# Aalborg University Copenhagen

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This thesis aims to propose a lighting design for the elderly with dementia as a part of care home case study - Nældebjerg Plejecenter. The criteria for the design are developed through interdisciplinary knowledge.

The main focus of this thesis is - how greenery and light can enhance the well-being of the care home residents. The role of natural elements, like daylight and plants are described based on the performed literature search and observations. The combination of both with electric light is creating an environment that enhances physiological and psychological well being. Lighting solution that cooperates with daylight and supports the circadian rhythm of the residents is one of the essential parts. Findings from the literature are summarized as theoretical criteria that are the basis for the design proposal. Analysis of case and co-case study is highlighting new findings, which relates to interaction with greenery and natural phenomena. All the ideas were examined through tests and simulation to end up with a successful design proposal. Space has been divided into three zones with different lighting scenarios: atmospheric, circadian and task light.

This thesis emphasizes the importance of enhancing elderly's connection with nature for their well-being. While providing an atmospheric solution it was still crucial to create conditions optimal for elderly's decreased visual capabilities. Finally, the investigation of a lighting design proposal that enhances natural elements through the electric lighting led to a stimulating, sensoric and intimate environment that avoids the institutional feeling in the space.

# Light and greenery for elderly with dementia at care homes

MASTER THESIS BY:

JOGILE CIBULSKYTE / BEATA KUR

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# Abstract

This thesis aims to propose a lighting design for the elderly with dementia as a part of care home case study - Nældebjerg Plejecenter. The criteria for the design are developed through interdisciplinary knowledge.

The main focus of this thesis is - how greenery and light can enhance the well-being of the care home residents. The role of natural elements, like daylight and plants are described based on the performed literature search and observations. The combination of both with electric light is creating an environment that enhances physiological and psychological well being. Lighting solution that cooperates with daylight and supports the circadian rhythm of the residents is one of the essential parts. Findings from the literature are summarized as theoretical criteria that are the basis for the design proposal. Analysis of case and co-case study is highlighting new findings, which relates to interaction with greenery and natural phenomena. All the ideas were examined through tests and simulation to end up with a successful design proposal. Space has been divided into three zones with different lighting scenarios: atmospheric, circadian and task light.

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# Summary

The aim of this thesis is to propose a lighting design for the elderly with dementia as a part of care home case study - Nældebjerg Plejecenter. The criteria for the design are developed through interdisciplinary knowledge. This thesis is composed of six chapters, which are related to the stages of the evolution of the design process.

The first chapter is introductory and is subdivided into five parts. Three first of them are presenting background, vision and aim for this project. The main focus of the thesis is how greenery and light can influence the well-being of the residents of the care home. The remaining parts are specifying delimitations of the project and which methodology was used to achieve the aim.

Chapter 2 examines the literature from the field of daylight, electric light, physiological reactions in the human body to light and widely approaches the topic of nature. Findings from the literature are summarized as theoretical criteria that are the basis for the design proposal.

Chapter 3 is subdivided into case- and co-case study. The analysis of both places highlighting new findings, which relates to interaction with greenery and natural phenomena.

Chapter 4 concentrates on the design development. All the ideas were examined through tests and simulation to end up with a successful design proposal. Space has been divided into three zones with different lighting scenarios: atmospheric, circadian and task light. It was still crucial to create conditions optimal for elderly's vision, while providing an atmospheric solution.

Chapter 5 discusses the proposed solution and relates it to the research question. It ends with the conclusion about the importance of enhancing elderly's connection with nature for their well-being. The aim of this thesis was achieved and described further works could be applied as the next steps.

# Preface

As part of our master studies we have attended an internship semester in architectural and digital storytelling companies based in Copenhagen. Jogile has spent half a year working with daylight and making sure that buildings fulfill building regulations as well as provide best indoor daylighting qualities for future occupants in residential and public buildings. Whereas Beata dove into the digital storytelling and exhibition lighting domain. She has worked with narratives, interaction and technology creating memorable experiences for users. Beata has as well participated in Copenhagen Lighting Festival two times in a row, implementing her skills gained during internship. Both of us attended the Erasmus + Strategic Partnership project LIGHT-4HEALTH. LIGHT4HEALTH is a novel educational course focusing on health research methods and findings, concentrating on educational and healthcare environments and physiological and psychological effects of light. We have previously worked together on a semester project and thus we have decided to join forces again for the final thesis and benefit from interdisciplinarity. When deciding the subject for this graduate thesis, we have decided to combine knowledge we gained throughout studies and courses: daylight, electric light and greenery. This decision drove us to work with a case study: Nældebjerg plejecenter, a elderly care center for people with dementia, and develop a new framework for dementia care units lighting.

With this thesis we are hoping to challenge the current views on how lighting in elderly with dementia care homes is approached, by offering a new perspective that takes into account needs of specific user groups and well being. It is our intent to open the possibilities for future works to have greater focus on aging people's visual needs and understanding of light's physiological and psychological effects on people.

# Table of content

# Chapter 1
## Background

Over the last few years, the number of people suffering from dementia rose as life expectancy is extending and diagnoses are becoming more accurate. Daycare institutions are usually the only solution when the disease is advanced. While moving from one place to another the relationship with space and nature is changing. Especially leaving the home environment and settling in a care home can be stressful and even depressing. Such institutions do not often have access to gardens or even indoor plants. Even though it is known that contact with nature can have a positive impact on the settling process and even calming the mood (Baldacchino & Draper, 2001).

Rising numbers in elderly with dementia and the stressful period of institualization, relocation into care home environments motivated us to work with care home environments and focus on subjects of light, nature and elderly. The initial interest of combining light and nature came from knowledge of positive effects of nature and physiological and psychological effects of light. Moreover the imagination of an initial environment designed with an atmospheric and functional approach that could contribute to the well-being of elderly and elderly with dementia settled at care homes.

Many leisure activities are connected to nature. It provides background for them or even it is a part of those activities. From art and folklore to gardening, experiencing nature provides psychological and physical benefits. Those features are essential for well being during everyday life. Moreover, the natural element is supporting rest and recovery period. Gardening and experiencing nature has fascinated people for ages. This feeling is evoking involuntary attention that is constant and effortless (Kaplan, 1973). Involuntary attention is like a leisure activity for the mind. Since it doesn't require any attention, it excludes mental effort from constant thinking and worrying. That is probably an unconscious reason why balconies and apartments are becoming filled with different types of plants (Kaplan, 1973). In care home environments often the components of nature are lacking and thus connection to nature diminishes, therefore we aim to include nature in our design as one of the primary elements.

Lighting is considered to be a significant component of therapeutic institutions (Torrington, Tregenza, 2006). In research conducted by Sörensen and Brunnström it was shown that the quality of life of elderly was affected by lighting and thus by adjusting it  to their specific needs daily routines became easier and more enjoyable (Sörensen, Brunnström, 1995). Though creating lighting design solutions for elderly can be challenging. This challenge is related to elderly eye, which reacts with the surroundings differently. Mainly it is connected to the reduced illuminance and contrast projected onto the retina. Therefore discomfort from glare is increasing with deterioration of the eye (Torrington, Tregenza, 2006). Another important aspect is the increased need for illuminance for elderly to perform tasks (Torrington, Tregenza, 2006). High lux values are confronting with a problem of contrast (Lighting design lab). Dark areas seem to be really unpleasant and moreover sharp shadows can be perceived as objects, which might be problematic to omit while working with high brightness outputs.

Everyday activities that elderly are engaged in involve many cognitive abilities. During winter time those abilities are even more challenged by lack of physiological stimulus of daylight. Insufficient amount of daylight stimulus results in circadian rhythm disruption and seasonal affective disorder, which contribute to disturbed sleeping patterns that increase agitation and dementia symptoms.

The indoor environment could be an active component in the care of the residents. Nature consists both of daylight and greenery. This project is an opportunity to explore design possibilities that could maximize the integration of those two aspects in living spaces. Atmospheric and functional light that supports daylight in its alerting stimuli with nature incorporated into indoor design could make the environment enjoyable and positively affect the behavior and well-being of residents.

# Vision

*"And so with the sunshine and the great bursts of leaves growing on the trees, I had that familiar conviction that life was beginning over again with the summer."*

*~ F. Scott Fitzgerald, The Great Gatsby*

Connection to nature is an important aspect of well-being. We can often feel institutionalized spaces as not pleasant to be in. We would rather escape to a forest or another place where we could experience sun, wind and touch trees. Those sensations could evoke a feeling that 'life was beginning over again'. We assume that would be valuable especially in older age, when the mind is tangled in a disease of dementia.

Imagine if we could create well-being through a lighting design and provide elderly with easy access to greenery. This idyllic vision could create a pleasant environment for daily activities in an environment that doesn't feel institutional. We wish to develop criterias that focuses on a specific user group - elderly with dementia. The criterias could be applied for the process of care home environment design and would result in greater quality of life.

Our core idea is to change the current perspective of institutional elderly care home environments and promote a new approach of designing environments for elderly with dementia that enhance their well-being through providing sensory stimulation and fulfill visual needs by using tools of light and greenery.

The special attention has to be paid when designing with electric light, since a natural process of aging results in deterioration of vision. Electric light not only supports visual needs, but also helps to promote well being with its non-visual effects. By designing with electric light we wish to support existing daylight conditions and create an environment that assists daily life of elderly with dementia in visual and non visual ways. Diminishing boundaries between indoors and outdoors could be achieved by strengthening connection with nature by bringing greenery indoors. Many would benefit from stimuli from daylight and greenery and therefore it could be an advantage to include these surroundings in specialized institutions.

In order to set a coherent investigation process, we have developed the following initial problem statement which is the base of this thesis:

*"Imagine if natural conditions like greenery and daylight supported by electric light could elevate the mood of people suffering from dementia, and thus enhance the quality of their life at care homes."*

Afterwards, we have subdivided the vision in smaller focus areas as it would help us to tackle the main question more adequately:

- *Connection to nature*
- *Enriching circadian rhythm stimulus by daylight supported with electric light*
- *Supporting visual needs of aged eye to perform tasks*
- *Atmospheric environment creating homeliness*

# Aim

The aim of our thesis is to create a lighting design for elderly with dementia at Nælderbjerg care home that will enhance the residents' well-being. For the purpose of promoting the well-being of residents, we are focusing on different fields of lighting design and combining a functional layer, which aims to support visual, physiological and psychological needs of elderly. In addition to that, the design will include an atmospheric layer of lighting, which contributes in creating a home-like atmosphere. In order to create a holistic design, we have widened our perspective as a context conscious approach and include greenery as a component of design, hoping to strengthen connection to nature - knowing that nature benefits mental health. The scientific approach of studying literature such as elderly vision, lighting and its effects as well as nature benefits - aim to develop design criteria that further can support our design process. We believe that with the help of an interdisciplinary approach we can create an environment that supports the daily life of elderly with dementia and thus enhances their overall quality of life.

# Delimitations and scope

This master thesis was written during a Covid-19 pandemic, in the period of lockdown, when different restrictions were imposed. These conditions limited our actions in conducting measurements and observations on the site, performing physical tests, as Nældebjerg Plejcenter did not allow access to anyone except employees of the center due to the fact that residents are part of a high risk group. Following limitations forced us to rely on computer simulations and data from co-case study Plejehjem Virumgård, as one of the members of the thesis group was granted access due to current employment at the center. Restricted access to university prevented us from borrowing equipment that could have been used for experiments during normal conditions, as well as access to the lighting laboratory.

# Methodology
## Design model

The structure of this report is inspired by a procedural model developed by Ellen Kathrine Hansen and Michael Mullins (Hansen, 2014). The model describes a problem-based design approach combining different disciplines of knowledge. Based on different fields of gathered knowledge, design criterias are developed. The structure of this model ensures that the fulfilment of the vision of the project is approached through design based on knowledge from literature study, analyses and experiments.

The report starts with a vision of the project and initial research questions starting 'Imagine, if…'. Next step is focused on analyzing different theories and investigating the case study and co-case study  through observations, interviews and lighting analysis.

The transdisciplinary approach of the thesis is divided into two parts, which are:

*Literature overview*
*Case/co-case analysis*

This thesis focuses on how lighting and greenery affects elderly with dementia living in care home institutions. The thesis uses a common space of rest and socialization in a healthcare context to unfold this topic.
The context-independent literature study starts with gathering information about the disease and aging eye vision, which contributes to the well-being of the elderly. Following aspects of electric light and nature have been reviewed. From the literature study we extract knowledge and develop guidelines for elderly care home environments.
A context-dependent case study is analyzed through light simulations in order to find characteristics of the space. Co-case study was observed to obtain information about behavior and needs of the residents, as well as the physical environment elderly live in.

Based on those analysis, we have established criterias that design is meant to achieve. The following step leads to a design proposal and how the criteria based on literature can be utilized and evaluated. Design process is unfolded and explained in further chapter - Design.

A graph (Fig. 1) illustrates the knowledge and data collection process of this thesis. It shows how actions of analysis together with findings from synthesis of analytical framework contribute to the design.

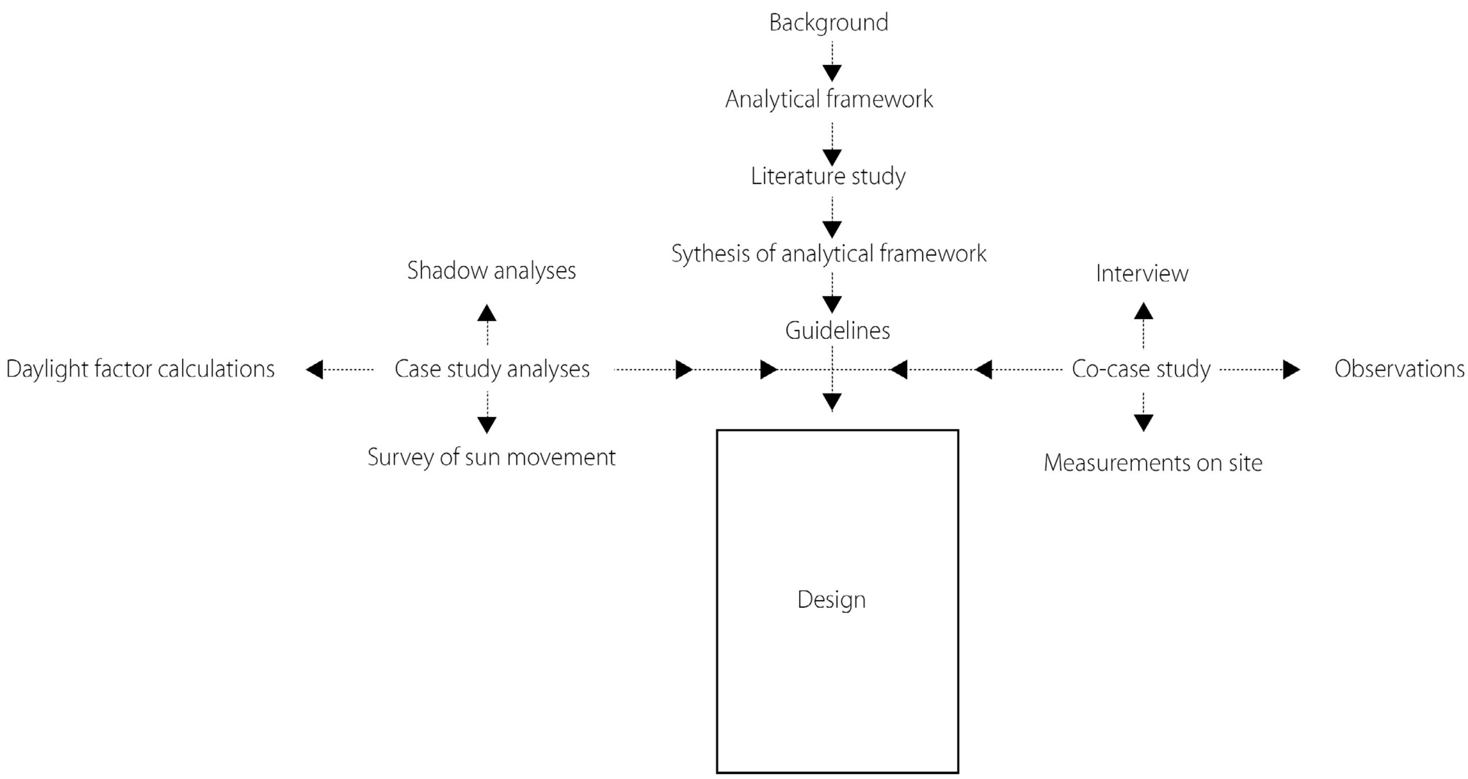



Fig. 1 Knowledge and data collection process

# Qualitative methods
## Literature search

Literature research for this thesis is based on the snowballing method. Snowballing method starts with setting keywords and identifying search strings. The number of found papers depends on the topic of research and on its focus. Diversity was a priority in the first stages of research. Therefore, during the first sessions of  searching different years, authors and publishers should be included. Keywords were formulated from research question with taking synonyms into account. First set of keywords didn't give significant results. It had to be extended based on a few first relevant articles, which resulted in a broad spectrum of topics and approaches to dementia. The spectrum was restricted by looking at highly cited papers (Wohlin, 2014).

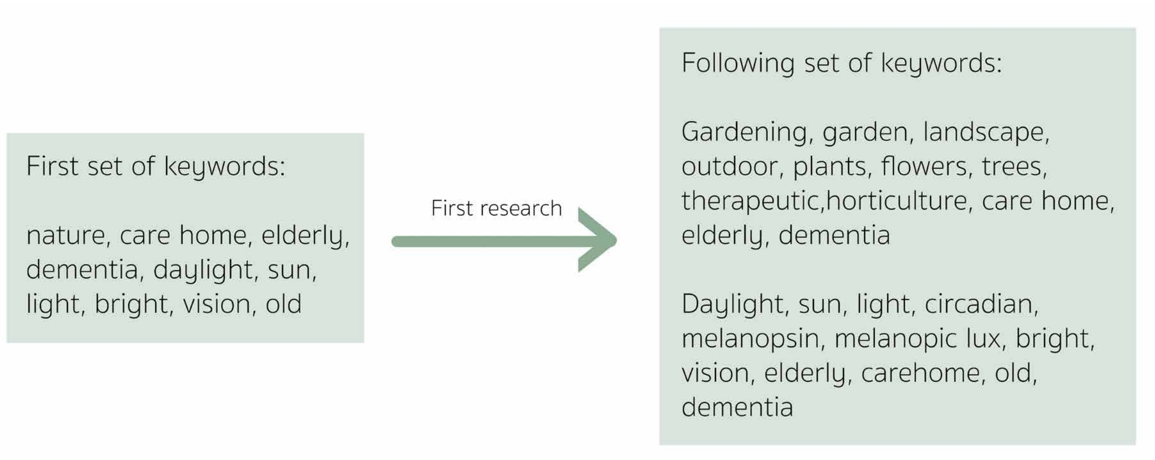



Fig. 2 Keywords

By applying this method we were able to gather data from a broad spectrum of topics related to elderly. Crucial element of the process was deciding on implementing or eliminating a paper from the research. This stage had an impact on further articles that were investigated.
As a result of the narrow field of investigation of dementia, it

wasn't possible to gather enough information only from searching keywords. Backward snowballing gave an opportunity to get acquainted with literature that didn't appear during forward snowballing in search engines, as it is using a reference list of chosen papers. According to Wohlin there are three important facts to consider during this process: author, title and publication. Authors can be an indicator of relevance of the paper. If they appeared before in research, it is a big chance that their work will be useful. Title describes what the authors wrote about. If it sounds dubious, it might be worth omitting the paper. The third factor is publication. Many relevant papers can be published by the same venue (Wohlin, 2014).

The literature search resulted in expanding of knowledge , which influenced the main points of this project - understanding elderly with dementia needs, light, greenery and homelike environment. Supported by the knowledge from literature search, the case- and co-case study were analyzed. Constructive design perspective was set based on the scientific knowledge from literature search, which was an essential point for the development of design criterias which supports creative process in the field of care home design.

# Participant observation

People suffering from dementia are a difficult group to study, because of their poorer communication skills as a result of the disease and cognitive declination. Based on this knowledge we have chosen to conduct participant observation using the Spradley method. Participant observation isn't based on conversation, but is analysing ethnographic context as a whole (Spradley, 1980). The main purpose of this observation was to investigate reactions and behaviour of demented elderly that are responding to an act of putting plants into the daily environment at the care home.

According to the author of the method, James Spradley, setting of the observation is crucial. Location and characteristics of the space, it's organization, can influence the behaviour during activities that are observed. Some behaviours can be influenced by recognizing social events (Spradley, 1980). In the case of a care home, it could be meal time, as all elderly are gathering together and they might already have their habits.

Performing participant observation as qualitative data collection turned out to be a perfect choice for this target group. Active participation was possible as being employed at the care home, so the elderly were already familiar with a person conducting research. Being engaged in evening activities provided useful data and gave an opportunity to observe changes in the dynamics of behaviour when plants were placed in different configurations and places. Characteristic patterns occurred in specific settings. Collected data provided an input into the arrangement of the designed space and its overall idea.

Data during observations at co case study Plejehjem Virumgård were taken by writing notes at the spot. Participant observation has a specific worksheet which should be filled at the beginning of the process. Worksheet form observation at care home is attached to this report as Appendix 1.

# Interview

We gather our primary data by using “non-standardized” interview, more precisely in this thesis we have executed a one-to-one interview, which was performed face to face (figure x).

The interview performed to gather data for this report was semi-structured. Semi-structured interview is a popular method since it is both universal and flexible (Kallio et al. 2016). It can be used for investigating an individual as well as a group of people (DiCicco-Bloom & Crabtree 2006). The interview conducted for this project was an interview with a caretaker employed at co-case study Plejehjem Virumgård.

Semi-structured interview contains both open-end, theoretical questions as well as explanation of participant experience with specific data in particular discipline. All the questions are guiding the interview to find the answers for some aspects of research. That examination should result in progression in the exploration of the scientific topic (Galletta,2013). The interview with the caretaker from Plejehjem Virumgård started with the interviewer having a list of prepared key questions, which needed to be covered through conversation. However some additional questions were addressed following the flow of conversation in order to discover the objectives of research more profoundly.

The reason for choosing a semi-structured interview was that its structure can be adjusted according to the needs of research (Kelly 2010). Moreover by using this interview method we can extract additional information useful for the project and allow the interviewee elaborate his knowledge gained throughout many years of experience at care home.

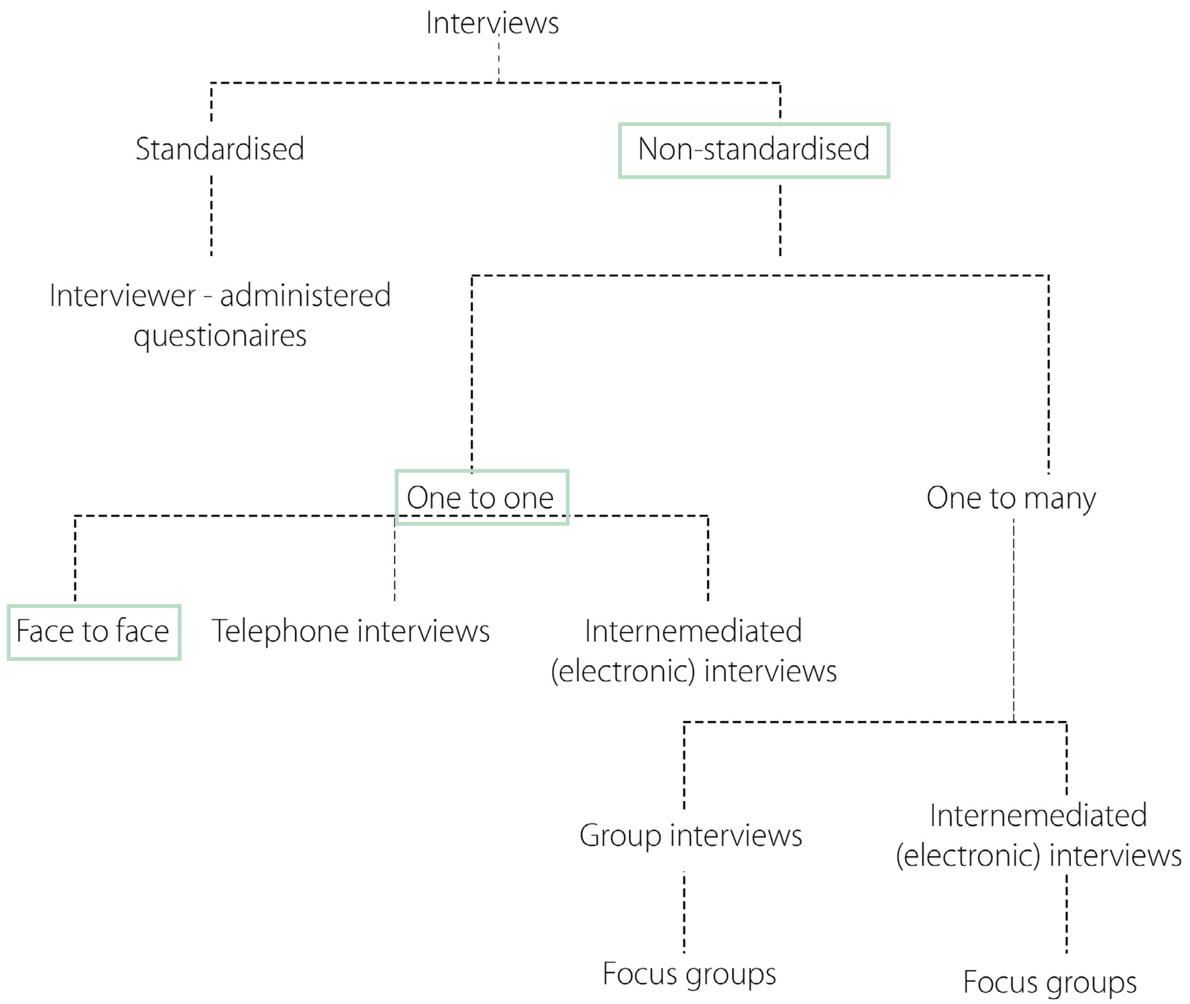



Fig. 3 Types/choice of interview(s)

# Mood boards

Mood board is an effective method helping to establish vision and communicate the intended character of the design. It helps to visualize conceptual ideas of how design is expected to look and what role it would play in an environment. Mood boards are a quick and useful method to use when it is needed to communicate common vision in a design team, it can help to establish initial requirements for the iterative design process (Benyon, 2014). The method of using mood boards helped us to get inspired and further communicate our primary ideas with sketches.

# Exploratory testing

Exploratory testing is used to test elements of design rather than the design as a whole. The focus of exploratory testing is defined as a thinking activity that helps to decide which solution could work in design. We have used exploratory testing to test different correlated color temperature (CCT). Such a test enabled the opportunity to see how different correlated color temperatures are perceived in space and how a set of objects looks in a range of 6500 - 2000 kelvin. Physical exploratory testing can communicate a more accurate message compared to stimulation test due to factors such as calibration of monitor colors, environment settings where virtual test is observed.

# Quantitative method
## Simulations and visualizations

3D models can be incredibly useful when it is needed to provide quality information for design. It can be used in larger scale as in the shape of a whole building or in a smaller scale as in the shape of product (Bryden, 2014).

> "The computer is an invaluable tool in the design process, enabling designers to create and output virtual models as high-quality rapid prototyped models in order to evaluate their designs in the real world."
>
> (p. 8, Bryden, 2014)

For 3D model creation in this thesis we have used software Revit. Visualizations have been established using the rendering plug in engine Enscape and post processed in Photoshop to ensure highest accuracy.
Simulations of current daylight conditions were calculated in software Velux Daylight Visualizer 2, which enabled the possibility to assess Daylight factor values in our case study environment. Shadow analyses were conducted in Revit by enabling real location and wanted time.
Electric light analyses were conducted in software DIALux to test illuminance levels and test light distribution. 3D software Rhino with plug in Alfa was used to perform the most accurate calculations of Equivalent melanopic lux (EML) (fig. 4).

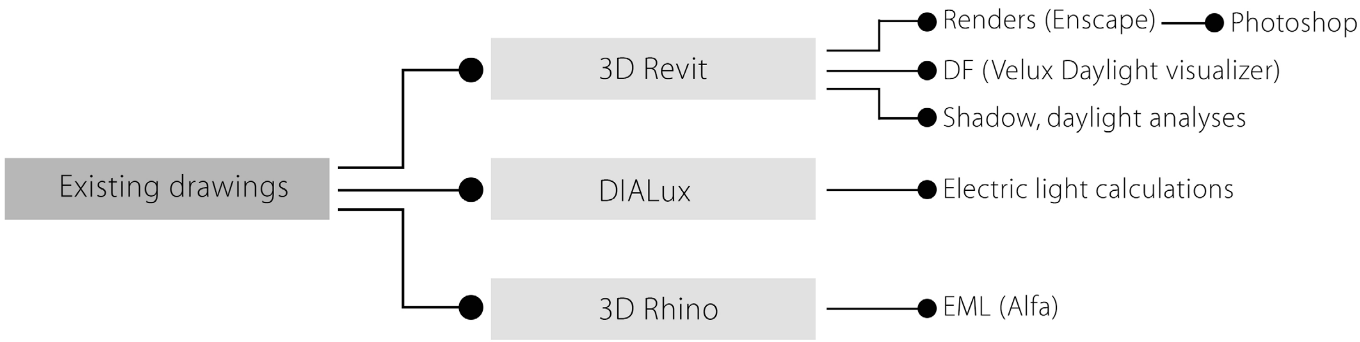



Fig. 4 Simulations diagram

# Chapter 2
## Analytical framework

In the following chapter we gather knowledge from study fields that are crucial for design of demented elderly care environments. The aim of this chapter is to find and extract relevant data available on which later on theoretical guidelines can be developed for this particular user group and environment they reside.

We begin with compiling information about dementia and its characteristics in order to understand the user group. We do as well look into rapidly growing numbers of elderly with dementia and hope to raise awareness of why care home environments should be designed consciously with light and greenery elements. Moreover we investigate changes in vision caused due to natural deterioration, to understand how lighting design should be developed to support elderly needs. To that we add a layer which analyses the influence of daylights physiological effects, and its importance for elderly with dementia. We further proceed with gathering data about electric light and prefered settings of light at care home environments. Crucial aspect that we dive into is psychological effects of light, analysing circadian rhythm, SAD, vitamin D and inputs contributing to those and how they affect people with dementia. Moreover, a section proceeds on humans and nature's connection, investigating impact of views, home gardens, horticultural therapy and their benefits for well being. Lastly we interrogate nordic characteristics of plants and light striving to implement knowledge and design the environment that is familiar and generates homeliness in an institutional environment. We do as well research why home-like environments are important for people with dementia. Literature review is focused on cooperating in creating guidelines and conscious, holistic design for our case study at Nældebjerg plejecenter.

# Dementia

The most common misconception - dementia is a part of the aging process. It is often confused with the mild decline of cognitive abilities like forgetfulness connected to normal aging (Levy, 1994). Dementia is a broad term that is describing the loss of memory, problem-solving, or language abilities that are impeding everyday life. It includes a wide spectrum of medical terms, including Alzheimer’s disease. All disorders are caused by structural changes in the brain that decline cognitive abilities, which has a severe effect on feelings and behavior (Alzheimer’s Association 2020). The chemistry and structure of the brain are becoming damaged according to 17 gradual declines in a person’s communicative abilities (Alzheimer’s Society, 2006). There are two kinds of changes occurring during the progression of the disease, but it is impossible to see a difference between them. The first of them characterizes the weakening of mental power, whereas the second shows changes in patterns of interactions with environment and relationships (Kitwood, 1997).

*Dementia can be categorized into three levels of severity:*

*Mild – a person has the ability to live independently,*

*Moderate – a person needs help in basic everyday tasks,*

*Severe – a person requires constant help and support.*

Although the disease is irreversible, there is a small percentage that is treatable (Chan, et al., 2006). Early diagnosis is giving access to the treatment and rehabilitation process. Explanation of behavioral changes and proper environment features are raising life quality and delaying severe symptoms (Marshall, 2005).

## Types of dementia

Dementia is a disease that is affecting all abilities necessary for independent living, including language, movement, judgment, memory, and problem-solving (Sadavoy, 1991; Zec, 1993). Reaction to those changes can manifest themselves in behaviours, like:

- *Behavioral disturbance*
- *Disturbance of affect (depression etc.)*
- *Psychiatric symptoms (hallucination)*
- *Personality changes (Burns, 1992, 1996; Gilley, 1993).*

The most common type of dementia is Alzheimer's disease (AZD), which is touching more than 50 % of all cases (Alzheimer's Association, 2006). The second most common type (26%) is caused by Lewy bodies dementia (LBD) (Zaccai et al., 2005). Many symptoms are similar to Parkinson's disease and moreover first of them are often the same since the same biological changes in the brain are occurring (Department of Health, 2001). The most common symptoms are loss of attention, visual hallucination, changes in personality, and movement problems (Department of Health, 2001). The third type which is affecting 20% of cases is vascular dementia, which is caused by strokes or inadequate blood flow that is damaging cells. Many patients have paralysis on one side of the body and have problems with understanding speech and speaking themselves (Alzheimer's Society, 2020). Frontotemporal dementia is the fourth common type, which is caused by proteins creating nerve cell damage in front lobes of the brain. It is causing changes in behavior, usually aggression. In later stages, it is connected to the loss of emotions, sweet food preferences, and lack of ability of comprehensive language (Alzheimer's Association, 2020).

## How many people are with dementia in Denmark/Europe/ world?

According to the Government Agency for Health Data the number of people diagnosed with dementia in Denmark rose from 35,800 cases in 2014 to 89,985 cases in 2018. In 2015 it was estimated that worldwide there are almost 47 million people suffering from dementia (National Research Strategy on Dementia 2025, 2018). Life expectancy is growing and so is the ratio of the disease. Due to women's longer lividity, there are 60% more female cases. People younger than 65 are also developing dementia, but the percentage is much lower. According to Danmarks Statistik 40000 people over 65-year-old live at care homes. Between 60 – 80% of them have dementia (Alzheimerforeningen, 2019).

| AGE RANGE | WOMEN | MEN | TOTAL |
|---|---|---|---|
| 65-69 | 1200 | 1500 | 2700 |
| 70-74 | 2000 | 2100 | 4100 |
| 75-79 | 3500 | 2700 | 6200 |
| 80-84 | 5100 | 3000 | 8100 |
| 85-89 | 5800 | 2400 | 8200 |
| 90-94 | 3600 | 900 | 4500 |
| 95 + | 1000 | 200 | 1200 |
| TOTAL | 22200 | 12800 | 35000 |

Fig.5. Registry-based prevalence of dementia in 2014, based on The Government Agency for Health Data (2016)

The growing numbers suggest how valid it is to design for elderly with dementia. This disease reduces the will of interaction. Therapy at a care home is patient centered and therefore it should be supported by the surrounding where the residents feel free to express themselves (Rogers, 1961). This target group has specific environmental needs which will be described later in this report.

# Elderly eye vision

The natural process of aging consequence in the deterioration of vision due to structural changes that occur in the eye. Age-related visual sensory modifications can dramatically alter functional performance (Lovering, 1990). Study done by Kosnik presents day to day activities that become more challenging due to natural deterioration of the eye, such as increased time in reading, performing hobbies become more difficult, trouble watching TV, seeing and recognizing faces and objects  at distance, difficulties sorting dark colors and seeing at night (Kosnik, 1988). Navigation within the space for aged people does as well become more challenging, Kosnik reports that elderly tend to accidentally bump into doorways, walls and other objects in the space (Kosnik, 1988). Older people become more impressionable to slips, trips and falls due to natural changes in motorics and vision, therefore providing quality lighting is essential (Feddersen, 2014).

A commonly observed phenomenon is the yellowing of the eye. Due to accumulation in yellow pigment, the lens turns yellow and thus decreases the ability to discriminate colors in the spectrum of blue, green, and violet colors (Whitbourne, 2002). Nonetheless, as the lens becomes cloudier it results in increased sensitivity to glare or reflections from shiny surfaces by elderly people. The other effects of yellowing and thickening of the lens also culminate in a reduced amount of light reaching the retina, hence there is the reduction of contrast, as well as illuminance of the image projected onto the retina and thus higher illumination levels are required to perform tasks (Lovering, 1990; Torrington, 2006). Studies show that people of age 75 and older require twice the light that 45-year-old people need to obtain alike visual responses (Turner, 2008). Retinal photoreceptors, rods, function in lower light levels, known as scotopic vision. According to studies, the number of rods decreases with advancing age (Jackson, 1999). The decreased quantity of rods and reduced pupil diameter caused due to atrophy of the muscle of the iris compromises adaptation to dark to light and light to dark conditions and results in prolonged adaptation time (Jackson, 1999; Nylen, 2014).

# Daylight

Daylight is known as a combination of direct and indirect light commencing from the sun during daytime. Daylight by its nature is dynamic and multidimensional. Daylight demonstrates its dynamic changes in irradiance, spectral power composition, which varies with latitude, time of the day, time of the year and the nature of the surrounding environment, such as reflections, buildings, and vegetation (Münch, 2020). Direct sunlight characteristics consist of very high intensity and constant movement. The illuminance level reaching earth's surface may outpace 100000 lux. The brightness of direct sunlight depends and varies on season, time of the day, location, and sky condition. Definition of skylight is known as the sunlight scattered by the atmosphere and clouds, due to which skylight is characterized as soft, diffused light. Overcast sky may produce illuminance reaching up to 10000 lux during winter season and up to around 30000 lux on a bright overcast summer day. Reflected light is light (sunlight and skylight) that is reflected from the surface, such as terrain, surrounding buildings, vegetation and so on. Reflectance of a surface is the main factor influencing the amount of reflected light that will reach the building.

## Physiological effects

Humans have evolved under the influence of daylight and the cycle of light and darkness. For millions of years daylight was the only source of light until the Stone Age, when the light was brought home in the form of fire and life of humans drastically changed (Buonocore, 2007; Solt, 2017). Nowadays, the time spent indoors by modern humans is reaching 90%, besides certain groups of people do not spend much time outdoors as well, such as elderly, recovering hospital patients (Solt, 2017; Altomonte, 2009). Rapidly decreasing time spent outdoors can negatively impact human health. There are a number of laboratory and clinical studies that confirm the importance of daylight.

Associations of daylight with alleviation of seasonal affective disorder (SAD), lower absenteeism, diminishing fatigue, decreased symptoms of depression, improved skin conditions, better vision, positive impact on behavioural Alzheimer disease symptoms and many other health advantages are presented in different studies (Aries, 2015; Robbins, 1986). All human processes are associated with the natural daily and seasonal cycles of daylight (Altomonte, 2009). Adequate exposure to daylight synchronises the internal biological clock, stimulates circulation, elevates the production of vitamin D, regulates protein metabolism, and controls hormones, such as stress hormone cortisol and sleep hormone melatonin (Van Bommel, 2006). Alzheimer's residents often experience a delay of agitation in bright morning sun (Ancoli-Israel, 2003). Whereas agitation is increasing during the afternoon, which is called sundowning. This phenomenon might be related to the length of shadows, which are longer in the afternoon and therefore might be frightening (Cooper, 2014). There are field studies indicating positive effects of sunlight exposure on recovery from depression in patient rooms (Beauchemin, 1996; Canellas, 2016). Elderly seem to receive positive effects of daylight as well. According to a study by Caldwell, daylight improves depressive symptoms and cognitive functions for elderly (Caldwell, 2014). In fact, depression is one of the most common conditions for Alzheimer's patients, clinically significant depression arises in about 20% to 30% of people living with Alzheimer's (Tsuno, 2009). An effective non drug treatment method for depression and neuropsychiatric symptoms of dementia is exposure to sufficient daylight (Konis, 2018). Study done by Konis presents findings that exposure to daylight in the mornings (8 am to 10 am) can be used as treatment to reduce depression in people with dementia (Konis, 2018). For those with dementia, absence of circadian effective light stimulus at appropriate time during the day can desynchronize the circadian clock and cause common problems such as disrupted sleep, night time wandering, night-day reversal and agitation (Konis, 2018). Common issues in long term environments where dementia people reside are found to be insufficient exposure to bright light (Konis, 2018).

Healthy individuals benefit from daylight too, 30 minutes exposure to natural light has been found to improve mood (Kaida, 2007). Performance and productivity of workers in offices are found to be increased with good quality light, one of the studies states 15% increase in productivity of their employees after moving to a building with better conditions of daylight (Edwards, 2002).

## Vitamin D

Vitamin D is vital for human health. Different effects are discussed in various studies, where lack of vitamin D results negatively for general health (DeLuca, 1988; Reichel, 1989). For elderly, lack of vitamin D can result in osteoporosis and muscle weakness (Holick, 1995; Bischoff-Ferrari, 2010). Interestingly, some studies suggest that high doses of vitamin D are found to be effective in reducing falls in care homes (Chapuy, 1992, Flicker, 2005).

Vitamin D is also important for mental health, Holick in his article addresses vitamins D importance for prevention of mental disorders such as schizophrenia and depression (Holick, 2007). Nonetheless, vitamin D is found to have a close relation with Alzheimer's disease.

According to observational studies, there is an association between low 25-hydroxyvitamin D (25(OH)D) concentration and cognitive impairments as well as dementia and Alzheimer's (Soni, 2012). Studies in the United States and Europe showed that participants with vitamin D deficiency were more than twice as likely to acquire dementia/Alzheimer's compared with those with higher vitamin concentration (Soni, 2012). Another study states findings that a deficiency of 25(OH)D had increased risk of dementia by 51%, and for those with severe deficient the risk increased by 121% (Littlejohns, 2014). Elderly who are already affected with dementia and have lower levels of vitamin D according to 72% of studies demonstrate significantly worse outcomes in cognitive tests and demonstrate higher frequency of dementia (Schlögl, 2014).

Even though, lack of vitamin D is mostly talked about as an increasing risk factor of developing Alzheimer, which would not be so relevant in this thesis as our user group is already affected with the disease. The findings present that vitamin D is vital for general health, such as muscular health for elderly. Moreover, some studies suggest that lack of vitamin D is linked to depression, and further cognitive decline and progression of dementia symptoms for those who are affected. Therefore, we find it essential to provide easy access to outdoors and allow daylight penetration indoors at care homes as by photosynthesis through skin 80-100% of needed vitamin D can be obtained (Glerup et al., 2000).

## Circadian rhythm

Humans and the majority of living species exhibit a daily activity cycle established on a 24-hour interval. For a while it is known that we have an internal clock that is responsible for keeping biological rhythms synchronized, such as regulating sleep-wake cycle, body temperature, blood pressure, hormone production, heart rate, gene expression and metabolism. Disruption of biological rhythm can lead to health and well being impairments (Vitaterna, 2001). According to studies disturbed sleep cycles that arise from dysfunction of circadian clock, night wandering and confusion are the primary causes of institutionalization for people suffering from dementia. (Hatfield, 2004; Coen et al. 1997; Pollak et al. 1990) It is due to nocturnal restlessness that leads to faster cognitive and functional declination. (Moe et al., 1995) In fact nearly half of the elderly suffer from chronic sleep disturbances, and elderly with dementia numbers are equal to one-quarter - half, that suffer from severe nocturnal restlessness (Van Someren, 2000). Potential outcomes related to sleep disorders in elderly with dementia encompass mortality, neurobehavioral and cardiovascular co-morbidities, and worse cognitive functions (Bombois, 2010; Pollak et al. 1990).

Neural processing of physiological and visual responses commences in the retina, where photoreceptors of retina absorb light stimuli, transform it to electric signals and send it to the brain through optic nerve. Retina comprises photoreceptors, rods and cones – cells that respond to light. Third cell of retina - intrinsically photosensitive retinal ganglion cell (ipRGC) was disclosed in 1990, ipRGC is sensitive to blue light and associated with circadian rhythm response (Tregenza, 2013). IpRGC is arbitrating non-visual forming photoreception and expresses photopigment melanopsin. Non-visual information is transferred to the suprachiasmatic nucleus (SCN), the primary pacemaker for the body's biological clock, hormone production regulation and coordination. SCN is driving melatonin production in pineal gland, during the time of exposure to daylight or light enriched in blue spectrum pineal gland is prevented from producing melatonin and we feel alert and awake. On the contrary, when light is not detected in SCN, pineal gland is producing melatonin, thus we feel drowsy and sleepy. During the natural process of aging SCN may deteriorate and thus light exposure decreases causing disruption of circadian rhythms. Moreover melatonin moderately decreases with aging resulting in circadian rhythm sleep disturbances (Bombois, 2010).

Entrainment depends on several factors, such as exposure time, time of the day and wavelength. According to studies SCN regulation is best maintained by high brightness and short wavelengths with peak sensitivity at 480nm, moreover the most powerful signal is defined as bright light, such as morning daylight (Livingston, 2014). Although daylight in the morning is stated to be the strongest signal, daylight spectral composition varies throughout seasons, as well as the number of daylight hours can vary depending on distance whether it is north or south Equator (Wurtman, 1975).

Elderly with dementia are spending most of their time indoors, and thus they are unable to receive sufficient light intensity that adjusts their circadian rhythm (Mishima et al. 2001). The factors of inadequate exposure that affect elderly in a study conducted by Mishima are stated as high incident angle of sunlight, decreased sun intensities through windows and little time spent outdoors (Mishima et al. 2001). According to Shockat, some nursing home environments provide a light intensity of a median of 54 lux, and the residents spend a median of 10.5 minutes in light settings over 1000 lux, and a median of 4 minutes in light over 2000 lux (Shochat et al. 2000).

Access to daylight and outdoors could be one of the ways helping to tackle disrupted circadian rhythm. Although, knowing the characteristics of elderly with dementia, especially the confusion that comes with not being able to understand natural phenomenons anymore, as well as resources needed to supervise and encourage elderly with dementia to go outdoors leads to another potential solution for stabilizing circadian rhythm. Various studies present successful methods of supporting circadian rhythm by using electric light, and those will be presented in the Electric light chapter.

## Seasonal affective disorder

Seasonal affective disorder (SAD) is defined as seasonal depression, which appears due to lack of adequate exposure to light, particularly light which is rich in blue content, that is closely related to endocrinal system. SAD for the first time was mentioned quite recently, in 1981 by Rosenthal, where he describes it as depression caused by lack of daylight (Rosenthal, 1981). SAD is characterized as emotional disorder, winter SAD demonstrates symptoms of depression, drastic mood swings, oversleeping, over-eating, and low energy. Whereas summer symptoms tend to be opposite, such as weight loss, loss of appetite and lack of sleep (Torrington, 2007). According to a study done by Rosen, participants of the SAD study reported that they felt worst during winter months, rather than summer (Rosen, 1990). It is noticed that effects of SAD disappear during summer and recur during autumn and predominantly are found in people that live at latitudes further away from the equator (Mersch,et al. 1999). Seasonal affective disorder is most often found in northern latitudes (Boubekri, 2008). Study conducted in Norway has shown that higher prevalence of winter depression is estimated in the northern counties than in southern (Lingjaerde, 1986). According to Dam, 12% of Danish population suffers from SAD (Dam, 1998). Several factors are responsible for the winter SAD, such as length of the day (photoperiod) is shorter, sunlight intensity is reduced and lastly the cold weather that limits the time most people spend outdoors (Eastman, 1990).

When talking about elderly with dementia, SAD can lead to accretion of dementia symptoms. Studies discuss effects of depression such as, cognitive impairments occur with depression, short term and long term memory is affected, decision making, psychomotor speed (O'Brien, 1993). As winter SAD is more predominant than summer, the missing stimulus of daylight can be supplemented with electric light according to available studies. Light therapy will be discussed further in the Electric light chapter.

# Electric light

This chapter aims to investigate and define characteristics of electric light that are best suitable for elderly people suffering from dementia and in the meantime can support wellbeing and ease day to day activities of institutionalized dementia patients.

The benefits of bright artificial light are discussed in various studies, where the findings promote better nutrition, prevention of falls and modification of behavioral issues (Brush, 2002; Marquardt, 2011). As mentioned before, the natural process of aging leads to deterioration of vision, which results in increased need of illuminance levels for elderly to perform activities and orientate in space. According to Turner, illuminance levels for elderly compared to younger people should be doubled to achieve the same visual response (Turner, 2008).

## Lighting for elderly

Specific illuminance levels for good vision that allows interpretation of the environment are descripted by Marquardt, according to empirical evidence and practical experience, sufficient ambient light is 500 lux, and up to 2000 lux in activity areas (Marquardt, 2011). Different approach is taken in a study done by De Lepeleire, where European lighting standards EN12464-1 were used as a reference and increased by 55%, considering that individuals need for light advances by 1% every year. In this study it is stated that activity areas should be lit with minimum 775 lux and general lighting should be minimum 155 lux (De Lepeleire, 2007). Another study presents answers from respondents of the survey, where one of the respondents discloses that ambient light should be 500 lux or more and task light 750 lux or more (Bowes, 2017). Higher illuminance numbers are presented in study by Benbow, where he states that ambient lighting should have values ranging from 320 to 750 lux, whereas task lighting should be between 550 to 1100 lux (Benbow, 2014).

There is not much evidence available providing specific illuminance numbers for dementia care units. Although it is clear that the preferences and needs for illuminance levels are individual and can vary from person to person. Bowes in her study emphasizes that not all of the residents preferred bright light and it was important for them have control of light and be able to set appropriate light levels: “one woman, for example, preferred to sit in near-darkness, which was more comfortable for her given the particular problems she had with her eyesight” (Bowes, 2017 p.916). Literature review leads to the conclusion that there is little knowledge on specific guidelines concerning illuminance levels, but most importantly electric light design should be person-centered and available recommendations therefore should be personalized and flexible to suit individual needs of elderly.

Besides brightness (illuminance) of light, correlated color temperature (CCT) influences how the space is perceived and guides one’s emotions. Same place with different CCT can be perceived visually and emotionally in a very distinctive way. In a luminous environment with lower CCT people generally feel more comfortable, relaxed, and warm, whereas higher CCT provides a cooler environment, which can improve concentration and create a better environment for working.

Light when designing for elderly should have a high CRI. The aim should be a CRI higher than 70 due to yellowing of the lens (Benbow, 2014). Higher CRI values can help elderly distinguish and perceive colors easier. Baucom states that good color rendering light can help elderly to see more clearly (Baucom, 1996). Another important aspect is contrast. Elderly people frequently develop diminished sensitivity to contrast, struggle with depth perception and thus face issues identifying objects against background in similar color (Benbow, 2014; De Lepeleire, 2007). De Lepeleire states that higher contrast in overall results in better visual perception (De Lepeleire, 2007). As previously mentioned in a chapter about elderly vision, adaptation to different lighting scenarios takes more time, especially from bright to dim light (Benbow, 2014). Impaired dark adaptation can blind elderly people for a minute or more when moving from bright environments to dark (McMurdo, 1991). Therefore uniformity in ambient lighting is essential (Waggoner, 2002). Besides the amount of light and contrast, reflections are crucial to be considered (De Lepeleire, 2007). Elderly often struggle with increased sensitivity to glare. Reflections from specular surfaces can cause glare, as well as direct light sources, such as unshielded bulbs or daylight, which can result in discomfort, disability glare, or temporary blindness (Benbow, 2014). Glare control in environments for elderly is essential: "…not controlling glare is the biggest failure in lighting for older eyes" (Waggoner, 2002, p.4). Furthermore shadows should be avoided as they are found to confuse and frighten dementia patients and set off aggressive behaviors (McCloskey, 2004). Bowes echoes the statement before by saying that shadows caused by lighting might be misinterpreted by people with dementia (Bowes, 2017).

*Knowledge that will be implemented into the design proposal:*

- *task light between 550 - 1100 lx*
- *CRI > 70*
- *avoidance of glare*
- *well distributed light to avoid sharp shadows*

## Circadian light and circadian metrics

Electric light can be used in two contexts: treating seasonal affective disorder (SAD) and disrupted circadian rhythm. Both of those syndromes can be observed in residents of care homes and its treatment through electric light is presented below.

Treatment by exposure to artificial daylight has been found to be an effective method tackling SAD, and thus light therapy is defined to be an effective antidepressant (Rosenthal, 1984). Whereas medicational melatonin inhibition showed no positive impact on reduction of depression (Rosenthal, 1984). Light therapy is usually performed during morning time, to mimic dawn/ morning daylight, it is commonly done between 6 to 9am. The method of light therapy is found to be efficient by receiving exposure to light for 30 minutes to 3 hours daily and the positive effects are noticed after 4 weeks (Livingston, 2014). Early morning artificial bright light of 2000 lux or more provides effective treatment for SAD (Rosenthal et al. 1985; Lewy, Sack 1986). Study comparing exposure to low intensity blue enriched white light (750 lux, 17000 K) and a standard full spectrum light treatment (10000 lux, 5000 K) revealed that both settings are equally effective (Meesters, 2011).

In care homes for elderly people and especially those suffering from dementia it is important to provide stimulation without the need to rely on light therapy devices. Due to characteristics of dementia, such as confusion and wandering, it is rather difficult to keep patients still in front of the light box device and such therapy would require supervision (Colenda et al., 1997). Study done by Royer implements light therapy solutions for long term care units in an all-purpose room for 4 weeks, 5 days a week between 9:30 am and 10:30 am (Royer, 2012). Light therapy stimulus of blue light emitting diodes with a peak wavelength of 464 nm providing 400 lux at the eye showed significant improvement for elderly with dementia on reducing symptoms of confusion, aggression, sundowning, tension and anxiety and improved cognition (Royer, 2012). Various studies demonstrate a range of methods successfully eliminating symptoms of SAD, although there is no direct evidence that light therapy can improve depressive symptoms of dementia patients (Gasio, 2003; Royer, 2012).

When tackling circadian rhythm disturbances, therapy of exposure to bright light is a commonly used method. The positive effect of this method on dementia patients is described in a study by Minishma, where elderly with dementia were exposed to 2 hours of bright electric light of 2500 lux in the morning and 2 hours in the afternoon, which resulted in increased levels of melatonin, improved sleep at night and less sleep during the day. (Mishima et al. 2001) In the environments where light settings are 1000 lux and over, demented patients that spend more time exposed to such light scenario have fewer awakenings at night. (Shochat et al. 2000) Also unattended indirect light therapy with increased light intensity using fluorescent lamps in the living rooms of elderly centers found to stabilize rest-activity rhythm. (Van Someren, 1997) Most of the studies found indicate that a daily 2-hour exposure to bright electric light reduces behavioral disorders such as wandering at night, agitation and improves sleep – wake and rest activity patterns for elderly suffering from dementia. Improvement of behavioral disorders would significantly enhance quality of life and well-being of the elderly. Besides illuminance values, color temperature is crucial in light therapy for disturbed circadian rhythm. High CCT is preferred and is found to have a greater effect (Benbow, 2014). Study aiming to support circadian rhythm in elderly care centers presents a solution of tunable CCT, where four different scenarios were used. Cool light of 6000 K was used to stimulate residents from waking hours to early afternoon, which was followed by warmer CCT of 4100 K from the afternoon until evening and even warmer temperature of 2700 K from 6pm to 8pm, night light settings were set to 2400 K (Davis, 2016). Positive effects on circadian rhythm were found by implementing high intensity light with high intensity CCT (6500 K), whereas yellowish light of

2700 K showed no effects (Van Hoof, 2009).

To ensure effectiveness of light therapy it is crucial to measure biological effects of light on humans - circadian circle. In this report the focus will be based on the circadian metric - EML. Equivalent Melanopic Lux (EML) is based on melanopic response of ipRGCs (intrinsically photosensitive retinal ganglion cells), which have their peak at 480 nm. It is measured at the eye level on the vertical plane. Assumed height is 1.2m above the ground, which is equal to the eye level of a seated person.

The report further follows melanopic light intensity standards from WELL. EML value requirements are similar for living environments, breakrooms, and learning areas. Requirements for work areas can be seen in figure x. One of the following must be fulfilled in order to meet the requirement (75 percent or for all workstations).

| Requirements for work areas | | | |
|---|---|---|---|
| Tables | EML value | Plane | Time |
| At 75 percent or more of workstations | ≥ EML= 200 (including daylight if present) | at 120 cm above the floor facing forward | 9:00 AM and 1:00 PM for every day of the year |
| For all workstations | ≥ EML = 150 | the vertical plane facing forward | maintained |

Fig. 6 Requirements for work areas based on WELL standard

EML will be used throughout this report as it is focusing on different spectral distributions and it is widely referred to in the lighting industry today with official standards. Aspects of circadian light are incorporated into the design proposal of general light for stimulating alertness while meeting visual needs of the aging eye.

# Nature

Many studies prove that the environment is an important factor that influences daily well-being and perception of the quality of life of people with dementia (Kolanowski, Whall, 2000). Environmental factors that have an impact on a person also include the experience of nature (Bossen, 2010). Being surrounded by nature contributes to a sense of normalcy while suffering from dementia (Duggan, Blackman, Martyr, Van Schaik, 2008).

Further topics related to nature and dementia are discussed in this report. Areas of biophilic design and horticulture are intersecting each other and have many aspects in common. There are some differences though. Figure 7 shows interrelation of those two subjects. Main difference is that horticulture includes an active component – gardening, which can provide elderly multisensory experience.

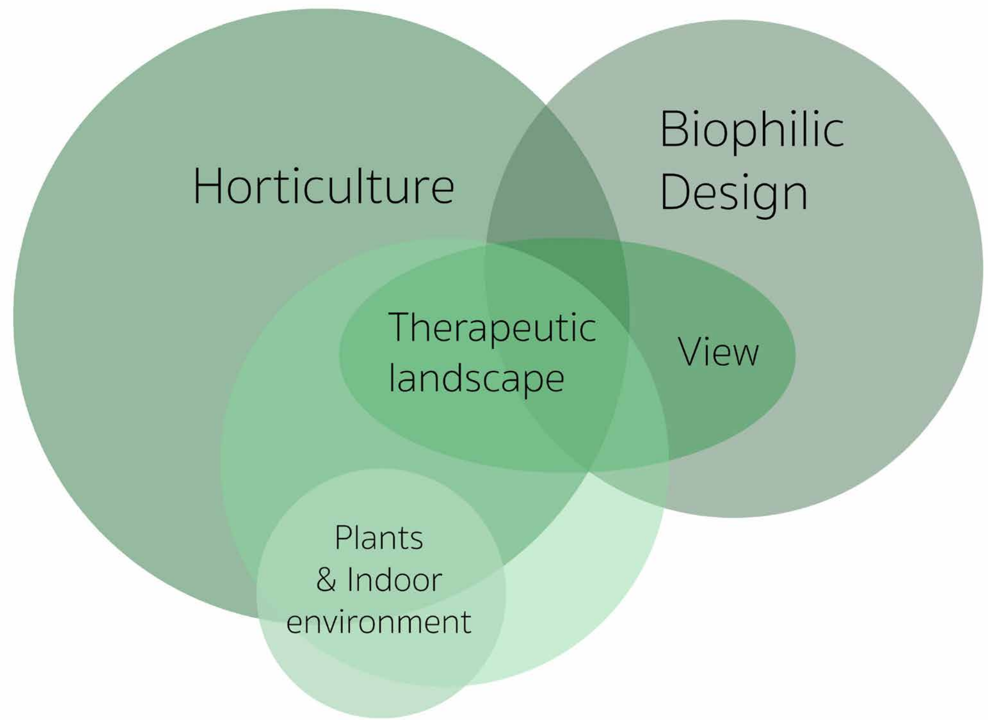



Fig. 7 Diagram of nature topics in research

There are many approaches to therapy for residents of care homes. The most crucial aspect is to understand the physical and mental needs of the elderly. Understanding environmental preferences and desired activities that are described in following chapters can help with enhancing the overall well-being of the residents.

## Biophilic design

The history of biophilic design dates all the way back to the 19th century, which was a remarkable period for health care architecture. Art Nouveau abounded in biomorphic forms visible in building elements and details (Terrapin Bright Green, 2014). Simultaneously experiencing nature in the mountains or seashore became a popular trend. Therefore bringing natural elements like views of greenery or daylight became an inseparable part of hospital design.

Thanks to biologist Edward Wilson the term biophilia became popular (Wilson, 1984). The term biophilia describes “innate tendency to focus on life and lifelike processes” (Wilson, 1984). The emotional reactions evoked by nature are related to instincts that were developed during the evolutionary process and natural selection of humans (Wilson, 2002). Therefore, according to Wilson, people feel bound to nature (Wilson, 2002). Wilson’s theory became a basis for different studies. One of them was conducted by Roger Ulrich. He performed a landmark study, where he was comparing recovery time of patients in rooms with and without view to nature (Ulrich, 1984). Findings of the following study assured many scientists of the healing power of nature.

Biophilic design can be divided into three categories:

- *Nature in the Space,*
- *Natural Analogues,*
- *Nature of the Space (Terrapin Bright Green, 2014)*

Those categories consist of 14 patterns and serve as a framework for the purpose of incorporating biophilia into a building environment.

In this projects the focus is based on the following patterns:

- *1. Visual connection with nature*
- *6. Dynamic and diffused light*
- *9. Material connection with nature*

*Visual connection with nature*

Through increasing levels of biodiversity in a space, fx indoor space, the psychological benefits of experiencing nature can be achieved even in a dense city structure. (Fuller et al., 2007). According to research, scenes with nature stimulate the visual cortex more intensively than non-nature views since they are activating pleasure receptors in our brain. The main purpose of this pattern is to shift focus to natural view, which will relax eye muscles and help with cognitive fatigue (Terrapin Bright Green, 2014).

One of the ways for working with this pattern is to ensure that the set up of furniture isn't blocking the view, which is also kept when users are in sitting position (Terrapin Bright Green, 2014). The "view" can be both related to outdoors and indoors. As the intention is to implement the greenery indoors, the plants will be also exposed to provide easy visual access.

*Dynamic & Diffuse Light*

Dynamic lighting creates significant conditions of variable shadows and intensities that shift during a day. This has a relation of expression of time and movement, which creates different scenarios, from dramatic to calming ones (Terrapin Bright Green, 2014). The pattern has its origin in features of daylight, moonlight, fire and seasonal light. Thus its focus is on maintaining circadian rhythm and stimulating the eye for evoking positive reactions.
A part of our work is focused on strengthening this pattern through supporting daylight with electric light. With this approach we aim to create a smoother transition between indoor and outdoor environments.

*Material connection with nature*

A pattern "Material connection with nature" relates to materials and elements in the designed surrounding that reminds of a local habitat (Terrapin Bright Green, 2014). Interior filled with natural materials can stimulate a sense of touch. More and more research is appearing about the impact of the interior products in a space on a participant. Human receptors can recognize a difference between synthetic and real material. Therefore it is preferred to use natural materials (Terrapin Bright Green, 2014).

This pattern inspires us to use natural materials in our design process.

## Views

Views of natural objects are triggering emotional, psychological and physiological processes (Kaplan, 2001). When a human being is recognizing natural environment as a not threatening one, it responses with positive emotions and arousal which creates changes in activity levels, decreases negative thoughts and emotions and moreover increases sustained attention (Berto, 2007; Kaplan, 2001; Rappe & Topo, 2007; Ulrich, 1984). Such emotional responses would be useful in everyday life for the dementia care home residents.

Caretakers' awareness of the impact of experiencing a natural environment on people with dementia is very important. The employees of nursing homes can encourage the residents to do different activities by the view to the outdoors. Just a view from a window and fresh air can be a natural stimulus. According to Bossen, implementing natural multisensory stimulation can enhance quality of life and its dignity, which is important for residents, especially those who have newly moved in (Bossen, 2010).

View of the greenery enhances control over the environment and has restorative and therapeutic values that can reduce discomfort (Treggenza, 2006). A study held by Chalfont focusing on the care home institutions found that just the presence of a window with a view can activate different social interactions and provide topics for conversations (Chalfont, 2006). Observation of the view of the garden from a well-known indoor area can help with recognizing the time of the day and the season. Many residents with dementia may suffer from short-term memory loss. Some people can even forget that there is an opportunity for outdoor green space, thus the view can remind them about it every day (Chalfont 2008). A view of people performing everyday outdoor activities or a view of trees showed great interest for residents of care homes. The most preferred situation was one with a view to people outside fx., when they are on the way to work or school. View of the entrance area is also very attractive (Chalfont 2008).

Position of the window is an important aspect in care home environments. Windows that are positioned at the end of the corridor can cause unpleasant reflections on glossy surfaces and unable recognition of objects and people can be perceived as silhouettes, which can be really misleading for the elderly (Torrington, Treggenza, 2007).

## Horticulture

Natural surroundings were used through centuries differently, according to cultural needs and beliefs. Between the 17th and 20th century elements like green landscape, daylight and fresh air - was a component of treatment at hospitals and sanatorium parks (Söderback. et al 2004). This can be considered as an origin of horticultural therapy.

Horticultural therapy is an active program that is implemented in different healthcare institutions, including residential places (Simson, Straus,1997). The whole process of the therapy is considered as a therapeutic activity and it is a part of the overall structure of treatment at residential institutions (Relf, 1978). Horticulture is improving mental health and well-being. This type of therapy involves gardening which can contribute to social and general health benefits (Haas & McCartney, 1996; Lewis & Mattson, 1988; Ryan, 1992). Therefore it is considered to improve cognitive and psychosocial abilities of people suffering from dementia (Yasukawa 2009).Not only the activities involving nature elements, but also its physical setting is healing.

Relf writes in "Cultural learning theory" that preference for known flowers or trees comes from the fact that the environment where humans developed feels more natural and adaptable (Relf, 1992). Theory called "the living environment", based on this statement,  suggests that surroundings should be designed to evoke memories from a period before severe stages of dementia (Relf, 1992).

Horticultural therapy is suitable for elderly, especially for those with cognitive disorders, since it can be easily modified so everyone can participate in it, no matter of different inabilities (Jarrott et al.2002). Tasks are adjusted according to the level of the disease so they can feel meaningful and therefore stimulate diverse actions in the thinking process (Jarrott et al.2002). Sensory stimulation is a big part of the process. Elderly can be exposed to contact with different flowers, which will stimulate a sense of sight and smell. Those sensations can evoke different memories from previous environments. Sense of touch can be activated by experiencing textures of plants and analysing their texture. This activity can be extended to barefoot walking on different surfaces (Söderback. et al 2004). Cultivation of fruits and vegetables is also a part of this therapy. It can give a lot of satisfaction from growing and then eating crops of your own work (Söderback. et al 2004).

Therapy should be adjusted to the abilities of the residents. Activities should be really simple and small in the start to encourage patients (Refl, Dorn, 1995). Even those who are not able to participate in the activities, can benefit just from passive watching. This can contribute to psychological benefits that will encourage further observation of plants and later might result in willingness to participate in taking care of the greenery (Refl, Dorn, 1995). Exercises of gardening can show elderly - that they are still valuable to the community and they are part of it (Refl, Dorn, 1995). The most motivational activities noted are potting plants and flower arrangement (Relf (Hefley) 1973; Relf, 1978).

# Therapeutic landscapes

A study performed by Cohen- Mansfield and Werner showed that residents who were spending their time outdoors were in a better mood and pacing behavior (Cohen- Mansfield,Werner 1998). When they were denied to go outside, they reacted with physical and verbal aggression (Cohen- Mansfield, Werner 1998). Researchers concluded that residents experienced physical and mental benefits from exposure to daylight, weather changes, and contact with earth and plants (McMinn and Hinton 2000).

Researchers Mooney and Nicell (1992) conducted an examination of violent incidents that occurred in five care homes for residents with Alzheimer's disease. The research showed a significant difference between institutions with and without gardens. Violent incidents increased by  681% in nursing homes without gardens, whereas in places with gardens violence dropped by 19% during the period 1989-1990. This led to the conclusion that the green spaces can be and started being used for calming and help manage behavioral problems of the residents (Lovering et al. 2002).

Specific guidelines should be considered while designing an outdoor space for people with dementia. The disease makes it difficult to plan the activity, which involves putting on appropriate clothes and finding the way outside. Spending time outdoors would be more likely if it is implemented into the program, where residents are taking part in meaningful activities with the assistance of the employees (Connell, Sanford, and Lewis 2007, 199).

Staff's attitude and organizational policy are as important as encouraging spending time outdoors. Some institutions are keeping their doors closed in order to prevent escaping or being afraid of residents being alone outdoors (Grant and Wineman 2007). This can lead to nonuse of the garden in the therapy. Promoting residents' independence and encouraging them to go out together with programmed activities in gardens can solve this problem and teach the elderly how to behave outdoors (Grant and Wineman 2007).

Gardens designed for Alzheimer's patients have different structures than traditional ones, which are characterized by many explorational paths. The most comfortable layout would be without any hidden areas which can easily cause confusion, disorientation, and loss of trackback home (Furness and Moriarty 2006). Entry doors can be designed as a landmark so they can help in the wayfinding process (Cooper Marcus, Sachs 2014). Status and plants of unfamiliar shapes should be avoided since their shadows can cause agitation.

Spending time outdoors can recall many childhood memories. Watching the landscape and seeing the horizon is a part of everyone's life. Outdoor activities would be very beneficial for the residents. Many seats would be a great help for the elderly. They should be placed at a regular frequency in a variety of shapes. Some of them could be movable to adjust to personal needs (Cooper Marcus, Sachs 2014).

Toxic plants should be avoided both indoors and outdoors (Parson, Ulrich, Tassinary 1994). Residents have a tendency to touch everything and even in the late stages put objects in their mouths (Cooper Marcus, Sachs 2014).  Also sharp-leafed or thorny plants should not be used in care home environments as they can be harmful to the skin, which is much thinner at old age.

Plants can be also used in therapy as they can remind of the past (Cooper Marcus, Sachs 2014). All those colors and smells are triggering senses and changing the perception of the space. Though the intensive smell should be avoided.

In the further design process we incorporate the following knowledge and aim to develop an easily accessible outdoor area that is filled with greenery and would have a positive impact on elderly with dementia.

## Plants & indoor environment

Not without a reason, many people decorate their homes with plants. People are connected to natural things as it is an enormous part of the physical world (Wilson, 1984).

Residents of the care homes are often denied such attractions. Moving from home into a care home institution can be a hard and confusing process, especially for the elderly with dementia. Many new residents during their first weeks are waiting until they will be picked up by family members, who will take them home. They are rejecting unfamiliar environments (Bhatti, 2006). Plants and gardening are often a reminder of activities from home. Therefore, use of plants in care home environments can be a successful method for reconstructing life in a new environment.

Domestic spaces filled with nature are affecting different emotions and needs. The most significant are "sense of continuity and choice" and "a significant influence on an older person's sense of determination" (Percival, 2002). Moreover, daily use of green areas is contributing to spiritual and emotional well-being (Sixsmith, 1991). Therefore, the importance of being with nature should be highlighted to all care providers as it has both restorative and healing effects (Kaplan, 1995, 2001).

Maintaining plants in good conditions is also evoking a sense of self-determination and observing the growth of the greenery is bringing a lot of joy and satisfaction (Percival, 2002). Watering plants brings a lot of positive feelings and a sense of responsibility to the elderly (Cooper Marcus, Sachs 2014). Because of the risk of overwatering the indoor plants should tolerate excessive watering (Rappe, 2004).

Benefits mentioned above can contribute to improved quality of life, which results in a healthy aging process. Hence, we incorporate plants in elderly with dementia care home as an element of our design.

# Homelike environments

Dementia makes it challenging for people suffering from it to live at home, given increased risk of self-harm, such as falls, forgetting turned on cooking appliances, running taps, and getting lost and confused. Increased cognitive declination, interest in improving well being for people suffering from dementia and the need for additional support are some of the primary reasons for institutionalization (Reimer, 2004).

Institutionalization is a profound change in life for elderly people. Moving to an unfamiliar environment can often be a stressful experience that can result in shock, withdrawal and anger (Hadjri, 2015). In fact, many of the behaviours associated with people suffering from dementia, partly is a consequence of institutional long-term care environments (Cohen, 1993; Day K, 2002). Growing evidence elaborates on physical environments and social care milieu effects, which can enhance or diminish life quality for demented people. One of the important aspects of the environment for people with dementia is "homeliness", a setting that makes the environment feel more like at home and less like an institution (Kelly, 2011).

A number of benefits of homelike environments are emphasized throughout literature. Calkins affirms that due to increased difficulties for people with dementia to adapt to changes, an environment that is continuous and can be related to the past will be less traumatic (Calkins, 1988). Another study states that recreation of domestic home qualities may be helpful in decreasing disorientation (Taft, 1993). Coons emphasizes familiarity of features such as sounds, aromas, visual cues and personal belongings and claims that it helps to encourage positive behaviours and helps residents to maintain their identities (Coons, 1990). Nonetheless, social interactions, meaningful activities can be encouraged, and personal associations triggered with objects that are familiar, as well as acquaint activities and spaces (Cohen, 1990). Study done by Morgan states that residents of care units feel less anxious in a homelike setting, because it is familiar to them (Morgan, 1999). Participants of the study stated that occupants of care units wish to live in homely environments that are personalized and help them feel at home, moreover, staff of care homes feel more joyful coming to work to environments that are perceived as homely, friendly, and comfortable (Hadjri, 2015). Hadjri states that it is undoubtful that design of home environments contributes to the wellbeing and functionality of people with dementia (Hadjri, 2015).

Interior design features highly contribute to a homelike setting, such as fabric valances instead of vertical blinds, carpets on the floor, domestic style lighting fixtures (Morgan, 1999; Schwarz, 2004; Kelly, 2011) Decorated public areas, planted flowers do as well contribute to homely and welcoming atmosphere, as well as usage of furniture and fitting that are found in home environments (Hadjri, 2015). Therefore, in our design we aim to incorporate familiar objects such as pendants, curtains and use plants as an element contributing to homeliness.

# Danish characteristics

## Light and atmosphere

Light and darkness can transform the environment in multiple ways. Light conditions have an influence on how we perceive space, different light levels change the appearance, and the spaces can appear bright, gloomy, or dark, thus each of these settings affect the atmosphere in distinctive ways. Absence of light can condition an environment that is perceived as intimate: “the curation of a home as a space for relaxation may be predicated on the ability to have intimate relations with others in the dark.” (Shaw, 2014, p.10). Whereas uniform light in space on the contrary creates a public, institutional atmosphere impression, yet when aiming to form a private atmosphere at home it should be avoided. Concept of light topography, also known as light zones, can be used as a valuable method whilst creating atmospheric lighting (Edensor, 2015). Other crucially important aspects in designing atmospheres with light are characteristics of light, such as illuminance levels, spatial distribution, darkness and brightness contrast, interplay of light and surface colours, highlighting objects or surfaces (Wänström, 2012).

In Denmark in winter daylight hours are very short, sun sets around 3.30 pm, as the darkness rules in winter season, light becomes a matter of importance. Danes have a strong tradition in creating a cozy, home like atmosphere by using light at home. The famous term hygge (cozy) plays a very important role and helps to overcome darkness during short daylight hours seasons (Billie, 2014). Hyggeligt (cozy) atmosphere and sense of being secure at homes is created by using candles in Denmark, in fact more than half of danish population light up candles almost daily during autumn and winter (Wiking, 2016). Although, it is not only the candles that contribute to a cozy atmosphere, in general Danes admire and pay a high attention to lighting. Development of atmosphere starts with careful selection of luminaires and thoughtful placement in space, and it all contributes to coziness:

*“When, in the evening, from the top of a tram car, you look into all the homes on the first floor, you shudder at how dismal people’s homes are. Furniture, style, carpets – everything in the home is unimportant, compared to the positioning of the lighting.”*

*~Poul Henningsen*

It is rather rare to find a private home in Denmark with uniform lighting, mostly the light will be arranged in zones, creating small caves of light around the room. Strong dining tradition and extensive time spent by the dinner table is as well supported by atmospheric light. Commonly pendants are hung above the dining table emitting a really warm colour temperature of 1800 kelvin creating a cozy, intimate and private atmosphere’ (Wiking, 2016).

We aim to implement this knowledge about the traditional danish lighting  for the development of atmospheric, homelike lighting design further in our process.

# Nature

Danmark is a country without mountains, where the highest hill reaches 172 m above sea level. Even though the landscape is quite simple, vegetation differs in various parts of the country. It happens because of a variety of soils, mainly limestone, loamy, clayey sand sand. The only part with a solid rock surface is Bornholm.
During the Atlantic period (around 5000 years ago) Denmark was covered with primeval broadleaved forest . Most popular species were the Small-leaved Lime (Tilia cordata), Large-leaved Lime (Tilia platyphylla), Wych Elm (Ulmus glabra), Small-leaved Elm (U. carpinifolia), Pedunculate Oak (Quercus robur) and Ash (Fraxinus excelsior).

The Atlantic period was a beginning of cultivation of the land and usage of forest. 2500 years ago climate started to change during a Subatlantic period. Colder temperatures resulted in change of the flora. The most dominant tree became the Beech (Fagus sylvatica), and it is still today's most common tree. Cultivation of the land created a more open landscape where light-dependent plants and fields of grass found their place. Nowadays only coasts are places of natural vegetation.

A common flower that can be found in Denmark is a wild orchid. There is an area near Copenhagen, Gentofte, where they can be seen. They appear on the shores of lakes and wet meadows. Two native species are the common spotted orchid (Dactylorhiza maculata ssp. fuchsii) and the northern marsh orchid (Dactylorhiza purpurella). Both of them have a purple color and spots on flowers. Another common flower is early coralroot (Corallorhiza trifida) with yellow flowers.

This research aiming to find the characteristics of Danish nature has inspired us to further investigate the biodiversities present in the surroundings of our case study. We expect that found flora will be perceived as familiar for elderly living at Nældebjerg care home and thus contribute to a familiar home-like atmosphere development.

# Synthesis for analytical framework

In the analytical framework chapter different research findings and theories have been reviewed and covered topics of light, its physiological effects, circadian rhythm and impact of nature on human physiology and psychology. Those subjects have been explored separately and this synthesis aims to investigate the knowledge of variable criteria affecting each subject and indicate the similarities and differences in presented research.

Dementia is a broad term that is describing the loss of memory, problem-solving, or language abilities that are impeding everyday life. Although the disease is irreversible, early diagnosis is giving access to the treatment and rehabilitation process. Explanation of behavioral changes and proper environment features are raising life quality and delaying severe symptoms. Therefore, it is important to provide the best environment. Light plays a crucial role since elderly have imparied vision. The lens is accumulating yellow pigment and becoming cloudier. This is a reason for a need of high illuminance values and avoidance of glare.

The most important aspect of daylight is that it influences circadian rhythm. Disturbed sleep cycles are the primary causes of institutionalization for people suffering from dementia. During the natural process of aging SCN may deteriorate and thus light exposure decreases causing disruption of circadian rhythms. Melatonin slowly decreases with aging resulting in circadian rhythm sleep disturbances. Since daylight improves depressive symptoms and cognitive functions for elderly, it could be used as a part of therapy to diminish some of the symptoms of the disease.

Both disrupted circadian rhythm and seasonal affective disorder can be treated by using electric light therapy. The scientific evidence says that depressive symptoms can not be treated with electric light, but the therapy does help to normalize sleeping patterns, wandering and other symptoms of dementia. Light therapy is usually performed through exposure to bright light mimicking daylight during morning hours. High intensities (1000 -2500 lx) are used. Tunable correlated color temperature can be used and can help to strengthen understanding of the passage of time. Cool CCT (6500-6000k) is used to stimulate alertness and has positive effects on circadian rhythm, whereas warm cct (2700k and lower) does not provide the stimuli and melatonin generation begins. Circadian metrics are helpful for adjusting the intensity of light. Further in the analysis the focus is on EML. It is based on the melanopic response of ipRGCs, which have their peak at 480 nm. It is measured at the eye level on the vertical plane. According to the WELL standard EML should be equal to 200 equivalent melanopic lux at the workstation.

Environment is an important factor that influences daily well-being and perception of the quality of life of people with dementia.  Biophilic design describes innate human tendency to affiliate with life and lifelike processes to create body-mind connection. One of the aspects connected to biophilia is a view of nature, daylight and preference of natural materials. Research shows that just the presence of a window with a view can activate different social interactions, like sitting in a group close to the window and a view from it is provided with topics for conversations.

Horticultural therapy is an active program that is implemented in different healthcare institutions, including residential places. It is improving mental and physical health and well-being. This type of therapy involves gardening and being surrounded by nature, which can contribute to social and general health benefits. Therefore it is considered to improve cognitive and psychosocial abilities of people suffering from dementia.  Plants indoors can help to create a homelike atmosphere and contribute to emotional well-being. Plants in elderly with dementia care environments have to be carefully chosen - avoid poisonous and thorny plants that can cause damage to the skin.

Institutionalization is a profound change in life for elderly people. A number of benefits of homelike environments are emphasized throughout literature. An environment that is continuous and can be related to the past will be less traumatic and may be helpful in decreasing disorientation. Interior design features highly contribute to a homelike setting, such as fabric valances instead of vertical blinds, carpets on the floor, domestic style lighting fixtures. Uniformed light distribution usually reminds of a public space. Absence of light is creating an intimate atmosphere and thus shape a place for relaxation. Other crucially important aspects in designing atmospheres with light are characteristics of light, such as illuminance levels, spatial distribution, darkness and brightness contrast, interplay of light and surface colours, highlighting objects or surfaces.

Danes have a strong tradition in creating a cozy, home like atmosphere by using light at home. Hyggeligt (cozy) atmosphere and sense of being secure at homes is created by using pools of light conceived with pendants and warm color temperature.

# Criterias

Extracted knowledge from the analytical framework helped to create theoretical criteria,  which we have summarised below. They work as guidelines for our design proposal for dementia care home - Nældebjerg plejecenter. These criterias do as well help to create a framework for tests and analysis of the space, ensuring that initial research questions stated in the first chapter will be successfully answered.

Criterias are divided into the four focus areas stated in a Vision:

- *Connection to nature*
- *Enriching circadian rhythm stimulus by daylight supported with electric light*
- *Supporting visual needs of aged eye to perform tasks*
- *Atmospheric environment creating homeliness*

# Connection to nature

- Local plants
- Accessibility to outdoors view
- Passage of the time
- Comfortable conditions of outdoor environment

Fig. 8 Connection to nature

## Enriching circadian rhythm stimulus by daylight supported with electric light

- Cool light in morning hours
- Zones of light to meet different needs and functions of the space

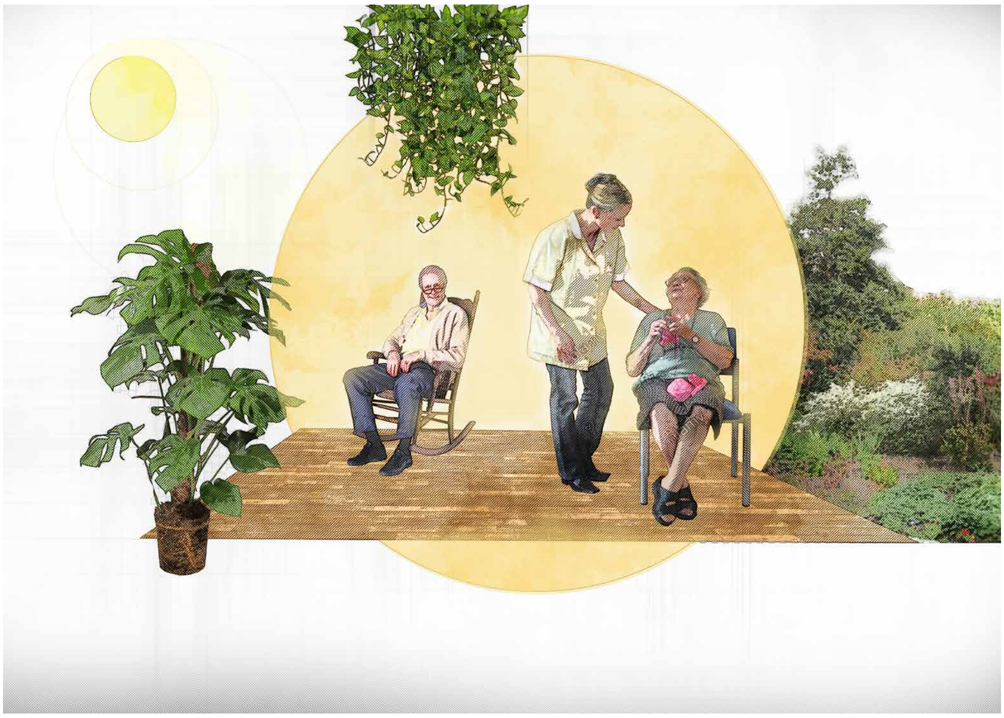


Fig. 9 Stimulus by daylight

## Supporting visual needs of aged eye to perform tasks

- Avoid glare
- Low contrast ratio
- Higher illuminance to perform tasks

## Atmospheric environment creating homeliness

- Creating familiar lighting environment
- Cozy atmosphere - warm light
- Familiar shading system
- Easy control over the space

Fig. 10 Visual needs and atmospheric environment

# Chapter 3
## Analyses

The material in the following section is material that we have received from Nældebjerg plejecenter, information found on the Greve kommune website and analyses - simulations, calculations that were performed by recreating a 3D model based on original floor plans, elevations and sections. The space of case study was analysed based on floor plans, and simulation that we have performed - current daylight factor conditions and shadow analyses. To support lacking information from physical observations, with expectations that older dementia elderly centers comprehend similar environments, a co-case study of Virumgård plejecenter is presented in this chapter. Due to the possibility to physically access the space, observations, interview and on site measurements were conducted at Virumgård elderly center.

# Case study
## Overview

Nældebjerg Plejecenter is located in Rådhusholmen 8B, Greve municipality, which is based about 21 kilometers south-west from Copenhagen. Until the 1960s Greve was primarily known as an agricultural area, the most occupied location at that time was coastal road Strandvejen, where businesses and holiday houses were located. From the late 1960s to 1970s migration from Copenhagen started into new homes built in Greve, thus quick development of the area started, districts formed. Today, Greve is known as one of the largest residential municipalities in the Greater Copenhagen area.

Nældebjerg elderly center is one of four Greve municipality dementia competences centers. Nældebjerg plejecenter was built in 1964, the building consists of building A, louisiana halfway and building B. In 2008 an extension project of building B took place. Care home consists of 57 nursing apartments and 12 apartments for residents with special needs. Apartment sizes vary between 2 rooms apartments of 53 square meters and 1 room apartments of 39 and 44 square meters. Moreover, the center includes common areas, cafe, kitchen and facility rooms.

Fig. 11 Nældebjerg plejecenter

Fig. 12 Nældebjerg plejecenter

# Space

The Selection process of the space for design has been highly influenced on following criterias, functionality and surrounding rooms, as well as daylight conditions and lastly accessibility to outdoors. Nældebjerg elderly care home as mentioned before consists of building A and building B, in the process of selecting space both buildings were analyzed.

To enable accessibility to outdoor areas we focus on spaces that are located on the ground floor, in this way providing level free access to the outdoors for all the residents of the center, including wheelchair users. Two areas that had a potential to be developed were studied in greater detail, which are staff room/ dining room in building B and cafe area in building A.

Building A mostly consists of circulation areas, common areas such as activity rooms, hobby rooms, cafe, terrace. Staff rooms are as well located in building A, although those do not have a direct access to our initial area for design - cafe, which is considered to be a positive aspect as it would not interfere nor disturb employees (Fig. 14). Moreover the cafe area provides a spacious environment with access to views as it is rich with curtain walls that also allows a great amount of daylight indoors. It as well has a direct terrace to terrace and is connected to the main entrance through the hallway. We expect that this space is or can be commonly used as a meeting point for both residents and families that come to visit their family members residing at the center. As this part of the building is filled with spaces for resident activities, a developed cafe area could encourage social interactions after scheduled activities or provide space for relaxation with a view, nature and atmospheric lighting.

Building B accommodates staff rooms, service rooms such as clinic rooms, meeting rooms and offices. Ground floor of building B includes apartments and only one common area designed for residents (Fig. 15). Initial area is way smaller compared to the area in building A, it is open space connected with the hallway and thus it does not provide separation with staff offices, meeting rooms and can cause distractions and noise. Right wing of the building hosts resident apartments, which in our perspective is a negative aspect as the functions would be mixed.

Daylight and shadow analysis highly influenced choice for design space, cafe area in building A has better satisfactory daylight factory level compared to other potential space. The space is not affected by surrounding buildings, no shadow is casted and the light allowance to indoors is higher. Precise analyses of daylight factor and shadow can be found in the following chapter.

After investigating both areas and comparing advantages and disadvantages we have decided to choose the cafe area in building A for our design.

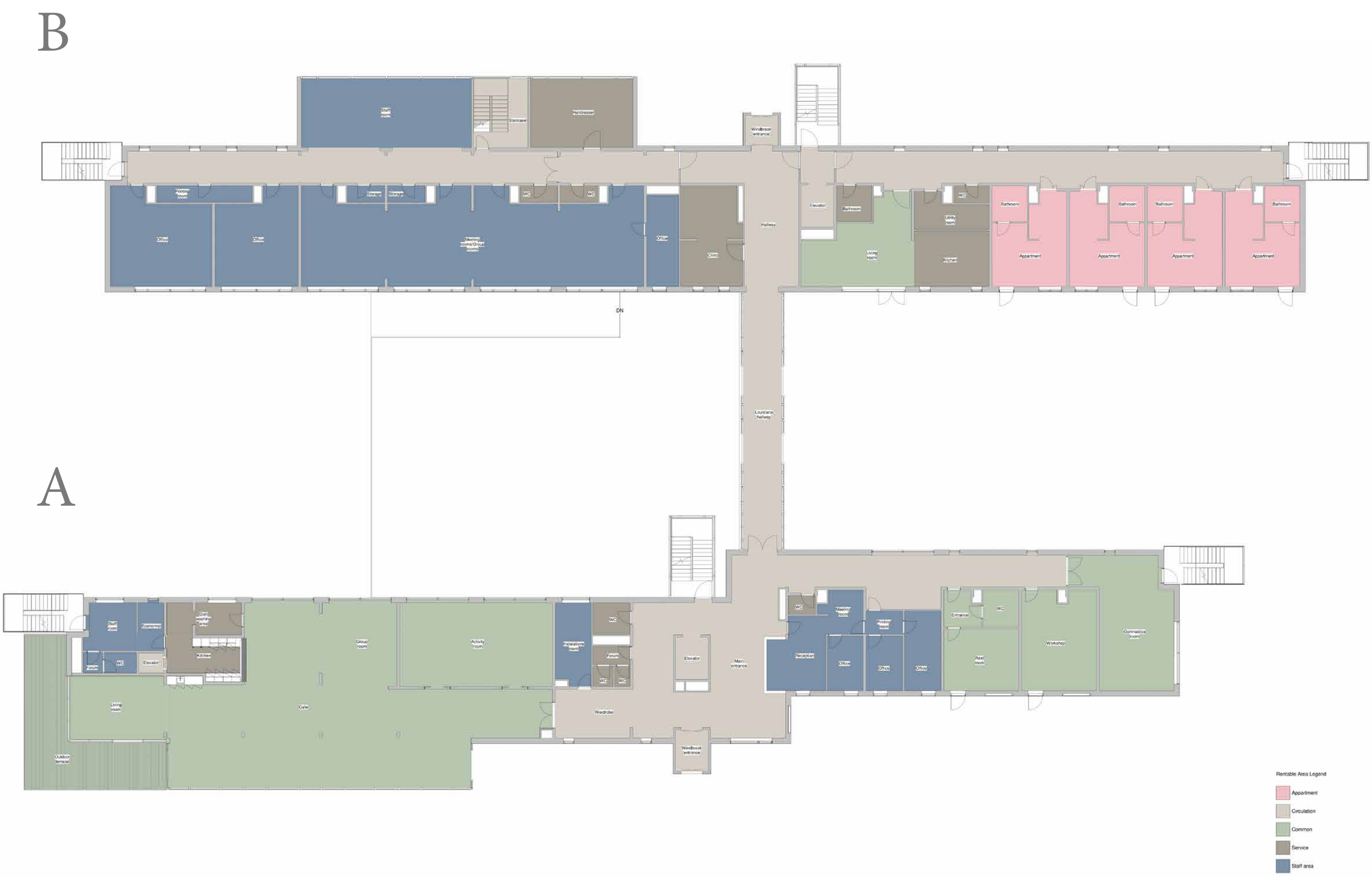



Fig. 13 Nældebjerg plejecenter ground floor - functionality

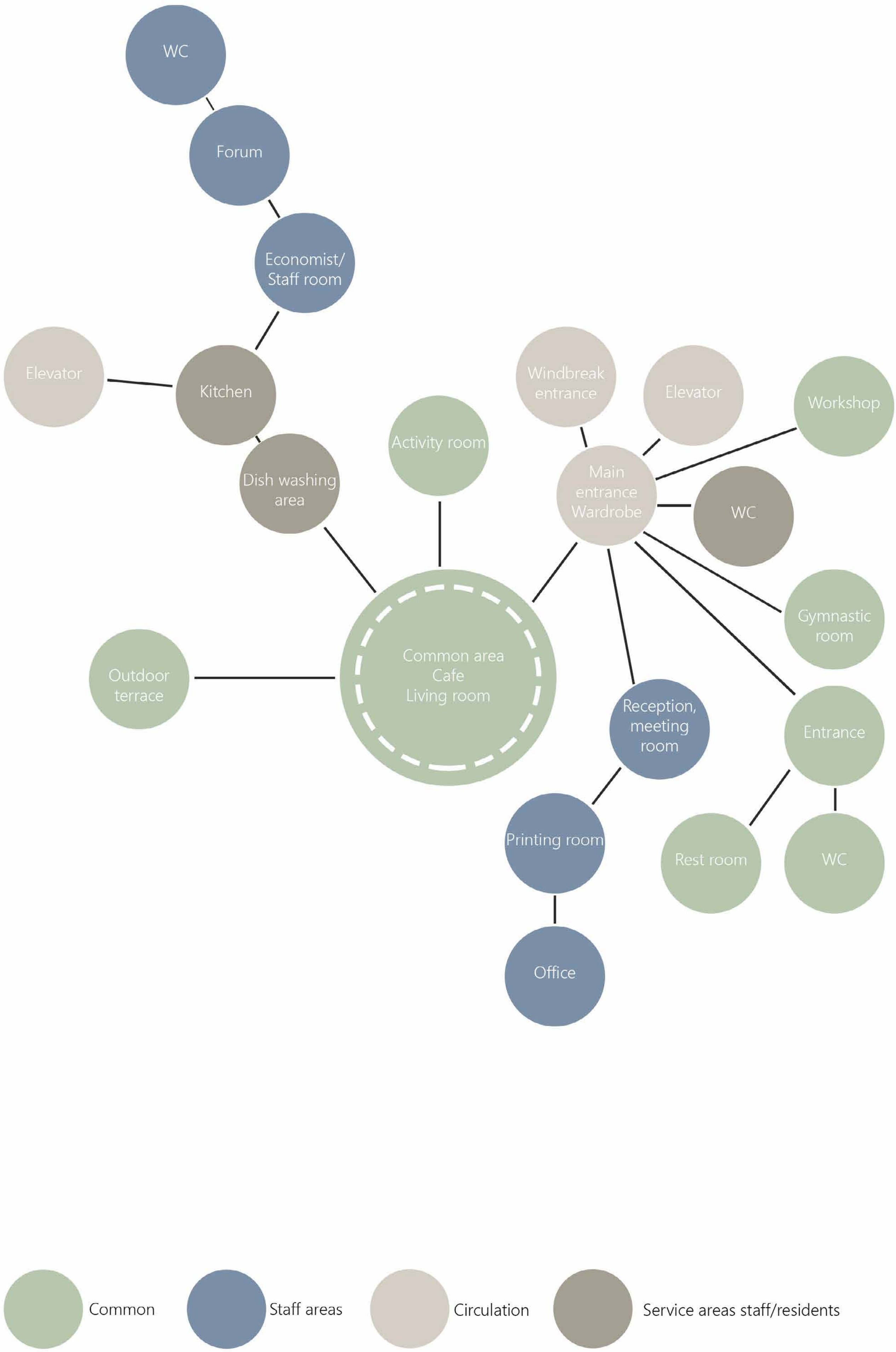



Fig. 14 Building A - areas relation

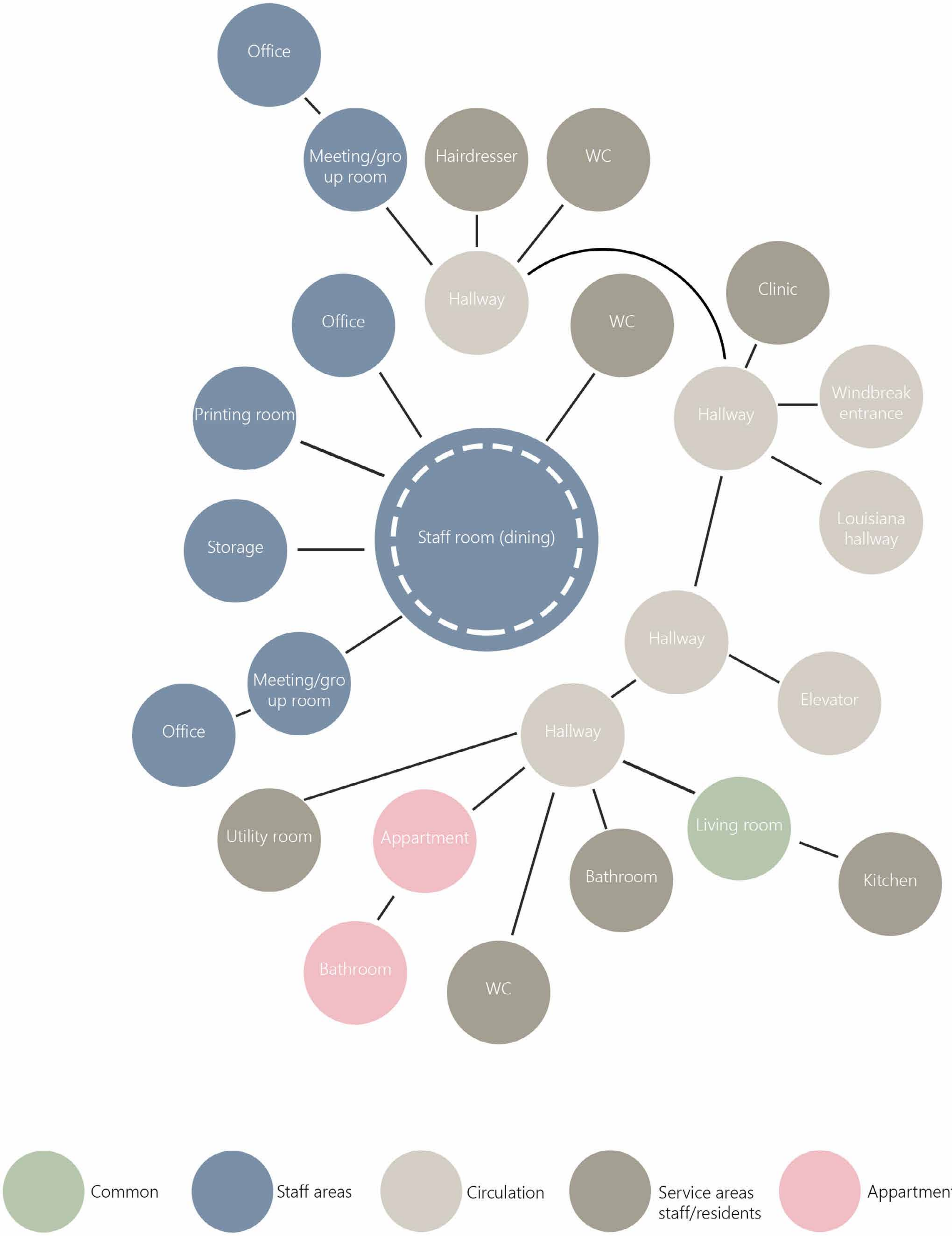



Fig. 15 Building B - areas relation

Fig. 16 Simulation of  current environment in Cafe area

Fig. 17 Simulation of  current environment in Cafe area

Fig. 18 Simulation of  current environment in Cafe area

Fig. 19 Simulation of  current environment in Cafe area

# Users

The users of an elderly care home can be categorized into three main categories, the residents - elderly people with dementia that are daily users of the space, the staff and the visitors. This report will only focus on the first group of users (elderly with dementia) since they have special needs and are the most vulnerable group that should receive environmental input that can make their daily life more pleasant and easier with the new proposed lighting design and environment.

The residents are people with varying physical, cognitive and visual abilities. The level of dementia is unknown and is expected to vary for each resident. The same situation is expected when talking about elderly vision. Natural deterioration of aging eyes can diverge to a great extent, thus the design will aim to provide solutions that are controllable and can suit individual needs, especially when it comes to task lighting.

The daily schedule of residents is expected to be flexible to some extent. Observations and working experience at co case study suggest that residents of care homes can set their own schedule according to their personal routines.  The residents have their own prefered waking up time. Although, it is known that elderly care homes do have a loose time schedule (fig. 20).

| Waking up time | Breakfast | Morning activities | Lunch | Relaxation time | Afternoon activities | Dinner | Evening activities | Sleeping time |
|---|---|---|---|---|---|---|---|---|
| ~7:00 am | ~8:00 am | 9:00 am - 12:00 pm | 12:00 pm | 13:00 - 14:00 pm | 14:00 - 17:30 pm | 17:30 pm | 18:00 - 21:00 pm | ~22:00 pm |

Fig. 20 Expected schedule at care home

In the morning, residents of care homes use common spaces to engage in different activities. Most commonly individual activities such as reading newspapers/books, hand crafts or group activities with other residents such as card games, social interactions while sitting by the table, watching television take place on a daily basis. In addition, activities with supervision of staff, such as exercising adapted to their physical abilities, singing, and events are executed periodically. During the day most commonly used spaces are dining rooms and living rooms for eating together and doing passive activities. In the afternoon and evening routines include socializing with other residents, watching television, reading whilst being in common space or at their private rooms.

The staff of elderly homes consist of skilled social and health assistants, caretakers/nurses, activity workers and maintenance staff. The staff is responsible for ensuring safety, supporting daily needs of residents, physiological and social, and taking care of them, supervising elderly throughout the day, providing medication, preparing or serving food and participating in residents activities.

# Materials

Materials and reflectance values of materials in space play a significant role in overall how the space is perceived, it influences brightness, and most importantly users comfort. Especially materials are important in this context, care home environments, as it was acknowledged in the literature research chapter. Changes in elderly vision contribute to increased sensitivity to glare and reflections. Therefore even though we did not have a chance to analyse the space physically, we did research online, looking for images taken at Nældebjerg center to find out what materials are used in the center.

Our materials research was successful and we did manage to find images from our case study - Nældebjerg plejecenter and images of the cafe area.  The environment can be defined as a standard institutional environment with white walls and white ceiling (fig. 21). The floor in the center is a wooden floor with a varnishing layer. It can clearly be seen in the image that the floor has high reflectance values and it creates bright light spots that could be visually uncomfortable and confusing for elderly with dementia (fig. 22). The reflectance values summarized in the table are based on assumptions and on DS/EN12464-1:2011 recommendations (fig. 23).

Fig. 21 Environment - Cafe area

Fig. 22 Reflections on floor

| Walls | Ceiling | Floor |
|---|---|---|
| 0,3-0,8 | 0,6-0,9 | **0,6** (DS/EN12464-1:2011 0,1-0,5) |

Fig. 23 Reflectance values of existing materials

# Quantitative measurements

## Daylight

Daylight analyses in this chapter are based on 3D simulations and visualizations made in softwares Revit and Velux. To develop a clear understanding how the space interferes with daylight throughout a year, 4 time settings were used for calculations: spring equinox, summer solstice, fall equinox, winter solstice. Daylight factor (DF) calculations provide clear information about daylight quality in a room. Another set of analyses are shadow analyses, which communicate clear message about obstructions in nearby surroundings and influence of those. Moreover we have performed analyses - survey of the movement of sunlight, which provides information of how the daylight penetrates the space during different seasons and times of the day and how the space appearance changes with variation of daylight throughout sunny and overcast weather conditions.

## Daylight factor

Daylight factor (DF) is a rather simple and profound method for investigation of daylight availability indoors. Daylight factor is the amount of daylight available inside a room compared to the amount of unobstructed daylight outside under specific sky conditions - overcast sky. DF is expressed in percentage.

Calculations of daylight factor were made for the whole building, including building A, B and louisiana hallway. DF factor calculations are available for ground floor, 1st floor, 2nd floor and 3rd floor (Appendix 3). Although in this chapter we are going to describe and analyse results focusing on two initial design areas - cafe and staff room/dining room.

Cafe area in building B is designed with large areas of glass, the facade facing south-west, west-north are constructed out of the curtain wall, and the north-west facade hosts 2 double windows of 4.32x2.13m. The fact that the cafe area accommodates three external walls that are rich with glass, enables lots of daylight to enter the space and that can be seen in daylight factor calculations. South-west and west-north facing areas reach a daylight factor of 8 percent up to about 2.7 meters away from the curtain wall. Five percent and higher daylight factor results in strongly daylit appearance of a space, meaning that during daytime electric light is usually not needed, although it can potentially result in thermal problems, such as overheating in summer season and heat loss during winter. From the point of 2.7 meters going further away daylight factor gradually diminishes to 6, 5, 4, 2 percent within approximately 1 meter distance. As the space is very deep, spanning 13.1 meters from one external wall to another, the center of the room receives only 1 percent of daylight factor. Areas with DF percentage of 2 and lower look gloomy and electric light supplementation is needed most of the day. North-east area of the room, right by the glazing, demonstrates a daylight factor of 5% up to 1 meter away. From the distance of 1 meter from the glazing area daylight factor gradually decreases to 2 percent at a point of approximately

2.4 meter away from the windows. Overall, daylight factor conditions in the space are good, especially taking into account the depth of the room and acknowledging that rooms rich in depth usually face the same issue, which can be supported and replaced with electric light.

Staff room/dining room in building B accommodates windows only in the north-west facade. The space is 56 square meters big and the existing amount of glazing area is able to provide enough daylight into the space according to calculations. Daylight factor of 5 percent is seen right by the glazing area and up to 1 meter away from it. DF gradually decreases going further away and reaches a minimum value of 3 percent.

Even though the results of building B could be considered as better results in comparison to the Cafe area in building A, other criterias such as size of the area, connectivity and location, and functionality of the room strongly influence our decision of working further with Cafe space.

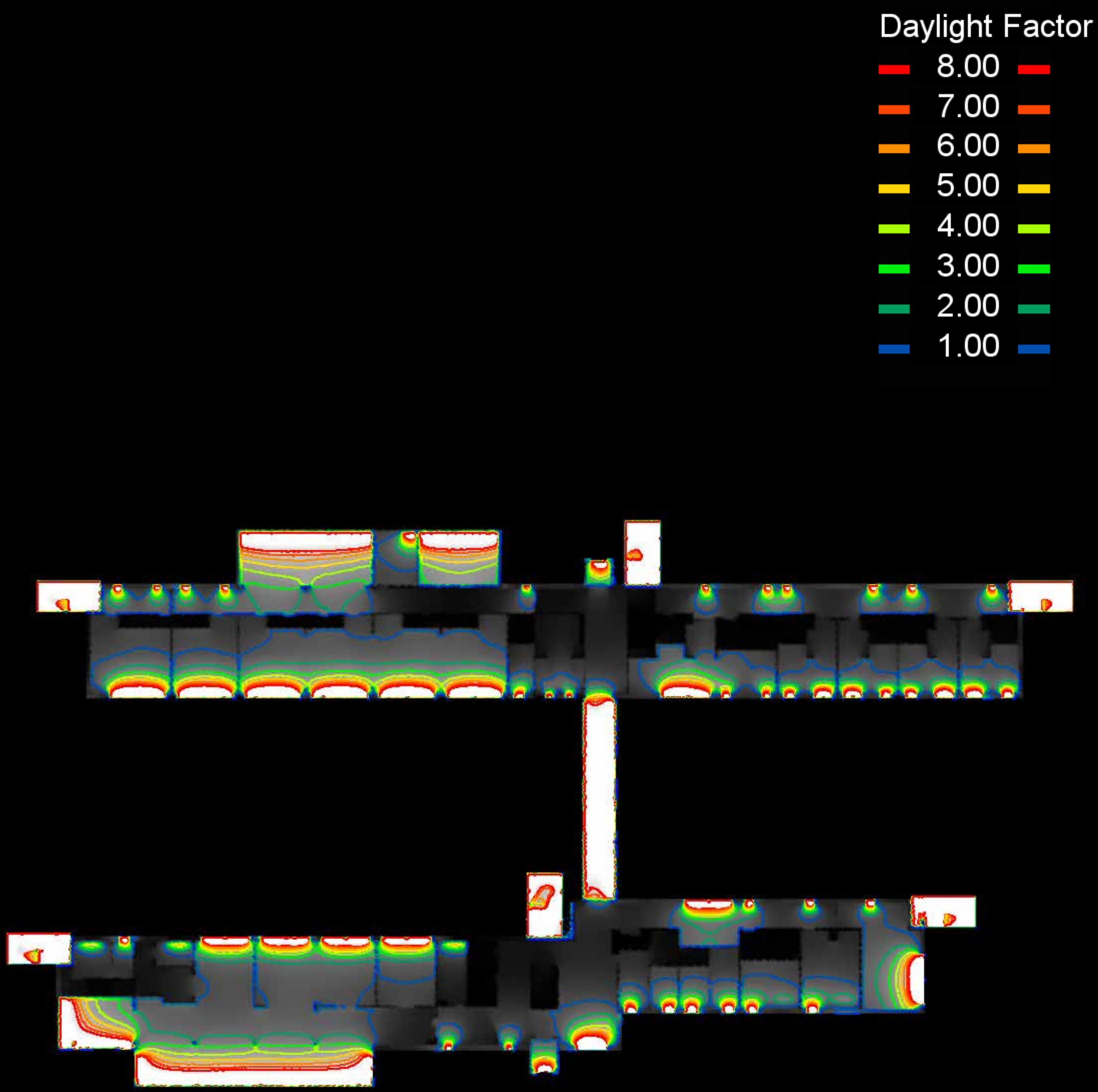



Fig. 24 Daylight factor - ground floor

## Survey of the movement of sun light

Analyses for spring equinox, summer solstice, autumn equinox and winter solstice demonstrating the way daylight penetrates our chosen area - Cafe. Analyses were made for a time span from 7am to 20pm for sunny weather conditions and overcast sky conditions (Appendix 5).

The cafe area facing south-west constructed with curtain walls allows direct sunlight to enter the space from 8am to 15pm creating distinctive shadows out of the window frames (Fig. 25). Other periods of time the area is filled with indirect daylight. The movement of sunlight in space during spring, summer and autumn creates a pleasant atmosphere that can as well lead to a correlation with the passage of time. Although it is important to consider the fact that computer simulation does not entirely represent reality and direct sunlight during autumn is not present often.

The opposite side of the area, facing north - east with two double sized windows during most of the day time receives indirect light during sunny weather conditions. Only before the sunset during summer months direct sunlight  can be perceived indoors entering the side from the west from 6pm to 20 pm. Throughout all the other seasons no direct sun can be seen entering space on this side of the space due to orientation.

During overcast sky conditions south-west side area as it was described in daylight factor analyses receives reflected skylight that from 2.7 meters from the curtain wall area slowly diminishes going further to the center of the room. The opposite side of the room appears darker compared to south-west and showcases brighter areas only right by the windows (Fig.26). The center of the room can be perceived as the gloomiest area in the room.

The sky conditions strongly influence the appearance of the space. During sunny days the characteristics of light create a warm and relaxing atmosphere. Whereas an overcast sky with reflected sky light creates a cool and refreshing atmosphere in the space.

Taking into consideration the analyses of daylight, the area in south-west has the biggest potential to be chosen as an area for circadian rhythm stimulus as it receives direct sunlight during sunny days and greater amount of reflected light during over-cast days.

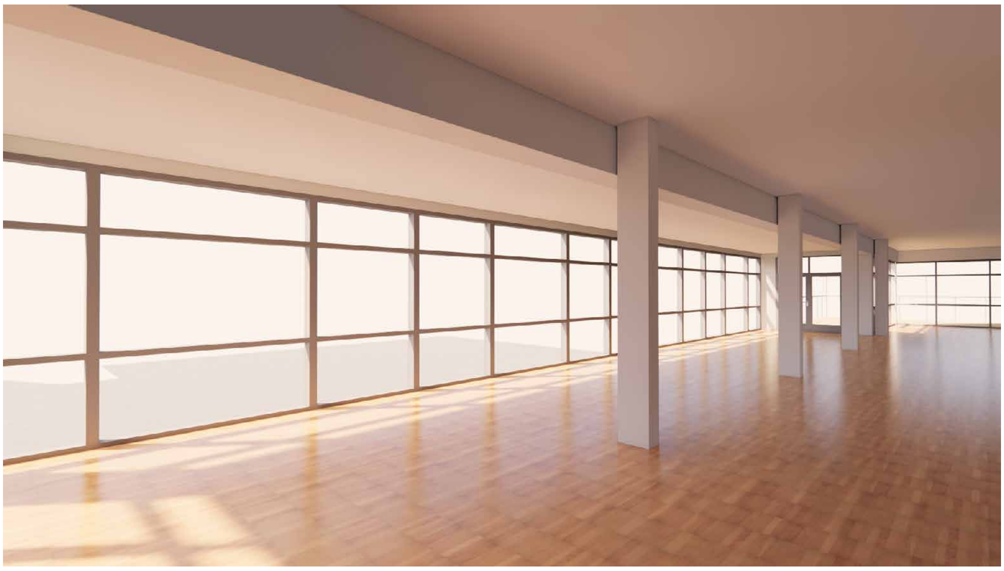


Fig. 25 Shadows in South-west of cafe area (summer solstice 10am)

Fig. 26 North-east of cafe area (summer solstice 10am; cloudy)

# Co-case study
## Overview

Care Home Virumgård is situated in Virum - a suburban residential area in Lyngby-Taarbæk Municipality, which lies 15 km from central Copenhagen. The village has been known on paper since the XII century, when it was firstly mentioned in papal letters. Care home is close to Sorgenfri Torv (virumgaard.dk). It consists of three departments for different focus groups.

Only department B of Plejehjem Virumgård was taken under the research. This building was built in 2001 with two floors. All 26 apartments are devoted for dementia imparied residents (virumgaard.dk). Every floor consists of two groups of caretakers, kitchen with dining room and a common living room. All the apartments are between 63 - 65 m2 and have a private bathroom. Because of security reasons there are no balconies attached to the apartments (virumgaard.dk).

# Interview

Semi-structured interview was conducted with one of care takes from Care Home Virumgård. The employee describes how it is important for everyone to have a daily rhythm. Most of the residents with dementia can't control it. The only time markers are meal times (Appendix 2). People with dementia don't really understand the concept of time. They are sleeping when they are tired and getting up when it feels comfortable, even though that might be in the middle of the night. Disrupted sleep pattern is deepening the existing confusion and unregulating natural rhythm (Appendix 2). Daily rhythm is a focus point of work in care homes. Employees are making sure that residents are active during sunny hours. At Virumgård some residents got light therapy to put them back on track with circadian rhythm. Room is filled with curtains and lamps that are imitating different light scenarios that are occurring during the day (Appendix 2) .

During winter time in Denmark people get up when it is dark and go directly to spaces illuminated with electric light (Appendix 2). Residents of care homes can easily confuse such dark mornings with nights. Night lighting should be more dimmed than during daytime. That could help with recognition of time. Interviewed caretaker suggests that the most beneficial for elderly with dementia could be going outside to experience natural light and learn phenomena like wind, coldness or rain again. He observed that many residents with severe symptoms are afraid to be under open sky (Appendix 2).

Sun is affecting elderly with dementia the same way as other people. During winter time they can suffer from seasonal affective disorder. Sunny weather can elevate their mood, especially after a gray, overcast period (Appendix 2).

Most care homes are filled with artificial plants, because of maintenance reasons. Living plants not only can provide better air quality but also a pleasant view (Appendix 1). Residents could take care of them with the help of a caretaker if needed.

That could be a part of weekly activities. Bad air quality is another problem of many institutions. This happens often because residents are complaining about shifts from warm to cold temperature when a window is open (Appendix 2).

The employee hasn't observed many cases of watering plants by the residents with dementia. It is mainly because of lack of encouragement from the caretakers - care takers could ask for help in some activities connected to taking care of the plants and in this way encourage residents to participate (Appendix 1). Elderly with severe symptoms need inspiration from outside to take some actions. He noticed a big interest in seasonal flowers that are a symbol of time of the year (Appendix 1). Poinsettia, in Denmark called julestjerne (Christmas star), is a popular flower in many counties that appear in apartments during the Christmas period. Its view is bringing a lot of joy and memories to residents (Appendix 2). Lilies and crocus are flowers typical for the Easter period. Those flowers have very intensive colors, which might be helpful with imparied vision. Plants that are noticed usually have a connection to memories (Appendix 2).

# Observations

Observation was conducted in the kitchen connected to the dining room with a focus on behavioral acts connected to the presence of plants on dining tables and in the area around (Appendix 2).

During the Christmas period care homes are providing common spaces with traditional plants like poinsettia (Euphorbia pulcherrima; julestjerne - christmas star). Figure 27 is presenting two plants which were at the dining room in January.

From those observations it can be concluded that the plants are creating big interest in the elderly during meal time. It gives easy topics for conversation and objects for admiration. During all the meetings the dining table scenario was similar (Appendix 2). It started with noticing the presence of plants and adjustment of their placement, if it wasn't satisfying. Usually plants were standing in the middle of the table and facing the most attractive side towards the elderly. Corners were considered to be an adverse location. Moreover they were talking about where the plant looks the best in relation to other plants and with which side.  As a next step elderly compared pots and discussed which one is the most attractive and how it matches to the plant (Appendix 2).

The next stage was a conversation about the beauty and colors of the flowers and choosing a favourite one. Usually words of ownership like my or our were used during description. It was mentioned a few times how the residents appreciate the presence of particular flowers, especially Poinsettia - typical christmas plant. One day it was mentioned how their mood is elevated while looking at this plant (Appendix 2). Sometimes conversations evolved to recalling old habits that involve greenery from child - and adulthood. The supper meeting usually finished with telling a story with big pride about who and how is watering plants. That might have been an indication of a need for activities connected to horticulture. All three women present

at the room were interested in if the plant needs watering. They were checking it by touching leaves and earth. During days when talkativeness was lower, residents were only looking at the flowers placed on the table (Appendix 2).
The observation can be concluded into a statement that plants do help to elevate mood, increase social interactions and bring back memories. Therefore, we can expect that using familiar natural elements in our design would lead to a similar positive effect.

Fig. 27 Plants in January at care home

# Quantitative

Illumination from electric light was examined by using a lux meter during evening hours. The values were lower than expected. In the kitchen are (Fig. 28) values are meeting a standard of 300 lux on a task area. Considering that this is a place devoted to the elderly, the values should be doubled (Turner, 2008). Numbers on Fig. 29 and Fig. 30 varies significantly, even though the light comes from the same luminaire. Materials in the corridor (Fig. 29) have glossy surfaces which is resulting in higher values of illumination. Many reflections are visible on the floor which might be confusing and unpleasant for residents. In this area, illuminance at eye level is reaching 300 lux, which would be satisfying in an environment for the younger population. Fig. 30 shows a part of common space with an exercise bike. Dartboard is placed just under the luminaire. It's black surface is absorbing light, which is resulting in low illuminance values.


Fig. 28. Illuminance values in a kitchen


Fig. 29 Illuminance values in a corridor


Fig. 30. Illuminance values in a common space

## Summary

Measurements show that materials and placement of the luminaires is significant. Placing luminaire on the wall can result in hot spots that might be perceived as disturbing and unpleasant. Hanging objects under a fixture disrupts a distribution of light and can cause high contrast, like on a Fig. 29. Pendants above tables created the best results with even distribution of light, without reflections on surfaces.

This observation raised awareness for our design process - we observed that materials that are very glossy create disturbing reflections, wall lamps distribution is very important to consider as it can create hot spots and lastly pendants as a choice of luminaire above tables work well in practice and can create even distribution of light on the table.

# Chapter 4
# Design

## Problem statement

After collecting knowledge from different fields and conducting analyses of case study and co-case study we have revisited our vision and formulated research question for our design, while keeping in mind a holistic approach.

*How can an environment contributing to well-being be created for the elderly suffering from dementia at care homes, through a nature and lighting design focusing on atmosphere, physiological and visual needs of the residents?*

In order to be more precise in creating lighting design, we have divided the research question into three sub questions:

*How can daylight supported by electric light:*

*- normalize disrupted circadian rhythm*

*How can electric light:*

*- provide sufficient illuminance for tasks*
*- create an atmosphere for relaxation and socialization?*

# Design process

In order to set a clear design process we have established a graph, which clearly communicates our steps towards a final design (Fig. 31).

First of all we have analysed the space and divided it into zones, where different lighting scenarios would support different needs of elderly and in this way create a stimulating multi purpose environment.

*Exploratory step*

The following step was a field trip, with which we aimed to investigate local nature and surroundings as well as get inspired. The aim of the field trip was to collect information about plants, elements present in local nature and use them in our design, so they are familiar for elderly with dementia, that would bring back memories and would not confuse them.
To gain a better understanding of how light is perceived in space we have conducted a CCT test. The aim of the test is to discuss and choose suitable color temperature for different light zones while bearing scientific knowledge in mind.

*Concept*

In a concept design we used mood boards to get further inspiration for designing environments enriched with nature elements and lighting design in institutions. During the concept phase we aimed to choose light, in particular characteristics of light that would suit the purpose of light zones for this specific user group. We have defined color temperature for each of the zones, initial placement of the light, distribution and discussed illuminance levels that are needed to support visual needs of elderly with dementia.

*Design development*

Design development phase in our process was meant for research of particular luminaires that would be able to fulfill our design vision and criterias. Here we have looked into different luminaires and their specifications, such as light distribution and lumen output, spectral power distribution and color temperature.

*Test*

Test is conducted with an aim to fulfill test criterias. Each zone has different criterias that we intend to fulfill in order to achieve holistic design of common spaces for elderly with dementia.

*Iterative process*

Iterative process connects test, concept and design development stages. If test criterias fail to be achieved, we revisit the steps before, meaning either we have to find new luminaires that would fulfill test criterias or revisit where the light is placed. The process continues until we achieve our aim.

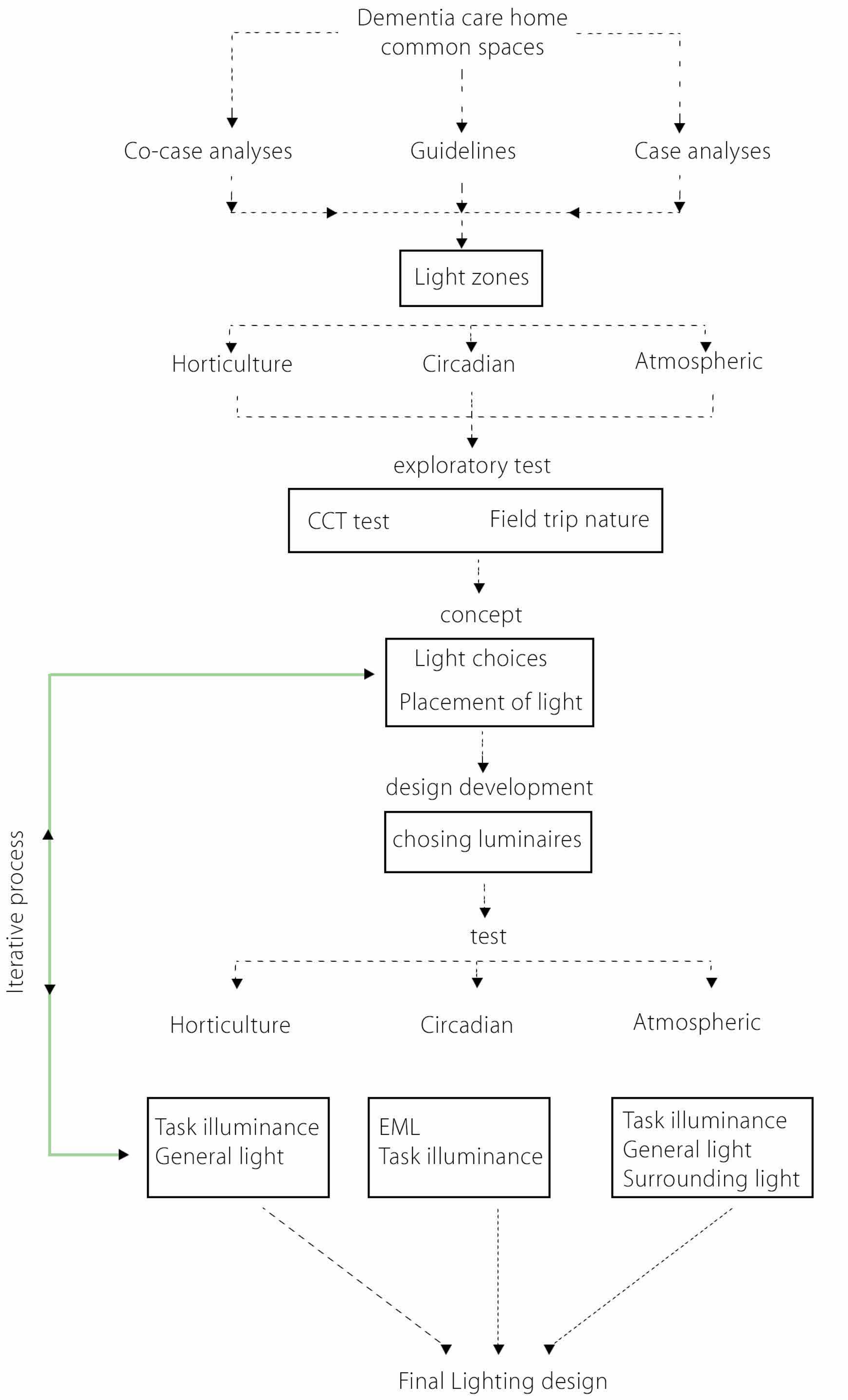



Fig. 31 Design process

# Light zones

Idea of creating different light zones came from knowledge gained throughout literature study and analyses. Elderly with dementia are a vulnerable group of people with a range of specific needs.  As the disease makes it impossible to live independently at home and moving into care homes becomes the only solution, we aim to create an environment that is supportive and contributes to well being. By implementing different light zones we hope to create holistic design that would make elderly daily life easier and withhold manifestation of dementia symptoms. Therefore we have decided to divide our chosen space into areas that would serve different purposes by using light as a tool. The space is arranged into zones of atmospheric zone, circadian zone and task lighting zone (Fig. 32).

**The Atmospheric zone (leisure area)** is developed as an area where residents of the space could enjoy their meal, socialize with other residents or have meetings with visitors. We aim to design this area as intimate, relaxing, warm and homelike. Our primary idea is to incorporate traditional danish lighting fixtures that would contribute to a homelike feeling and could be perceived as familiar rather than institutional. Moreover we expect to achieve mentioned characteristics of the space by using low CCT and distributing light into pools of light.

**Circadian zone** is designed to help to normalize disrupted daily rhythm and help to tackle seasonal affective disorder. We have chosen an area by the curtain wall where the biggest amount of daylight was noticed in analyses. Circadian lighting is meant to support daylight, when daylight physiological stimulus is not sufficient, such as early mornings and dark seasons. By incorporating daylight in circadian lighting, we aim to reduce energy consumption. Nonetheless, by choosing this specific location we enable access to views and provide understanding of passage of time. Our primary idea is to create uniform lighting in order to provide stimulus in most of the area.

**Task lighting area (horticulture area)** is an area where the residents can engage into gardening activities. Chosen location provides access to views and is filled with daylight, thus we expect that these qualities of chosen space would encourage social engagement, accommodate the eye, support mental well being and help to understand passage of time. The lighting in this area is aimed to provide efficient task light that suits deteriorated vision of elderly. Acknowledging the fact that each individual's vision deteriorates to different extent we aim to provide an individually dimmable lighting system. To keep the coherence in overall space and as well provide a homelike feeling we are planning to use pendant lighting fixtures.

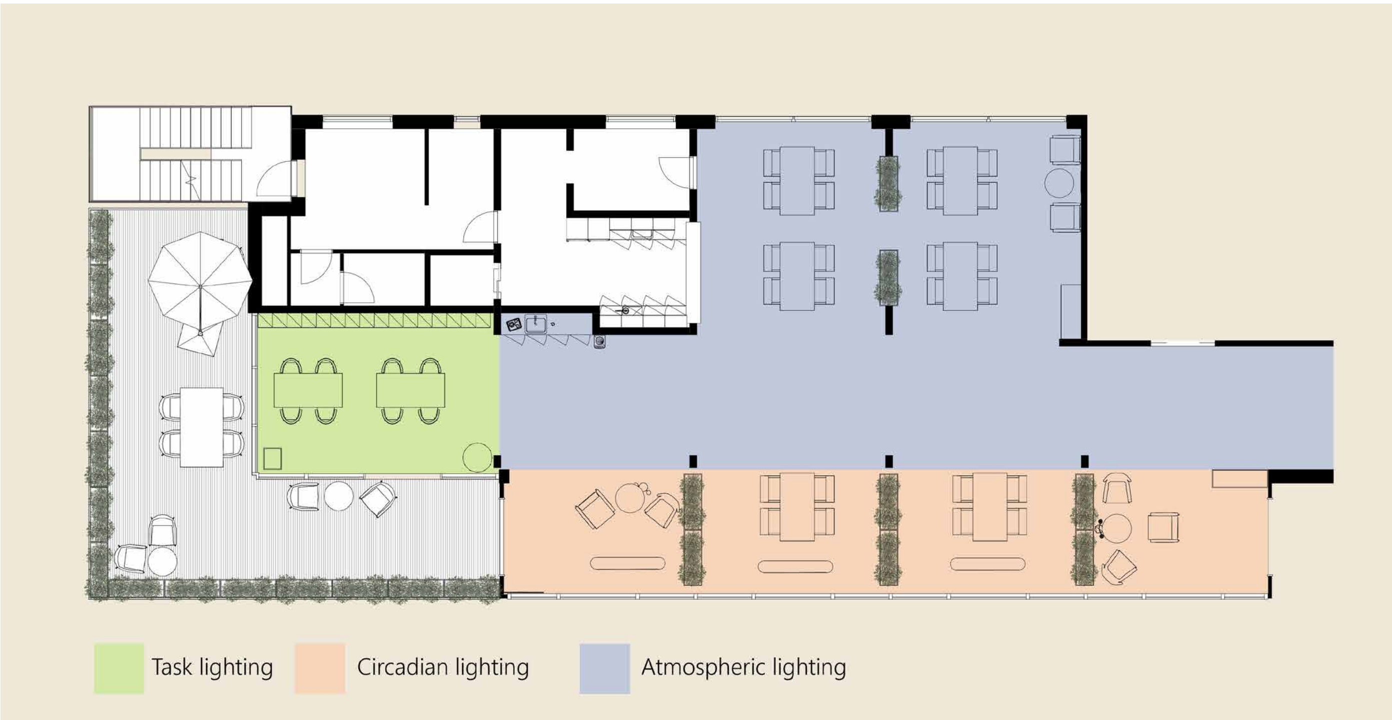



Fig. 32 Light zones

# Exploratory steps

## Field trip

In the afternoon of 19th of April, we went on a field trip to Greve. As nature is one of the important elements in our design we decided to observe a local nature and its surroundings and thus this idea led us to Greve Strand and Trylleskoven. We expect that these two areas are closely related to the residents of Nældebjerg plejecter and they have emotional value for them. Therefore we expect that nature elements observed in these areas could be included into our design as they would be familiar and could bring back memories for elderly with dementia, encourage social interactions and further contribute in creating a cozy and familiar atmosphere as well as strengthen diminished connection to nature.

On a sunny afternoon we took a long walk by the coast and in the forest taking pictures of different plants and trees. The field trip was not only documented in pictures, but also observed by us in a sensory way, by touching and smelling the plants. As nature is just waking up after the winter season, our findings were more narrow than they potentially would be in a summer period. Nevertheless, we still managed to find different plants and trees present in the area.

The forest was filled with spiky pine trees and birch trees with fragile buds just starting to appear (Fig. 33). We noticed several shrubs with soft and silky catkins, scientifically known as salix caprea (Fig. 34). Ranges of area were filled with ammophila grasses, which is a very common seacoast plant (Fig. 35). Closer to the water we observed reeds, that just as previously mentioned grass felt very dry and sharp (Fig. 36). We walked through widely spreading areas of fluffy and pleasingly soft moss, which is very common in Denmark and is scientifically known as hypnum cupressiforme (Fig.37). Moving forward we came across fern growing in a grassy area (Fig. 38). Happily we spotted a colorful blooming flower, which felt unusually silky, which we later managed to identify as pulsatilla pratensis (Fig.39). There were plants that we observed and seen before in danish seacoast, but could not identify.

As our focus in this thesis is light, we do not further research specific plants, but we do encourage to follow the guidelines developed for dementia care units, which as well cover the domain of plants.

While wandering around the seacoast we came across a shed (Fig. 40). This finding inspired us to use wood in our design, as an element that is sustainable, commonly observed and goes in line with biophilic design approach - pattern of natural materials.

Fig. 33 Birch tree

Fig. 34 Salix caprea


Fig. 35  Ammophila grasses


Fig. 36  Reeds


Fig. 37  Moss


Fig. 38 Fern


Fig. 39 Pulsatilla pratensis


Fig. 40 Shed


Fig. 41 Landscape of a forest


Fig. 42 Landscape of a seacoast

## Exploratory CCT test

In order to understand how different correlated color (CCT) temperatures influence the perception of the space and in order to select suitable CCT for different light zones we have conducted exploratory tests. The test was performed with Philips Hue Go transportable light. The test was done on April 22 between 7pm to 8pm. The room where the test was performed had closed window blinds, so no daylight entered the space. We have tested 5 different color temperatures: 6500 K, 4200 K, 2900 K, 2300 K, 2000 K.

6500 K makes the space look cool and bluish. This color resembles cool daylight and thus feels more energetic. According to knowledge gained this CCT setting is often used and works well in environments that are designed to stimulate circadian rhythm and promote alertness (Fig. 43).

4200 K is perceived as cool white light, it is less bluish compared to 6500k, although it still has a slightly blue tint. It can be perceived as clean and efficient, it is often used in hospitals and schools (Fig. 44).

2900 K is perceived as warmer light and not as stimulating, it has a slightly yellowish white appearance. Such a light setting is commonly seen in households (Fig. 45).

2300 K is perceived as slightly orange/amber light. It creates a more relaxing, intimate and warm atmosphere. Such color temperature is commonly used in Denmark above dining tables both in households and restaurants (Fig. 46).

2000 K is perceived almost as candle light, or a warm light that comes just after sunset or sunrise seen before sun passes horizon. It has a warm, orangey glow. The light is calm and very warm. It can be used for relaxation areas and is used in street lighting in some areas (Fig. 47).

Fig. 43 6500 K

Fig. 44 4200 K

Fig. 45 2900 K

Fig. 46 2300 K

Fig. 47 2000 K

# Concept design

## Moodboards

Moodboards were divided into two categories according to focus disciplines - greenery and light. They were an inspiration for designing environments with elements of nature and lighting design in care home institutions.

The benefits of therapeutic landscapes and views found in scientific papers encouraged us to create a view of nature through a big window opening. Figure 48 presents images illustrating first associations with the topic of greenery. Pictures show characteristics of nordic nature and elderly immerse into the greenery through different senses.

As we discovered in literature research - daylight and electric light can contribute to well being, support visual needs, stimulate circadian rhythm and contribute to the atmosphere of the environment. Figure 49 is the composition of images connected to daylight, electric light and luminaires that inspire us. Picture in the top left corner is related to the idea of dividing space into light zones. Bottom row of this mood board is composed of illustrations of fixtures and their placement that create a familiar, homelike atmosphere in public spaces.

Fig. 48 Moodboard - greenery

Fig. 49 Moodboard - light

## Sketching initial ideas

After we got inspired by mood boards, bearing scientific knowledge observed and information from analyses in mind we continued with the design process by sketching initial ideas. Sketching process started with exploring how the zones would function and look like in space and ended with first concept design. Some of the sketches are presenting specified solutions and others – light distribution. Different ideas from this stage of the project are presented in figures 50,51 .

As we aim to create an environment that is homelike, during the brainstorming process we have decided to sketch different domestic style lighting fixtures and see how they would look and the light distribution they would create. Our goal in the circadian zone is to provide physiological stimuli, therefore we want to maintain uniform lighting. During the process of sketching and discussion, we realized that pendants would not fulfil our goal in the circadian zone and thus, we have sketched different solutions that lead us to the potential idea of incorporating ceiling recessed lighting fixtures.

Overall, in the space we want to incorporate plants as a component of the design as they can contribute to well-being and strengthen connection with nature. Figure 52 shows our initial ideas of greenery.

Figure 53 presents our initial ideas of terrace design. As we found out through literature and the interview with a caretaker - elderly with dementia do not understand natural phenomena like wind anymore and the sun can be frightening for them. Moreover, we acknowledged the importance of views and therapeutic landscapes and their positive effects. Therefore, we sketched some ideas that can contribute to an environment outdoors that is stimulating, comfortable and inviting – protection from wind, sun shading, and plant placement ideas can be seen in a sketch.

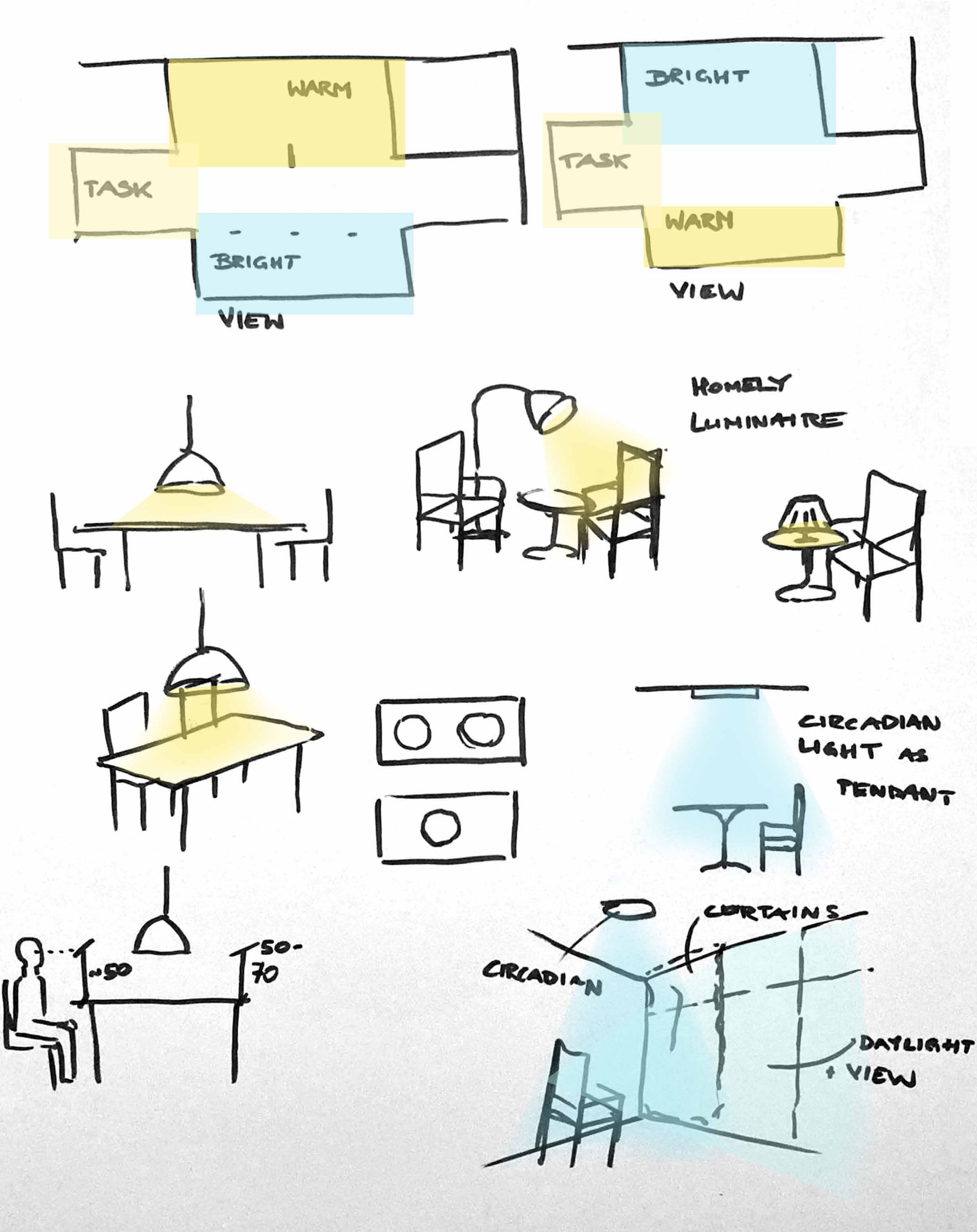



Fig. 50 Initial ideas - lighting

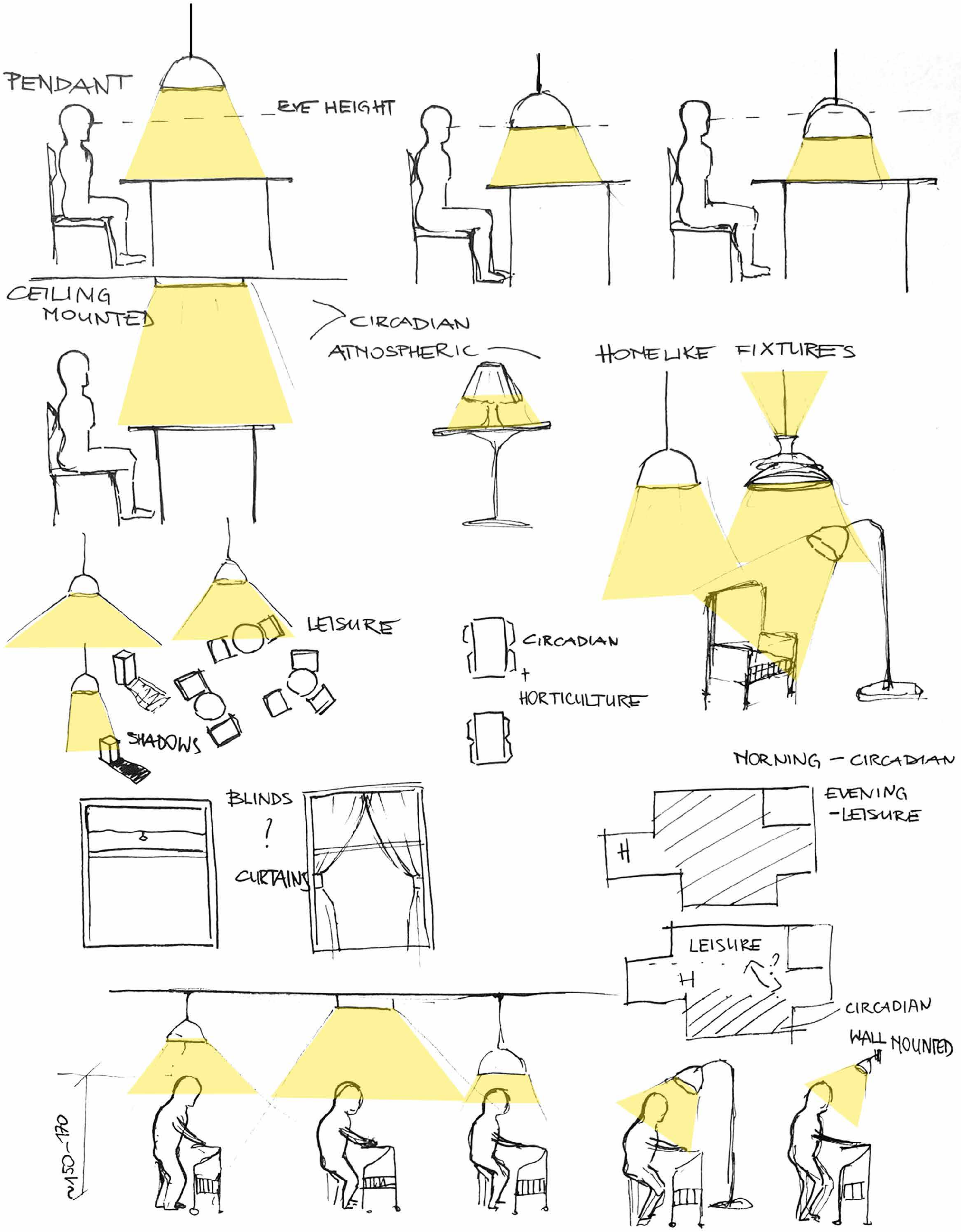



Fig. 51 Initial ideas - lighting

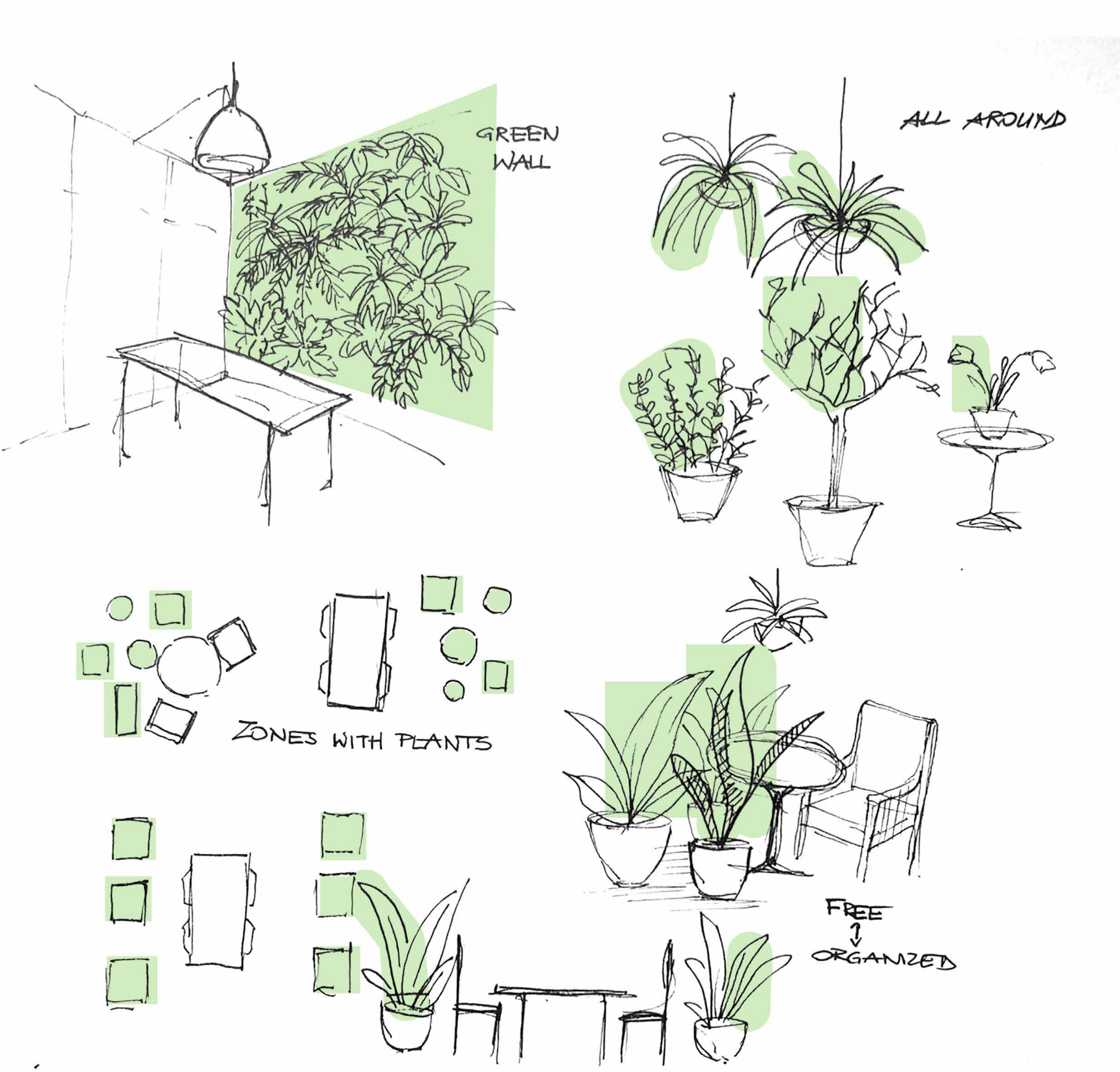



Fig. 52 Initial ideas - greenery

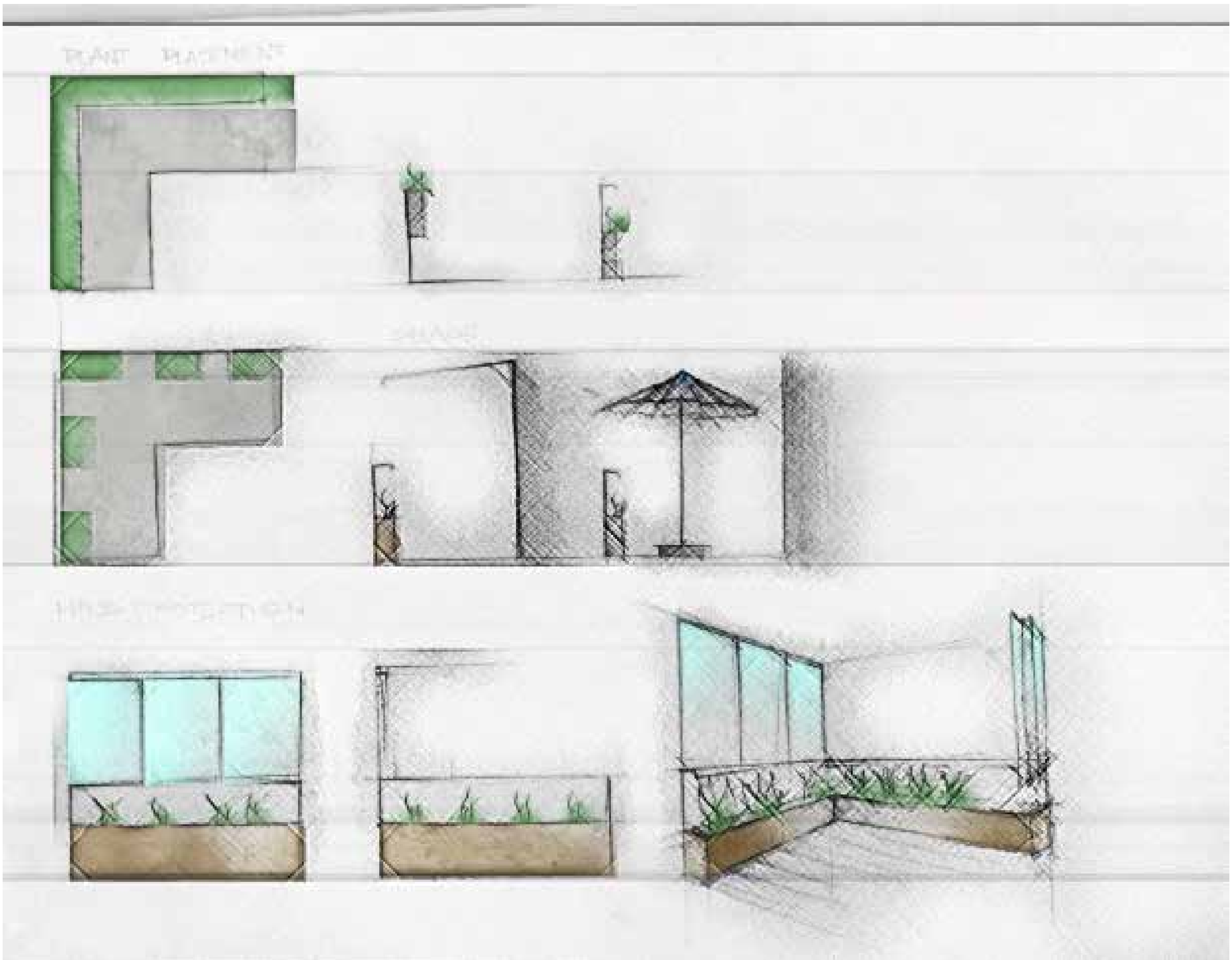


Fig. 53 Initial ideas - terrace

# Design development

After getting inspired by moodboards and sketching our initial ideas, the following step, as we call it, is design development. In this step we work on different zones and a space as a whole. We specify our initial ideas and list characteristics of light we imagine different zones should have, such as CCT, illuminance level, distribution and location of light. Moreover we investigate different luminaires and select the most suitable ones that can help to fulfill our aims. The whole process goes in line with gained knowledge and analyses. In this way we are ensuring that we fulfill elderly with dementia visual and well-being needs and create an environment that is stimulating and supportive for their daily life.

**Atmospheric zone (leisure area)**

In the atmospheric zone, as mentioned before, we want to create an intimate and relaxing environment for elderly that would create conditions to enjoy their meal, engage in socializing with other residents or to spend time with their visitors. The color temperature that would help to achieve atmospheric feeling based on analyses and literature we chose to use is 2300k. Even though illuminance levels in such lighting settings for pendants above tables are commonly used as lower values, having in mind increased need for illuminance for elderly, as they usually have imparied vision, we aim to provide a maximum illuminance level of up to ~550lx on the table surface (work plane). Although, as elderly vision varies from person to person and different light intensity might be prefered, we are providing dimming control for every table. Dimming the light is as well beneficial for energy saving, as during daylight hours maximum intensity might not be needed. The control would be accessible by staff only.

The choice of luminares we look into is pendants. Pendants are commonly used at homes and help to create a homelike atmosphere, nonetheless by using pendants it is easier to create pools of light that contribute to a relaxing atmosphere. We have analysed different pendants, although our focus was centered on danish design, as we expect they would appear more familiar for elderly with dementia. Our investigation ended with three different luminaires that caught our attention and according to specifications have characteristics (CRI, CCT) we aim to have in our design. Therefore we have conducted exploratory stimulation tests to observe which light distribution each pendant offers, how the light appears in space and which of the pendants is most suitable for our design.

The test analyses pendants from Louis Poulsen: Cirque, PH, Keglen. The test environment is a room with no daylight entering the space, that helps to clearly visualize light distribution of different luminaires. The pendants are hanging 0.7m from the desk.

Louis Poulsen Cirque creates a nice atmospheric pool of light, the highest intensity is at the center of the table, whereas moving from the center light intensity diminishes. This light distribution does create contrast between sides of the table and center and the boundaries of the table seem to disappear, which could be visually confusing for elderly with dementia (Fig. 54).

Louis Poulsen PH has wider light distribution and thus the table and chairs are illuminated. Compared to Cirque, PH is less atmospheric and provides more uniform light as well as indirect light emitted from the top of the luminaire, which is then reflected from the ceiling and further illuminates the room (Fig. 55).

Keglen illuminates all the table area, the center of the table is the brightest area, where the light fades towards the edges. The chairs are illuminated as well, but compared to PH the light is less intense. Keglen provides direct light, therefore the pool of light is casted on the area where the pendant is located, and the surrounding is not affected. This pendant can contribute to atmospheric lighting and provide more uniform light compared to Cirque, that is visually comfortable for elderly vision (Fig. 56).

Fig. 54 Light distribution Louis poulsen Cirque

Fig. 55 Light distribution Louis poulsen PH

Fig. 56 Light distribution Louis poulsen Keglen

After the exploratory stimulation test, we have decided to further work with Louis Poulsen Keglen. The specification sheets of luminaires from the manufacturer can be seen in appendix (Appendix 6).

**Circadian zone**

During the interview with the care home employee we acknowledged that many elderly with dementia have disrupted day-night cycle. Literature we investigated echoes the following statement and thus we aim to tackle this issue.

Circadian zone is designed to support the daily rhythm of elderly and provide a stimulus for the circadian system as well as tackle seasonal affective disorder in dark months of the year, when the daylight presence drastically reduces. Based on knowledge gained throughout literature study we expect that the circadian zone would further contribute to the well being of elderly by normalizing disturbed sleep patterns and so reducing manifestation of dementia symptoms, such as wandering, confusion.

According to studies the biggest stimulus can be achieved by using lighting with cool CCT, which has a full spectrum or is enriched by blue waves. The successful results in different studies were achieved by implementing CCT of 6000 - 6500 K in the designs. Blue light stimulates alertness and blocks melatonin production, which makes people feel sleepy.

We aim to create electric light design that follows day rhythm and changes color accordingly - energizing lighting scenario from the waking up hours to lunch time, whereas afterwards the CCT gradually changes from cool to a warm color, which stops stimulating circadian rhythm and closer to the bedtime hours melatonin production can start. Therefore we have developed a 24 hours lighting scheme, which is based on various knowledge gained throughout literature study (Fig. 57). From 7am to 2pm we create an environment that is bright, energizing and stimulates alertness and provides input helping to normalize circadian rhythm. First period is designed with 6500k, which mimics bright daylight. From 2pm until 6pm the color is changed to 4000k, cool white, that is perceived as warmer and aims to demonstrate the passage of time towards evening time. During this period the circadian stimulus is reduced. In the evening time from 6pm to 8pm the color temperature is changed to warm white, 2700k indicating evening time and preparation for bedtime. Color temperature of 2700k according to scientific research has no stimulus for circadian rhythm, thus melatonin production is estimated to kick in. The last scenario is the night time scenario where we use a CCT of 2200k. This very warm light provides no stimulus for circadian rhythm and is perceived as relaxing and atmospheric.

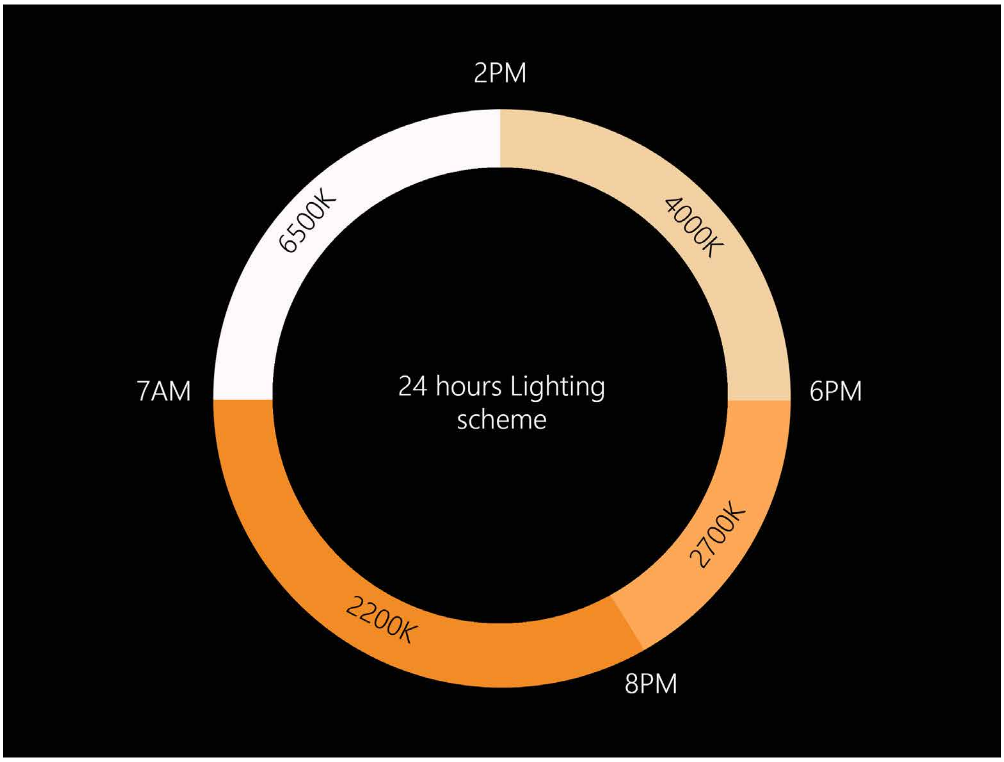



Fig. 57 24h CCT scheme

The Illumination level we hope to provide is up to 600lx at the table, which can support elderly vision for performing tasks comfortably - for example reading. The main concern is to choose luminaires that can provide stimulus for circadian rhythm. Following WELL recommendations we hope to achieve a minimum of 200 equivalent melanopic lux (EML) at the desks (work plane). When choosing luminaires for circadian zone, primary criteria was - the luminaire is tunable and can accomplish 24 hours scheme. Furthermore, the luminaire has to be able to provide an EML of minimum 200. Based on these primary criteria we have chosen three luminaires: Philips RC160V LED40S 865 W60L60 PSU, Ligman MALMO 1 (MAL-80003) and Ligman MALMO 1 (MAL-80023). The specifications from the manufacturer can be seen in appendix (appendix 7).

Afterwards we conducted a test, which aimed to reveal which of the following luminaires can fulfill 200 EML criteria. The test was performed in an Alfa plug-in, using a 3D model built in Rhino. Settings of the test were chosen to reveal full potential of luminaires, thus the time chosen for the test is the darkest period with no daylight present, which is winter solstice - 21st of december at 7am in the morning during overcast sky conditions. Four luminaires were placed in the circadian area (figure x).

Philips RC160V LED40S 865 W60L60 PSU results showed that the average equivalent melanopic lux at the tables in the area is equal to 58 EML (appendix 8).

Ligman MALMO 1 (MAL-80003) results showed that the average equivalent melanopic lux at the tables in the area is equal to 29 EML (appendix 8).

Ligman MALMO 1 (MAL-80023) results showed that the average equivalent melanopic lux at the tables in the area is equal to 79 EML (appendix 8).

The test reveals that the highest EML value is achieved with

Ligman MALMO 1 (MAL-80023), which is essential for regulating circadian rhythm. Therefore we chose this lighting fixture for our further design process. The results do not comply with WELL standard requirements and therefore we have to further work with the amount of fixtures and their location.

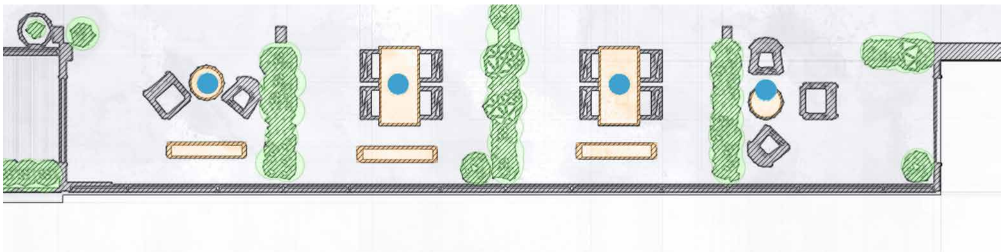


Fig. 58 Circadian fixtures location

**Task lighting area (horticulture area)**

For the task lighting we have decided to use warm white light, that is commonly used in households and is rather neutral than energizing, thus we propose 2700 K. We aim to provide a light level that is comfortable for elderly and supports their increased need for illuminance to perform tasks. Therefore, we aim to provide a minimum of 600 lx at the task area. Meantime we consider the individual preference of elderly and provide an individually dimmable solution. For the choice of luminaire, we want to keep coherence and the space and atmosphere of homeliness. The performed pendant light distribution test and the lighting fixture, which we chose for the atmospheric zone, has characteristics that fulfill our primary expectations. Louis Poulsen Keglen fits well in the task lighting zone, therefore we decided to use identical pendants as in the atmospheric zone.

**Terrace**

We do not propose electric light design for outdoor terrace as we do not expect the place to be used by residents in the dark hours. Although, we implement some of the changes, which include elements of nature, that are found to be important for mental health. The changes that we propose in this area aim to encourage elderly people with dementia to use outdoor space and receive daylight exposure more frequently than before.

According to the interview with the care taker from Plejehjem Virumgård, wind can feel frightening for demented elderly, as well as direct sun can be overwhelming. The existing outdoor terrace does not support the needs of elderly with dementia, as it doesn't provide protection from wind and direct sunlight. Moreover, it does not look appealing and lacks character (Fig. 59).

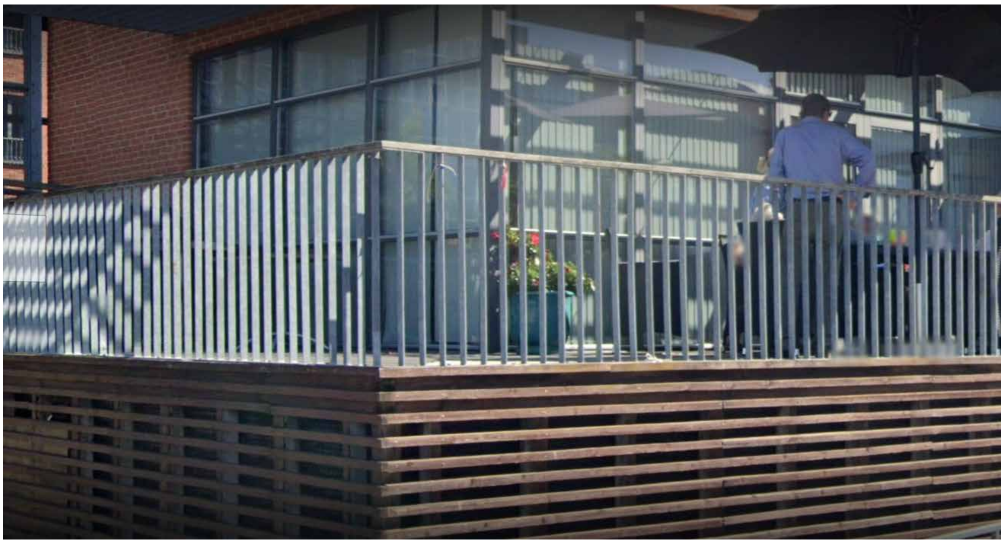


Fig. 58 Circadian fixtures location

To reduce wind impact we propose a new extended railing system, which functions as a curtain wall (Fig. x). At the same time we want to keep the possibility for air circulation, as well as provide the opportunity to feel and experience wind and learn this phenomenon again if wished. Therefore we propose a system, where the top part of the "curtain wall" is designed with sliding panels made out of glass. The choice of glass as material does not influence daylight penetration and as well provides access to views (Fig. 60).

The shading system for daylight is very simple and user friendly. We do not want to block daylight that penetrates indoors, therefore we did not choose to work with shading systems that are constructed as parts of the roof, such as pergolas, or similar. Instead we propose having umbrellas as simple shading devices, which as well allows residents to choose whether they want to be under shade or direct daylight.

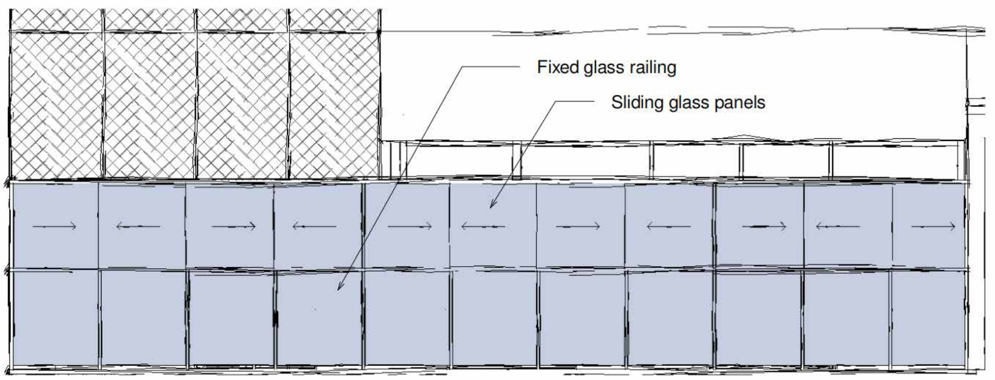



Fig. 60 Terrace wind protection proposal

Lastly an important component of our design is incorporated in the terrace - nature. Inspired by the field trip we have decided to design plant stands from the natural material - wood. We aim to recreate the shed cladding that we came across in Greve strand, natural, untreated wood contributing to biophilic design approach. The sizes of the plant stands are designed to suit elderly and wheelchair users needs. The height of the box allows people who sit or stand to observe the plants, touch them or even perform gardening activities (Fig. 61).  All of the measurements used in the design of the plant stand comply with wheelchair user needs, providing knee space and comfortable hand height (Fig. 62). The plant stand accommodates local, non-poisonous, non harmful for the skin (no sharp, thorny) plants, herbs. We imagine that this design can further contribute to the mental health and wellbeing of elderly with dementia and strengthen connection to nature, providing inviting space for social interactions and access to daylight.

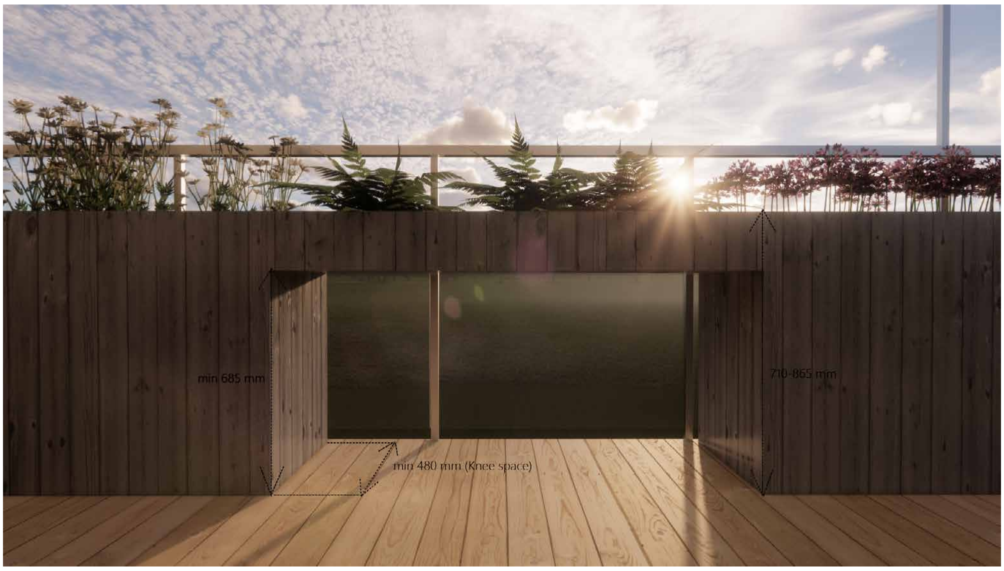



Fig. 61 Flower stand design

Fig. 62 Flower stand design

**Overall**

The same design of flower stands is incorporated in indoor areas, providing greenery and as well functioning as elements that subdivide areas into more private compartments.
The primary lighting plan showcases our ideas on how we aim to design light and where it is going to be placed (Fig. 63).

Fig. 63 Primary lighting design

# Tests
## Test criterias

Tests were conducted to find the best lighting scenario for the cafe area at the care home. The test aimed to examine whether our design proposal presented in design development is satisfactory. In order to figure out if design is successful we have developed test criteria. As there are no standards focusing on optimal lighting conditions for elderly, the criterias are based on and developed from scientific knowledge we have investigated previously. Test criterias are listed below:

Illuminance:

- illuminance at workplane between 500-600 lx
- illuminance of the surrounding approximately at 200 lx
- illuminance in circulation area ~200 lx

EML:

- EML ≥ 200 EML

The test has two parts - illuminance and EML. First of all we are testing illuminance for the design proposed in the design development chapter. Illuminance test is performed for the place as a whole - we do not test each zone separately. As mentioned previously our design is based on an iterative process. Therefore in case the design fails to fulfill illuminance test criterias, it will be revisited and a new proposal will be tested. The process will continue until the criterias are achieved. After criterias are achieved we conduct a test for the circadian zone, where we test if equivalent melanopic lux values fulfill the criteria - EML ≥ 200 lx.

# Illuminance

Simulations for testing illuminance levels were conducted in DIALux software. The illuminance is calculated on the work plane (on a horizontal surface of tables). First test is performed for the design proposed in the design development chapter. The placement of the luminaires can be seen in figure 64.

Tested fixtures:

- *atmospheric area and horticulture room: Keglen from Louis Poulsen; 1195 lm, mounted 0.7 m above table (1.5 m above the floor)*
- *circadian area: Malmo from Ligman 5427 lm; recessed ceiling luminaire*

All the fixtures in each zone provide approximately 300 lx on a work plane, which was counted at the height of the table. Since the criteria was set for illuminance to reach 500 - 600 lx, different lighting scenarios had to be proposed and tested as the current fixtures aren't strong enough to meet the requirements we have established.


Fig. 64 Placement of luminaires,

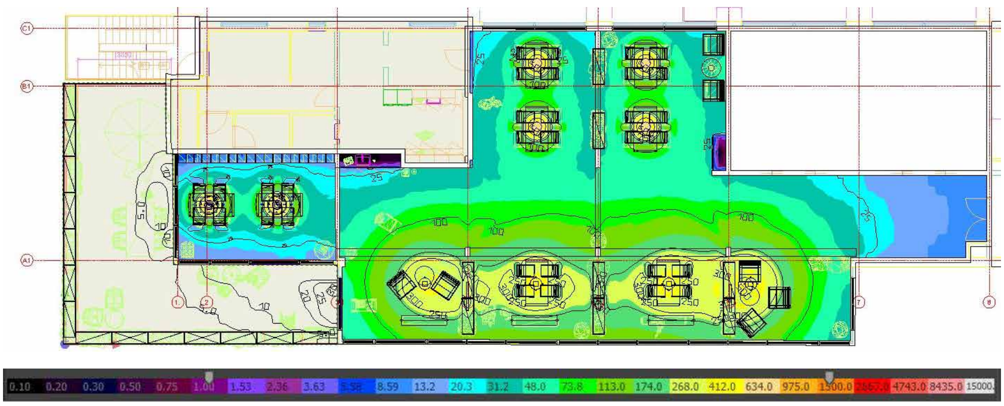


Fig. 65 Results with Keglen 1195 lm, Malmo Ligman 5427lm

As the values weren’t satisfactory with luminaire Kenglen with output equal to 1195 lm, we decided to change it for a more powerful version of the same luminaire - with lumen output of 2035 lm. It resulted in values around 500 lx on every work plane in the atmospheric area and horticulture room. The values in two zones are fulfilling criteria for task lighting, although general lighting is missing and surrounding illuminance values are too low (Fig. 66). Therefore we propose a new design that will include general lighting.

The lighting in the circadian zone will be adjusted as a last step.

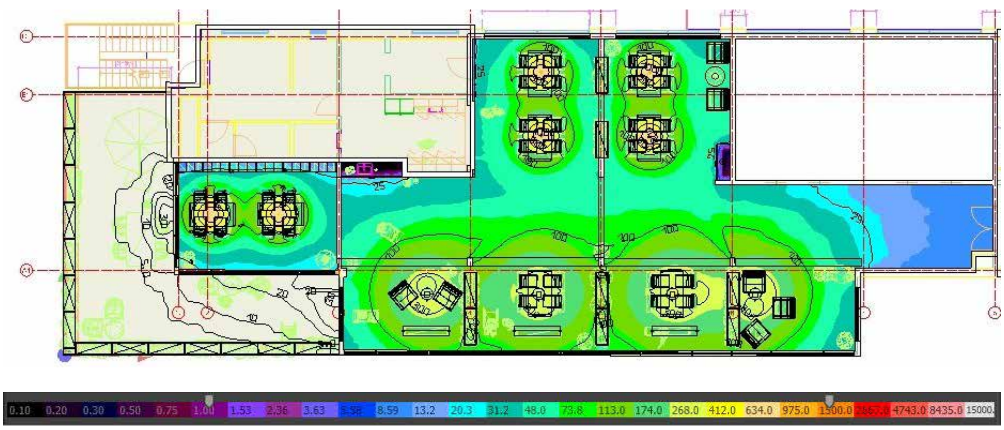


Fig. 66 Results with Keglen 2035 lm, Malmo Ligman 5427lm

General light proposal started with examining the effect of the same Keglen fixtures placed in the corridor area (circulation area) at the height of 2,5 m above the floor (Fig. 67). Values in this area are reaching approximately 200 lx, which means that it fulfills the criteria (Fig. 68). Illuminance from those lamps didn't interfere with the achieved results in the atmospheric area and horticulture room.

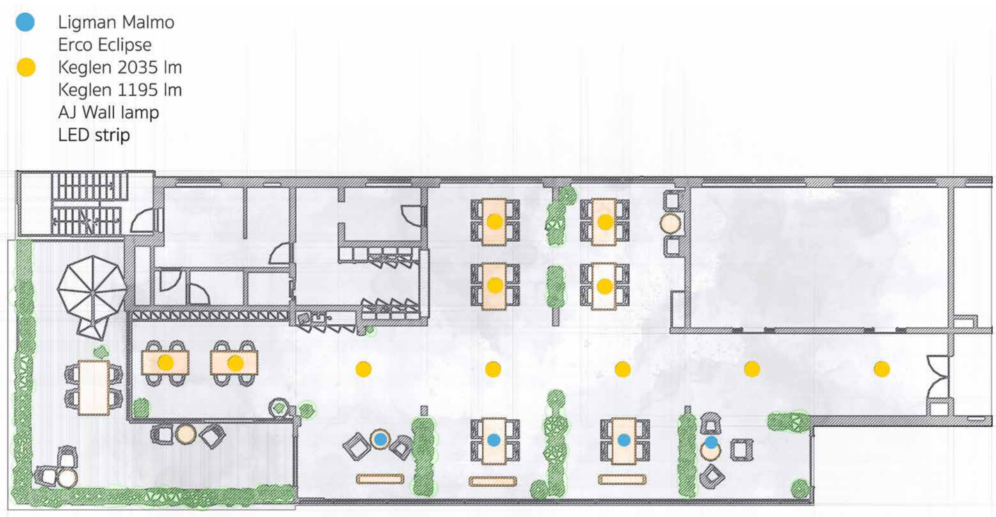



Fig. 67 Placement of luminaires

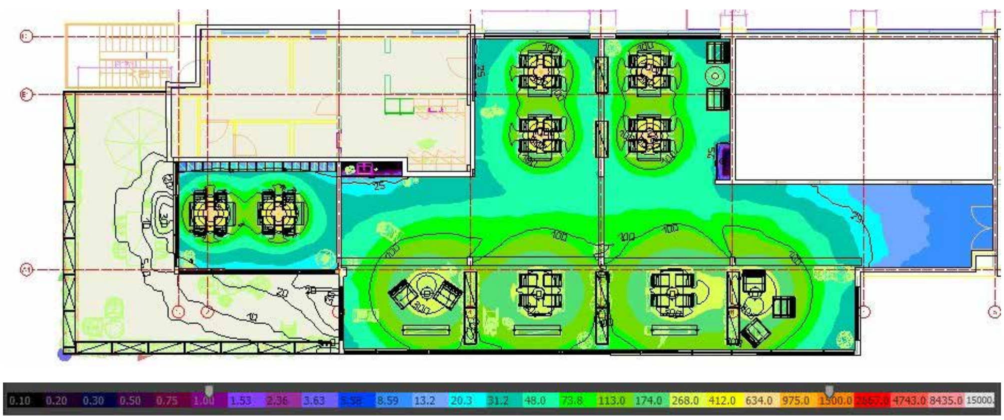


Fig. 68 Results with Keglen (2035 lm) in the corridor

Previously created lighting resulted in big differences in illuminance values between lighting at the tables (work planes) and background. According to the literature, the dark corners could be conjuring for the elderly. Therefore additional fixtures had to be added (Fig. 69). In the horticulture room one line of track lights was added to illuminate objects located on shelfs. This type of fixture gives the possibility of changing direction of the light that can be adjusted to the needs of users. The same track lights have been used  in the atmospheric area above pots for plants where the path in between those is located. Side walls of this area were illuminated with wall mounted fixtures placed 1,8m above the ground. All those fixtures combined together diminished differences in illuminance levels without disrupting achieved values on work planes that are fulfilling the criteria (Fig. 70). As all the values are satisfactory in horticulture and atmospheric areas, on the next step we come back and reevaluate the circadian zone.

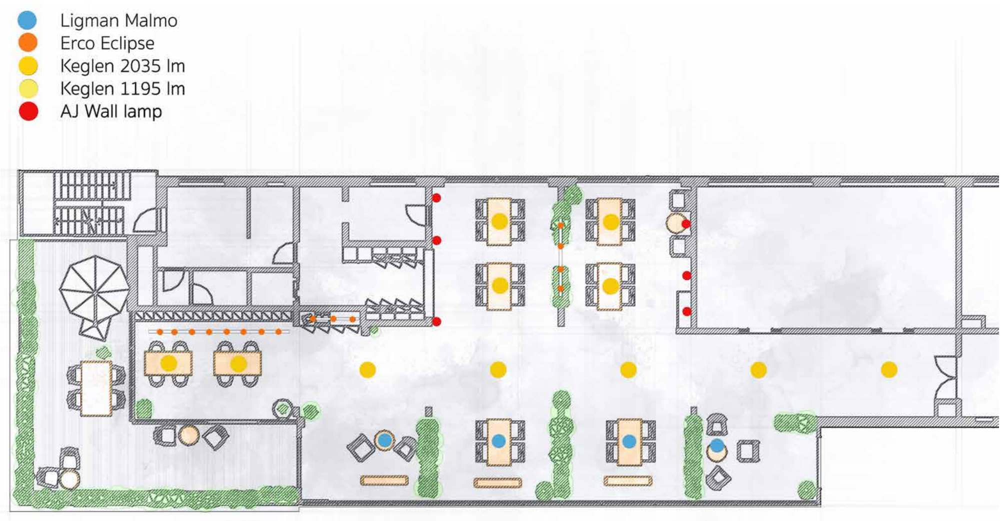



Fig. 69 Placement of luminaires

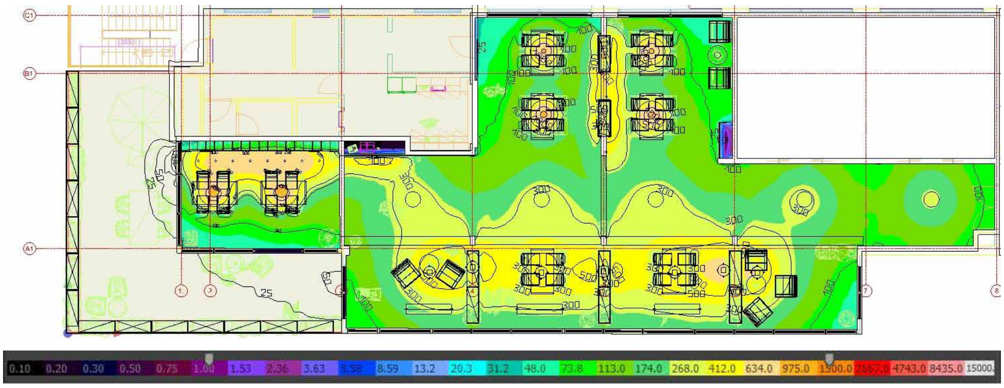


Fig. 70 Results - general lighting

In the first step values achieved with fixture Malmo with output of 5427 lm were reaching approximately 300 lx, which weren't fulfilling the criteria. As well as in the test performed in development design for choosing circadian lighting luminaire, EML values were too low. Therefore design had to be revisited in this zone.
We assumed that a more powerful lamp could cause glare issues, thus we decided to examine if adding three of the same fixtures would solve the problem. All seven Malmo fixtures were placed in equal distance. In order to locate lamps directly above the tables, placement of furniture located at the sides of the zone was changed. Tables and chairs were moved approximately 1 m towards the side of the zone. After this adjustment four of the fixtures were located directly above the tables. Three remaining ones were placed in between, so all the seven lamps are in the same distance from each other. After proposed changes, values on the workplane fulfilled aimed criteria (Fig. 71).

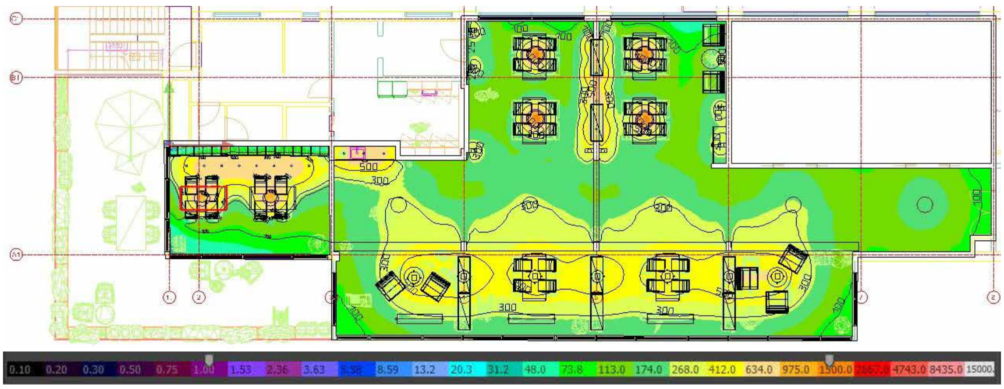


Fig. 71 Results - final proposal

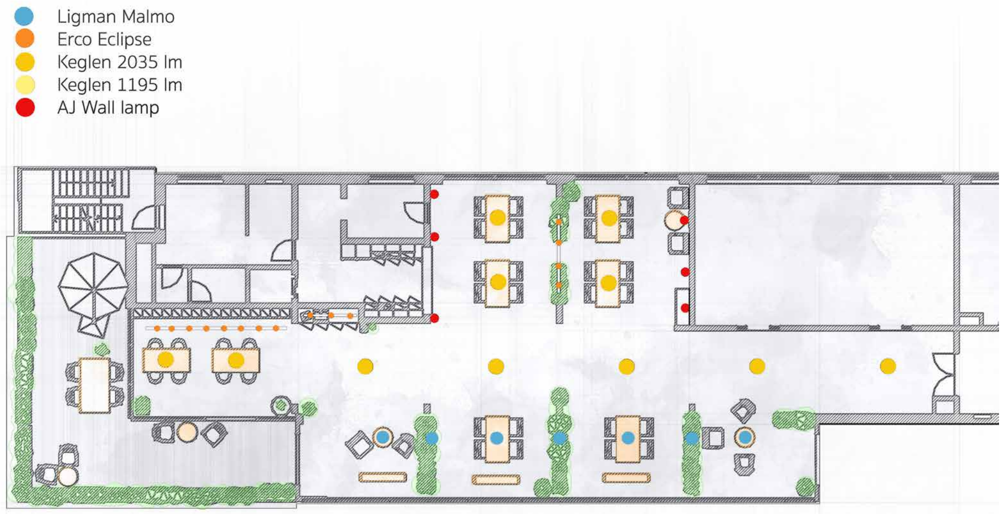



Fig. 72 Final proposal luminaires placement

Fig. 73 shows fixtures used in final design. The choice of the fixtures was dictated by the desired homelike atmosphere and color temperature.

| |  |  |  |  |
|---|---|---|---|---|
| Lamp | Keglen | Malmo | AJ Wall Lamp | Eclipse |
| Lumen | 2035 | 5427 | 800 | 1432 |
| CCT/CRI | 2700/2300 K | TUW | 2300 K | 2700/2300 K / 92 |
| Wattage | 31 W | 43 W | 6 W | 13,9 W |
| Producer | Louis Poulsen | Ligman | Louis Poulsen | Erco |
| System | DALI | DALI | - | DALI |

Fig. 73 Light fixtures

Table below presents achieved values from simulations. Just by looking at the numbers it may seem that there isn't a big difference in the illuminance of surrounding and background. Since the numbers are average values, they don't show nuances in light distribution that can be visible in false color and the renders presented in the final design part.

| **Leisure Area** | Task | Surrounding | Backgroung |
|---|---|---|---|
| Table 1 | 518 | 394 | 196 |
| Table 2 | 526 | 465 | 194 |
| Table 3 | 518 | 399 | 196 |
| Table 4 | 535 | 464 | 195 |
| | | | |
| | | | |
| **Circadian Area** | Task | Surrounding | Background |
| Table 1 | 583 | 223 | 198 |
| Table 2 | 574 | 235 | 198 |
| Table 3 | 556 | 191 | 198 |
| Table 4 | 551 | 193 | 199 |
| | | | |
| | | | |
| **Horticulturte Room** | Task | Surrounding | Background |
| Table 1 | 633 | 356 | 216 |
| Table 2 | 675 | 390 | 210 |

Fig. 74 Illuminance values

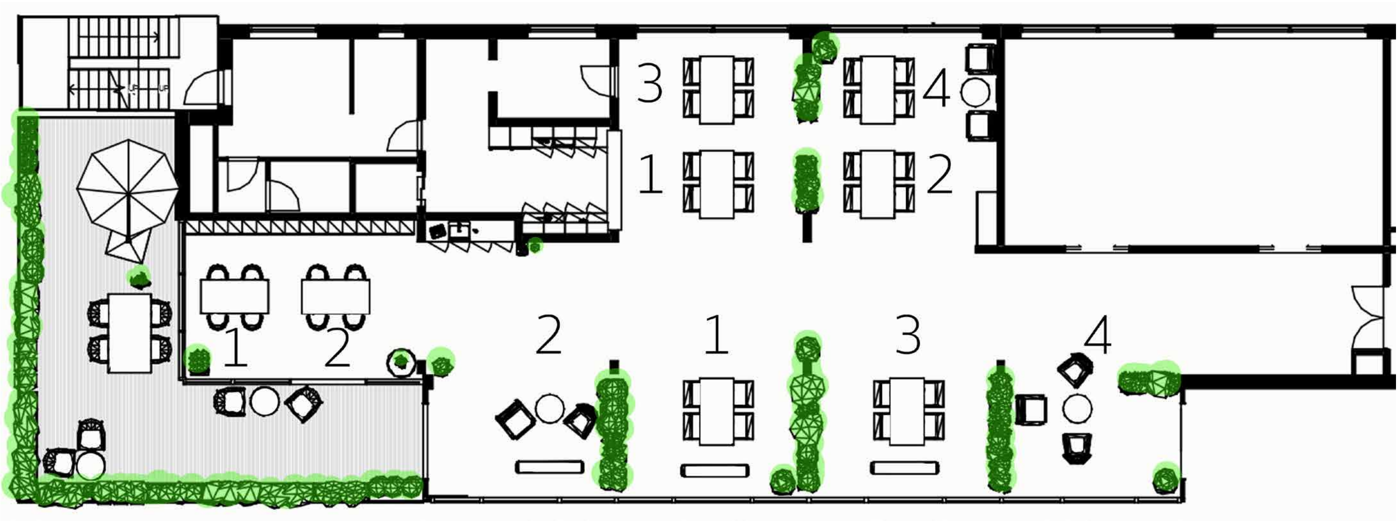


Fig. 75 Table numbering principle

## Melanopic EML in ALFA

The EML test was conducted in the Alfa plug-in for Rhino. A 3D model based on a design that successfully fulfilled illuminance criteria was modeled in Rhino.

Because of spectral raytracing a program can simulate the amount of light absorbed by a photoreceptors of a person being in this space. Reliable numbers are calculated based on the location, time and date. Equivalent melanopic lux (EML), is referred to the quantity of absorbed melanopsin. By using Alfa we could test if the proposed lighting design is meeting a minimum of 200 equivalent melanopic lux during different seasons, sky conditions and times of the day.

Simulations were conducted with proposed electrical light and daylight. Test was conducted every hour in the time frame from 7am to 2pm. Time frame was chosen based on our proposed 24 hour lighting scheme - when the alertness is aimed to be stimulated. The impact of the design was tested during following dates for clear sky and overcast sky conditions:

- 20 of march (spring equinox)
- 21 of june (summer solstice)
- 22 of september (autumn equinox)
- 21 of december (winter solstice)

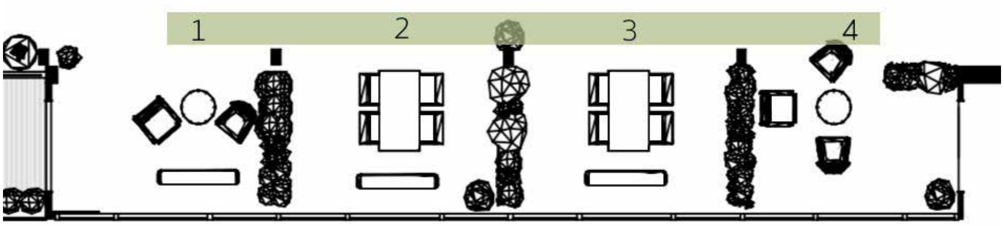



Fig. 76 Table numbering principle

**Spring Equinox**

Results of EML tests during clear sky conditions with daylight and electric light are reaching very high values on every table. Peak values are between 11am to 14pm. Whereas during overcast conditions - daylight together with electric light is providing results that are 5 times lower (and 9 times lower on table 1), compared to clear sky.

The results show that no electric light is needed during spring time in clear sky conditions. Daylight itself is providing sufficient EML values. Whereas during overcast sky conditions electric light might be needed only in the early morning - at 7am. All the other times of the day daylight provides sufficient EML. Therefore circadian lighting can be turned off to save energy.

**Summer Solstice**

Almost all EML values are above 2000. The differences between overcast and clear sky conditions aren't as dramatic as in the spring equinox. Results during clear sky are twice higher compared to overcast.

The results show that no electric light is needed during summer time. Daylight is providing sufficient EML values. Therefore circadian lighting can be turned off to save energy.

**Autumn Solstice**

Results between 11am to 14pm show very high values reaching approximately 8000 EML during clear sky conditions and 1500 EML on an overcast day. Table 1 is exceptional - highest values of 29090 lx are achieved at 13pm during clear sky and 3315 lx on a cloudy day.

After analysing results, we find out that support from electric light is needed between 7am to 9am.

**Winter Equinox**

During morning hours (7am - 9am) values are slightly higher than 200 EML in a clear sky and overcast sky conditions. Such a drastic change between values compared to other seasons is a result of the later sunrise during the winter season - sun rises around 8.30am. During 7am to 9am users are dependent only on the electric light as a circadian stimuli. During clear sky conditions values are higher than 1000 EML from 10am to 14pm. Whereas during overcast sky the values over the space mostly peak to ~500 EML. Therefore we suggest keeping electric light switched on for the purpose of circadian stimulus.

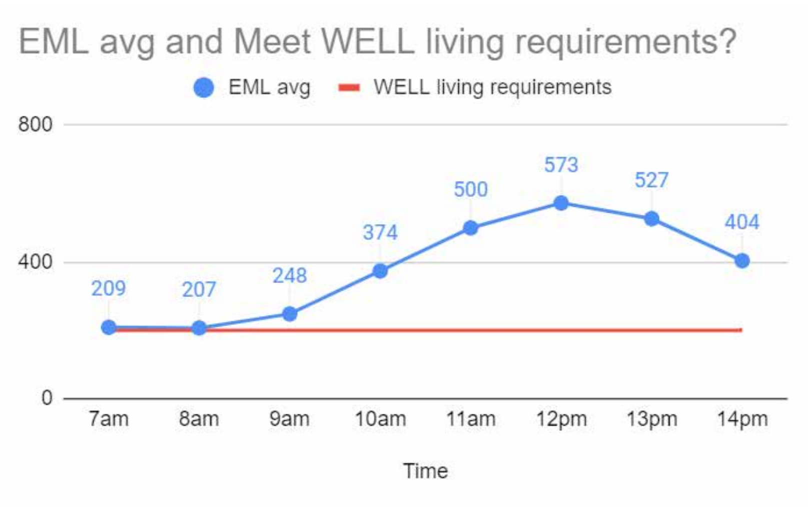



Fig. 77 EML values from table 3 with overcast sky

**Conclusion**

Proposed electric light design fulfils WELL requirement of EML ≥ 200. When daylight is present the values are higher than 200 EML and during summer, spring and clear sky autumn EML values are very high, thus electric light can be switched off. Based on results we suggest that electric light should be switched on during following times:

- Spring overcast sky conditions 7am to 8am
- Autumn 7am to 9am
- Winter clear sky conditions 7am to 10am
- Winter overcast sky conditions throughout the day
- All the data from this test can be found in Appendix 8.

# Final design

Final design for Nældebjerg care home has been developed with a holistic and interdisciplinary approach. The knowledge gained throughout literature study and analyses assisted in establishing design that ensures - elderly with dementia needs are not neglected. Moreover, the criterias which were developed from scientific knowledge guided the design process towards final design, which can contribute to the well being of elderly. Test criterias helped to validate our choices of lighting fixtures/ characteristics and to ensure that visual and physiological needs of elderly will be supported.

Essential part of this project is greenery. In this proposal we do not suggest any particular plants, besides the fact that the flora used in the design should be related to the neighbourhood. Though we have created criterias for greenery that can be used indoors and on the terrace.

Criteria for greenery inside the care home based on the literature:

- Non poisonous plants
- Thorny or sharp-leaved plants avoided
- Plants that frequently drop their leaves or flowers avoided
- Plants that can tolerate harsh treatment and excessive watering

Plants are organically composed throughout the cafe area, so it blends into everyday activities by providing the view indoors and sensory stimulation through smell and touch. The terrace is a continuum of the process of contact with nature. Containers for plants are made of the same material, but they vary in form. The height of the box allows people who sit or stand to observe the plants, touch them or even perform gardening activities
As it was acknowledged by the interviewed caretaker, protection from the wind would be helpful for the elderly to explore outdoor areas. The proposed railing system with curtain wall will

give a possibility of air circulation, as well as provide the opportunity to learn this phenomenon again if wished through experiencing the blow of the wind. The shading system consists of umbrellas as a familiar device.

The chosen space - Cafe area is divided into three lighting zones that support the functionality of the space and creates a stimulating environment for elderly. Since the zones are devoted for different activities, they vary in color temperature, applied fixtures and their placement.


Fig. 78 Section of Cafe area

## Circadian zone

The main purpose of the circadian zone is to support disrupted day and night cycles of elderly with dementia. Additional benefits of proposed lighting design is to tackle seasonal affective disorder in dark months of the year. Developed 24 hours lighting scheme, based on literature study (figure x) showing how the CCT is changing during the day.  After conducting an EML test in Alfa it turned out that the light doesn't have to support the daylight throughout the whole year. It can be turned down during spring and summer time. It is crucial to use it during the winter season from 7:00 to 10:00 with CCT at 6500 K to support recommended melanopic lux. Through such a scenario all the seasons can be expressed through the daylight and mark the passing of time. This scenario is customized to the approximate schedule of residents at the care home, so it can successfully support biological rhythm from waking up to late evening hours. The DALI protocol is controlling the change of CCT throughout the day. Fixtures are turned on and off manually. This action can be performed by the staff of the care home.

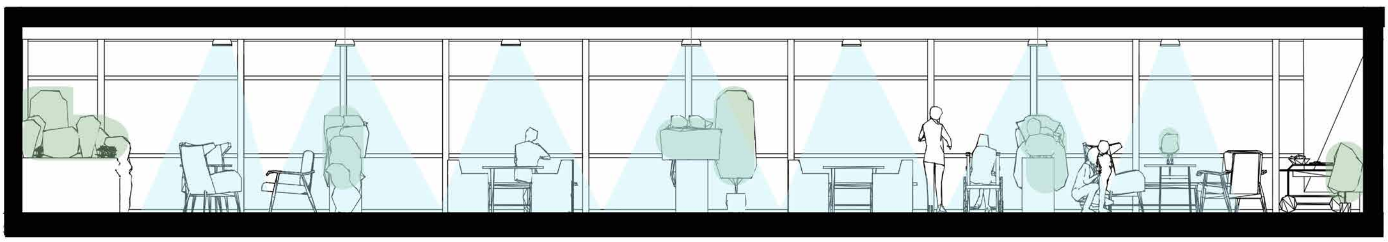


Fig. 79 Section of  Circadian zone

## Atmospheric area

This zone is characterized by 2300 K color temperature to support a cozy atmosphere. The light principles for this area consists of pendants, wall mounted fixtures and track lights. Even though this space is devoted for relaxation and socialization, visual needs still play the main role, therefore we provide illuminance of 500lx on every table.

In Denmark, because of a strong dining tradition, pendants are often hanging just above the table. This feature has been used to create a familiar and cozy environment supported by 2300 K color temperature. Lighting distribution is creating an intimate and private atmosphere.

Track lights (Eclipse) and wall mounted fixtures (AJ) have been added to the room to create an ambient luminescence to support the composition of the pendants. Test of spatial distribution showed that the pendants have to be supported in order to avoid dark corners. This solution is supporting the use of the space by creating gradual transition from task to general light. Those fixtures also have CCT equal to 2300 K.

Corridor area is a transition between all three zones. Therefore the proposed CCT is 2700 K, as it will compose coherently with evening circadian light and the atmospheric zone. Illuminance in this zone hovers around 200 lx.

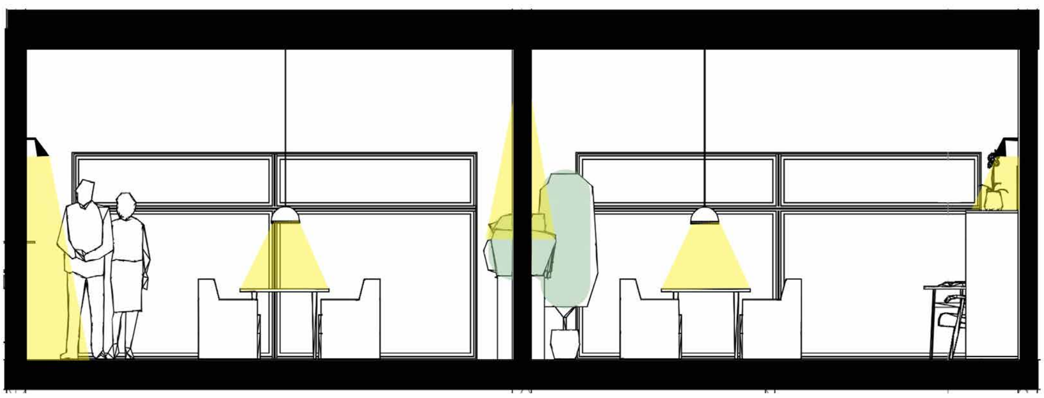


Fig. 80 Section of Atmospheric zone

**Horticulture area**

This area consists mainly of task lighting. Achieved values of approximately 600 lx provide a light level that is comfortable for elderly and enable to perform taste connected to horticulture. For keeping a coherence between this space and a leisure area, we have chosen the same pendants. They vary though in CCT. Warm white light of 2700 K is used there, as it isn't blocking melatonin production and provides good CRI. In this space CRI is important for color recognition and examination of the plants by the elderly.

Descriptions of the light fixtures can be found in the Appendix 5. Uneven distribution of light can be seen at the renderings. It is creating spatial depth. Hotspots of the  light are visible at the walls from wall mounted fixtures. That is highlighting the material of the wall and furniture placed by it. The circadian zone has more uniformed lighting, which is a result of placing fixtures in even distance and at the same height. The shadows are noticeable, but don't create any sharp forms, which might be confused with objects by the elderly (Cooper Marcus, Sachs 2014). Therefore it was one of the goals of this proposal. Pendants in the corridor create a soft transition from one zone to another.

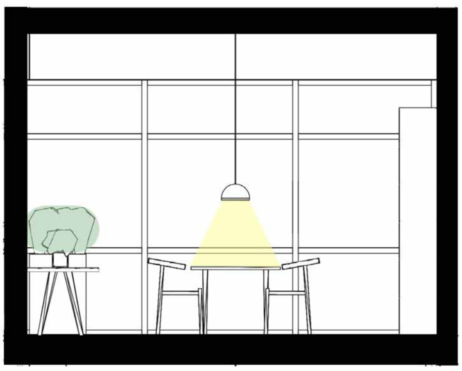


Fig. 81 Section of Horticulture zone


Fig. 82 Final lighting plan

**Environment**

Designed space has big windows on one side and a curtain wall on the other. Because of this structure a great amount of daylight is entering the space. Since the elderly are sensitive to glare and the sun has solar altitude in Denmark, we assumed that glare would be an issue, especially during summer time. Glary reflections were also visible during conducting simulations. One of the solutions was to change floor material. Commonly used linoleum with high reflectance values was changed to floor panels.  Another solution is to use curtains. This solution might block the view for many hours and lower the illuminance values coming from daylight. Change of the material solved the problem in the simulations, but further investigation through conducting glare tests in specialized software Climate Studio would be useful as a next step of the project.
Additional aspect to consider is to prevent fixed objects in the common space. This action can enable mobility for the objects and placing them according to the preferences of the users.

- protection form the wind

Fig. 83 Final design - day time



Fig. 84 Final design Circadian zone - day time


Fig. 85 Final design Circadian zone - day time


Fig. 86 Final design Circadian zone - day time

Fig. 87 Final design Hallway/Atmospheric - day time



Fig. 88 Final design Atmospheric - day time

Fig. 89 Final design Task area - day time

Fig. 90 Final design Task area - day time

Fig. 91 Final design Terrace - day time

Fig. 92 Final design Terrace - day time

Fig. 93 Final design - night time



Fig. 94 Final design Circadian zone- night time

Fig. 95 Final design Atmospheric zone- night time

Fig. 96 Final design Atmospheric zone- night time

Fig. 97 Final design Hallway- night time

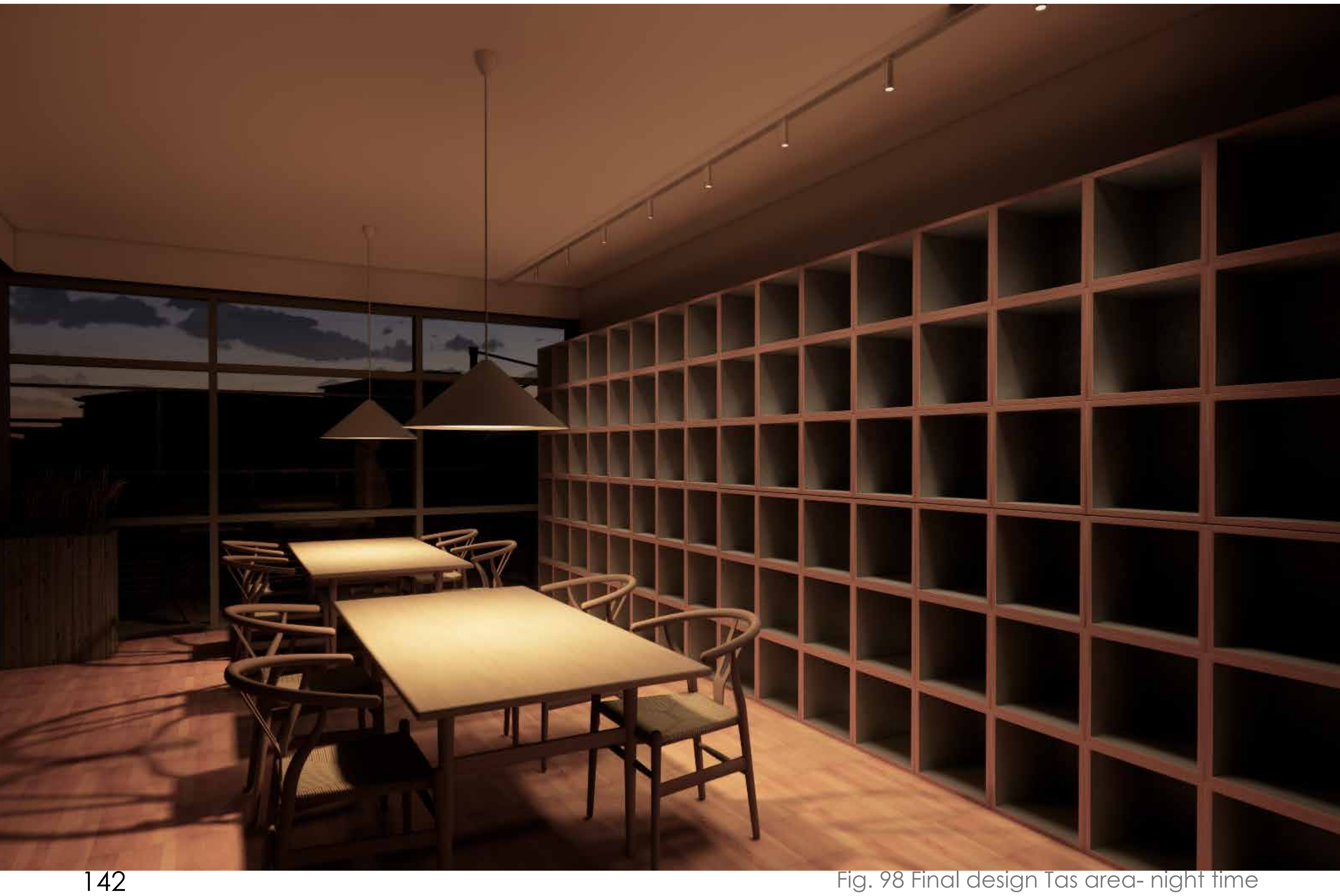




Fig. 98 Final design Tas area- night time

# Chapter 5
## Discussion

The thesis has been concerned with the influence of lighting and greenery on elderly with dementia. The methodology used to approach this topic was built on the procedural model, developed by Hansen and Mullins, where multidisciplinary knowledge lays the basis for a design process. This exploration was based on a context-independent literature study, in a field of physiological effects of light, impact of nature on well-being and details of light therapy.

In the following chapter the criteria from the framework and design proposal are analysed and discussed in relation to the research question:

*How can an environment contributing to well-being be created for the elderly suffering from dementia at care homes, through a nature and lighting design focusing on atmosphere, physiological and visual needs of the residents?*

We aim to answer our research question through the theoretical criteria connected to subquestiones.

*How can daylight supported by electric light normalize disrupted circadian rhythm?*

*How can electric light:*

*- provide sufficient illuminance for tasks*
*- create an atmosphere for relaxation and socialization?*

The framework was developed to further specify the theoretical criteria, which were later used as a basis for the design process. A primary investigation regarding elderly eye vision, circadian rhythm, biophilia and horticulture have contributed to the development of the design. The theoretical criteria based on literature study focus on objective benefits as well as the potential environment design of the space.

We have learned from the analytical framework that elderly suffer from disrupted circadian rhythm and seasonal affective disorder can also influence their conditions during winter seasons. Reconnecting with nature through daylight supported by electric light and greenery can balance those conditions.
By defining criteria for the fixtures, their output and distribution we created zones that are fulfilling the needs of the residents. Through conducted tests and achieved results we believe that proposed design can truly enhance well-being through reconnecting to biological rhythm.

A lot of information was gained through quantitative methods used to analyze case study – Nældebjerg Plejecenter. From observations and interviews at co-case study it was possible to get closer to the elderly and understand their needs and behaviors. By analyzing both of those spaces, and extracting information essential for this thesis, a practical aspect could have been applied. Most of the knowledge is based on the literature and it was really beneficial to support the project by experiencing one to one contact with elderly with dementia through participant observation and being at the care home. One might argue how the method of participant observation can be valid for such a case. Because of demented mind conversation does not always make sense - is not trustful source of information. Therefore, the focus was on observing behavioral patterns and extracting knowledge from it.

It can be argued if proposed criteria are sufficient and if their effect will be visible on the elderly. That would require further observations in a space. However, through analyzing the criteria and conducting tests presented in this thesis, proposed design will cause positive changes in daily life of the elderly.

Answer for the first subquestion (*How can daylight supported by electric light normalize disrupted circadian rhythm?)* is related to the second theoretical criteria:

**Enriching circadian rhythm stimulus by daylight supported with electric light**

*- Cooler light in morning hours*
*- Zones of light to meet different needs and functions of the space*

First criterion is fulfilled through applying the proposed 24-hour lighting scheme (Fig. X). The transitions of color temperatures support the physiological effects  of daylight through using 6500 K short-wavelength light between 7:00 - 10:00 and dimming towards 2300 K light during the evening to regulate users' circadian rhythms. Daily rhythm is enhanced by different functions of the zones adjusted to regular activities like meetings with family or gardening i horticulture area.

Second subquestion *(How can electric light provide sufficient illuminance for tasks?)* can be answered through third theoretical criterion:

**Supporting visual needs of aged eye to perform tasks**

- Avoid glare
- Low contrast ratio
- Higher illuminance to perform activities

Visual needs are supported by optimal average 500 lx illuminance on every table.  In order to lower contrast ratio general lighting has been applied. The placement of the light sources was dictated by their characteristics and proposed furniture layout of the space. This action ensured the desired results, in terms of illuminance, uniformity, and atmosphere. Avoidance of glade would require further investigation in situ through material analysis. Simulations haven't shown any glare issues, but the results aren't as reliable as real life test.

Third subquestion *(How can electric light create an atmosphere for relaxation and socialization?)* is connected to two remaining criterias:

- Connection to nature
- Local plants
- Accessibility to outdoors view
- Expression of the seasons
- Comfortable conditions of outdoor environment

**Atmospheric environment creating homeliness**

- Creating familiar lighting environment
- Cozy atmosphere through warm light
- Familiar shading system
- Easy control over the space

Atmosphere devoted to relaxation is mainly achieved through familiar lighting - placement of the fixtures and warm CCT. Such an environment can create conditions for socializing and the plants used as a part of inferior provide topics for conversations and contemplations.

After this description of the design proposal and its details, the design proposal is found to fulfil the theoretical criteria based on the literature. The vision for this project was that this space would enhance the well-being of the residents through creating a comfortable environment that meets the visual needs by applying high illuminance values and supporting their circadian rhythm. Since the tests showed a fulfillment of the design criteria, the vision is also considered to be fulfilled. Therefore, the lighting design supports the needs of the elderly and enhances their well-being.

# Chapter 6

## Conclusion

The thesis has illustrated how lighting can influence the well-being of the elderly. Through the research question broken into subquestions the overall vision of the thesis has been achieved. By evolving initial design, which went through the interactive process, including tests, we were able to form a final proposal which consists of different functions based on transdisciplinary knowledge. Even though the project was written under the restrictions of the pandemic Covid - 19, we aimed to approach tests and analysis with methods that provided successful results.

The proposed design offers conscious lighting design in care homes that could be applied into different institutions after adjustments. Following the criteria would help to create an environment where elderly can deal easily with everyday tasks by fulfilling their visual needs by increasing illuminance levels and regulating day and night patterns, and thus ensure their well-being, which could be cultivated through relaxing and socializing in the intimate and familiar conditions. The character of the criteria elevates the importance of connection to nature, not only by contact with greenery but also by experiencing effects of daylight.

# Future works

The solutions incorporated into the design proposal can be used in other care homes environments. Application of three zones offer flexibility in a space. However, as previously mentioned in the delimitations and discussion, there are additional elements that can be further explored and implemented into this project to ensure its strength.

Firstly, once the Covid-19 restriction would allow visiting Plejecenter, it would be beneficial to investigate materials and current light levels in order to gather empirical data that could influence proposed design and adjust it. As we assumed, the current floor might cause glare. Gathering data about materials would show if they function well with the lighting design in this area or the change is needed. On-site investigation could be supported by glare analysis in plug-in Climate Studio used with Rhino software.

Participant observation could be repeated in the designated area in Nældebjerg Plejecenter., which would focus on behaviours of the residents. The investigation would focus on prefered lighting conditions and interest in greenery.

In order to promote horticulture activities we could suggest a weekly plan for using the horticulture room. Tasks would promote gardening and sensory experiences with greenery.

Lastly, a real scale model of proposed lighting could be tested in the cafe area of case study. That would show how the zones are cooperating together.

# References


Ancoli-Israel, S., J. L. Martin, P. Gehrman, T. Shochat, J. Cory- Bloom, M. Marler, S. Nolan, and L. Levi. 2003. "Effect of Light on Agitation in Institutionalized Patients with Severe Alzheimer Disease." American Journal of Geriatric Psychiatry 11 (April): 194–203.

Alzheimer's Association, 2006 https://www.alz.org/alzheimers-dementia/what-is-dementia/types-of-dementia/frontotemporal-dementia

Altomonte, S. (2009). Daylight and the Occupant. Visual and physio-psychological well-being in built environments: PLEA.

Alzheimerforeningen, (2019); Retrieved 14.02.2021; https://www.alzheimer.dk/media/196119/2019-02-07-notat-om-aeldre-og-demens.pdf

Aries, M. B., Aarts, M. P., & van Hoof, J. (2015). Daylight and health: A review of the evidence and consequences for the built environment. Lighting Research & Technology, 47(1), 6-27.

Baldacchino, D. and Draper, P. (2001) Spiritual Coping Strategies: A Review of the Nursing Research Literature. Journal of Advanced Nursing, 34, 833-841.
https://doi.org/10.1046/j.1365-2648.2001.01814.x

Baucom, A H. (1996). Hospitality design for the graying generation: Meeting the needs of a growing market. New York: John Wiley & Sons.

Beauchemin, K. M., & Hays, P. (1996). Sunny hospital rooms expedite recovery from severe and refractory depressions. Journal of affective disorders, 40(1-2), 49-51.

Benbow B., Benbow (2014) Best Practice Design Guidelines: Nursing Home, Complex Care and Dementia, (BPDG), Retrieved: 21.03.2020, Available: http://wabenbow.com/wp-content/uploads/2010/03/Benbow-Best-Practice-Design-Guideline-November-2014-compressed.pdf

Benyon, David. (2014). Spaces of Interaction, Places for Experience. 10.2200/S00595ED1V01Y201409HCI022).

Berto, R. (2007). Assessing the restorative value of the environment: A study on the elderly in comparison with young adults and adolescents. International journal of psychology, 42(5), 331-341.

Bhatti, M. (2006). 'When I'm in the garden I can create my own paradise': Homes and gardens in later life. Sociological Review, in press.

Bibobent. dk, Retrieved 12.04.2021 http://www.biobent.dk/danklidk.html

Bille, M. (2015). Lighting up cosy atmospheres in Denmark. Emotion, Space and Society.

Bischoff-Ferrari HA.(2010) Vitamin D and fracture prevention. Endocrinol Metab Clin N Am. 2010;39(2):347–53.

Bombois, S., Derambure, P., Pasquier, F., & Monaca, C. (2010). Sleep disorders in aging and dementia. The journal of nutrition, health & aging, 14(3), 212-217.

Bossen, A. (2010). The importance of getting back to nature for people with dementia. Journal of Gerontological Nursing, 36(2), 17-22.

Bowes, A., Dawson, A., Greasley-Adams, C., & McCabe, L. (2018). Developing best practice guidelines for designing living environments for people with dementia and sight loss. Ageing and Society, 38(5), 900-925.

Boubekri, M. (2008). Daylighting, architecture and health: building design strategies. Routledge.

Brush, J. A., MEEHAN, R. A., & CALKINS, M. P. (2002). Using the environment to improve intake for people with dementia. Alzheimer's Care Today, 3(4), 330-338.

Bryden, D. (2014). CAD and rapid prototyping for product design . London, England: Laurence King Publishing.

Buonocore Pablo, Light as cultural asset, 2007 https://issuu.com/da-magazine/docs/da04

Burns, A. (1992). Psychiatric phenomena in dementia of the Alzheimer's type. International Psychogeriatrics, 4(Suppl. 1), 43-54.

Burns, A. (1996). Psychiatric and behavioral disturbances in dementia: A review of therapy. International Psychogeriatrics, 8(Suppl. 2), 201-207.

Caldwell, K., Fernandez, R., Traynor, V., & Perrin, C. (2014). Effects of spending time outdoors in daylight on the psychosocial well-being of older people and their family carers: a systematic review. JBI Evidence Synthesis, 12(9), 277-320.

Calkins, M. (1988). Planning environments for the elderly and confused. Owings Mills, MD: National Health Publishing.

Canellas, F., Mestre, L., Belber, M., Frontera, G., Rey, M. A., & Rial, R. (2016). Increased daylight availability reduces length of hospitalisation in depressive patients. European archives of psychiatry and clinical neuroscience, 266(3), 277-280.

Chan, H.Y., Cheng, K.M., Lo, M.W., Chan, C.M., Cheung, Y.L. (2006). A treatable case of dementia-- intracranial dural arteriovenous fistula. Hong Kong Medical Journal, 12(1), 74-76.

Chalfont, G. (2008). Design for Nature in Dementia Care. London: Jessica Kingsley Publishers.

Chalfont GE.(2006) Connection to nature at the building edge: towards a therapeutic architec- ture for dementia care enviornments PhD thesis Sheffield. University of Sheffield, 2006.

Chapuy MC, Arlot ME, Duboeuf F, Brun J, Crouzet B, Arnaud S, Delmas PD, Meunier PJ

(1992) Vitamin D3 and calcium to prevent hip fractures in elderly women. N Engl J Med 327: 1637–1642

Cohen-Mansfield, J., and P. Werner. (1998). "Visits to an Outdoor Garden: Impact on Behavior and Mood of Nursing Home Residents Who Pace." Pp. 419–36 in Research and Practice in Alzheimer's Disease, edited by B. Vellas and L. J. Fitten. New York: Springer Publishing.

Cohen U, Day K: (1993). Contemporary Environments for People with Dementia. Baltimore, MD: The Johns Hopkins University Press, 1993.

Cohen, U., & Weisman, G. D. (1990). Experimental design to maximize autonomy for older adults with cognitive impairments. Generations: Journal of the American Society on Aging.

Colenda, C.C., Cohen, W., Mc Call, W.V., Rosenquist, P.B., (1997). Phototherapy for patients with Alzheimer disease with disturbed sleep patterns: results of a community-based pilot study. Alzheimer Dis. Assoc. Disord. 11, 175–178.

Connell, B. R., J. A. Sanford, and D. Lewis. (2007). "Therapeutic Effects of an Outdoor Activity Program on Nursing Home Residents with Dementia." Pp. 195–209 in Outdoor Environments for People with Dementia, edited by S. Rodiek and B. Schwarz. Binghamton, NY: The Haworth Press.

Coons, D. H., & Mace, N. (1990). Residential care for persons with dementia. Dementia care: Patient, family, and community, 337-373.

Coper- Marcus, C. Sachs, N. (2014). Therapeutic Landscapes: An Evidence-Based Approach to Designing Healing Gardens and Restorative Outdoor Spaces.

Dam H, Jakobsen K, Mellerup E. (1998) Prevalence of winter depression in Denmark. Acta Psychiatr Scand.

Davis, R. G., & Wilkerson, A. M. (2016). Tuning the light in senior care: Evaluating a trial LED lighting system at the ACC Care Center in Sacramento, CA (No. PNNL-25680). Pacific Northwest National Lab.(PNNL), Richland, WA (United States).

Day K, Calkins MP(2002): Design and dementia. In Bechtel R, Churchman A (eds.): Handbook of Environmental Psychology. New York: John Wiley and Sons.

De Lepeleire, J., Bouwen, A., De Coninck, L., & Buntinx, F. (2007). Insufficient lighting in nursing homes. Journal of the American Medical Directors Association, 8(5), 314-317.

DeLuca, H. F. (1988). The vitamin D story: a collaborative effort of basic science and clinical medicine 1. The FASEB Journal, 2(3), 224-236.

DiCicco-Bloom B. & Crabtree B.F. (2006) The qualitative research interview. Medical Education 40(4), 314–321. doi:10.1111/j.1365-2929.2006.02418.x

Duggan, S., Blackman, T., Martyr, A., & Van Schaik, P. (2008). The impact of early dementia on outdoor life: A "shrinking world"? Dementia, 7, 191-204.

Eastman, C. I. (1990). Natural summer and winter sunlight exposure patterns in seasonal

affective disorder. Physiology & behavior, 48(5), 611-616.
Edensor, T. (2015). Light design and atmosphere. Visual Communication, 14(3), 331-350.

Edwards, L., & Torcellini, P. (2002). A literature review of the effects of natural light on building occupants. National Renewable Energy Laboratory.

Feddersen, E., & Lüdtke, I. (Eds.). (2014). Lost in space: Architecture and dementia. Birkhäuser.

Fitzgerald, F. Scott (Francis Scott), 1896-1940. (1925). The great Gatsby. New York :C. Scribner's sons,

Flicker L, MacInnis RJ, Stein MS, Scherer SC, Mead KE, Nowson CA, Thomas J, Lowndes C, Hopper JL, Wark JD (2005) Should older people in residential care receive Vitamin D to prevent falls? Results of a randomized trial. J Am Geriatr Soc 53: 1881–1888

Furness, S., & Moriarty, J. (2006). Designing a garden for people with dementia—in a public space. Dementia, 5(1), 139-143.

Fuller, R.A., K.N. Irvine, P. Devine-Wright, P.H. Warren, & K.J. Gaston (2007). Psychological Benefits of Greenspace Increase with Biodiversity. Biology Letters 3 (4), 390-394.

Galletta, A., & CROSS, W. (2013). The Semi-Structured Interview as a Repertoire of Possibilities. In Mastering the Semi-Structured Interview and Beyond: From Research Design to Analysis and Publication (pp. 45-72). New York; London: NYU Press.

Gasio, P. F., Kräuchi, K., Cajochen, C., van Someren, E., Amrhein, I., Pache, M., ... & Wirz-Justice, A. (2003). Dawn–dusk simulation light therapy of disturbed circadian rest–activity cycles in demented elderly. Experimental gerontology, 38(1-2), 207-216.

Gilley, D. W. (1993). Behavioral and affective disturbances in Alzheimer's disease. In R. W. Parks, R. F. Zec & R. S. Wilson (Eds.), Neuropsychology of Alzheimer's Disease and other Dementias (pp. 112-137). New York: Oxford University Press.

Glerup, H., Mikkelsen, K., Poulsen, L., Hass, E., Overbeck, S., Thomsen, J., ... & Eriksen, E. F. (2000). Commonly recommended daily intake of vitamin D is not sufficient if sunlight exposure is limited. Journal of internal medicine, 247(2), 260-268.

Grant, C. F., and J. D. Wineman. (2007). "The Garden-Use Model— An Environmental Tool for Increasing the Use of Outdoor Space by Residents with Dementia in Long-Term Care Facilities." Journal of Housing for the Elderly 21 (1/2): 89–115.

Hadjri, K., Rooney, C., & Faith, V. (2015). Housing choices and care home design for people with dementia. HERD: Health Environments Research & Design Journal, 8(3), 80-95.

Hansen, E. K., & Mullins, M. (2014). Lighting Design-Toward a synthesis of science, media technology and architecture.

Haas, K. L., & McCartney, R. (1996). The therapeutic qualities of plants. Journal of Therapeutic Horticulture, 8, 61-67.

Hatfield, C. F., Herbert, J., Van Someren, E. J., Hodges, J. R., & Hastings, M. H. (2004). Disrupted daily activity/rest cycles in relation to daily cortisol rhythms of home-dwelling patients with early Alzheimer's dementia. Brain, 127(5), 1061-1074.

Heningsen, P. https://www.scandinaviandesign.com/poulHenningsen/

Holick MF.(1995) Environmental factors that influence the cutaneous production of vitamin D. Am J Clin Nutr. 1995;61(Suppl 3):638s–45s.

Holick, M. F. (2007). Vitamin D deficiency. New England Journal of Medicine, 357(3), 266-281.

Jackson GR, Owsley C, McGwin G Jr.(1999). Aging and dark adaptation. Vision Res. 1999 Nov;39(23):3975-82. doi: 10.1016/s0042-6989(99)00092-9. PMID: 10748929.

Jarrott, S. E., Kwack, H. R., & Relf, D. (2002). An observational assessment of a dementia-specific horticultural therapy program. HortTechnology, 12(3), 403-410.

Kaida, K., Takahashi, M., & Otsuka, Y. (2007). A short nap and natural bright light exposure improve positive mood status. Industrial health, 45(2), 301-308.

Kallio, H., Pietilä, A. M., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: developing a framework for a qualitative semi□structured interview guide. Journal of advanced nursing, 72(12), 2954-2965.

Kaplan R. (1973) Some Psycholog Ical Benefits of Gardening. Environment and Behavior. 1973;5(2):145-162. doi:10.1177/001391657300500202

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. Journal of Environmental Psychology, 15, 169-182.

Kaplan, S. (2001). Meditation, restoration, and the management of mental fatigue. Environment and Behavior, 33, 480-506.

Kelly, F., Innes, A., & Dincarslan, O. (2011). Improving care home design for people with dementia. Journal of Care Services Management, 5(3), 147-155.

Kelly S.E. (2010) Qualitative interviewing techniques and styles. In The SAGE Handbook of Qualitative Methods in Health Research (Bourgeault I., Dingwall R. & De Vries R., eds), SAGE, London, pp. 307–327.

Kitwood, T. (1997). Dementia reconsidered: the person comes first. Buckingham: Open University Press.

Kolanowski, A.M., Whall, A.L. (2000). Toward holistic theory-based intervention for dementia behavior. Holistic Nursing Practice, 14, 67-76.

Kosnik, William & Winslow, Laura & Kline, Donald & Sekuler, Robert. (1988). Visual Changes in Daily Life Throughout Adulthood. Journal of gerontology. 43. P63-70. 10.1093/geronj/43.3.P63.

Konis, K., Mack, W. J., & Schneider, E. L. (2018). Pilot study to examine the effects of indoor daylight exposure on depression and other neuropsychiatric symptoms in people living with dementia in long-term care communities. Clinical interventions in aging, 13, 1071.

Konis, K., & Schneider, E. L. (2018). The Importance of Daylight in Dementia Care Communities: A Call to Action. Seniors Housing & Care Journal, 26(1).

Levy R. (1994). Aging-associated cognitive decline. International Psychogeriatrics, 6, 63–68.

Lewis, J. F., & Mattson, R. H. (1988). Gardening may reduce blood pressure of elderly people: activity suggestions and models for intervention. Journal of Therapeutic Horticulture, 25-37.

Lewy AJ, Sack RL (1986): Light therapy and psychiatry. Proc Sot Exp Biol Med 183:I I-18.
Lighting design lab; Retrieved 25.02.2021; Accent Lighting and Contrast Ratios https://www.lightingdesignlab.com/resources/articles/articles-lighting-productivity/accent-lighting-and-contrast-ratios#:~:text=Our%20eye%20is%20naturally%20drawn,a%202%3A1%20contrast%20ratio.

Lingjaerde, 0.; Bratlid, T.; Hansen, T.; and Grotestam, K.G. (1986). Seasonal affective disorder and midwinter insomnia in the far north: Studies on two related chronobiological disorders in Norway. Proceedings of the (hllegium Internationale Neuro- Psychopharmacologicurn. 9:187-189, 1986.

Littlejohns TJ, Henley WE, Lang IA, Annweiler C, Beauchet O, Chaves PH, et al.(2014) Vitamin D and the risk of dementia and Alzheimer disease. Neurology. 2014;83:920–8.
Livingston, J. (2014). Designing with light: the art, science and practice of architectural lighting design. John Wiley & Sons.

Lovering, M. J. (1990). Alzheimer's disease and outdoor space: Issues in environmental design. American Journal of Alzheimer's Care and Related Disorders & Research, 5(3), 33–40. https://doi.org/10.1177/153331759000500030

Lovering, M. J., C. A. Cott, D. L. Wells, J. Schleifer Taylor, L. M. Wells. (2002). "A Study of a Secure Garden in the Care of People with Alzheimer's Disease," Canadian Journal on Aging 21 (3), 417–27.

Marshall, M. (Ed.). (2005). Perspectives on rehabilitation and dementia. London: Jessica Kingsley.

Marquardt, G. (2011). Wayfinding for people with dementia: a review of the role of architectural design. HERD: Health Environments Research & Design Journal, 4(2), 75-90.

McCloskey, R. M. (2004). Caring for patients with dementia in an acute care environment. Geriatric Nursing, 25(3), 139-144.

McMinn, B. G., and L. Hinton. (2000). "Confined to Barracks: The Effects of Indoor Confinement on Aggressive Behavior among Inpatients of an Acute Psychogeriatric Unit." American Journal of Alzheimer's Disease 15 (1) (January/February): 36–41.

McMurdo ME, Gaskell A.(1991). Dark adaptation and falls in the elderly. Gerontology 1991;37:221–224.

Meesters, Y., Dekker, V., Schlangen, L. J., Bos, E. H., & Ruiter, M. J. (2011). Low-intensity blue-enriched white light (750 lux) and standard bright light (10 000 lux) are equally effective in treating SAD. A randomized controlled study. BMC psychiatry, 11(1), 1-8.

Mersch PP, Middendorp HM, Bouhuys AL, Beersma DG, van den Hoofdakker RH. (1999). Seasonal affective disorder and latitude: a review of the literature. J. Affective Disorders 1999; 53(1): 35–48.

Mishima, K., Okawa, M., Shimizu, T., & Hishikawa, Y. (2001). Diminished melatonin secretion in the elderly caused by insufficient environmental illumination. The Journal of Clinical Endocrinology & Metabolism, 86(1), 129-134.

Moe, K. E., Vitiello, M. V., Larsen, L. H., & Prinz, P. N. (1995). Sleep/wake patterns in Alzheimer's disease: relationships with cognition and function. Journal of sleep research, 4(1), 15-20.

Mooney, P., and P. L. Nicell. (1992). "The Importance of Exterior Environment for Alzheimer's Residents: Effective Care and Risk Management." Health Care Management Forum 5 (2): 23–29.
NOELL-WAGGONER, E. U. N. I. C. E. (2002). Light: An essential intervention for Alzheimer's disease. Alzheimer's care today, 3(4), 343-352.

Morgan, D. G., & Stewart, N. J. (1999). The physical environment of special care units: Needs of residents with dementia from the perspective of staff and family caregivers. Qualitative health research, 9(1), 105-118.

Münch, M., Wirz-Justice, A., Brown, S. A., Kantermann, T., Martiny, K., Stefani, O., ... & Skene, D. J. (2020). The role of daylight for humans: gaps in current knowledge. Clocks & sleep, 2(1), 61-85.

National Research Strategy on Dementia 2025, 2018 https://www.sst.dk/-/media/Udgivelser/2018/National-Research-Strategy-on-Dementia-2025_Final.ashx

Nylén, P., Favero, F., Glimne, S., Teär Fahnehjelm, K., & Eklund, J. (2014). Vision, light and aging: A literature overview on older-age workers. Work, 47(3), 399-412.

O'Brien, J.,T., Sahakian, B. J., & Checkley, S. A. (1993). Cognitive impairments in patients with seasonal affective disorder. The British Journal of Psychiatry, 163(3), 338-343.

Parson, Ulrich, Tassinary (1994) Experimental Approaches to the Study of People-Plant Relationships

Percival, J. (2002). Domestic spaces: uses and meanings in the daily lives of older people. Ageing and Society, 22(6), 729-749.

Pickupflowers, Retrieved: 12.04.2021 https://www.pickupflowers.com/flower-guide/national-native-popular-flowers-of-denmark

Pollak, C. P., Perlick, D., Linsner, J. P., Wenston, J., & Hsieh, F. (1990). Sleep problems in the community elderly as predictors of death and nursing home placement. Journal of community health, 15(2), 123-135.

Rappe, E., and L. Lindén. (1992). "Plants in Health Care Environments: Experiences of the Nursing Personnel in Homes of People with Dementia." Pp. 75–81 in D. Relf, ed., The Role of Horticulture in Human Well-Being and Social Development. Portland, Oregon: Timber Press.

Reichel, H., Koeffler, H. P., & Norman, A. W. (1989). The role of the vitamin D endocrine system in health and disease. New England Journal of Medicine, 320(15), 980-991.

Reimer, M. A., Slaughter, S., Donaldson, C., Currie, G., & Eliasziw, M. (2004). Special care facility compared with traditional environments for dementia care: A longitudinal study of quality of life. Journal of American Geriatric Society, 52, 1085–1092.

Relf (Hefley), P.D. (1973). Horticulture—A thera- peutic tool. J. Rehab. 39(1):27-29.

Relf P.D. (1978). Horticulture as a recreational activity. Amer. Health Care Assn. J. 4(5 ):68–71.

Relf, D.(1992) Human issues in horticulture. Horticulture Technology, 2: 1–11, 1992.

Relf, D., & Dorn, S. (1995). Horticulture: Meeting the needs of special populations. HortTechnology, 5(2), 94-103.

Robbins, C. L. (1986) Daylighting Design and Analysis, New York: Van Nostrand Reinhold Company.

Rogers, C. (1961). On Becoming a Person: A Therapist's View of Psychotherapy. Boston: Houghton Mifflin

Rosen, L. N., Targum, S. D., Terman, M., Bryant, M. J., Hoffman, H., Kasper, S. F., ... & Rosenthal, N. E. (1990). Prevalence of seasonal affective disorder at four latitudes. Psychiatry research, 31(2), 131-144.

Rosenthal NE, Sack DA, Carpenter CJ, Mendelson WB. Wehr TA (1985): Antidepressant effects of light in seasonal affective disorder. Am J Psychiatry 142606-608.

ROSENTHAL, N. W., SACK, D. A. & GILLIN, J. (1984) Seasonal affective disorder. Archives of General Psychiatry, 41, 72-80

Royer, M., Ballentine, N. H., Eslinger, P. J., Houser, K., Mistrick, R., Behr, R., & Rakos, K. (2012). Light therapy for seniors in long term care. Journal of the American Medical Directors Association, 13(2), 100-102.

Ryan, A. (1992). Positive gardening-the benefits for elderly people'. Growth Point, (190).
Sadavoy, J. (1991). Psychodynamic perspectives on Alzheimer's disease and related dementias. The American Journal of Alzheimer's Disease Care and Related Disorders and Research, 12(12).

Schlögl, M., & Holick, M. F. (2014). Vitamin D and neurocognitive function. Clinical interventions in aging, 9, 559–568.

Schwarz, B., Chaudhury, H., & Tofle, R. B. (2004). Effect of design interventions on a dementia care setting. American Journal of Alzheimer's Disease & Other Dementias®, 19(3), 172-176.

Shaw, R (2014) Controlling darkness: Self, dark and the domestic night. Cultural Geographies.

Shochat, T., Martin, J., Marler, M., & Ancoli-Israel, S. (2000). Illumination levels in nursing home patients: effects on sleep and activity rhythms. Journal of sleep research, 9(4), 373-379.

Simson, S., & Straus, M. (1997). Horticulture as therapy: Principles and practice. CRC Press.

Sixsmith, A. J., & Sixsmith, J. A. (1991). Transitions in home experience in later life. The Journal of Architectural and Planning Research, 8(3), 181-191.

Solt, J., Aarts, M. P. J., Andersen, M., Appelt, S., Bodart, M., Kaempf, J., Bueno, B., Kuhn, T. E., Coccolo, S., Scartezzini, J-L., Schüler, A., Szybinska Matusiak, B., Volf, C., Wienold, J., Wirz-Justice, A., & Fournier, C. (2017). Daylight in the built environment. In Changing perspectives on daylight: science, technology, and culture (pp. 24-32). (Science; Vol. Supplement). Science/AAAS. https://daylight.academy/wp-content/uploads/2017/11/Daylight-Booklet_3-Nov-2017_med_single-pages.pdf

Soni, M., Kos, K., Lang, I. A., Jones, K., Melzer, D., & Llewellyn, D. J. (2012). Vitamin D and cognitive function. Scandinavian Journal of Clinical and Laboratory Investigation, 72(sup243), 79-82.

Söderback, I., Söderström, M., & Schälander, E. (2004). Horticultural therapy: the 'healing garden'and gardening in rehabilitation measures at Danderyd Hospital Rehabilitation Clinic, Sweden. Pediatric rehabilitation, 7(4), 245-260.

Sörensen S, Brunnström G. (1995).Quality of light and quality of life: An intervention study among older people. International Journal of Lighting Research and Technology. 1995;27(2):113-118.

Spradley, J.P. (1980). Participant Obsevation. New York: Holt, Rinehart and Winston.

Taft, L. B., Delaney, K., Seman, D., & Stansell, J. (1993). Creating a therapeuticmilieu in dementia care. J Gerontol Nurs, 19(10), 30-9.

Terrapin Bright Green. (2014.)"The Economics of Biophilia." Terrapin Bright Green, LLC,

Torrington, J. M., & Tregenza, P. R. (2007). Lighting for people with dementia. Lighting Research & Technology, 39(1), 81-97.

Tregenza, P., & Loe, D. (2013). The design of lighting. Routledge.

Tsuno, N., & Homma, A. (2009). What is the association between depression and Alzheimer's disease?. Expert review of neurotherapeutics, 9(11), 1667-1676.

Turner P.L., Mainster M. A., (2008) "Circadian photoreception: ageing and the eye's important role in systemic health", in: British Journal of Ophthalmology. London 92 (2008), 11, pp. 1439–1444.

Ulrich R.S.(1984) View through a window may influence recovery from surgery. Science 1984; 224(42): 421.

Van Bommel, W. J. (2006). Non-visual biological effect of lighting and the practical meaning for lighting for work. Applied ergonomics, 37(4), 461-466.

Van Hoof, J., Aarts, M. P., Rense, C. G., & Schoutens, A. M. (2009). Ambient bright light in dementia: Effects on behaviour and circadian rhythmicity. Building and Environment, 44(1), 146-155.

Van Someren, E. J., Kessler, A., Mirmiran, M., & Swaab, D. F. (1997). Indirect bright light improves circadian rest-activity rhythm disturbances in demented patients. Biological psychiatry, 41(9), 955-963.

Virumgård; Retrieved 25.03.2021, https://virumgaard.ltk.dk/plejecentret/om-plejecenter-virumgaard/afdeling-b

Vitaterna, M. H., Takahashi, J. S., & Turek, F. W. (2001). Overview of circadian rhythms. Alcohol Research & Health, 25(2), 85.

Waggoner Noel, E. U. N. I. C. E. (2002). Light: An essential intervention for Alzheimer's disease. Alzheimer's care today, 3(4), 343-352.

WELL. 2019. The WELL Building Standard v2 with Q1 2019 Addenda. New York, NY: WELL Building Institute

Whitbourne, S. K. (2002). The aging individual: Physical and psychological perspectives. Springer Publishing Company.

Whitehead, T. L. (2006). Workbook for descriptive observations of social settings, acts, activities & events. Cultural Ecology of Health and Changes: Ethnographically Informed Community and Cultural Assessment Research Systems (EICCARS) Workbooks, 1-11.

Wiking, M. (2016). The little book of hygge: The Danish way to live well. Penguin UK.

Wilson, E.O. (1984). Biophilia. Cambridge, MA: Harvard University Press

Wilson, E.O. (2002). The Future of Life, Alfred A. Knopf, New York, 256 p.

Wohlin, C. (2014, May). Guidelines for snowballing in systematic literature studies and a replication in software engineering. In Proceedings of the 18th international conference on evaluation and assessment in software engineering (pp. 1-10).

Wurtman, R. J. (1975). The effects of light on the human body. Scientific American, 233(1), 68-79.

Wänström Lindh, U. (2012). Light shapes spaces: experience of distribution of light and visual spatial

Yasukawa, M. (2009). Horticultural therapy horticultural therapy for the cognitive functioning of elderly people elderly people with dementia. In International Handbook of Occupational Therapy Interventions (pp. 431-444). Springer, New York, NY.boundaries.

Zaccai, J., McCracken, C., & Brayne, C. (2005). A systematic review of prevalence and incidence studies of dementia with Lewy bodies. Age and Ageing, 34(6), 561.

Zec, R. F. (1993). Neuropsychological functioning in Alzheimer's disease. In R. W. Parks, R. F. Zec & R. S. Wilson (Eds.), Neuropsychology of Alzheimer's disease and other dementias (pp. 3-80).New York: Oxford University Press

# Figures list

# Appendix

## Appendix 1 - Observations

James P. Spradley in 1980 created a method for qualitative interviewing called 9 Dimensions of Descriptive Observation and is based on a worksheet presented below. This work was created to standardize observations of ethnographers and anthropologists (shiftcomm). Spradley's method is ensuring that data collection consists of analysis and narrative construction (Spradley 1980).

**1. The Social Setting**

Kitchen / Eating area (pictures in the folder) ; first floor of care home
Ethnographic scene: Care home / Plejehjem Virumgård

Fig. 1 Kitchen

**2. The Physical Environment**

The kitchen is open to the corridor where many residents are passing by. Through the regular size windows another department of the care home is visible.  The balcony (door size) windows are opening to the path filled with trees. During the dark hours the curtains are covering windows.

**3. Space and the Objects in the Setting**

Space is filled with furniture typical for the care home (see Fig.1). There are 4 pots with different flowers on the table.

Fig. 2 Small plant and julestjerne

Fig. 3 Julestjerne and new plant

**4. Actors in the Setting**

In the kitchen there are three female residents and an observer. All three of them are suffering from dementia, at different stages. Theis age is between 80-98. They were born and raised in Denmark. Two of them are around 160 cm tall and one is 170 cm tall.

**5. Events**

Everyday there is a planned super at 18. Firstly two residents are coming and starting eating. They are eating a meal prepared by one of the employees. The third one is joining 15 minutes later. She is preparing sandwiches from products that were prepared on separate plates. All are receiving their evening medicine.

**6. Time**

All the observations are conducted from friday to sunday from 18-19:30. I conducted them between January and march.

**7. Individual Behavior**

22.01.
Two types of plants
Bigger interest in julestjerne

Small plant - they thought it was cute and fake
Big interest in watering and if plants need water

23.01.

Small plant have been recognized as real one. All three ladies agreed that this is their favourite plant and it is always with them when they are eating.

06.02.

Two women were talking about how they have a better mood when they are looking at the red plant.

One lady saw a new plant at the table. I asked if she can help me with taking care of this plant. She said yes - she is watering all the plants here. It felt like it was a big responsibility for her and she was proud of that.

Three ladies were talking about the placement of the plants. Where they look the best (in the center of the table, not in the corner). Moreover they were talking about where the plant looks the best in relation to other plants. They were comparing pots and discussing which one is the nicest and matches to the plant.

One of the plants, which was placed on the window, wasn't standing in the center of the windowsill. I've been asked to move the plant to the center.

07.02.

The plant in the window was standing in the middle. It didn't receive any comments.

Two 'julestjerne' were moved to stand closer to the residents by one of them. At the beginning there was no conversation about the flowers, but it changed after the ladies talked for a few minutes. There were comments like 'our pretty flowers' and then one lady said 'I'm watering them once in a while, when I have water in my glass. It's nice to have them here around.'

I've been asked by two ladies to water the small plant. They thought it looked sad. After I've done it, they said thank you happily and also imitated that the plant is saying thank you.

The third lady wasn't participating in the conversation, but observing and smiling.

07.03

Placing the red plant in the center of the eating table. Three ladies were talking about how it is nice to have this red flower so close. They were happy that is holding so long from Christmas. Margaret said that it is because she is watering it once in a while. Without her, it would be dead already.

**8. Activities.** Record whether there are groups of behavioral acts that seem to be related. Here, the various activities of an event may be recorded, and then broken down into specific acts, or the reverse may be done, in which acts are noted, and then patterns are looked for in terms of the relationships between acts.

**9. Actor Groups**

Actors are linked by living in the same care home.

**10. Interactive Patterns**

One of the residents is insisting on the conversation and controlling it fully. She also tries to control the employees by giving them tasks and asking for favour in some activities even though she could do that herself. She is paying a lot of attention to the placement of plants and how they look.

Second of the residents is refusing to talk about personal issues connected usually to her family (privacy needs or doesn't remember much). When the first lady is not present she is much more talkative and friendly. She is noticing new plants, but not making any comments.

Third one is nice and polite and tries to make small jokes from the first lady. She likes all the plants, no matter how they look.

**11. Language**

Actors are using simple language to communicate. Further explanation of thoughts wasn't usually needed. When there appeared disagreement, one of the actors tried to offend others in an indirect manner as if they couldn't hear her.

**12. Non-Verbal Behavior and Metalingual Properties in Conversation**

There haven't appeared any gestures besides pointing at particular objects.

**13. Expressive Culture**

Culture is expressed only in the conversation by referring to different books, movies or travels.

**14. Ideational Elements**

Behaviour and interactive patterns showed actors attitude to familiar settings that was slightly changed by putting different plants into the kitchen space.

**15. Goals, Motivations, or Agendas**

Besides fulfilling basic needs of eating, the time during meals is the longest time when the residents are together. One of them is showing big social needs and insists on constant conversation during meal time which seems like the main goal of this activity.

### 16. Broader Social Systems

It is possible that social systems from younger ages, like family and work environment have influenced some of the behaviours.

### 17. Human Needs

**Communal Needs** are met through dinner gathering and conversations

**Communicative Needs** are met through communicating and explaining thoughts

**Affective Needs** are met through being part of the group gathering for a dinner everyday

**18. Other Domains** not included above.

### References


Spradley, J.P., (1979) The Ethnographic Interview. New York: Holt. Rinehart and Winston.

Spradley, J.P., (1980) Participant Observation. New York: Holt. Rinehart and Winston.

Whitehead, T. L. (2006). Workbook for descriptive observations of social settings, acts, activities & events. Cultural Ecology of Health and Changes: Ethnographically Informed Community and Cultural Assessment Research Systems (EICCARS) Workbooks, 1-11.

# Appendix 2 - Interview

**Interview with one of the employees from Plejehjem Virumgård**

*Interviewer: Do you have any observations in change of behaviour during different times of the day?*
Caretaker: First of all, I would like to start with highlighting how it is important for everyone to have a daily rhythm. Most of the residents with dementia can't control it. The only time markers are meal times. People with dementia don't really understand the concept of time. They are sleeping when they are tired and getting up when it feels comfortable, even though that might be in the middle of the night. Disrupted sleep patterns are deepening the existing confusion and unregulating natural rhythm. Daily rhythm is a focus point of work in care homes. We are making sure that residents are active during sunny hours. At Virumgård some residents got light therapy to put them back on track with circadian rhythm. There is a special room created for it. Room is filled with curtains and lamps that are imitating different times of the day.

*I:How about different times of the year? Are there any changes in behaviour of the residents?*
C: We live quite far north from the equator. So the weather and amount of sun isn't really optimal here. Maybe people shouldn't even live so far north. During winter time in Denmark people get up when it is dark and turn on the electric light. It is so easy for the residents of care homes to confuse such dark mornings with nights. I think that night lighting should be more dimmed than during daytime and maybe fully off during night time. That could help with recognition of time. Actually the most beneficial thing for elderly with dementia could be going outside to experience natural light, wind, rain and so on. They don't remember how it is to experience those phenomena and are afraid of it. Especially to be under the open sky or feeling cold seems to be very uncomfortable.

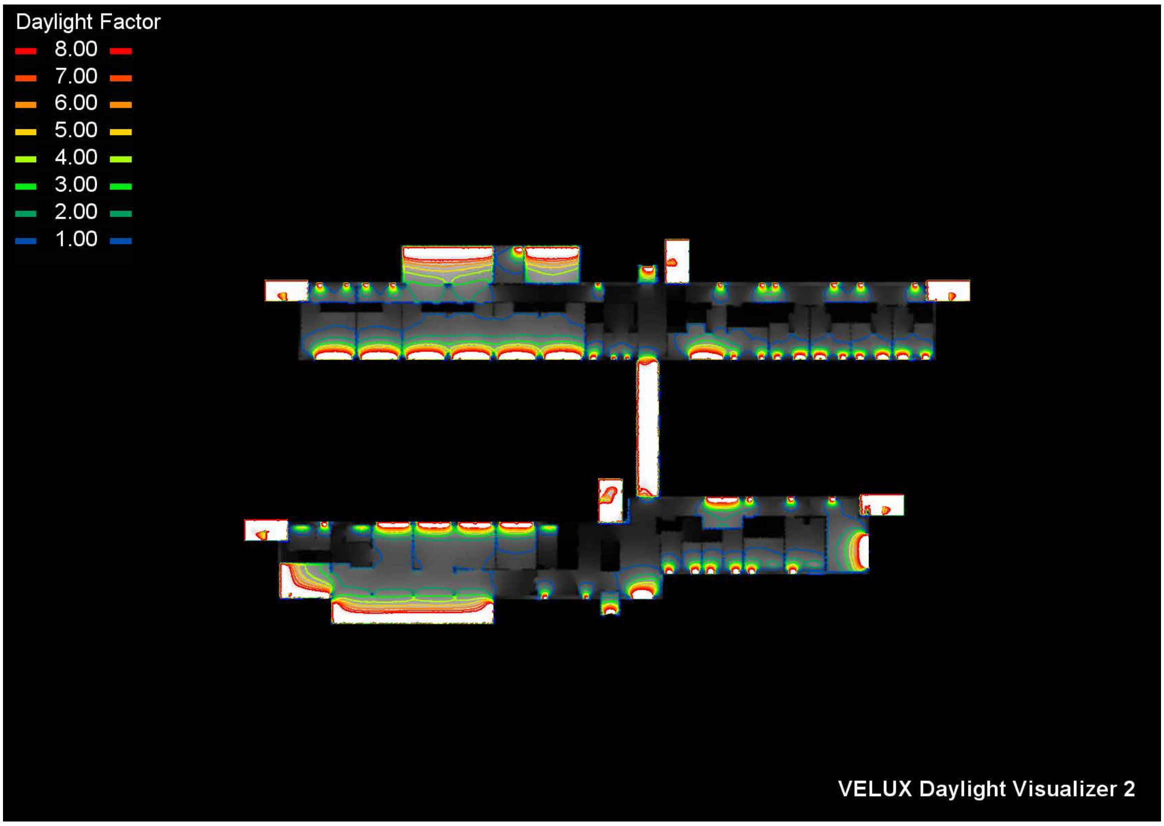
*I: That's interesting. Have you observed any impact of sun or sunny weather on the mood of the residents?*
C: Well, the sun is affecting everyone in a similar way. Those elderly, like me and you feel much better and happier during sunny days after a period of gray weather. During winter time they can suffer from seasonal affective disorder which disappears during summer time.

I: I can see quite a lot of fake plants. What is their purpose?
C: It's just because of maintenance reasons. Almost no one has the time or will to take care of those plants. I think it could be used as part of daily activities with the resident. In one care home where I worked there was an aquarium. Noone wanted to clean it. But I got an idea that I'll do that with the help of the residents. They really enjoyed looking when I was putting fishes in new containers and cleaning the big aquarium.

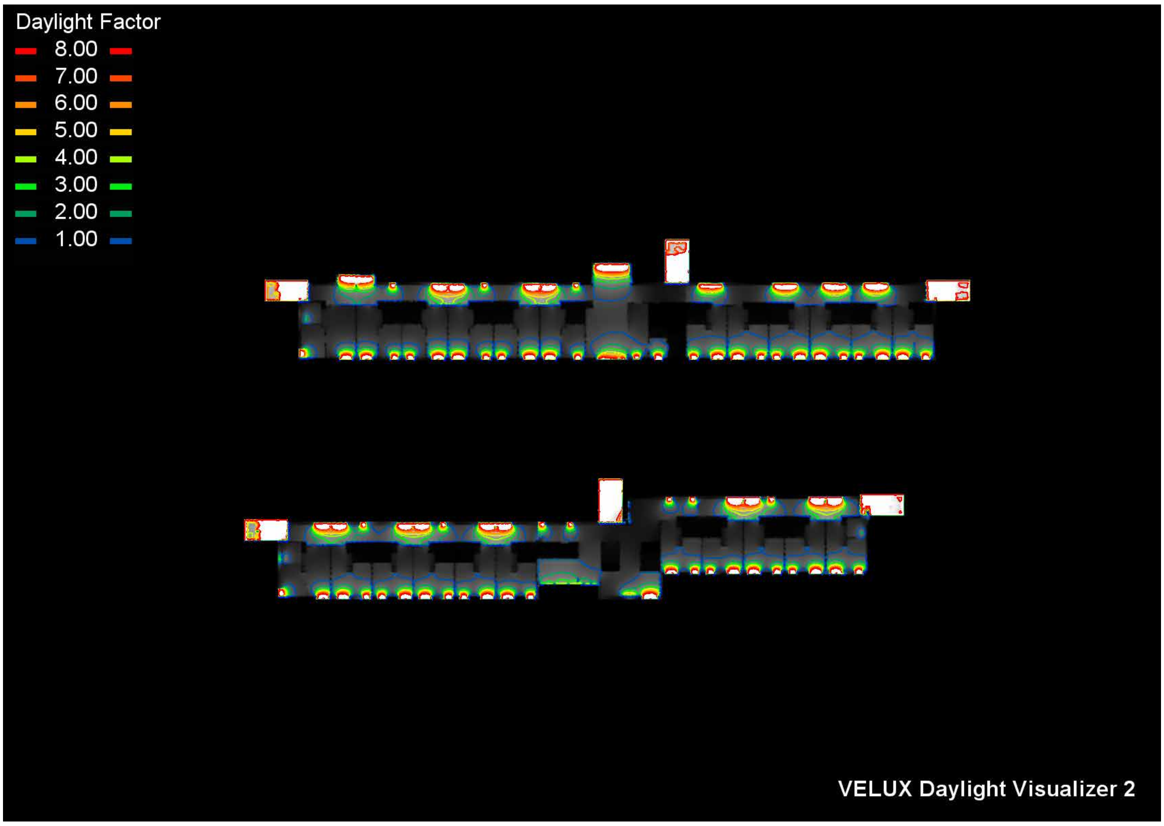
*I: That's a really nice idea.*
C: Yes, and I think that residents could take care of some plants with the help of a caretaker if needed. That could be a part of weekly activities. Another bothering thing is bad air quality. I try to open a window for 30 min every day. But then someone comes and says 'Oh, I am freezing! Can you close that window?' So I have to close it, but I open it when they are in their beds.

*I: Have you observed any interest in living plants, like watering or even just looking?*
C: Hm, not really. I haven't seen anyone watering plants. At different departments where the elderly are just old, without dementia, I saw them having plants in their own rooms and taking care of them. Here elderly need some inspiration from outside to take some actions, so the staff would have to show how to take care of the plant. But the thing I noticed is a big interest in the seasonal flowers that we have here once in a while. They are a symbol of time of the year. For example julestjerne (Christmas star), is a popular flower. Also lilies and crocuses are here every year in the Easter period. Plants that are noticed usually have a connection to memories. Those other ones don't really create any interest.

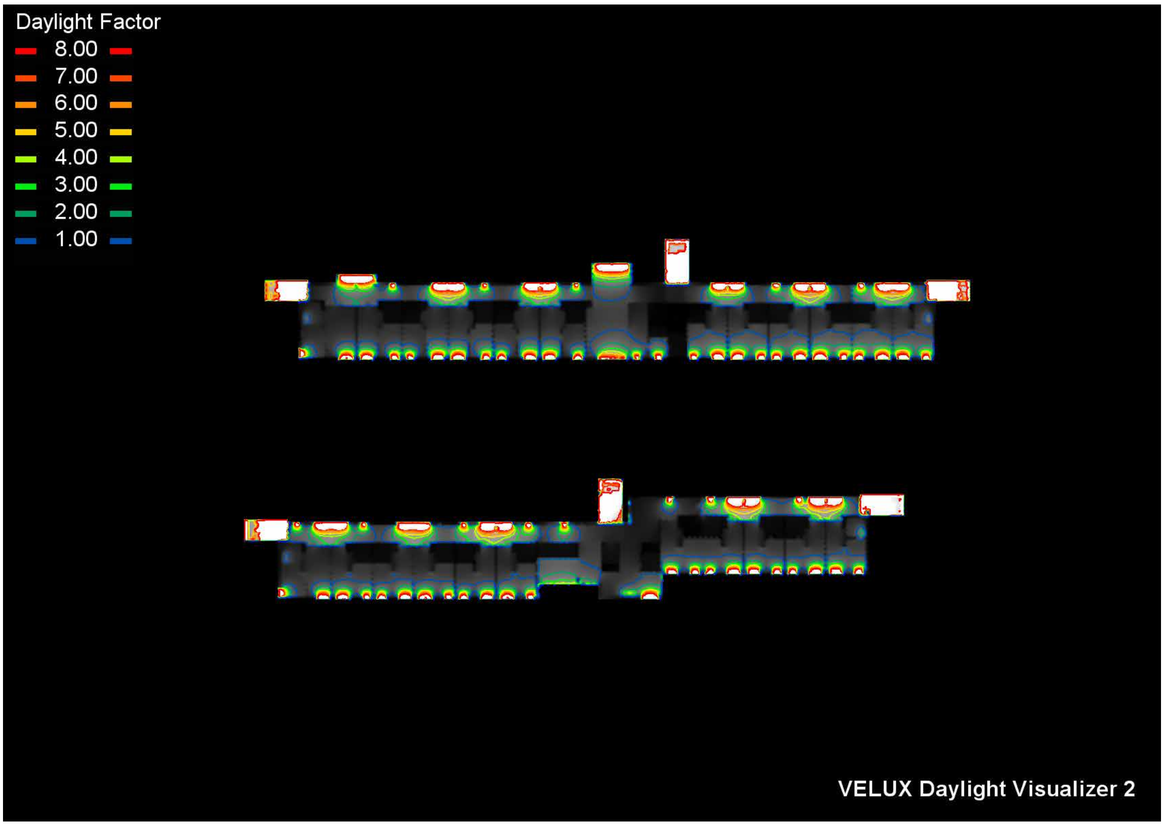
# Appendix 3 - Daylight factor



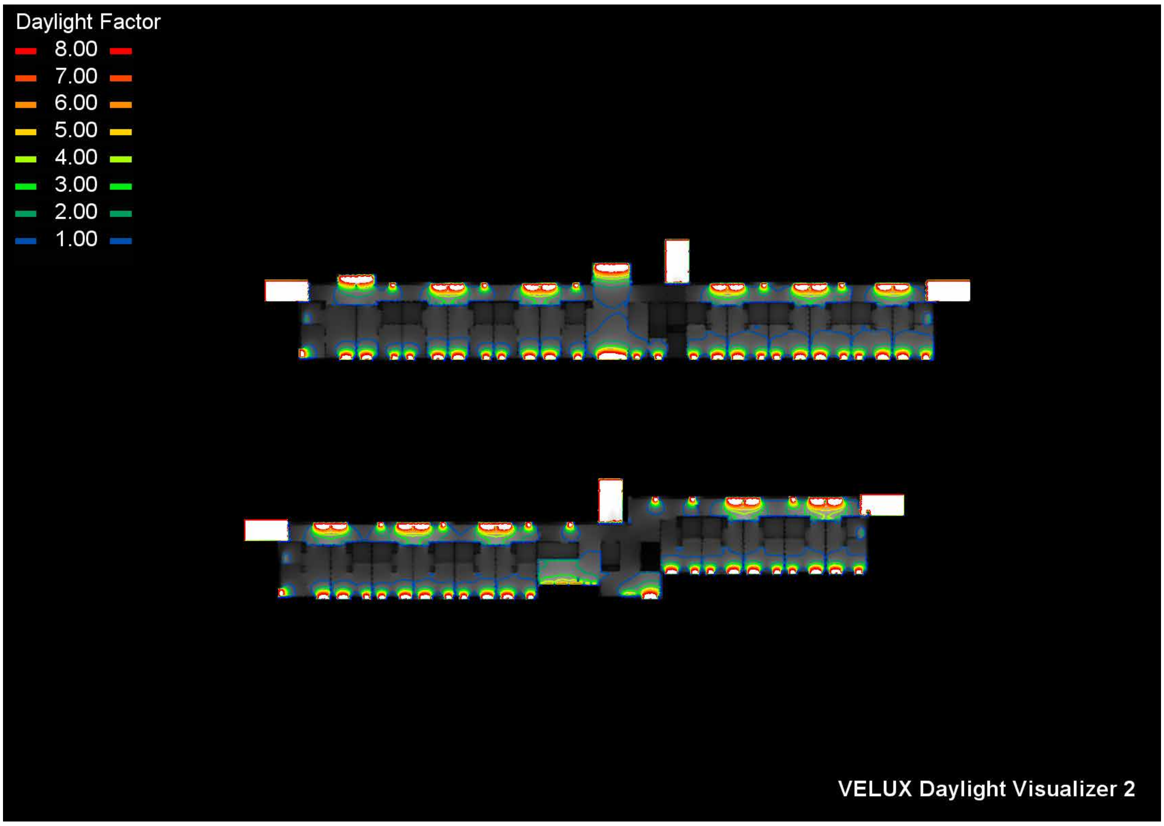

Groundfloor




1st Floor




2nd floor




3rd floor

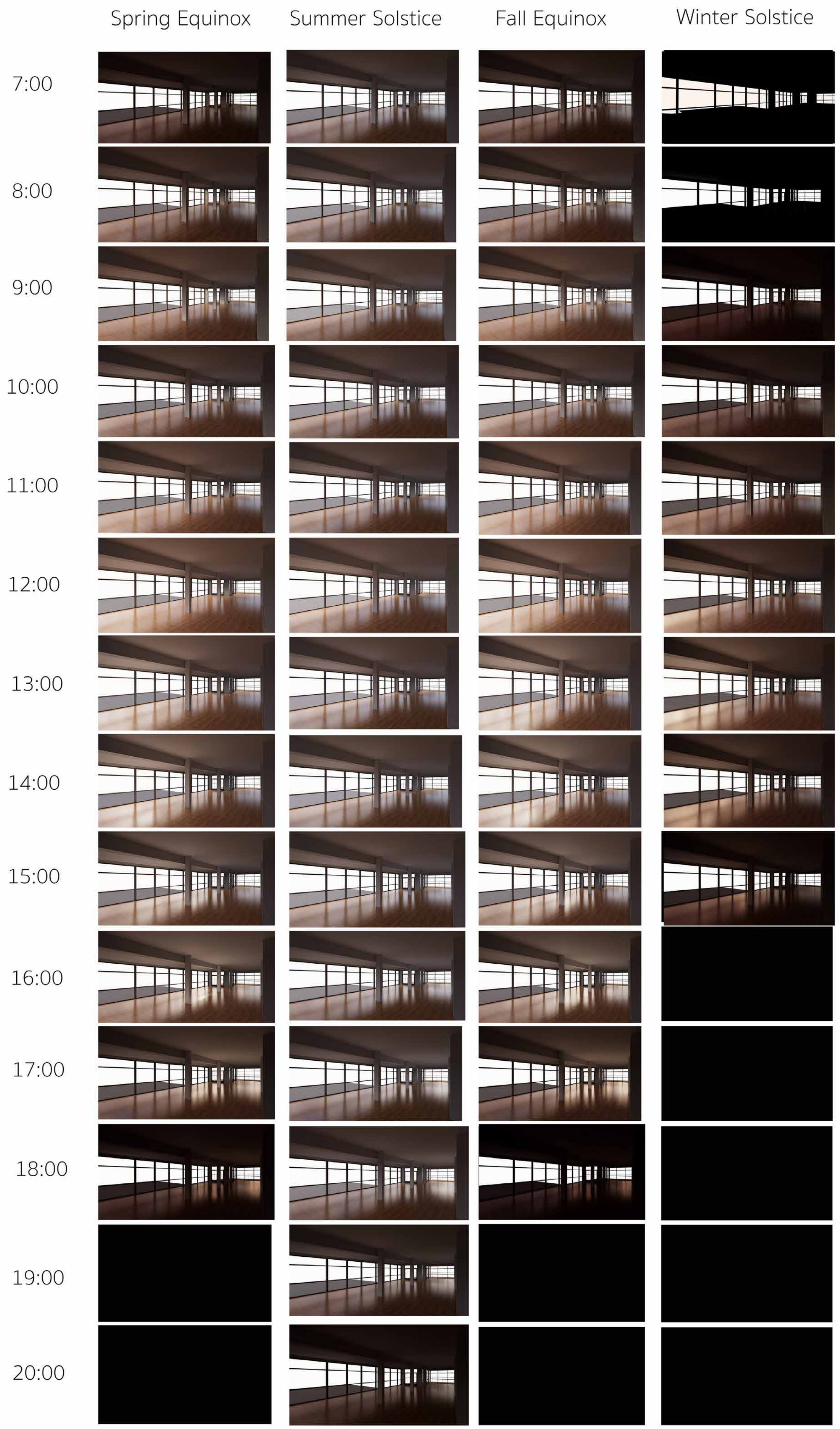
# Appendix 3 - Shadow analyses

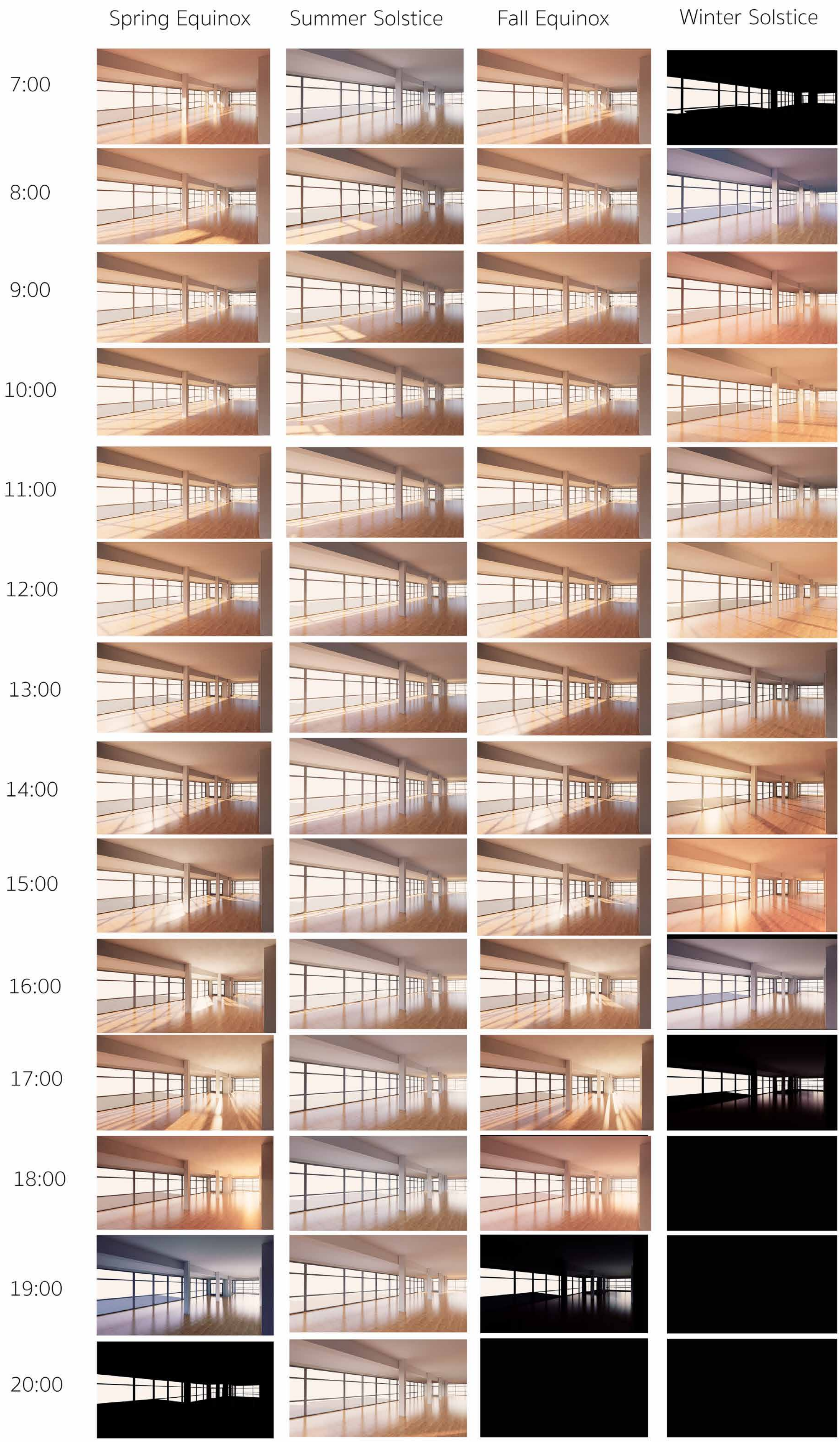
https://drive.google.com/drive/folders/1U5B-cD5Ue8EyTrYbRBkB9y2knZYAjCUPm?usp=sharing

# Appendix 4 - Survey of the movement of sun


Spring Equinox
Summer Solstice
Fall Equinox
Winter Solstice
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00

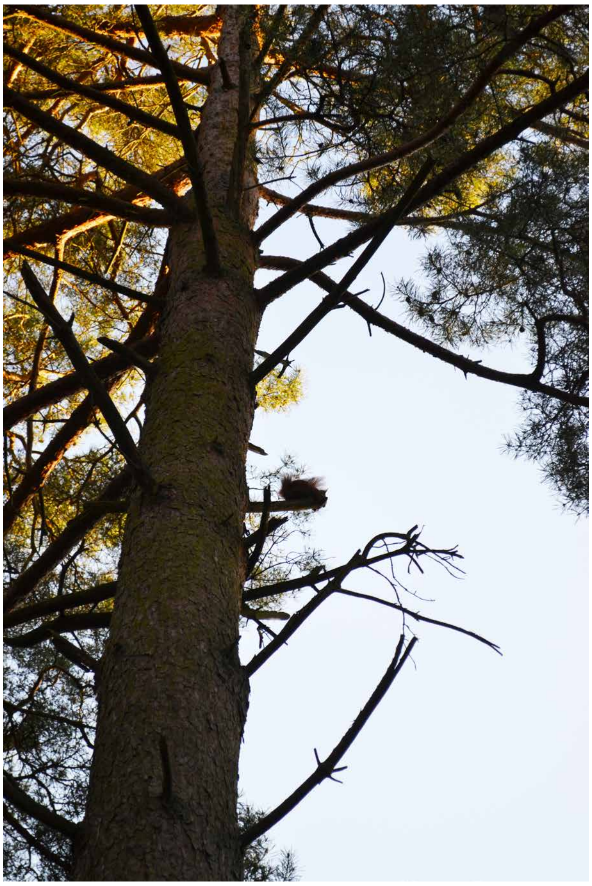

Spring Equinox
Summer Solstice
Fall Equinox
Winter Solstice
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00

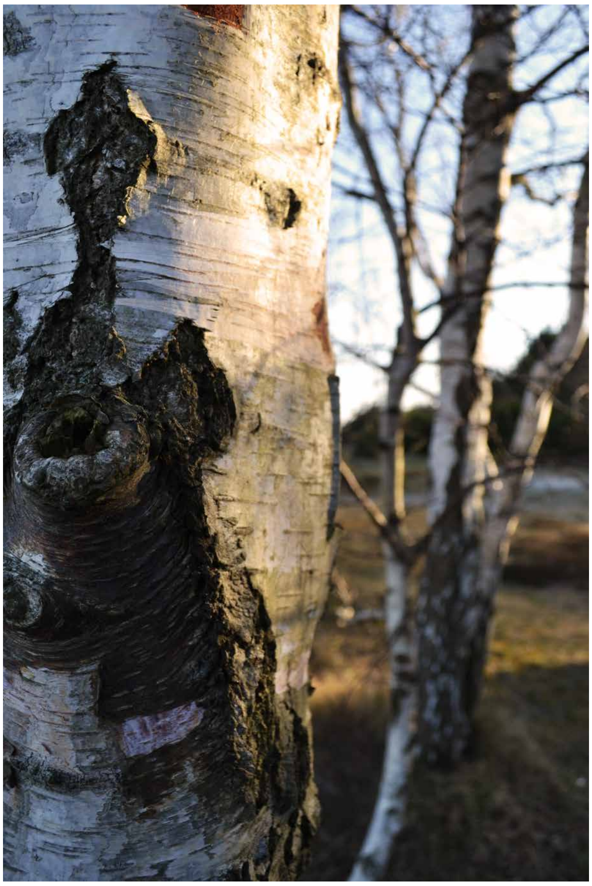

Spring Equinox
Summer Solstice
Fall Equinox
Winter Solstice
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00

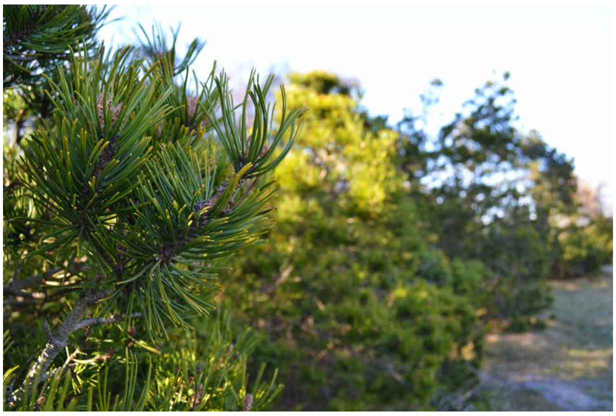


Spring Equinox
Summer Solstice
Fall Equinox
Winter Solstice
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00

# Appendix 5 - Field trip

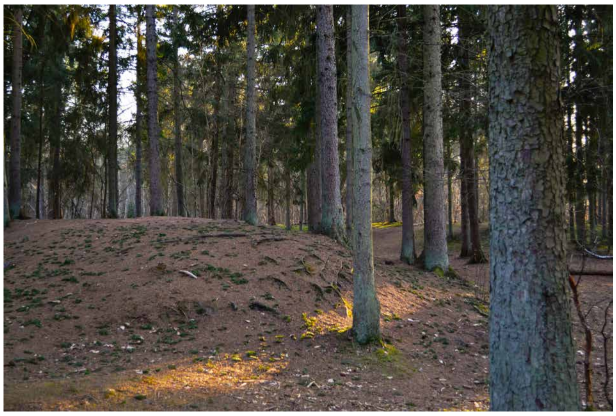










# Appendix 6 - Pendant fixture specifications



## Product info

**Montage**
Ophæng: ledning 2x0,75mm2. Baldakin: Ja. Ledningslængde: 3m.

**Overflade**
Grå top, Kobber top, Rød top eller Gul top, våd lakeret.

**Materialer**
Skærm: Optrukket aluminium.

**Størrelser og vægt**
Bredde x højde x længde (mm) | 220 x 295 x 220 Maks. 1,6 kg | 380 x 478 x 380 Maks. 3,9 kg | 150 x 189 x 150 Maks. 1,1 kg

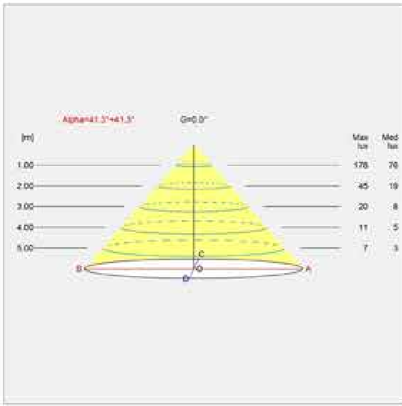
**Klasse**
Tæthedsklasse IP20. Isolationsklasse II.

**Lyskilde**
1x25W E27

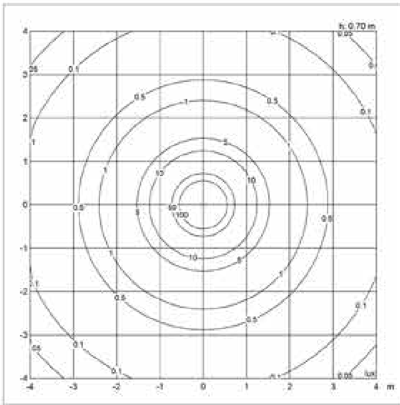

Link to the full specification sheet: https://www.louispoulsen.com/da-dk/catalog/professional/dekorativ-belysning/pendler/cirque?v=91663-5741094862-01&t=about&t=downloads&t=data

# Lysdistributionsdiagram

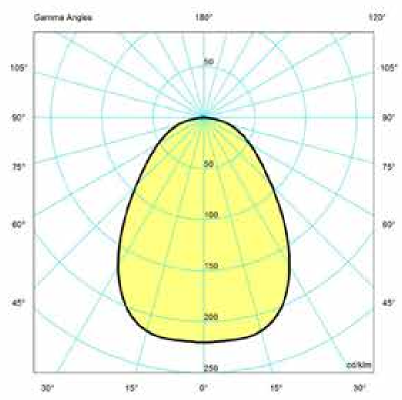
## Cartesian



## Isolux



## Polar



# Reservedele & tilbehør

| Product | Variant number |
|---|---|
| BALDAKIN HVID 2-DELT, TOPHAT ® | 5749329034 |

# Dataspecifikationer

| | |
|---|---|
| Farve | **Grå top** |
| Bredde | **150** |
| Indbygningshøjde | **-** |
| Klasse | **II** |
| Standby (W) | **-** |
| Startstrøm | **-** |
| Lyskilde | **1x25W E27** |
| CRI | **-** |

| | |
|---|---|
| Længde | **150** |
| Højde | **189** |
| IP-klasse | **20** |
| Nettovægt | **0.6** |
| Effektfaktor (P = 100 % / P = 50 %) | **-** |
| Transientbeskyttelse, Imax. [T2] IEC 61643-1 | **-** |
| Kelvin | **-** |
| SDCM | **-** |

# Product info

**Information**

Kompatibel med forkants- og bagkantsdæmpere. Bemærk, at det lave strømforbrug på nogle produkter kan påvirke lysdæmpningen.

**Montage**

Ophængstype: Ledning og wire, 2 x 0,75 mm² Baldakin: Ja. Ledningslængde: 4 m.

**Overflade**

Sort eller hvid, mat, vådlakeret.

**Materialer**

Skærm: Optrukket aluminium. Diffusor Sprøjtestøbt PC.

**Størrelser og vægt**

Bredde x højde x længde (mm) | 400 x 270 x 400 Maks. 4,9 kg | 175 x 134 x 175 Maks. 2,4 kg | 250 x 270 x 250 Maks. 3,7 kg | 650 x 270 x 650 Maks. 6,6 kg

**Klasse**

Tæthedsklasse IP20. Isolationsklasse I.

**Lyskilde**

LED 2700K 31W <br />Lumen: 2104

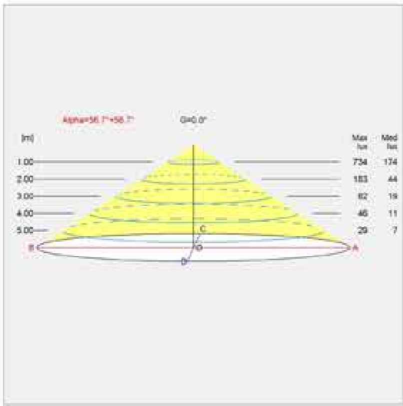
**Information**

Kompatibel med forkants- og bagkantsdæmpere. Bemærk, at det lave strømforbrug på nogle produkter kan påvirke lysdæmpningen.

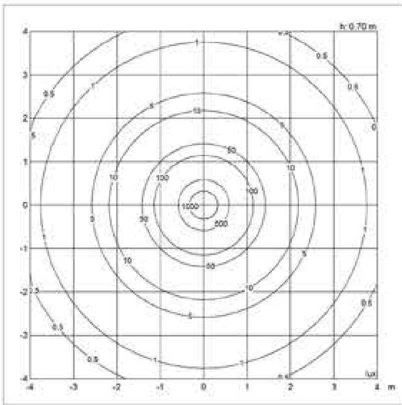

Link to the full specification sheet: https://www.louispoulsen.com/da-dk/catalog/professional/dekorativ-belysning/pendler/keglen?v=91772-5741103805-01&t=about&t=downloads&t=data

# Lysdistributionsdiagram

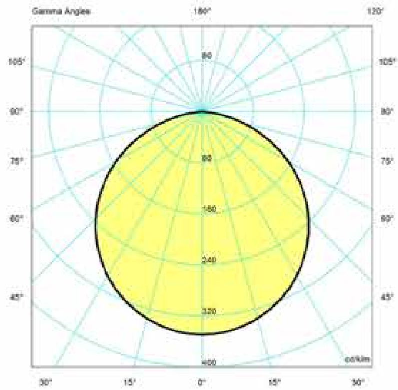
## Cartesian



## Isolux



## Polar



# Dataspecifikationer

| | | | |
|---|---|---|---|
| Farve | **Hvid** | Længde | **650** |
| Bredde | **650** | Højde | **270** |
| Indbygningshøjde | **-** | IP-klasse | **20** |
| Klasse | **I** | Nettovægt | **6.6** |
| Standby (W) | **<0,5** | Effektfaktor (P = 100 % / P = 50 %) | **-** |
| Startstrøm | **5 A / 50 µs** | Transientbeskyttelse, Imax. [T2] IEC 61643-1 | **-** |
| Lyskilde | **LED 2700K 31W** | Kelvin | **2700** |
| CRI | **90** | SDCM | **3** |
| Lumen | **2104** | Watt | **31** |
| Efficacy | **68** | Min. dæmpniveau (%) | **1** |
| UGR transversal / aksial | **18.9/18.9** | L80B50 (timer) | **>50000** |
| L80B10 (timer) | **-** | Driver life | **-** |

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# Product info

**Information**
Farve på afblændingsskærm: Classic, monokrom blå og Hues of Orange: Blå. Hues of Red og Hues of Rose: Grøn. Hues of Green og Hues of Blue: Rød. Hues of Grey og Modern White: Rosa. Monokrom sort: Sort. Monokrom hvid: Hvid. Kobberversion: Kobber. Messingversion: Messing. Farve på stag: Classic: Lilla. Kobberversion, messingversion og monokrom hvid: Hvid. Monokrom blå: Blå. Monokrom sort: Sort. Modern White og farvenuancer (Hues): Bronzefarvet. Ledning og baldakin: Monokrom sort: Sort ledning og baldakin. Alle andre: Hvid ledning og baldakin. Bemærk, at kobber- og messingoverfladen er ubehandlet. Det betyder, at overfladen vil ændre sig over tid og patinere. Denne proces kan allerede være begyndt, når produktet leveres.

**Montage**
Ophængstype: Ledning 2 x 1 mm². Baldakin: Ja. Ledningslængde: 3 m.

**Overflade**
Classic (hvid) eller Modern White: mat, pulverlakeret. Monokrom sort, monokrom blå, monokrom hvid, Hues of Blue, Hues of Green, Hues of Grey, Hues of Orange, Hues of Red, Hues of Rose: mat, vådlakeret. Metalversioner: Poleret messing eller kobber og hvid, mat pulverlakeret. Bemærk, at kobber- og messingoverfladen er ubehandlet. Det betyder, at overfladen vil ændre sig over tid og patinere.

**Materialer**
Skærme og afblændingsskærm: Optrukket aluminium, optrukket kobber eller optrukket messing. Stag: valset aluminium.

**Størrelser og vægt**
Bredde x højde x længde (mm) | 500 x 267 x 500 Maks. 3,5 kg

**Klasse**
Tæthedsklasse IP20. Isolationsklasse II uden jording.

**Bemærkninger til varianter**
Den teknologiske udvikling indenfor lyskilder sker hurtigt. Derfor angives den maksimale wattage samt fatningstype for lyskilder.

**Lyskilde**
1x75W E27

**Information**
Farve på afblændingsskærm: Classic, monokrom blå og Hues of Orange: Blå. Hues of Red og Hues of Rose: Grøn. Hues of Green og Hues of Blue: Rød. Hues of Grey og Modern White: Rosa. Monokrom sort: Sort. Monokrom hvid: Hvid. Kobberversion: Kobber. Messingversion: Messing.
Farve på stag: Classic: Lilla. Kobberversion, messingversion og monokrom hvid: Hvid. Monokrom blå: Blå. Monokrom sort: Sort. Modern White og farvenuancer (Hues): Bronzefarvet.
Ledning og baldakin: Monokrom sort: Sort ledning og baldakin. Alle andre: Hvid ledning og baldakin.
Bemærk, at kobber- og messingoverfladen er ubehandlet. Det betyder, at overfladen vil ændre sig over tid og patinere. Denne proces kan allerede være begyndt, når produktet leveres.

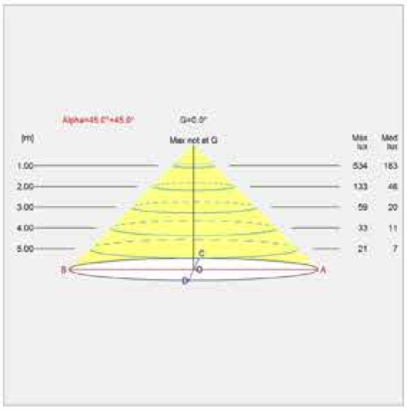

Link to the full specification sheet: https://www.louispoulsen.com/da-dk/catalog/professional/dekorativ-belysning/pendler/ph-5-pendel?v=90293-5741099870-01&t=about&t=downloads&t=data

# Produktfamilie

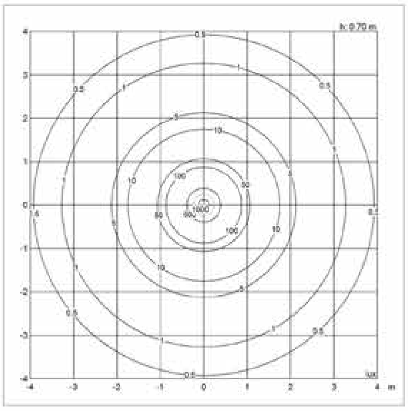
PH 5 Mini

# Lysdistributionsdiagram

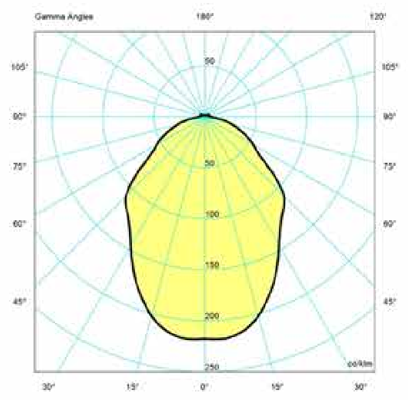
## Cartesian



## Isolux



## Polar



# Dataspecifikationer

| | | | |
|---|---|---|---|
| Farve | **Hvid moderne** | Længde | **500** |

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# Appendix 7 - Circadian fixtures specifications

LiGMAN

Indoor | Recessed ceiling luminaires | MALMO

**MALMO 1** (MAL-80003)

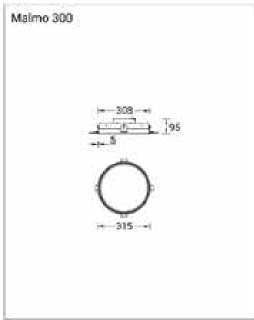
IP20

### Luminaire structure

- Extruded aluminium bended profile with powder coating
- Stainless steel fasteners in grade 316
- Stainless steel brackets and screws for mounting
- PMMA diffuser with Opal (UGR <19) and micro prismatic (UGR <13) options for better glare control
- Up and down light distribution options
- Passive thermal management
- Integral control gear
- Wireless control available through Bluetooth connection
- Daylight and occupancy sensor options
- Emergency module (1 or 3 hours) is available upon request with 3 options (BASIC, SELF-TEST, PRO-DALI)

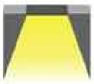
### Product description

Down - 315 mm - TW



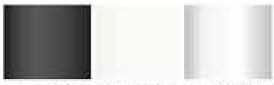

Link to the full specification sheet: https://www.ligman.com/specsheet/products/MAL-80003-en.pdf

### Light symbol



P

### Product colour



01 - Black (RAL 9011) | 03 - White (RAL 9003) | 05 - Matt Silver (RAL 9006)

### Special finishes upon request

SU01 - Concrete - Urban | SU02 - Softscape - Urban | SU03 - Stone - Urban | SU04 - Corten - Urban | SW01 - Oak - Woodland | SW02 - Walnut - Woodland | SW03 - Pine - Woodland

### Technical information

| | |
|---|---|
| **Lamp** | 336 LED |
| **Lamp type** | LED |
| **Dimming type** | DALI |
| **EEC** | A++ |
| **Material** | Aluminium |
| **Weight** | 1.5 kg |
| **Operating temperature** | -20 °C to 40 °C |

| **Luminaire** | |
|---|---|
| Power | 21 W |
| Lumen | 1956 lm |
| Efficacy | 93 lm/W |
| CCT / CRI | TW |
| Drive current | 500 mA |

| | |
|---|---|
| Optic | O [Opal], P [Micro-prismatic] |
| MacAdam Ellipse | 3 SDCM |
| Lifetime L90B10 (hours) | 34,000 |
| Lifetime L80B10 (hours) | 69,000 |
| Lifetime L80B50 (hours) | 100,000 |



02:17, 28-05-2021

https://www.ligman.com/malmo-1-mal-80003/

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+66 2 108 6700
**info@ligman.com**

# MALMO 1 (MAL-80023)

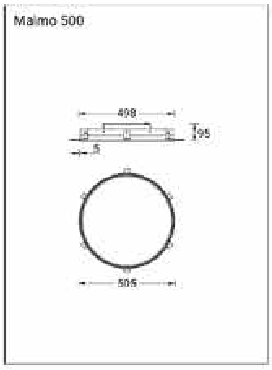
CE | ⏚ | IP20

## Luminaire structure

- Extruded aluminium bended profile with powder coating
- Stainless steel fasteners in grade 316
- Stainless steel brackets and screws for mounting
- PMMA diffuser with Opal (UGR <19) and micro prismatic (UGR <13) options for better glare control
- Up and down light distribution options
- Passive thermal management
- Integral control gear
- Wireless control available through Bluetooth connection
- Daylight and occupancy sensor options
- Emergency module (1 or 3 hours) is available upon request with 3 options (BASIC, SELF-TEST, PRO-DALI)

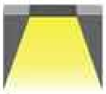
## Product description

Down - 505 mm - TW



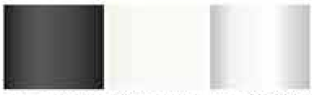

Link to the full specification sheet: https://www.ligman.com/specsheet/products/MAL-80023-en.pdf

## Light symbol



P

## Product colour



01 - Black (RAL 9011) | 03 - White (RAL 9003) | 05 - Matt Silver (RAL 9006)

## Special finishes upon request

SU01 - Concrete - Urban | SU02 - Softscape - Urban | SU03 - Stone - Urban | SU04 - Corten - Urban
SW01 - Oak - Woodland | SW02 - Walnut - Woodland | SW03 - Pine - Woodland

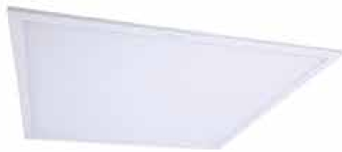
## Technical information

| | |
|---|---|
| **Lamp** | 864 LED |
| **Lamp type** | LED |
| **Dimming type** | DALI |
| **EEC** | A++ |
| **Material** | Aluminium |
| **Weight** | 3.6 kg |
| **Operating temperature** | -20 °C to 40 °C |

| **Luminaire** | |
|---|---|
| Power | 43 W |
| Lumen | 5427 lm |
| Efficacy | 126 lm/W |
| CCT / CRI | TW |
| Drive current | 400 mA |

| | |
|---|---|
| Optic | O [Opal], P [Micro-prismatic] |
| MacAdam Ellipse | 3 SDCM |
| Lifetime L90B10 (hours) | 34,000 |
| Lifetime L80B10 (hours) | 69,000 |
| Lifetime L80B50 (hours) | 100,000 |

PHILIPS
Lighting



# GreenPerform Panel

Link to the full specification sheet: https://www.lighting.philips.com/api/assets/v1/file/PhilipsLighting/content/fp911401719512-pss-global/911401719512_EU.en_AA.PROF.FP.pdf

## RC160V LED40S 865 W60L60 PSU

- - Wide beam - Polystyrene bowl/cover prismatic - 110°

GreenPerform Panel is the slimmest Panel with highest efficacy in the market. It offers two lumen options with four dimension types, 200X1200, 300X1200, 600x600,600x1200, and three mounting options, recessed, suspended and plaster ceiling.

### Product data

| General Information | |
|---|---|
| Beam angle of light source | - ° |
| Light source color | 865 cool daylight |
| Light source replaceable | No |
| Number of gear units | 1 unit |
| Driver/power unit/transformer | - |
| Driver included | Yes |
| Optic type | Wide beam |
| Optical cover/lens type | Polystyrene bowl/cover prismatic |
| Luminaire light beam spread | 110° |
| Control interface | - |
| Connection | Internal connector |
| Cable | - |
| Protection class IEC | Safety class II |
| Glow-wire test | Temperature 650 °C, duration 30 s |
| Flammability mark | - |
| CE mark | CE mark |
| ENEC mark | - |
| Warranty period | 3 years |
| Constant light output | No |
| Number of products on MCB of 16 A type B | 90 |
| EU RoHS compliant | Yes |
| Light source engine type | LED |
| Service tag | Yes |

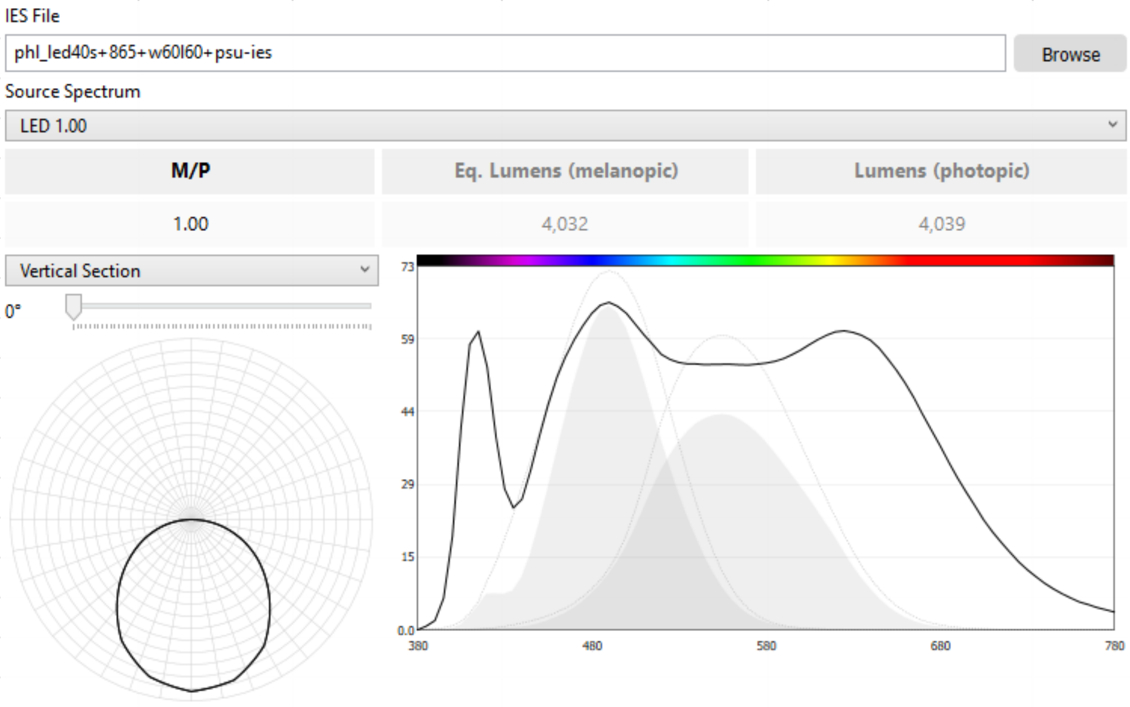
| Operating and Electrical | |
|---|---|
| Input Voltage | 220 to 240 V |
| Input Frequency | 50 to 60 Hz |
| Initial CLO power consumption | NA W |
| Average CLO power consumption | NA W |
| Inrush current | 15.8 A |
| Inrush time | 181 ms |
| Power Factor (Min) | 0.9 |

| Controls and Dimming | |
|---|---|
| Dimmable | No |

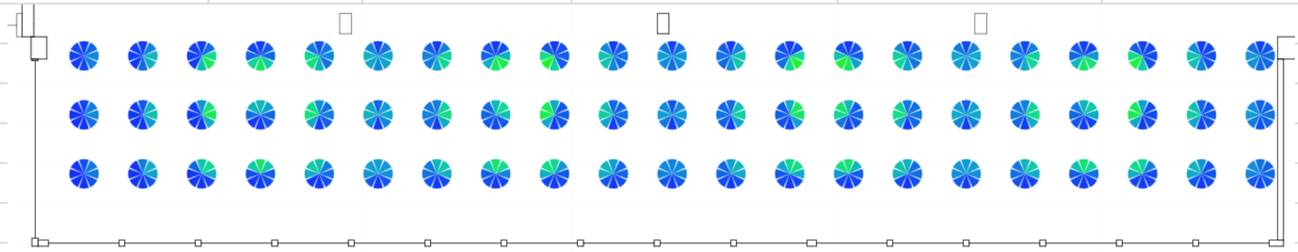
| Mechanical and Housing | |
|---|---|
| Housing Material | Aluminum |
| Reflector material | - |

# Appendix 8 - Alfa test - choosing fixture

**Philips RC160V LED40S 865 W60L60 PSU**

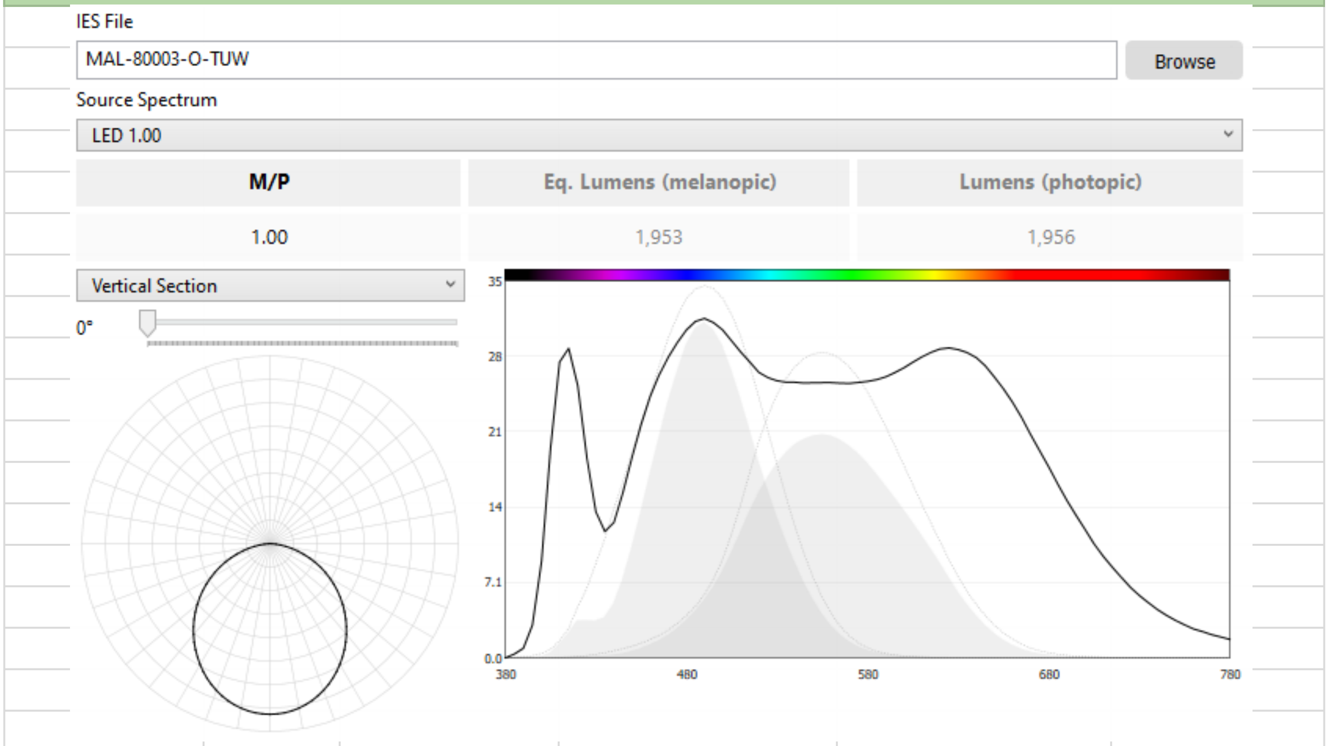



| Date | Time | Sky conditions | EML (avg) | WELL requirement | Fullfills Yes/No |
|---|---|---|---|---|---|
| Winter solstice | 7am | Overcast | 58 | 200 | No |

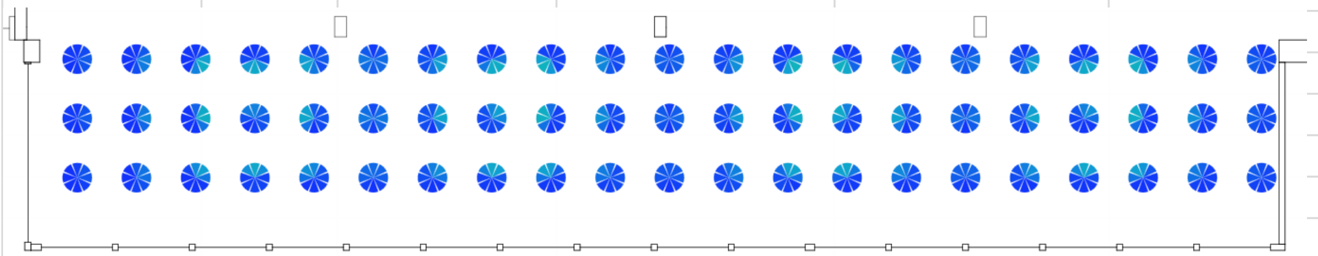


*200 EML threshold is not fulfilled in all area, nor at seating areas where values vary between 140-190 EML

## Ligman MALMO 1 (MAL-80003)

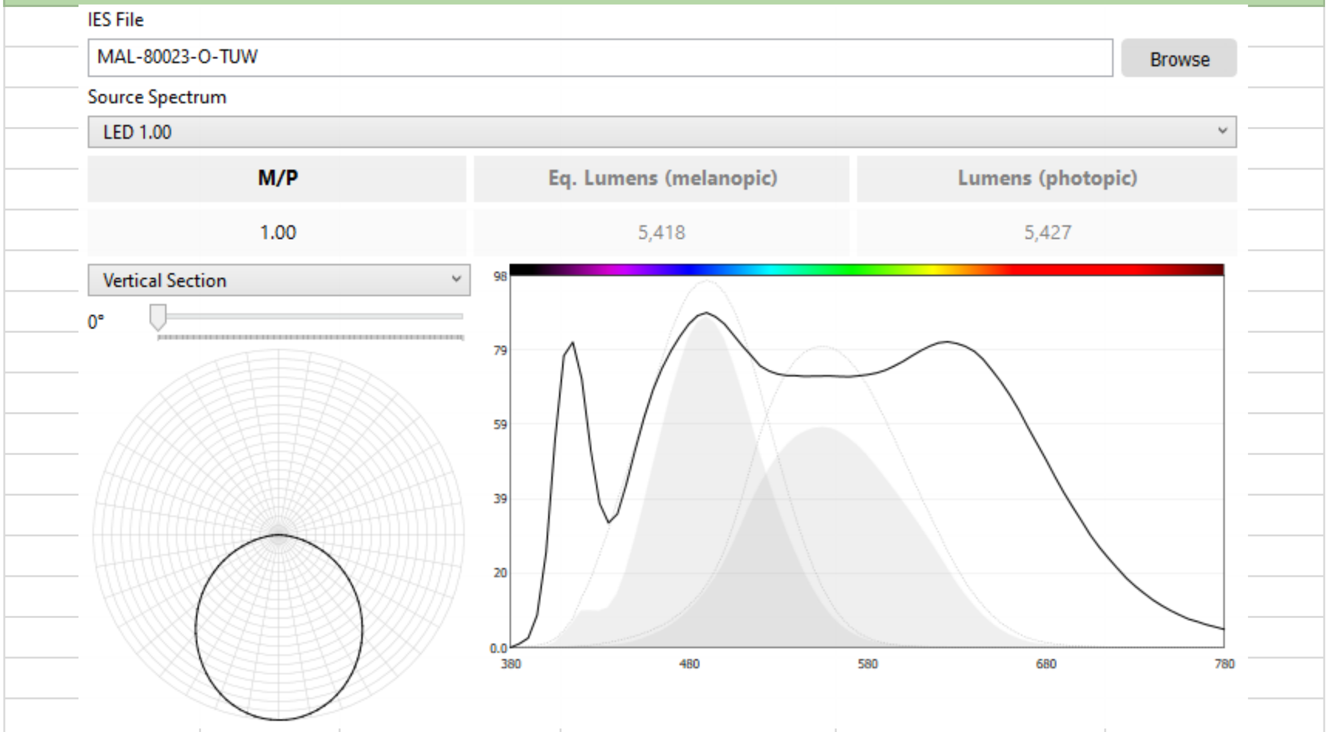



| Date | Time | Sky conditions | EML (avg) | WELL requirement | Fullfills Yes/No |
|---|---|---|---|---|---|
| Winter solstice | 7am | Overcast | 29 | 200 | No |

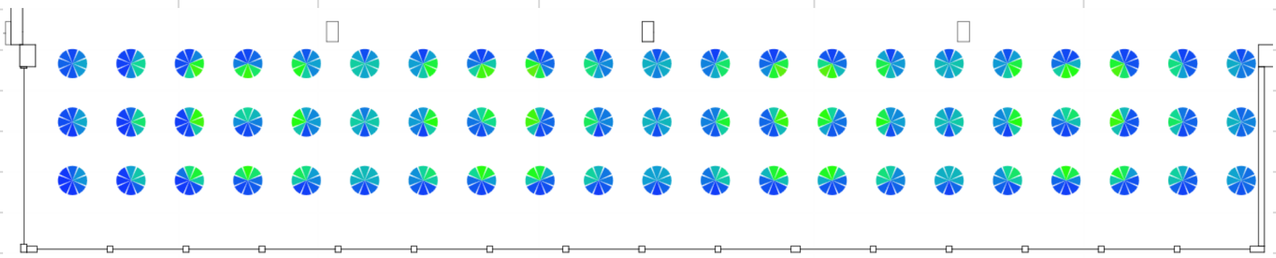


*200 EML threshold is not fulfilled in all area, nor at seating areas

**Ligman MALMO 1 (MAL-80023)**

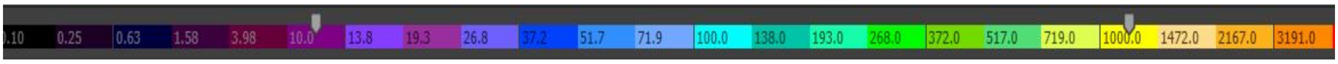



| Date | Time | Sky conditions | EML (avg) | WELL requirement | Fullfills Yes/No |
|---|---|---|---|---|---|
| Winter solstice | 7am | Overcast | 79 | 200 | No |



*200 EML threshold is not fulfilled in all area, but is fullfilled at seating areas

# Appendix 9 - Dialux



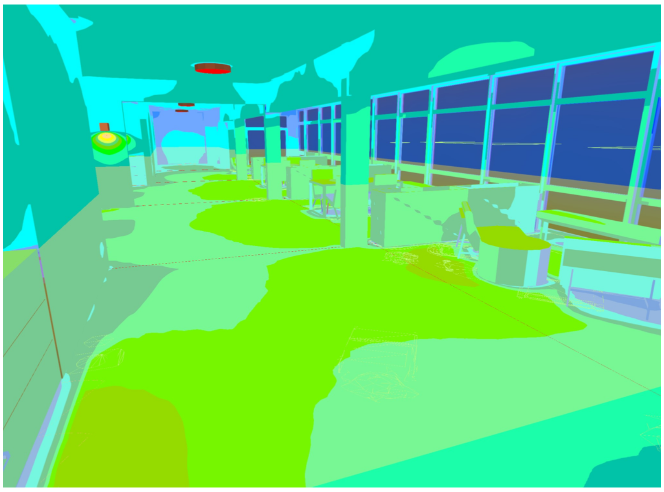



Fig. 1 View on the circadian area

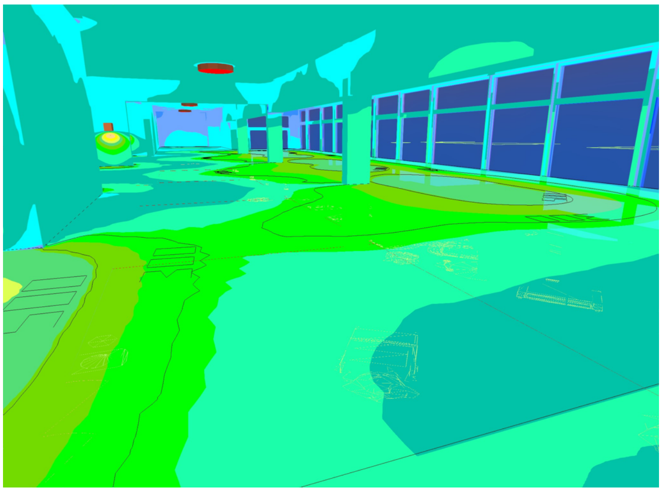
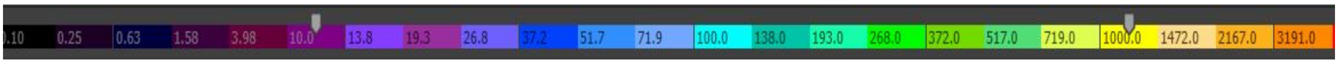


Fig 2. Work plane results of the circadian area



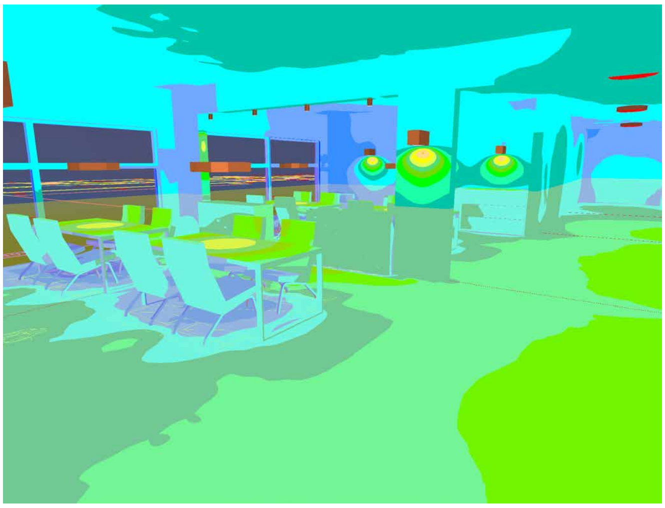



Fig. 3 View on the atmospheric area

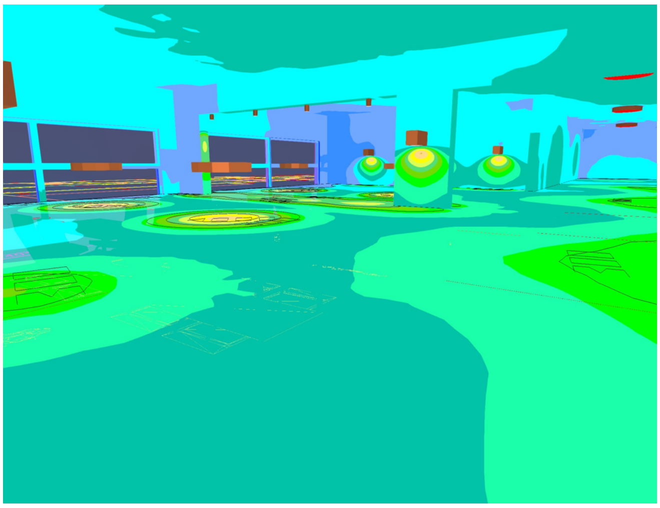
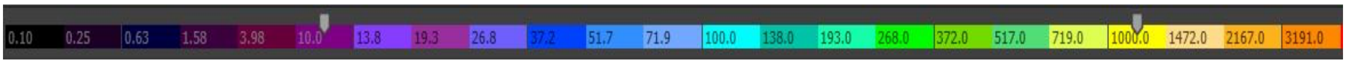
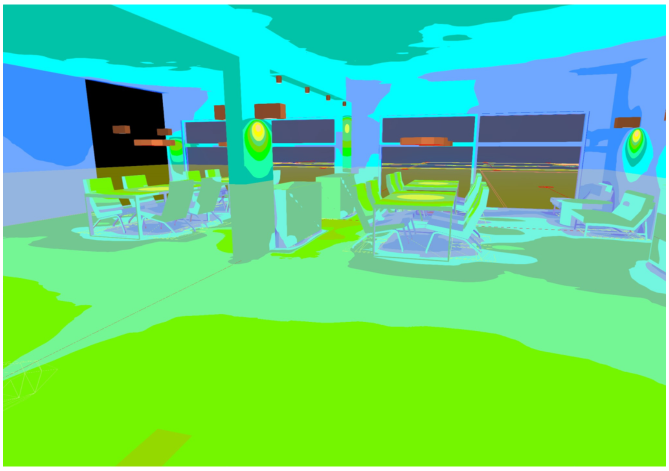


Fig. 4 Work plane results of the atmospheric area



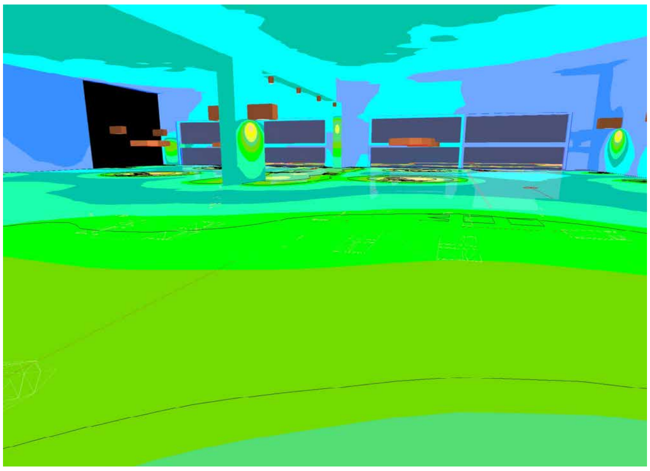
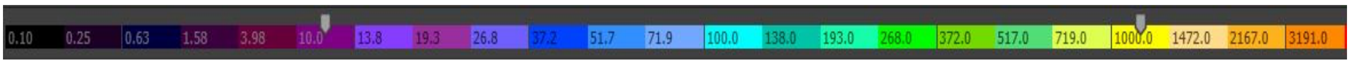
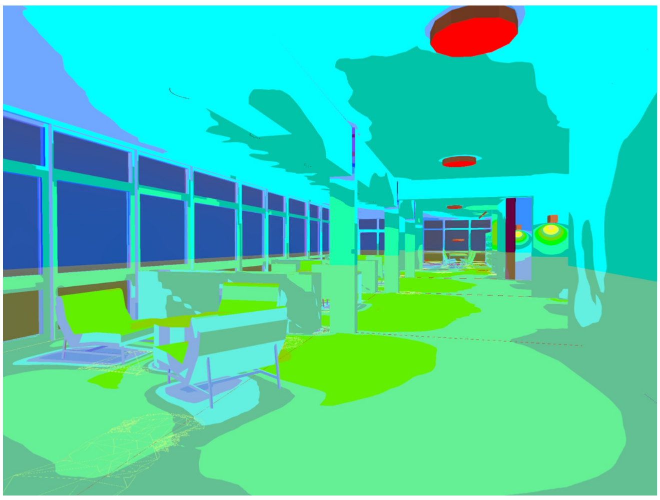


Fig. 5 View 2 on the atmospheric area

Fig. 6 Work plane results of the atmospheric area 2



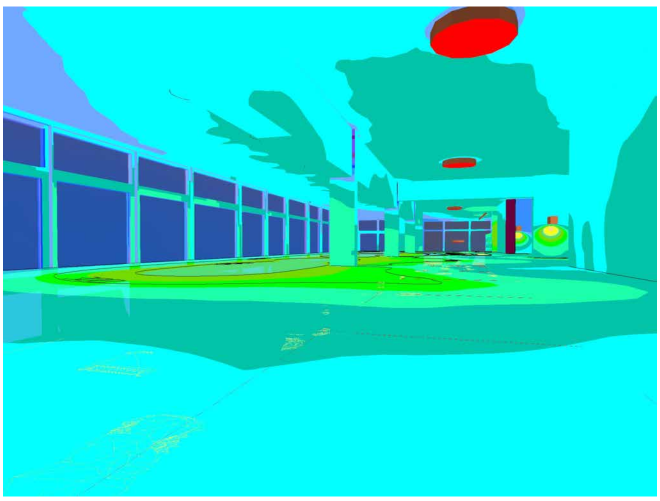
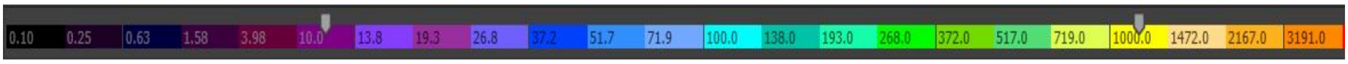


Fig. 7 View on the corridor area

Fig. 8 Work plane results of the corridor area



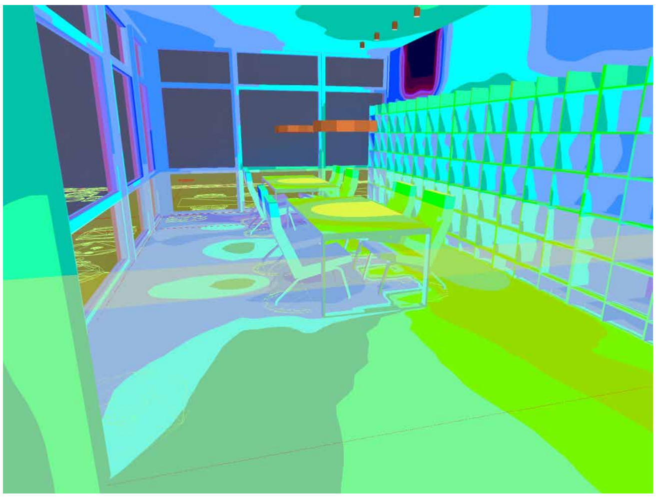



Fig. 9 View on the horticulture room

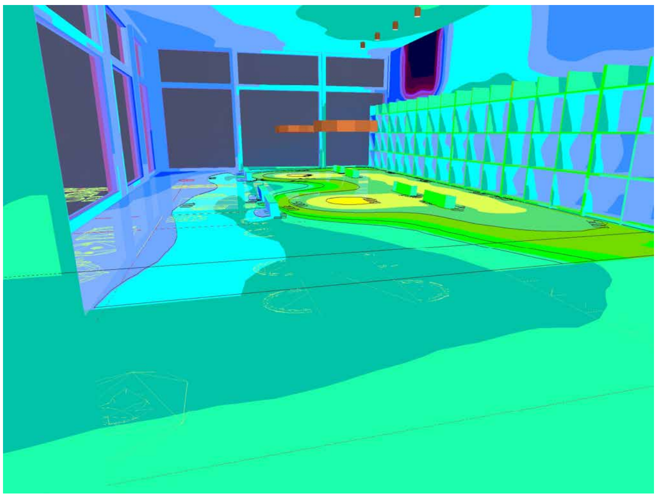


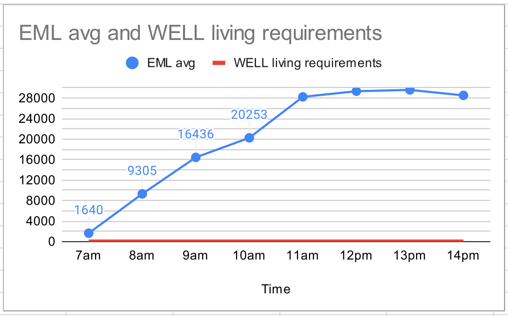
Fig. 10 Work plane results of the horticulture room

# Appendix 10 - Alfa results

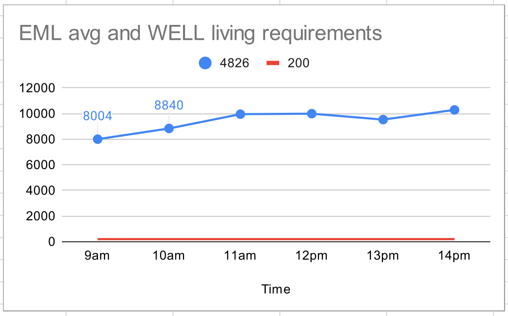
**Spring equinox Clear sky**

**Ligman Malmo 1**

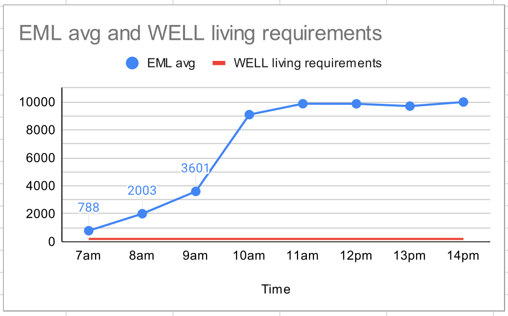
| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 1 | 7am | 1640 | 200 | Yes |
| | 8am | 9305 | 200 | Yes |
| | 9am | 16436 | 200 | Yes |
| | 10am | 20253 | 200 | Yes |
| | 11am | 28247 | 200 | Yes |
| | 12pm | 29353 | 200 | Yes |
| | 13pm | 29608 | 200 | Yes |
| | 14pm | 28538 | 200 | Yes |



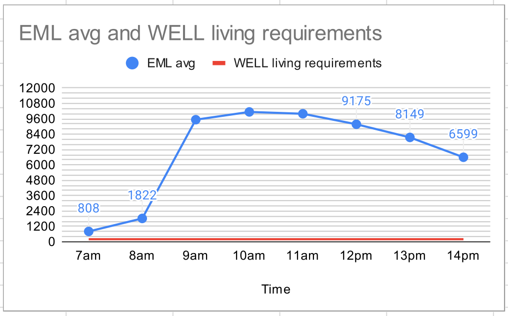

| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 2 | 7am | 808 | 200 | Yes |
| | 8am | 4826 | 200 | Yes |
| | 9am | 8004 | 200 | Yes |
| | 10am | 8840 | 200 | Yes |
| | 11am | 9957 | 200 | Yes |
| | 12pm | 9995 | 200 | Yes |
| | 13pm | 9534 | 200 | Yes |
| | 14pm | 10290 | 200 | Yes |




| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 3 | 7am | 788 | 200 | Yes |
| | 8am | 2003 | 200 | Yes |
| | 9am | 3601 | 200 | Yes |
| | 10am | 9098 | 200 | Yes |
| | 11am | 9878 | 200 | Yes |
| | 12pm | 9872 | 200 | Yes |
| | 13pm | 9706 | 200 | Yes |
| | 14pm | 10000 | 200 | Yes |

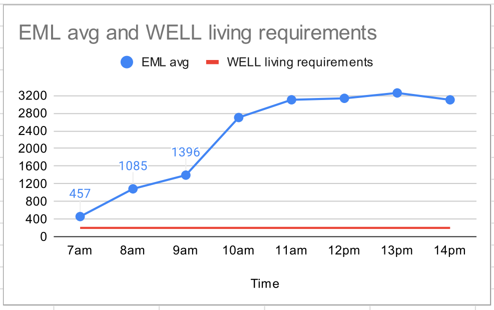



| Area | Alertness | | | |
|---|---|---|---|---|
| | Time | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 4 | 7am | 808 | 200 | Yes |
| | 8am | 1822 | 200 | Yes |
| | 9am | 9532 | 200 | Yes |
| | 10am | 10139 | 200 | Yes |
| | 11am | 9996 | 200 | Yes |
| | 12pm | 9175 | 200 | Yes |
| | 13pm | 8149 | 200 | Yes |
| | 14pm | 6599 | 200 | Yes |

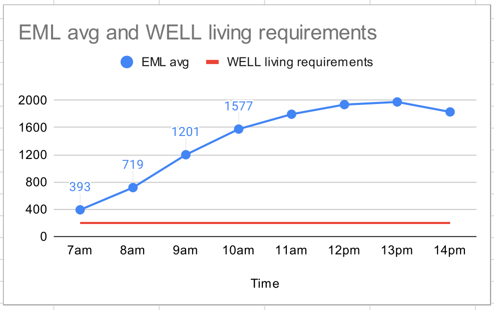


**Spring equinox Overcast**
**Ligman Malmo 1**

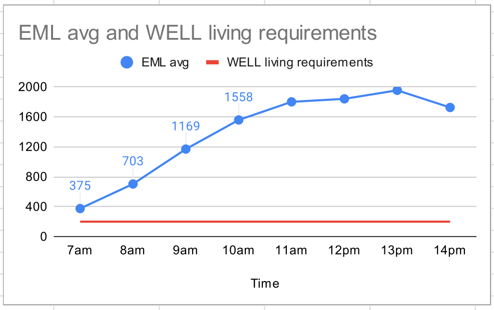
| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 1 | 7am | 457 | 200 | Yes |
| | 8am | 1085 | 200 | Yes |
| | 9am | 1396 | 200 | Yes |
| | 10am | 2702 | 200 | Yes |
| | 11am | 3104 | 200 | Yes |
| | 12pm | 3137 | 200 | Yes |
| | 13pm | 3259 | 200 | Yes |
| | 14pm | 3103 | 200 | Yes |



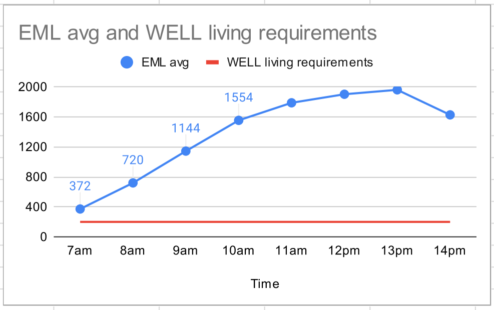

| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 2 | 7am | 393 | 200 | Yes |
| | 8am | 719 | 200 | Yes |
| | 9am | 1201 | 200 | Yes |
| | 10am | 1577 | 200 | Yes |
| | 11am | 1795 | 200 | Yes |
| | 12pm | 1936 | 200 | Yes |
| | 13pm | 1975 | 200 | Yes |
| | 14pm | 1829 | 200 | Yes |




| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 3 | 7am | 375 | 200 | Yes |
| | 8am | 703 | 200 | Yes |
| | 9am | 1169 | 200 | Yes |
| | 10am | 1558 | 200 | Yes |
| | 11am | 1800 | 200 | Yes |
| | 12pm | 1840 | 200 | Yes |
| | 13pm | 1954 | 200 | Yes |
| | 14pm | 1725 | 200 | Yes |



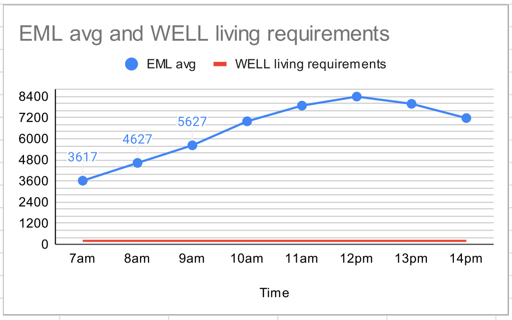

| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 4 | 7am | 372 | 200 | Yes |
| | 8am | 720 | 200 | Yes |
| | 9am | 1144 | 200 | Yes |
| | 10am | 1554 | 200 | Yes |
| | 11am | 1788 | 200 | Yes |
| | 12pm | 1902 | 200 | Yes |
| | 13pm | 1961 | 200 | Yes |
| | 14pm | 1627 | 200 | Yes |



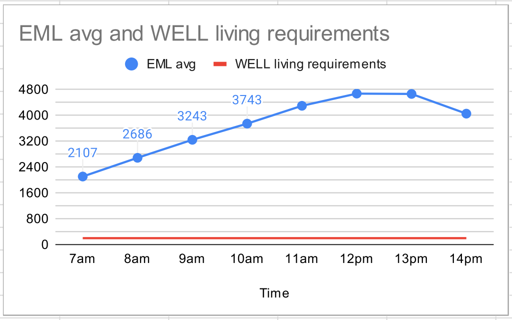
**Summer solstice Clear sky**

**Ligman Malmo 1**

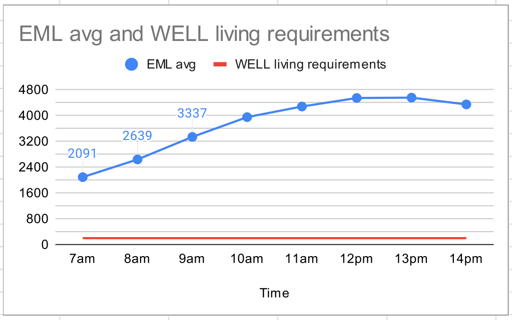
| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 1 | 7am | 3617 | 200 | Yes |
| | 8am | 4627 | 200 | Yes |
| | 9am | 5627 | 200 | Yes |
| | 10am | 6991 | 200 | Yes |
| | 11am | 7881 | 200 | Yes |
| | 12pm | 8396 | 200 | Yes |
| | 13pm | 7985 | 200 | Yes |
| | 14pm | 7175 | 200 | Yes |



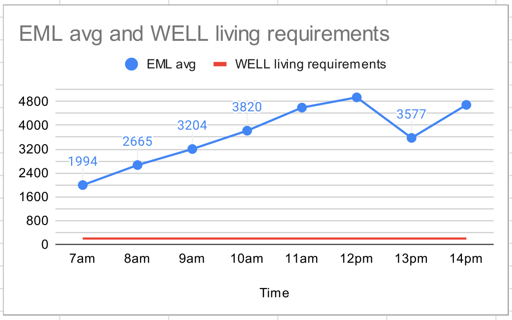

| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 2 | 7am | 2107 | 200 | Yes |
| | 8am | 2686 | 200 | Yes |
| | 9am | 3243 | 200 | Yes |
| | 10am | 3743 | 200 | Yes |
| | 11am | 4295 | 200 | Yes |
| | 12pm | 4672 | 200 | Yes |
| | 13pm | 4662 | 200 | Yes |
| | 14pm | 4052 | 200 | Yes |




| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 3 | 7am | 2091 | 200 | Yes |
| | 8am | 2639 | 200 | Yes |
| | 9am | 3337 | 200 | Yes |
| | 10am | 3950 | 200 | Yes |
| | 11am | 4279 | 200 | Yes |
| | 12pm | 4543 | 200 | Yes |
| | 13pm | 4554 | 200 | Yes |
| | 14pm | 4344 | 200 | Yes |



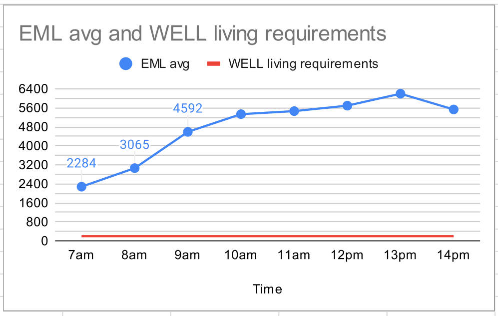

| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 4 | 7am | 1994 | 200 | Yes |
| | 8am | 2665 | 200 | Yes |
| | 9am | 3204 | 200 | Yes |
| | 10am | 3820 | 200 | Yes |
| | 11am | 4594 | 200 | Yes |
| | 12pm | 4938 | 200 | Yes |
| | 13pm | 3577 | 200 | Yes |
| | 14pm | 4686 | 200 | Yes |



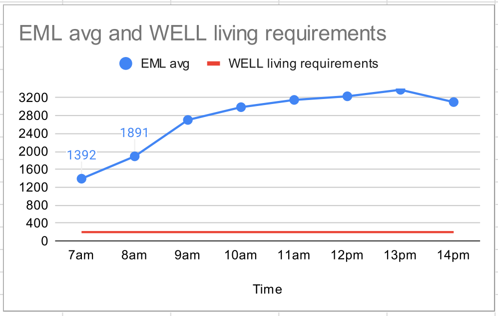
**Summer solstice Overcast**

**Ligman Malmo 1**

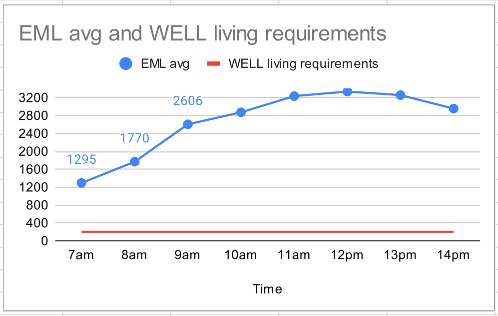
| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 1 | 7am | 2284 | 200 | Yes |
| | 8am | 3065 | 200 | Yes |
| | 9am | 4592 | 200 | Yes |
| | 10am | 5336 | 200 | Yes |
| | 11am | 5464 | 200 | Yes |
| | 12pm | 5694 | 200 | Yes |
| | 13pm | 6197 | 200 | Yes |
| | 14pm | 5534 | 200 | Yes |



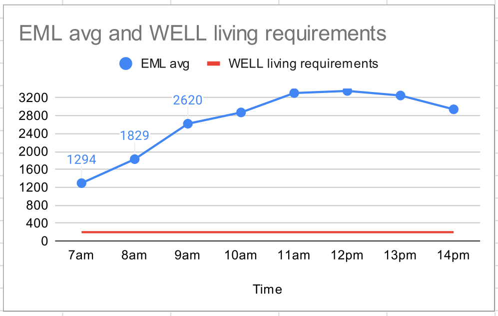

| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 2 | 7am | 1392 | 200 | Yes |
| | 8am | 1891 | 200 | Yes |
| | 9am | 2703 | 200 | Yes |
| | 10am | 2988 | 200 | Yes |
| | 11am | 3150 | 200 | Yes |
| | 12pm | 3231 | 200 | Yes |
| | 13pm | 3376 | 200 | Yes |
| | 14pm | 3102 | 200 | Yes |




| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 3 | 7am | 1295 | 200 | Yes |
| | 8am | 1770 | 200 | Yes |
| | 9am | 2606 | 200 | Yes |
| | 10am | 2874 | 200 | Yes |
| | 11am | 3237 | 200 | Yes |
| | 12pm | 3338 | 200 | Yes |
| | 13pm | 3259 | 200 | Yes |
| | 14pm | 2957 | 200 | Yes |



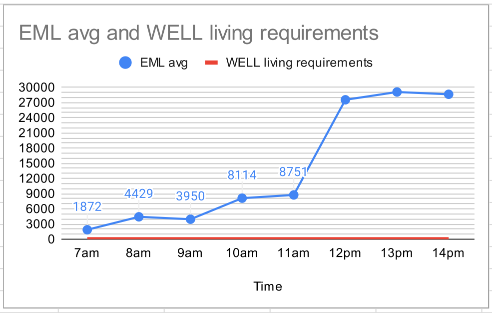

| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 4 | 7am | 1294 | 200 | Yes |
| | 8am | 1829 | 200 | Yes |
| | 9am | 2620 | 200 | Yes |
| | 10am | 2872 | 200 | Yes |
| | 11am | 3305 | 200 | Yes |
| | 12pm | 3352 | 200 | Yes |
| | 13pm | 3250 | 200 | Yes |
| | 14pm | 2942 | 200 | Yes |



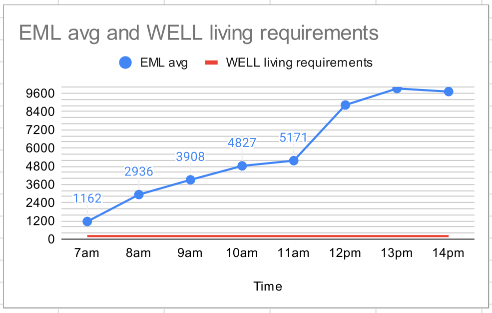
**Autumn solstice Clear sky**

**Ligman Malmo 1**

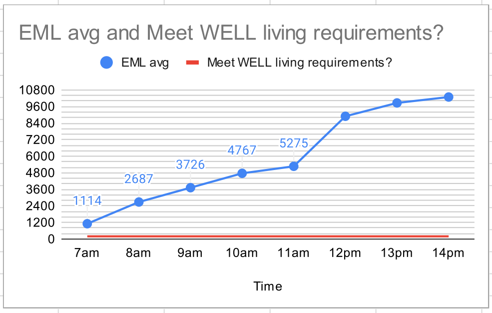
| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 1 | 7am | 1872 | 200 | Yes |
| | 8am | 4429 | 200 | Yes |
| | 9am | 3950 | 200 | Yes |
| | 10am | 8114 | 200 | Yes |
| | 11am | 8751 | 200 | Yes |
| | 12pm | 27553 | 200 | Yes |
| | 13pm | 29090 | 200 | Yes |
| | 14pm | 28640 | 200 | Yes |



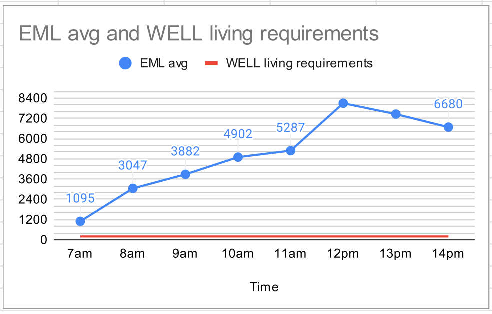

| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 2 | 7am | 1162 | 200 | Yes |
| | 8am | 2936 | 200 | Yes |
| | 9am | 3908 | 200 | Yes |
| | 10am | 4827 | 200 | Yes |
| | 11am | 5171 | 200 | Yes |
| | 12pm | 8835 | 200 | Yes |
| | 13pm | 9922 | 200 | Yes |
| | 14pm | 9720 | 200 | Yes |




| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | Meet WELL living requirements? | Is WELL fulfilled? |
| Table 3 | 7am | 1114 | 200 | Yes |
| | 8am | 2687 | 200 | Yes |
| | 9am | 3726 | 200 | Yes |
| | 10am | 4767 | 200 | Yes |
| | 11am | 5275 | 200 | Yes |
| | 12pm | 8899 | 200 | Yes |
| | 13pm | 9866 | 200 | Yes |
| | 14pm | 10294 | 200 | Yes |



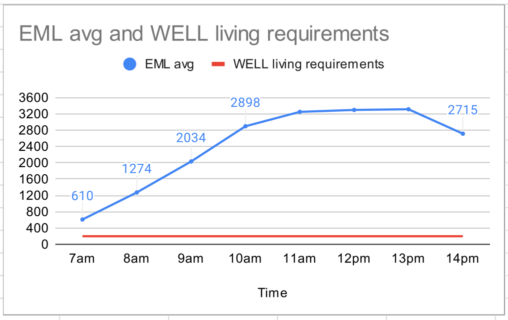

| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 4 | 7am | 1095 | 200 | Yes |
| | 8am | 3047 | 200 | Yes |
| | 9am | 3882 | 200 | Yes |
| | 10am | 4902 | 200 | Yes |
| | 11am | 5287 | 200 | Yes |
| | 12pm | 8097 | 200 | Yes |
| | 13pm | 7453 | 200 | Yes |
| | 14pm | 6680 | 200 | Yes |



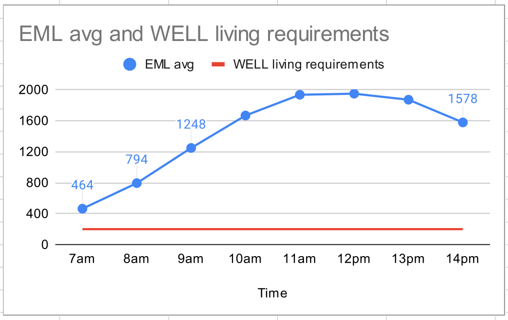
**Autumn solstice Overcast**

**Ligman Malmo 1**

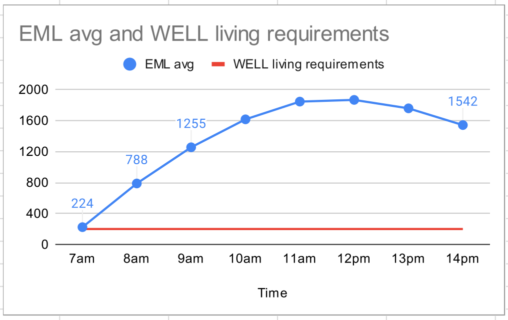
| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 1 | 7am | 610 | 200 | Yes |
| | 8am | 1274 | 200 | Yes |
| | 9am | 2034 | 200 | Yes |
| | 10am | 2898 | 200 | Yes |
| | 11am | 3251 | 200 | Yes |
| | 12pm | 3298 | 200 | Yes |
| | 13pm | 3315 | 200 | Yes |
| | 14pm | 2715 | 200 | Yes |



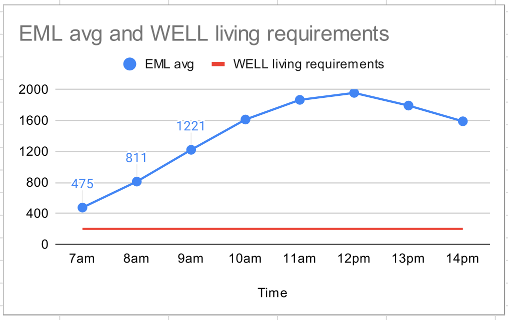

| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 2 | 7am | 464 | 200 | Yes |
| | 8am | 794 | 200 | Yes |
| | 9am | 1248 | 200 | Yes |
| | 10am | 1667 | 200 | Yes |
| | 11am | 1935 | 200 | Yes |
| | 12pm | 1949 | 200 | Yes |
| | 13pm | 1871 | 200 | Yes |
| | 14pm | 1578 | 200 | Yes |




| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 3 | 7am | 224 | 200 | Yes |
| | 8am | 788 | 200 | Yes |
| | 9am | 1255 | 200 | Yes |
| | 10am | 1616 | 200 | Yes |
| | 11am | 1845 | 200 | Yes |
| | 12pm | 1867 | 200 | Yes |
| | 13pm | 1758 | 200 | Yes |
| | 14pm | 1542 | 200 | Yes |



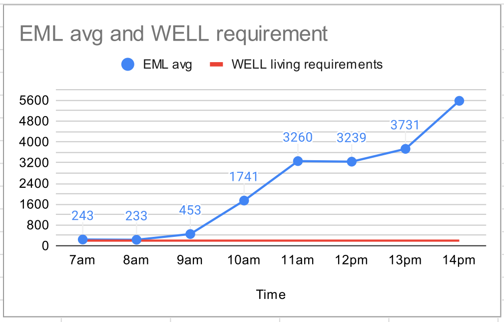

| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 4 | 7am | 475 | 200 | Yes |
| | 8am | 811 | 200 | Yes |
| | 9am | 1221 | 200 | Yes |
| | 10am | 1612 | 200 | Yes |
| | 11am | 1866 | 200 | Yes |
| | 12pm | 1956 | 200 | Yes |
| | 13pm | 1792 | 200 | Yes |
| | 14pm | 1589 | 200 | Yes |



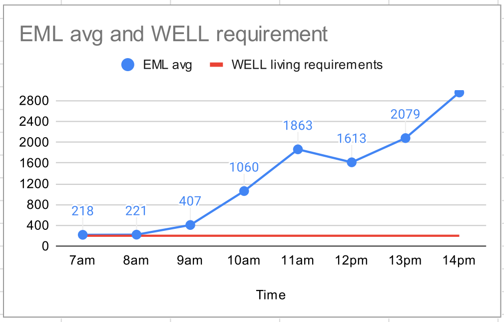
**Winter equinox Clear sky**

**Ligman Malmo 1**

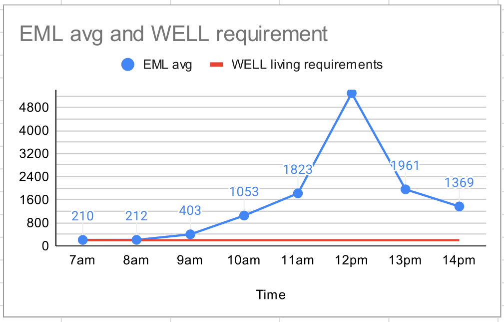
| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 1 | 7am | 243 | 200 | Yes |
| | 8am | 233 | 200 | Yes |
| | 9am | 453 | 200 | Yes |
| | 10am | 1741 | 200 | Yes |
| | 11am | 3260 | 200 | Yes |
| | 12pm | 3239 | 200 | Yes |
| | 13pm | 3731 | 200 | Yes |
| | 14pm | 5580 | 200 | Yes |



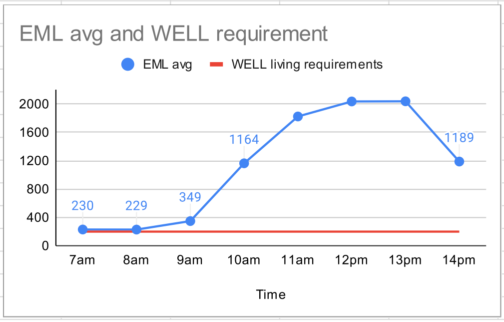

| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 2 | 7am | 218 | 200 | Yes |
| | 8am | 221 | 200 | Yes |
| | 9am | 407 | 200 | Yes |
| | 10am | 1060 | 200 | Yes |
| | 11am | 1863 | 200 | Yes |
| | 12pm | 1613 | 200 | Yes |
| | 13pm | 2079 | 200 | Yes |
| | 14pm | 2957 | 200 | Yes |




| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 3 | 7am | 210 | 200 | Yes |
| | 8am | 212 | 200 | Yes |
| | 9am | 403 | 200 | Yes |
| | 10am | 1053 | 200 | Yes |
| | 11am | 1823 | 200 | Yes |
| | 12pm | 5292 | 200 | Yes |
| | 13pm | 1961 | 200 | Yes |
| | 14pm | 1369 | 200 | Yes |



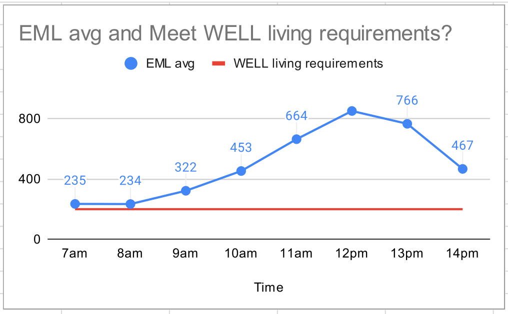

| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | EML avg | WELL living requirements | Is WELL fulfilled? |
| Table 4 | 7am | 230 | 200 | Yes |
| | 8am | 229 | 200 | Yes |
| | 9am | 349 | 200 | Yes |
| | 10am | 1164 | 200 | Yes |
| | 11am | 1825 | 200 | Yes |
| | 12pm | 2037 | 200 | Yes |
| | 13pm | 2039 | 200 | Yes |
| | 14pm | 1189 | 200 | Yes |



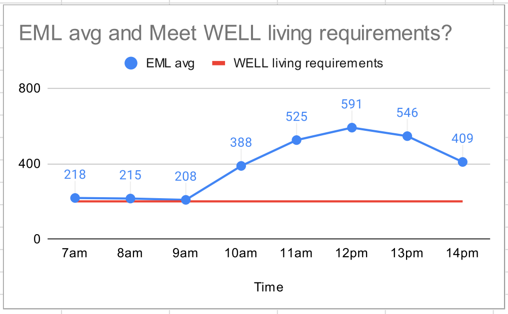
**Winter equinox Overcast**

**Ligman Malmo 1**

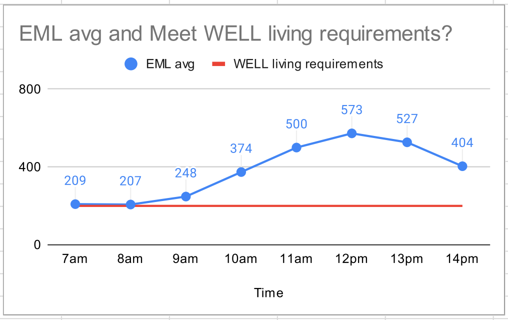
| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | **EML avg** | **WELL living requirements** | **Is WELL fulfilled?** |
| Table 1 | 7am | 235 | 200 | Yes |
| | 8am | 234 | 200 | Yes |
| | 9am | 322 | 200 | Yes |
| | 10am | 453 | 200 | Yes |
| | 11am | 664 | 200 | Yes |
| | 12pm | 851 | 200 | Yes |
| | 13pm | 766 | 200 | Yes |
| | 14pm | 467 | 200 | Yes |



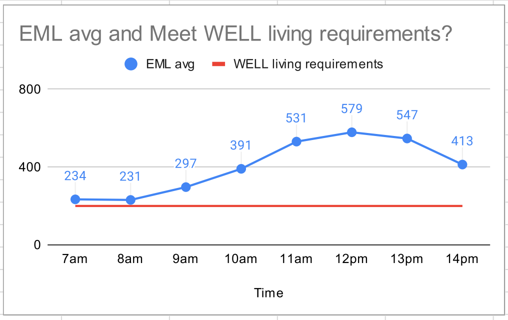

| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | **EML avg** | **WELL living requirements** | **Is WELL fulfilled?** |
| Table 2 | 7am | 218 | 200 | Yes |
| | 8am | 215 | 200 | Yes |
| | 9am | 208 | 200 | Yes |
| | 10am | 388 | 200 | Yes |
| | 11am | 525 | 200 | Yes |
| | 12pm | 591 | 200 | Yes |
| | 13pm | 546 | 200 | Yes |
| | 14pm | 409 | 200 | Yes |




| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | **EML avg** | **WELL living requirements** | **Is WELL fulfilled?** |
| Table 3 | 7am | 209 | 200 | Yes |
| | 8am | 207 | 200 | Yes |
| | 9am | 248 | 200 | Yes |
| | 10am | 374 | 200 | Yes |
| | 11am | 500 | 200 | Yes |
| | 12pm | 573 | 200 | Yes |
| | 13pm | 527 | 200 | Yes |
| | 14pm | 404 | 200 | Yes |




| Area | Time | Alertness | | |
|---|---|---|---|---|
| | | **EML avg** | **WELL living requirements** | **Is WELL fulfilled?** |
| Table 4 | 7am | 234 | 200 | Yes |
| | 8am | 231 | 200 | Yes |
| | 9am | 297 | 200 | Yes |
| | 10am | 391 | 200 | Yes |
| | 11am | 531 | 200 | Yes |
| | 12pm | 579 | 200 | Yes |
| | 13pm | 547 | 200 | Yes |
| | 14pm | 413 | 200 | Yes |



# Appendix 11 - Chosen fixtures specification



**AJ Væg**

## Product info

**Information**
Den hvide version leveres med hvid ledning. De andre versioner leveres med sort ledning.

**Montage**
Ledningstype: Plast med stikprop. Ledningslængde: 2,4m. Afbryder: På bagdåse.

**Overflade**
Rustfrit stål, poleret. Hvid, sort, aubergine, mørk grøn, mørk grå, lys grå, midnat blå, lys petroleum, rustrød, okkergul, vådlakeret.

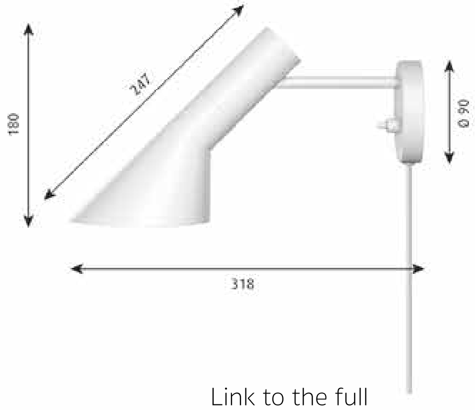
**Materialer**
Skærm: Optrukket stål eller rustfrit stål. Bagdåse: Optrukket stål eller dybttrukket rustfrit stål. Arm: Stål eller rustfrit stål.

**Størrelser og vægt**
Bredde x højde x længde (mm) | 318 x 180 x 125 Maks. 0,9 kg

**Klasse**
Tæthedsklasse IP20. Isolationsklasse II uden jording.

**Lyskilde**
1x20W E14

**Information**
Den hvide version leveres med hvid ledning. De andre versioner leveres med sort ledning.




Link to the full specification sheet: https://www.louispoulsen.com/da-dk/catalog/professional/dekorativ-belysning/vaeglamper/aj-vaeg?v=90403-5743161780-01&t=about&t=downloads&t=data

## Produktfamilie


AJ Royal


AJ Mini Bord


AJ Bord

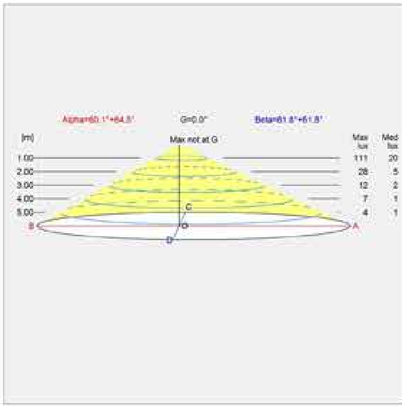

AJ Gulv


AJ 50 Væg

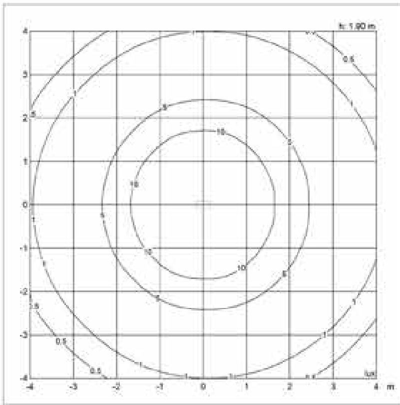
louis poulsen

# Lysdistributionsdiagram

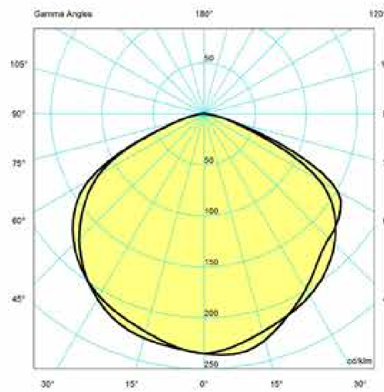
## Cartesian



## Isolux



## Polar



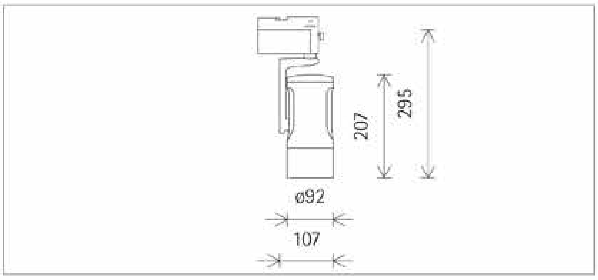
## Dataspecifikationer

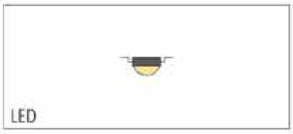
| | | | |
|---|---|---|---|
| Farve | **Hvid** | Længde | **125** |
| Bredde | **318** | Højde | **180** |
| Indbygningshøjde | - | IP-klasse | **20** |
| Klasse | **II** | Nettovægt | **0.8** |
| Standby (W) | - | Effektfaktor (P = 100 % / P = 50 %) | - |
| Startstrøm | - | Transientbeskyttelse, Imax. [T2] IEC 61643-1 | - |
| Lyskilde | **1x20W E14** | Kelvin | - |
| CRI | - | SDCM | - |
| Lumen | - | Watt | - |
| Efficacy | - | Min. dæmpniveau (%) | - |
| UGR transversal / aksial | **20.9/21.4** | L80B50 (timer) | - |
| L80B10 (timer) | - | Driver life | - |

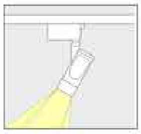
**ERCO**

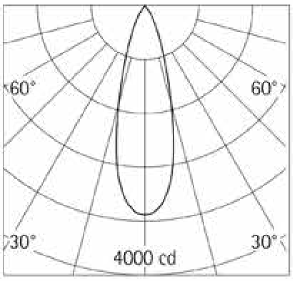
# Eclipse Spotlight

**with transadapter**






| h(m) | E(lx) | D(m) |
|---|---|---|
| | | 29° |
| 1 | 3109 | 0.52 |
| 2 | 777 | 1.03 |
| 3 | 345 | 1.55 |
| 4 | 194 | 2.07 |
| 5 | 124 | 2.59 |

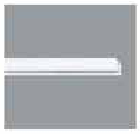
**A0021177** White (RAL9002)
LED 13.9W 1432lm 2700K warm white
Phase dimmable+ On-board Dim
Version 1
Size M
Darklight lens flood

**Product description**
Housing: cast aluminium, powder-coated; can be swivelled through 270° on the bracket. Upper cover made of polymer.
Bracket: cast aluminium/polymer, coated; can be rotated through 360° on the adapter.
Transadapter for ERCO 220-240V track: polymer, white.
ERCO control gear, dimmable. Rotary control for brightness regulation.
LED module: high-power LEDs. Collimating lens made of optical polymer.
Lens unit: polymer, white. Darklight lens made of optical polymer. Optical cut-off 40°.
Dimming with external dimmers possible (trailing edge).
Weight 1.21kg

Link to full specification sheet:
https://www.erco.com/en/products/indoor/luminaires-for-track/eclipse-7080/?colour_temperature%3Aeq=2700&colour_rendering_index%3Agte=92&colour_rendering_index%3Alte=92&specsheet=A0021177

**Technical data**

| | |
|---|---|
| Luminous flux of the luminaire | 986lm |
| Connected load | 18.9W |
| Luminaire efficacy | 52lm/W |
| Colour deviation | 1.5 SDCM |
| Colour rendition index | CRI 92 |
| Lumen maintenance (LED manufacturer specifications) | L90/B10 ≤50000h<br>L90 ≤100000h |
| LED failure rate | 0.1% ≤50000h |
| Dimming range | 1%-100% |
| Dimming method | CCR |
| LMF | E |
| Energy efficiency class | EEI A+ |
| Standby power per control gear | 0.4W |
| Luminaires per circuit breaker B16 | 150 |



**Mounting**
ERCO 3-circuit track
Hi-trac 3-circuit track

For your regional contact in the ERCO Sales network click here
www.erco.com/contact



Technical Region: 220-240V 50/60Hz
We reserve the right to make technical and design changes.
Edition: 21.12.2020
Current version under
www.erco.com/A0021177

# Product info

**Information**

Kompatibel med forkants- og bagkantsdæmpere. Bemærk, at det lave strømforbrug på nogle produkter kan påvirke lysdæmpningen.

**Montage**

Ophængstype: Ledning og wire, 2 x 0,75 mm² Baldakin: Ja. Ledningslængde: 4 m.

**Overflade**

Sort eller hvid, mat, vådlakeret.

**Materialer**

Skærm: Optrukket aluminium. Diffusor Sprøjtestøbt PC.

**Størrelser og vægt**

Bredde x højde x længde (mm) | 400 x 270 x 400 Maks. 4,9 kg | 175 x 134 x 175 Maks. 2,4 kg | 250 x 270 x 250 Maks. 3,7 kg | 650 x 270 x 650 Maks. 6,6 kg

**Klasse**

Tæthedsklasse IP20. Isolationsklasse I.

**Lyskilde**

LED 2700K 31W <br />Lumen: 2104

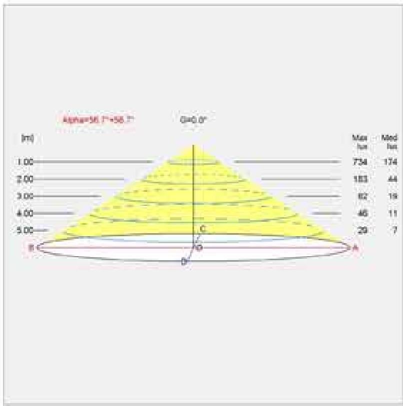
**Information**

Kompatibel med forkants- og bagkantsdæmpere. Bemærk, at det lave strømforbrug på nogle produkter kan påvirke lysdæmpningen.

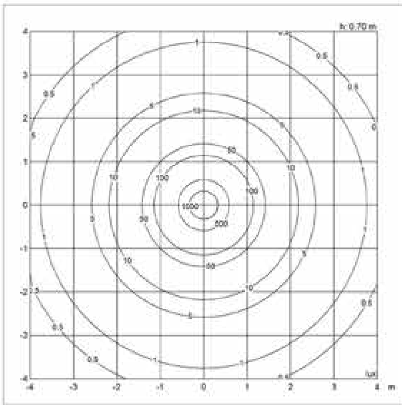

Link to the full specification sheet: https://www.louispoulsen.com/da-dk/catalog/professional/dekorativ-belysning/pendler/keglen?v=91772-5741103805-01&t=about&t=downloads&t=data

# Lysdistributionsdiagram

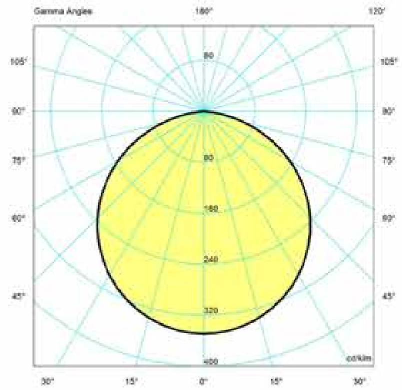
## Cartesian



## Isolux



## Polar



# Dataspecifikationer

| | | | |
|---|---|---|---|
| Farve | **Hvid** | Længde | **650** |
| Bredde | **650** | Højde | **270** |
| Indbygningshøjde | **-** | IP-klasse | **20** |
| Klasse | **I** | Nettovægt | **6.6** |
| Standby (W) | **<0,5** | Effektfaktor (P = 100 % / P = 50 %) | **-** |
| Startstrøm | **5 A / 50 µs** | Transientbeskyttelse, Imax. [T2] IEC 61643-1 | **-** |
| Lyskilde | **LED 2700K 31W** | Kelvin | **2700** |
| CRI | **90** | SDCM | **3** |
| Lumen | **2104** | Watt | **31** |
| Efficacy | **68** | Min. dæmpniveau (%) | **1** |
| UGR transversal / aksial | **18.9/18.9** | L80B50 (timer) | **>50000** |
| L80B10 (timer) | **-** | Driver life | **-** |

# MALMO 1 (MAL-80023)

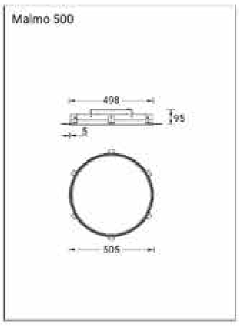
CE | IP20

## Luminaire structure

- Extruded aluminium bended profile with powder coating
- Stainless steel fasteners in grade 316
- Stainless steel brackets and screws for mounting
- PMMA diffuser with Opal (UGR <19) and micro prismatic (UGR <13) options for better glare control
- Up and down light distribution options
- Passive thermal management
- Integral control gear
- Wireless control available through Bluetooth connection
- Daylight and occupancy sensor options
- Emergency module (1 or 3 hours) is available upon request with 3 options (BASIC, SELF-TEST, PRO-DALI)

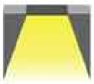
## Product description

Down - 505 mm - TW



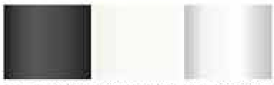

Link to the full specification sheet: https://www.ligman.com/specsheet/products/MAL-80023-en.pdf

## Light symbol



P

## Product colour



01 - Black (RAL 9011) | 03 - White (RAL 9003) | 05 - Matt Silver (RAL 9006)

## Special finishes upon request

SU01 - Concrete - Urban | SU02 - Softacape - Urban | SU03 - Stone - Urban | SU04 - Corten - Urban | SW01 - Oak - Woodland | SW02 - Walnut - Woodland | SW03 - Pine - Woodland

## Technical information

| | |
|---|---|
| **Lamp** | 864 LED |
| **Lamp type** | LED |
| **Dimming type** | DALI |
| **EEC** | A++ |
| **Material** | Aluminium |
| **Weight** | 3.6 kg |
| **Operating temperature** | -20 °C to 40 °C |

| **Luminaire** | |
|---|---|
| Power | 43 W |
| Lumen | 5427 lm |
| Efficacy | 126 lm/W |
| CCT / CRI | TW |
| Drive current | 400 mA |

| | |
|---|---|
| Optic | O [Opal], P [Micro-prismatic] |
| MacAdam Ellipse | 3 SDCM |
| Lifetime L90B10 (hours) | 34,000 |
| Lifetime L80B10 (hours) | 69,000 |
| Lifetime L80B50 (hours) | 100,000 |



02:17, 28-05-2021

https://www.ligman.com/malmo-1-mal-80023/

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