illuminance distribution in each of the three corridor types.



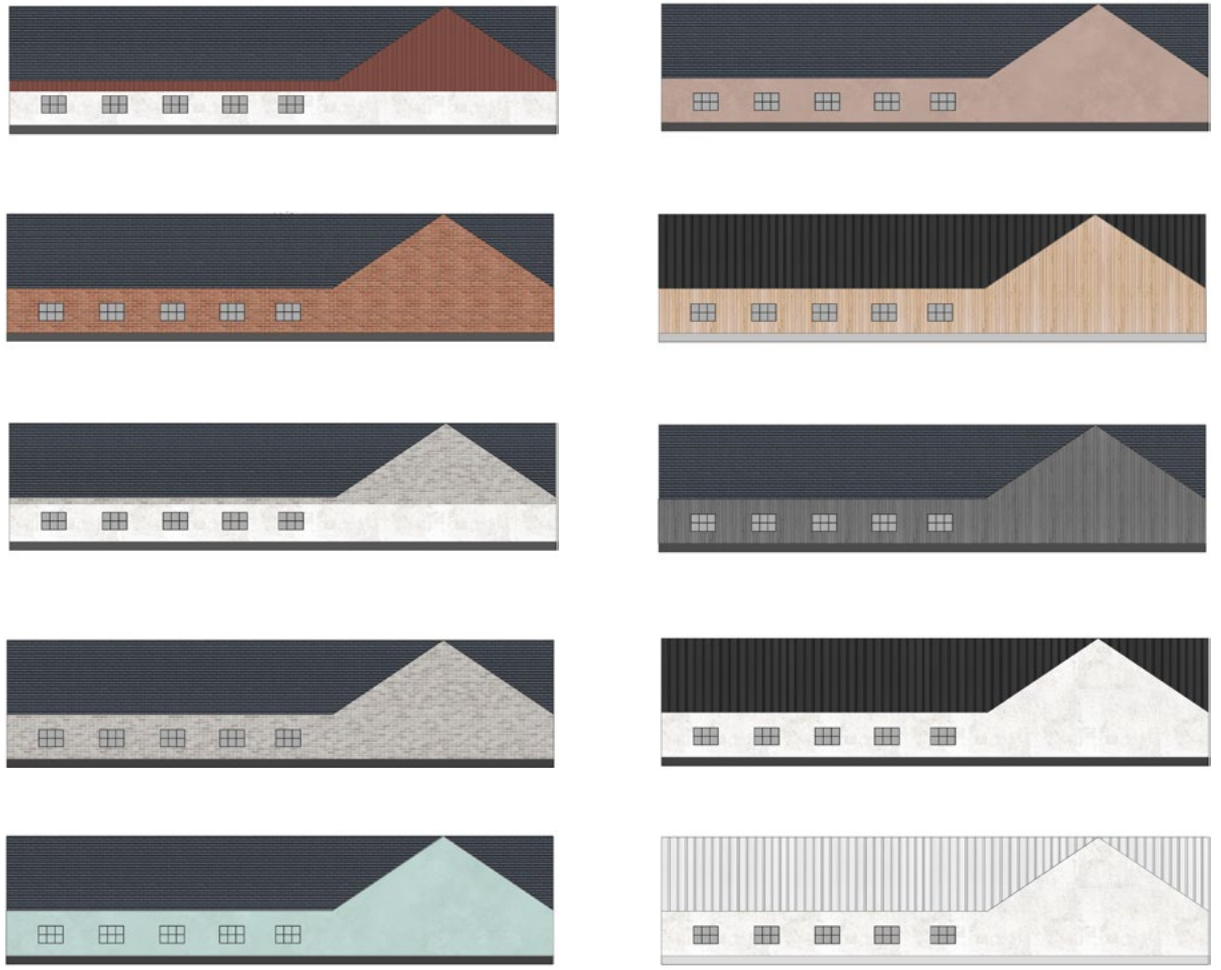
Illu. 108 - The views of the courtyard when walking around the corridors the corridor.

Various facade materials, including bricks, lime-washed bricks, and wood, are examined to find an expression that emphasizes the simple and minimalistic expression in the form. 'External' views of the facade from the road and paths around the building are the same material and color to create a cohesive facade that connects each of the departments, contrary to the various materials used on extensions and renovation that mark newer farm structures (illu. 70, nr. 2, p. 65).

In addition, experimentation is conducted on the 'internal' facades visible from the courtyards, exploring the use of different materials and/or colors (illu. 109). The idea is to e.g. lime-wash each residential courtyard in a different color, which in combination with the glass walls, is gonna affect the experience when entering the departments as well as create a clear distinction between them and thereby improve way-finding.



Illu. 109 - Each courtyard are defined by different facade materials or color.



Illu. 110 - Several different facade expression examinations are made through various wall and roof materials and colors.

ACOUSTIC INDOOR CLIMATE

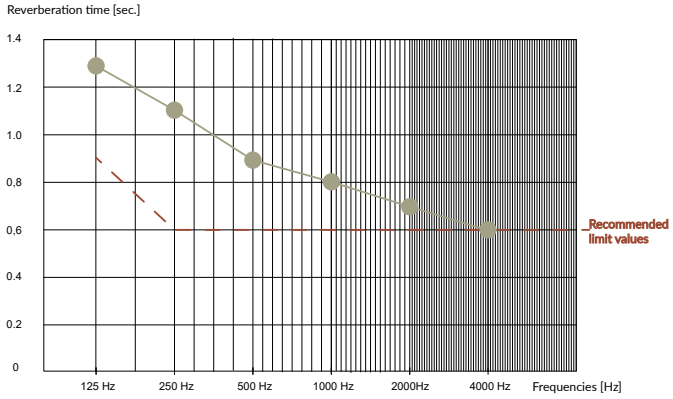
RAY TRACING AND REVERBERATION TIMES

The acoustic indoor climate is examined through calculations of the reverberation times and ray tracing of sound waves, as some people with dementia can be affected by difficulties when processing auditory information, which includes problems with filtering sounds.

Two rooms have been selected as the most critical in terms of acoustic indoor environment and examined in relation to reverberation times (see appendix 11). Firstly, the gathering hall is examined due to the large surfaces combined with the multitude of people and activities conducted within the space at once, which can cause a high noise level due to the overlapping sounds. The first design serves as a point of comparison with no initiatives to reduce the reverberation times. In the second examination, acoustic ceiling panels consisting of lamellae with felt fabric in between are mounted at three of the walls, while the third examination consists of the same reverberation time reducing design initiatives just mounted at the ceiling. By comparing the graph for examination 2 (illu. 112, p. 93) and examination 3 (illu. 113, p. 93), it is seen that the third option complies with the requirements regarding a reverberation time of maximum 0.9 sec. at 125 HZ and 0.6 sec. between 250 Hz-4000 Hz (Bygningsreglementet, 2018d, §368-376, stk. 2.5). Implementing materials with a lower absorptions coefficient at the largest surface area, which is the ceiling with 330 m², results in the highest reduction in reverberation times. Changing the wall material does not have as big an impact as it is only 135 m².

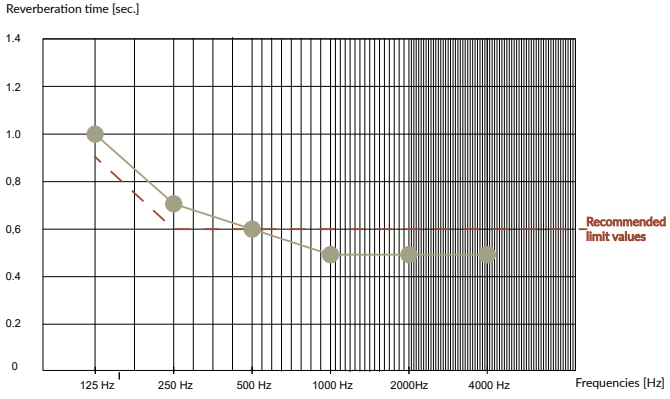
Moreover, an apartment is examined because it is a space where many of the residents spend most of their time or in some cases all their time. The following examinations illustrate a scenario, where the partition wall is set aside to examine the most crucial case with the largest surface areas and room volume. In the first examination (illu. 114, p. 94) with no initiatives to reduce the reverberation times, it is discovered that the requirements regarding a maximum of 0.6 sec. between 125 Hz-4000 Hz (Bygningsreglementet, 2018d, §368-376, stk. 2.5). When implementing lamellae with a felt underlay in examination 2 (illu. 115, p. 93), or on two of the walls in examination 3 (illu. 116, p. 92), the reverberation times decrease and in both cases abide by the rules. However, considering the spatial experience of the space and comparing both examinations, examination 3 makes the room feel smaller and more compact. By placing the lamellae on the walls, the space feels constricting in contrast to examination 2, which opens up the space up more in comparison.

EXAMINATION 1



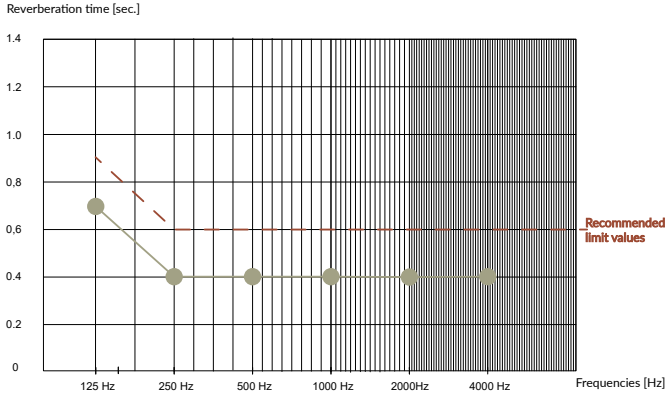
Illu. 111 - The reverberation times experienced in the gathering hall with no initiatives to reduce the reverberation times.

EXAMINATION 2



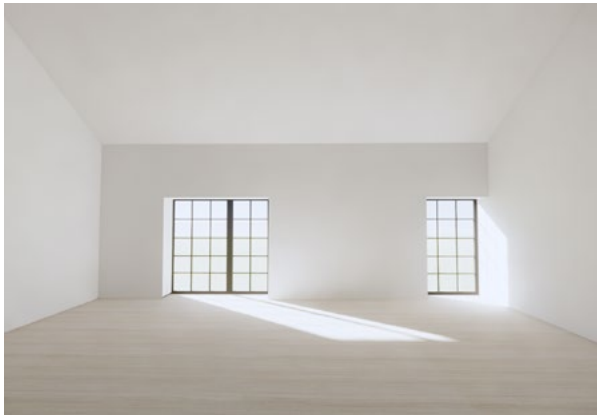
Illu. 112 - The reverberation times experienced in the gathering hall with inclusion of acoustic walls consisting of lamellas on felt to reduce the reverberation times.

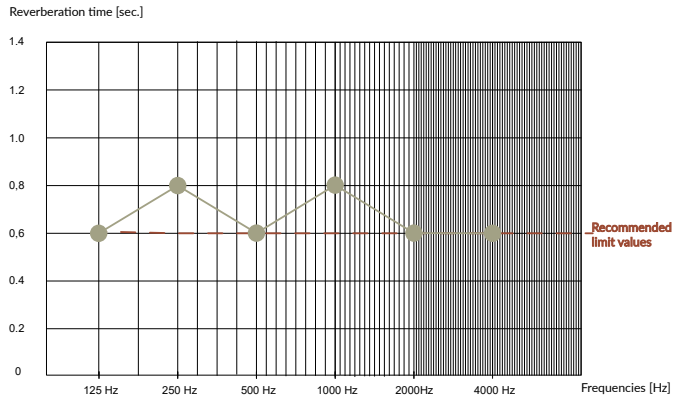
EXAMINATION 3



Illu. 113 - The reverberation times experienced in the gathering hall with inclusion of an acoustic ceiling consisting of lamellas on felt to reduce the reverberation times.

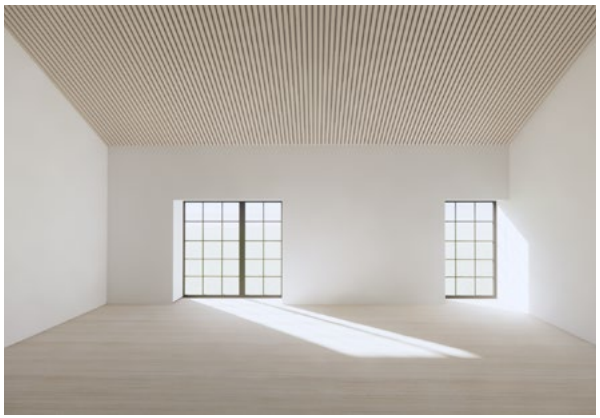
EXAMINATION 1

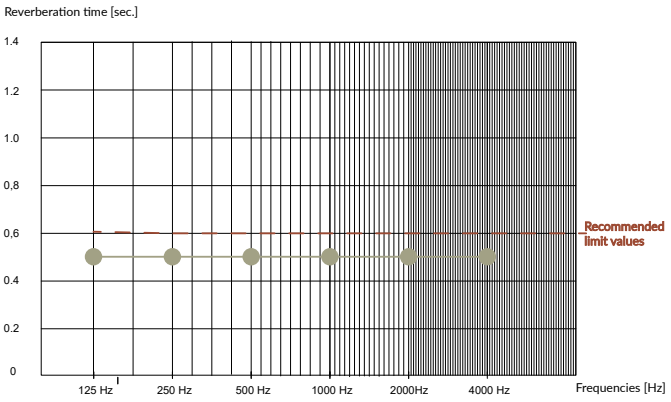




Illu. 114 - The reverberation times experienced in the apartments with no initiatives to reduce the reverberation times.

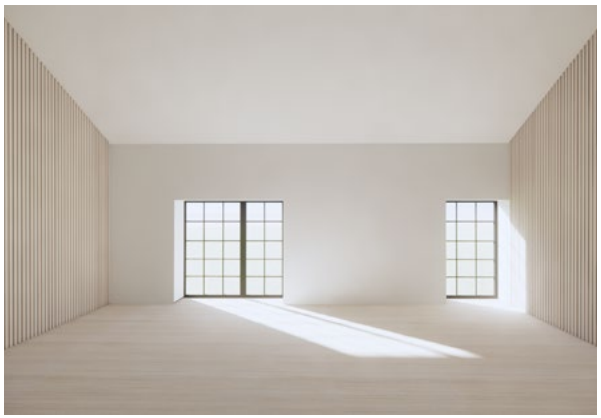
EXAMINATION 2

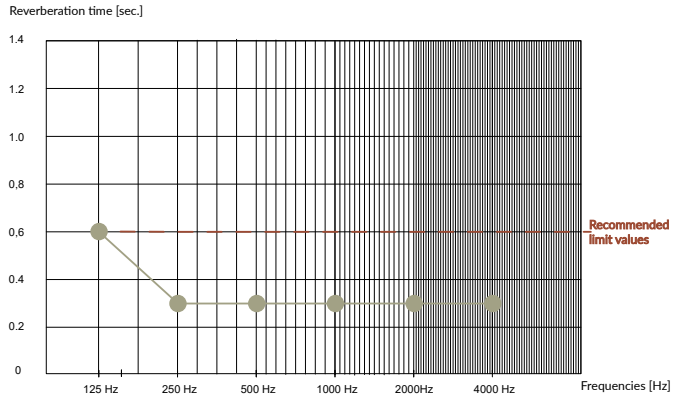




Illu. 115 - The reverberation times experienced in the apartments with inclusion of an acoustic ceiling consisting of lamellas on felt to reduce the reverberation times.

EXAMINATION 3

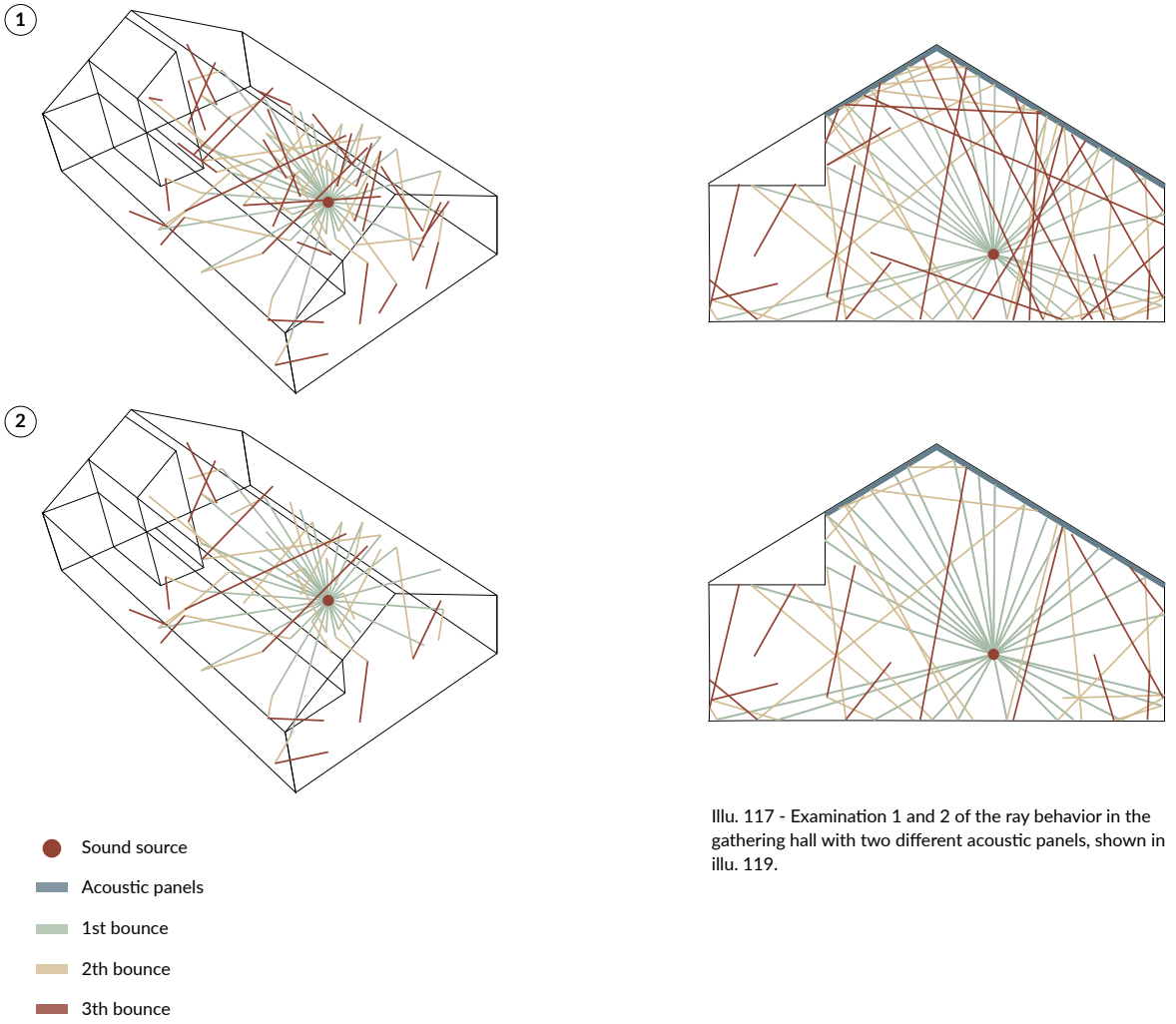




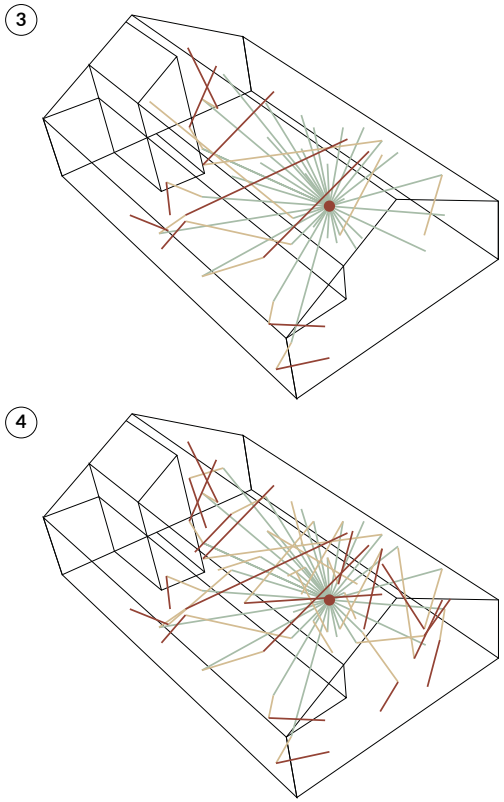
Illu. 116 - The reverberation times experienced in the apartments with inclusion of acoustic walls consisting of lamellas on felt to reduce the reverberation times.

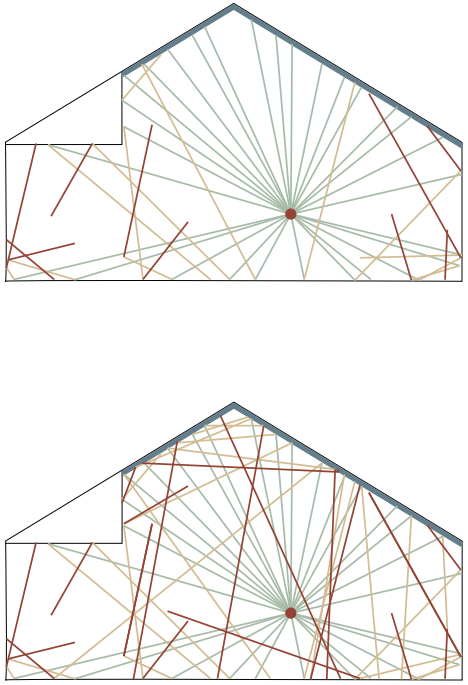
Additionally, sound waves in the gathering hall are examined through ray-tracing in the program Rhino - Grasshopper with an omnidirectional sound source placed in the middle of the room with a height of 1.3 m above the floor to get a general understanding of how sound is reflected in the room. Four different acoustic ceilings are modeled with lamellae varying in the depth of the niche, the distance between each lamella, and shape of the lamella (illu. 117, p. 95, and illu. 118, p. 96). The aim is to analyze which acoustic ceiling is most efficient when it comes to capturing the sound bounces inside the niche as each time a ray hits a surface it loses energy due to absorption and scattering. Thereby much projected sound is prevented in becoming reflected sound that can confuse the residents and worsen the communication between caregivers and residents.

Each of the four explorations is made with 32 random ray directions, each with three bounces to present a more tangible illustration of how the sound waves behave in the surroundings. In examination 1, the depth of the acoustic ceiling is too short and distance between the lamellae is too long, as the niches do not capture the rays effectively. By increasing the depth and increasing the width of the lamellae as well as the distance between each lamellae in examination 2, it is experienced that more rays are captured. The cavities in examination 3, are the most efficient panels out of the four, as it captures the most first bounces and prevents second bounces from being reflected into the zone where people are sitting. Lastly, the panels in examination 4 capture a few more rays than examination 1 and therefore are not effective enough to attain acoustic comfort.

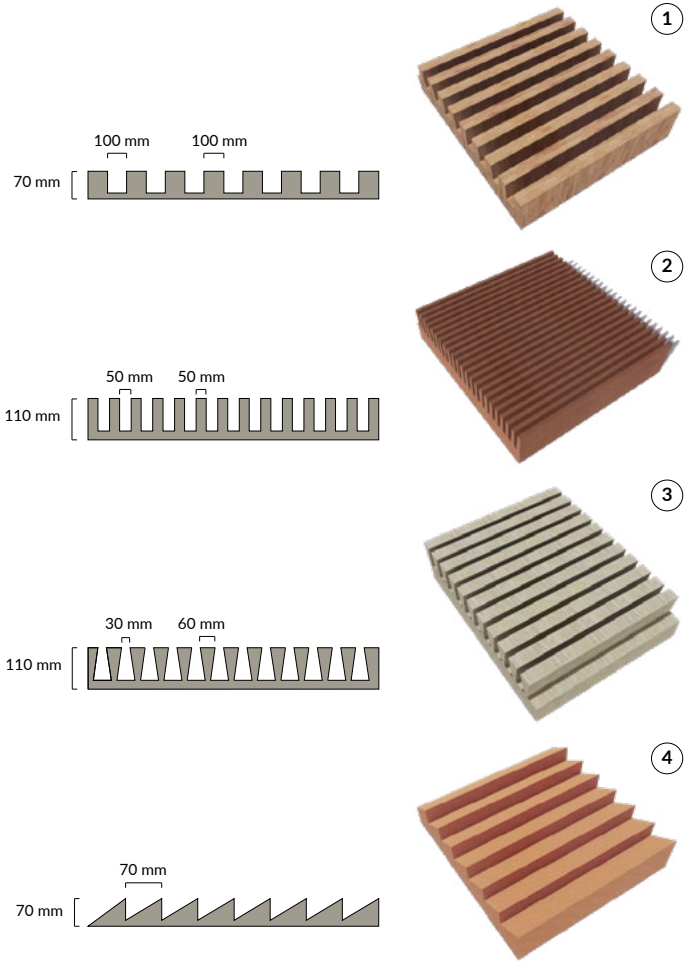


Illu. 117 - Examination 1 and 2 of the ray behavior in the gathering hall with two different acoustic panels, shown in illu. 119.





Illu. 118 - Examination 3 and 4 of the ray behavior in the gathering hall with two different acoustic panels, shown in illu. 119.



Illu. 119 - The shape of the acoustic ceiling panels. The influence on the ray behavior for each panel is examined in illu. 117-118 to the corresponding numbers.

04

PRESENTATION

PRESENTATION

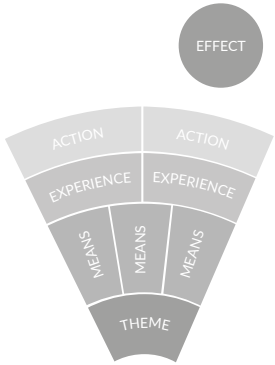
This chapter presents the final building design through a visual and written presentation of the design merged in the ‘Synthesis’ phase through both architectural and technical aspects.

The design criterias concluded in the Program chapter are reintroduced, as they represent the fundamental requirements and objectives that guided the decision making process through the project. Additionally, the design principles implemented to fulfill these criterias is presented through five different themes. Moreover, the architectural vision for the building and urban landscape is elaborated, the final concept clarified, and the interconnection between form, function, and aesthetics, considered in the final design, explained.

DESIGN STRATEGIES

'EFFECT COMPASS'

Illu. 120 - Completed 'Effect Compass' for the nursing home (AART Architects, n.d.).



Illu. 121 - 'Effect Compass' explained (AART Architects, n.d.)

The following presents the final design proposal for a dementia nursing home in Tornby. With inspiration from the 'Effektkompas' developed by AART Architects, the presentation will consist of five overall themes including 'Safe Common Rooms', 'Private Apartments', 'Practial Staff Functions', 'Healing Urban Spaces', and 'Healthy Indoor Climate'.

The 'Effektkompas' is a strategic tool developed with the ambition to create measurable and noticeable effects through architecture. To concretise and convey these effects, a graphic representation of user behavior and experience, the architectonic design principles used to attain these, and the envisioned effect of the building is made. For each build project a corresponding 'Effektkompas' is made consisting of an introductory definition of the desired effect, the design effect of the architecture, and the final documented effect measured by revisiting the site (AART Architects, n.d.).

The inspiration from the tool lies in the thought process behind it, as the design is merely part of a thesis and not a built building. Illustration 120 presents the design principles and desired effects for each of the five themes, while the meaning of each layer is described in illustration 121.

VISION

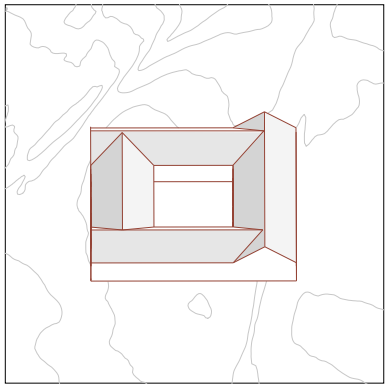
The vision behind the following design proposal is to design a nursing home for elderly diagnosed with a dementia disease, with focus on creating a safe environment that accommodates the needs that follow when having dementia. Moreover, the proposal puts the residents in the center, takes the interplay with the relatives into consideration, and supports the caregivers flow of work.

My aspiration is that the design connects the residents to the agricultural history of their past, which had a substantial impact on their life whether they grew up on or around farms, and thereby strengthen their sense of belonging at the nursing home. The nursing home must provide a homely environment for elderly with different stages of dementia and backgrounds, and provide accessible functions and daily activities that strengthen the residents' bodily habits from previous daily tasks, habitual behaviors, or routines. With time these bodily habits will gradually start to form a rhythmic fit to the surroundings, resulting in a stronger sense of home. Furthermore, it is important that residents can leave their personal mark and take ownership over their apartments to strengthen their perception of home.

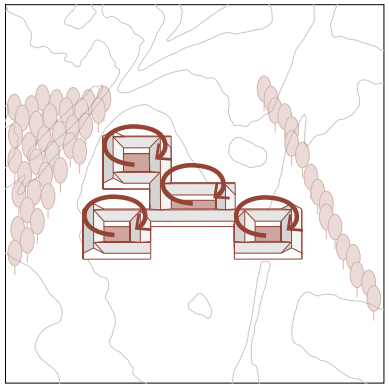
The nursing home must provide a healthy indoor environment through atmospheric, thermal, visual, and acoustic comfort, and integrate design solutions that do not require interaction from the residents. An environment that diminishes discomfort through a combination of structural, functional, and aesthetical considerations for the integrated design principles.
A practical spatial layout that enhances the caregivers overview and monitoring of the residents, and staff can retreat when necessary. Simultaneously, a clear layout that is easy for the residents to navigate and enhances their wayfinding skills, while providing safe indoor and outdoor spaces for wandering. Furthermore, the aim is to implement functions and activities that invite the residents to participate and encourage community, while strengthening the relationship and communication between residents and their caregivers and relatives, when visiting. To create an environment where relatives feel welcomed and can spend meaningful time with their loved ones.

Lastly, the vision is that the building becomes an integrated part of the site, subordinate to the landscape, and creates a harmonious interaction with the landscape. A building that adjusts to the context through movement patterns, sightlines, terrain etc. and becomes an integrated part of the existing surroundings. Moreover, a nursing home that invites the local community to become a part of the daily life at the nursing home, and collaborations with local institutions and stores takes place. A space where people with different backgrounds and life situations interact across generations.

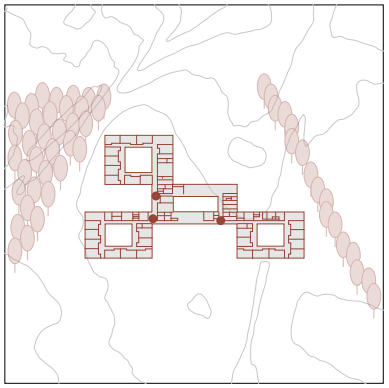
CONCEPT
MAIN THEMES



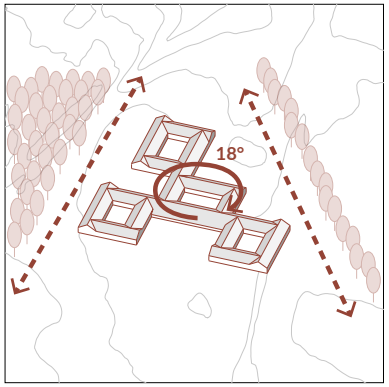
(1) Inspiration is drawn from the simple and uncluttered essence of the 'four-winged farm', which had a great influence on the evolution of farm structures, through the form to connect the residents with the agricultural history of their past and strengthen their sense of belonging.



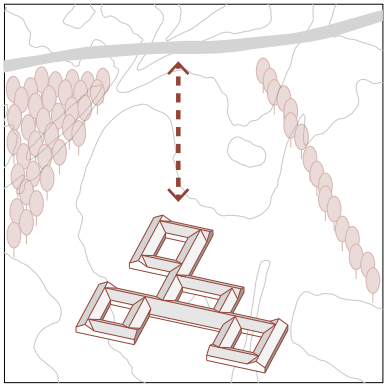
(2) Four connected departments consisting of four continuous loops bring a closer connection to nature through the courtyards, while opening up the corridor with views to the outdoors.



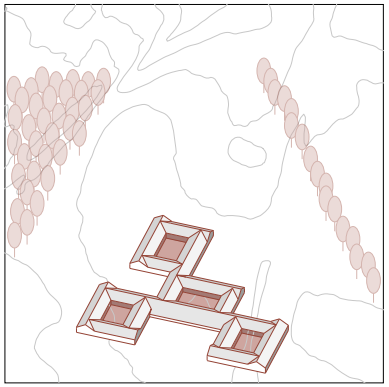
(3) Landmarks are placed at 'decision points', which are located in the intersection between each residential department and the inner department with common functions, to improve the residents' wayfinding skills.



(4) A harmonious interaction with the landscape is achieved by rotating the building 18° clockwise to preserve the lines of sight to the open landscape and horizon line as well as the flow patterns that connect the site with the local community.



(5) The building is pulled back from the main road to create an intentional pause in the landscape that strengthens the conceptual expression, when driving by or arriving at the nursing home.

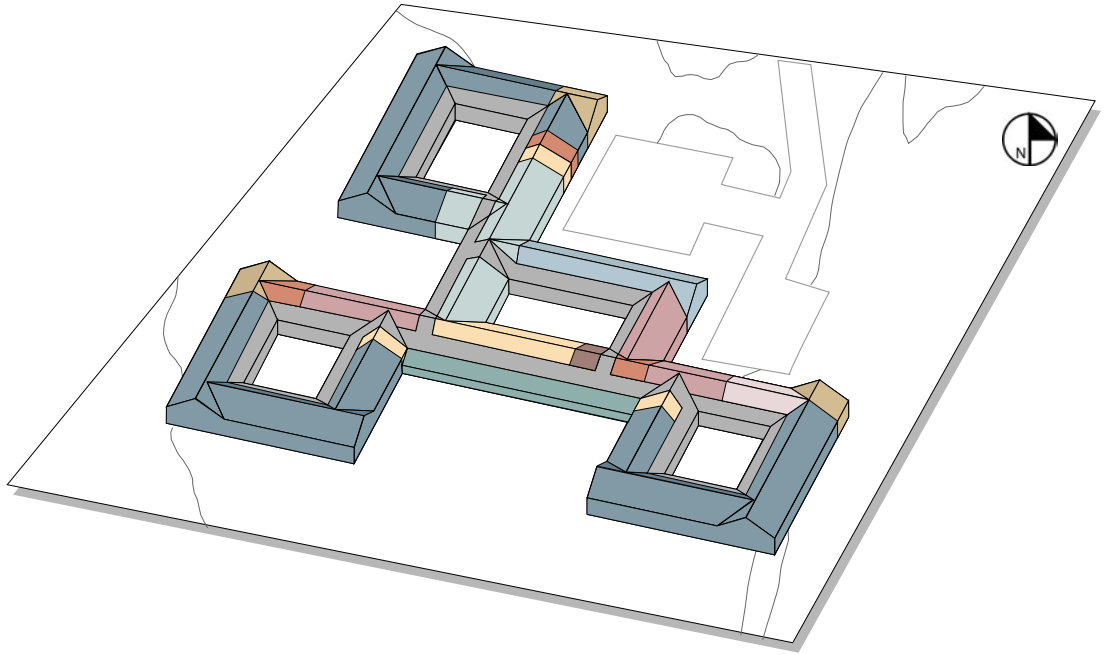


(6) Each courtyard is characterized by a different colored facade that corresponds to an internal accent wall, which is visible when entering each department to differentiate the departments from each other and improve the residents' navigation skills.

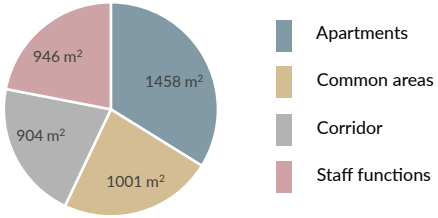
Illu. 122 - Concept diagrams showing the conceptual development in the building structure and placement.

FUNCTIONS

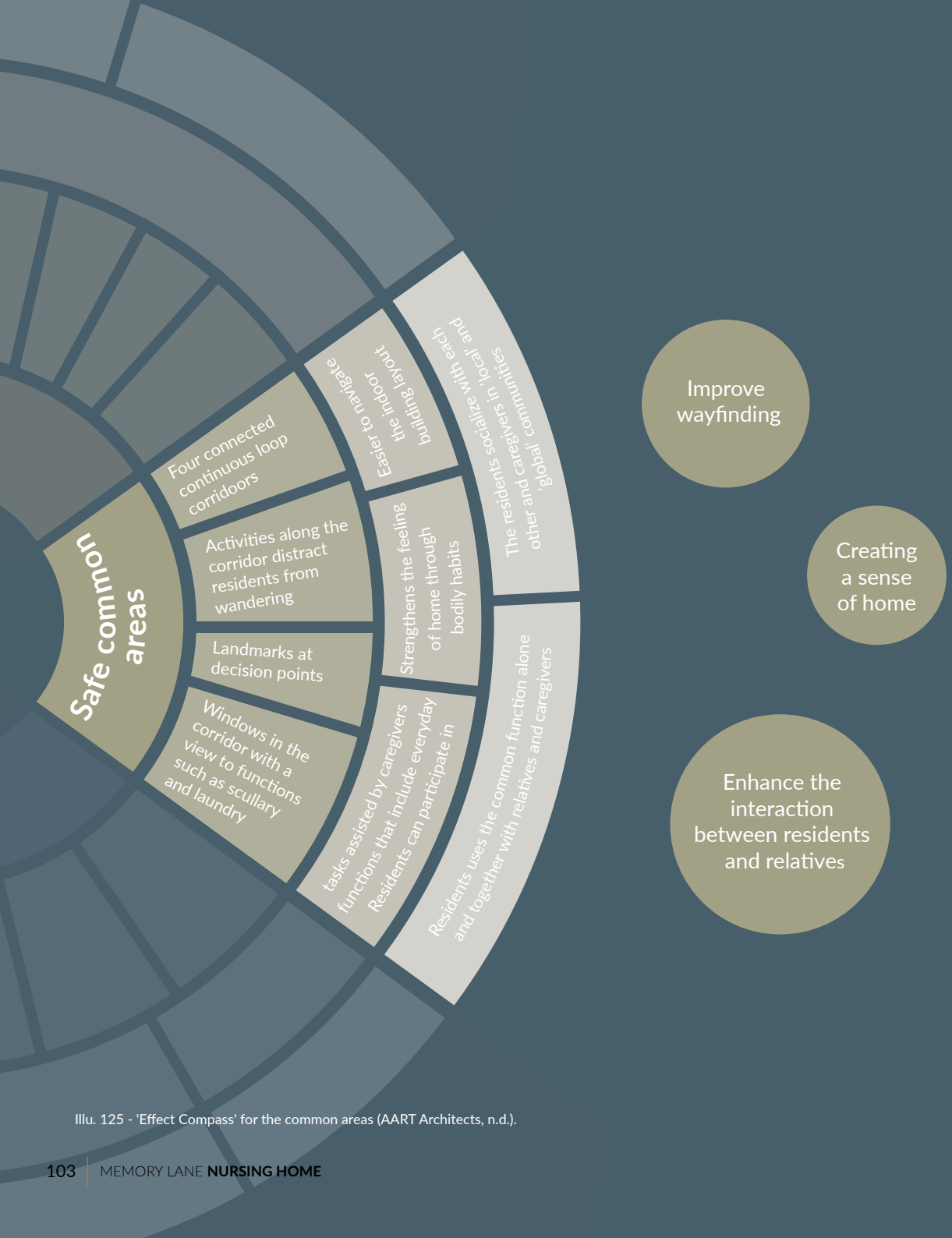
01	**Wandering corridor**	904 m²
02	**Staff functions**	
	Offices and meeting room	182 m²
	Changing rooms	≈ 24 m²
	Cleaning supplies and storage	≈ 14 m²
	Break room	36 m²
03	**Common functions**	
	Dining room	128 m²
	Kitchen	22 m²
	Laundry	≈ 17 m² each
	Living rooms	71 m² each
	Winter garden	145 m²
	'Experience store'	60 m²
	Bar	47 m²
	Gym	62 m²
	Wellness	92 m²
	Hairdressing salon	31 m²
04	**Residential apartments**	54 m² each
05	**Gathering hall for residents and local community**	211 m²



Illu. 124 - Function diagram.



Illu. 123 - Distribution of the overall functions.



Illu. 125 - 'Effect Compass' for the common areas (AART Architects, n.d.).

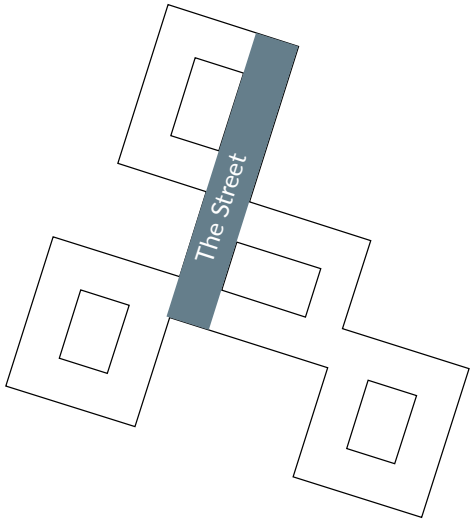
COMMON AREAS

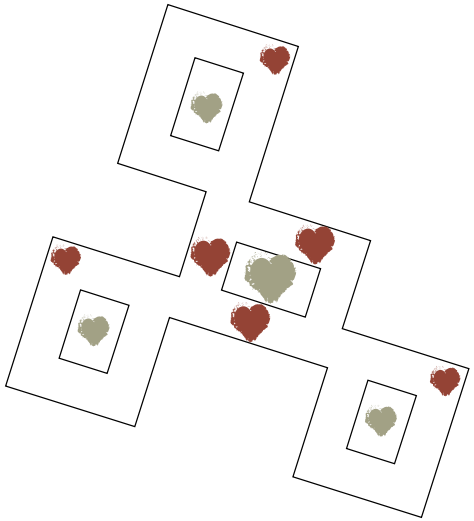
DESIGN STRATEGIES

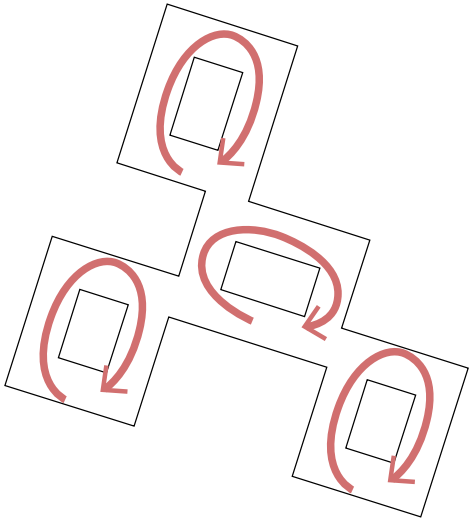
The completed 'Effektkompas' shows the correlation between the design strategies implemented in the common areas and corridor, the expected actions and experiences these strategies bring, as well as the desired effect for residents, relatives, caregivers, and staff.

The goal is to improve the residents' wayfinding skills and make it easier to navigate the indoor building layout, which is achieved through several design principles including four continuous loop corridors and landmarks at 'decision points'.

To enhance the interaction between residents and relatives, it is desired that they utilize common functions during visits to the extent that is possible. To achieve this, several functions that are both relevant and appealing to residents and relatives, and can improve their health and well-being, are provided.







Illu. 126 - Diagrams that describes the common areas.

'THE STREET'

'The Street' is a corridor marked by life and activities through several diverse functions, such as an exercise room, a hairdresser, a bar, an experience store etc. The many functions create a lively atmosphere, where the resident and relatives can visit to strengthen their interaction through new topics of conversations and activities that they can participate in together.

COMMUNAL SPACES

The three residential departments make up smaller 'local communities' with a living room and a courtyard, where the residents can relax and immerse themself. The connecting communal department makes up the larger 'global community' for the entire nursing home and local community. Here, a courtyard with room for social gatherings is an extension of the dining room and gathering hall.

CIRCULATION

Each of the four departments is built on the concept of four connected, continuous loops that provides a safe space for the residents to wander around the entire nursing home, where they are met by the changeable atmosphere of the corridor. Throughout the route, activities, functions, and objects are placed strategically to interrupt the wandering, to stimulate the senses and strengthen social interactions.

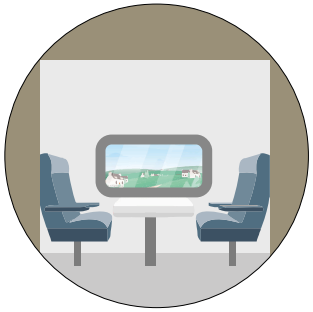
WAYFINDING
'DECISION POINTS'

An important part of the design is to improve the residents' wayfinding skills as dementia causes many people to lose sense of direction and experience difficulties with the ability to recognize places. Often they feel compelled to walk around without having any place to go or they are searching for their old homes, relatives, or activities that have played a significant role in their past. Therefore, the spatial layout consists of four connected continuous loops that provide a space for managed wandering in a safe environment. Along the corridors intriguing activities and functions are meant to not only stimulate the residents' senses and strengthen their social interactions, but the placement of the common functions are a way to distract the residents from endless wandering. Moreover, when walking through the corridors, residents can take a break from wandering and sit in the seating arrangements or in the many windows that have a low sill height.

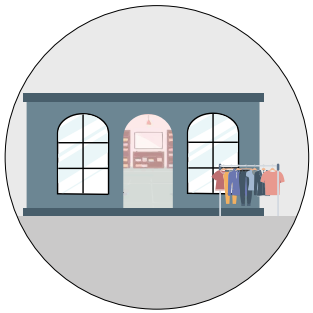
The nursing home improves wayfinding through strategic placement of recognizable landmarks at decision points to create a physical distinction between the departments. This includes the 'wandering train' where residents can attain the feeling of movement and wandering through a screen that simulates the view when riding a train, without leaving the building.

At another 'decision point' an 'Experience store' is placed, where residents together with their relatives can walk down to the store to get a change of scenery, and when searching for new subjects of conversation, as these often are repetitive and can be tiring for the relatives. Articles are changed regularly, providing the perfect environment for the relatives to have new topics to talk with their loved ones about. Through the large shop windows that showcase objects, residents can easily see what is inside the store from the corridor. Thereby, an open and welcoming atmosphere that melts out into the corridor is created, and invites you in when passing by.

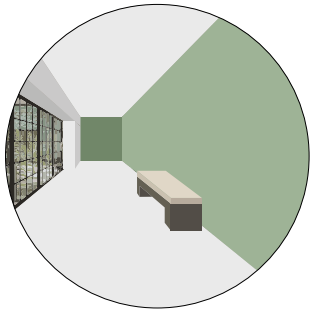
PHONEBOOTH



WANDERING TRAIN



EXPERIENCE STORE



ACCENT WALLS

Illu. 127 - Landmarks placed at 'decision points' and accent walls at the entrance to each residential apartment to improve wayfinding.

Illu. 128 - 1 level plan of the nursing home in 1:700.

Illu. 129 - Plan of the connecting courtyard in 1:250.

LOCAL COMMUNITY

GATHERING HALL & 'THE STREET'

To enhance the residents' sense of belonging, strengthen their social bonds, and spread joy in the nursing home, an important factor of the design is the connection to the local community. The gathering hall is a space that opens up the nursing home to local associations, clubs, the school, kindergarten, mother's groups etc., where the elderly can connect with the children, play games or music, and talk with each other. It is a space that invites community and provides the residents with a feeling of being a part of a community and an active part of the town. Likewise, in the 'The Movement Court', 'The Animal Yard', 'The Green Garden', and 'The Communal Yard' (illu. 148, p. 124), visitors can watch the chickens, play on the movement path, grill and dine together during summer etc. together with the elderly and through activities to enhance their interaction and create a connection to the people, who are part of their local community.

Moreover, the Experience Store is a space with interesting objects and nicknacks that relate to the residents' past, create a good foundation for a conversation, or spark their curiosity. Objects are regularly switched, and the store is ever changing to provide relatives and residents with new conversation pieces. The store is mainly run by volunteers in collaboration with the local thrift store through donations and products that are possible for the resident to buy e.g. when visiting the store with their relatives.

Illu. 130 - The gathering hall is a space that invites the local community into the nursing home to spend time and create meaningful interactions with the elderlies.

Illu. 131 - The experience store is one of the landmarks that help navigating the corridors of the nursing home. Here residents and relatives can visit, buy products, or just have a conversation about the many objects and reminiscence about the past.

Illu. 132 - In the common dining room, residents, who are not bedridden, spend time together when eating breakfast, lunch, dinner, and drinking afternoon coffee. The open kitchen allows the residents to smell and watch when food is being prepared, and invites them to participate in smaller baking or cooking projects. Due to practicalities the majority of the food is delivered and arranged in the scullery, to which a window in the internal wall provides a visual connection for the residents from the corridor.

To develop a sense of home for the residents when moving into the nursing home, some of the most common past habits, activities, and routines are integrated into the design and accessible for the residents. This entails functions such as the laundry rooms, where caregivers together with the residents can do laundry, sort and fold clothes, and the common kitchen where residents have the possibility to help cooking or baking. By providing the residents with the opportunity to watch or proceed with everyday tasks that have become bodily habits and part of their routine for most of their life, it can create a sense of purpose and relation to prior experiences and help them adapt to the new surroundings more easily, as they are bringing previous habits into their new environment. Furthermore, windows in the internal walls to the laundry, scullery, and dishwashing rooms, provide a visual contact to these functions from the corridor, while isolating the noise and loud sounds associated with these tasks. Hence, a sense of transparency is provided, and residents have the opportunity to participate in everyday tasks.

In continuation of the common dining area, an indoor winter garden that brings the outside in, and vice versa, is located, for the enjoyment of plants and nature all year round. It is a large communal area with direct access to the laundry rooms, where residents, caregivers, and relatives can water plants, garden, or sit and wait while doing their laundry.

Illu. 133 - The winter garden is a space where residents can spend time and connect with nature by wathering or grow plants or simply just sit, relax, and watch the landscape and animals in the distance during bad weather where it is not possible to go outdoors.

Illu. 134 - 'Effect Compass' for the apartments (AART Architects, n.d.).

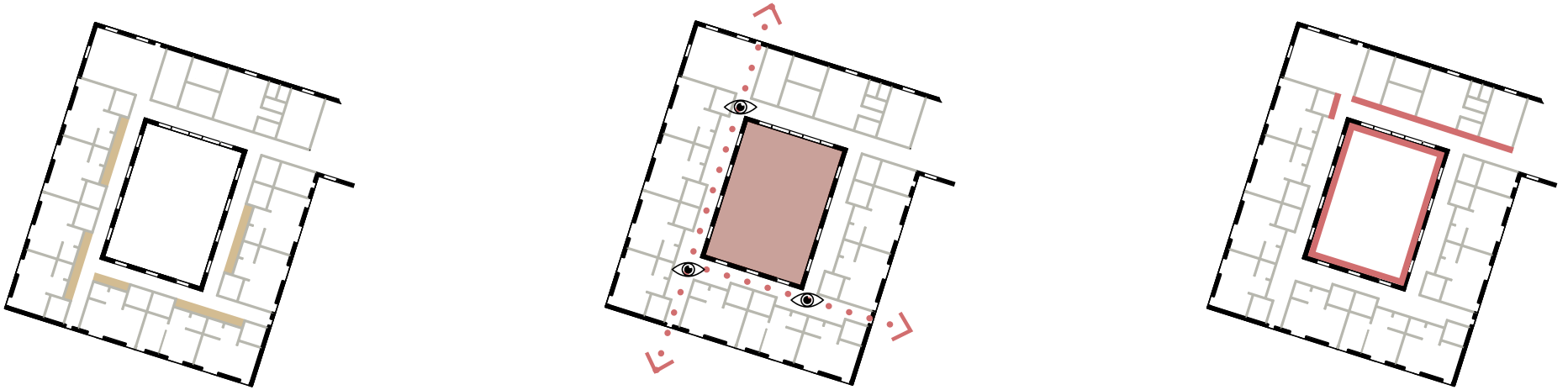
APARTMENTS

DESIGN STRATEGIES

The completed 'Effektkompas' shows the correlation between the design strategies implemented in the apartments, the expected actions and experiences these strategies bring, as well as the desired effect for residents, relatives, caregivers, and staff.

The aim is to improve the residents' wayfinding skills and recognition of their own apartment, which is achieved through several design principles including niches with room for personal objects or furniture along the corridor in the residential departments and a clear distinction in the entrances to each apartment.

To enhance the residents' sense of home and create a safe space where they can be themselves, the apartments are spacious with room for bringing personal belongings and furniture, space for relatives to stay the night when needed and gatherings with the family, as well as private terraces.



Illu. 135 - Diagrams that describe the residential departments.

'FRONT YARDS'

Niches in the corridors provide a space for the residents to personalize with furniture and personal objects that spark their memory to improve wayfinding in the corridors and to strengthen their recognition of their apartments as the space is an extension of the apartments and functions as a ‘front yard’.

OUTDOOR VIEWS

Windows along the corridor provides a view of the centralized courtyard and creates a bright and open atmosphere in close relation to nature when walking in the corridors. Moreover, several fire doors are placed at the ends of the corridors, which provide a view to the surrounding landscape and connect to the outside.

ACCENT WALLS

Each courtyard is marked by a different colored facade with a corresponding internal accent wall, which is visible when entering each residential department. A large glass wall on the opposite side of the accent wall provides a view to the entire courtyard and binds the rooms together, and helps differentiate each department from each other.

Illu. 136 - Plan of a residential department in 1:250.

To improve the residents' wayfinding skills and recognition of their own apartments, several niches are made along the corridors in the residential departments in front of each apartment. Thereby, creating a space for the residents to personalize with furniture and personal objects that the residents have formed a relationship with throughout their lives and is part of each of the residents' perception of home. By personalizing the entrance to their apartments, it can also improve the residents' wayfinding skills when navigating at the nursing home.

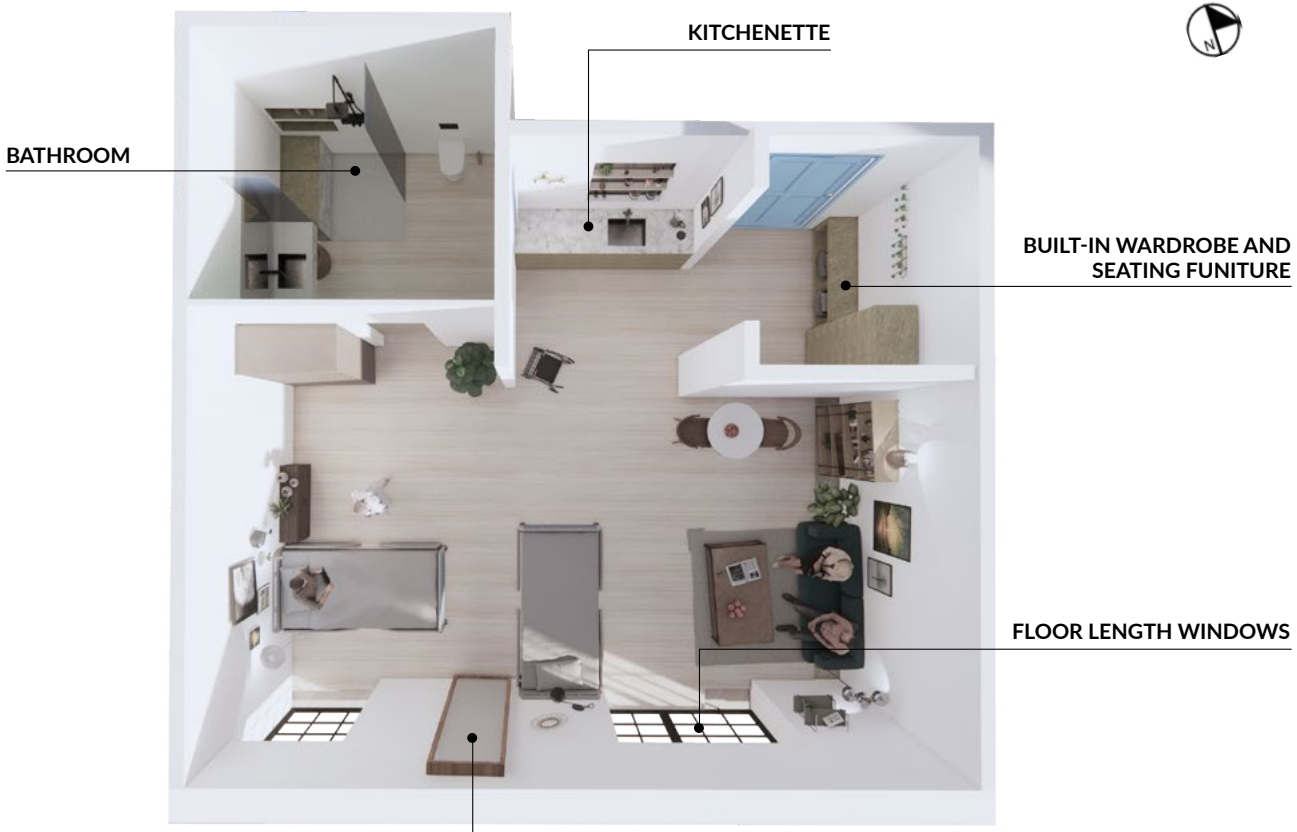
Additionally, each apartment is provided with a door that is unique to the nursing home through color and looks, and a door that is similar to the front door of their prior home. This creates a sense of individuality throughout the nursing home, and helps the residents take ownership of their home. Moreover, a window with a view from the apartment to the corridor, lets more daylight into the apartment, while creating another space to put personal mementos on the window sill or shelves to recall memories. All things considered, a space where residents can express themselves and welcome themselves into their apartments.

Illu. 137 - The niche in front of the entrance to each apartment provides a space for the residents to place familiar furniture and objects to improve their navigation skills.

Illu. 138 - Each apartment is provided with personalized doors in different colors and with different expressions to create individuality and strengthen the residents' wayfinding skills.

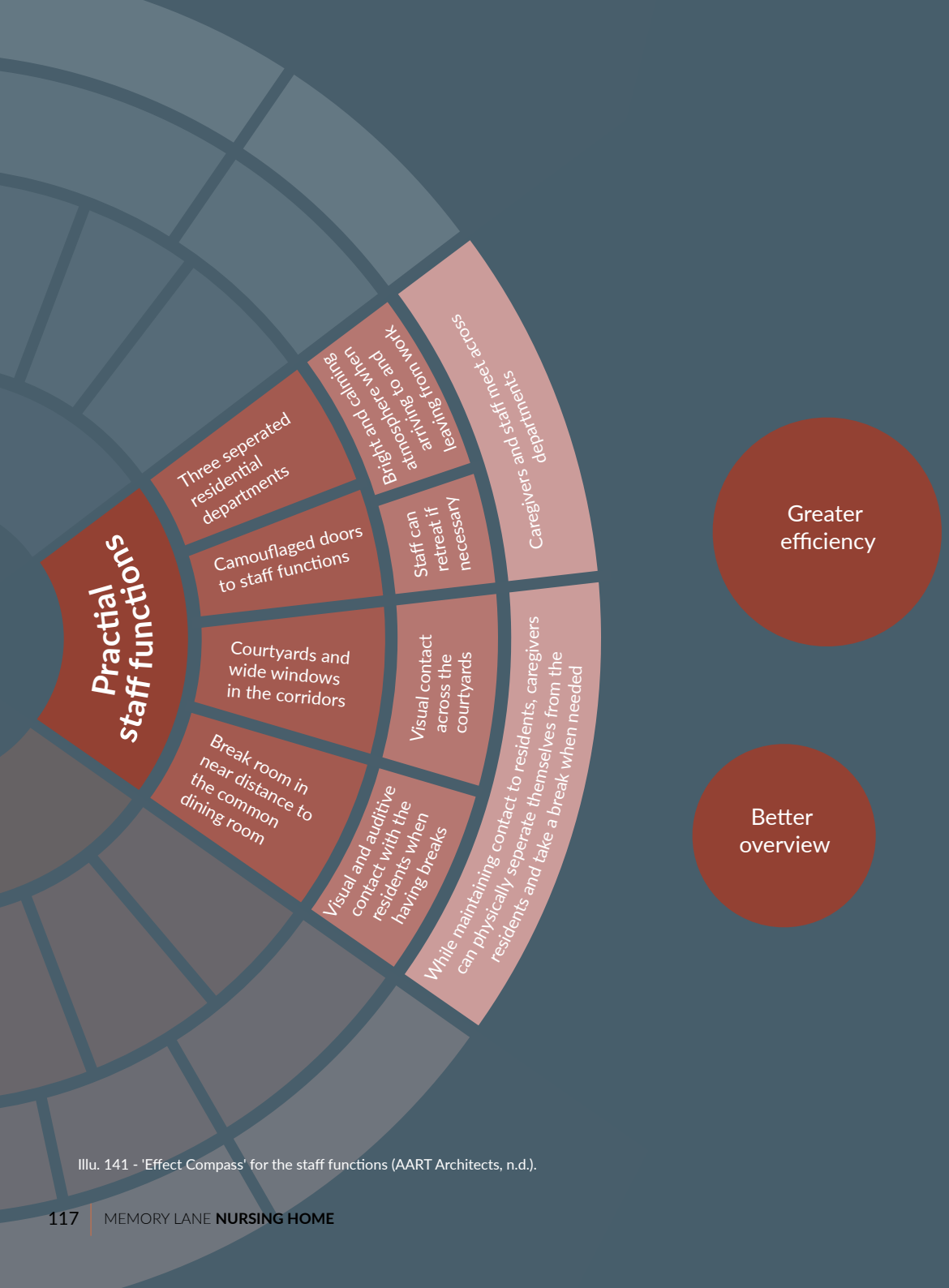
The apartments are bright and spacious with room for residents to bring their own furniture and leave their own personal mark. Floor length windows open up the room and create a fluent transition between inside and outside, as well as a view of the landscape and the ever changing surroundings as the days and seasons progresses. Outside each apartment there is a private terrace that leads out into a safe, enclosed urban area. Here, the residents can retreat from the community and enjoy nature in silence or savoring afternoon coffee with their family. In addition, it is possible for bedridden residents, that do not have the ability to utilize the nursing home's many communal functions and activities, to be rolled out onto the terrace during fine weather to give them the opportunity to spend time outdoors, stimulate their senses, enhance their circadian rhythm, and improve their sleep patterns.

Each apartment is designed with flexibility in mind and has the ability to be modified to certain circumstances, through the implementation of a partition wall that divides the living room from the bedroom. In case the resident becomes sick or is dying, it is possible to move the wall aside and roll in an extra bed for a relative to stay the night, without compromising the necessary space for essential work tasks provided by caregivers.



Illu. 139 - An apartment layout in a case, where a relative is staying the night. The partition wall is put aside, and an extra bed is rolled into the room.

Illu. 140 - The residential apartments are light and spacious with room for bringing personal furniture when moving in. Large floor windows open up the apartment to the outdoors and create a close connection to the landscape.



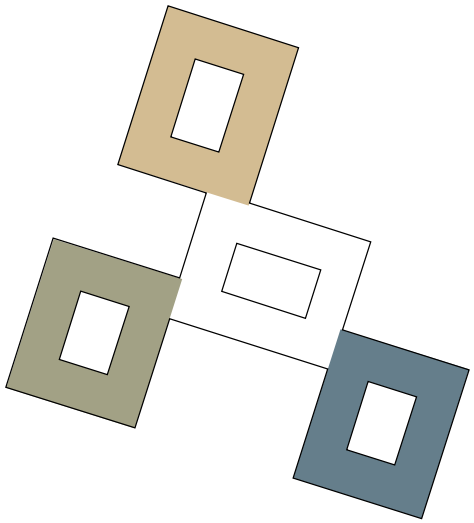
Illu. 141 - 'Effect Compass' for the staff functions (AART Architects, n.d.).

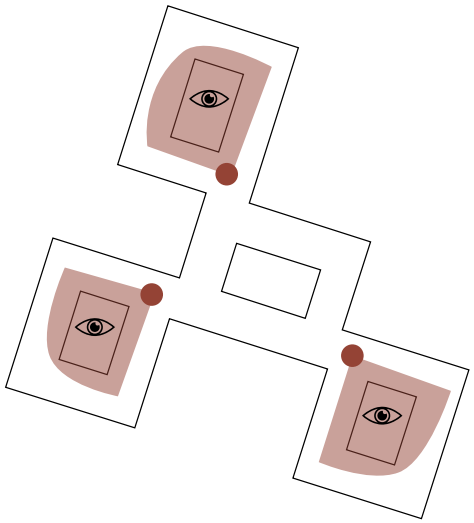
STAFF DEPARTMENT

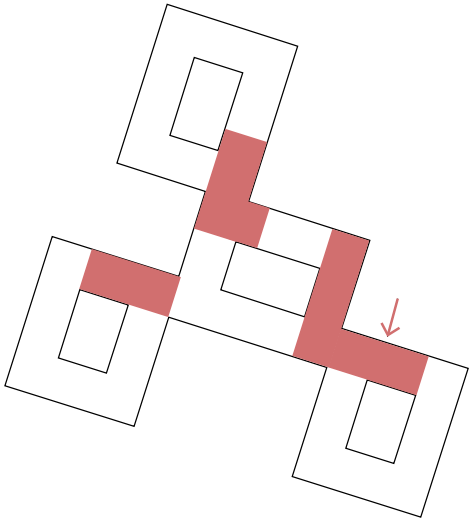
DESIGN STRATEGIES

The completed 'Effektkompas' shows the correlation between the design strategies implemented in the staff areas, the expected actions and experiences these strategies bring, as well as the desired effect for caregivers and staff.

The goal is for the caregivers to attain a better overview of the nursing home and its residents, which is achieved through several design principles including three separated residential departments with courtyards and wide windows in the corridor to improve visual contact across the courtyard. In addition, to create greater efficiency it is important for caregivers and staff to have spaces where they can retreat when necessary, while maintaining an overview of the residents, which is possible through the windows implemented in internal walls which improve visual contact of the residents when having a break.







Illu. 142 - Diagrams that describe the staff departments.

DEPARTMENTS

The nursing home is divided into three residential departments, each comprising 9 apartments. This division creates well-defined areas, making it easier for each caregiver to monitor their respective fields of responsibility.

VISUAL OVERVIEW

From the connecting department, caregivers can easily get an overview of the nursing home and the location of residents in the communal indoor as well as outdoor areas.

PLACEMENT OF STAFF FUNCTIONS

Changing rooms and offices for caregivers are placed in close relation to the staff entrance, while cleaning supply rooms and storage rooms are spread out in the departments to minimize the distances.

Illu. 143 - In the break room, staff and caregivers can retreat, while still being able to monitor the residents through the windows that provide visual contact to the common dining room.

Illu. 144 - The first and last room that caregivers meet on a shift is the changing room. Here they change into uniform, prepare for their workday and possible difficult tasks, or change out of uniform and get ready to go home.

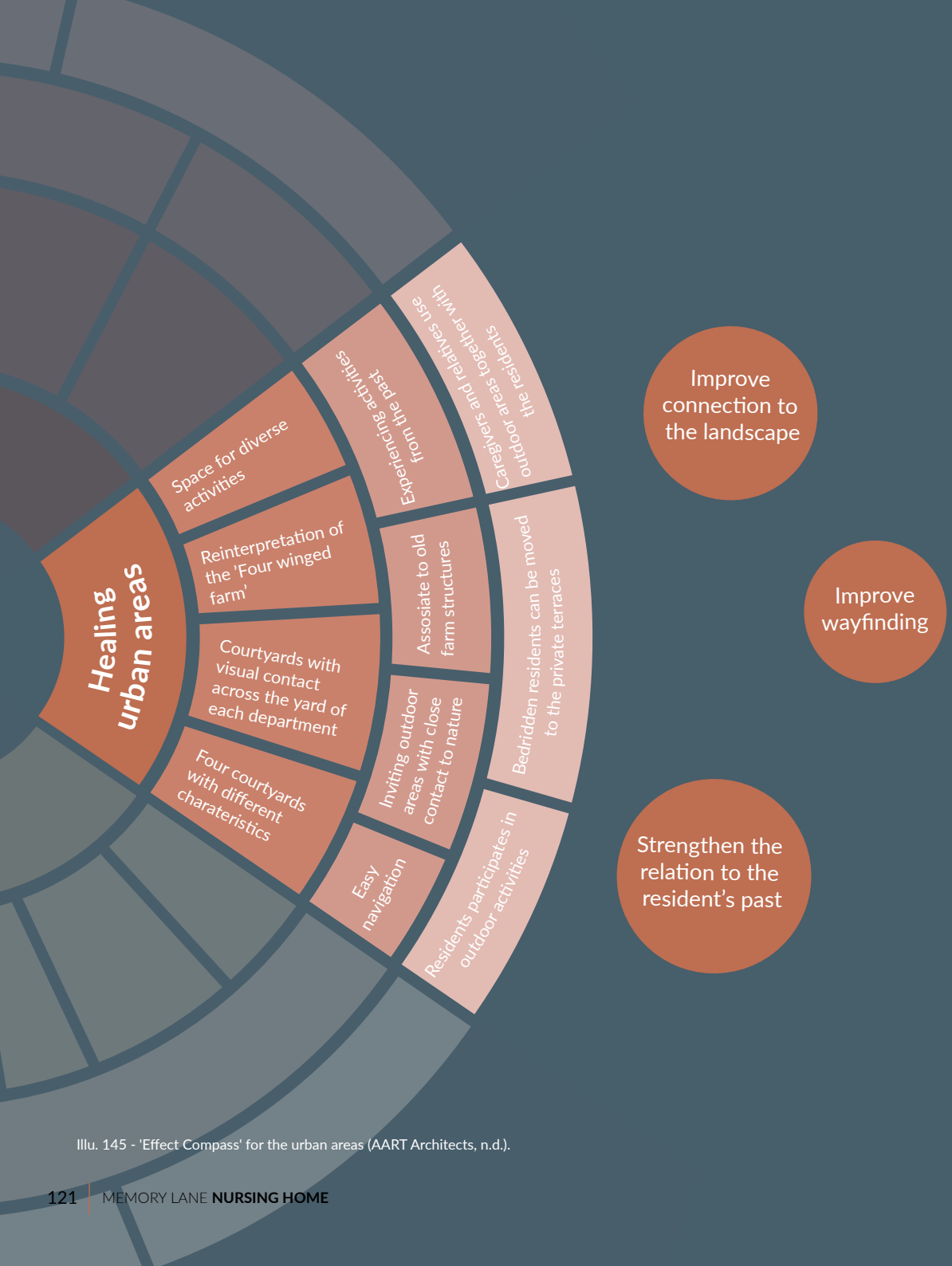
After entering and exiting the building, the first and last room a caregiver utilizes is the changing room. Here, they change into uniform while preparing for their workday and possible difficult tasks in relation to their work, or change out of uniform and get ready to go home. Therefore, it is important to design this room with careful consideration.

This objective is achieved by creating an inviting and bright atmosphere with the implementation of a large window with frosted glass, which provides both natural light and privacy. Moreover, the room is furnished with blue lockers that provide a private space to store their possessions and a blue accent wall that binds the room together, adding depth and color to the room.

When it is time for caregivers and other staff at the nursing home to take a break from their work, they can retreat from the residents in the break room. The purpose with the room is to provide caregivers with a breathing space where staff can recover from a difficult situation and confide in their colleagues, or just relax in the lounge area, eat together, and socialize at the dining table.

The break room is located next to the common dining room, as breaks are often held while the residents are eating, since the majority of all residents are gathered in one room and occupied, leaving the caregivers with a little time for a break, while still being able to monitor them through the windows placed in the internal wall that separates the dining room from the break room. Hence, the caregivers have a visual contact to the room, without having a direct contact to the residents.

Staff doors are camouflaged throughout the entire nursing home to prevent residents from entering staff functions, by implementing doors, door frames, and door handles with the same color as the walls, while entrances to residents' apartments are clearly marked. As a part of wandering behavior and the searching for prior homes or family members, doors often are intriguing to people with dementia and are synonymous with going home. Functions that are not accessible to the residents are locked, which can be aggravating for people with dementia when wandering and trying to open doors. Therefore, camouflaging the door to these functions can prevent residents from feeling trapped. Likewise, the open corridors with wide windows direct the gaze to the courtyards and the activities taking place here to give the residents the feeling of freedom and being able to wander. Thereby, leading their gaze away from the staff doors.



Illu. 145 - 'Effect Compass' for the urban areas (AART Architects, n.d.).

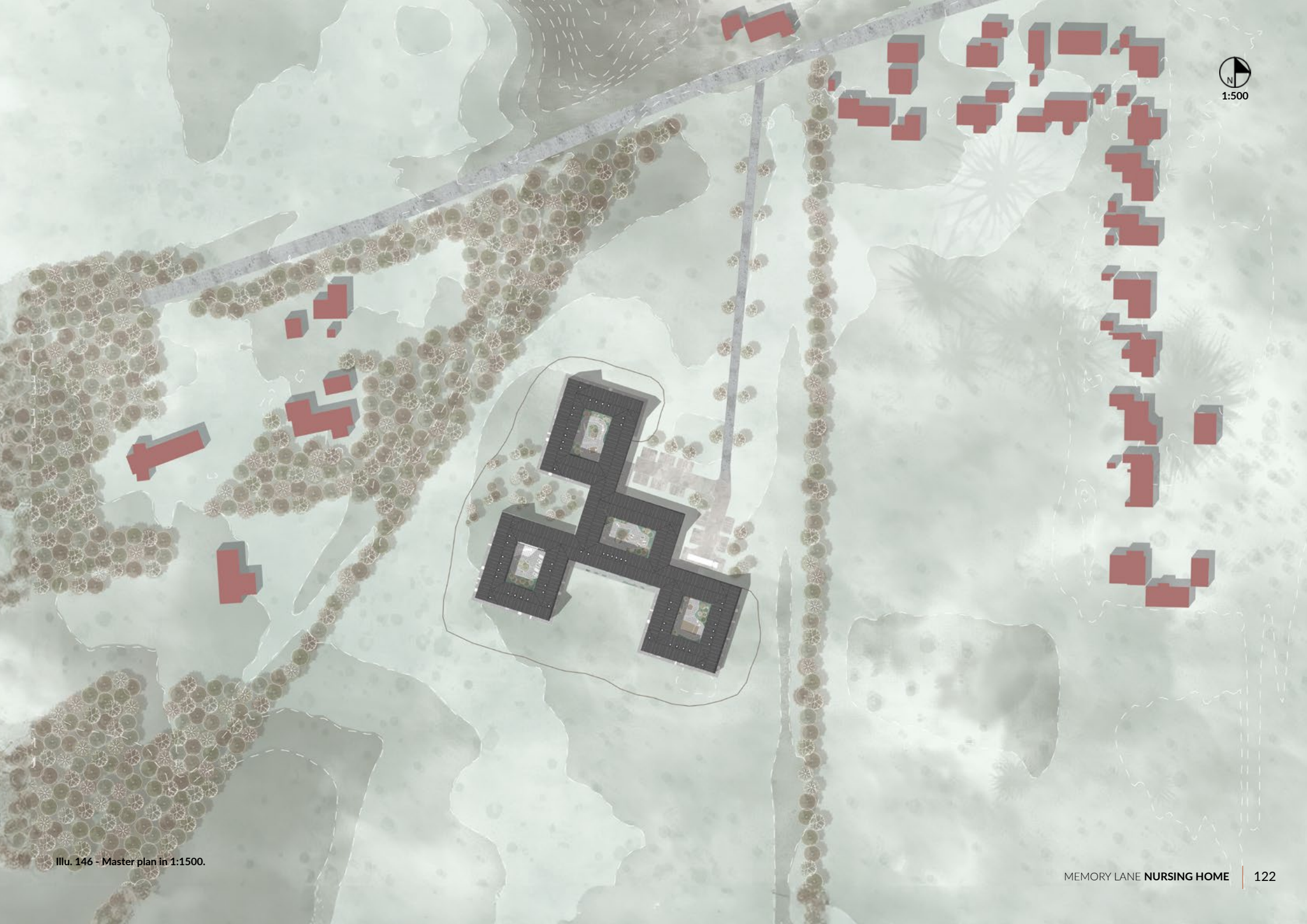
URBAN AREA

DESIGN STRATEGIES

The completed 'Effektkompas' shows the correlation between the design strategies implemented in the urban areas, the expected actions and experiences these strategies bring, as well as the desired effect for residents, relatives, caregivers, and staff.

The aim is to strengthen the residents' relation to their past through the building structure with inspiration from and a reinterpretation of the 'Four-winged farm', and by implementing diverse activities that invites the residents to participate or evoke memories from their past.

To improve the connection to the landscape, the building structure incorporates nature in each of the four departments through four courtyards that provide a direct view from the corridors to the outside when wandering. In addition, from each apartment a view of the surrounding landscape is provided through floor windows that connects the inside with the outside, melts the floor with the landscape, and allows bedridden residents to be moved outside on the private terraces.



Illu. 146 - Master plan in 1:1500.

EXPERIENTIAL VALUES

THE OUTDOOR ENVIRONMENT

8 experiential values developed by the University of Copenhagen for Realdania in collaboration with the University of Sweden are implemented in the urban landscape. It is a model with focus on how to develop and optimize existing green areas through various experiential values that contribute to an improved mental health (Jørgensen et al., 2014). Each value is represented in the four courtyards or in the surrounding landscape to create diverse urban spaces that meet the nursing home's need for a close interaction with nature to strengthen the residents health and well-being (illu. 148).

PEACEFUL

The experience of a quiet, calm, and undisturbed environment with no noise and not too many people (Jørgensen et al., 2014).

SPATIAL

Wide and open expanses with no distractions and only a few disruption from roads or paths (Jørgensen et al., 2014).

WILD

Experiencing the dynamic and vibrant nature on its own terms, and feeling a relaxing atmosphere and sense of safety (Jørgensen et al., 2014).

RICH IN SPECIES

A space with a rich diversity of plant and animal life through its many species (Jørgensen et al., 2014).

SANCTUARY

A shielded space where people can interact with animals, and watch or participate in play through e.g. playground or training equipment for all ages (Jørgensen et al., 2014).

CULTURE-HISTORICAL

The experience of culture and history through physical objects that initiate conversation and memory (Jørgensen et al., 2014).

COMMON

Large, open, and well-trimmed grass area with a view of the surroundings and a space to play e.g. soccer (Jørgensen et al., 2014).

ENTERTAINMENT AND SERVICE

A space that offers opportunities for dining and refreshments, enjoying entertainment, and socializing with other people (Jørgensen et al., 2014).

Illu. 147 - The 8 experiential values in the urban landscape.

THE MOVEMENT COURT

A yard with a dynamic atmosphere, where there is space for movement and play.

THE WOODS

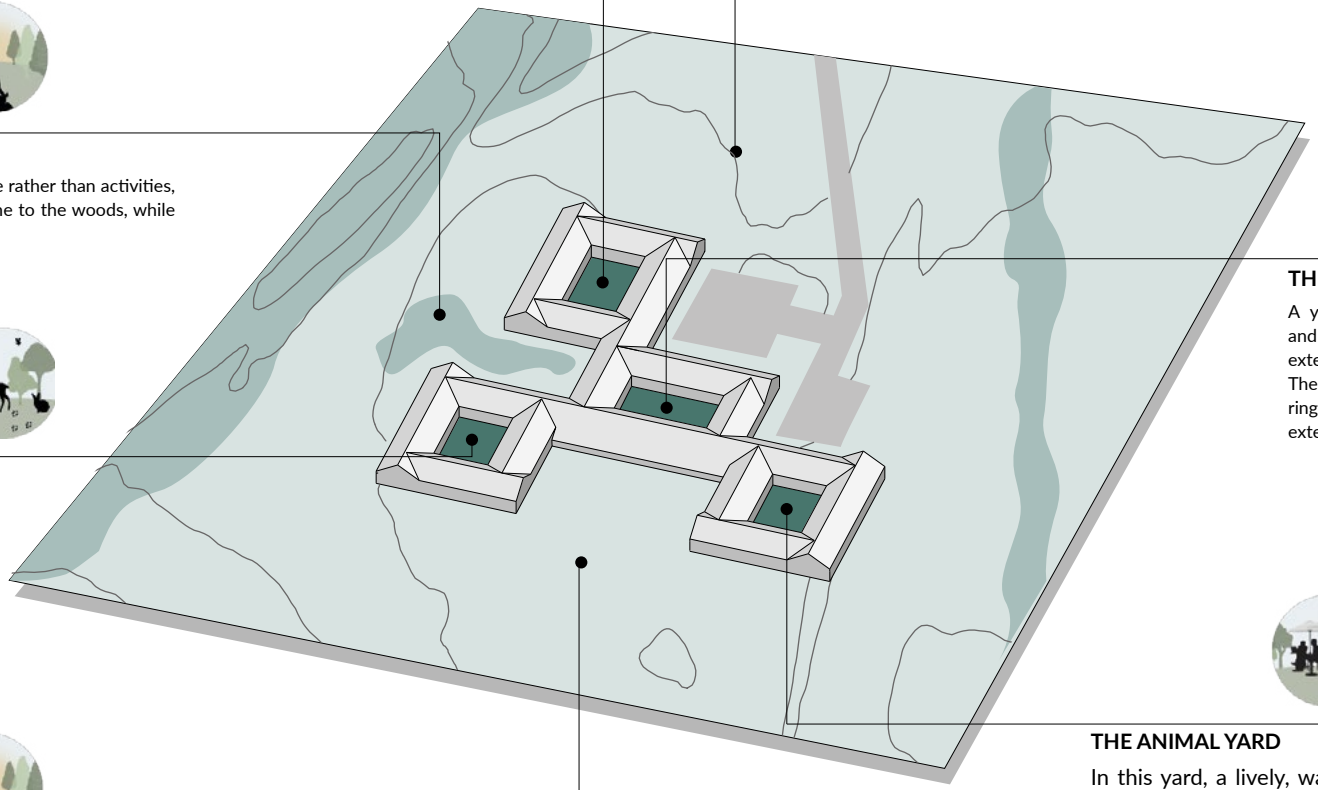
A more wild outdoor area marked by nature rather than activities, and a space that connects the nursing home to the woods, while creating a grounding feeling.

THE GREEN GARDEN

A sensory garden with activities that include harvesting fruits from the orchard and vegetables from the vegetable garden as well as walking through the small corn field and experiencing a part of the surrounding agricultural landscape.

THE OPEN LANDSCAPE

A space solely marked by the simpleness and peaceful atmosphere of the open landscape with a view of the fields and vast expanse in the distance.



THE ARRIVAL

A large, open space that creates a distance between the main road and landscape to emphasize the conceptual expression, while forming an inviting atmosphere and peaceful arrival to the nursing home.

THE COMMUNAL YARD

A yard that protects the 'global community' and provides a space for social gatherings as an extension of the dining room and gathering hall. The space includes an outdoor eating area during summer and outdoor training equipment in extension of the workout room.

THE ANIMAL YARD

In this yard, a lively, warm atmosphere is created, as well as an opportunity for an interaction with animals that does not demand verbal communication, which can be difficult when having dementia, providing a safe space to take a break from interacting with other residents or caregivers.

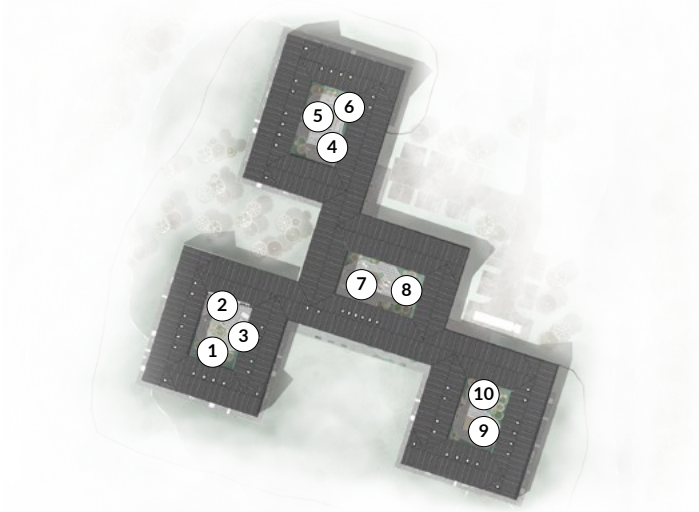
Illu. 148 - Where and how the 8 experiential values are incorporated in the urban landscape.

Illu. 149 - In 'The Green Garden' the residents can harvest fruit from the orchard and vegetables from the vegetable garden or walk through the small corn field and experience a part of the surrounding agricultural landscape.

Illu. XX

URBAN ACTIVITIES

Each courtyard, ‘The Movement Court’, ‘The Animal Yard’, and ‘The Green Garden’, is intentionally designed to foster a strong connection to the residents’ memories and is characterized by different atmospheres that engage all the senses. The diverse range of activities offered in each courtyard ensures that residents can participate in meaningful activities that resonate with their past experiences.



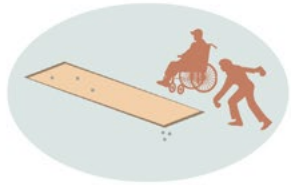
Illu. 151 - Placement of the presented activities in each courtyard.

1 FRUIT TREES

2 VEGETABLE GARDEN

3 CORNFIELD

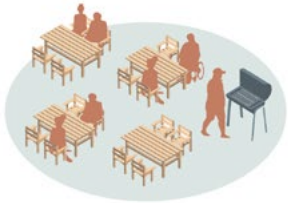
4 SWING



5 PENTANQUE

6 MOVEMENT PATH

7 OUTDOOR TRAINING EQUIPMENT



8 GRILLING AREA

9 CHICKEN YARD

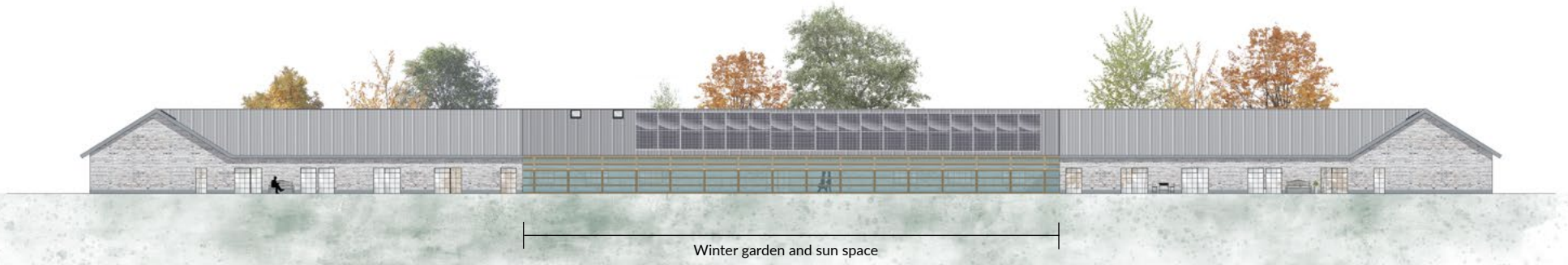
10 BIRD CAGE

Illu. 150 - The 10 activities included in the courtyards, involving different levels of active involvement to accommodate different stages of dementia.

FACADES

ELEVATIONS

Illu. 152 - Northeast elevation in 1:500.



Illu. 153 - Southwest elevation in 1:500.

Illu. 154 - Northwest elevation in 1:500.

Illu. 155 - Southeast elevation in 1:500.

Illu. 156 - The nursing home is placed with a distance to the main road, providing a structural void in the landscape that emphasizes the conceptual expression, while forming an inviting atmosphere and peaceful arrival to the nursing home through the avenue with trees on both sides that lead to the nursing home.

The external walls consist of an outer layer of light gray bricks in various shades and built in a running bond pattern. In each of the three residential departments, the bricks are painted in a different color adding to the distinction between the yards, while enhancing wayfinding in the physical surroundings. As a result, each courtyard takes on a unique character with different activities and atmospheres, complemented by different colored facades that match the internal corridor wall that is visible even before entering each residential department., ensuring a seamless transition from the exterior.

In addition to the colored bricks, a glass wall with a view to the courtyard further enhances the experience when entering each department. This provides not only a visual connection to the outdoor space, but it also emphasizes the distinction between them.

The facades viewed from the outside of the nursing home as well as in the Communal Yard are not painted and are of the same color to create a cohesive facade that connects each of the departments.

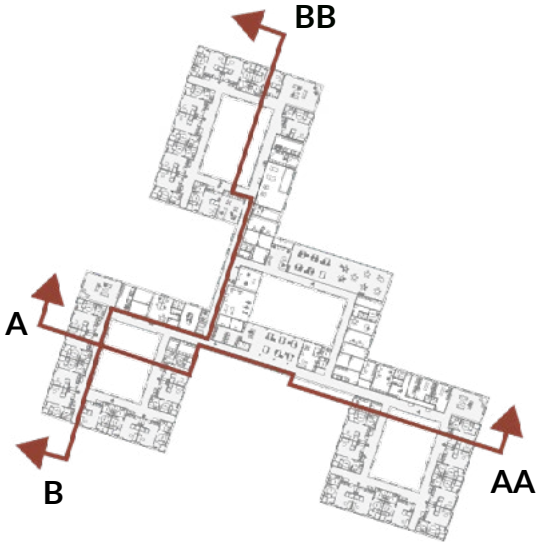
Illu. 157 - Each courtyard is marked by a different colored facade with a corresponding internal accent wall, which is visible when entering each residential department. A large glass wall on the opposite side of the accent wall provides a view to the entire courtyard and binds the rooms together, and helps differentiate each department from each other.

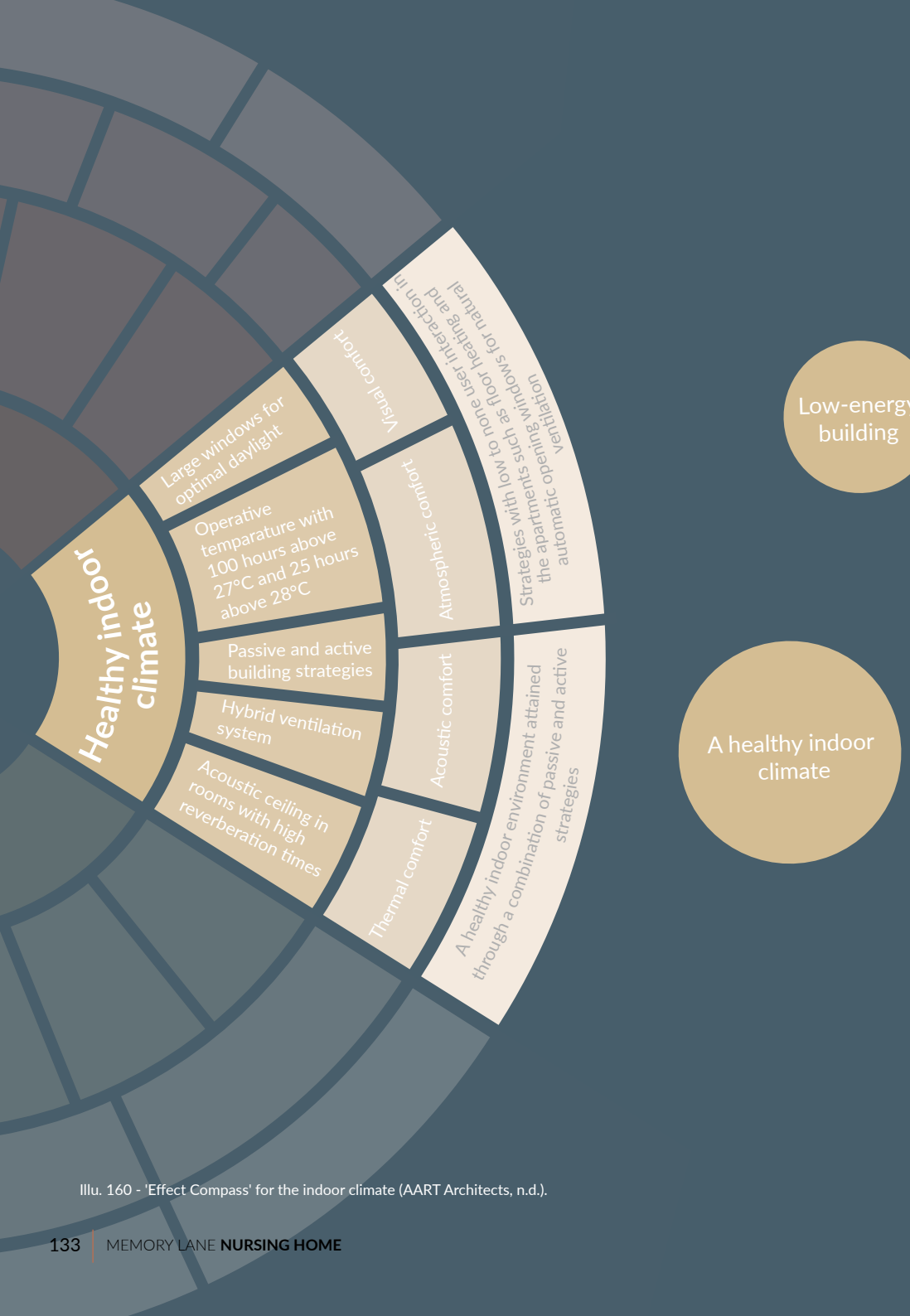
Illu. 158 - A-AA section in 1:300.

Illu. 159 - B-BB section in 1:300.

AA

BB





Illu. 160 - 'Effect Compass' for the indoor climate (AART Architects, n.d.).

INDOOR ENVIRONMENT AND ENERGY PERFORMANCE

DESIGN STRATEGIES

The completed 'Effektkompas' shows the correlation between the design strategies implemented in relation to the indoor environment and the building's energy performance, the expected actions and experiences these strategies bring, as well as the desired effect for residents, relatives, caregivers, and staff.

The aim is to achieve a healthy indoor climate, where the users experience visual, atmospheric, acoustic, and thermal comfort when living, working, or visiting the nursing home. This is achieved through several design principles that are implemented to meet the requirements stated in BR18, which includes focus on optimal daylight, operative temperatures, ventilation systems, and reverberation times.

A low-energy building is achieved through integrated design solutions as well as passive and active design strategies that minimize the consumption of energy, while providing a healthy indoor environment. All systems are automatically controlled through sensors and do not require interaction from residents.

ENERGY PERFORMANCE

PASSIVE AND ACTIVE STRATEGIES

Energy calculations made in Be18 document that the building meets the requirements for a low-energy building class in BR18 (Bygningsreglementet, 2018, §474), as the total need for energy supply for heating, ventilation, cooling, and domestic hot water is 17.7 kWh/m² pr. year.

With the aim to design a building with sustainable solutions, passive and active design strategies are implemented in the design to minimize the consumption of energy, provide a healthy indoor environment, and produce renewable energy to cover the building's energy use.

PASSIVE STRATEGIES

Passive strategies include integrated design principles that utilize natural resources, such as solar radiation and wind, for cooling, heating, and ventilation with no need for power for the operation.

Natural ventilation is used during summer to reduce energy consumption from air conditioning in the apartments through stack ventilation based on thermal buoyancy, while cross and single-sided ventilation based on wind forces are used in common functions and staff functions.

The building's **thermal envelope** is airtight and well-isolated to reduce heat loss in winter and to gain heat in summer. The U-values for the construction is as follows:

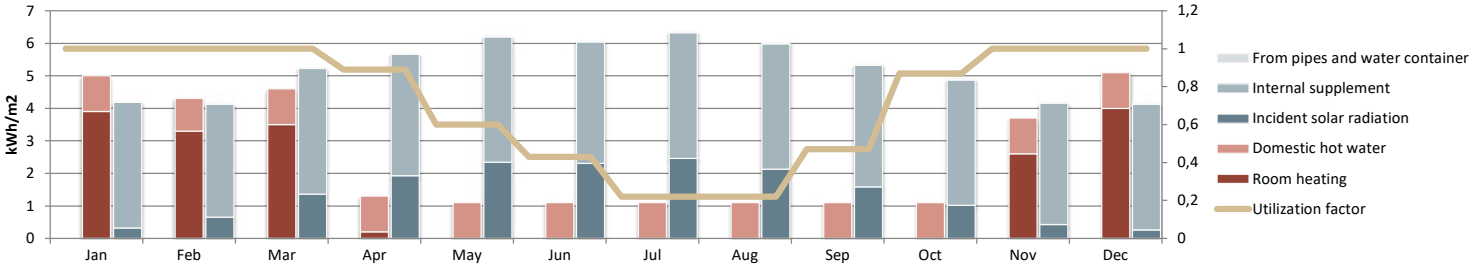
	U-value [W/m^{2}K]	Insulation [mm]
Roof	0.06	475
Ground deck	0.07	400
Exterior wall	0.12	510

The attached winter garden serves as a **sun space** with vents that naturally heats the room itself and the adjacent dining room through both solar radiation and convection. During the night, the vents are closed to keep the heat from convection to go in the right direction.

Solar shading is implemented through an overhang that prevents solar radiation from entering the building during the warm summer months and thereby adding additional heat and excess temperatures, while providing optimal solar heat gain in winter where the altitude angle of the sun is lower.

ACTIVE STRATEGIES

To comply with the requirements for the low-energy frame, it is necessary to establish renewable energy sources, as the energy consumption is calculated to be 29.6 kWh/m² a year. Therefore, photovoltaics, solar thermal collectors, and a heat pump are inte-



Illu. 161 - The heating demand (marked with red) vs. the heat supply (marked with blue).

grated in the design.

Photovoltaics that convert sunlight into electricity energy in the inverter, which pass on the energy to the building. If there is any excess energy that is not used, it will be stored in the battery, making it possible to use later in case of cloudy weather. In addition, the system is connected to the electricity grid to pass on excess energy that is not used or stored in the battery.

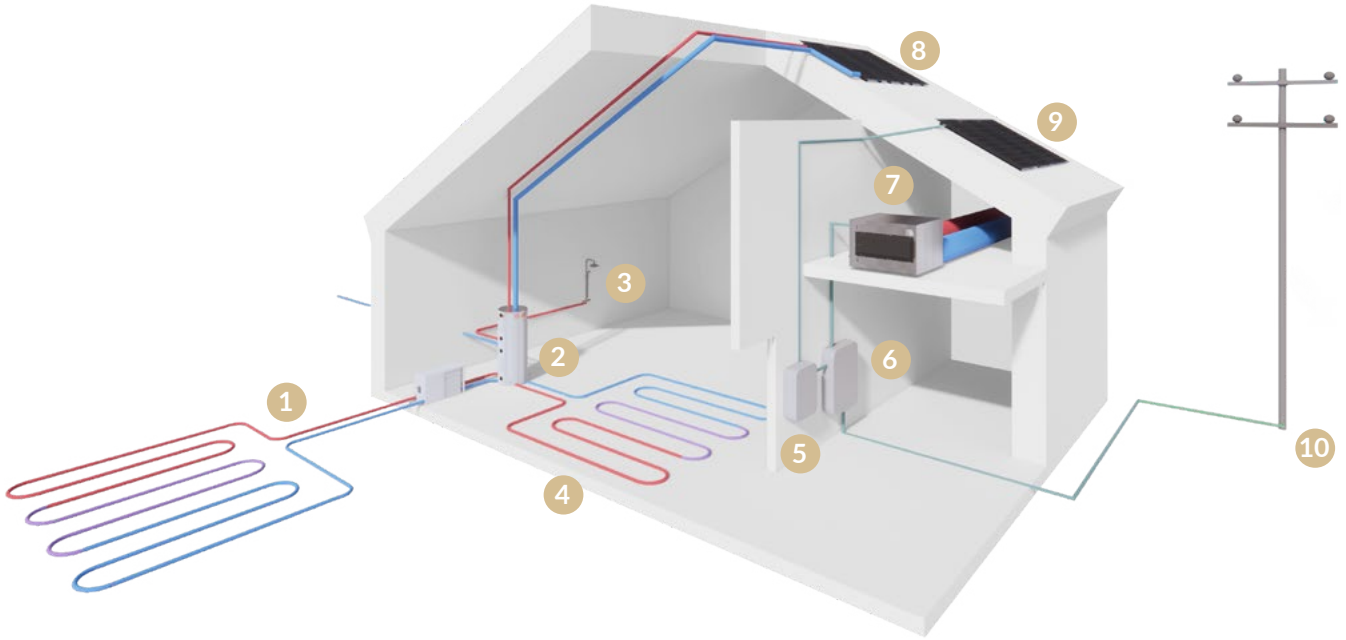
In addition, **thermal collectors** that absorb heat from the sun, preheat the water for domestic use. Both photovoltaic and thermal collectors are placed on the roof with a 30° angle, directed toward southwest, and cover an area of 100 m² respectively.

Water-to-water heat pump with geothermal heat exchange that takes advantage of the subterranean temperatures is implemented to provide warm water for domestic use and heating during winter through an in-floor radiant heating system.

The **Mechanical ventilation system** with heat recovery in winter preheats incoming outdoor air with exhaust indoor air through a cross flow heat exchanger. The system introduces an equal rate of fresh air and exhausted air, creating a blanched system that neutralizes the pressure in the building.

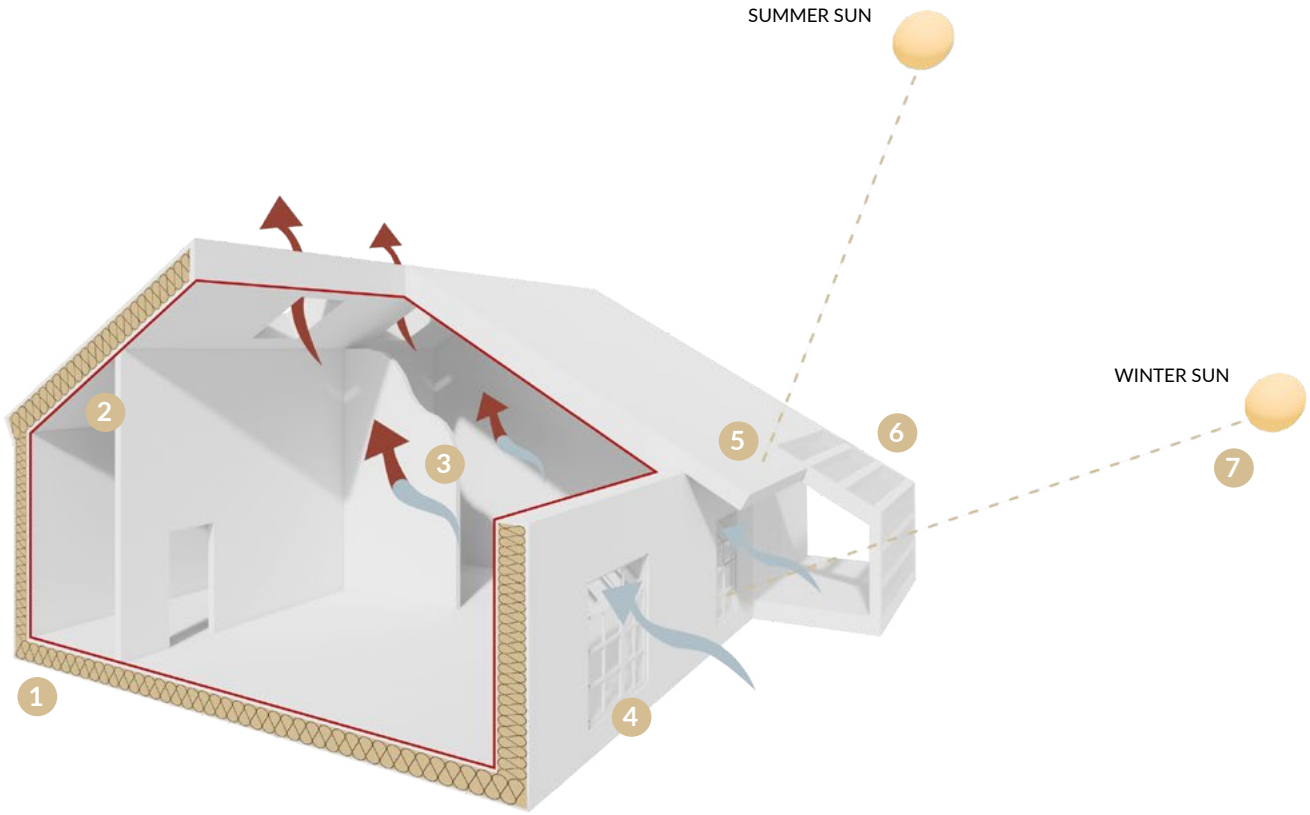
The result is an energy consumption of 17.7 kWh/m² a year, and thereby a significant reduction is achieved through the use of active strategies.

The passive and active strategies influence on the health of the resident, relatives, caregivers, and staff as well as the indoor environment is elaborated in the following sections.



1 WATER-TO-WATER HEAT PUMP
2 WATER TANK
3 DOMESTIC HOT WATER
4 FLOOR HEATING
5 INVERTER
6 BATTERY
7 MECHANICAL VENTILATION SYSTEM (DURING HEATING MONTHS)
8 THERMAL SOLAR COLLECTORS
9 PHOTOVOLTAIC
10 ELECTRICITY GRID

Illu. 162 - All active strategies incorporated to minimize the energy consumption and provide a healthy indoor environment.



1 INSULATION

2 AIRTIGHT

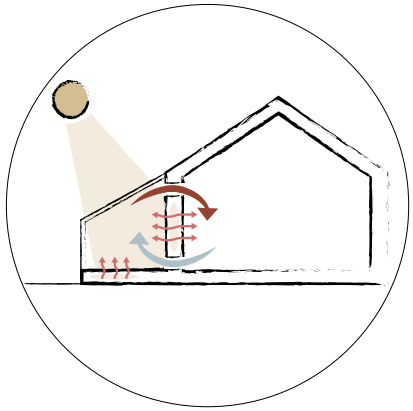
3 NATURAL STACK VENTILATION OUTSIDE HEATING MONTHS

4 HIGH PERFORMANCE WINDOWS

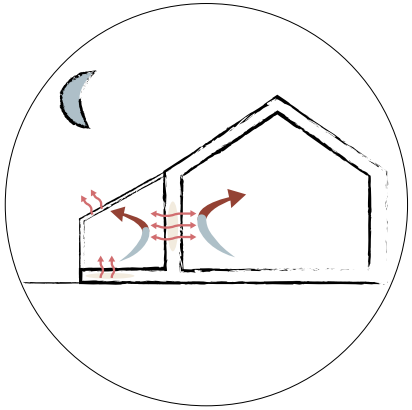
5 OVERHANG

6 SUNSPACE

7 SOLAR HEAT GAIN



SUN SPACE DURING THE DAY



SUN SPACE DURING THE NIGHT

Illu. 163 - All passive strategies incorporated to minimize the energy consumption and provide a healthy indoor environment.

ATMOSPHERIC
INDOOR ENVIRONMENT

When working with the atmospheric indoor environment, it is important to ensure a good indoor air quality through ventilation strategies that do not require the resident to enable or interact with, as the olfactory sense often is affected when having dementia. It may influence the perception of different smells and residents may not be aware of a smell that needs ventilation. Therefore, an automatically operated ventilation system, which ensures that the ventilation can be controlled and serviced without entering the apartments and disturbing the residents in their room, is implemented.

The atmospheric comfort is ensured through a fulfillment of the following requirements:

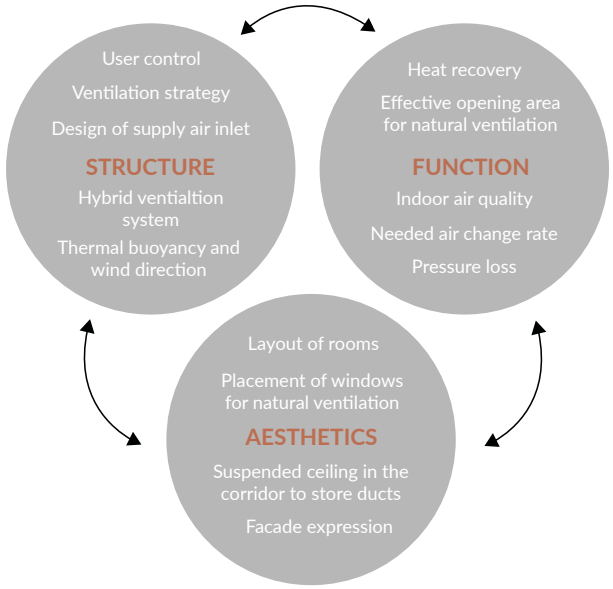
- A maximum concentration of 1000 ppm CO2-pollution in the room during dimensioned conditions, meaning the normal operation of the building.

Several considerations were made through the correlation between structure, function, and aesthetics when it comes to the design of the atmospheric indoor environment at the nursing home (illu. 164).

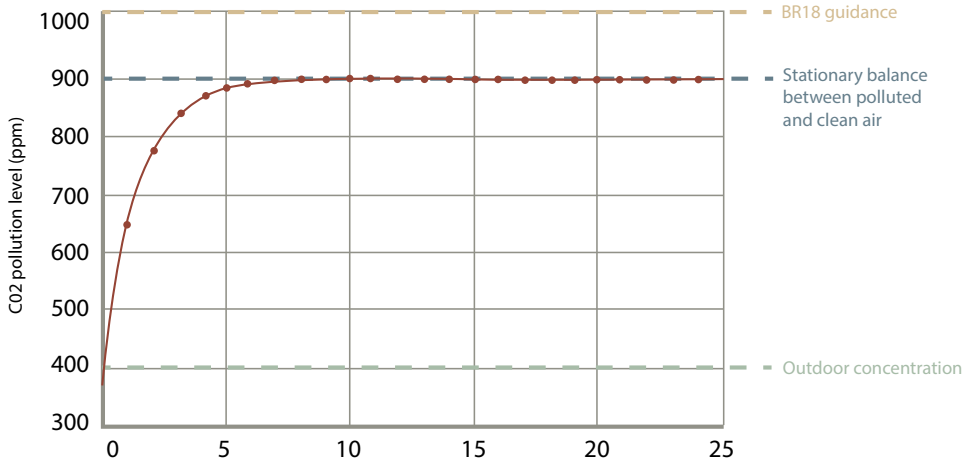
STRUCTURE

A hybrid ventilation system is implemented with mechanical ventilation during winter and natural ventilation based on thermal buoyancy in the apartments and cross ventilation or single-sided ventilation in common rooms and staff rooms based on wind forces.

To avoid unnecessary waste of energy and reduce the annual energy consumption for operating the mechanical ventilation system, an VAV control principle is implemented, as the rooms in the nursing home are used to varying extents throughout the day. Residents spend time at the many functions, wander in the



Illu. 164 - Structural, functional, and aesthetical considerations made when designing the atmospheric indoor environment.



Illu. 165 - Development in CO2 pollution level in an apartment.

Illu. 166 - Section of an apartment that shows the natural ventilation principle based on thermal buoyancy, as well as the placement of the air supply inlet from the mechanical ventilation system in the wall above the living room.

corridors, and eat in the common dining room throughout the day, and sleep in their apartments during the night, or in some cases are bedridden and therefore spend all the time in their room. Therefore, reducing the airflow when there are no residents present in the rooms or adjusting the air flow according to the peopleload in the room, energy is saved on heating outdoor air as well as the electricity consumption for operating the fans.

The system consists of three heat recovery units that supply fresh outdoor air and exhaust polluted indoor air in each of the three divisions marked on illu. 167. In the apartments, the supply air inlet is placed in the wall in the living room where it creates a mixing ventilation with fresh air introduced at the ceiling level that ensures an even distribution of air throughout all areas of the space (see appendix 7).

FUNCTION

The dimensioning of the ventilation ducts is calculated with an air velocity of maximum 4-8 m/s (see appendix 12) based on the calculated needed air change rate in each room (see appendix 5, table 5.3). Moreover, the CO2-pollution in the apartments reaches a stationary balance at 880 ppm after 8 hours in a case, where the resident is bedridden (see appendix 5), and therefore does not exceed the requirements.

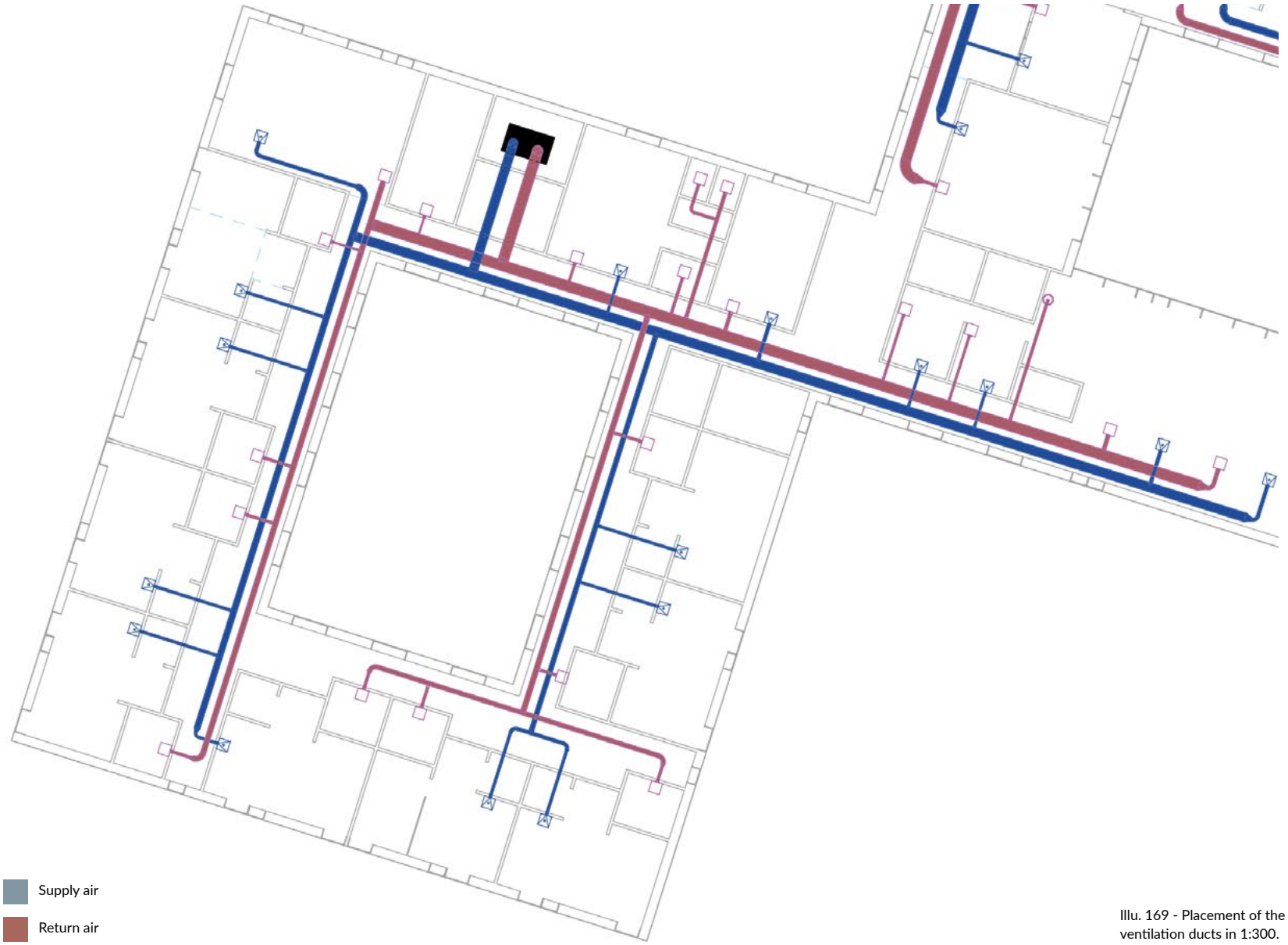
In the apartment, the needed effective opening area for natural ventilation is calculated to be 0.027 m^2 at each of the two window openings at the 1. floor and an opening area of 0.050 m^2 in each of the two roof windows, while an opening area of 0.02 m^2 at each of the five windows placed at the windward side in the gathering hall, and an opening area of 0.20 m^2 in each of the five windows placed on the leeward side, is needed (see appendix 6).

AESTHETICS

A roof window is placed in the kitchen to achieve natural ventilation based on thermal buoyancy and bring in daylight. In addition, the vaulted ceiling increases the room volume in the apartments, and subsequently decreases the CO2-pollution concentration in the room, allowing warm, polluted air to ascend to the ceiling outside the comfort zone. Moreover, to store and conceal the mechanical ventilation ducts, the ceiling is suspended in the corridors, which create a more clean appearance with no disruption of mechanical elements.

Illu. 167 - The mechanical ventilation system is run by three units that provide fresh air and extract polluted air from three different zones, which is marked with colors on this illustration.

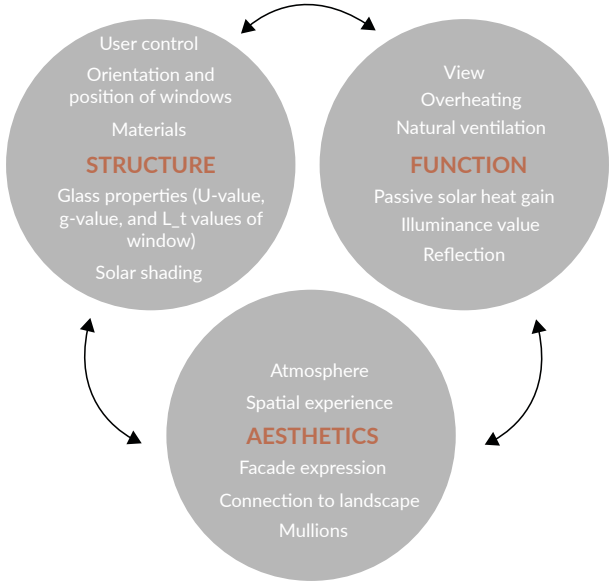
Illu. 168 - Placement of the mechanical ventilation ducts in 1:700.



Illu. 169 - Placement of the mechanical ventilation ducts in 1:300.

VISUAL
INDOOR ENVIRONMENT

When working with the visual indoor environment, it is essential to provide sufficient daylight and enable the control of direct sunlight and subsequently the solar heat gain to ensure thermal comfort. Daylight considerations are important when designing for people with dementia, as it is critical to their perception of space and can, if not used correctly, confuse, aggravate, or even frighten the residents due to the delayed interpretation in visual perception that often occurs when having dementia. Moreover, placement of windows and daylight can improve the residents' circadian rhythm and prevent falls during night time as well as improve their sleeping patterns.



Illu. 170 - Structural, functional, and aesthetical considerations made when designing the visual indoor environment.

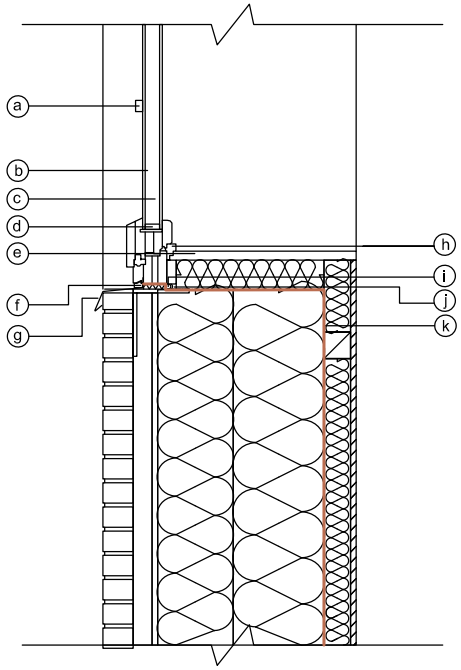
The visual comfort is ensured through a fulfillment of the following requirements and criteria:

- A glazing area that corresponds to minimum 10% of the relevant floor area (Bygningsreglementet, 2018b, §379, stk. 2).
- Interior illuminance from daylight is 300 lux or more on minimum 50% of the relevant floor area for at least half of the daylight hours (Bygningsreglementet, 2018b, §379, stk. 2).
- Direct view of the landscape from the living room, kitchen, and bedroom in residential apartments.
- Sill height leveled with the floor in the living room and bedroom in residential apartments.

Several considerations were made through the correlation between structure, function, and aesthetics when it comes to the design of the visual indoor environment at the nursing home (illu. 170).

STRUCTURE

To prevent glare, window shading is implemented through venetian blinds which are integrated in the window between the two layers of glazing with an automatic sensory control, where the shading is controlled based on the incoming light on the facades. When the illuminance measured on the external wall that each window is located exceeds the 'shade close' value of 10.000 lux, the shading is activated (see appendix 8).



Illu. 171 - Wall and window detail in 1:20.

a) Integrated venetian blids
b) Sash bar
c) 2 layer energy efficient glazing
d) Window fame
e) Desiccant
f) Internal sill
g) Expansion joint
h) Sill flashing
i) Weather strip
j) Cavity closer
k) Airtight seal
l) Vapour barrier

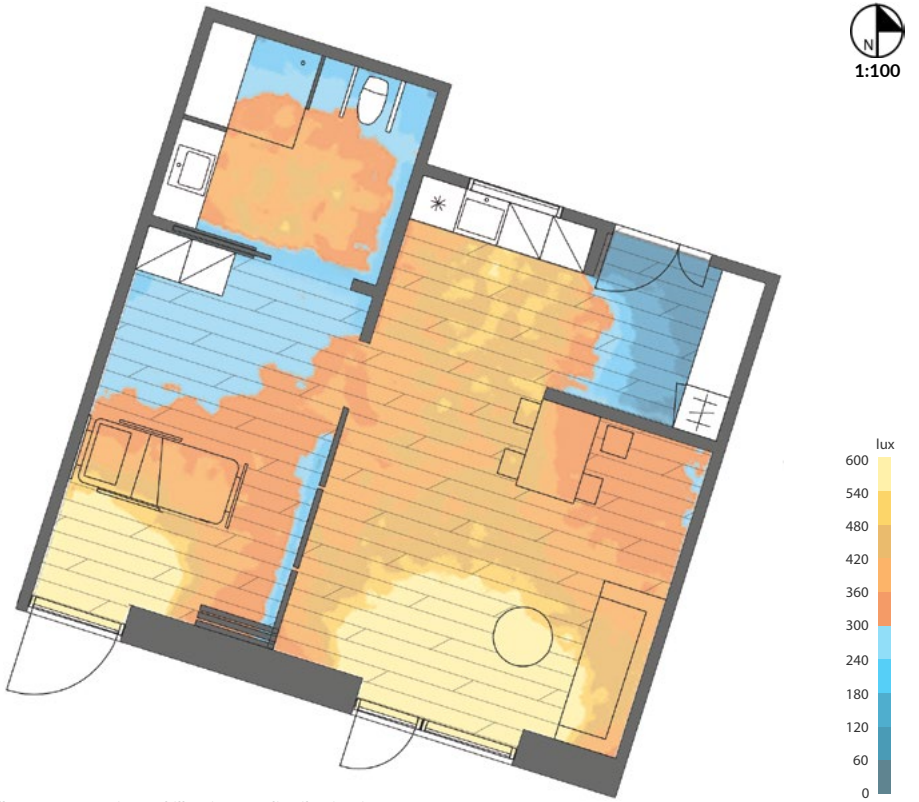
FUNCTION

The floor windows in the apartments increase the vertical field of view for the residents and melts the room and landscape together, which especially is important for bedridden residents who spend majority of the time in their beds. The low sill height creates a strong connection to the landscape, opens up the room to nature, and makes it possible for bedridden residents to still feel connected to the outdoors.

Sufficient daylight is ensured through the placement and size of windows that allow natural daylight to penetrate the room with an illuminance of 420 lux on minimum 50% of the relevant floor area (illu. 172).

AESTHETICS

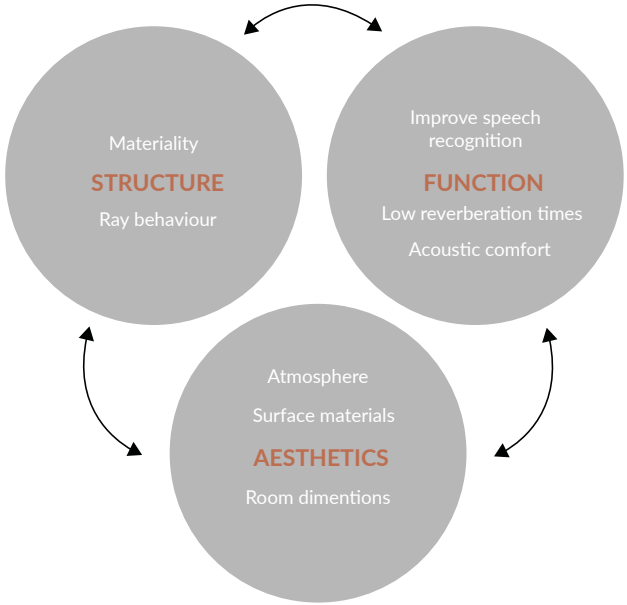
All windows have mullions to avoid causing the residents confusion by giving a clear indication of the placement of windows, and not to be confused with an opening in the facade with direct access to the outside. Furthermore, these windows are characteristic for old farm buildings and creates a connection to the landscape as well as an association to the architectural style of farm buildings in the facade expression.



Illu. 172 - Experienced illuminance distribution in an residential apartment in 1:100.

ACOUSTIC
INDOOR ENVIRONMENT

Working with the acoustic indoor environment is of great importance when designing for people with dementia, as they often can be affected by difficulties when processing auditory information or develop a hypersensitivity to auditory stimulation. Noise can be distressing, isolating, and cause challenges with speech recognition as well as communication between residents and their caregivers.



Illu. 173 - Structural, functional, and aesthetical considerations made when designing the acoustic indoor environment.

The acoustic comfort is ensured through a fulfillment of the following requirements and criteria:

- A reverberation time of maximum 0.9 sec. at 125 HZ and 0.6 sec. between 250 Hz-4000 Hz in the gathering hall Bygningsreglementet, 2018, §369-376, stk. 2.5).
- A reverberation time of maximum 0.6 sec. between 125 Hz-4000 Hz in the apartments Bygningsreglementet, 2018, §369-376, stk. 2.5).
- Absorbing materials are integrated in the architecture and with other materials.

Several considerations were made through the correlation between structure, function, and aesthetics when it comes to the design of the acoustic indoor environment at the nursing home (illu. 173).

STRUCTURE

Ray behavior of the sound was examined in the gathering hall to improve speech recognition, resulting in a trapeze shape for the lamellae mounted in the ceiling. This shape captures a significant amount of the sound, hence preventing noise from being reflected and causing confusion for the residents.

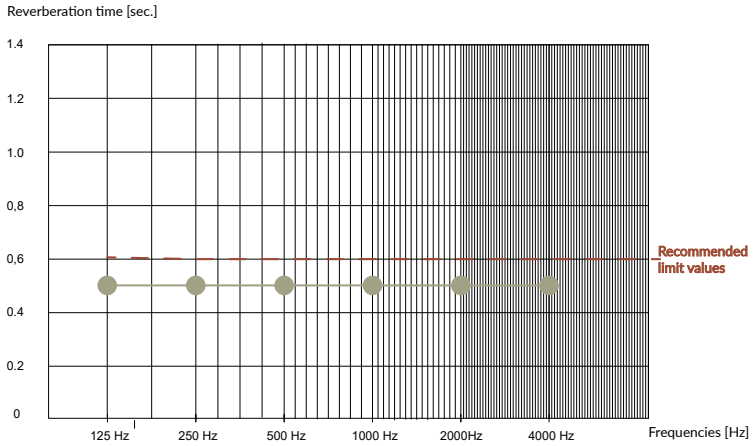
FUNCTION

To attain reverberation times that meet the requirements, an acoustic ceiling consisting of lamellae on a felt underlay is mounted in both the apartments and the gathering hall. These acoustic absorbing ceilings reduce the reverberation times and improve speech intelligibility to make it easier to hear and understand conversations, as well as optimize the physical conditions for strengthening the communication between residents and their caregivers or relatives.

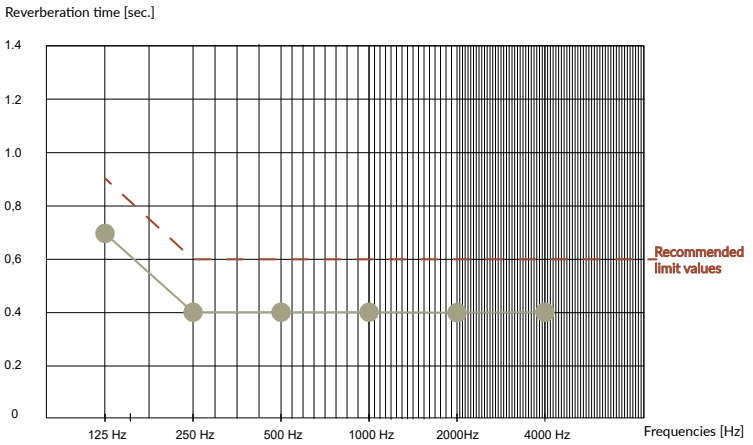
AESTHETICS

The design focuses on providing residents, relatives, caregivers, and other staff with an optimal acoustic indoor environment, characterized by a calm and relaxed atmosphere. The wooden lamellae in the ceiling of the apartments introduce a visual warmth to the room that can add a sense of coziness and comfort to the space as well as an inviting atmosphere. Moreover, the lamellae add a level of contrast to the room with its white walls and texture to the space that breaks the monotony and adds character to the room.

Lastly, to achieve acoustic comfort, the spatial layout has been influenced. Functions that cause high, sudden noises, such as the dish washing room and the scullery for preparing food, are isolated in separate rooms from the dining room where the residents stay.



Illu. 174 - The reverberation times experienced in the apartments with inclusion of an acoustic ceiling consisting of lamellas on felt to reduce the reverberation times.



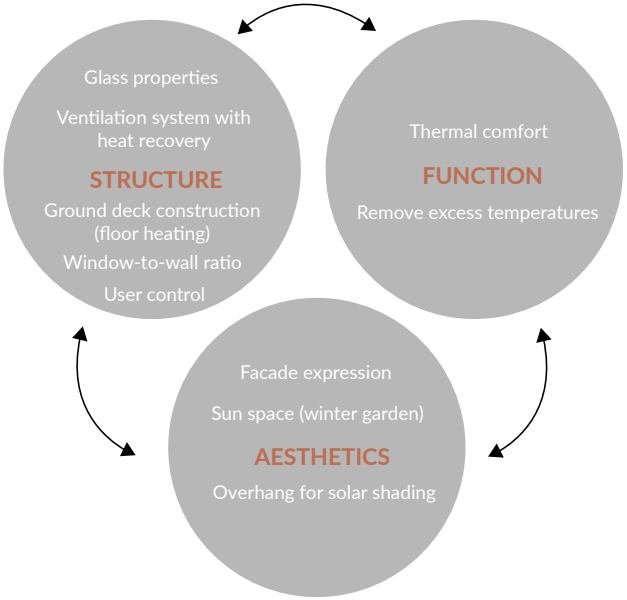
Illu. 176 - The reverberation times experienced in the gathering hall with inclusion of an acoustic ceiling consisting of lamellas on felt to reduce the reverberation times.

Illu. 175 - An apartment with an acoustic ceiling that decreases the reverberation times in the room to attain acoustic comfort.

Illu. 177 - The gathering hall with an acoustic ceiling that decreases the reverberation times in the room to attain acoustic comfort.

THERMAL
INDOOR ENVIRONMENT

When working with the thermal indoor environment, it is important to consider the indoor temperature, overheating, and user control, as it may not be clear for people with dementia that a room is too cold or too warm due to the decreasing ability to regulate body temperature in response to a lowered activity level.



Illu. 178 - Structural, functional, and aesthetical considerations made when designing the thermal indoor environment.

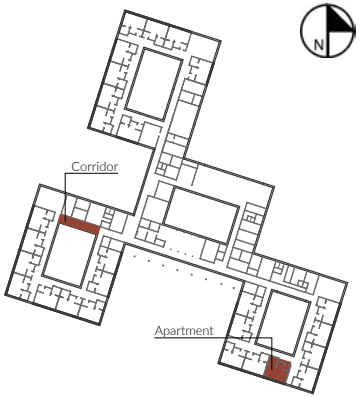
The thermal comfort is ensured through a fulfillment of the following requirements and criteria:

- Indoor operative mean temperatures with a maximum of 100 hours above 27°C and 25 hours above 28°C (Bygningsreglementet, 2018a, §385-§392, 1.0).
- Maintaining 20°C<t_o<24°C within the heating season and 23°C<t_o<26°C outside the heating season (Dansk Standard, 2019, DS/EN 16798-1:2019 DK NA:2021, p.5).
- No user interaction with the systems is needed from residents to attain thermal comfort.

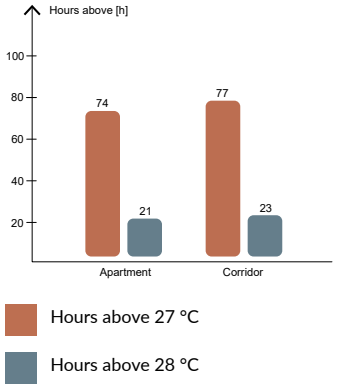
Several considerations were made through the correlation between structure, function, and aesthetics when it comes to the design of the thermal indoor environment at the nursing home (illu. 178).

STRUCTURE

Ventilation, solar shading, and window consideration, including size, placement, glazing values, and window-to-wall ratio, ensures that excess temperatures are avoided. The systems regulate automatically after the indoor room temperature and do not require user interaction from residents to attain thermal comfort. This includes a mechanical and natural ventilation system with room sensors and automatically opening windows, an integrated blinds system in the windows, and floor heating that ensures an even heat distribution in the room (see appendix 8).



Illu. 179 - Location of the two critical rooms examined in relation to the thermal indoor environment.



Illu. 180 - The amount of hours above 27 °C and 28 °C experienced in the two examined rooms.

FUNCTION

To attain thermal comfort that meets the requirements and remove excess temperatures, an overhang of 0.5 m is implemented in the design (illu. 183, p. 147) to block heat energy from the sun during summer when the altitude angle of the sun is high, while still allowing heat energy to enter in winter when the sun's altitude angle is low. Moreover, windows with integrated blinds placed between the two layers of glazing, contribute to the solar shading. These are automatically controlled with the option for user override, and

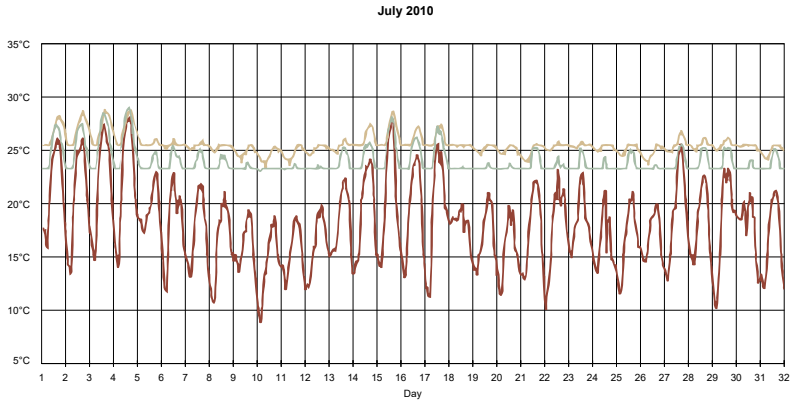
The two most critical rooms in the building, a residential apartment and one zone in the corridor with a large glass wall, both meet the requirements. In the apartment an indoor operative temperature above 27°C is experienced in 74 hours a year and 21 hours above 28°C, while 74 hours above 27°C and 21 hours above 28°C is experienced in the corridor. Moreover, the ventilation air volume is regulated based on the indoor temperature to maintain $20°C<t_o<24°C$ in summer and $23°C<t_o<26°C$ in winter, when the CO2-pollution concentration does not exceed 1000 ppm.

AESTHETICS

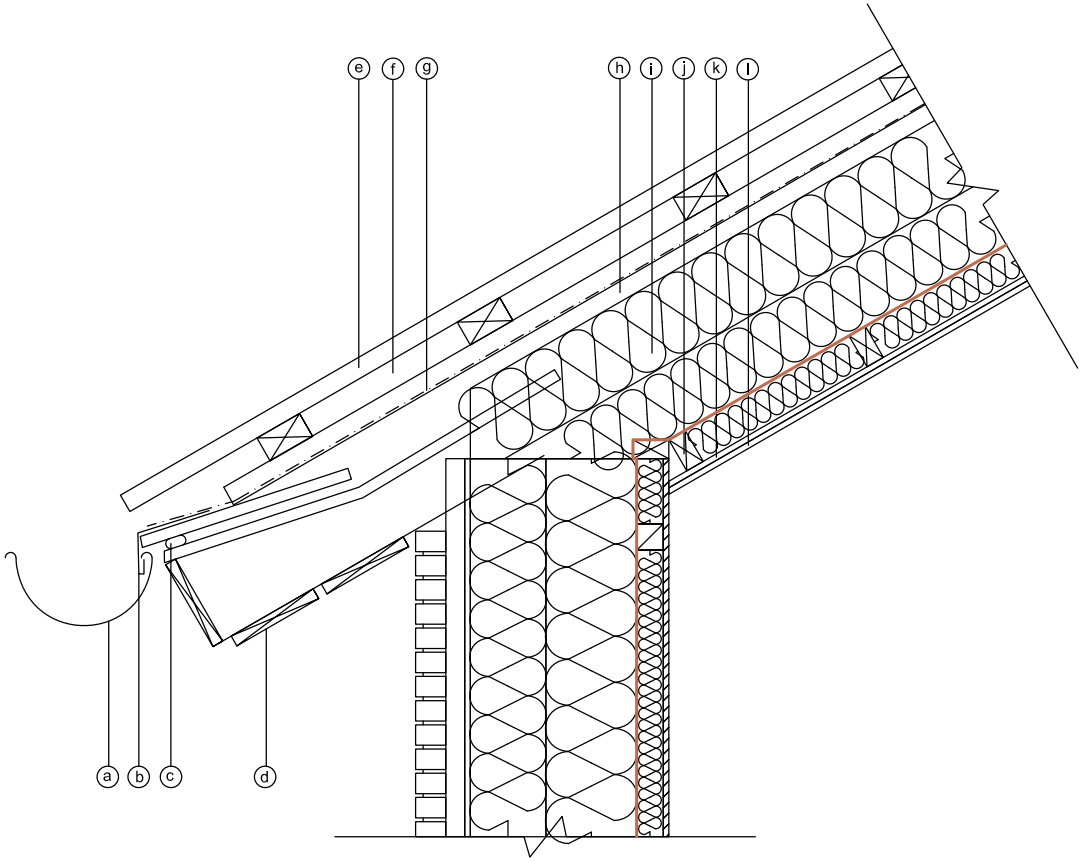
Solar shading consisting of an overhang affects the facade expression by adding to the traditional style through a subtle architectural detail. It also creates shadows, which adds depth to the facade. Moreover, the overhang is continued at the gables as an extension of the gable roof's triangular sides to provide a symmetrical and traditional expression.

The winter garden, which is located on the southwest facade in the indentation of the two residential departments, is an integrated part of the building structure with the same angled roof. However, the visible beams and columns create a contrast to the remaining, more simple, facades (illu. 153, p. 127). The sunspace adds a more open facade that leads to the open landscape and fields towards south, emphasizing the close relation to the landscape and how the building embraces it.

Illu. 181 - One of the examined rooms is a section of the corridor, where a large glass wall results in a high solar heat gain.

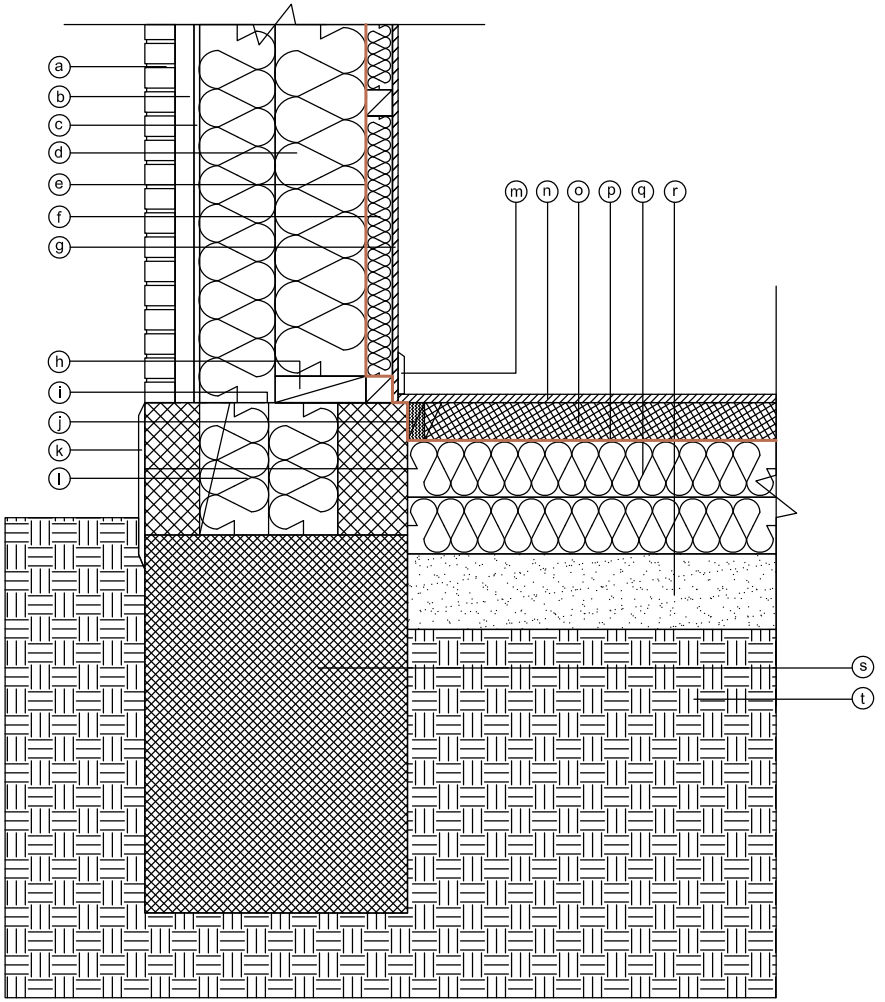


Illu. 182 - The experienced operative temperatures in each of the two examined rooms and the expected outdoor temperatures in July, which is the month where the highest temperatures are measured.



Illu. 183 - Roof and wall detail in 1:20.

a) Gutter
b) Fascia
c) Snow catch pipe
d) Soffit
e) Metal roof
f) Battens
g)Breathable sarking membrane
h) Rafter
i) Insulation 380 mm
j) Insulation 95 mm
k) Plaster 15 mm
l) Acoustic ceiling/Wodden lamellas



Illu. 184 - Ground deck and wall detail in 1:20.

a) Bricks 8 mm
b) Ventilation gap 50 mm
c) Wind barrier 15 mm
d) Insulation 440 mm
e) Vapour barrier
f) Insulation 70 mm
g) Plasterboard 15 mm
h) Pressure treated wall bottom plate
i) Radon barrier
j) Edge insulation
k) Plinth render
l) Two Leca blocks
m) Baseboard
n) Wooden flooring 15 mm
o) Concrete with floor heating 100 mm
p) Vapour barrier
q) Pressure-resistant insulation material 300 mm
r) Anti-capillary base
s) Concrete foundation
t) Ground

05

OUTRO

OUTRO

This chapter entails the conclusion for the thesis, followed by a reflection containing considerations in regards to the applied methods, the overall design process, and the final design, which was made at the end of the thesis as the final part.

Furthermore, a bibliography entailing a detailed list of sources applied and cited throughout the thesis is included, and several appendices are added to elaborate technical calculation and simulations as well as an interview with a caregiver and photographs from field studies.

CONSLUSION

The aims for this thesis were to design a nursing home that accommodates the needs of people with dementia, makes the residents feel at home, encourages community, and an environment that stimulates senses, and creates a meaningful life for people with dementia. A building and spatial layout that accommodate the needs from both residents and staff members in regards to wayfinding and logistical conditions, and a healthy indoor environment through acoustic, thermal, visual, and atmospheric comfort. Lastly, to design a welcoming environment where relatives can spend time with their loved ones and be part of their everyday life when visiting, and a building that reflects the site context by adapting to the landscape.

To answer the problem statement that paved the way for this thesis, through theory, research, observations, and interviews the physiological, psychological, and social challenges that can occur when having a dementia disease, working with or being a relative to a person with dementia, is presented. The sense of home that people living with dementia develop after moving to a nursing home can be explained by the integration of their past habits, activities, and routines, with their new environment in relation to physical, social, and psychological aspects. To enhance the feeling of home, previous habitual activities and routines are accessible for the residents to participate in, including cooking, baking, laundry, and gardening. Furthermore, functions that enhance social interaction, both verbal and nonverbal, between residents and caregivers, residents and relatives, and among residents is an important part of the design. This includes a bar, a workout gym, a well-ness department with a swimming pool, massage tables, and a hairdressing salon, all with focus on comfort, care, positive interactions, and previous routines.

Additionally, the decreasing ability in orientation skills is met by placing landmarks at the three ‘decision points’ in the knot where each residential department overlaps with the connecting common functions department. To enhance wayfinding, each courtyard is characterized by different activities and atmospheres as well as different colored facades that match the internal corridor wall, visible before entering each residential department.

The increasing wandering behavior that often is seens when people have dementia is managed through the spatial layout consisting of four connected loops that provide a safe space for managed wandering and a continuous route with no dead-ends. To stop endless wandering, functions and activities are strategically placed along the route to engage the residents in an activity and to create a sense of purpose to their wandering.

Another significant part of the thesis was the research and analyses related to the open, simple landscape in which the chosen site is located, and how the building adapts to its surrounding environment. A harmonious interaction with the landscape is achieved by preserving the lines of sight to the open landscape and horizon line as well as the flow patterns that connect the site with the rest of the town. The low-rise building is a reflection of the flat terrain, which creates a harmonizing interaction with the landscape. Moreover, the building is placed with a distance to the main road to create an intentional pause in the landscape that strengthens the conceptual expression when driving by or arriving at the nursing home.

Additionally, the development of farm structures and its influence on today's farm buildings were examined with the intention to draw inspiration from a building style that has great significance for people living in the Municipality of Hjørring, and implement architectural tectonic principles, characteristic in old farm buildings. The strong and simplistic expression from the ‘four winged farm’ represents a substantial part of the architectural concept for the final design with the intent to connect the residents to the agricultural history of their past, and strengthen their sense of belonging at the nursing home.

The final result is a nursing home that accommodates the needs for people with dementia, their caregivers, and relatives. Moreover, a building that opens up to the local community through the volume and facades, and invites local organizations, daycare, and school classes into 'The Street' and gathering hall in the building, to strengthen the understanding and bonds between people from different life situations and generations, as well as preserve or enhance the residents relation with the local society, as memory loss can be deeply disconnecting to other people.

However, memories are reflected through architecture. Structural principles, layout, and facades make an impression that becomes part of our identity and feeling of home, as the perception of the buildings that forms us leaves a mark in our mind. Each building has its own language that speaks differently to each individual. When memories start to obliterate from the mind, this language remains and the body remembers.

REFLECTION

When reflecting upon the final design, methods, and design process utilized in this thesis, the following considerations were made.

METHODS

New research in regards to architecture's influence on dementia is still being published, and it is a topic that is under development. In this project, interesting and important research papers in relation to wayfinding, spatial layout, circadian rhythm, sense of home etc. have been implemented and have had a great influence on my understanding of the challenges that occur when having dementia, as well as the architectonic design principles used in the design to enhance the condition of life and provide the residents with health and well-being.

Designing a nursing home with focus on accommodating the needs of people diagnosed with a dementia disease have been a challenging project. People diagnosed with dementia are a user group with specific needs in relation to their architectural environment and indoor climate, which made an interesting iterative process between the two fields of architecture and engineering throughout the project, and resulted in a dynamic progression in the work process. E.g. sufficient daylight and a view to the outdoors is required to improve their circadian rhythm and ensure visual comfort, while meeting the temperature requirements in BR18 and achieving thermal comfort in response to the residents' decrease in the ability to regulate body temperature. This resulted in large floor windows that simultaneously created a fluent transition between the indoors and outdoors, but due to a decrease in speed of perception and the brain's capacity to process information, mullions were added, which additionally created association to the architectural style of farm building from their past. Hence, a lot of considerations were made through the entire design process, which were built on design principles that laid the foundation of the design and directed the design towards the final proposal. Moreover, this project is an example of the importance of being able to perform an integrated design process in the search for better architecture that enhances the living conditions for its residents.

In regards to the methods used in the 'Research' phase to achieve a deeper user understanding, it is important to mention the challenges with acquiring insight in the primary user group consisting of people with dementia, as interviews with the residents at the visited nursing homes and in other relations were not an option. Furthermore, it was difficult to find research studies where people with dementia are active participants. For example, in the section 'Wayfinding' (pp. 17-18) a paper regarding orientation and wayfinding in unfamiliar environments with the aim to develop age and dementia friendly design principles, is mentioned. However, none of the participants was diagnosed with a dementia disease or memory impairments. All participants were screened for their cognitive ability which was within the normal range for healthy aging adults according to the Montreal Cognitive Assessment (MoCA) (O'Malley et al., 2020), but it is stated that research in relation to the score suggests that the participants do show impaired navigation abilities, which often is a sign of early atypical aging (Nasreddine et al., 2005).

The reason for this can be explained through the ethical and methodological challenges that follow when including people diagnosed with dementia in research. As dementia diseases affect the brain and change the perception of space and environment as well as memories, questions may not be understood correctly and answers may not be reliable. However, the exclusion of people with dementia due to aging and increasing cognitive fragility, often causes their voices to be silenced. Although, growing evidence shows that including people with dementia is more likely to provide beneficial effects, by validating their experiences and feelings, than causing them potential emotional distress (Hellström et al., 2007). Having people with dementia voice their opinions and be included in research is evident to develop relevant and helpful architecture that improve health and well-being, guided by and designed for people with dementia. Moreover, consent relies deeply on cognitive ability as opposed to a process that is more contextually relevant and builds upon remaining strengths instead of emphasizing their weaknesses, often resulting in an exclusion of people with dementia in research studies (Hellström et al., 2007). To improve architecture for people with dementia, this thought process needs to be changed to achieve a greater inclusion in research.

Regardless of these challenges, the voice of people with dementia was included in the development of the design through an interview made by a secondary source, an active member of the

Scottish Dementia Working Group and former vice chair of the European Working Group Person with Dementia. In addition, I was in a position where I, as a relative to a person with dementia, was able to include the voice and viewpoint directly from a person with dementia through an informal interview.

TECHNICAL FOCUS

The technical focus of this thesis lies on creating a healthy indoor environment consisting of acoustic, visual, thermal, and atmospheric comfort as well as the building's energy consumption.

The final building design consists of a relatively large surface area as a result of the architectural concept, which gave an annual energy consumption of 29.6 kWh/m² a year without applying any active strategies. More energy efficient solutions were considered, e.g. making the building more compact to reduce the heat loss form factor and surface-to-volume ratio. However, it was assessed that the concept, association to the historic development of farm buildings, and improved wayfinding that the building created, counterbalanced the slightly high energy consumption that exceeds the Low-energy class in BR18 without any active strategies. Therefore, the importance of the layout and its many benefits resulted in a compromise with the slightly high energy consumption, and the implementation of active strategies was necessary to meet the requirement of the Low-energy frame as a supplement to the many passive strategies.

In continuation, the floor area of the corridor makes up 21 % of the total gross area. Therefore, a significant amount of space is used in creating a safe wandering space for the residents, which is justified by the multifunctional purpose that it serves, including the necessity to provide indoor circulation to all apartments and functions, while drawing inspiration from the 'four-winged farm'. The division of the four departments creates more floor area for the corridor, but it plays an important role in providing an overview for the staff, while bringing in nature through the courtyards, which opens up the corridor, creates a close relation to nature, and improves wayfinding. Lastly, functions are placed along the corridor and melt out into the wandering area to stop endless wandering, the gathering hall and common dining room is an extension to the corridor with no interior wall separating the two, and 'front yards' through niches are made in front of the entrance to each apartment to improve wayfinding. Therefore, the corridor becomes an important part of the design and is the main artery of the nursing home, as these design principles create a lively atmosphere in the corridor that binds all four departments together.

To sum up, challenges with the inclusion of the experiences of people with dementia were experienced throughout the design process. More inclusion in the research field will be beneficial to the development of dementia friendly design in architecture in the furture, and a reconsideration of consent in relation to the contextual circumstances of the user group is important. Additionally, a more compact building volume could decrease the heat loss form factor and achieve a Low-energy building class without active strategies, but the form, spatial layout, and courtyards were of greater importance for the conceptual expression.

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APPENDIX 1

INTERVIEW WITH CAREGIVER

An extract of a longer interview with Nathalie Galfe Østergaard, who is an educated SOSU Assistent, who currently works as a SOSU Helper at Pleje- og Omsorgscenter Banebo in Viborg municipality, is presented in the following through selected questions and answers. The interview was conducted on the 18th of February 2023, and permission was given to record and transcript the interview.

Maria: "Hvad består dine arbejdsopgaver af på plejehjemmet?"

Nathalie: "Jamen, det er pleje og opgaver, altså det er jo både plejeopgaver og dokumentation. Alt, hvad jeg gør, det skal dokumenteres."

Maria: "Hvordan ser en typisk arbejdsdag ud for dig, fra når du kommer? Hvad for nogle arbejdsopgaver har du i løbet af en vagt?"

Nathalie: "Allerførst, så får jeg en overlevering fra vores dagvagt. Jeg arbejder som fast aftenvagt, så jeg møder ind, så får man sådan en overlevering af dagvagten omkring, hvad der kan være, man skal være opmærksom på fra aftenvagten. Det kan være, at der er en, der har haft besøg, som ikke har det så godt, og man lige skal være lidt ekstra opmærksom på, og det kan være at nogen skal have målt værdier, altså blodtryk og puls og saturation, respiration og sådan nogle ting. Så vi får sådan en overlevering. Så går jeg ind i afdelingen og hilser på dem alle sammen - dem der nu er oppe og sidder og drikker eftermiddagskaffe. Og hvis der er nogen, der ligger, fordi de ikke er vågnet fra deres eftermiddagslur, så tager vi dem op, så de kan komme op og deltage i dagen. Så hjælper vi dem på toilettet, vi sørger for, at de får noget at drikke, og under måltidet omkring klokken 05.30, der sidder vi så vidt muligt med de borgere, vi har. På vores afdeling er der 17 borgere, og vi er 2 mand i en aftenvagt, så vi har cirka sådan 7-8 borgere hver, som vi tager os af. Og der kan være nogen imellem der, som ikke selv kan spise, eller som skal have lidt hjælp i forhold til at få skåret noget mad ud. Det er det, man kalder et pædagogisk måltid, hvilket betyder, at personalet er til stede. Jeg sidder så og snakker med dem og hygger lidt med dem. Nogle gange så kan vi finde på at synge, når vi er færdige med sådan et måltid, eller vores flexarbejder, som også hjælper i køkkenet, kan godt finde på at læse lidt for dem, altså sådan der sker lidt. Så holder vi lidt pause efter det, og så ved 07.30 tiden bliver der serveret aftenkaffe. Og hvis der for eksempel er en håndboldkamp, Melodi Grand Prix eller bagedysten eller et eller andet, så samler vi dem - sådan at vi har et fællesskab, dem der har lyst. Det er ikke noget, man skal, men de får tilbudt, at de kan få aftenkaffe sammen, og så sidde og hygge med det der nu er i fjernsynet. Her for ikke så længe siden var der Grand Prix, hvor jeg smed en omgang æbleskiver i ovnen. Og så fik de bare æbleskiver og det der hører til, kaffe og sådan noget. Så sad de simpelthen og hyggede og så Grand Prix og spiste æbleskiver. Og så efterhånden som aftenen skrider frem, sådan kl. 08.30 og fremadrettet, så begynder vi lige så stille at hjælpe dem i seng. Nogle kan selv, og det skal de også, hvis de kan. De skal måske have lidt guidning i forhold til at få børstet tænder eller lige lave et par toiletbesøg, men de får så vidt muligt lov til at gøre de ting, som de selv kan, og så er der jo nogen, der skal have total hjælp - der skal op i en lift, der skal hjælpes på toilettet, der skal hjælpes i nattøj, børste tænder og alle de ting man gør. Så inden vi ser os om, er klokken 10.00-10.30. Så begynder vi at rydde op, og vi får skrevet nogle journalnotater. Og så klokken 10.50 kommer vores nattevagt, og så overgiver vi til hende, det hun skal være opmærksom på, ligesom jeg gjorde, da jeg kom klokken 15.00, så jeg arbejder fra klokken 15 til 23."

Maria: "Har I også omklædningsrum på arbejdspladsen?"

Nathalie: "Ja, det har vi. Vi må ikke have lov at gå hjem i vores uniform. Det har noget med hygiejne at gøre. Så når jeg kommer på arbejde om eftermiddagen, så går jeg ned og tager mit eget tøj af, og så tager jeg en uniform på. Det samme, når jeg skal hjem - ned igen og have uniformen af, smide den til vask og så i mit eget tøj. [...] Og det skal vaskes ved nogle bestemte grader, så det er ikke noget, vi selv står for. Det bliver gjort ude. Og så når vi kommer næste gang, så ligger der en ny, ren uniform til os."

Maria: "Hvor mange pauser har du løbet af din vagt?"

Nathalie: "En halv time, har vi, og så tager jeg nogle selv en gang imellem. Jeg tror ikke helt, de er lagt ind i planerne. Så man tager 5 minutter her og 5 minutter der, hvis man altså har muligheden for det. Og andre gange så flyver vi jo rundt. Så sidder vi dernede fra, vi kommer, til vi går. Det kommer lidt an på, hvordan dagen er,

når vi kommer, og hvordan folk har det, og hvor meget der er at se til i vagten. Nogle dage kan det være roligt, og andre dage kan det være temmelig travlt, så det er sådan meget forskelligt, men som regel en halv times pause. Så måske en gang på et kvarter en anden gang på et kvarter eller en samlet halv time, hvis det kan lade sig gøre."

Maria: "Hvorhenne holder du de pauser, og hvad foretager du dig i pauserne?"

Nathalie: "Vi forsvinder ikke væk, altså vi har sådan et stort fællesrum, hvor de ældre mennesker sidder i, og hvis vi går ud fra det fællesrum, så har vi en stor gang med borde og stole ind til vores kontor. Så der sidder vi, og det er som regel mig og min makker og vores to kollegaer fra den anden side af gangen, som også har 17 borgere over på deres afdeling. Vi mødes og får en kop kaffe og lige snakker sammen. Det kan være omkring borgerne, altså noget sparring i forhold til borgerne, men det kan også bare være helt almindelig, privat snak for lige at holde den pause. Men samtidig så er det også sådan, at selvom vi har pause, så kan borgeren stadigvæk kalde på vores kalder. Altså det er jo ikke sådan, at de ikke kan komme i kontakt med os, og de kan også godt se os, så vi er ikke sådan lige væk. [...] Borgerne inde ved os kan selvfølgelig se os, fordi vi sidder så tæt på dem, hvorimod borgerne over på den anden afdeling, de kommer selv over, de ved godt, hvor vi er. Så hvis de gerne vil have fat i os, så kan de faktisk godt komme og hente os, og hvis de ikke kan, så bruger de deres kalder, og så kalder de på os. Så vi er der hele tiden."

Maria: "Så I er hele tiden på. Det er ikke en reel pause fra det hele?"

Nathalie: "Der er stadigvæk en åbning for, at de ældre kan komme i kontakt med os, fordi de bliver selvfølgelig utrygge og sådan noget, hvis vi er helt væk. Så vi er faktisk mere eller mindre på. Så pause og pause.... men vi sidder trods alt stille."

Maria: "Hvor meget tid tilbringer du sammen med beboerne i forhold til, hvor meget tid du bruger på administrative opgaver?"

Nathalie: "Vi går med en iPad i vores vagt. Og på den iPad, er der en køreliste, som vi faktisk har med os i hele vagten. Så når jeg går ind til en borger, så er det fordi jeg skal tage nogle støttestrømper af, jeg skal give noget medicin, jeg skal hjælpe dem på toilettet, jeg skal nogle forskellige ting. [...] Det er sådan en to-do-liste, hvor der for eksempel står, at hvem og hvornår der skal gives medicin. Jeg starter tit med at give medicin omkring senest kl. 05.10, og vi skal spise 5.30, så vi vil gerne have givet den her medicin, inden de kommer med op og spiser ved fællesbordet. Så man går med sin iPad ind til hver enkelt borger og holder øje med om det medicin der er doseret rent faktisk også er det, der ligger i doseringsæsken. Og når du har givet medicinen, så kvitterer du, for du har gjort det på iPad'en. Så er der egentlig meget dokumentation. Bare ved at du skal ind og stå og krydse af på den der iPad, hver gang du har udført en eller anden funktion. Der er hele tiden et eller andet, du skal ind og godkende. Og nogle gange så skal du også ind og skrive en observation, hvis du har set noget, der er lidt usædvanligt. Så er det en god ide at skrive det sådan, at de andre vagtlag også er klar over, at der kan være et eller andet man skal være opmærksom på. [...] Meget detaljeret. Det er det. Vi skal simpelthen virkelig dokumentere rigtig meget, og det er jo også det, der bliver snakket om så meget i medierne. Det er jo det der med at, vi nogle gange ville ønske, at der ikke var så meget dokumentation, og man rent faktisk kunne bruge sin arbejdstid til at gøre noget godt for borgeren. Men tit og ofte så bruger du også noget tid på at stå med den iPad og ind og sidde og krydse af og gøre ved, i stedet for måske at gøre noget andet med borgeren. Så det er nogle gange lidt træls, at det fylder så meget, men det gør det. Der skal altid være dokumentation på, hvad det bliver foretaget, altså om så det er et lille toiletbesøget, så bliver det også dokumenteret."

Maria: "Hvis du kunne ændre noget på din arbejdsplads i forhold til de fysiske rammer, hvad skulle det så være?"

Nathalie: "Det ved jeg faktisk ikke, fordi jeg synes egentlig, der er nogle gode fysiske rammer. Der er god plads på deres stuer, og der er god plads på deres badeværelse. Der er gode gangarealer, der er et godt fællesrum. Og ud fra vores fællesrum, der er der en ret stor altan, hvor vi har havemøbler og blomster og grill, altså så de om sommeren kan de komme derud, og så griller vi nogle pølser, laver nogle pølsebrød og hygger os med dem derude. Og det er der på alle etager, der er de der store terrasser, hvor vi kan gøre nogle hyggelige ting sammen med dem. Der er også en ret stor dagligstue, som også er rigtig hyggelig. Så jeg synes egentlig på den måde, der er det rigtig godt indrettet."

Maria: "Hvad med de rum, som kun bliver benyttet af jer som plejepersonale – kontorer, vaskerum og depoter?"

Nathalie: "Vi har et vaskeri, men det er nede i stueetagen, og det bruger vi faktisk kun hvis vi skal ned og vaske en dyne eller en pude. Ellers så er det vores rengøringspersonale i dagvagten, der går ned med viskestykker, klude og alt det der. Det går de ned med og sørger for at det bliver vasket og kommer op på afdelingen. Vores kontor - Jamen det er kun dem, der er på den afdeling, hvor jeg arbejder. Ovre på den anden afdeling, har de også deres eget kontor, og de har også sådan et stort gangareal, hvor de har stole og borde og sådan noget til deres kollegaer. Så det er ikke sådan, at der kun er et sted og et kontor på etagen, der er to kontor. Et til hver afdeling. Ophold/pauserum for personalet er der også to af, og de er også store rum. [...] Og der står PC'er inde og de ting, vi har brug for. E-tavle med overblik over vores borgere osv., det er inde på det kontor. Og der er jo fint plads til os to. Og i dagvagten, der er de højst seks, og det er der også

plads til, men man sidder ikke seks mand. Jo, det gør man måske lige når man møder ind om morgenen - der mødes de selvfølgelig også og snakker sammen med nattevagten, men ellers så sidder man ikke sådan særlig meget på kontorerne. Man er jo ude i plejen - ude ved de ældre. Så vi bruger ikke kontoret så meget igen. Jeg kan sige, at sygeplejersker og sådan noget, de bruger måske vores kontorer til at gøre nogle ting. Det kan også være at der er en SOSU Assistent, der vælger at sætte sig ind på kontoret og lukke døren og så lave doseringer derinde. Der er et medicinrum i forlængelse af konteret på den anden afdeling, hvor vi destruerer gamle mediciner, og hvor ny medicin kommer ind. Men derovre kan man også som SOSU Assistent sætte sig ind og få ro til at sidde ved en computer, dosere medicin, fordi der skal helst ikke ske fejl, når du doserer, så det er vigtigt, at man har lidt ro til det, og man kan lukke døren dertil."

Maria: "Hvor ofte er der besøg fra pårørende, og hvor foregår besøgene henne?"

Nathalie: "På stuen er vores pårørende altid velkommen. Har vi nogle, der er døende, så gør vi faktisk sådan, at vi har en gæsteseng, som vi tilbyder at stille op på borgerens stue. Ikke i deres soveværelse, men i deres stue [...] Så hvis vi har døende, så bliver pårørende nogle gange tilbudt at de gerne må overnatte hos deres mor eller far eller mormor. I weekenden vil jeg nok sige, er der, hvor kommer flest pårørende. Der hvor folk har fri fra arbejde og har tid til at hoppe forbi og sige 'goddag' til dem de har kært. Der er også nogle, der kommer i dagligdagen. De fleste kommer omkring, når der er eftermiddagskaffe, og de er blevet taget op fra middagslur. Ved to-tiden, der er tit mange der kommer forbi også på helt almindelige dage. Og så kan de stadigvæk sidde der, når vi møder til aftenvagten, men det er som regel nede hos borgeren selv de sidder."

Maria: "Så de bruger ikke fællesarealerne?"

Nathalie: "Jo, det gør de, hvis borgeren sidder oppe i fællesarealet, når de kommer, og de egentlig synes, det er rart nok at sidde der, og det er okay, at der går personale og andre borgere rundt omkring. Der er også nogle, der går ind i dagligstuen, fordi de måske er lidt flere, og det kan være der er nogle mindre børn med. Så sidder de derhjemme og hygger sig, fordi der har vi et stort fjernsyn, lidt legetøj og nogle spil, noget som børnene kan lege med, og hvor de føler, at der er plads, og at de ikke forstyrrer alt for meget. Så det er meget forskelligt, hvor de egentlig er."

Maria: "Tager de også på udflugter med deres pårørende uden for plejehjemmet?"

Nathalie: "Ja, så kommer de og fortæller os det. For eksempel i dag er der jo smaddergodt vejr, stormen er væk, så kan det godt være, at de kommer op og siger 'ved du hvad, jeg tager lige min mor med ud og går en lille tur'. Det kan godt være, de går i Lidl, fordi hun mangler lidt sodavand eller et eller andet, 'så vi går lige en tur, vi er nok væk en lille times tid'. Så ved vi, at de ikke er der. [...] Eller de tager dem med hjem og siger 'ved du hvad, vi tager lige min mor med hjem, hun kommer tilbage inden, hun skal i seng'."

Maria: "Hvor ofte tager I beboerne med på udflugter?"

Nathalie: "Vi gør ikke. Plejecentret gør, men aftenvagten gør ikke. Det kan vi simpelthen ikke nå. Vi har jo de der hjælpere i køkkenet, som er ansat i ydertimer, så der er én både om dagen og én i aftentimerne - de kan godt finde på at tage nogle borgere med ud og gå en tur i en times tid eller bare være ude. [...] Kigge på, om der er kommet nogle vintergækker eller noget. Og der bliver også arrangeret deciderede ture. Omkring november, tror jeg, var der nogle borgere og noget personale, som tog i sommerhus i tre dage. Vi har ikke vores egen bus, det er der nogle plejecentre, der har. Så havde man så sørget for at arrangere en bus, sådan at det både var kørestolsbrugere og nogen, der selv kan gå, som kom med. [...] Der bliver også arrangeret juleture, altså hvor der igen bliver arrangeret bus, og så kører man måske ud i Bilka, og tager sådan en juledag derude, hvor de måske kan få købt lidt julegaver. [...] Det gælder alle borgere, men kommer an på, hvordan de har det, og hvilken fysisk form de er i. [...] Ja, de kommer faktisk på mange udflugter, synes jeg. Der bliver gjort rigtig meget, endda også holdt fester på stedet, hvor vi har haft Kandis på besøg, og vi har haft pølsevogne på besøg, hvor der kommer to pølsevogne og laver en hotdog til dem, og så bliver det en festaften med musik og hotdogs. Der bliver holdt efterårsfest, sommerfest, vinterfest, julefest, der bliver faktisk gjort mange ting, synes jeg, på stedet, men der er også meget ude af huset. Plus at vi jo også har de der terrasser, jeg talte om, hvor de kan komme ud og hygge sig. Vi slår parasollerne op og laver grillpølser eller et eller andet hyggeligt. Sidste Halloween var der nogle af mine kollegaer, der simpelthen gik ud på terrassen og stod og lavede de der lygtehoveder af græskar sammen med dem."

Maria: "Vil du beskrive det, som værende meget stressende at have så mange beboere tilknyttet dig, og at du har ansvar for så mange på en gang?"

Nathalie: "Nogle gange. Nogle gange er det jo, hvis det er sådan, at der er rigtig meget. For eksempel dengang der var isolation i forhold til corona, eller når du skal have alt det der beskyttelsestøj på, hver eneste gang du går ind på en stue og så videre. Det var lidt op ad bakke. Det var lidt hårdt. Eller hvis der er nogen, der har omgangssyge, og vi skal isolere dem og være sådan lidt på dem. Så kan det godt være stressende. Det er meget op og ned, synes jeg. I øjeblikket har vi for eksempel to tomme stuer. Det betyder jo så, at der er to borgere, vi ikke skal tage os af. Vi har normalt 14 i alt, så bare det, at vi kun har 7 borgere hver. Det gør,

at der lige pludselig er en lille smule tid til at give lidt stjernestunder til dem, der så er der. Det betyder også, at der er en lille smule mere stille, fordi der mangler de her 2 ekstra borgere. [...] Så der skal egentlig ikke så meget til for, at det flytter sig. Altså du kan have en periode, hvor du nærmest ikke får sat dig ned fra du kommer til, du går. Det føles i hvert fald lige sådan. Og så er der andre perioder, hvor der er lidt ro og lidt plads til, at du kan gøre lidt ekstra for dem. Og det gør man, fordi det er faktisk rart. Det er derfor man gerne vil arbejde med det."

Maria: "Så hver dag er forskellig fra hinanden, og det varierer meget?"

Nathalie: "Ja, du ved egentlig ikke altid, hvad du møder ind til. Det gør du faktisk ikke."

Maria: "Det at arbejde tæt med borgere med demens kan være anstrengende både mentalt og fysisk. Hvordan bliver du påvirket af at arbejde sammen med folk med demens?"

Nathalie: "Altså jeg har ingen tålmodighed i mit private liv, men med demente mennesker, der har jeg faktisk en engle tålmodighed. Jeg kan ikke rigtig stå for dem. De stresser mig ikke. Jeg synes de på en eller anden måde er kære, selvom de også kan være aggressive. Selvom at de også kan begynde at gå jo lidt i barndommen. De kan finde på at græde, fordi de ikke kan finde deres mor eller far. Det er ikke noget, der irriterer mig. Jeg gør alt, hvad jeg kan for at give dem den bedste oplevelse - Den bedste aften."

Maria: "Personligt kan jeg godt blive lidt småirriteret, når jeg har haft den samme samtale med min mormor 10 gange på en time."

Nathalie: "Ja, altså jeg passer en dame som konstant siger, 'hvad skal der ske nu?' 'Hvad skal der ske nu?' 'Hvad skal der så ske nu?' Eller også siger hun 'I dag er det den 16. Februar og klokken er ...'. Det siger hun rigtig mange gange. Man lærer lidt tricks til, hvordan man kan omgås dem uden at blive irriteret på dem, for de kan jo ikke gøre for det. Det kan jo vitterligt ikke gøre for det. De kan ikke huske - de forstår ikke, at man kan blive irriteret på dem, for de kan bare ikke huske, at de lige har spurgt om det der, eller sagt det der. Tit så mærker demente og ser demente rigtig meget mere end, man regner med. De ser dine ansigtsudtryk og din irritation mere end du tror."

Maria: "Ja, det er vigtigt at være fattet og tålmodig omkring dem."

Nathalie: "Meget tålmodig. Tålmodighed er en dyd, det kan jeg godt sige dig. [...] De kan jo også blive aggressive, og det er jo i virkeligheden fordi de taber deres identitet en lille smule. Det er lidt skræmmende for dem. De ved godt, at der sker noget, men de kan ikke finde ud af, hvad det er, der sker, men de kan godt fornemme, der sker noget. Det kan din mormor garanteret også. [...] Jeg er tit en af de kollegaer, hvortil de andre siger 'jeg har ikke lige overskud til at gå ind til hende der' og spørger 'kan du ikke tage hende - du er så god til de demente'. Det kan jeg godt, og så er der så en, der tager en af mine i stedet for, fordi jeg har en god tilgang til dem"

Maria: "Så man kan godt skifte borgere engang imellem for at aflaste hinanden?"

Nathalie: "Ja, for der kan måske også godt være en borger, jeg måske ikke lige kan med. Så man bytter borger og siger 'jeg kan ikke lige håndtere hende her', 'jeg kan ikke lige overskue hende' eller 'nu har jeg haft hende mange dage i træk', fordi det er jo de samme borgere, jeg kommer ind til hver dag. Så du kan godt komme til et punkt, hvor man tænker 'åh jeg magter ikke lige den her borger'. Så bytter man borgere indbyrdes og overtager hinandens køreplan. Det er en rigtig god ting, fordi selvfølgelig når du passer de samme borgere, så kan det godt nogle gange være hårdt. [...] Hvis der er nogen, der er fysisk tunge og skal styrkes med lift - Der er vi to medarbejdere, sådan vi ikke bliver fuldstændig ødelagt i hele kroppen, for selvom du har hjælpemidler, så er det stadigvæk hårdt at sætte folk på toilettet og hjælpe dem op i en lift."

Maria: "Hvor mange har brug for den slags hjælp med lift ud af de 14?"

Nathalie: "Lige nu har jeg to nede på min gang, og min kollega har på hendes gang tre liftbrugere. [...] Hvis du forestiller dig, at de sidder i en kørestol, så har du et sejl, som du skal have ind bag ryggen og ned under deres lår. Så du skal have dem til at rette sig frem i stolen, men så siger de 'ja' og i stedet for at rette sig frem, retter de sig tilbage. Og så kan de være ret tunge. [...] Det kan godt nogle gange være lidt tungt, hvis det er en meget tung borger, og så er det rart, at vi er to, så jeg ikke skal stå og bruge så mange kræfter. Det kan man jo godt mærke i sine skuldre og sådan noget der, hvis man har haft mange af sådan nogle løft."

[...]

Maria: "Hvad er din rolle i forhold til beboernes pårørende? Skal du snakke med dem og hvordan?"

Nathalie: "Ja, det skal jeg. Uanset om du er Social og Sundhedshjælper eller Social og Sundhedsassistent, så snakker du også med de pårørende. De kan komme og spørge, 'hvordan har min mor det lige?' eller 'oplever du også, at min mor glemmer mere og mere?'."

Maria: "Er det kun mens, de er der, eller ringer de også til jer?"

Nathalie: "De kan også godt finde på at ringe til os, hvis de ved, deres mor har haft en dårlig dag, og de har snakket med dagvag-

ten, og hun har ikke haft det så godt. Så kan de finde på at ringe igen om aftenen og spørge 'min mor har ikke haft det så godt i dag. Jeg talte med dagvagten - Hvordan ser det ud nu?' Og så kan vi jo så fortælle dem 'Jamen, det går meget bedre. Hun har været med oppe og spise'."

[...]

Nathalie: "Det vi har gjort nogle gange, er at de selv er med til at lave mad, især om sommeren, hvor vi tit får nye kartofler og jordbær og sådan nogle ting. Så får de handsker på, og så sidder der måske 3-4 damer inde ved et af vores borde i fællesrummet og skræller nye kartofler eller skyller jordbær og gør dem klar til om aftenen, fordi så har de været med til at yde noget, og så glæder de sig faktisk også til, de skal være med til at spise det. [...] Nogle gange behøver man ikke at sige det til dem, men det ligger simpelthen i dem, at når de er færdige med at spise, så kan der sidde en ved det bord, som begynder at samle tallerkener ind fra de andre ligesom på en efterskole eller en højskole. [...] Så for at hjælpe os, så samler de tallerkenerne og bestikket og går hen med det til den vogn, hvor det skal stå på med opvask - For at være deltagende og for at hjælpe os. [...] Det er ikke altid vi har tid til eller mulighed for det, men når vi har, så prøver vi virkelig at gøre noget ekstra, ligesom da jeg lavede æbleskiver til til Melodi Grand Prixet. Så man prøver så vidt muligt at gøre noget ekstra, så de får nogle gode stjernestunder og nogle gode oplevelser, så livet ligesom har en mening, selv om man er på plejehjem. Det er bare ikke altid, der er ressourcer og tid til det, men man prøver at finde det."

[...]

Nathalie: "Noget af det, du skal huske, Maria, når du designer, er at få lavet noget udendørs plads, både uden omkring plejehjemmet, men også i forbindelse med plejehjemmet. Enten med en have eller ligesom her [på Banebo], hvor de har mulighed for at gå ud på en terrasse med en grill og så videre. Dengang jeg arbejdede på Margrethelund i Dronninglund, der havde vi et decideret demensafsnit. Og i forbindelse med det afsnit, der havde man en have, hvor der var lidt høns, og der var mulighed for, at de kunne dyrke grøntsager, gulerødder og lidt forskellige ting. Nogle af de ældre demente, de vil jo gerne gøre sig nyttige og gerne gøre nogle af de ting, som de kan huske. For eksempel havde vi en gammel gartner, han var lykkelig og så glad for, at han kunne gå ud i den have og gå og rode i det jord derude. Så der lavede man plads til, at han kunne gå ud og gøre noget, han kendte fra dengang, han havde sit almindelige liv, inden han blev dement. Og der var to katte på demensafsnittet, fordi mange af dem er jo vant til, at de havde husdyr; katte, hunde, køer og alt det der. Der var også de her to demente damer, der synes det var fantastisk at gå ud i solen med en kurv under armen og så hænge tøj op med klemmer ude i haven. [...] Og så sørgede man også for, at der, hvor man gik ind og ud af døren til demensafsnittet, der havde man malet det sådan, at de ikke rigtig kunne gennemskue, at det rent faktisk var en dør."

[...]

Maria: "Ja, man bliver nødt til at skabe mening i deres hverdag. De skal have noget at stå op til, noget der får dem ud af deres værelse, får dem til at interagere med andre, og aktiviteter der tiltaler dem."

Nathalie: "Lige præcis. Det var netop sådan noget med, hvor man sagde 'jamen, du er nødt til at stå op og afløse, fordi jeg kan høre din lille, hun græder, så du er nødt til lige at stå op nu'. Så kom hun jo futtende ud med morgenkåbe på og ud og finde den der bette Baby Born dukke, der som jo i hendes verden er et rigtigt barn. Og så passede hun jo på det barn en hel dag. Tog den med hen, når hun skulle spise og holdt øje med den, når den skulle sove til middag, og hvad ved jeg. Sådan at det gav en mening for dem. Det synes jeg var en fed ting deroppe - At man havde tænkt på det i indretningen af plejecentret, og at man havde de her to katte, som gik rundt som en naturlig ting i afdelingen, som de også tog sig af og sad med om aftenen og sad og aede for og så fjernsyn."

APPENDIX 2

PHOTOGRAPHS FROM FIELD STUDY

The following pictures were taken of two different farm buildings in the municipality of Hjørring, when I was examining the development of farm buildings, and how the 'four winged farm' still marks farm structures today. When documenting, I had a focus on the facades, details, windows, gables, and materials included at the farms.

Illu. 185 - Characteristic, vertically oblong cast iron windows with mullions and a rounded top.

Illu. 186 - Characteristic, horizontally oblong cast iron windows with mullions and a rounded top.

Illu. 187 - Gable dominated by large, green, wooden sliding doors.

Illu. 188 - Lime washed brick facade with a metal plate bond on the top of the facade.

Illu. 189 - Symmetric and simple facade expression with exposed bricks on the top of the facade and the centered gable.

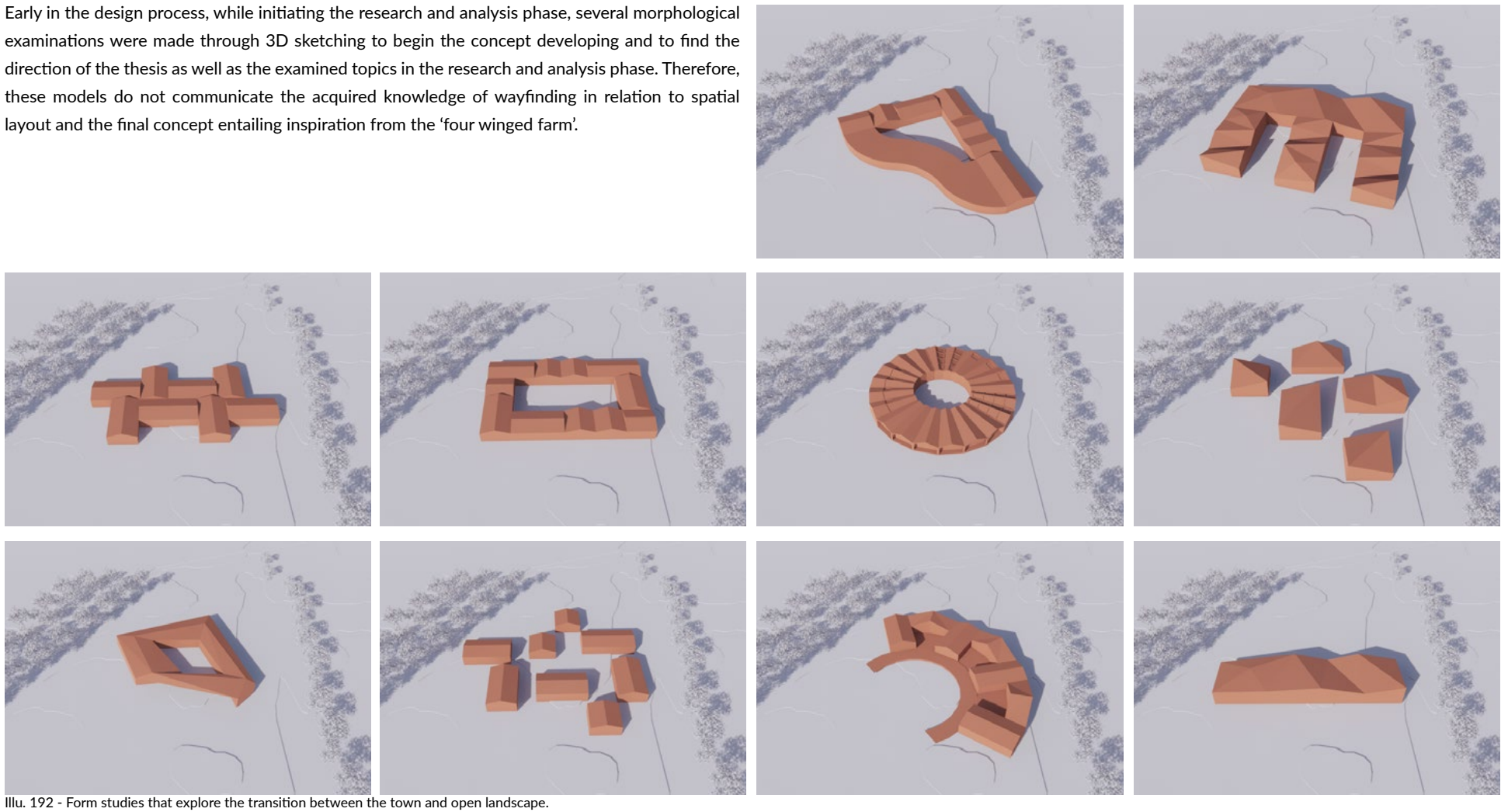
Illu. 190 - Symmetric gable with details and a rounded gate.

Illu. 191 - Roof consisting of ink plates with a simple expression.

APPENDIX 3

INITIATING FORM STUDIES

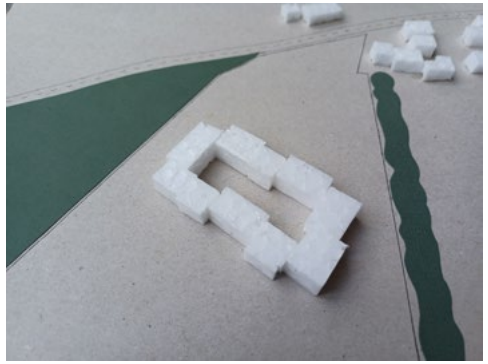
Early in the design process, while initiating the research and analysis phase, several morphological examinations were made through 3D sketching to begin the concept developing and to find the direction of the thesis as well as the examined topics in the research and analysis phase. Therefore, these models do not communicate the acquired knowledge of wayfinding in relation to spatial layout and the final concept entailing inspiration from the 'four winged farm'.



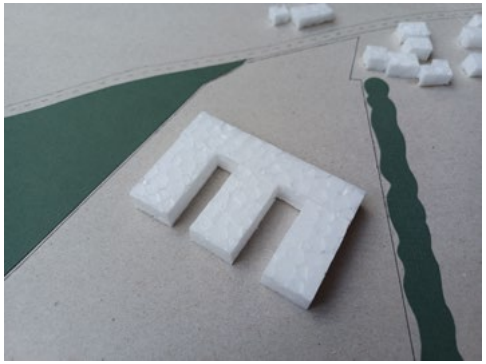
Illu. 192 - Form studies that explore the transition between the town and open landscape.

APPENDIX 4
FORM STUDIES

Later in the design process, after learning about wayfinding in relation to spatial layout during the research phase, several morphological examinations were made of different spatial layouts as well as transitions between the town and open landscape through the building structure. These examinations were made through 3D sketching in physical models to get a greater understanding of scale and form.



Illu. 193



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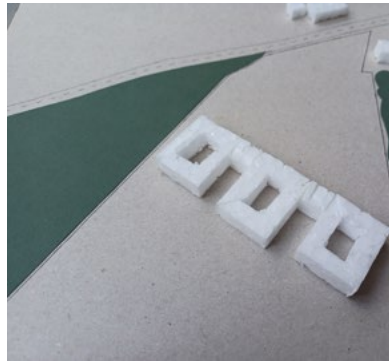
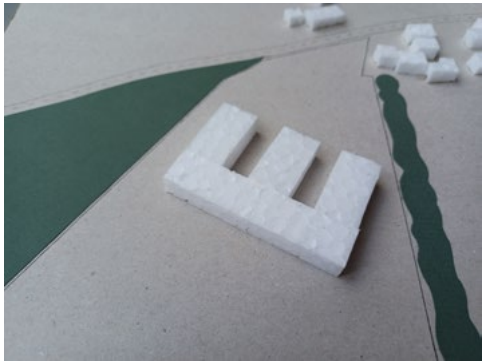
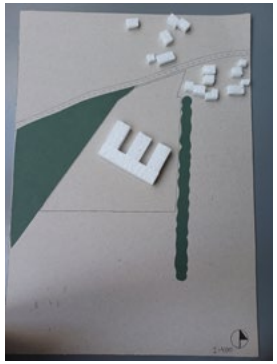
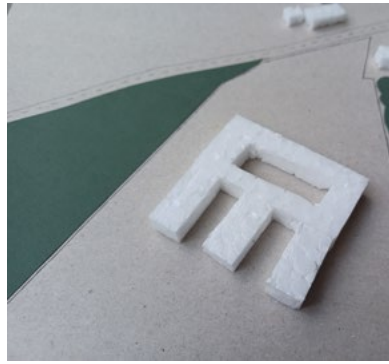

Illu. 195



Illu. 196



Illu. 197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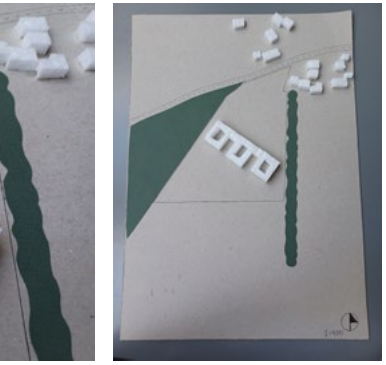

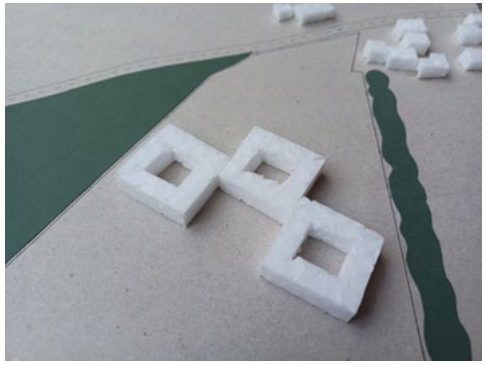


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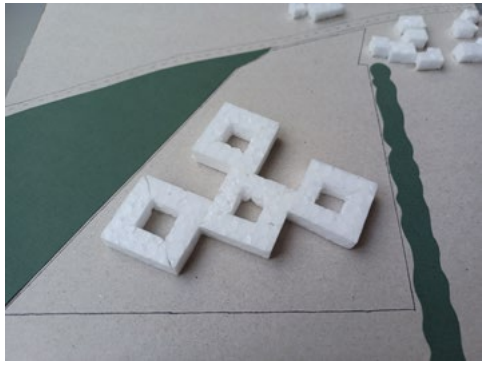
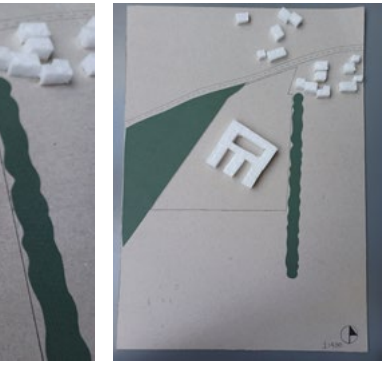
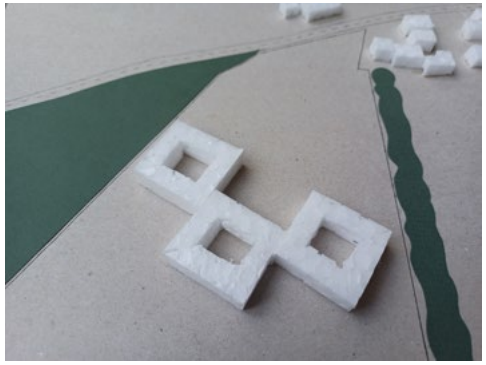
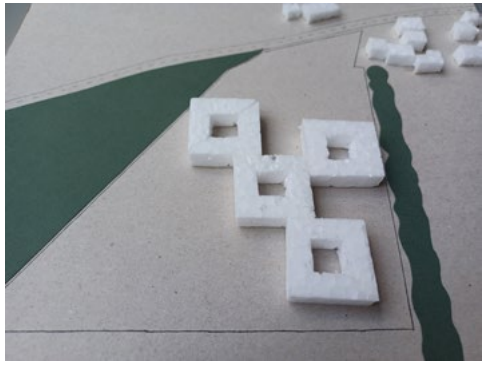



Illu. 200






Illu. 201




Illu. 202

APPENDIX 5

NEEDED AIR CHANGE RATE IN AN APARTMENT

The atmospheric indoor climate is examined in relation to the needed air change rate in a residential apartment with the aim to comply with the requirement in BR18 regarding a maximum concentration of 1000 ppm CO2-pollution in the room during dimensioned conditions, meaning the normal operation of the building (Bygningsreglementet, 2018b, §420-§452, ch. 1.7). Therefore, the following calculations represent a scenario, where a resident is bedridden and is staying in the apartment at all times. At the same time, two relatives are visiting the resident, and one caregiver is present to help with feeding.

The required outdoor air supply is calculated according to method 1 in Dansk Standard, which is based on perceived air quality (Dansk Standard, 2019, p.21). The total ventilation rate in the breathing zone is calculated by combining two components: 1) ventilation to remove pollution (bio effluents) from occupants, and 2) ventilation to remove emission from the building and systems. The ventilation rate value for each component is read in the stated tables under category 2, concerning a Predicted Percentage Dissatisfied (PPD) of <20% (Dansk Standard, 2019, p. 51, table B.6):

$$q_{tot} = n * q_p + A_R * q_B \quad (1)$$

Where:

$q_{tot} = total\ ventilation\ rate\ for\ the\ breathing\ zone\ [l/s]$

$n = number\ of\ persons\ in\ the\ room$

$q_p = ventilation\ rate\ for\ occupancy\ per\ person\ [l/s]$ (Dansk Standard, 2019, p.51, table B.6).

$A_R = floor\ area\ [m^2]$

$q_B = ventilation\ rate\ for\ occupancy\ for\ emissions\ from\ building\ [l/s * m^2]$ (Dansk Standard, 2019, p.52, table B.7).

$$q_{tot} = 4 * 7\ l/s * 46\ m^2 * 0.7\ l/s * m^2 = 60.2\ l/s = 216.7\ m^3/h$$

The bedroom and living room/kitchen is all in one room with a partition that divides the two spaces to either open up the space if a bedridden resident has visitors, or a family member chooses to spend the night in case a resident becomes sick, and the family member needs visual contact with the resident. Therefore the room volume is V = 214 m³, and the air change rate is as follows:

$$n = \frac{V_L}{V_R} \quad (2)$$

Where:

$n = air\ change\ rate\ [h^{-1}]$

$V_L = ventilation\ rate\ [m^3/h]$

$V_R = room\ volume\ [m^3]$

$$n = \frac{216.7\ \frac{m^3}{h}}{214\ m^3} = 1.01\ h^{-1}$$

The CO_2-pollution emission in the room is ccalculated based on each of the occupants activity levels as shown in table 5.1 based on Dansk Standard, 2006, p.18, table B.1:

People	Activity level [met]
1 caregiver	1,9
1 resident	1.0
2 relatives	1.6

Table 5.1 - The columns show each of the five people who spends time in the critical room and their corresponding activity level in met.

$$m_{CO2} = 17\ *\ M \qquad (3)$$

Where:

$m_{CO2} = pollution\ supply\ [\ l/h]$

$M = \ metabolism/activity\ level\ [met\ ]$

$$m_{CO2} = 17\ *\ ((1,9\ met\ \ *\ 1\ caregiver) + (1.0\ met\ *\ 1\ resident) + (1.6\ met\ *\ 2\ relatives)) = 103.7\ l/h = 0.1037\ \frac{m^3}{h}$$

To document that the required air change rate is able to comply with the requirements that the indoor CO_2-pollution concentration does not exceed 1000 ppm, the caltulated air change rate is inserted in the dilution equation (Dansk Standard, 2021, p.74), where the time (τ) will change according to the amount of hours after the using time's beginning:

$$c_{rum} = \frac{m_{CO2}}{n*V} * (1 - e^{-n*\tau}) + (c_0 - c_i) * e^{-n*\tau} + c_i \quad (4)$$

Where:

$c_{rum} = concentration\ of\ pollution\ in\ the\ room\ [m^3/m^3\ luft]$

$m_{CO2} = pollution\ supply\ [m^3/h]$

$c_0 = start\ concentration\ [m^3\ CO_2/m^3\ luft]$

$c_i = concentrations\ of\ pollution\ in\ supply\ air\ [m^3 CO_2/m^3\ luft]$

$n = air\ change\ rate\ [h^{-1}]$

$V = volume\ [m^3]$

$\tau = time\ [h]$

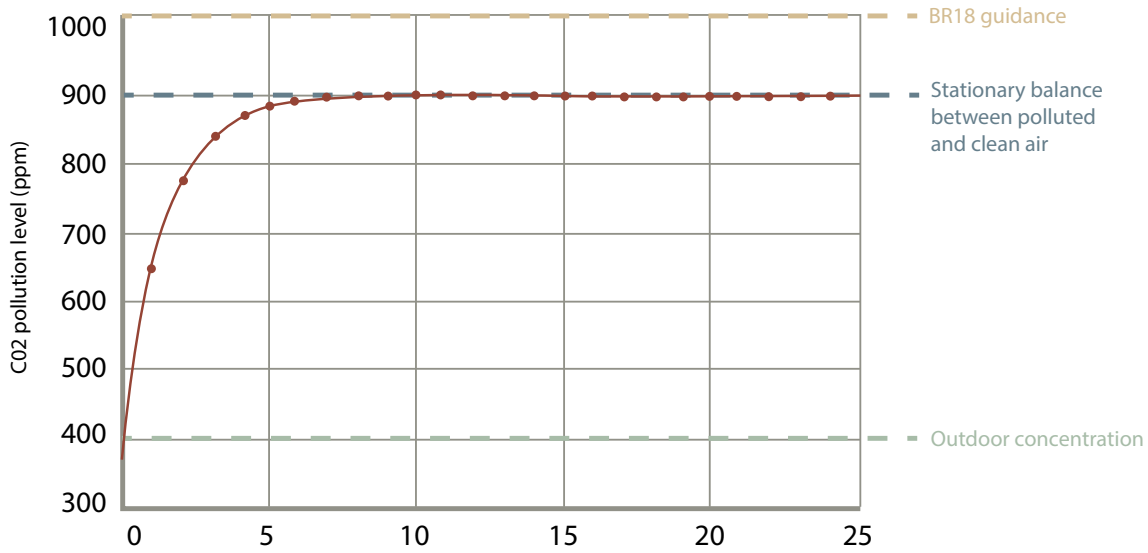
$$c_1 = \frac{0.1037 \frac{m^3}{h}}{1.01\ h^{-1} * 214\ m^3} * \left(1 - e^{-1.01\ h^{-1} * 1h}\right) + \left(0.0004 \frac{m^3[CO_2]}{m^3[luft]} - 0.0004 \frac{m^3[CO_2]}{m^3[luft]}\right) * e^{-1.01\ h^{-1} * 1h} + 0.0004 \frac{m^3[CO_2]}{m^3[luft]} = 0,000705 \frac{m^3[CO_2]}{m^3[luft]} = 705\ ppm$$

Equation (4) is used for each time interval for a day, which result in the set of values in table 5.2:

τ	[ppm]	τ	[ppm]	τ	[ppm]	τ	[ppm]	τ	[ppm]
0	400	5	877	10	880	15	880	20	880
1	705	6	879	11	880	16	880	21	880
2	816	7	879	12	880	17	880	22	880
3	857	8	880	13	880	18	880	23	880
4	871	9	880	14	880	19	880	24	880

Table 5.2 - The dilution equation (4) is used for a each time interval for a day to examine the development of CO_2 concentration in the inside air by replacing the value $\tau = time\ [h]$. Each column shows the hour and corresponding CO_2 concentration in ppm.

The values is inserted in a graph to illustrate the development in CO2 concentration:



Illu. 203 - Graphic representation of the values from table 5.2 that describes the development of CO_2-pollution in the apartment.

To conclude, the required air change rate of 1.01 h^{-1} is able not to exceed 1000 ppm with a CO2-pollution emission from the four occupants' activity levels of 0.1037 m^3/h. It is important to underline that the CO2-pollution concentration, as illustrated through the graph, is constant in the hours after the stationary balance between polluted and clean air is attained. However, the number of people and their activity levels will of course change throughout the day with relatives and caregivers coming and going from the room and from day to day. This example only shows a common scenario with a relatively high occupancy consisting of 1 resident, 2 relatives, and 1 caregiver.

The same approach is used to calculate the needed air change rate in each room in the building in table 5.3:

	Floor area	Room volume	Ceiling	Number of occupants	Activity level	Required ventilation rate for occupancy per person	Required ventilation rate for occupancy for emissions from building	Total ventilation rate for the breathing zone		Needed outdoor air supply pr. person	
	[m^2]	[m^3]			[met]	[l/s]	[l/s·m^2]	[l/s]	[h^{-1}]	[l/h]	[h^{-1}]
Common functions											
Living room	71	275		10	1	7	0,7	119,7	0,4	170	0,2
Scullery	19	74		3	2	7	0,7	34,3	0,5	102	0,1
Dishwashing	17	66		3	2	7	0,7	32,9	0,5	102	0,1
Pantry	6	18	Suspended ceiling	1	2	7	0,7	11,2	0,6	34	0,0
Dining room	124	485		31	1,2	7	0,7	303,8	0,6	632,4	0,6
Laundry	17	65		2	2	7	0,7	25,9	0,4	68	0,1
Experience store'	60	126		4	2	7	0,7	70	0,6	136	0,1
Bar	47	187		22	1,6	7	0,7	186,9	1,0	598,4	0,6
Gym	62	186	Suspended ceiling	4	2,8	7	0,7	71,4	0,4	190,4	0,2
Wellness department	92	276	Suspended ceiling	5	1,2	7	0,7	99,4	0,4	102	0,1
Changing room	14	53		2	2	7	0,7	23,8	0,4	68	0,1
Hairdressing salon	31	122		3	1,2	7	0,7	42,7	0,4	61,2	0,1
Gathering hall	211	964		60	1,6	7	0,7	567,7	0,6	1632	1,6
Staff functions											
Staff entrance	31	123		2	1,6	7	0,7	35,7	0,3	54,4	0,1
Office leader	24	94		3	1,2	7	0,7	37,8	0,4	61,2	0,1
Office assistant leaders	26	101		3	1,2	7	0,7	39,2	0,4	61,2	0,1
Office staff	35	136		4	1,2	7	0,7	52,5	0,4	81,6	0,1
Office nurse/medicin room	18	73		2	1,2	7	0,7	26,6	0,4	40,8	0,0
Office activity employee	45	175		4	1,2	7	0,7	59,5	0,3	81,6	0,1
Meeting room	34	133		12	1,2	7	0,7	107,8	0,8	244,8	0,2
Break room	36	142		5	1	7	0,7	60,2	0,4	85	0,1
Changing room 1	22	87		3	2	7	0,7	36,4	0,4	102	0,1
Changing room 2	26	101		3	2	7	0,7	39,2	0,4	102	0,1
Laundry	12	48		1	2	7	0,7	15,4	0,3	34	0,0
Cleaning supply room	14	43		1	2	7	0,7	16,8	0,4	34	0,0
Storage room	23	100		1	2	7	0,7	23,1	0,2	34	0,0
Other											
Reception	42	132		5	1,6	7	0,7	64,4	0,5	136	0,1
Delivery entrance	20	60	Suspended ceiling	2	2	7	0,7	28	0,5	68	0,1
Wandering corridor (1 yard)	314	942	Suspended ceiling	5	2,4	7	0,7	254,8	0,3	204	0,2

Table 5.3 - The needed air change rate for each room in the building is calculated based on two components: 1) ventilation to remove pollution (bio effluents) from occupants and 2) ventilation to remove emission from the building and systems. The CO2-pollution emission in the room is also calculated based on each of the occupants activity levels. The air change rate for each room is decided according to which of the two, required needed air change rate or CO2-pollution emission, that requires the highest air change rate (highlighted with green).

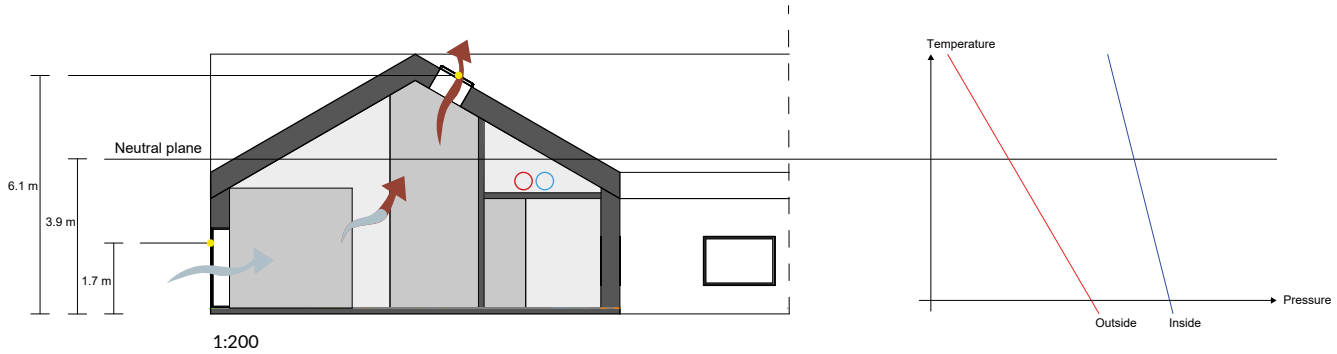
APPENDIX 6

THE DIMENSIONING EFFECTIVE OPENING AREA FOR NATURAL VENTILATION

GATHERING HALL

Based on the calculated needed air change rate in appendix 5, the necessary effective opening area for natural ventilation in an apartment is calculated in table 6.1 based on thermal buoyancy, where air exchange between inside and outside is caused by differences in air density, mainly due to temperature differences. The pressure will equalice at the neutral plan, while openings below the neutral plan will have an inflow of air, because the outside pressure is higher than the indoor pressure, and openings above the neutral plan will have an outflow of air as the inside pressure is higher than the outdoor pressure (illu. 204).

To meet the required outdoor air supply of 216.7 m^3/h = 0.06 m^3/s which is calculated in formula (1), the Air Flow Rate (AFR (thermal)) is sat to 0.03 m^3/s at each of the two openings with an inflow of air and -0.03 m3/s at the openings with an outflow of air. The result is an opening area of 0.027 m^2 at each of the two windows at the 1. floor and an opening area of 0.050 m^2 in each of the two roof windows.



Illu. 204 - Illustration of the opening areas and the corresponding neutral plane as well as the differences in pressure between inside and outside in a case where the outside temperature is lower than the inside temperature.

Pressure Coefficient			**Windfactor**	-		**Pwind**	-	pa			
Windward	-		**Vmeteo**	-	m/s	**Pmin**	-	pa			
Leeward	-		**Vref**	-	m/s	**Pmax**	-	pa			
roof	-										
Location of neutral plan, Ho	5,1 m					**Buildingvol.**		m^3			
Outdoor temperature	12 C					**Volume**		m^3/section/floor			
Zone temperature	23 C										
Discharge coefficient	0,7					**Internal pressure,**	pa	0,00			0,00
Air density	1,25 kg/m^3										

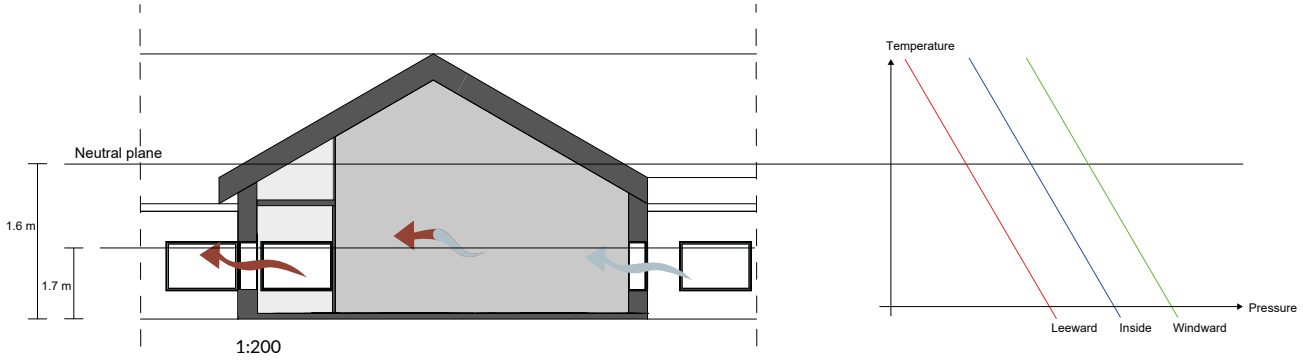
	Opening area m^2	Eff. Area m^2	Height m	Thermal Buoyancy pa	AFR (thermal) m^3/s	Pres Coefficient	Wind pressure pa	AFR Wind) m^3/s	Wind pressure pa	AFR total m^3/s
1. floor	0,027	0,019	1,7	1,548	0,03	-	-	-	-	-
1. floor	0,027	0,019	1,7	1,548	0,03	-	-	-	-	-
Roof	0,050	0,035	6,1	-0,459	-0,03	-	-	-	-	-
Roof	0,050	0,035	6,1	-0,459	-0,03	-	-	-	-	-
				Mass balance	0,00		Mass balance	0,00		0,00

Table 6.1 - Calculation of the needed size of opening areas for natural ventilation to meet the needed air change based on thermal buoyancy.

GATHERING HALL

A second calculation is made for the effective opening area for natural ventilation in the gathering hall based on wind pressure, where air exchange between inside and outside is caused by a difference in air pressure, which mainly is caused by positive wind induced pressures on the windward facade and negative pressures on the leeward facade and roof (illu. 205).

The Air Flow Rate (AFR (wind)) is sat to 0.32 m^3/s at the opening with an inflow of air and -0.06 m^3/h at the opening with an outflow of air, which results in an opening area of 0.02 m^2 at each of the five windows placed at the windward side, and an opening area of 0.20 m^2 in each of the five windows placed on the leeward side (table 6.2).



Illu. 205 - Illustration of the opening areas and the corresponding neutral plane as well as the differences in pressure between inside, the windward and leeward facade.

Pressure Coefficient			**Windfactor**	0,57		**Pwind**	7,3 pa			
Windward	0,25		**Vmeteo**	6 m/s		**Pmin**	-5,1 pa			
Leeward	-0,8		**Vref**	3,42 m/s		**Pmax**	1,8 pa			
roof	-0,7									
Location of neutral plan, Ho	1,6 m					**Buildingvol.**	214 m^3			
Outdoor temperature	12 C					**Volume**	46 m^3/section/floor			
Zone temperature	23 C									
Discharge coefficient	0,7					**Internal pressure,**	pa	-5,77		1,83
Air density	1,25 kg/m^3									

	Opening area m^2	Eff. Area m^2	Height m	Thermal Buoyancy pa	AFR (thermal) m^3/s	Pres Coefficient	Wind pressure pa	AFR Wind) m^3/s	Wind pressure pa	AFR total m^3/s
1. floor	0,020	0,014	1,7	-	-	0,25	7,600	0,05	0,000	-
1. floor	0,020	0,014	1,7	-	-	0,25	7,600	0,05	0,000	-
1. floor	0,020	0,014	1,7	-	-	0,25	7,600	0,05	0,000	-
1. floor	0,020	0,014	1,7	-	-	0,25	7,600	0,05	0,000	-
1. floor	0,020	0,014	1,7	-	-	0,25	7,600	0,05	0,000	-
1. floor	0,200	0,140	1,7	-	-	-0,8	-0,076	-0,05	-7,676	-
1. floor	0,200	0,140	1,7	-	-	-0,8	-0,076	-0,05	-7,676	-
1. floor	0,200	0,140	1,7	-	-	-0,8	-0,076	-0,05	-7,676	-
1. floor	0,200	0,140	1,7	-	-	-0,8	-0,076	-0,05	-7,676	-
1. floor	0,200	0,140	1,7	-	-	-0,8	-0,076	-0,05	-7,676	-
				Mass balance	0,00		Mass balance	0,00		0,00

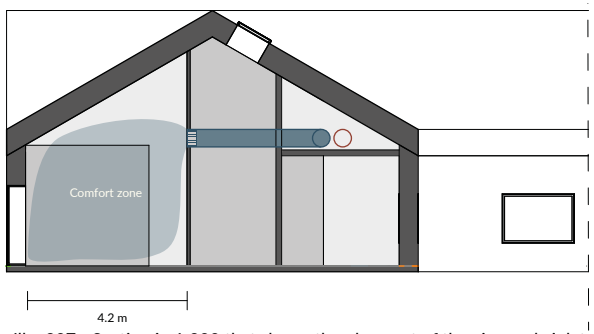
Table 6.2 - Calculation of the needed size of opening areas for natural ventilation to meet the needed air change based on wind

APPENDIX 7

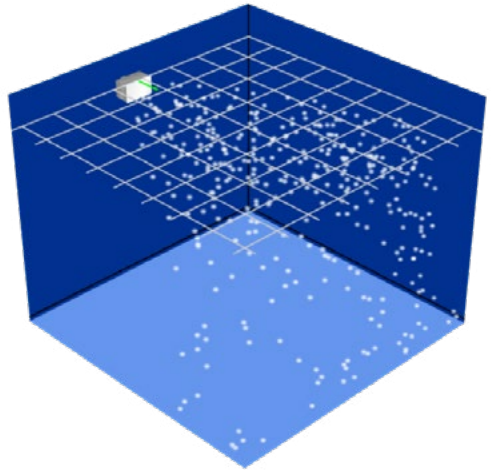
MECHANICAL AIR SUPPLY INLET

The supply air inlet is dimensioned through LinQST (Lindab AB, 2023) by inserting the data in table 7.1, resulting in a throw length of 3.7 m with a duct connection dimension of 200 mm, which does not exceed the distance of 4.2 m between the supply inlet and the opposite wall (illu. 207).

Illu. 206 - The air supply inlet (Lindab AB, 2023).



Illu. 207 - Section in 1:200 that shows the placment of the air supply inlet in an apartment.



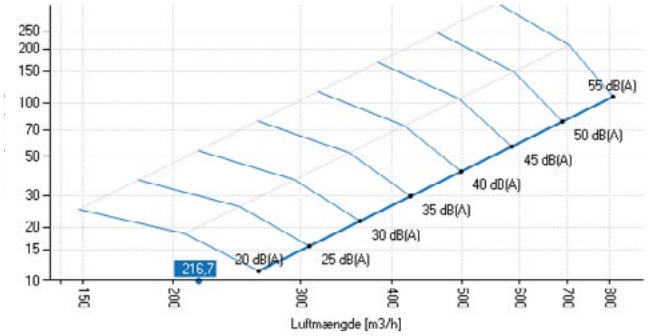
Illu. 209 - Simulation of the throw length (Lindab AB, 2023).

Inputs		
Airflow	216.7	m^3/h
Room damping	4	dB
Air velocity	0.2	m/s
Duct connection dimension	200	mm
Comfort zone height	2	m

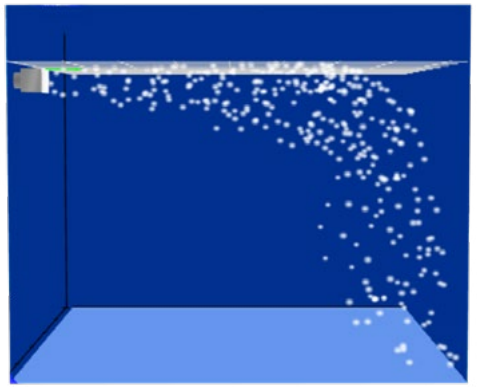
Table 7.1 - Inserted values in LinQST (Lindab AB, 2023).

Results		
Speed in opening	1.6	m/s
Total pressure loss	8	Pa
Sound effect	<20	dB
Sound effect level	<20	dB
Throw distance	3.7	m

Table 7.2 - Results from LinQST (Lindab AB, 2023).



Illu. 208 - The correlation between supply air volume and noise level for this type of air supply inlet (Lindab AB, 2023).

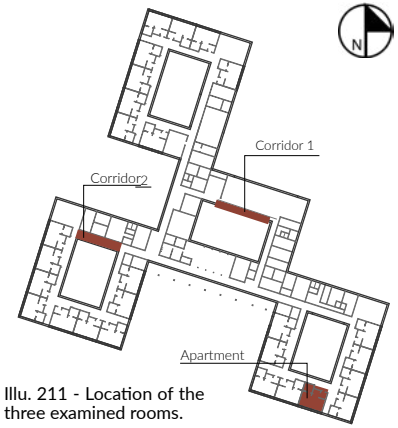


Illu. 210 - Simulation of the throw length viewed from the side (Lindab AB, 2023).

APPENDIX 8

BSIM SYSTEMS

The two tables present the data input in BSim for the three rooms that are examined in relation to thermal comfort during the design process. Moreover, the description and regulations for each of the following systems: equipment, infiltration, heating, ventilation, venting, window shading, and peopleload, is described.



Illu. 211 - Location of the three examined rooms.

h	Apartment		Corridor 1		Corridor 2	
	Weekdays and weekends		Weekdays and weekends		Weekdays and weekends	
	Occupants	Appliances	Occupants	Appliances	Occupants	Appliances
1	0,25	0,25	0.2		0.2	
2	0,25	0,25	0.2		0.2	
3	0,25	0,25	0,2		0.2	
4	0,25	0,25	0,2		0.2	
5	0,25	0,25	0,2		0.2	
6	0,25	0,25	0,2		0.2	
7	0,25	0,25	0,2		0.2	
8	0,50	0,25	0,2		0.2	
9	0,25	0,25	0,2		0.2	
10	0,25	0,50	0,2		0.2	
11	0,25	0,50	0,2		0.2	
12	0,75	0,50	1		1	
13	0,75	0,50	1		1	
14	0,75	0,50	1		1	
15	0,50	0,50	1		1	
16	0,25	0,50	1		1	
17	0,50	0,50	1		1	
18	0,25	0,50	1		1	
19	0,25	0,50	1		1	
20	0,25	0,50	1		1	
21	0,50	0,25	1		1	
22	0,25	0,25	0.2		0.2	
23	0,25	0,25	0,2		0.2	
24	0,25	0,25	0,2		0.2	

Table 8.1 - DayProfile for the amount of occupants and appliances in the rooms in the course of a day. The factor is multiplied with the heat gain from the number of occupants and the appliances, respectively (table 8.2).

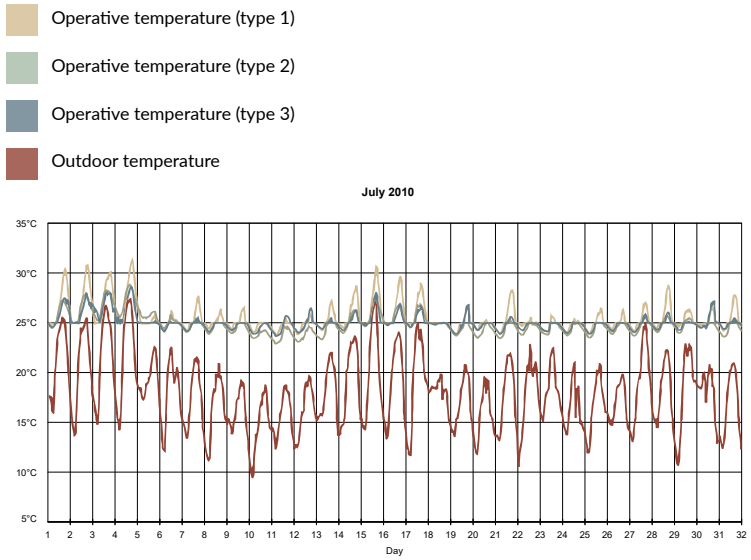
Systems							
	Description				Unit	Regulation		Unit
		Apartment	Corridor 1	Corridor 2				
Equipment	Heat Load	0,788	0	0	kW			
	Part to Air	0.5	-	-				
Infiltration	Basic AirChange	0.5	3,64	3,055	h^{-1}			
	TmpFactor	0.1	-	-	h^{-1*K}			
	TmpPower	0.5	-	-				
	WindFactor	0.25	-	-	s/m/h			
Heating	MaxPow	3.51			kW	**FloorHeatCtrl**		
	Fixed Part	0	-	-		Factor	1	
	Part To Air	0.6	-	-		Set Point	23	°C
						Max. Surf. Tmp	20	°C
						Design Temp	-12	°C
						MinPow	1	kW
						Te Min	17	°C
Ventilation	**Input**					**VAVCtrl**		
	Supply	0,06		0,0593	m^3/s	VAV max factor	3	
	Pressure Rise	900	-	-	Pa	Min Inlet Temp	18	°C
	Total Eff.	0.7	-	-		Max Inlet Temp	28	°C
	Part to Air	0.5	-	-		Setp Indoor Air	25	°C
						Setp Cooling	23	°C
	Output					Setp CO_2	1000	ppm
	Return	0,06		0,0593	m^3/s	Air Hum	0.07	kg/kg
	Pressure Rise	600	-	-	Pa			
	Total Eff.	0,75	-	-				
	Part to Air	0.5	-	-				
	Recovery Unit							
	Max Heat Rec	0.8	-	-				
	Min Heat Rec	0.8	-	-				
	Max Cool Rec	0	-	-				
	Max Moist Rec	0.6	-	-				
	Heating Coil		-	-				
	Max Power	2	-	-	kW			
Venting	Basic air change	1,01		0,4	h^{-1}			
	Tmp. Factor	0,1	-	-				
	Tmp. Power	0,5	-	-		**VentingCtrl**		
	Wind Factor	0,2	-	-	s/m/h	SetPoint	25	°C
	Max AirChange	5	-	-	h^{-1}	SetP CO_2	1000	ppm
	Max Wind	0	-	-	m/s	Factor	1	
Window Shading	Shading coeff.	0.5	-	-		**SensorCtrl**		
	Max Sun	150	-	-	W/m^2	Shading Coeff.	0.5	
	Reflection	0.5	-	-	m/s	Shade Close	10000	lux
	Transmittance	0.5	-	-		Shade open	2000	lux
	Slat With	0,5	-	-	m	Sf4 Close	0,05	
	Slat Distance	0,042	-	-	m	Sf4 Open	1	
	Position	Integrated	-	-				
People	Number of people	4	3	3				
	Heat gen.	0,1	-	-	kW			
	Moisture gen.	0,06	-	-	kg/h			

Table 8.2 - The designed systems in the building, utilized to examine the thermal indoor environment in BSim.

APPENDIX 9

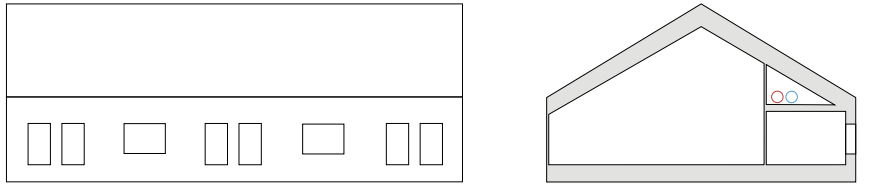
THERMAL COMFORT IN CORRIDOR

The thermal indoor climate is examined in corridor 2 (see appendix 8, illu. 211, p. 176) in BSim for each of the three facade explorations. Due to the high window-to-wall ratio combined with relatively small volume, and direction of the windows towards south, the number of hours above 27°C and 28°C do not comply with the requirements. On the contrary, type 2 and 3 do meet the requirements. Type 3 has a slightly larger window-to-wall ratio than type 2. Therefore, the windows are replaced with a window with a lower g-value, which decreases the transmittance of solar heat gain through the glazing, and an overhang with a depth of 0.5 m is added.



Illu. 212 - The experienced operative temperatures in each of the three corridor types and the expected outdoor temperatures in July, which is the month where the highest temperatures are measured.

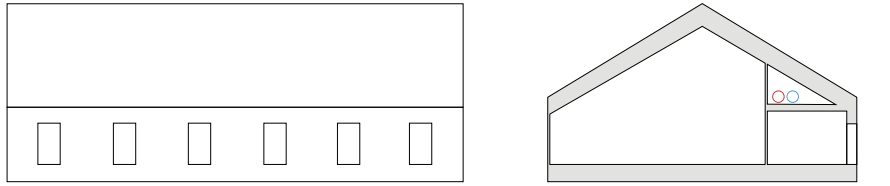
TYPE 1



U-value: 0.6 W/m² ·K
G-value: 57 %
L_t-value: 0.78
Overhang: 0 m

Window-to-wall ratio: 22.4%
Volume: 158 m³
Hours above 27°C: 384
Hours above 28°C: 209

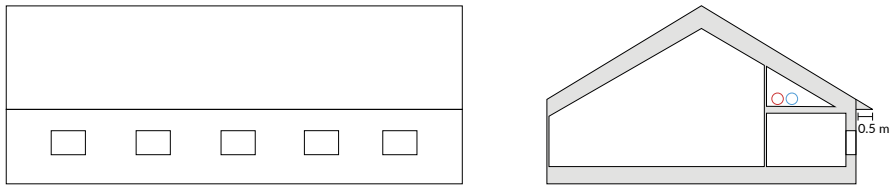
TYPE 2



U-value: 0.6 W/m² ·K
G-value: 57 %
L_t-value: 0.78
Overhang: 0 m

Window-to-wall ratio: 12.6%
Volume: 158 m³
Hours above 27°C: 85
Hours above 28°C: 18

TYPE 3



U-value: 0.7 W/m² ·K
G-value: 42 %
L_t-value: 0.67
Overhang: 0.5 m

Window-to-wall ratio: 13.8%
Volume: 158 m³
Hours above 27°C: 87
Hours above 28°C: 20

Illu. 213 - The examined conditions for three different corridor types.

APPENDIX 10

BE18 INPUT

The following tables presents the inserted data in the program Be18, which was used to document that the building complies with the energy requirements in Bygningsreglementet (BR18).

Photovoltaic (PV)				
			Value	Units
A	Total area of modules		100	m^2
B	Module efficiency		17	%
C	Installed Power	(A*B)/100	17	kW_{peak}
D	Efficiency of the systems		0,8	-
E	Solar radiation intensity	See table 10.2	1124	kW/m^2
	Annual yield	C*D*E	15286,4	kWh
			3,8	kWh/m^2

Table 10.1 - Calculations of the needed area of photovoltaics.

E	Solar radiation effiency										
	East	South east				South	South west				West
	-90	-75	-60	-45	-30	0	30	45	60	75	90
0°	999	999	999	999	999	999	999	999	999	999	999
15°	988	1017	1044	1067	1084	1097	1080	1062	1038	1011	981
30°	958	1012	1060	1100	1130	1152	**1124**	1092	1050	1001	947
45°	914	963	1045	1096	1134	1163	1128	1087	1033	971	901
60°	853	928	997	1052	1092	1124	1087	1042	983	916	839
75°	772	845	912	967	1005	1033	998	957	901	833	759
90°	671	738	795	841	873	892	867	833	785	726	662

Table 10.2 - Values of annual solar energy on a inclined surface in Denmark (Teknologisk Institut (n.d.).

The building		
Building type	Attached houses	
Number of residential units for non-detached houses	1	deg
Rotation	18	deg
Area of heated floor	4074	m2
Heat capacity	120	Wh/Km2
Normal usage time	168	h pr. week
Usage time (start-end)	0-24	
Heat supply and cooling		
Basic heat supply	District heating	
Electric panels	No	
Wood stoves, gas radiators etc.	No	
Solar heating plant	Yes	
Heat pumps	Yes	
Solar cells	Yes	
Wind mills	No	
Mechanical cooling	No	

Table 10.3 - Values descriping the building in general.

Room temperatures, set points		
Heating	20.0	°C
Wanted	23.0	°C
Natural ventilation	24.0	°C
Mechanical cooling	25.0	°C
Heating store	15.0	°C
Dimensioning temperature		
Room tem.	20.0	°C
Outdoor temp.	-12.0	°C
Room temp. store	15.0	°C

Table 10.4 - Values descriping room temperature through set points.

External walls, roof and floors			
	Area	U	b
Building component	m2	W/m2K	-
Exterior walls	2570.0	00.12	1.0
Roof	6147.0	00.06	1.0
Floor	4796.0	00.07	1.0
Total	13513.0	-	1.0

Table 10.5 - Values descriping the external walls, roof and floors in the building.

Foundations etc.			
	l	Loss	b
Building componant	m	W/mK	-
Exterior walls fundation	874.0	0.1	1.0
Windows and doors	1430.0	0.1	1.0
Total	2277.0	-	-

Table 10.6 - Values descriping the building's line loss.

Windows and outer doors										
	Number	Orientation	Inclination	Area	U	b	Ff	g	Shading	Fc
Building component	-	-	-	m2	W/m2K	-	-	-	See table 10.8	-
Glass door (2.1*0.9)	16	SW	90	1.9	0.6	1.0	0.65	0.42	"Building volume in courtyard"	0.20
Apartment windows (2.1*1.2)	14	SW	90	2.5	0.6	1.0	0.75	0.42	"Building volume in courtyard"	0.20
Glass door (2.1*0.9)	8	NW	90	1.9	0.6	1.0	0.65	0.42		0.20
Apartment windows (2.1*1.2)	14	NW	90	2.5	0.6	1.0	0.75	0.42		0.80
Glass door (2.1*0.9)	9	NE	90	1.9	0.6	1.0	0.65	0.42		0.80
Apartment windows (2.1*1.2)	6	NE	90	2.5	0.6	1.0	0.75	0.42		0.80
Glass door (2.1*0.9)	14	SE	90	1.9	0.6	1.0	0.65	0.42	"Overhang"	0.80
Apartment windows (2.1*1.2)	20	SE	90	2.5	0.6	1.0	0.75	0.42	"Overhang"	0.80
Medium window (1.3*1.9)	18	SW	90	2.5	0.6	1.0	0.70	0.42	"Building volume in courtyard"	0.20
Medium window (1.3*1.9)	18	NW	90	2.5	0.6	1.0	0.70	0.42	"Building volume in courtyard"	0.80
Medium window (1.3*1.9)	23	NE	90	2.5	0.6	1.0	0.70	0.42	"Building volume in courtyard"	0.80
Medium window (1.3*1.9)	23	SE	90	2.5	0.6	1.0	0.70	0.42	"Building volume in courtyard"	0.80
Floor to ceiling windows (2.1*1.8)	20	NE	90	3.8	0.6	1.0	0.90	0.42	"Building volume in courtyard"	0.80
Floor to ceiling windows (2.1*1.8)	2	SE	90	3.8	0.6	1.0	0.90	0.42	"Building volume in courtyard"	0.80
Roof windows (1*1.2)	8	SW	30	1.2	0.6	1.0	0.85	0.42		1.0
Roof windows (1*1.2)	14	NW	30	1.2	0.6	1.0	0.85	0.42		1.0
Roof windows (1*1.2)	14	NE	30	1.2	0.6	1.0	0.85	0.42		1.0
Roof windows (1*1.2)	20	SE	30	1.2	0.6	1.0	0.85	0.42		1.0
Floor to ceiling windows (2.1*1.8)	10	SW	90	3.8	0.6	1.0	0.90	0.42	"Building volume in courtyard"	0.80
Floor to ceiling windows (2.1*1.8)	5	NW	90	3.8	0.6	1.0	0.90	0.42	"Building volume in courtyard"	0.80
Total	276			634.5						

Table 10.7 - Values descriping the all windows and other doors in the building.

Shading					
	Horizon	Eaves	Left	Right	Window opening
Description	°	°	°	°	%
"Building volume in courtyard"	15	30	90	90	10
"Overhang"	0	30	5	5	10

Table 10.8 - Values descriping the shading at certain windows (see table 10.7 - 'Shading').

Internal heat supply				
	Area	Persons	App.	App, night
Zone	m2	W/m2	W/m2	W/m2
All rooms	4074	1	3.5	0.0

Table 10.9 - Values descriping internal heat supply.

Ventilation													
Zone	Area	Fo	qm (winter)	nvgv	ti	El-HC	qn (winter)	qi,n (winter)	SEL	qm,s (summer)	qn,s (summer)	qm,n (night)	qn,n (night)
	m2		l/s*m2		°C		l/s*m2	l/s*m2	kJ/m3	l/s*m2	l/s*m2	l/s*m2	l/s*m2
Common areas	1738	1.0	0.30	0.80	18.0	No	0.09	0.00	0.60	0.62	0.60	0.00	0.00
Apartments	1458	1.0	0.30	0.80	18.0	No	0.06	0.00	0.60	0.60	0.60	0.00	0.00
Staff areas	365	1.0	0.30	0.80	18.0	No	0.07	0.00	0.60	0.60	0.60	0.00	0.00
Storage room, cleaning room etc.	199	1.0	0.30	0.80	18.0	No	0.00	0.00	0.60	0.60	0.60	0.00	0.00
Corridor	314	1.0	0.30	0.80	18.0	No	0,05	0.00	0.60	0.60	0.60	0.00	0.00

Table 10.10 - Values descriping the ventilation in different zones of the building.

Heat distribution plant				
Composition and temperature				
Supply pipe temperature	70.0	°C		
Return pipe temperature	40.0	°C		
Type of plant	2-string	Fjernvarme		
Pumps				
	Description	Number	Pnom	Fp
Pump type			W	
Time-controlled service during heating season	Pump	1	25.0	0.40

Table 10.11 - Values descriping heat distribution plant.

Mechanical cooling		
Description	Mechanical cooling	
Share of floor area	0	
El-demand	0.0	kEh-el/kWh-cool
Heat-demand	0.0	kEh-el/kWh-cool
Load factor	1.2	
Heat capacity phase shift (cooling)	0	Wh/m2
Increase factor	1.5	

Table 10.12 - Values descriping mechanical cooling.

Domestric hot water		
Hot-water consumption, average for the building	250.0	l/year per m2 of floor area
Domestic hot water temp.	55.0	°C
Hot-water tank		
Number of hot-water containers	1	
Tank volume	300.0	l
Supply temperature from central heating	70.0	°C
El. heating of DHW	No	-
Solar heat tank with water tank	No	-
Heat loss from hot-water tank	2.9	W/K
Temp. factor for setup room	0.0	-
Charging pump		
Effect	10.0	W
Controled	No	-
Charge effect	50.0	kW
Heat loss from connector pipe to DHW tank		
Length	Loss	b
m	W/K	-
8.0	0.2	0.0

Table 10.13 - Values descriping domestic hot water (DHW).

Heat pumps			
Type	Combined		
Share of heating requirement	1.0		
El. driven heat pump			
	Room heating	DHW	
Nominal effect	5.0	0.8	kW
Nominal COP	3.20	2.20	-
Rel. COP at 50% load	0.80	0.00	-
Test temperature			
	Room heating	DHW	
Cold side	0.0	0.0	°C
Warm side	35.0	35.0	°C
Type			
	Room heating	DHW	-
Cold side	Eart hose	Earth hose	-
Warm side	Room air	-	-

Table 10.14 - Values descriping the heat pump.

Solar collector		
Type	Domestic hot water	
Area	100	m2
Solar col. start eff.	0.8	-
Coefficient of heat loss, a1	3,5	W/m2K
Coefficient of heat loss, a2	0.0	W/m2K
Orientation	S	-
Slope	30	-
Anglefactor	0.9	-

Table 10.15 - Values descriping the solar collector.

Solar cells		
Area	100	m2
Orientation	SW	-
Horizon	0.0	°
Slope	30.0	-
Left	10.0	°
Right	10.0	-
Peak power	0,17	kW/m2
Efficiency	0.75	-

Table 10.16 - Values descriping the solar cells.

Summer comfort		
Floor area	4074 m2	
Ventilation, winter	0.3	l/s*m2
Ventilation, summer, 9-16	0.3	l/s*m2
Ventilation, summer, 17-24	0.3	l/s*m2
Ventilation, summer, 0-8	0.5	l/s*m2

Table 10.17 - Values descriping summer comfort.

APPENDIX 11

REVERBERATION TIMES CALCULATIONS

The following presents six acoustic examinations in relation to reverberation times at six different frequency levels based on Sabine's equation:

T=(0.16*V)/((Sa*s)+(Sn*A)+(4*m*V)) = (0.16*V)/A

Where:
T=reverberation time
V=volume of room
α=absorption coefficient
S=surface area of material
Sα=A=total absorption area

GATHERING HALL - EXAMINATION 1

Equivalent absorption area	Materials	Area	125 Hz		250 Hz		500 Hz		1000 Hz (1kHz)		2000 Hz (2kHZ)		4000 Hz (4kHz)	
		S(m^2)	α	Sα	α	Sα	α	Sα	α	Sα	α	Sα	α	Sα
Floor	Wood	255	0,15	38,3	0,11	28,1	0,10	25,5	0,07	17,9	0,06	15,3	0,07	17,9
Ceiling	Plaster	330	0,10	33,0	0,15	49,5	0,20	66,0	0,25	82,5	0,30	99,0	0,35	115,5
Walls	Plaster	180	0,10	18,0	0,15	27,0	0,20	36,0	0,25	45,0	0,30	54,0	0,35	63,0
Window	Glass	57	0,18	10,3	0,06	3,4	0,04	2,3	0,03	1,7	0,02	1,1	0,02	1,1

Amount of people and chairs		Amount (r	α	αn	α	αn	α	αn	α	αn	α	αn	α	αn
Seats (fabric-upholstred, fully occupied)		8	0,60	4,8	0,74	5,9	0,88	7,0	0,96	7,7	0,93	7,4	0,83	6,6
Chairs	Wood	66	0,15	9,9	0,30	19,8	0,44	29,0	0,45	29,7	0,46	30,4	0,46	30,4
Tables	Wood	12	0,50	6,0	0,40	4,8	0,45	5,4	0,45	5,4	0,60	7,2	0,60	7,2

Absorption in air	Volume	125 Hz		250 Hz		500 Hz		1000 Hz (1kHz)		2000 Hz (2kHZ)		4000 Hz (4kHz)	
v/50% RF	(m^3)	4m	mV	4m	mV	4m	4mV	4m	4mV	4m	4mV	4m	4mV
	67,2	0	0	0	0	0,00	0,11	0,00	0,27	0,01	0,65	0,02	1,64

Total absorption			120,2	138,5	171,4	190,1	215,1	243,3
Reverberation time	T=(0,16*V)/((Sa*s)+(Sn*A)+(4*m*V))		**1,3**	**1,1**	**0,9**	**0,8**	**0,7**	**0,6**
	T=(0,16)*V)/A							
		BR18	≤0,9	≤0,6	≤0,6	≤0,6	≤0,6	≤0,6
	A: total absorption							
	V: volume							

Table 11.1 - This calculation examines the gathering hall's acoustic comfort with no inclusion of initiatives to reduce the reverberation times.

GATHERING HALL - EXAMINATION 2

Equivalent absorption area	Materials	Area	125 Hz		250 Hz		500 Hz		1000 Hz (1kHz)		2000 Hz (2kHZ)		4000 Hz (4kHz)	
		S(m^2)	α	Sα	α	Sα	α	Sα	α	Sα	α	Sα	α	Sα
Floor	Wood	255	0,15	38,3	0,11	28,1	0,10	25,5	0,07	17,9	0,06	15,3	0,07	17,9
Ceiling	Plaster	330	0,10	33,0	0,15	49,5	0,20	66,0	0,25	82,5	0,30	99,0	0,35	115,5
Walls	Acoustic wall lamellas with felt	135	0,40	54,0	0,80	108,0	0,95	128,3	0,95	128,3	0,95	128,3	0,90	121,5
Corridor wall with sitting windows	Plaster	45	0,10	4,5	0,15	6,8	0,20	9,0	0,25	11,3	0,30	13,5	0,35	15,8
Window	Glass	57	0,18	10,3	0,06	3,4	0,04	2,3	0,03	1,7	0,02	1,1	0,02	1,1

Amount of people and chairs		Amount (r	α	αn	α	αn	α	αn	α	αn	α	αn	α	αn
Seats (fabric-upholstred, fully occupied)		8	0,60	4,8	0,74	5,9	0,88	7,0	0,96	7,7	0,93	7,4	0,83	6,6
Chairs	Wood	66	0,15	9,9	0,30	19,8	0,44	29,0	0,45	29,7	0,46	30,4	0,46	30,4
Tables	Wood	12	0,50	6,0	0,40	4,8	0,45	5,4	0,45	5,4	0,60	7,2	0,60	7,2

Absorption in air	Volume	125 Hz		250 Hz		500 Hz		1000 Hz (1kHz)		2000 Hz (2kHZ)		4000 Hz (4kHz)	
v/50% RF	(m^3)	4m	mV	4m	mV	4m	4mV	4m	4mV	4m	4mV	4m	4mV
	67,2	0	0	0	0	0,00	0,11	0,00	0,27	0,01	0,65	0,02	1,64

Total absorption			160,7	226,2	272,6	284,6	302,8	317,6
Reverberation time	T=(0,16*V)/((Sa*s)+(Sn*A)+(4*m*V))		**1,0**	**0,7**	**0,6**	**0,5**	**0,5**	**0,5**
	T=(0,16)*V)/A							
		BR18	≤0,9	≤0,6	≤0,6	≤0,6	≤0,6	≤0,6
	A: total absorption							
	V: volume							

Table 11.2 - This calculation examines the gathering hall's acoustic comfort with inclusion of acoustic walls consisting of lamellas on felt to reduce the reverberation times.

GATHERING HALL - EXAMINATION 3

Equivalent absorption area	Materials	Area	125 Hz		250 Hz		500 Hz		1000 Hz (1kHz)		2000 Hz (2kHZ)		4000 Hz (4kHz)	
		S(m^2)	α	Sα	α	Sα	α	Sα	α	Sα	α	Sα	α	Sα
Floor	Wood	255	0,15	38,3	0,11	28,1	0,10	25,5	0,07	17,9	0,06	15,3	0,07	17,9
Ceiling	Acoustic ceiling lamellas with felt	330	0,40	132,0	0,80	264,0	0,95	313,5	0,95	313,5	0,95	313,5	0,90	297,0
Walls	Plaster	180	0,10	18,0	0,15	27,0	0,20	36,0	0,25	45,0	0,30	54,0	0,35	63,0
Window	Glass	57	0,18	10,3	0,06	3,4	0,04	2,3	0,03	1,7	0,02	1,1	0,02	1,1

Amount of people and chairs		Amount (r	α	αn	α	αn	α	αn	α	αn	α	αn	α	αn
Seats (fabric-upholstred, fully occupied)		8	0,60	4,8	0,74	5,9	0,88	7,0	0,96	7,7	0,93	7,4	0,83	6,6
Chairs	Wood	66	0,15	9,9	0,30	19,8	0,44	29,0	0,45	29,7	0,46	30,4	0,46	30,4
Tables	Wood	12	0,50	6,0	0,40	4,8	0,45	5,4	0,45	5,4	0,60	7,2	0,60	7,2

Absorption in air	Volume	125 Hz		250 Hz		500 Hz		1000 Hz (1kHz)		2000 Hz (2kHZ)		4000 Hz (4kHz)	
v/50% RF	(m^3)	4m	mV	4m	mV	4m	4mV	4m	4mV	4m	4mV	4m	4mV
	67	0	0	0	0	0,00	0,11	0,00	0,27	0,01	0,65	0,02	1,64

Total absorption			219,2	353,0	418,9	421,1	429,6	424,8
Reverberation time	T=(0,16*V)/((Sa*s)+(Sn*A)+(4*m*V))		**0,7**	**0,4**	**0,4**	**0,4**	**0,4**	**0,4**
	T=(0,16)*V)/A							
		BR18	≤0,9	≤0,6	≤0,6	≤0,6	≤0,6	≤0,6
	A: total absorption							
	V: volume							

Table 11.3 - This calculation examines the gathering hall's acoustic comfort with inclusion of an acoustic ceiling consisting of lamellas on felt to reduce the reverberation times.

APARTMENT- EXAMINATION 1

Equivalent absorption area	Materials	Area	125 Hz		250 Hz		500 Hz		1000 Hz (1kHz)		2000 Hz (2kHZ)		4000 Hz (4kHz)	
		S(m^2)	α	Sα	α	Sα	α	Sα	α	Sα	α	Sα	α	Sα
Floor	Wood	46	0,02	0,9	0,03	1,4	0,03	1,4	0,03	1,4	0,03	1,4	0,02	0,9
Ceiling	Plaster	49	0,20	9,9	0,40	19,7	0,65	32,1	0,55	27,1	0,70	34,6	0,70	34,6
Walls	Plaster	118	0,29	34,2	0,10	11,8	0,06	7,1	0,05	5,9	0,04	4,7	0,04	4,7
Windows	Glass	8	0,18	1,4	0,06	0,5	0,04	0,3	0,03	0,2	0,02	0,2	0,02	0,2

Amount of people and chairs		Amount (r	α	αn	α	αn	α	αn	α	αn	α	αn	α	αn
Seats (fabric-upholstred, fully occupied)		8	0,60	4,8	0,74	5,9	0,88	7,0	0,96	7,7	0,93	7,4	0,83	6,6
Tables	Wood	1	0,50	0,5	0,40	0,4	0,45	0,5	0,45	0,5	0,60	0,6	0,60	0,6

Absorption in air	Volume	125 Hz		250 Hz		500 Hz		1000 Hz (1kHz)		2000 Hz (2kHZ)		4000 Hz (4kHz)	
v/50% RF	(m^3)	4m	mV	4m	mV	4m	4mV	4m	4mV	4m	4mV	4m	4mV
	67,2	0	0	0	0	0	0,00	0,11	0,00	0,27	0,01	0,65	0,02	1,64

Total absorption				51,7		39,7		48,4		43,1		49,5		49,2
Reverberation time	T=(0,16*V)/((Sa*s)+(Sn*A)+(4*m*V))			**0,6**		**0,7**		**0,6**		**0,7**		**0,6**		**0,6**
	T=(0,16)*V)/A													
		BR18		≤0,6		≤0,6		≤0,6		≤0,6		≤0,6		≤0,6
	A: total absorption													
	V: volume													

Table 11.4 - This calculation examines the apartment's acoustic comfort with no inclusion of initiatives to reduce the reverberation times.

APARTMENT- EXAMINATION 2

Equivalent absorption area	Materials	Area	125 Hz		250 Hz		500 Hz		1000 Hz (1kHz)		2000 Hz (2kHZ)		4000 Hz (4kHz)	
		S(m^2)	α	Sα	α	Sα	α	Sα	α	Sα	α	Sα	α	Sα
Floor	Wood	46	0,02	0,9	0,03	1,4	0,03	1,4	0,03	1,4	0,03	1,4	0,02	0,9
Ceiling	Acoustic ceiling lamellas with felt	49	0,40	19,7	0,80	39,5	0,95	46,9	0,95	46,9	0,95	46,9	0,90	44,4
Walls	Plaster	118	0,29	34,2	0,10	11,8	0,06	7,1	0,05	5,9	0,04	4,7	0,04	4,7
Windows	Glass	8	0,18	1,4	0,06	0,5	0,04	0,3	0,03	0,2	0,02	0,2	0,02	0,2

Amount of people and chairs		Amount (r	α	αn	α	αn	α	αn	α	αn	α	αn	α	αn
Seats (fabric-upholstred, fully occupied)		8	0,6	4,80	0,74	5,92	0,88	7,04	0,96	7,68	0,93	7,44	0,83	6,64
Tables	Wood	1	0,5	0,5	0,4	0,4	0,45	0,45	0,45	0,45	0,6	0,6	0,6	0,6

Absorption in air	Volume	125 Hz		250 Hz		500 Hz		1000 Hz (1kHz)		2000 Hz (2kHZ)		4000 Hz (4kHz)	
v/50% RF	(m^3)	4m	mV	4m	mV	4m	4mV	4m	4mV	4m	4mV	4m	4mV
	67,2	0	0	0	0	0	0,00	0,11	0,00	0,27	0,01	0,65	0,02	1,64

Total absorption				61,6		59,4		63,3		62,8		61,8		59,1
Reverberation time	T=(0,16*V)/((Sa*s)+(Sn*A)+(4*m*V))			**0,5**		**0,5**		**0,5**		**0,5**		**0,5**		**0,5**
	T=(0,16)*V)/A													
		BR18		≤0,6		≤0,6		≤0,6		≤0,6		≤0,6		≤0,6
	A: total absorption													
	V: volume													

Table 11.5 - This calculation examines the apartment's acoustic comfort with inclusion of an acoustic ceiling consisting of lamellas on felt to reduce the reverberation times.

APARTMENT- EXAMINATION 3

Equivalent absorption area	Materials	Area	125 Hz		250 Hz		500 Hz		1000 Hz (1kHz)		2000 Hz (2kHZ)		4000 Hz (4kHz)	
		S(m^2)	α	Sα	α	Sα	α	Sα	α	Sα	α	Sα	α	Sα
Floor	Wood	46	0,02	0,9	0,03	1,4	0,03	1,4	0,03	1,4	0,03	1,4	0,02	0,9
Ceiling	Plaster	49	0,40	19,7	0,80	39,5	0,95	46,9	0,95	46,9	0,95	46,9	0,90	44,4
Walls	Acoustic ceiling lamellas with felt	54	0,40	21,5	0,80	43,0	0,95	51,1	0,95	51,1	0,95	51,1	0,90	48,4
Walls	Plaster	64	0,29		0,10		0,06		0,05		0,05		0,05	
Windows	Glass	8	0,18	1,4	0,06	0,5	0,04	0,3	0,03	0,2	0,02	0,2	0,02	0,2

Amount of people and chairs		Amount (n	α	αn	α	αn	α	αn	α	αn	α	αn	α	αn
Seats (fabric-upholstred, fully occupied)		8	0,6	4,80	0,74	5,92	0,88	7,04	0,96	7,68	0,93	7,44	0,83	6,64
Tables	Wood	1	0,5	0,5	0,4	0,4	0,45	0,45	0,45	0,45	0,6	0,6	0,6	0,6

Absorption in air	Volume	125 Hz		250 Hz		500 Hz		1000 Hz (1kHz)		2000 Hz (2kHZ)		4000 Hz (4kHz)	
v/50% RF	(m^3)	4m	mV	4m	mV	4m	4mV	4m	4mV	4m	4mV	4m	4mV
	67,2	0	0	0	0	0	0,00	0,11	0,00	0,27	0,01	0,65	0,02	1,64

Total absorption				48,9		90,7		107,3		108,0		108,2		102,8
Reverberation time	T=(0,16*V)/((Sa*s)+(Sn*A)+(4*m*V))			**0,6**		**0,3**		**0,3**		**0,3**		**0,3**		**0,3**
	T=(0,16)*V)/A													
		BR18		≤0,6		≤0,6		≤0,6		≤0,6		≤0,6		≤0,6
	A: total absorption													
	V: volume													

Table 11.6 - This calculation examines the apartment's acoustic comfort with inclusion of acoustic walls consisting of lamellas on felt to reduce the reverberation times.

APPENDIX 12

MECHANICAL VENTILATION - DUCT SIZES

The following table describes the air supply ducts in the mechanical ventilation system for one of the three zones (illu. 167, p. 139, marked with yellow) through the length of the ducts as well as the air supply volume and velocity. The dimensioning of each duct is calculated in MagiCAD with a sizing method based on a max. velocity between 4-8 m/s.

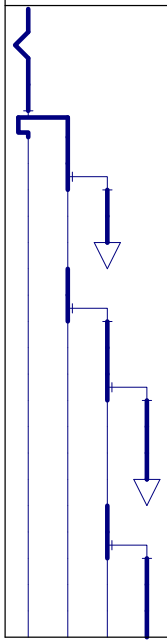
Location	Level	Node	Type	Series	Product	Size	L [m]	qv [l/s]	v [m/s]	dp/L [Pa/m]	Sizing|method
	Level 1		DUCT	Taps	Taps	482	0,3	1090,3	6,0	0,73	4-8 m/s
	Level 1		BEND-90	Taps	1.5 D	482		1090,3	6,0		
	Level 1		DUCT	Taps	Taps	482	6,2	1090,3	6,0	0,73	4-8 m/s
	Level 1	1	TAP	Taps	Standard	482/482		1090,3	6,0		
	Level 1		DUCT	Taps	Taps	482	0,6	1090,3	6,0		4-8 m/s
	Level 1		DUCT	Taps	Taps	482	7,1	669,6	3,7	0,30	4-8 m/s
	Level 1		DUCT	Taps	Taps	482	0,2	669,6	3,7		4-8 m/s
	Level 1	50	TAP	Taps	Standard	482/125		39,2	3,2		
	Level 1		DUCT	Taps	Taps	125	1,8	39,2	3,2	1,23	4-8 m/s
	Level 1	30	SUPPLY		ECO-W-125	125		39,2	3,2		
	Level 1		DUCT	Taps	Taps	482	2,5	630,4	3,5	0,27	4-8 m/s
	Level 1		DUCT	Taps	Taps	482	0,3	630,4	3,5		4-8 m/s
	Level 1	51	TAP	Taps	Standard	482/250		240,8	4,9		
	Level 1		DUCT	Taps	Taps	250	10,3	240,8	4,9	1,13	4-8 m/s
	Level 1		DUCT	Taps	Taps	250	0,2	240,8	4,9		4-8 m/s
	Level 1	32	TAP	Taps	Standard	250/139		60,2	4,0		
	Level 1		DUCT	Taps	Taps	139	4,2	60,2	4,0	1,59	4-8 m/s
	Level 1		REDUCER	Taps	45 Degree	139/125		60,2	4,0		
	Level 1	33	SUPPLY		ECO-W-125	125		60,2	4,9		
	Level 1		DUCT	Taps	Taps	250	2,9	180,6	3,7	0,67	4-8 m/s
	Level 1		DUCT	Taps	Taps	250	0,2	180,6	3,7		4-8 m/s
	Level 1	34	TAP	Taps	Standard	250/139		60,2	4,0		
	Level 1		DUCT	Taps	Taps	139	4,2	60,2	4,0	1,59	4-8 m/s
	Level 1		REDUCER	Taps	45 Degree	139/125		60,2	4,0		

Table 12.1 - Dimensioning of the air supply ducts in the mechanical ventilation system for one zone.

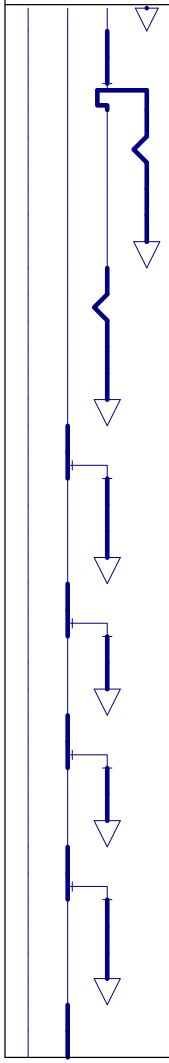
Location	Level	Node	Type	Series	Product	Size	L [m]	qv [l/s]	v [m/s]	dp/L [Pa/m]	Sizing|method
	Level 1	35	SUPPLY		ECO-W-125	125		60,2	4,9		
	Level 1		DUCT	Taps	Taps	250	8,1	120,4	2,5	0,32	4-8 m/s
	Level 1	36	TAP	Taps	Standard	177/250		120,4	2,5		
	Level 1		DUCT	Taps	Taps	177	0,3	120,4	2,5		4-8 m/s
	Level 1		DUCT	Taps	Taps	177	1,7	60,2	2,4	0,49	4-8 m/s
	Level 1		BEND-90	Taps	1.5 D	177		60,2	2,4		
	Level 1		REDUCER	Taps	45 Degree	177/139		60,2	2,4		
	Level 1		DUCT	Taps	Taps	139	3,6	60,2	4,0	1,59	4-8 m/s
	Level 1		REDUCER	Taps	45 Degree	139/125		60,2	4,0		
	Level 1	37	SUPPLY		ECO-W-125	125		60,2	4,9		
	Level 1		DUCT	Taps	Taps	177	0,6	60,2	2,4	0,49	4-8 m/s
	Level 1		BEND-90	Taps	1.5 D	177		60,2	2,4		
	Level 1		REDUCER	Taps	45 Degree	177/139		60,2	2,4		
	Level 1		DUCT	Taps	Taps	139	3,6	60,2	4,0	1,59	4-8 m/s
	Level 1		REDUCER	Taps	45 Degree	139/125		60,2	4,0		
	Level 1	38	SUPPLY		ECO-W-125	125		60,2	4,9		
	Level 1		DUCT	Taps	Taps	482	5,3	389,6	2,1	0,11	4-8 m/s
	Level 1		DUCT	Taps	Taps	482	0,2	389,6	2,1		4-8 m/s
	Level 1	52	TAP	Taps	Standard	482/177		107,8	4,4		
	Level 1		DUCT	Taps	Taps	177	1,8	107,8	4,4	1,42	4-8 m/s
	Level 1		REDUCER	Taps	45 Degree	177/125		107,8	4,4		
	Level 1	39	SUPPLY		ECO-W-125	125		107,8	8,8		
	Level 1		DUCT	Taps	Taps	482	8,1	281,8	1,5	0,06	4-8 m/s
	Level 1		DUCT	Taps	Taps	482	0,2	281,8	1,5		4-8 m/s
	Level 1	53	TAP	Taps	Standard	482/125		32,9	2,7		
	Level 1		DUCT	Taps	Taps	125	1,8	32,9	2,7	0,90	4-8 m/s
	Level 1	40	SUPPLY		ECO-W-125	125		32,9	2,7		
	Level 1		DUCT	Taps	Taps	482	3,5	248,9	1,4	0,05	4-8 m/s
	Level 1		DUCT	Taps	Taps	482	0,2	248,9	1,4		4-8 m/s
	Level 1	54	TAP	Taps	Standard	482/125		34,3	2,8		
	Level 1		DUCT	Taps	Taps	125	1,8	34,3	2,8	0,97	4-8 m/s
	Level 1	41	SUPPLY		ECO-W-125	125		34,3	2,8		
	Level 1		DUCT	Taps	Taps	482	9,6	214,6	1,2	0,04	4-8 m/s
	Level 1		DUCT	Taps	Taps	482	0,2	214,6	1,2		4-8 m/s
	Level 1	55	TAP	Taps	Standard	482/177		107,3	4,4		
	Level 1		DUCT	Taps	Taps	177	1,6	107,3	4,4	1,40	4-8 m/s
	Level 1		REDUCER	Taps	45 Degree	177/125		107,3	4,4		
	Level 1	42	SUPPLY		ECO-W-125	125		107,3	8,7		
	Level 1		DUCT	Taps	Taps	482	5,2	107,3	0,6	0,01	4-8 m/s
	Level 1		REDUCER	Taps	45 Degree	482/177		107,3	0,6		

Table 12.1 continued - Dimensioning of the air supply ducts in the mechanical ventilation system for one zone.

Location	Level	Node	Type	Series	Product	Size	L [m]	qv [l/s]	v [m/s]	dp/L [Pa/m]	Sizing|method
	Level 1		BEND-90	Taps	1.5 D	177		107,3	4,4		
	Level 1		DUCT	Taps	Taps	177	1,6	107,3	4,4	1,40	4-8 m/s
	Level 1		REDUCER	Taps	45 Degree	177/125		107,3	4,4		
	Level 1	43	SUPPLY		ECO-W-125	125		107,3	8,7		
	Level 1		DUCT	Taps	Taps	482	6,1	420,7	2,3	0,13	4-8 m/s
	Level 1	21	TAP	Taps	Standard	317/482		420,7	2,3		
	Level 1		DUCT	Taps	Taps	317	0,6	420,7	2,3		4-8 m/s
	Level 1		DUCT	Taps	Taps	317	1,8	119,7	1,5	0,10	4-8 m/s
	Level 1		BEND-90	Taps	1.5 D	317		119,7	1,5		
	Level 1		REDUCER	Taps	45 Degree	317/177		119,7	1,5		
	Level 1		DUCT	Taps	Taps	177	5,3	119,7	4,9	1,71	4-8 m/s
	Level 1		BEND-90	Taps	1.5 D	177		119,7	4,9		
	Level 1		DUCT	Taps	Taps	177	0,4	119,7	4,9	1,71	4-8 m/s
	Level 1		REDUCER	Taps	45 Degree	177/125		119,7	4,9		
	Level 1	56	SUPPLY		ECO-W-125	125		119,7	9,8		
	Level 1		DUCT	Taps	Taps	317	4,1	301,0	3,8	0,54	4-8 m/s
	Level 1		DUCT	Taps	Taps	317	0,2	301,0	3,8		4-8 m/s
	Level 1	57	TAP	Taps	Standard	317/139		60,2	4,0		
	Level 1		DUCT	Taps	Taps	139	4,2	60,2	4,0	1,59	4-8 m/s
	Level 1		REDUCER	Taps	45 Degree	139/125		60,2	4,0		
	Level 1	45	SUPPLY		ECO-W-125	125		60,2	4,9		
	Level 1		DUCT	Taps	Taps	317	2,8	240,8	3,1	0,36	4-8 m/s
	Level 1		DUCT	Taps	Taps	317	0,2	240,8	3,1		4-8 m/s
	Level 1	58	TAP	Taps	Standard	317/139		60,2	4,0		
	Level 1		DUCT	Taps	Taps	139	4,2	60,2	4,0	1,59	4-8 m/s
	Level 1		REDUCER	Taps	45 Degree	139/125		60,2	4,0		
	Level 1	46	SUPPLY		ECO-W-125	125		60,2	4,9		
	Level 1		DUCT	Taps	Taps	317	13,1	180,6	2,3	0,21	4-8 m/s
	Level 1		DUCT	Taps	Taps	317	0,2	180,6	2,3		4-8 m/s
	Level 1	59	TAP	Taps	Standard	317/139		60,2	4,0		
	Level 1		DUCT	Taps	Taps	139	4,2	60,2	4,0	1,59	4-8 m/s
	Level 1		REDUCER	Taps	45 Degree	139/125		60,2	4,0		
	Level 1	47	SUPPLY		ECO-W-125	125		60,2	4,9		
	Level 1		DUCT	Taps	Taps	317	2,3	120,4	1,5	0,10	4-8 m/s
	Level 1		DUCT	Taps	Taps	317	0,2	120,4	1,5		4-8 m/s
	Level 1	60	TAP	Taps	Standard	317/139		60,2	4,0		
	Level 1		DUCT	Taps	Taps	139	4,2	60,2	4,0	1,59	4-8 m/s
	Level 1		REDUCER	Taps	45 Degree	139/125		60,2	4,0		
	Level 1	48	SUPPLY		ECO-W-125	125		60,2	4,9		
	Level 1		DUCT	Taps	Taps	317	3,9	60,2	0,8	0,03	4-8 m/s

Table 12.1 continued - Dimensioning of the air supply ducts in the mechanical ventilation system for one zone.

Location	Level	Node	Type	Series	Product	Size	L [m]	qv [l/s]	v [m/s]	dp/L [Pa/m]	Sizing|method
	Level 1		REDUCER	Taps	45 Degree	317/139		60,2	0,8		
	Level 1		BEND-90	Taps	1.5 D	139		60,2	4,0		
	Level 1		DUCT	Taps	Taps	139	1,1	60,2	4,0	1,59	4-8 m/s
	Level 1		REDUCER	Taps	45 Degree	139/125		60,2	4,0		
	Level 1	49	SUPPLY		ECO-W-125	125		60,2	4,9		

Table 12.1 continued - Dimensioning of the air supply ducts in the mechanical ventilation system for one zone.

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