Universal school

Aalborg University

Department of Architecture & Design

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Group MA4-ARK15

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Abstract

This project aims to design a school for a variety of different individuals suffering from both physical and psychological illnesses. The project's goal is to create facilities which are able to adapt to the various individual needs and furthermore contain students with special needs from all Northern Jutland. In this way the individual student can benefit from a greater amount of common facilities. The present VUK facilities on Studievej 5, Noerresundby are being replaced by a design, which secures a more equal solution according to accessibility. This particular project has a focus upon the architectural ideas and how to optimize the built surrounding to accommodate learning situations according to the individual. In addition to this, social and environmental sustainability is important in all aspects of the design process.

Titlepage

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Title

Universal school

Theme

Sustainable architecture, sustainable environment, institutional building, young people with special needs.

Project period

02.01.2013 - 05.22.2013

Education

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Contents

Program

This program contains an introduction to the project's challenges and complexity in general; herein methods, theories and room program. The program is meant as a departure for the project and represents its realm.

Reading guide

Due to the various themes the program should be read as individual themes, and it should provide general information.

Methods

The primary method used in this project is The Integrated Design Process (IDP)[1], which gives initiative for an iterative and inter-disciplinarian process. The process has the ability to combine both an empiric-analytical and a phenomenological approach when designing architecture. It is important to take account for both positivistic methods and also hermeneutic and phenomenological approaches from the beginning to create a holistic design, which embodies both the engineering and architectural qualities.

The positivistic methods are quantitative and work around hypothetic-deduction, which is about investigating a hypothesis and approximating whether it is falls or true through mathematical calculations[2].

The phenomenological approach is qualitative and drives from human experiences. This method is used as a departure for drawing inspiration in the target group's everyday activities and implementing different theories on how to create emotional detachment and atmospheres within a building[3].

The Integrated Design Process (IDP)

The Integrated Design process is divided into five main phases and revolves around problem based learning (PBL). It is important not to go through the phases as a linear process but instead to go back and forth between them. This should secure a holistic solution where the project increases its level of detail for each iteration[4].

"The integrated design methology focuses on combining the architect's artistic approach with strategically selected technical parameters from engineering right from the start of the design process"

(Knudstrup, 2010) [5]

The project idea phase

The first phase involves determining and describing the projects realm. It is important to consider the architectural idea behind the project and the problem, which it has to solve also in terms of sustainability. It is important to make a Problem Formulation as a starting point for the whole process[6].

The analysis phase

The second phase involves analysing the topography and its surrounds to investigate whether there is a possibility of using passive energy sources, such as wind direction for natural ventilation, sunlight for heat gain, and possible shadows. This phase also involves architectural considerations on how to implement the passive energy sources and create high architectural quality and good indoor environment. It is important to outline the design parameters and focus points of the project, which should fulfil the Problem Statement[7].

The sketching phase

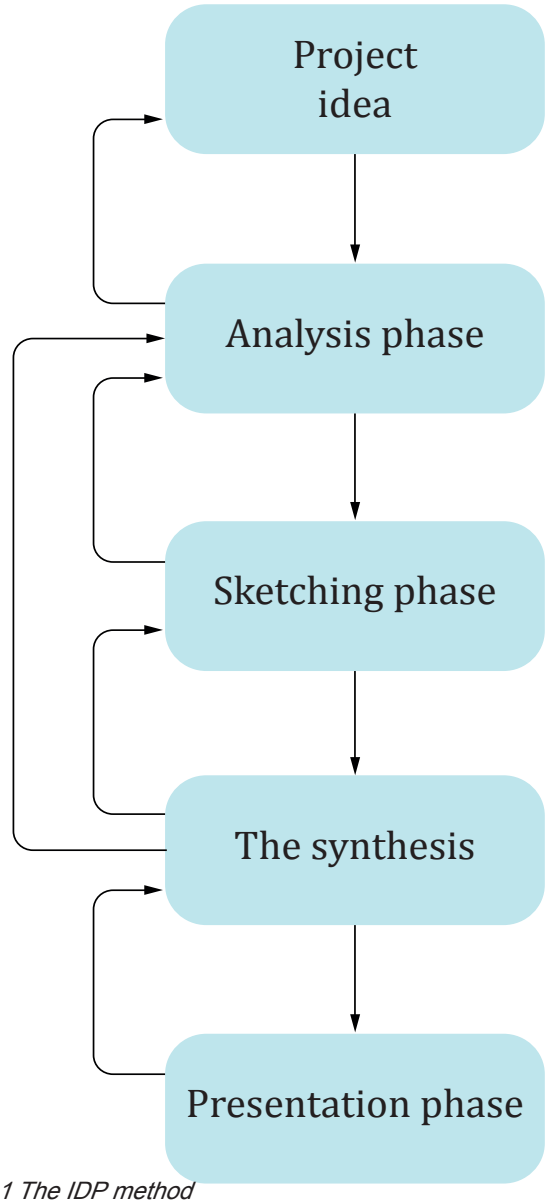
The third phase is where a fusion of the knowledge gained from the analysis phase is taken in to account to create an initial concept for a design proposal. It is important to work in terms of sketching and modelling on all the different design parameters involving in the project[8].

The synthesis phase

In the fourth phase the project is becoming a whole and completes the demands and design parameters made in the initial phases of the process[9].

The presentation phase

The fifth and final face of the project is Presentation where the entire project is presented in the best possible way, which includes all of the aspects of its realm[10].



III. 1 The IDP method

Introduction

This project takes its departure with inspiration from an on-going development for an addition to VUK *(Grown up school for education and communication)* called "The Intelligent Class Room"[11].
This particular project concerns a remake of the entire facilities at VUK at Studievej in Noerresundby plus new and desired additions. The additions concern, primarily, multiple disabled young people who have special needs in terms of accessibility, but VUK is in general a wide spread educational centre for young people aged between 17-21 with highly diverse special needs, which makes it important to take every individual into account when designing. Therefore it is important to emphasize each individual's opportunities of learning and interacting. The new facilities are to school about 80 pupils on approximately 3900 m^2. The current school has a major lack of flexibility which results in adding more squaremeters to meet the ever changing needs. Furthermore the school is not accessible to all of the scholars especially not the ones in wheelchairs. This project will therefore focus upon designing a flexible environment which is accessible for all.
The intension with the project is to enhance the architectural aspects of designing a school for people with a high degree of diverse disabilities. This means that the target group is of great importance when considering the organization, because of the individual diversity. The architectural ideas will have a strong relation to accessibility and how the built surroundings can emphasize certain atmospheres and affect all of our senses and create a welcoming and pleasant environment that stimulates the scholars to interact and improve their individual skills despite their disabilities. There will be a strong focus on creating a facility that encourages independence to accommodate a desire to be, act and live as normal as possible despite a handicap. This project will take sustainability into consideration where the aim is to design a building, which fulfils BR 2020 standards with passive means. Furthermore will active means be used as an energy reduction to the overall energyframe.
It is of equal importance to create a good indoor environment in terms of minimum pollution and temperature variations.

Ill. 2 Community

Word explanation

Sustainability

Sustainability in this project refers to The Brundland Report definition. The project takes account for a duality between Environmental Sustainability and Social Sustainability.

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own need."
(Brundland Report Definition.)[12]

Flexibility

Flexibility in this project should be understood, not as a means of removable or movable walls or surfaces, but merely as a room arrangement, which embodies and upholds the opportunity to create a different room arrangement to meet an ever-changing purpose.

Tectonics

In this project tectonics refers to a phenomenological approach to construction, drawing inspiration from the Vitruvian understanding, which involves a combination of; function, construction and aesthetics to create a harmonies design.

"Inasmuch as the tectonic amounts to poetics of construction it is art, but in this respect the artistic dimension is neither figurative nor abstract."
(Kenneth Frampton)[13]

Accessibility

In this project accessibility is understood as "Universal Design"[14], which means designing facilities, which are accessible to all. Accesibility is a strong parameter in this project and will therefore also consider equality among the students[15].

Architectural vision

When looking upon architecture and how to perceive it, it is commonly thought of as a visual experience. But when engaging with a building; actually walking trough it or living in it, it becomes much more than what the eyes can see. Throughout our lives we use all of our senses to investigate the world and the objects within it; these experiences enable us to connect emotionally with our surroundings and experience them with our whole body to create a thorough understanding.

"Every touching experience of architecture is multi-sensory; qualities of space, matter and scale are measured equally by the eye, ear, nose, skin, tongue, skeleton and muscle. Architecture strengthens the existential experience one's sense of being in the world, and this is essentially a strengthened experience of self. Instead of mere vision, or five classical senses, architecture involves several realms of sensory experience which interact and fuse onto each other"

(Pallasmaa) [16]

Ill. 3 Vision

Touch

As a child we investigate the world and the things in it by touching everything with our hands, feet and with our whole body to determine and experience the difference between surfaces, weights, temperatures and shapes of objects surrounding us. This gives us an intuitive reacting of proportion, materials and the use of the substances. These experiences are stored in our memory, which gives us a good estimate of how objects feel by merely just looking at them[17].

"The skin reads the texture, weight, density and temperature of the matter".

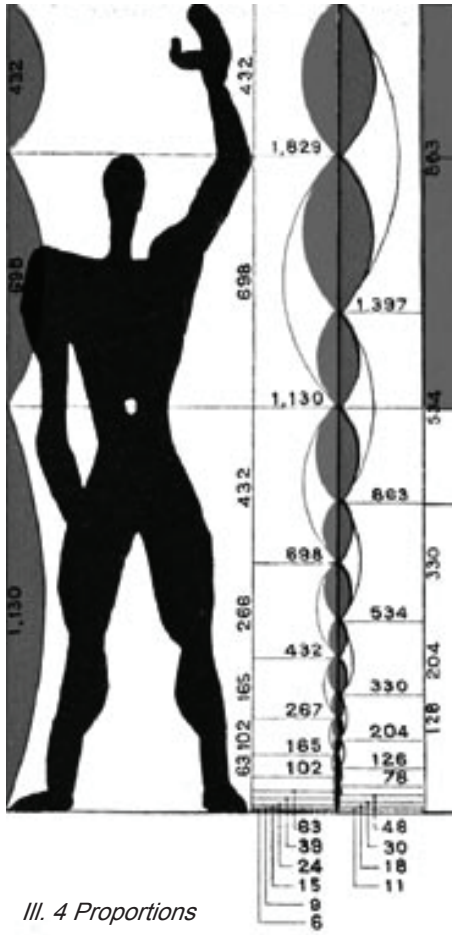
(Pallasmaa)[18]

It is important to consider how we emotionally connect with our surroundings; how we at an early age used all of our senses to engage with dead objects. These memories able us to reinterpret in new surroundings what makes us feel good and at home and what is out of our context and confuses us or makes it or us feel out of place[19]. The difference in materials creates a difference in atmosphere, which is determined emotionally on how it feels on our skin [20].

Vision

Experiencing architecture has a strong emphasis on the visual images it gives us. We are able to visualize something three dimensional by merely looking at a small piece of the whole [21].

This also has to do with previous experiences, that allows our mind determine shapes and forms to create a whole. When walking through a building our vision helps us to understand a unity, it gives us strong connections to the materials used and the



Ill. 4 Proportions

dimensions and proportions involved by measuring with our body and recollecting how thing feel to touch, how they smell, the sounds in the room – without actually touching anything[22].

Hearing

"Interiors are like large instruments. Collecting sound, amplifying it, transmitting it elsewhere."
(Zumptur) [23]

The sounds that are in a room can tell a lot about how it is built. In terms of materials, whether it is a soft or hard material reflecting the sounds back towards you. Without sight it is possible to experience how the sound bounces up against the walls, the floors and the roofs of a building. Experiencing architecture through sound can give you an estimate of the shape and the size – the whole rooms characteristics by transmitting sound the architecture talks back to you. Hearting Architecture can create an atmosphere telling a story about tactility, which creates emotional references from previous experiences.[24]

"There are buildings that have wonderful sounds, telling me that I can feel at home, I'm not alone"
(Zumptur) [25]

Conclusion

To really understand a building all of our senses are at play. That we not only by vision interact with built surroundings but engage with architecture with the whole body. We measure buildings in proportion to our own body, we feel the tactility of the materials through our own skin. We are able to design architecture, which creates an atmosphere translated by all of our senses, so that even if you are deprived one of your senses you are still able to, emotionally, relate and engage with the current surroundings.

Ill. 5 Experiencing hands

Universal design

"The Concept is based on the universal design principles. These principles apply to the design of buildings, infrastructure, building and consumer products.

1. The objective is the provision of the environments which are convenient, safe and enjoyable to use be everyone, including people with disabilities.

2. The universal design principle rejects the division of the human population into able-bodies and disabled people.

3. Universal design includes supplementary provisions where appropriate."[26]

Universal Design is about designing for all, despite disabilities; this means to take all disabilities into consideration in order to create a design which is not only suited for all but also enjoyed by all on equal terms. An important point of view to consider is that people with a handicap wants to live and enjoy life on equal terms as everybody else. It is therefore better to create an environment with subtle implications such as leading lines, even surfaces, proper signage and so on(Passive Solutions). More than implementing permanent technical solution and installations which is not properly design for the buildings and makes the people look more handicapped than they actually are (Active Solutions). It is therefore better to encourage independence[27].

The Danish Handicap Organization has categorized handicaps into seven different categories to able relative workers to take everyone into consideration in order to create a solution that is equal to all. The seven categories visualize a thorough description of what could be a design solution and implementation to take into consideration[28].

Ill. 6 Universal diversity

Wheelchair users

This group is often related to muscle- and/or joint restraints, where to some extent a wheelchair is a necessity to get around. A wheelchair can either be manual or electric controlled. Manual wheelchairs are significantly smaller because of no driving engine. Depending on which wheelchair it causes some challenges, both in terms of access and moving ability. Because of the size and the energy used for the wheelchair ones range is decreased drastically. To have a wheelchair decreses the feeling of independence since the person might not be able to push certain buttons or to look above a simple desktop.

- Even surfaces
- Relative small risings
- Broad doors which are easy to access
- Sufficient width in hallways
- Turning possibilities
- Inventory in relating heights
- Elevators
- Toilets for wheelchair users
- Parking close to the entrance[29]

Walk, arm and hand restrained

These individuals can be divided into two main groups: Walking restraints and arm & hand restraints. People with walking restraints are having a hard time moving around freely, this means the problem is primarily the legs. They are forced to use walking sticks, walkers and some even wheelchairs. Arm & hand restrained people are not having a hard time moving around, but more to use their arms and hands to open doors and use “normal” press buttons. They are often shaking on their hands and their movements are not fully controlled. In both cases pain might restrain them even more than they physically are.

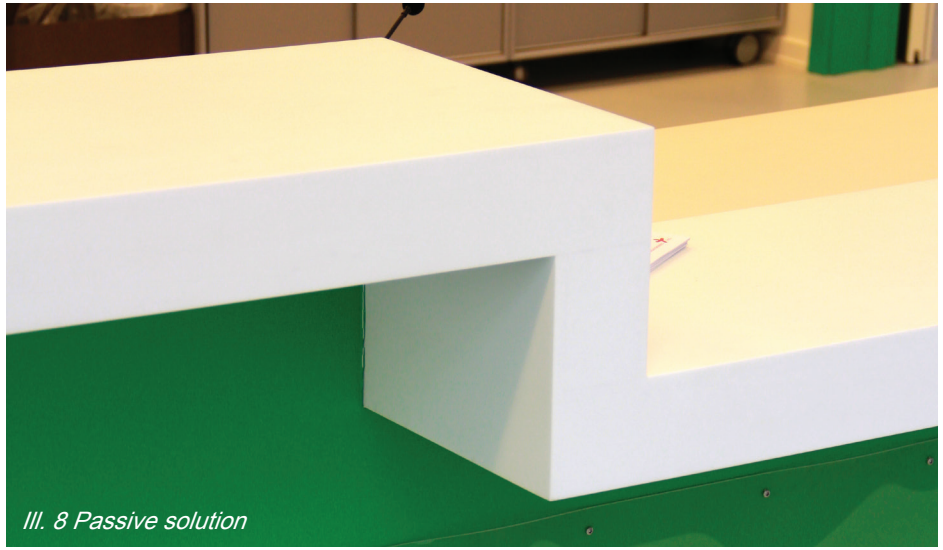
- Railings beside stairs
- Stairs with few and small steps
- Elevators
- Short distances between functions
- Plenty places to rest on a distance
- Even surface
- Little or no rising on the floors
- Doors with sufficient width
- Doors with good handles
- Sufficient width on passages
- Placement of inventory in correct heights
- Parking near to the entrance
- Use accessibility with low use of muscle
- Use interaction with stiff hand joint
- The placement of inventory is correct
- Correct size of the interaction modules[30]

Vision restrained

The degree of this disability has a great diversity. Most individuals with this disability are not completely blinded, but have a little vision and can therefore see something. Their common challenges are to navigate themselves according to the circumstances. For example objects in head height, stairs, and changing in levels can be an issue. Every related situation cause great problems for the one without a fully functioning vision.

- Simple composition of the environment
- Mark of stairs and change in levels
- Railings to follow
- Tactility shift
- Leading lines
- Attention fields
- Marking by contrast colors
- Good, not blinding light
- Communication with tactility in writings
- Communication with sound[31]

Ill. 7 Danish handicap organization



Ill. 8 Passive solution

Hearing restrained

Hearing restrained people can be categorized into three sub-categories: Individuals, who have lost most or partly hearing at an early age, people who have lost most or partly hearing at a later stage and people who have a little hearing disability who use hearing apparatus to grant better and sufficient hearing.

Those who have lost their hearing at an early age normally have no verbal language and have trouble to communicate even in writing, therefore they are using sign language – some can read the mouth. The ones who have lost partly or all hearing in a late stage have a normal written language, and can talk normally – but have problems understanding what other people say. Those who use hearing apparatus, use the remaining hearing as good as possible.

- Good visual orientation
- Good and appropriate lighting
- Contrasts to read faces
- Even light for distribution areas
- Verbal information is available on writing
- Good acoustics
- Telecoil service[32]

Allergic restrained

To be allergic restrained increases the caution of contact to a different kind of pollution. This can affect the mouth, the nose and the eyes and therefore become restricting. Walking in public areas where normal detergent appears can be a threat to these people.

- Appropriate choice of building materials
- Effective ventilation
- Regular service on ventilation filters
- Good and regular cleaning
- Detailed information about allergens[33]

This specific restrain will be taken into consideration in terms of insuring limited pollution by implementing a proper ventilation system. Researching all the different kinds of allergies and creating a building adapt for all of them will not be the focus of this project. due to the fact that there is no information of which allergies the scholars have or suffer from. It will therefore be considered on delimitation.

Growth restrained

Growth restrained individuals has a diverse form of function disabilities. They can likewise have mental problems, which reduce the ability to learn and understand. This kind of disabilities can be inborn, but can also occur from an accident.

- Recognizable surroundings
- Surroundings that are easy to navigate in
- Shift in material and colors will enhance the ability to navigate
- Simple and clear signage with pictograms to ease the navigation[34]

Reading restraint

A reading handicap is a verbal restriction. This restriction causes slow and insecure reading that affects the understanding of what is read. This further causes learning difficulties. Therefore people who suffer from this restriction are having big troubles to get knowledge from written materials.

- Written material is available on sound books, CD or visual guiding material
- Writing should be simple and carefully worked through with visual guidance[35].

Ill. 9 Tactile writings

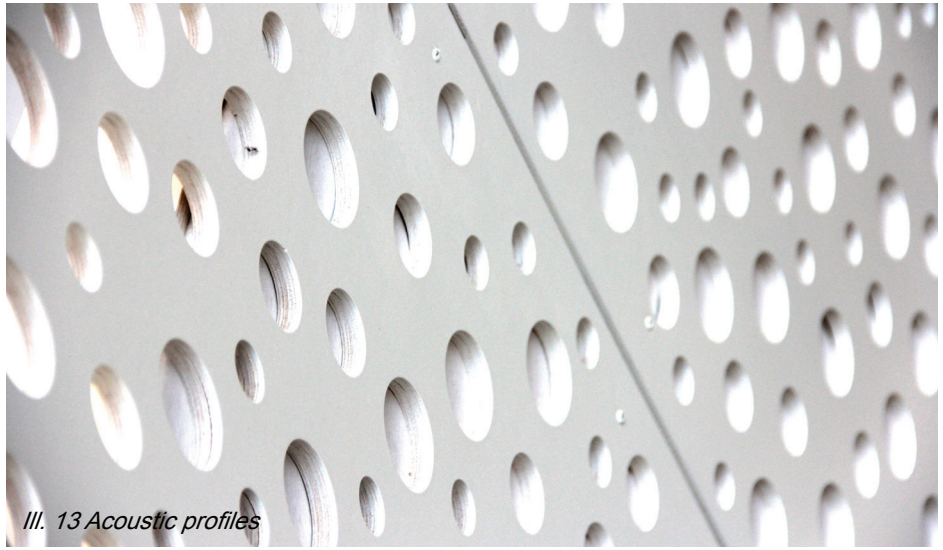
Conclusion

It is important to consider all the seven categories in order to make equal and universal design. It is though not possible to take all the precautions into consideration and it is therefore important to make compromises which makes it equal for all and not just adapt for one or two groups.

Ill. 10 Leading lines in carpet

Ill. 11 Handicap parking spots

Ill. 12 Acoustic and open environment



Ill. 13 Acoustic profiles

Schools tendencies

Today's schools are developing into an unknown identity, but there are tendencies that indicate what the strategies move toward. To understand the important characteristics of a school and its surrounding environment, a study on schools and the tendencies in how new schools are organized have been made. This is to investigate what can make for a good environment, that increases the wellbeing and learning potentials for the scholars. The study draws from a Danish analysis on school called model program for primary schools [36].

The important strategies in school design today are learning flexibility, wellbeing and cooperation 37. Learning flexibility is concentrated around being able to adapt according to the individual's way of learning. There are plenty of different learning situations connected to general schooling. Here in: Class lessons, team teaching, individual teaching, quiet immersion and physical activities[38]. It is important to embrace these kind of learning situations by differentiating the outer circumstances because the more diverse opportunities the better possibility of success[39].

School environment

Wellbeing of the individual is important since the first 10 years of the individual's social life is happening at the educational institution[40]. Wellbeing is achieved through small and safe communities that feel like "home"[41]. Here is the classroom of great importance, because each pupil gets attached to the classroom, which therefore becomes a personal safety zone[42]. Wellbeing also affects the confidence and the will to engage in social interactions and learning situations. Cooperation in today's lessons is getting more IT based rather than interacting personally. Even so it is still important to create small corners where small groups can work and discuss the tasks. Cooperation is important to the individual because interaction is enhancing the understanding of a given subject and it furthermore contributes to social skills[43].

School arrangement

A tendency in the primary school is that common areas are becoming larger. The common areas are for example small corners, cafeteria, libraries, multiuse areas, etc. These areas grow larger on the behalf of the normal classrooms, which means the teachers increase their use of common areas as study areas. The common areas are primarily made with a connection to walkways. In them wardrobes, workstations and cosy corners are commonly in-

Ill. 14 Nature in atrium

Ill. 15 Atrium

cluded. Greater common areas should be zoned properly because open areas often feel unsafe and unpleasant, and thereby demotivating the scholar. Therefore zoning smaller areas within a bigger area might be beneficial to both learning situations and social engagement[44].

External conditions

Different kind of learning situations and rooms require different external conditions like: Light, ventilation and acoustics. They are all important to the room and the activity inside it[45]. Direct sunlight is good in zones where interacting is the primary function, where indirect and stable light is good for IT equipment and reading.

Conclusion

To conclude upon the school tendencies it suggests a new way of thinking when designing an educational centre or a school. The important factors are how to increase the individual's experience of learning to enhance the scholar's preoccupation of knowledge. To enable this reaction the room arrangement must be more flexible and be able to adapt to all sorts of educational situations, to emphasize the needs of the individual.

Ill. 16 Atrium

Ill. 17 Nature in atrium

Learning

To practice learning situations with cognitive disabled scholars, the staff from VUK is using the following theory developed by their own experiences and research material. The theory has four different focus points, that affects each other. These four are all a part of the idea of creating an independent individual.

Memory

Memory is associated with the registrations of the various occurrences and communication attained throughout life. Therefore memory can be described from three aspects. The basic memory is the procedural memory that connects experiences and behaviour together. This knowledge is subconscious and cognitive according to the other two styles of memory: Episodic and semantic memories. Episodic memories are based on earlier episodes – a timeline. With that we learn or at least memorize how to behave in different situations. This memory articulates the consciousness of WHEN the experience was obtained. Semantic memory is more an experience and memorizing of the world and gives consciousness of WHAT the experience is. This makes it possible to recall earlier obtained knowledge[46].

Motivation

Motivation is about the individuals' interest in learning. This interest is created from earlier experiences and present conditions of learning. Another aspect of motivation is the expectations of the result both from the individual, but also from outside. From having earlier experiences, expectations are made to the new task. If the expected performance is lower than the actual performance, the experienced performance is worse[47].

Understanding

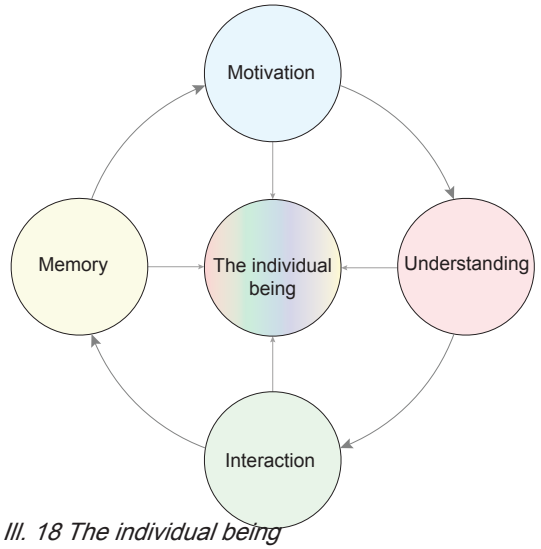
To understand, communication is needed. Without communication there is nothing to understand. Communication can appear from different media. Incoming communication must be decrypted and to ensure any form of decryption, experiences and memories are necessary. The opportunity of learning lies within the new incoming communication, whether motivation appears or not[48].

Interaction

A common horizon is relevant for an objective interaction. Interaction happens on the behalf of different knowledge or divergence on a specific subject. Interaction is a two-way communication, which improves memory and maybe a better understanding within the subject of discussion. This interaction has other great benefits like expansion of social competencies and enhanced communication skills[49].

Conclusion

These four steps are connected closely to each other, since a missing link will provoke worse or no learning. Learning is what creates one as an individual: to interact, memorize, understand, getting motivated and interested in whatever the future brings. This is important to have in mind, when designing a facility for multiple disabled young people, who might have restricted potential in all subcategories.

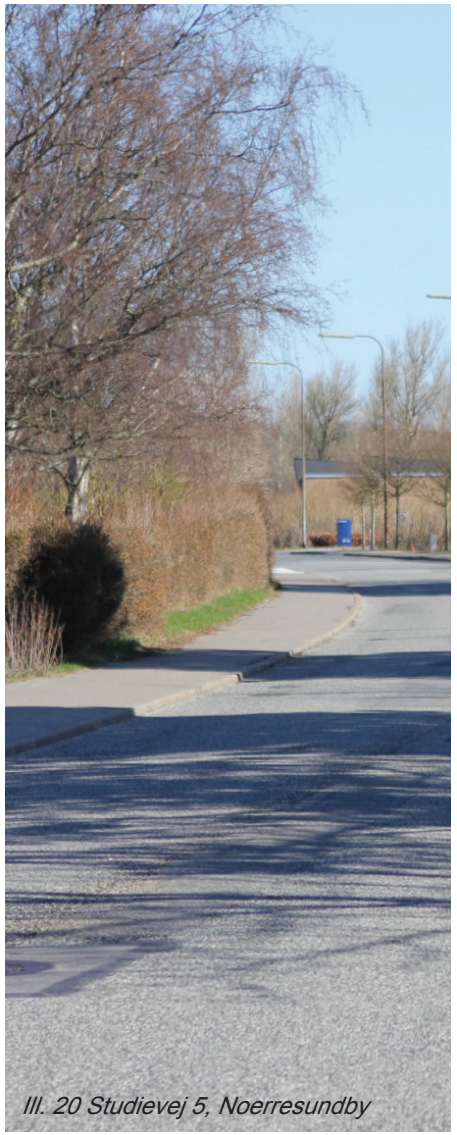


Ill. 18 The individual being

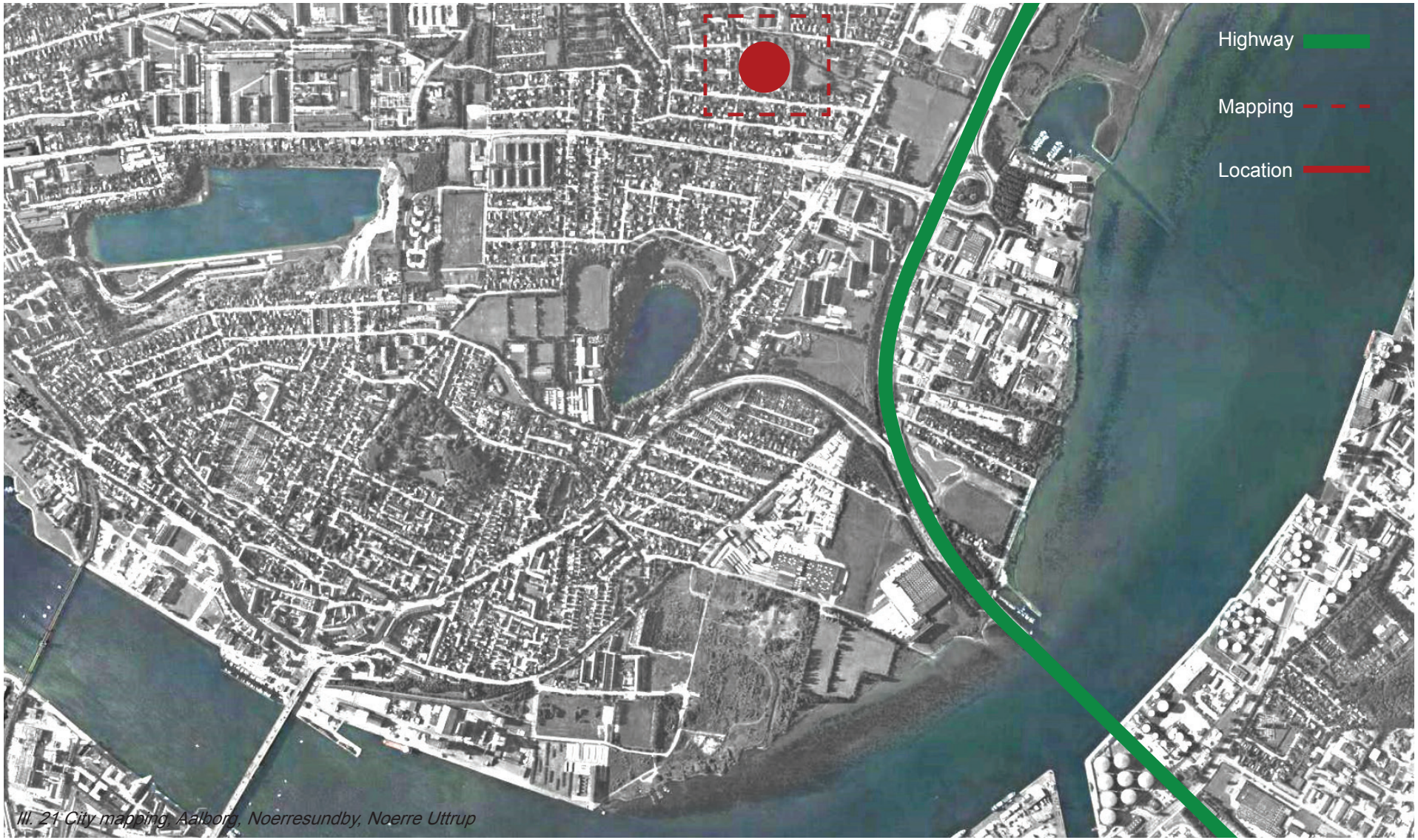
Ill. 19 Physical learning

Mapping

The new facilities are to be designed on Studivej 5. Studievej 5 is located in Noerresundby just north to Aalborg and the Limfjord. The school is to manage students from North Jutland and requires therefore a great amount of private and individual transportation. The highway is just east to the location, which simplifies the demanding transport to the school.
On the illustration is the red dot illustrating the site, where the dashed line illustrates the close-up mapping on the next page.



Ill. 20 Studievej 5, Noerresundby



Ill. 21 City mapping, Aalborg, Noerresundby, Noerre Uttrup

The school lies within a district of family housing. The dwellings have a great diversity in shape, expression, and gardening. There are both modern and classic housing in the district around the school, which means the green areas are many. The pictures show the great variation within this neighborhood. The great amount of housing and dwelling affects the amount of nearby public facilities. There are therefore very limited public facilities the school can benefit from. The illustrations beside visualize the circumstances, where there is gardening and great differences in expression and construction. on the mapping it is illustrated where the pictures are taken from, and how the division of the location is.

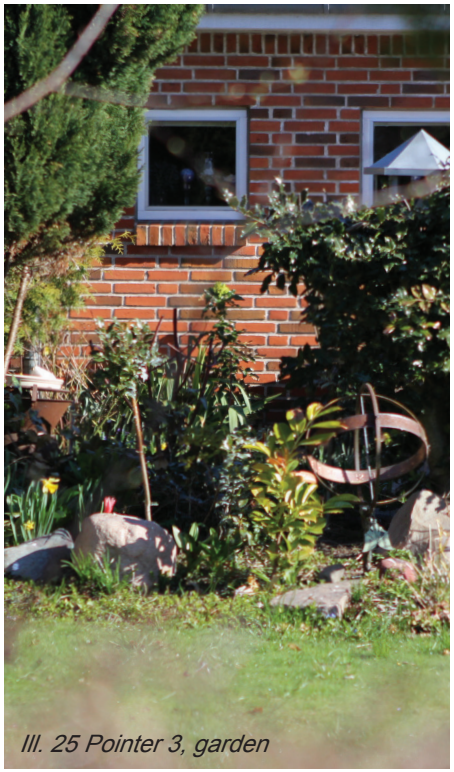
Conclusion

The area around the location is primary dwellings. There is a great lack of public facilities to benefit from. The garden city has a great diversity and expression that should be taken into consideration when creating a new building within its range.


Ill. 22 Pointer 1, limitation


Ill. 23 Pointer 2, context


Ill. 24 Pointer 4, garden


Ill. 25 Pointer 3, garden


Ill. 26 Pointer 5, context dwelling


Ill. 27 Pointer 6, context dwelling


The site
Dwelling areas
Public areas
1
2
3
4
5
6
1:2000
Site surroundings
Ill. 28 mapping

Room program

This room program is made as a combination of what needs and wishes the school has and wants. The roomprogram is divided into the different goups at the approximately 4000 m² school. Further description of the groups and their disabilities will be presented in the analysis. The building should fulfil the SBi 222 –instructions with quality level A indoor environment. Furthermore should it fulfill the Building Regulations 2020 with passive means. This includes a daylightfactor above 3% at workstations, good accessibility, little use of active solutions, and low temperature differences in each room[50].

The designcriterias are made as general expectations of the rooms within the building. Thus giving the students a good indoor environment.

Group A, Multihandicapped (*20 persons*)

Restroom	100 m²
Individual workst.	160 m²
Bookclub	50 m²
Classroom	50 m²
Wardrobe	10 m²
Hand. toilet w. bed	15 m²
Common areas	100 m²
Summerize	485 m²

Group A has the need of a restroom, bookclub, handicap toilet with bed and individual workstations. These are divideable into grouprooms, classrooms and handicap toilets to maintain flexibility.

Group U, Inf. Autists & Mentally restrained (*20 persons*)

Individual workst.	160 m²
4 x Classroom	200 m²
Wardrobe	10 m²
Common areas	100 m²
Summerize	470 m²

Group U has the need of good individual workstations to concentrate and stay focused in work situations. Besides that they need classrooms for gatherings.

Group B, socio emotionel & physical hand. (*30 persons*)

3 x Classroom	150 m²
6 x Grouproom	240 m²
Wardrobe	15 m²
Common areas	100 m²
Summerize	505 m²

Group B has the need of grouprooms and classrooms which can be freely used by the groups.

Group E, late developped young people (*10 persons*)

Classroom	50 m²
2 x Grouproom	80 m²
Wardrobe	10 m²
Common areas	50 m²
Summerize	190 m²

Group D, ADHD (*10 persons*)

Classroom	50 m²
Grouproom	40 m²
Individual workst.	40 m²
Wardrobe	10 m²
Common areas	50 m²
Summerize	190 m²

Group Q, Quiet young people (*5 persons*)

Classroom	50 m²
Grouproom	40 m²
Wardrobe	10 m²
Comon areas	25 m²
Summerize	120 m²

Summerize	500 m²

Due to the same social skills and same requirements of classrooms and grouprooms these three groups can be collected into one group. (meeting with VUK)

Common areas

Pool	60 m²
Carpentry	80 m²
Creative workshop	120 m²
Virtual	120 m²
Science	160 m²
Gym	130 m²
Kitchen	100 m²
Home econ.	160 m²
Cafeteria	250 m²
Music	160 m²
5 x Normal toilet	25 m²
4 x Hand. toilet	40 m²
Headmaster	25 m²
Meeting room	25 m²
Counselor	25 m²
Staff room	60 m²
Offices	120 m²
Server room	30 m²
Technical room	50 m²
Storage	50 m²
Cleaning	20 m²
Summerize	1935 m²

Conclusion

The assignment will be made in accordance with the Integrated Design Process. The Integrated Design Process is divided into five phases: Project idea phase, Analysis phase, Sketching phase, Synthesis phase and Presentation phase. The organisation of the process will be divided into these different categories to make an overview and to ensure an integrated design process.

All senses should be implented in a way such the architectural vision will emphasize the use of the new building.

The design is to be developed on the location of Studievej 5 in Noerresundby. The buildings in the area are primarily family housing with small gardens and green areas which gives a homey-feel to the area. The future institution will measure approximately 3900 m^2, and will contain various functions that are specialized to accommodate the schools requirements.

The new facilities should be designed for VUK (adult school for education and communication). The scholars on VUK have a wide spread diverse disabilities. Disabilities can in general be categorized into seven different groups: Wheelchair users, Walk, arm and hand restrained, Vision restrained, Hearing restrained, Allergic restrained, Growth restrained and reading restrained. Allergic restrained is not taken into consideration in the final design, since the school has no information on the matter. Suggest different design solutions to take into consideration, this will be done drawing inspiration from the design concept “universal design”. It is therefore important to consider which initiatives could help their everyday life and promote emancipation. It is furthermore important to take all into account equally to enhance the possibility of creating a community, which encourages social interaction between all of the scholars, and create a flexible environment, that adapts for different learning situations.

Present normal schools have a tendency and theory on how scholars perform in the best possible way. A major focus is on how flexibility can help the ability to adjust to new methods and theories, and at the same time interact with technology and wellbeing of the individual. This wellbeing can be improved by general ideas of having small cosy corners and creating a homey feel and intimate environments – ownership can be a factor in this. To promote wellbeing is the primary concern when designing a school, because it is strongly related to the schools primary purpose namely learning.

The best ways to learn depends on the individual, everyone has a preferred way of learning. The staff at VUK has created their own methods to ensure and enhance learning possibilities within this more specific group of people. They found out that memory, motivation, understanding and interaction are all a great part of creating us as individuals. Without one or more of the conditions the learning falls apart. It is therefore important to take every individual’s requirements and restrictions into account when designing this new school.

The initial investigations made in the program are meant as a general guideline for this project. The program lists both architectural theories, theories on building schools and design criteria for a sustainable environment, which will be implemented in the project as a departure for the design process. These initiatives have lead to a Problem Formulation for the project.

Ill. 29 Environment

Problem statement

Ill. 30 Environment

How is it possible to create an educational institution for a wide spread of scholars, that fulfils the special requirements each individual user may demand; and still create functional and aesthetic architecture that is social and environmental sustainable by using the Integrated Design Process?

Ill. 31 Environment

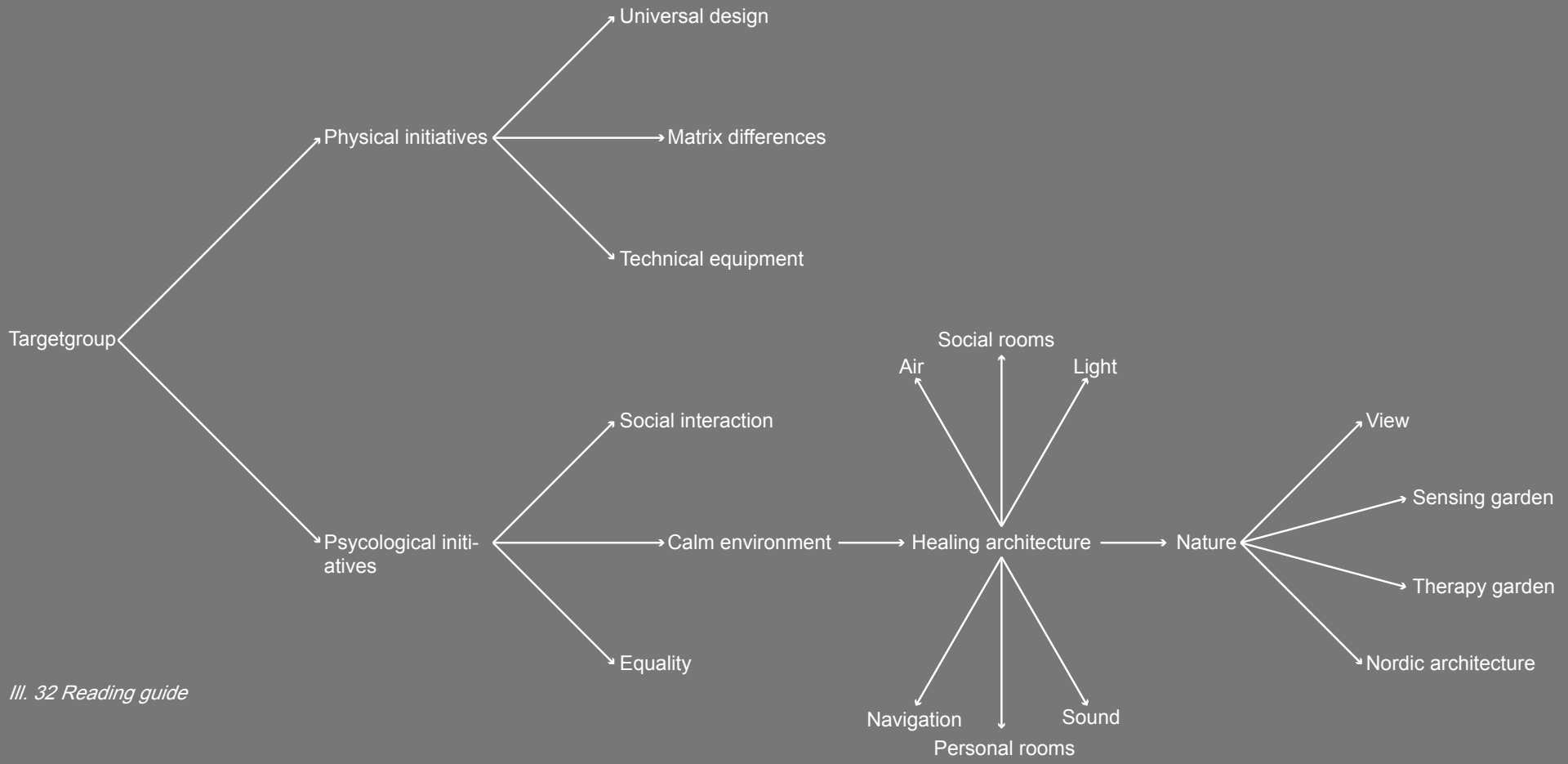
Analysis

This analysis will outline the challenges which lie within designing a school for people with a variety of disabilities both physical and mental. This is done by investigating each target group to gain knowledge upon what has to be taken into consideration. This leads to what kind of physical and psychological requirements the building design has to take into account. The analysis then discusses relevant theories on how architecture can assist the needs and wants of the target group drawing inspiration from “Helende Arkitektur”, “Therapy Gardens” and “Sensing Gardens. The architectural inspiration will draw from the concept of nature being a significant assistance in decreasing mental distress. The concept of using nature and relating to the context is corresponding with certain theories of Nordic architecture which will be the inspiration for the architectural expression.

Reading guide

The diagram shows how the analysis is corresponding and connecting each of the different topics within the analysis. With the target group as the point of departure and the architectural inspiration in Nordic architecture at the end.
The target group is divided into what physical requirements according to initiatives that can be done to improve the everyday, and what technical installations that is neccessary. The psychological initiatives have a greater point of departure, and describes how to improve the psychological environment. Each topic is concluded upon and then new topics are outlined and certain focus points for this project are then investigated further.

Contents



Ill. 32 Reading guide

Target group

The target group will outline the different individuals, what groups they are a part of and what disabilites each individual might suffer from on an daily basis.

Multi handicapped

Group A is a class of young people with special needs who require help on a daily basis. The young people have multiple mentally and physical disabilities, which makes it impossible for them to complete a normal youth education. Therefore they are to be educated according to their individual potential. To understand and enhance their potential it is important to give them a greater independence throughout their everyday activities[51].

In order to describe what the pupils' needs consists of it might be helpful to define some of their disabilities. Some pupils cannot speak, but they are able to communicate with the use of other senses. Technology is a immense help - herein: speech machines, IT, smartboards and special developed digital books. These are called AAC (Augmentative & alternative communication) and ICT (Information and communication technologies). Furthermore it is important that the professionals around them understand their everyday physical and verbal signs. There are plenty of various technologies connected to the pupils' special needs both with smaller and greater influence. Those who have a physical disability require wheelchairs, there are cases where a wheelchair in itself isn't enough and one from the staff has to move the pupils around in the building. Not being able to move on your own can increase stress levels and result in depression and nervousness. Therefore it is important to place technology and switches in the right heights and places to improve the individual pupils' independence. Since the pupils have physical disabilities, they often have less resistance to outer conditions like airspeed and change in temperature. The various disabilities cause lack on social competencies and restricts each individual in general. It is hard for them to seek contact with other people and appear independent in the various challenges, that occurs during an everyday – this means it is hard for them to manage and control their own lives[52].

Infantile Autism

Infantile autism is a serious genetic disease, which affects the ability to interact with the world and its surroundings[53]. Infantile Autistic people are severely cognitive handicapped and can have a fragmented language[54]. The disease affects the concentration and the ability to attain a high level of information. It is very important for the scholars with this disability to have the right stimulation besides their schoolwork to learn, this means screening from the surroundings and a very structured day with precise information is necessary. They do not lack the ability to concentrate; it is rather that their brains focus too much on small things around them and easily take their minds away from the school work[55].

It is important to create a safety zone among equals and document everything that goes on in the scholar's lives both outside and inside the classroom[56]. This helps the scholar to recollect what they have learned and how they have evolved throughout their education. It is essential to encourage social interaction because people with autism have a tendency to feel lonely and depressed about not being able to connect with other people even though they want to[57].

Many people with autism suffer from comorbid diseases like Downs-syndrome, ADHD, and OCD[58]. They often have a ten-

Ill. 33 Wheelchair

dency to easily feel depressed, stressed and anxious about the world they live in[59].

Mentally restrained

The scholars in Group U suffer from a high amount of learning disabilities, which means that they evolve and learn slowly and have a hard time adapting to social situations. The scholar's languages skills are often prohibited and their motor skills are reduced. They usually suffer from illnesses such as Down-syndrome, which affect their IQ drastically[60].

In Group U there is a strong focus upon independence and social interaction to create as normal an environment as possible. They are often suffering from low self-esteem and anxiety due to their disability. They want to do and be like everybody else but at times unsuccessful, which is highly depressing [61].

Socio-Emotionelle

People suffering from Socio-Emotionel disabilities often lack self-control, show bad behavior and lack social skills. Their disabilities are usually a product of their home environment. They have throughout their lives experienced an unstructured upbringing[62]. This means they have not developed ordinary social skills and shows signs of ADHD behavior in a learning situation[63]. They often suffer from low self-esteem and self-worth which affect their learning ability. It is important for them to develop their social skills and give them a calm environment which feels safe and stable[64].

Physical Handicapped

People with physical handicaps often have difficulties adapting to their situation especially if it isn't a birth defect. They tend to have low self-worth and low confidence which makes them feel odd worthy when around people their own age who have no disabilities. This leads to them being on their own and feeling lonely and depressed. It is important that they are around equals to able them to gain confidence and learn to adapt to society[65].

Ill. 34 Present individual workstation

ADHD

The scholar from Group D suffers from Attention Deficit/Hyperactivity Disorder (ADHD), which affects their concentration ability drastically. They often have a hard time relaxing and might also have learning disabilities[66]. It can also affect their motor skills and they have a hard time participating in a normal learning situation due to restlessness[67]. It is important that the scholars are stimulated in a calm environment to able them to concentrate without getting inattentive[68]. People suffering from ADHD often have difficulties interacting socially and adapting to their environment which makes them feel distressed and leads to anxiety and depression. It is common that people with ADHD also suffers from Obsessive Compulsive Disorder (OCD)[69]. It is essential to learn and interact with equals but also to encourage interaction with others[70].

Late developed young people

Group E is a group of young people who have difficulties following a normal education. They are late developed and have a hard time learning and understanding ordinary schoolwork, which means they need more time and more individual attention to learn what they need to properly function in the everyday life. Their education has a strong focus upon increasing the scholars self-worth and giving them confidence to move from being a child into adulthood[71].

Quiet young people

Group Q is for young people, who require more self-worth and confidence to able, them to structure and complete a normal youth education. They often suffer from Obsessive Compulsive Disorder (OCD) or Aspergers Syndrome. Aspergers Syndrome is within the Autism Spectrum but is a very mild form of autism. They can have a hard time concentrating and often have cormorbid diseases like mild ADHD[72]. They have trouble interacting with other people, not because of a lack of interest but due to a lack of empathy for other people[73]. Their lack of social skills usually means they have hard time fitting in and gets rejected by people their own age. This leads to nervousness, stress and depression when in social situations[74]. The same goes for people with OCD they also have mental diseases such as anxiety and depression[75] and there can be a connection between OCD and ADHD[76]. Their anxiety is due to the fact that their minds create images which they cannot control. These images lead to forced actions[77].

Generally

All of the scholars meet at school at 9 AM and leaves again at 3 PM. While they are there they all follow an individual education-plan made especially for them to accommodate their special interest, needs and wants. In the morning they meet up in their groups and get divided out from there to go and do their schoolwork. They generally work at their individual work stations or in their group rooms in the morning and do practical subjects or receive class lessons in the afternoon.

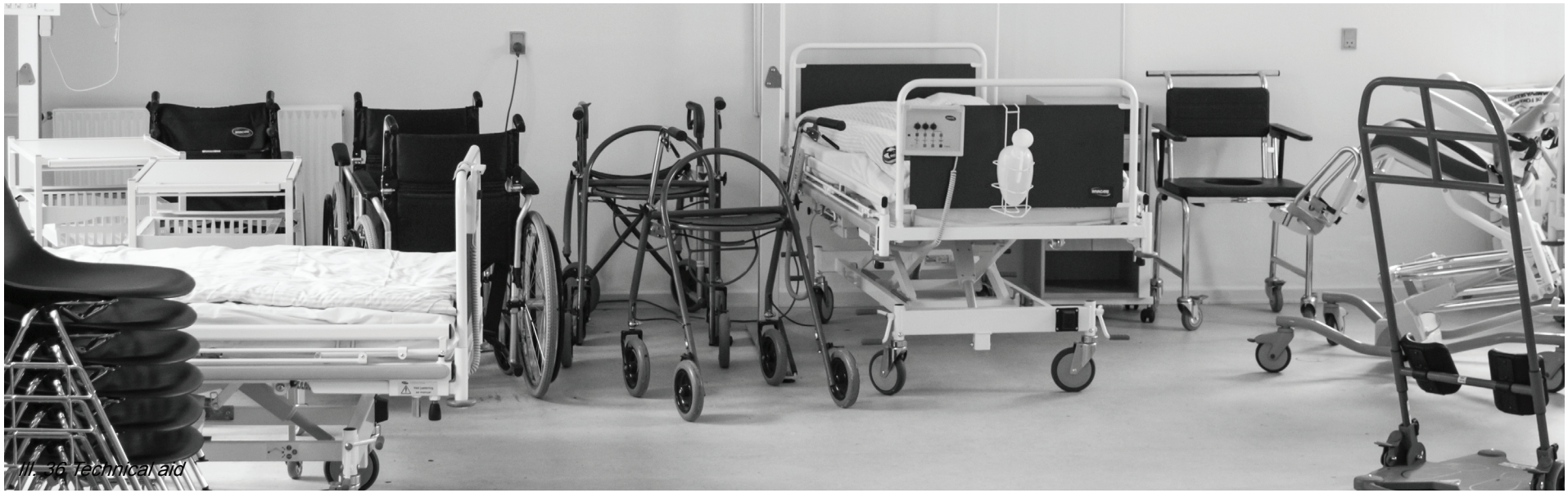
Ill. 35 Present facilities

Conclusion

The scholars of the VUK-institution suffer from a wide range of different disabilities, which means they have very different learning situations and requires different working environments. Even so are there a lot of the group's requirements, which are common.

This allows for a lot of social interaction within and between the groups and common facilities can be made, which can be suited for all. One of the most important factors which are common for all the groups is that they suffer from comorbid mental illnesses such as anxiety, stress and depression. It can in general be difficult to have a handicap both mentally and physically – it can make you feel a strained and ill fitted for your environment. They all have had a hard time growing up and haven't experienced a lot of success.

This means they are in strong need of a calm and safe environment which can reduce their stress levels and help them feel better. There is also a need to consider the physical requirements for a building which has to adapt for everyone with physical handicaps.



Ill. 36 Technical aid

Physical requirements

It is important that the scholar don't feel a strained when suffering from a physical disability. It is therefore essential that the physical environment is adapt to all and can be accessed by all.

Universal Design

The design concept "Universal Design" works to ensure that positive actions are made to able people with all sorts of different disabilities to enjoy buildings on equal terms as well as people without handicaps. It is important to consider what can be done with Passive Solutions – the arrangement of the building design without technical installations and add on equipment.

Technical equipment

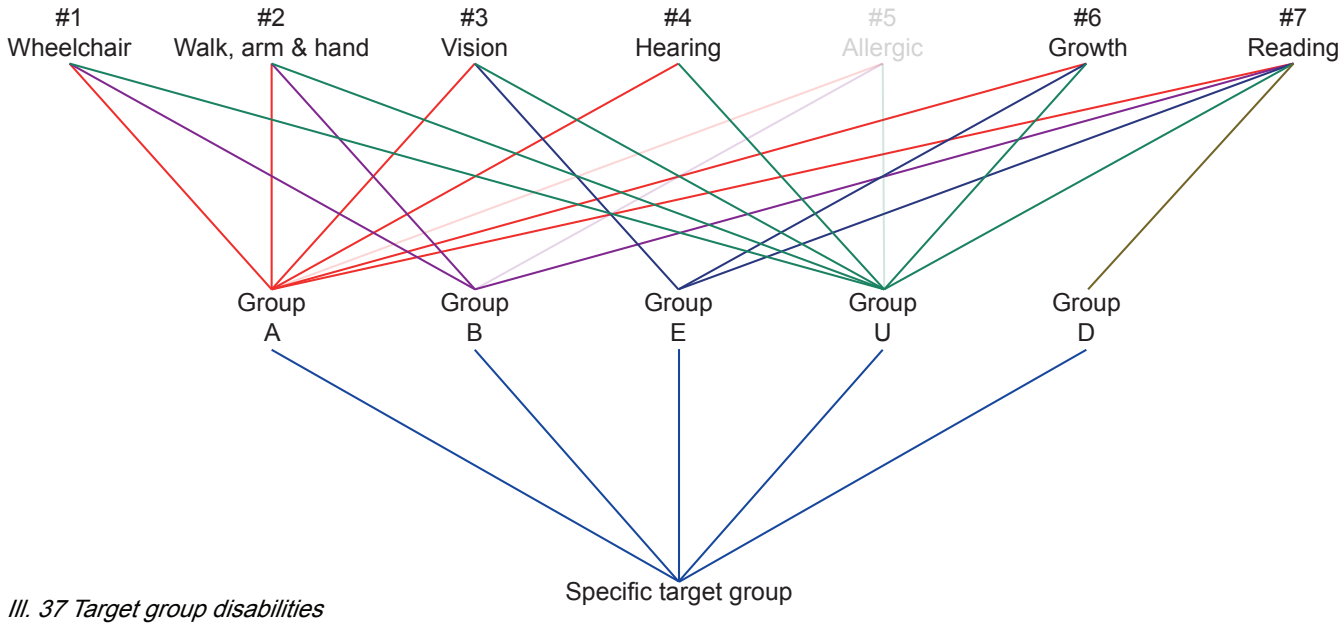
In specific learning situations some of the scholars are in need of technical installations and equipment which should be taken into consideration in the design process and in general the organization of the building.

Matrix

To outline what can be done to create a design which is flexible and can be suited for all of the scholars. The actions recommended by The Danish Handicap Organization and the specific need and wants the scholars have are investigated. This is done to create an overview of how to arrange the building.

Conclusion

Many of the procedures which can assist a certain group is either, also good for others or it does not conflict with others needs. Some of the actions are though a hazard to others and has to be taken into consideration and a compromise must be made. The most important result from this investigation is that many of the technical installations are concentrated on the specific groups learning situation and can therefore be installed at the workstations and taken down again and moved if in need of swapping seats or rooms. It makes it possible to create a more flexible solution which is adapted to the concept of "Universal Design". This able to create a building where all rooms are adapt to all of the scholars. Even so are there different learning situations for each of the different groups of scholars which the interior design has to be adapting for.



Ill. 37 Target group disabilities

Groups	Multi hand.	Infantile autism	Phys. & ment.	ADHD	Socio emot.	Physical	Late devel.	Conclusion
Tactility change in floor	÷	÷	÷			÷		Leading lines are good for vision restrained people but they might be an issue for wheelchair users, or people with muscle reduction in the legs. Contrasts could be an solution for path finding.
Contrast colors	√	√	√	÷		√		Lots of colors can be a way to navigate in the building, and they provide a lot of mental energy, but this will overstimulate scolars suffering from ADHD. *
Contrast materials	√	√	√			√		Contrast materials can be good for navigating in a building, but too great tactility will make the cleaning harder in terms of greater and smaller surfaces.
Contrast light	√	√	√			√		Contrast light is good for visual or hearing restrained because contrasts makes the face more readable, but in transit areas where movement is dominant, the change in light direction will disturb concentration.
Short distances	√	√	√			√		Short distances is good for the physical restrained, who have muscle restrictions or sits in a wheelchair.
Railings	√	√	√			√		Railings is an initiative for the physical restrained, but can also be used as leading lines and navigation in the building.
Resting areas	√	√	√			√		Resting areas are good when the distances between functions become too great. Furthermore resting areas can be used for social interaction areas.
Entrance close to parking	√	√	√			√		To create the entrance close to the parking helps the physical restrained people, because the distance to travel becomes shorter. It can furthermore help the morning delivery rush.
Accessibility in general and in terms of inventory	√	√	√	√	√	√	√	Accessibility is good for the ones in wheelchairs and the ones with muscle restraints, since even surfaces and broad doors will enhance the experience in a wheelchair. Placing the contacts in the right height both for wheelchair users and users without a physical restraint is also important.
Good and simple visual orientation	√	√	√	√	√	√	√	good visual navigation will give an experience of a calmer and better movement. *
Written information	√	√	√	√	√	√	√	To have written information will provide general information to a wide spread group of users. But as some groups can't read, more solutions should be available.
Sound information	√	√	√	√	√	√	√	Sound information is effective to reach those who can't read, but for those who can't both hear and see might need tactile writings.
Good acoustics	√	√	√	√	√	√	√	Good acoustics is positive for those who have a hearing handicap. And to organize the sounds good acoustics is a great initiative. Furthermore is sound something that stimulates the ear, and can therefore be a problem to the group with ADHD if the sounds are uncontrolled and wild. *
Good ventilation	√	√	√	√	√	√	√	As some of the scholars can't control their own wheelchair they are more vulnerable to outer conditions and good ventilation is necessary. Here are especially the multihandicapped and the physical handicapped exposed. But fresh air and open windows furthermore stimulates the individual in a positive way.
Minimum change	√	√	÷	÷	÷	÷	÷	To make minimum changes is good for the multihandicapped and the autists. This because a little change in their everyday will provoke worse learning and make a more insecure environment for them. But the other groups will benefit from changes, as changes stimulate new thought and ideas to the individual.
Flexible facilities	√	√	√	√	√	√	√	Flexibility is a positive intiative for everyone because they have the opportunity to vary the size of the groups, and fit as the group acts best possible. This means they can be rather static or ever changing.
Social conductive surroundings	√	÷	√	√	√	√	√	The group with infantile autism has a hard time communicating and interacting with the other groups but they should still be encouraged to interact with others.
Stimuli	√	√	√	÷	√	√	√	All groups have great benefits of getting stimulated in the right way. The stimuli can be made in quiet ways; such it will not provoke the energy level but still will create secure environments that affect the motivation of learning. *
Screening	√	√			√			The people suffering from autism, multiple handicap and ADHD are the ones who need most screening from each other. These screens are not in need to be permanent but should rather be movable to ensure flexibility.

* contrast colors[78], * Good and simple navigation[79], * Good acoustics[80], Stimuli[81].

Ill. 38 Matrix

Psychological requirements

To get a high level of psychological comfort the mental requirement of the scholars are taken into consideration to create a good and safe social environment.

Social interaction

The scholars all need to be encouraged to partake in social interaction among the other scholars both in and outside their own group. This will help them to create a stronger self-worth and to develop into adulthood.

Equality

To create a safe environment which affects the scholars learning ability positively, it is important to create an environment where they can feel like they are among equals.

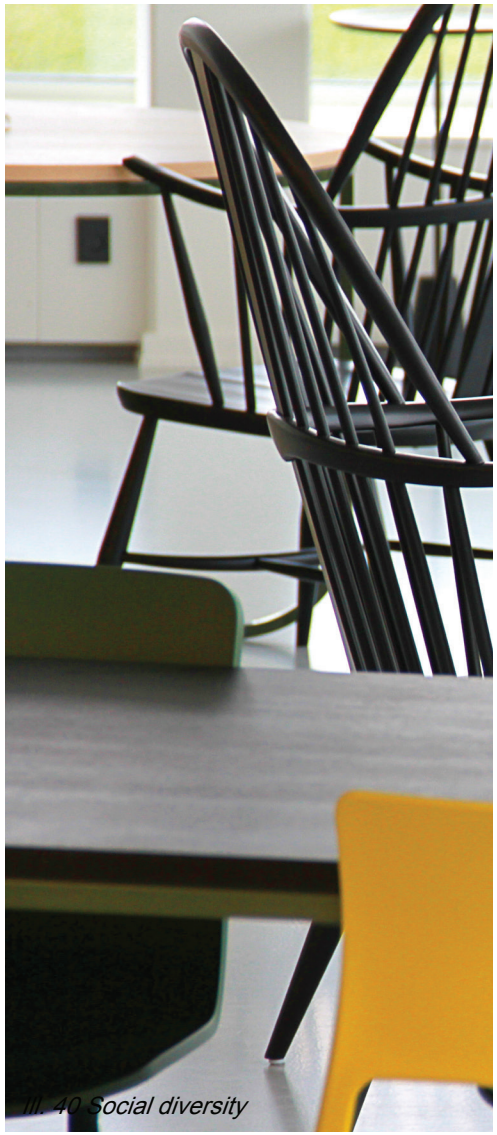
Calm environment

It is essential to create the best learning environment for the scholars where they feel safe and calm. To create a calm environment there has been drawn inspiration from a design concept for hospitals “Helende Arkitektur”[82] as a general guideline and casestudy. The reason for this specific case is that it takes account for many of the mental affections the environment can provide when people are at the hospital which is a similar effect for the scholars at VUK suffering from many different illnesses.

Conclusion

It is important to create spaces that encourages social interaction to enhance the individuals social skills. This must be done with a focus on equality since everybody needs good conditions to interact. A calm environment further enhances the motivation to interact and learn because such environment makes one feel safe.

Ill. 3: Social environment



Ill. 40 Social diversity

Ill. 41 Calm environment

Ill. 42 Calm environment

Ill. 43 Calm environment

Healing architecture

”Helende Arkitektur” is a design concept which revolves around that a building can be planned and designed to decreases stress and anxiety and therefore increase comfort and enjoyment[83]. This can be done by considering seven different aspects of architectur when designing a new building; Light, Art, Acoustics, Air, Personal Space, Social Space, Outdoor Space and Navigation. The different categories are subdivided into what proceedings should be done in the building design and how it affects the people using the building[84]. The schemes gives an overview of the effects each category has on the mental health.

Ill. 44 Environment

Light

Light is an important factor when designing a building. Rooms with good light conditions are strongly connected to the well-being of the people using the room. Having a window towards east can reduce the possibility of depression[85].

Physical arrangement	Factor	Psychological implications	
Placement	Light	Stress	Communication
disposition	Art	Depression	Privacy
Plan solution	Acoustics	Satisfaction	Comfort
Interior design	Air	Mood / Joy	Control
Materials	Personal space	Orientation	Togetherness
Technical installations	Social space	Calm	Security
	Outdoor space	Distraction	Grieve
	Navigation	Anxiety	Concentration

Ill. 45 Light diagram

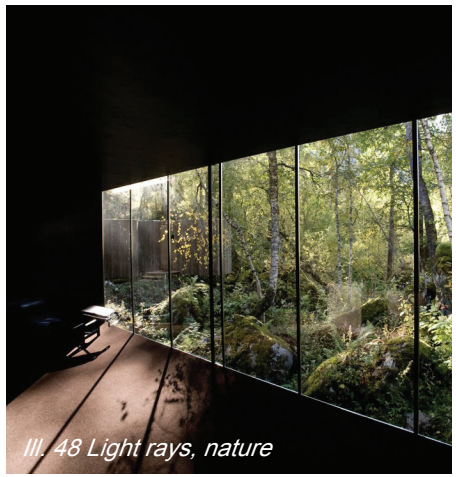
Acoustics

Buildings with good acoustics have a better effect on humans than a building with a high level of noise. The best way to make people feel calm and safe is to minimize noise from technical installation which can seem stressful and constant[86].

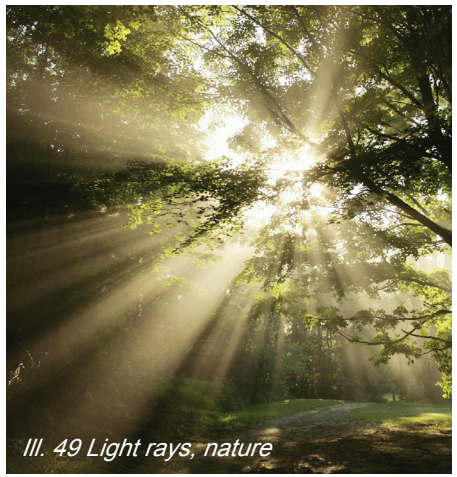
Physical arrangement	Factor	Psychological implications	
Placement	Light	Stress	Communication
disposition	Art	Depression	Privacy
Plan solution	Acoustics	Satisfaction	Comfort
Interior design	Air	Mood / Joy	Control
Materials	Personal space	Orientation	Togetherness
Technical installations	Social space	Calm	Security
	Outdoor space	Distraction	Grieve
	Navigation	Anxiety	Concentration

Ill. 46 Acoustic diagram

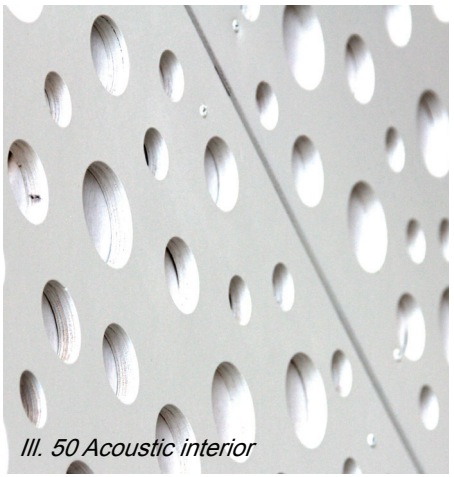
Ill. 47 Light beam



Ill. 48 Light rays, nature



Ill. 49 Light rays, nature



Ill. 50 Acoustic interior

Art

It is not a proven fact that art has a positive effect on humans but it shows that people who experience pictures of landscapes can receive the same stimulation as when looking outside the window framing green surroundings[87].

Physical arrangement	Factor	Psychological implications	
Placement	Light	Stress	Communication
disposition	Art	Depression	Privacy
Plan solution	Acoustics	Satisfaction	Comfort
Interior design	Air	Mood / Joy	Control
Materials	Personal space	Orientation	Togetherness
Technical installations	Social space	Calm	Security
	Outdoor space	Distraction	Grieve
	Navigation	Anxiety	Concentration

Ill. 51 Art diagram

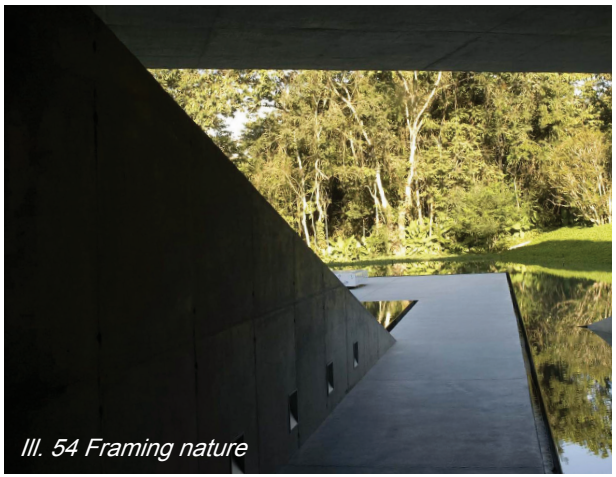
Air

Air and pollution can be a strong stress factor and can be quite damaging to the well-being of the users. It is important to ensure a good indoor environment with minimum pollution, drafts and overheating[88].

Physical arrangement	Factor	Psychological implications	
Placement	Light	Stress	Communication
disposition	Art	Depression	Privacy
Plan solution	Acoustics	Satisfaction	Comfort
Interior design	Air	Mood / Joy	Control
Materials	Personal space	Orientation	Togetherness
Technical installations	Social space	Calm	Security
	Outdoor space	Distraction	Grieve
	Navigation	Anxiety	Concentration

Ill. 52 Air diagram

Ill. 53 Nature art



Ill. 54 Framing nature

Ill. 55 Fresh environment

Personal space

To have the possibility to be on your own is quite significant when it come to well-being. In this specific case, “being on your own” refers to also be ing able to be alone with your family and friends. 80 This is seen in relation to this project as being among equals – a place where you feel safe[89].

Physical arrangement	Factor	Psychological implications	
Placement	Light	Stress	Communication
disposition	Art	Depression	Privacy
Plan solution	Acoustics	Satisfaction	Comfort
Interior design	Air	Mood / Joy	Control
Materials	Personal space	Orientation	Togetherness
Technical installations	Social space	Calm	Security
	Outdoor space	Distraction	Grieve
	Navigation	Anxiety	Concentration

Ill. 56 Personal space diagram

Social space

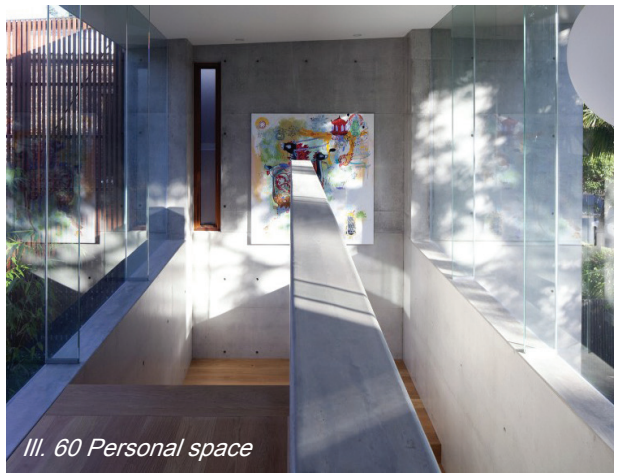
Social interacting can have a highly positive effect on humans. It is important not to become isolated or to feel lonely to prohibit the effect of depression[90].

Physical arrangement	Factor	Psychological implications	
Placement	Light	Stress	Communication
disposition	Art	Depression	Privacy
Plan solution	Acoustics	Satisfaction	Comfort
Interior design	Air	Mood / Joy	Control
Materials	Personal space	Orientation	Togetherness
Technical installations	Social space	Calm	Security
	Outdoor space	Distraction	Grieve
	Navigation	Anxiety	Concentration

Ill. 57 Social space diagram

Ill. 58 Personal space

Ill. 59 Social space



Ill. 60 Personal space

Outdoor space

Being in nature and having green surrounding have a strong positive effect on us as humans. It is important to have a view towards something green which gives perspective and reveals a landscape. It can also have a distressing effect and encourage social interaction[91].

Physical arrangement	Factor	Psychological implications	
Placement	Light	Stress	Communication
disposition	Art	Depression	Privacy
Plan solution	Acoustics	Satisfaction	Comfort
Interior design	Air	Mood / Joy	Control
Materials	Personal space	Orientation	Togetherness
Technical installations	Social space	Calm	Security
	Outdoor space	Distraction	Grieve
	Navigation	Anxiety	Concentration

Ill. 61 Outdoor space diagram

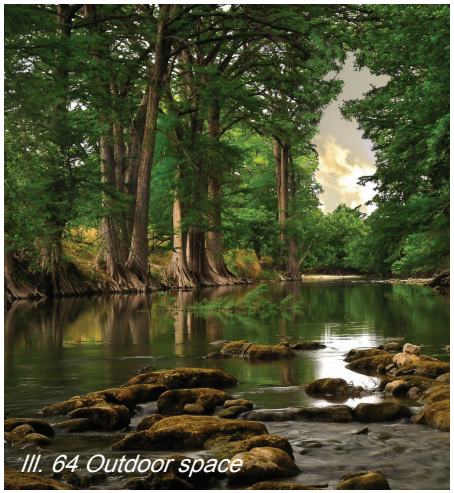
Navigation

Navigating around in a building has a strong effect on the people using the premises. It is better to make a simple plan solution rather than plastering everything with signs. “Environment and Behavior” has made studies on how to navigate buildings. The result suggests that a plan solution should have as few interconnections as possible – this method is called “Interconnection Density” (ICD)[92]. The investigation showed that having a main access through the building and only breaking it orthogonal was the easiest way-finding system. Working with parallels also made it easier for the users to create an accurate “mental map” of the premises[93]. ”one of the factors presumed to be responsible for the way-finding difficulties people experienced in this particular building is the misalignment of the central part of the circulation system”(Environment and behavior)[94]

Physical arrangement	Factor	Psychological implications	
Placement	Light	Stress	Communication
disposition	Art	Depression	Privacy
Plan solution	Acoustics	Satisfaction	Comfort
Interior design	Air	Mood / Joy	Control
Materials	Personal space	Orientation	Togetherness
Technical installations	Social space	Calm	Security
	Outdoor space	Distraction	Grieve
	Navigation	Anxiety	Concentration

Ill. 62 Navigation diagram

Ill. 63 Tactile w[illegible]



Ill. 64 Outdoor space

Conclusion

These seven parameters are very important to implement when designing a new building which should create a sense of calm and peace. Many of these actions should be included in the design process in the beginning to ensure a holistic atmosphere. Within many of the case studies used to create the material for “Helende Arkitektur” nature or merely a view towards greenery plays a very significant role in creating the calm environment.


Ill. 65 Nature and architecture

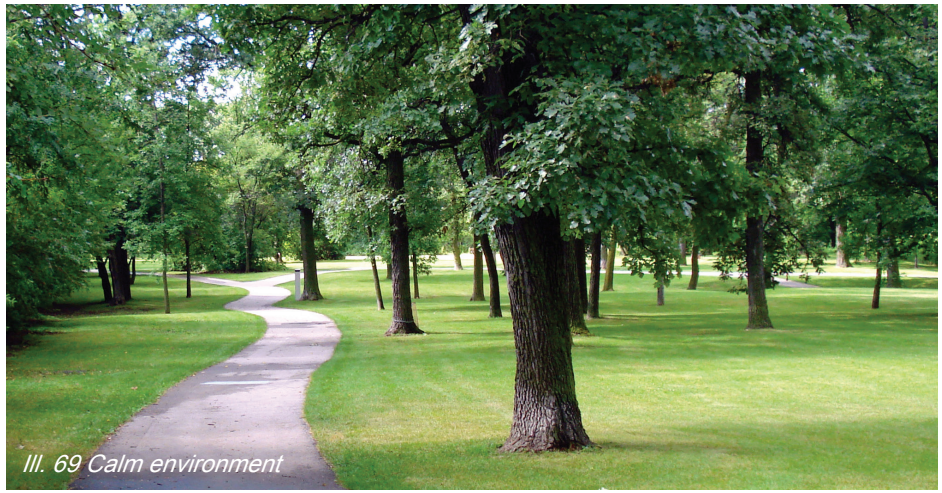

Ill. 66 Nature and architecture


Ill. 68 Light and materials


Ill. 70 Outdoor scene


Ill. 71 Nature and architecture


Ill. 67 Nature and architecture


Ill. 69 Calm environment

Nature

It is commonly known that nature and gardening has a positive effect on humans in general. This concept of healing gardens or garden which can decrease stress or help people who suffer from anxiety has been strongly developed in newer times. This includes the concept of “Sensing Gardens” and Therapy Garden. Being deprived of nature can have a negative effect on our well-being which is why merely a view towards a green landscape can create a positive effect.

View

A view toward nature has a positive impact on our well-being[95]. Being in a city environment which is overpowering the mind with high-speed stimuli from cars or depriving the mind from activating the senses with a view to a concrete back-alley has a negative effect on our well-being[96].

Sensing Gardens

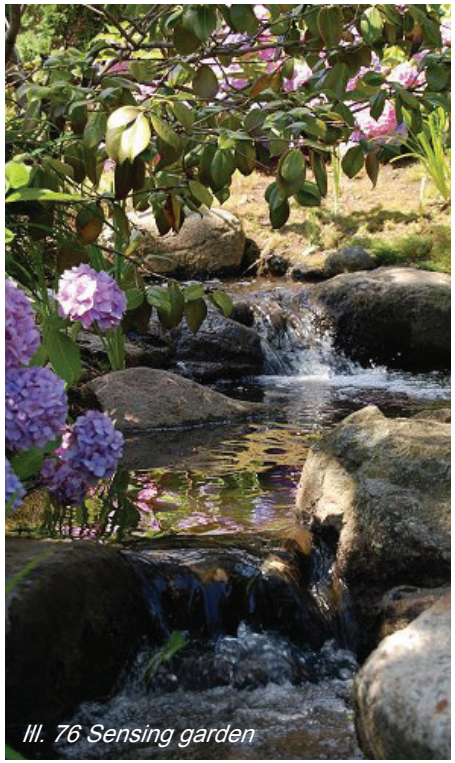
Sensing Gardens are often used to assist people with physical handicaps to able them to experience elements in nature which is difficult to experience when sitting in a wheelchair. It is important when creating such a garden to stimulate all the senses which means to include some of nature’s strongest elements such as; “the forest, a meadow, the beach, mountains, waterfalls and so on”[97].

Ill. 72 Forest

Ill. 73 Mountains

Ill. 74 Waterfall

Ill. 75 Sunset on the beach



Ill. 76 Sensing garden

Ill. 79 Rain and color

Ill. 78 Wind and water

Ill. 77 Light dispersion

Ill. 80 Color, scent and flowers

Conclusion

It is important to both see, touch and experience nature in general, to maintain a high level of well being. The nature has various different instruments and affects the human body in just as many different ways.

Therapy gardens

Nature has a impact on our emotions and creates a sense of calmness which has a positive effect on anxiety, stress and depression. Therapy Gardens was made as a mean to help war veterans in the United States of America.

This concept has developed greatly to assist people with emotional illnesses and people with handicaps in general. Gardening has been measured to have an effect on concentration and the pulls and heart rhythm[98].

The Gardens have a positive effect no matter the mood, which means it is for all people no matter their emotional state of mind. The therapy Gardens are therefore not merely an artistic matter but also a functional matter[99].

The concept for Therapy Gardens is made from urban development where a certain amount of different spaces can tend to different fundamental and emotional needs.

The therapy Gardens have eight different spaces which all have a different effect and include a different activity[100].

The Peaceful Garden

The peaceful Garden is a place for distressing in a calm environment. This space should have no disturbing objects and very few colors which able the mind to shut completely off[101].

The Wild Garden

The Wild Garden is where nature has taken over and developed in its own pace. Everything seems to have grown on its own and each path has been made by small animals passing through[102].

The Living Garden

The Living Garden is where small insects and animals can gather in flowers and bushes. The garden strive to affect us with the ability to watch and feel like a part of the animals circle of life[103].

The thoughtful Garden

The thoughtful Garden is where you let you mind wonder and allow yourself to get lost in between bushes and trees. This Garden should feel endless which allows for a peaceful environment[104].

The Social Garden

The Social Garden is an environment where the activity involves being around other people.

This garden is where you sit and enjoy food or something to drink whilst talking or watching green surroundings[105].

The Playful Garden

The playful Garden is a place for growing and tending to plants. In this garden you can enjoy watching things grow and being creative with the gardening[106].

The Space for entertainment

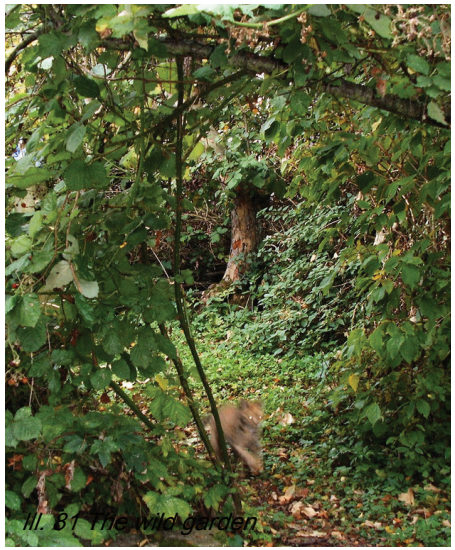
This space is for enjoying social activities as playing ball or climbing in tress. The Space for entertainment is a more high-speed area than the rest of the seven gardens[107].

The Cultural Garden

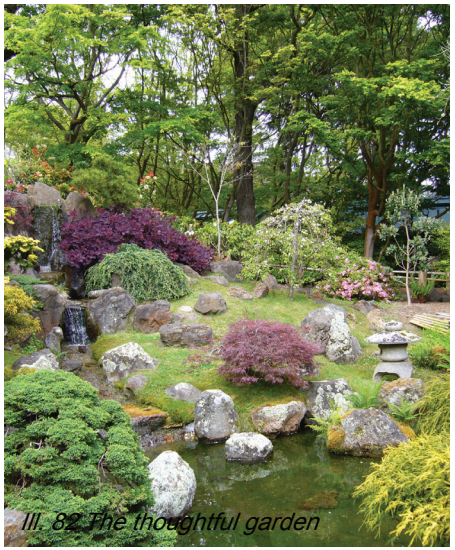
The cultural garden is a calm space, where artifacts and systematic gardening is visible. This garden is made as historical planning of urban spaces with water fountains and small pounds and so on[108].

Conclusion

The nature consists of various elements. Each element has its own positive effect to the human being, and these eight gardens stimulates the human body in each different way.

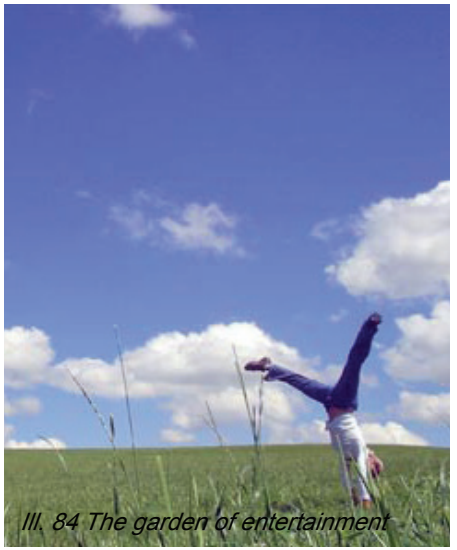


Ill. 81 The wild garden



Ill. 82 The thoughtful garden

Ill. 83 The playing garden



Ill. 84 The garden of entertainment

Ill. 85 The living garden

Ill. 86 The social garden

Ill. 87 The cultural garden

Ill. 88 The peaceful garden

Nordic architecture

”Public architecture in Nordic countries is characterized by reflecting the fundamental values of Nordic society: architecture must be inviting, democratic, humanized and organized around a sense of community”[109](New Nordic).

In the Nordic countries there is a tendency for the architecture to have a strong reference to the norm of the society in which it is situated. The architecture is reflecting the socialistic societies of the north where public architecture in general have a modest design which is logically constructed with a use of local materials[110].

The buildings in the Nordic countries celebrate local craftsmanship and the Nordic sky and its ever changing moods. It is about connecting to the context in which it is built and enhances the traditions. The architecture is simplistic but has a thorough understanding of how the sun moves and the season’s changes and adapts to the naturalistic colors of the material[111].

“One must know that the simpler a form or a composition is in its expression, the easier it is to understand and the stronger its effect on us”[112] (Nordic Architecture).

Ill. 89 Uniform housing

Ill. 90 Uniform housing

Ill. 91 Nordic architecture

Ill. 92 Nordic architecture

Ill. 93 Nordic architecture

Ill. 94 Framing nature

Conclusion

Nordic architecture has the tradition to reflect the society by using local and good materials. The nature is used in nordic architecture to visualize the four seasons by its different expressions and feelings.

Ill. 95 Nordic architecture

Ill. 95 Calm environment

Conclusion

In this analysis the target group has been a point of departure to ensure a new building would adapt to their wants and needs. The general outcome and notion to investigate about this variety of people is that they have had a life which mainly has been focused upon what they can't do and how they are different to others. This project wants to create an environment which reflects on what they can do instead of what they can't. The focus has therefore been to investigate what the architecture could do to inflect a positive atmosphere. Looking at the design concept for hospitals it has become clear that many small and subtle things can be done in the design process to create a calm and safe environment. It comes across that the outdoor surrounds plays a significant role in creating an environment which adapts too many different states of mind which corresponds to a flexibility needed for a target group as diverse as the one for this project. The target group has various needs and requirements, some sits in a wheelchair, while others are having trouble concentrating and learning. The physical disabilities are important to notice, since a wheelchair must be able to turn and get through walkways.

When looking at what the students need for their education most of their materials are based upon their desktop, which means there are no further requirements to the architecture. Nature has a positive effect on the human body, and can be a way to create an environment that is able to stimulate every group of people in a different way. Because nature has many elements to use, it is possible to create different scenes of nature, that aims for a specific target group. The nature can be drawn up by nordic architecture that reflects the society around the building. Nordic architecture uses nature to create a calm experience of the use of materials and views.

Nordic architecture and nature two parameters that can be combined into a major concept, to create a diverse calm and safe environment, that can stimulate each individual in the right way and at the same time draw inspiration from the context to create holistic architecture.

Ill. 96 Nature and architecture

Design parameters

- Healing Architecture (7-categories)
- Use nature to catalyse well being
- Nordic architecture
- Logical composition (ICD)
- Universal Design
- Connection between function, con struction and aesthetics
- Social and environmental sustainability
- Logic in construction
- Promote well being
-Promote learning
- Draw inspiration from the target group and the society in the context
- Create a community despite differences
- Safe environment
- Good lighting according to function
- Flexibility
- Architecture for all the senses
- Logic infrastructure
- Contrast colors
- fulfill BR2020
- Create renewable energy that relates to the architecture
- Use category A as a guideline towards creating a good indoor environment

Vision

The vision of the project is to make a facility that focuses on equality. Since the disabilities are of great variety it is not possible to creating the best for all, but to make an accessible school for all kind of individuals. These initiatives should be done with inspiration in “Universal Design” to minimize the use of non-relevant technology. This goes for the environmental sustainability too. Passive means are preferred to minimize the use of developing active solutions. It is further more a vision to make the great diversity meet and create a special society within the given frames, and give each individual the opportunity to act and interact as the needs are. These frames should provide the motivation to interact and learn about an independent life. It is further more significant to draw inspiration from relevant theories revolving around creating an environment which is calm and peaceful to ensure the well-being of the occupants. Here in inspiration from gardening, nordic architecture and healing architecture is drawn.

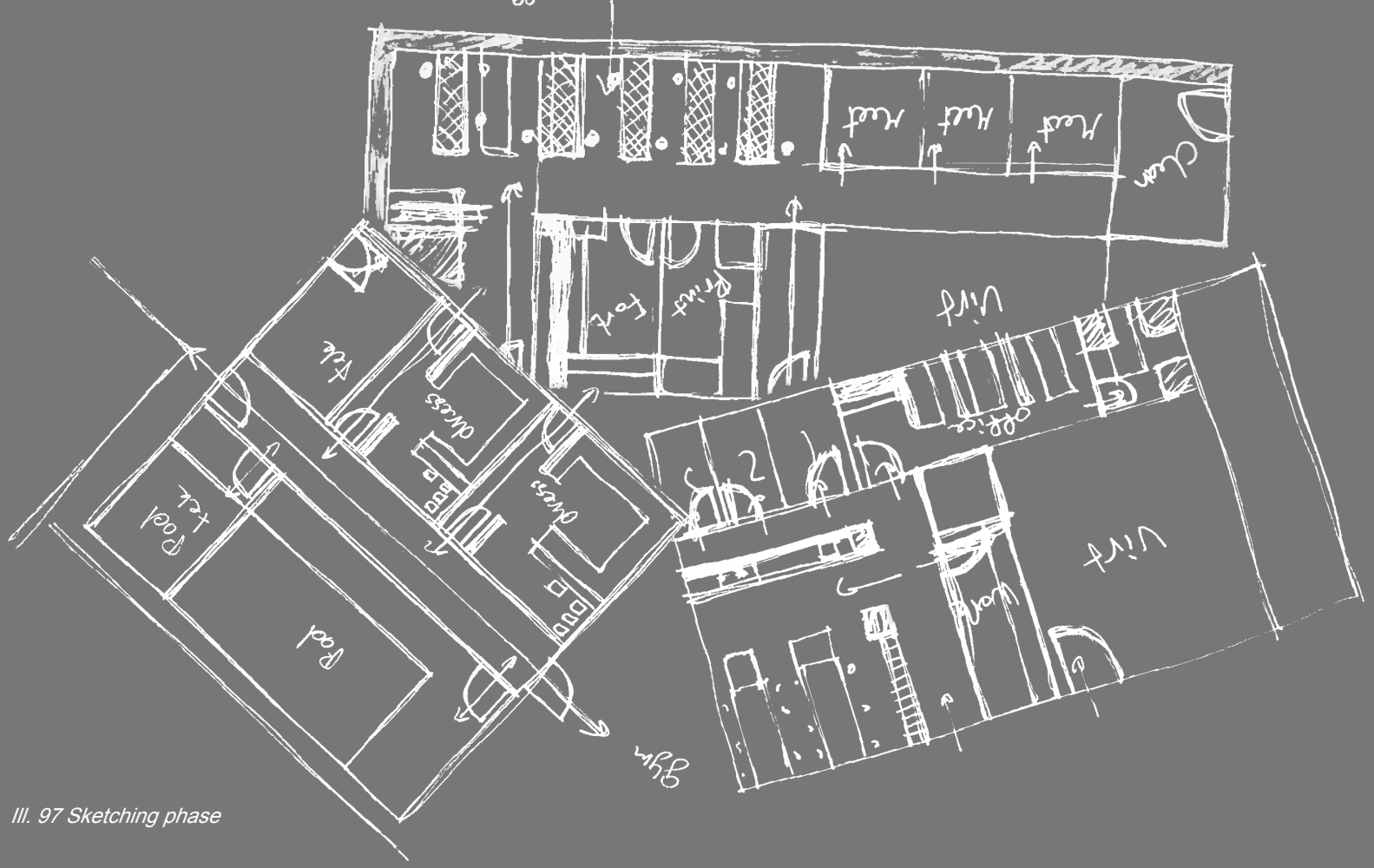
Process

The concept for this project is to create a complex which can affect the senses positively. It should offer a calm and distressing environment with views to naturalistic surroundings. It should have a simplistic expression with strong relation to its context as well as a simple floor plan which should be able to both gather and spread out the scholars to accommodate the target group's great diversity. It is therefore important to create small entities which act as safety zones for the scholars where they can learn and interact. It is of equal significance to make sure the scholars are encouraged to interact and gather all at ones. This means there is a need for a public central core where the scholars can meet purposely but also unannounced to give them an opportunity to attain new social bonds. It is significant not to exclude anybody no matter their physical requirements this means creating a flexible arrangement which is adapt to change but also makes it possible for the scholars to move freely around within the whole complex.

Reading guide

The process is divided into five different themes "Aesthetics, Experience and Concept", "Function", "Light and Energy", "Over temperatures and Energy". This has been done to create an overview of the process and how the design has developed. The process has not been a linear process but has been iterative and in correspondence to the "Integrated Design Process". This means going back and forth between all the phases and themes.
The diagram shows how the process is presented in the project. Furthermore should it create an overview of how the process has worked to optimize the building going back and forth in-between the themes and the five phases from the "Integrated Design Process".

Contents



Ill. 97 Sketching phase

Ill. 98 Reading guide

Function - iteration 1

This section illustrates the process to achieve a high functionality. The process has a connection to all of the other steps in this overall process description. This part of the process illustrates mostly what initiative there have been made in terms of functional purposes.

Volume Organization

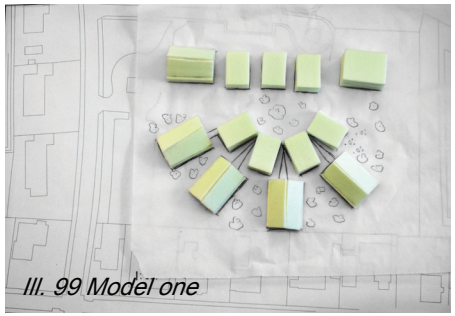
These volume studies were made as an initiative to investigate the rooms and their functions and how they could be situated on site. The main idea was to have a central core surrounded by the practical functions to create a “public” common area. This could enhance spontaneous meetings between the different groups which could encourage more social interaction. The group entities are placed as pavilions at the outer rim of the site for the scholar to have a more private safety zone among equals.

Conclusion

The general outcome when placing the functions around a central core was that the common space in between became too large and the rooms often had oblique angles. The groups placed as small entities or pavilions where too separated from the central core which made them seem unattached. Furthermore were the pavilions either shadowed upon by the practical workshops or by other group pavilions which decreases the possibility for solar gains.

Model one

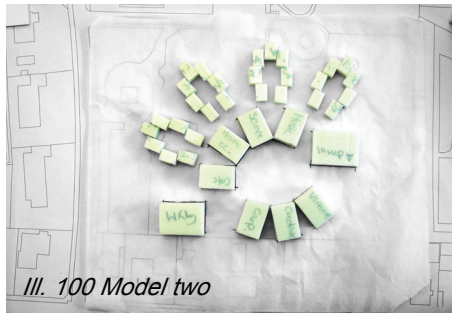
This model shows how the functions were placed around a central core. The common space used too many square meters.



Ill. 99 Model one

Model two

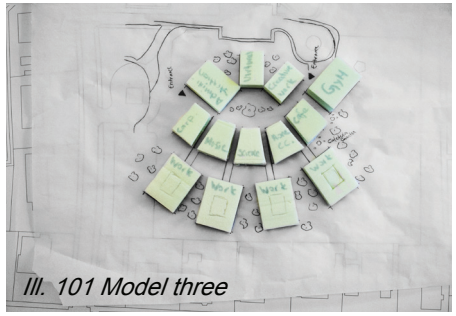
This model explores the concept further and has a circular common area which even further increases the size of the area. The other function takes up to much of the outdoor space since they are separated to ensure the possibility of solar heat gain and to create a correspondence to the building in the context.



Ill. 100 Model two

Model three

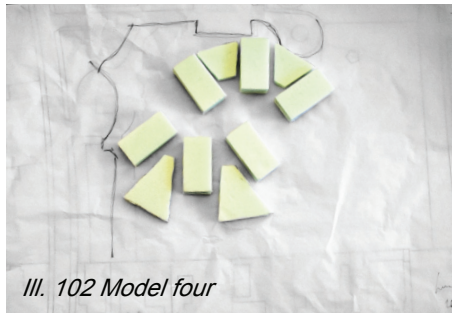
This model decreases the common areas size but still takes up a lot of the outdoor areas due to the fact that the one in between the group are quit exposes, small and have limited amount of solar exposure. A lot of the function are also shadowing from one another which decreases the possibility of solar heat gain.



Ill. 101 Model three

Model Four

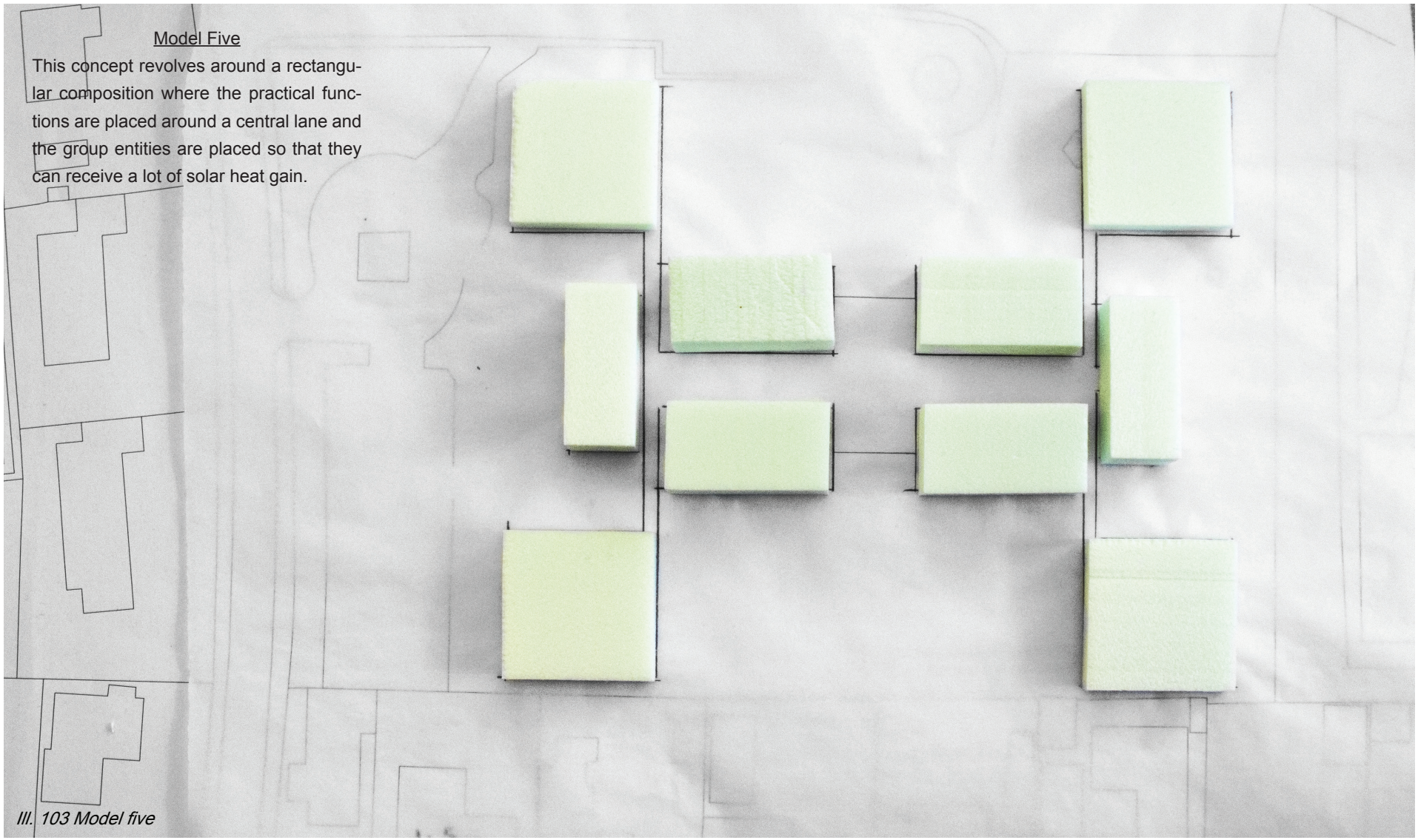
This model explore the concept of a curvy central lane which able the functions to be placed so they do not cast too many shadows on one other. This model does only hold the practical functions due to the fact that the site was not large enough for this concept. With this concept most of the room would have oblique angles which could be very space consuming.



Ill. 102 Model four

Model Five

This concept revolves around a rectangular composition where the practical functions are placed around a central lane and the group entities are placed so that they can receive a lot of solar heat gain.



Ill. 103 Model five

Function - iteration 2

This initial sketch shows a concept where the groups are divided into four pavilions connected to a central lane which is surrounded by the practical workshops. This has been done to secure the groups can have a safety zone where they can be among equals. In each group is there a semi-private area in the middle of the pavilion which is surrounded by the group rooms or rooms for individual workstations and the classrooms. The large lane or walkway in the middle of the whole complex is directly connected to the practical workshop and a social area in the middle; this has been done to create a place which is central and shared by all to encourage social interaction between all of the different groups.

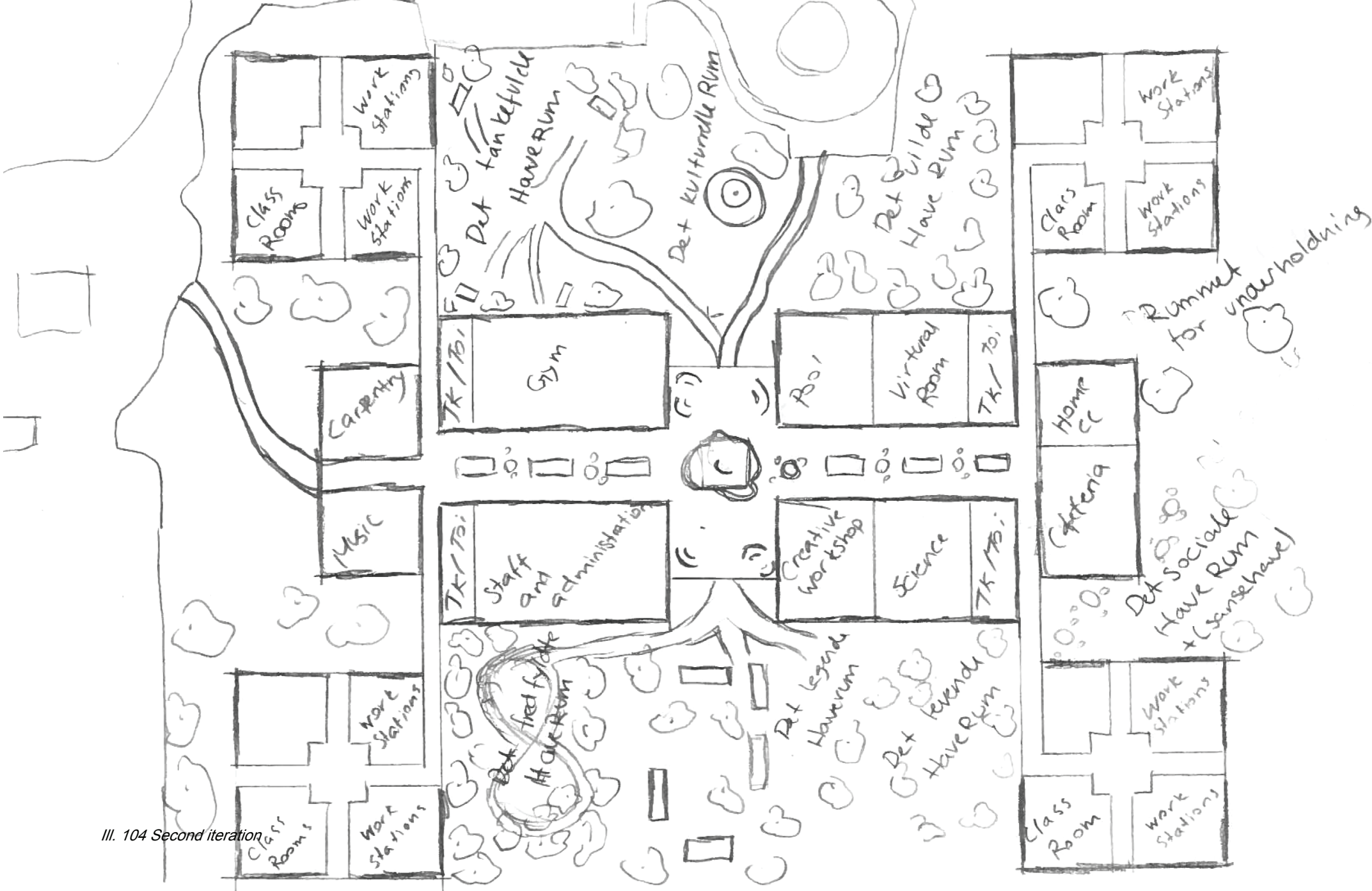
The initial thought was to place the groups with the lowest activity level towards south to make sure they got a lot of solar heat gain. The toilets and technical rooms are placed at each end of the central lane making them easily accessible for the groups as well as the practical workshops. Room such as gymnastic, the pool and the virtual room are placed towards north because it is functions which needs the least or no exposure to sunlight and minimum glare. The cafeteria and Home Economics are placed next to each other so that they benefit from each other's stock facilities. Carpentry and music is placed toward west which able good light and further more is carpentry place at one of the two entrances at the site to able proper stock delivery access.

The Creative Workshop, staff and Science are placed towards south. The staff facilities are therefore able to obtain a lot of solar heat gain and proper daylight and further more is the facilities close to each entrance. The Creative Workshop and Science needs good light too and further more need to be close to a garden where it is possible to grow plants and investigate small animals or insects. This means that the Living Garden and the Playful Garden is placed in connection to the Science facilities. The Social Garden and the Garden for Entertainment is placed in connection to the cafeteria so that these can be enjoyed at recess.

The Cultural Garden is placed at north where the main entrance is situated to create a welcoming entrance with artefacts or fountains. The other gardens are placed in close connection to the groups so they can be accessed easily when in need of a quiet movement.

Conclusion

The walkways from the central lane and towards the groups are not giving an overview of what is coming when moving towards the groups. There are a big number of interconnections when moving through the promises (ICD). There are a lot of undefined spaces within the big central lane and the rooms for the practical workshop are quite deep which could create problems in terms of proper light.



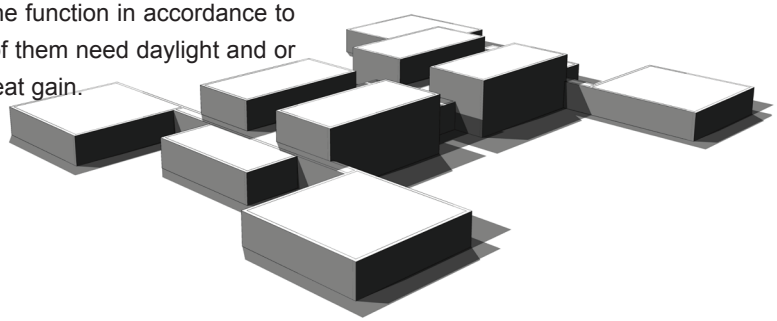
Ill. 104 Second iteration

Shadow studies

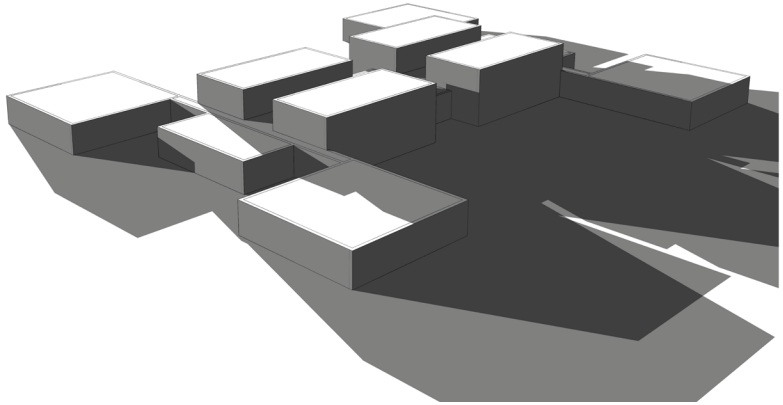
version 1

North-East, summer 1st of July, times 9, 12 & 15

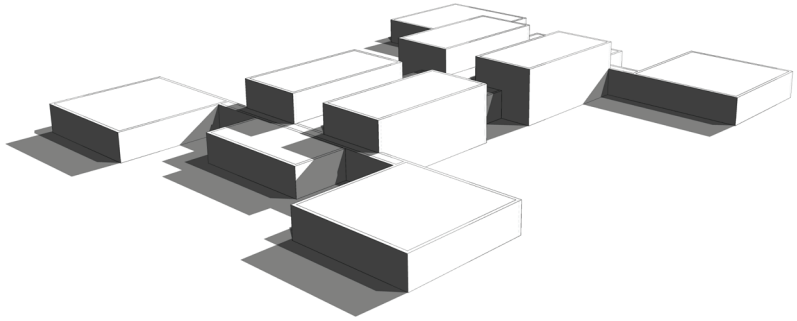
These studies are made as an indicator on where it is possible to archive solar heat gain and where to place the function in accordance to which of them need daylight and or solar heat gain.



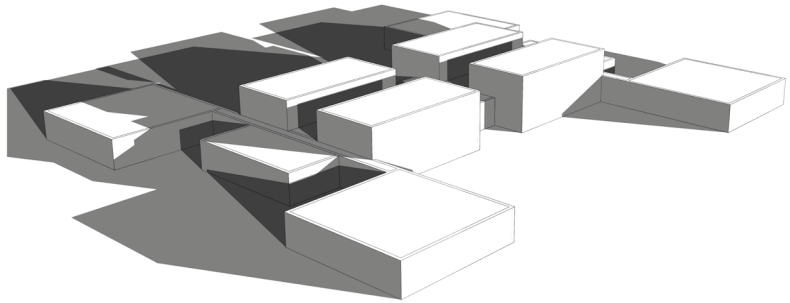
North-East, winter 1st of January, times 12 & 15



South-West, summer 1st of July times 9, 12 & 15



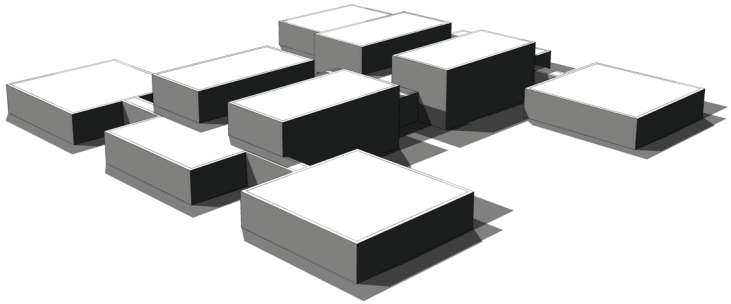
South-West, winter 1st of January times 12 & 15



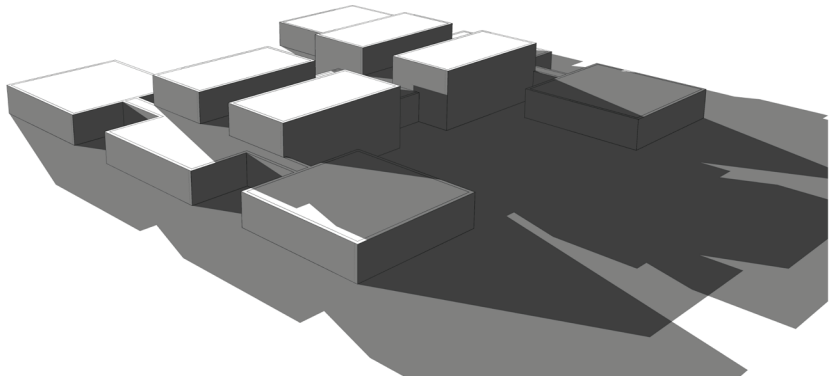
Ill. 105 Lightstudies

version 2

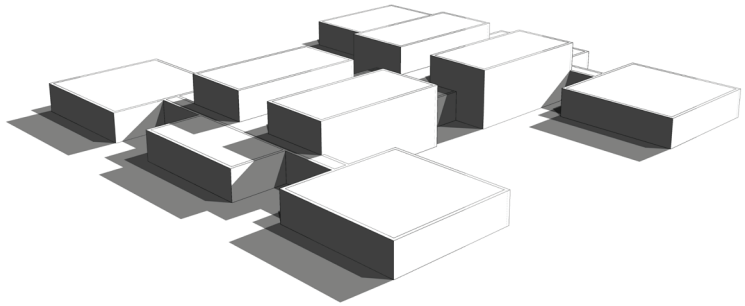
North, summer 1st of July, times 9, 12 & 15



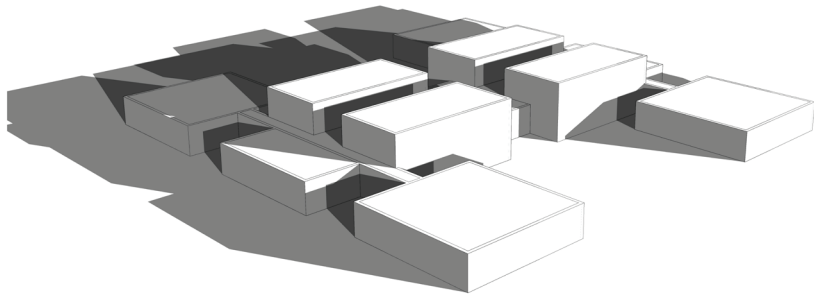
North, winter 1st of January, times 12 & 15



South, summer 1st of July times 9, 12 & 15



South, winter 1st of January times 12 & 15



Ill. 106 Lightstudies

Room requirements

Initially general energy calculations were made for each vital room in the building. The parameters from the rooms are taken from the first sketching phases and an overview of the rooms is to be found in the appendix C. These different calculations give an indication of which rooms require more heat gain. The rooms are different according to people load, people activity and size, which means the requirements, will differ. The solar incidence is most towards south and less towards north. This means the rooms that require the most energy can be placed towards south, or at least have southern windows to contribute to the overall energy frame. The calculations are based upon the sensoric ventilation calculated in appendix B.

Ill. 107 Solar incidence

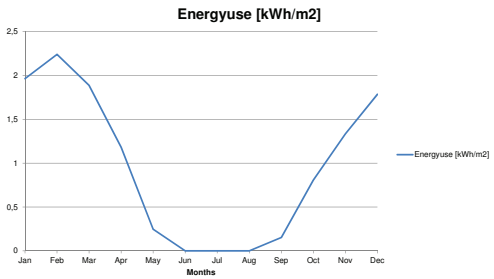
Gymnastics without restraints

The box below shows the geometry of the room without windows.

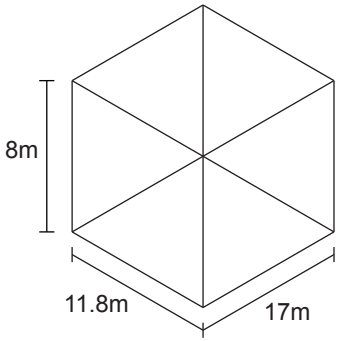
Data

Area	200.6m^2
Persons	15
Schedule	40% hours 9-15
Activity level	2.8 met
Heatgenerating	2.8met • 58W/m^2 • 1.8m^2 = 0.3kW/pers
Ventilation	(3.17l/s•m^2 • 200.6m^2)/1000 = 0.63m^3/s
Summer temp:	19^{o}C
Winter temp:	19^{o}C

Energyuse during a year: 11.6 kWh/m^2



Ill. 108 Energyuse of gymnastics



Ill. 109 Dimensions of gymnastics

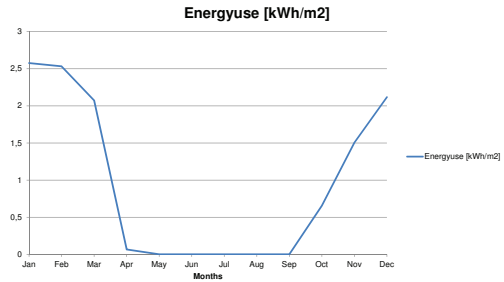
Classroom without restraints

The box below shows the geometry of the room without windows.

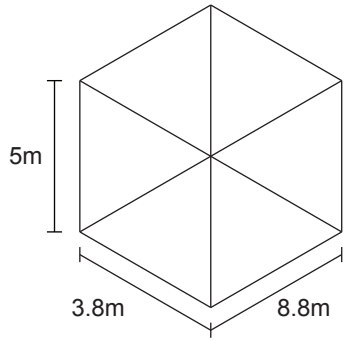
Data

Area	33.4m^2
Persons	10
Schedule	40% hours 9-15
Activity level	1.2 met
Heatgenerating	1.2met • 58W/m^2 • 1.8m^2 = 0.125kW/pers
Ventilation	(4.52l/s •m^2 • 33.4m^2)/1000 = 0.152m^3/s
Summer temp	24^{o}C
Winter temp	22^{o}C

Energyuse during a year: 11.4 kWh/m^2



Ill. 110 Energyuse of classroom



Ill. 111 Dimensions of classroom

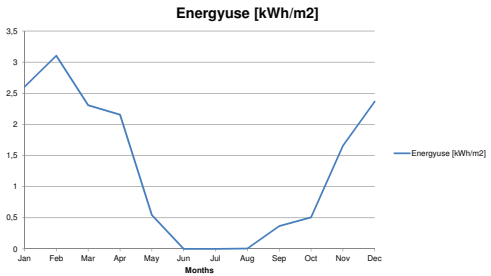
Creative workshop without restraints

The box below shows the geometry of the room without windows.

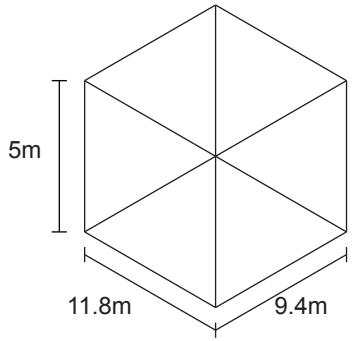
Data

Area	110.9m^2
Persons	10
Schedule	40% hours 9-15
Activity level	2 met
Heatgenerating	2[met] • 58W/m^2 • 1.8m^2 = 0.21kW/pers
Ventilation	(3.17l/s•m^2 • 110.9m^2)/1000 = 0.35m^3/s
Summer temp	20^{o}C
Winter temp	17^{o}C

Energyuse during a year: 15.6 kWh/m^2



Ill. 112 Energyuse of creative workshop



Ill. 113 Dimensions of creative

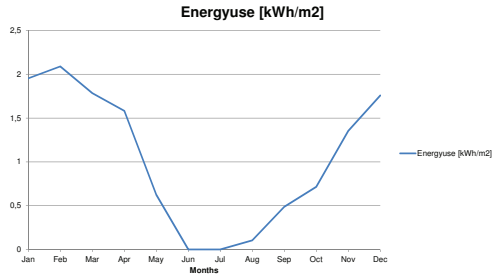
Science without restraints

The box below shows the geometry of the room without windows.

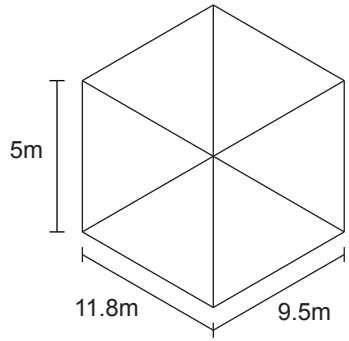
Data

Area	112m^2
Persons	10
Schedule	40% hours 9-15
Activity level	1.6 met
Heatgenerating	1.6[met] • 58W/m^2 • 1.8m^2 = 0,167kW/pers
Ventilation	(2.14l/s•m^2 • 112m^2)/1000 = 0,24m^3/s
Summer temp	22^{o}C
Wintertemp	20^{o}C

Energyuse during a year: 12.4 kWh/m^2



Ill. 114 Energyuse of science



Ill. 115 Dimensions of science

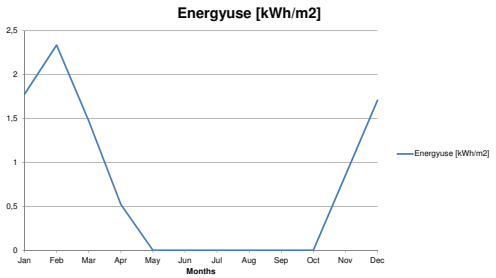
Music witthout restraints

The box below shows the geometry of the room without windows.

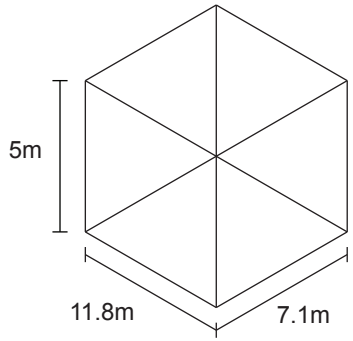
Data

Area	83.7m^2
Persons	10
Schedule	40% hours 9-15
Activity level	2 met
Heatgenerating	2met • 58W/m^2 • 1.8m^2 = 0.21kW/pers
Ventilation	(3.81l/s•m^2 • 83.7m^2)/1000 = 0.32m^3/s
Summer temp	20°C
Winter temp	17°C

Energyuse during a year: 8.7 kWh/m^2



Ill. 116 Energyuse of music



Ill. 117 Dimensions of music

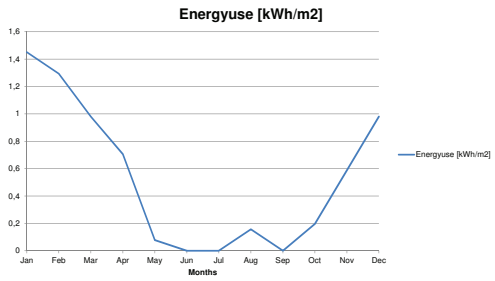
Individual workspace with restraints

The box below shows the geometry of the room without windows.

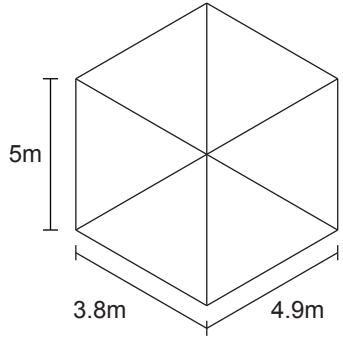
Data

Area	18.6m^2
Persons	4
Schedule	80% hours 9-15
Activity level	1 met
Heatgenerating	1met • 58W/m^2 • 1.8m^2 = 0.1kW/pers
Ventilation	(3.3l/s•m^2 * 18.6m^2)/1000 = 0.152m^3/s
Summer temp	23°C
Winter temp	22°C

Energyuse during a year: 6.4 kWh/m^2



Ill. 118 Energyuse of individual workst.



Ill. 119 Dimensions of individual workst.

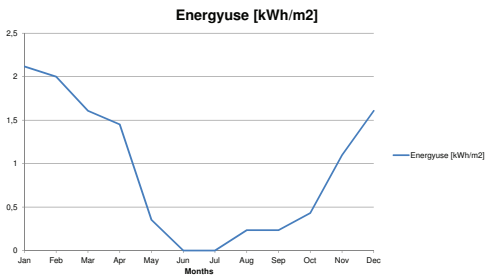
Individual workspace without restraints

The box below shows the geometry of the room without windows.

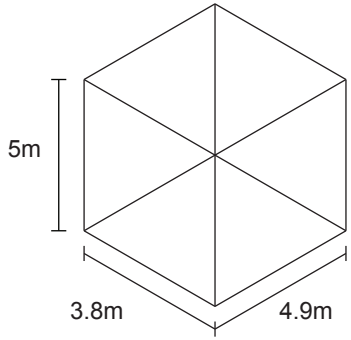
Data

Area:	18.6m^2
Persons:	6
Schedule:	40% hours 9-15
Activity level:	1.2 met
Heatgenerating	1.2met • 58W/m^2 * 1.8m^2 = 0.125kW/pers
Ventilation	(5.0l/s•m^2 * 18.6m^2)/1000 = 0.152m^3/s
Summer temp	24°C
Winter temp	22°C

Energyuse during a year: 11.1 kWh/m^2



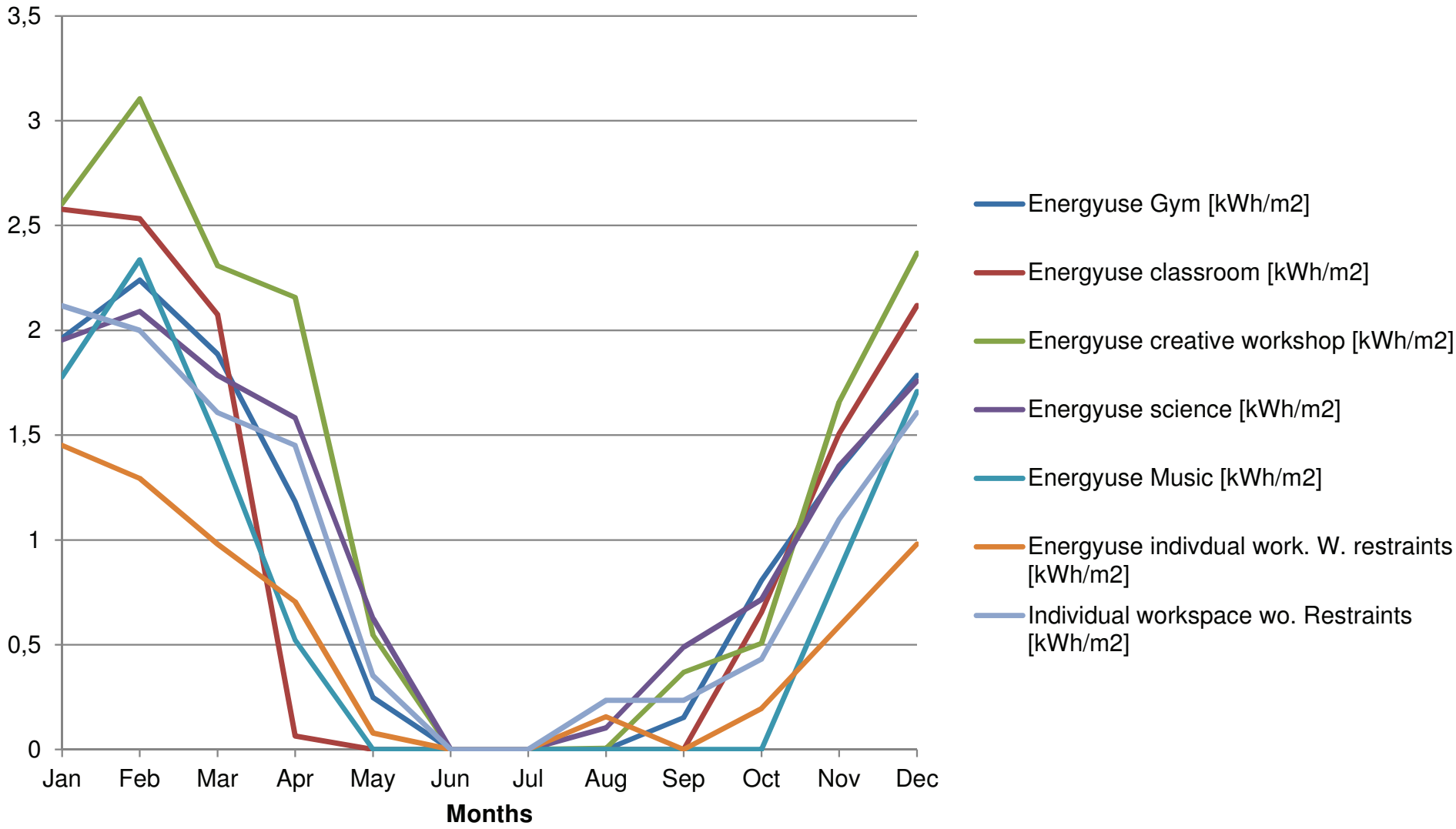
III. 120 Energyuse of individual workst.



III. 121 Dimensions of individual workst.

Conclusion

The larger rooms with less activity require more energy than the little rooms with more activity. Especially the individual group rooms and the creative workshop are interesting, since the little areas are greatly influenced by its time of use. The restrained scholars are using these individual group rooms a lot more than the ones without, which means they also require less energy for heating – actually about half. And the creative workshop requires a little more energy than the rest common facilities because of the great volume, its high temperature and its little activity.



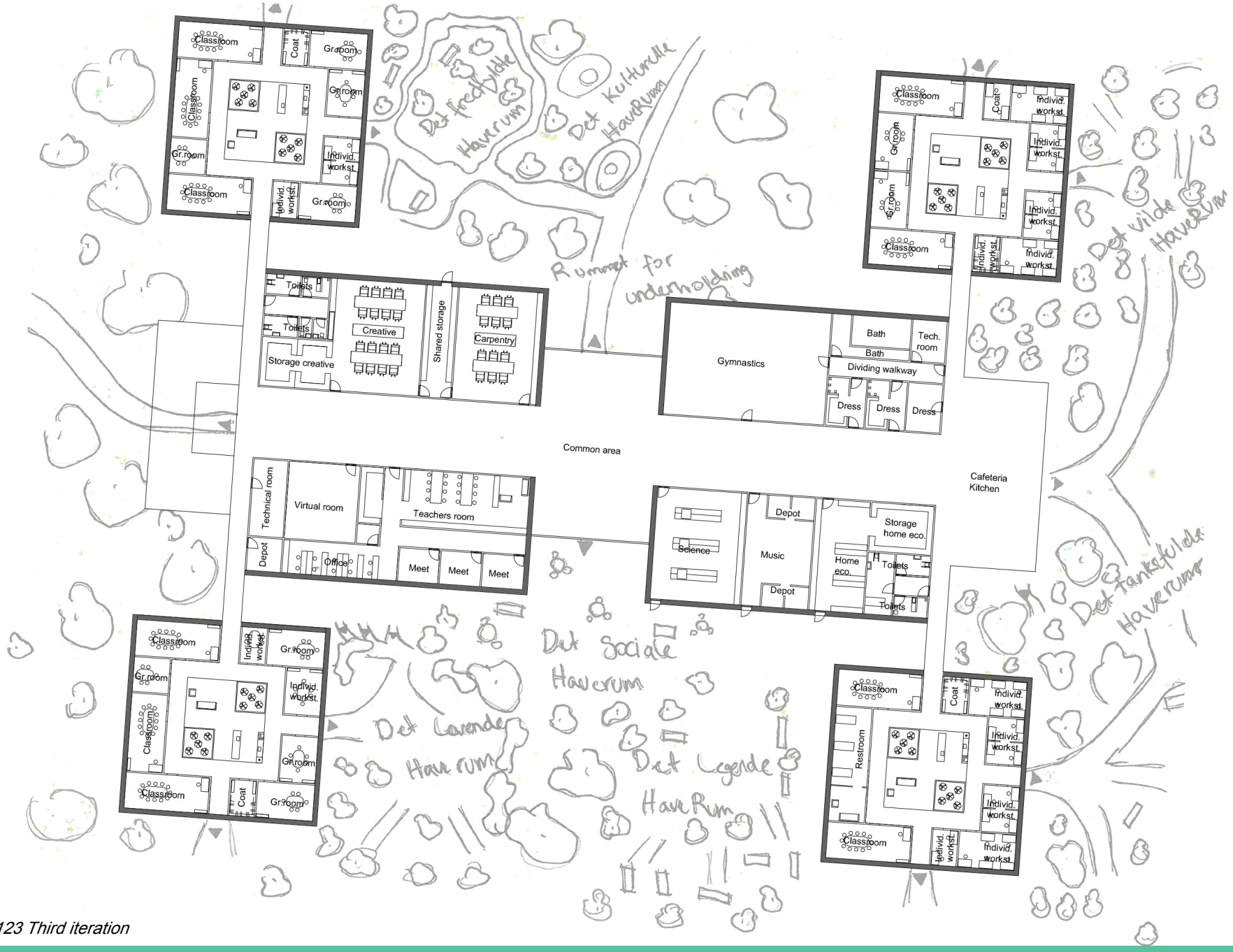
Ill. 122 Comparison of energyuse and time

Function - iteration 3

The second drawing has less interconnection (ICD) than the original. When walking towards the group entities you go straight through to a semi-private space. The individual groups have been defined, where all the workstations and the group rooms are toward east which able the scholars to have proper daylight and solar heat gain when working there in the morning. The classrooms are either towards west or south which ensures good daylight and the possibility of solar heat gain when in use at midday or in the afternoon. All of the groups are arrangement in the same way just the interior design is different. This has been done in order to create a flexible design where the furniture can be arranged to suit the individual's needs or in case they need to swap the groups around due to the fact that the amount of scholars can change from year to year. Drawing inspiration from the shadow studies made, some of the practical workshops have been moved around. Gymnastic is the space which requires the largest room height; it has therefore been moved from west to east though still situated at north. This has been done to ensure the group entities have decent solar exposure from east to assist their signs of depression. The Pool is still situated next to Gymnastics which able them to share dressing facilities. Functions which require no daylight have been placed at the intersection of the groups and the central lane, where solar gains are prohibited.

Conclusion

There is still too much undefined space in the central lane and the rooms are still too deep to ensure proper daylight conditions. The outdoor area seems undefined and has no intimacy and natural boundaries. Between the group entities and the common area, containing the practical workshops, there is an outdoor gab which has very prohibited solar exposure which would make for an unattractive outdoor area.



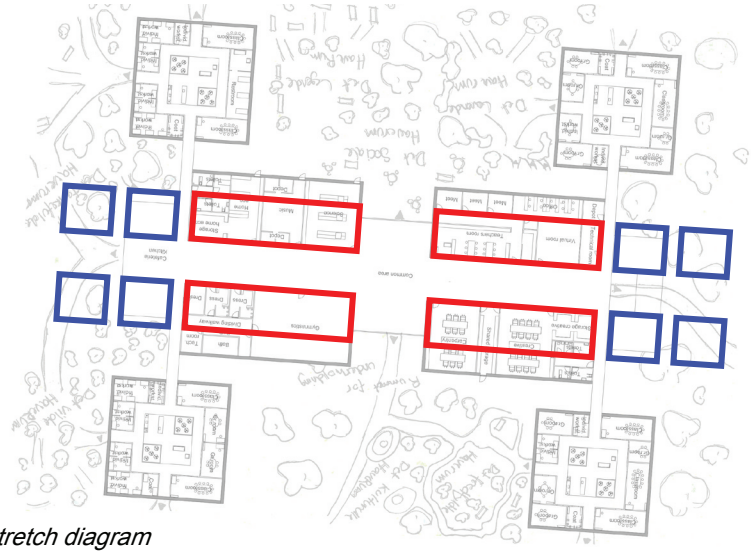
Ill. 123 Third iteration

Stretch diagrams

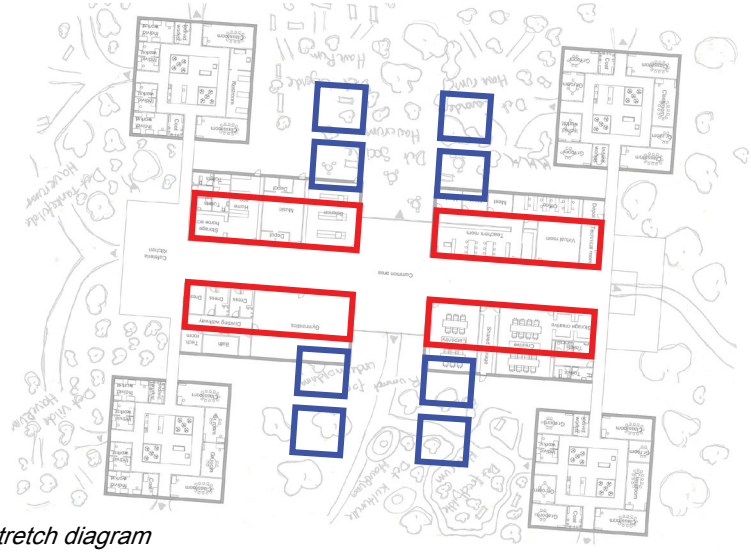
To create a building which works better and appears more as a whole a new sketching phase was necessary. It was therefore important not just to work with selecting the proper place for each function but also to work with the shape of the building to create an expression where the indoor arrangement and the outdoor arrangement could benefit from and at the same time would work with the concept.
On the illustrations it shows which initiatives could be a possibility. The red box is the reduction of the common area - this were a certain thing, since it was an issue to get light deep into the rooms. Some squaremeters were cut because of the reduction in the middle which means additional squaremeters should be placed. These are illustrated by the blue boxes.

Conclusion

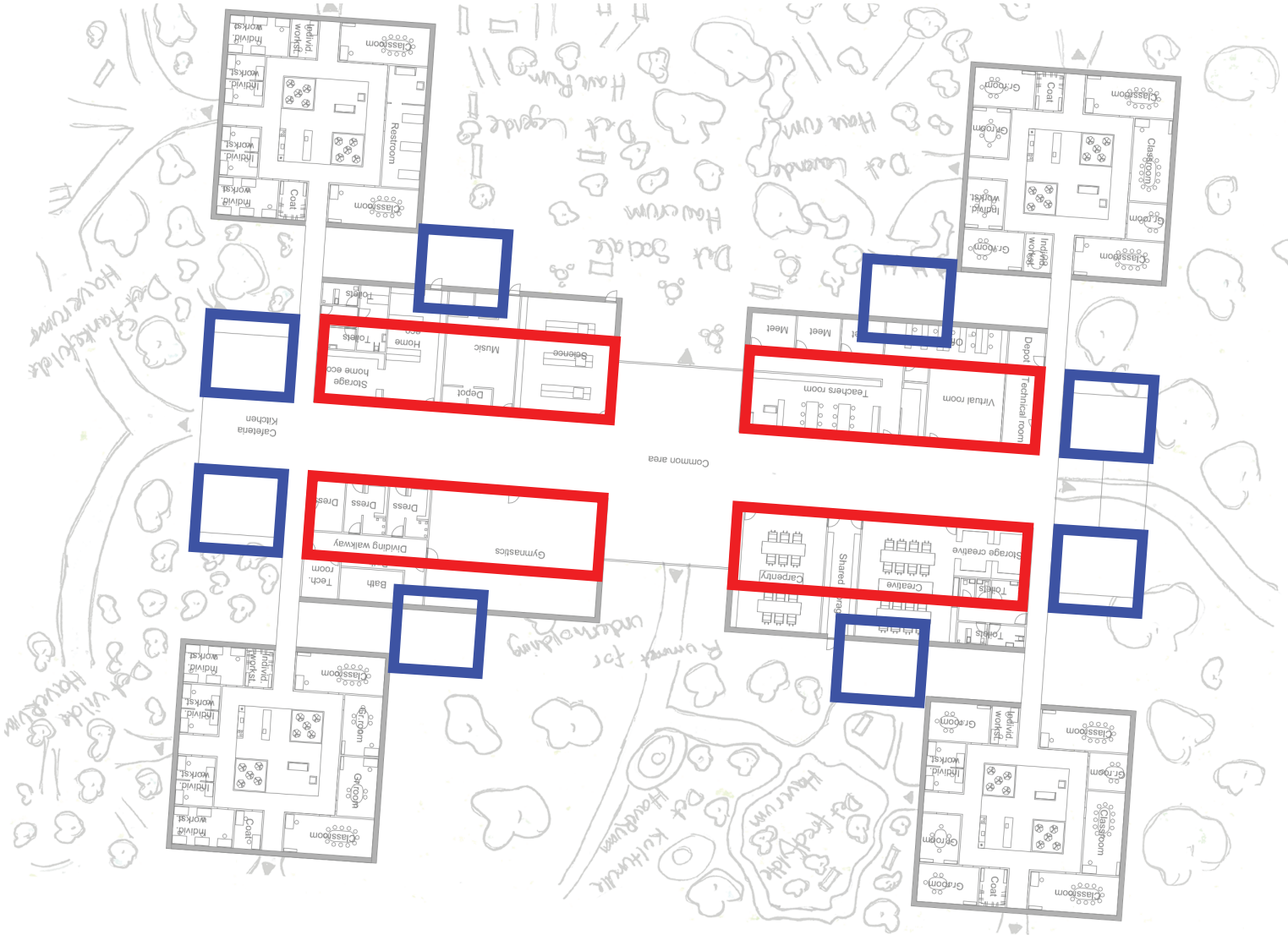
The final suggestion was to extend the middle in both directions, to enhance the expression of having smaller scale units. Furthermore the north/south extend creates a special room between the entities and the common facilities. The extension in East/West direction follow the lines from the entities and helps to create the expression of a gathered unit but still have a distance between the common facilities and the more private groups. Furthermore the opening at the main entrance gets the character of being the primary access to the building. This model of extension is chosen to be further detailed.



Ill. 124 Stretch diagram



Ill. 125 Stretch diagram



Ill. 126 Chosen stretch

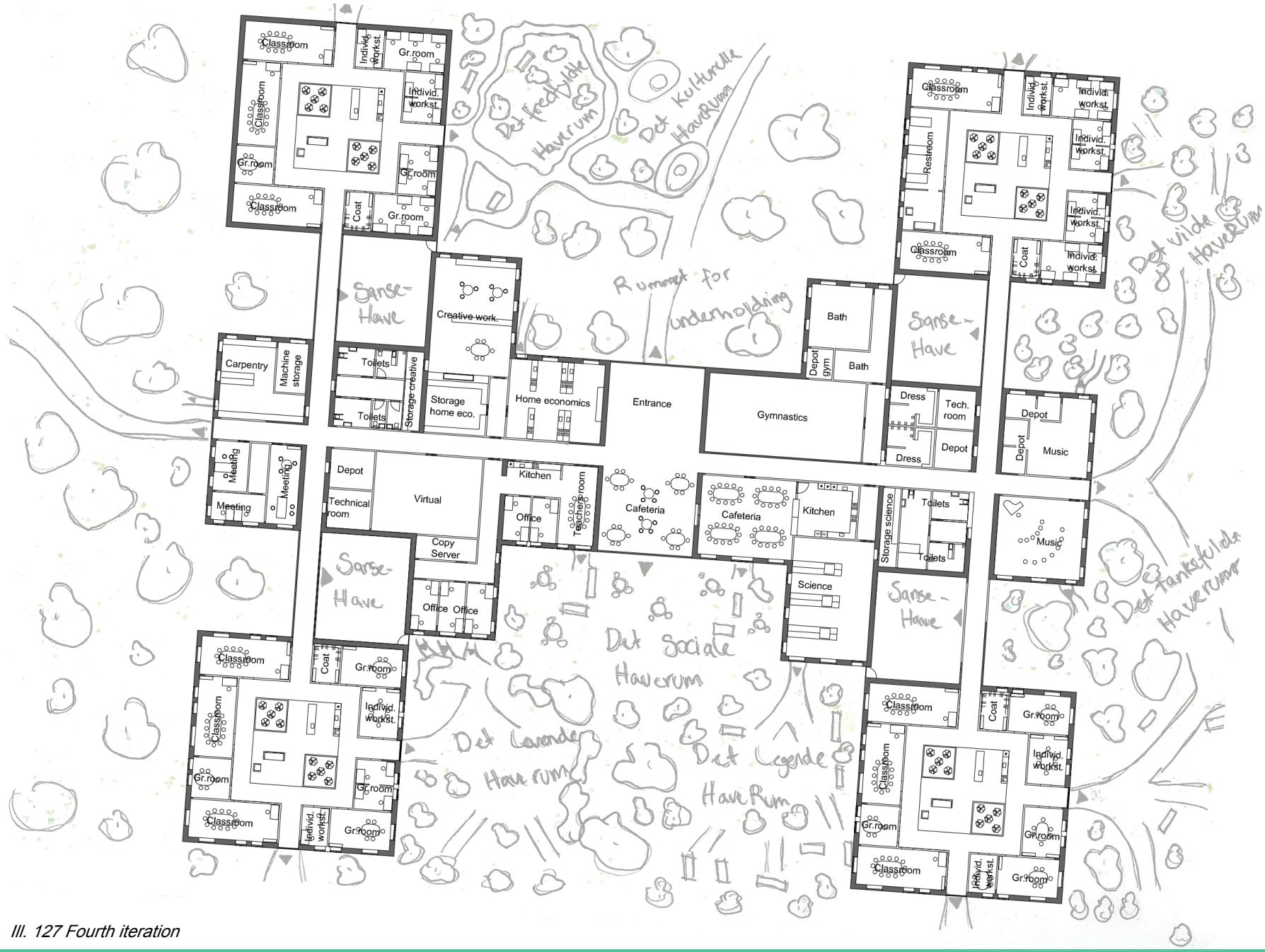
Function - iteration 4

The new arrangement was made to ensure that the rooms for the practical workshop and the staff facilities could receive enough light especially the offices which with their small size compared to the other facilities in the central lane acquired a different overall design solution than the previous. This also allowed for establishing four unique sensing garden in between the central lane and the group entities. This has been done in order to assist the way-finding in terms of recognition, so that each group has a different Sensing Garden with a different expression. The new design creates room to establish more defined outdoor area with the buildings shape framing natural intimate spaces. The central lane has been decreased in width which gives only one greater common area.

The different types of function have been moved around due to results from testing them in Bsim. This was done to ensure that the groups and the practical workshops were situated to accommodate the need for solar heat gain. The result showed that Group A with the lowest activity level should actually be place towards north because the heat from a wheelchair was higher and the need for ventilation was lower than for groups with high activity level.

Conclusion

There is still a need to define the common areas properly. The cultural Garden and The Space for Entertainment are situated together, which could mean that some of the artifacts from the cultural garden could be ruined when playing ball in The Space for Entertainment. The plan has some problems with a lot of internal walkway which means a lot of the practical workshops are not accessible from the central lane. This increases interconnections (ICD) and makes it less possible to create an accurate “Mental Map” of the complex. The design is neither optimize for stock delivery and some of the storage space are not properly accessible.

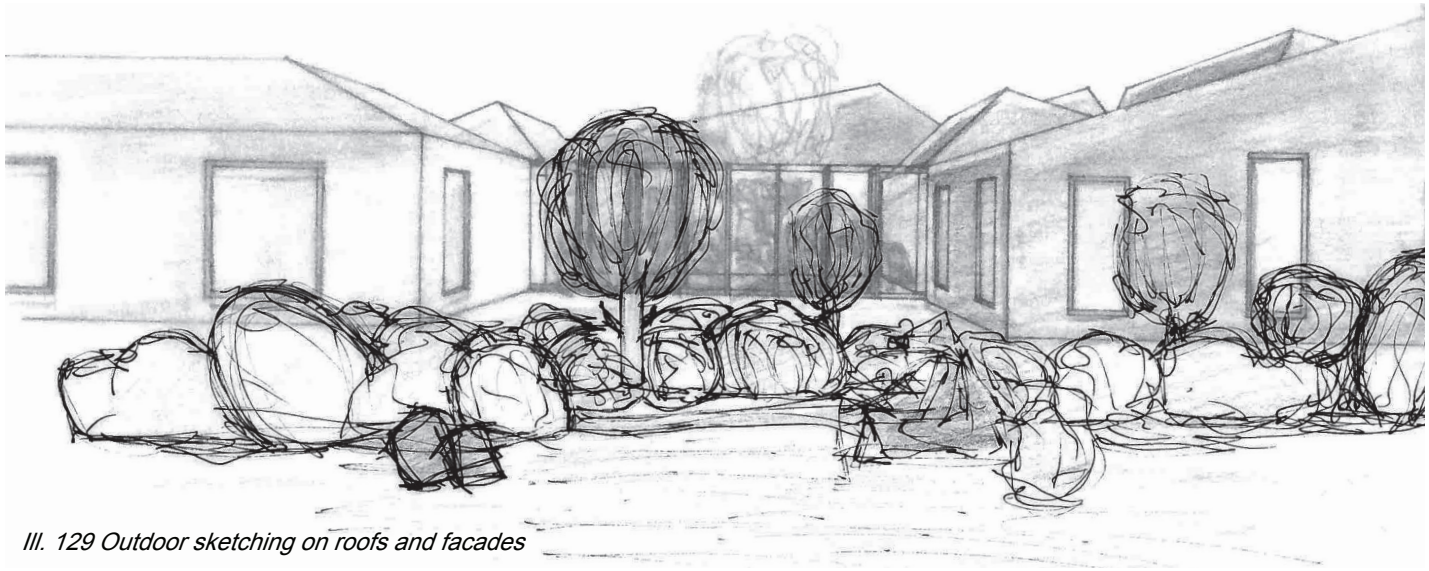


Ill. 127 Fourth iteration

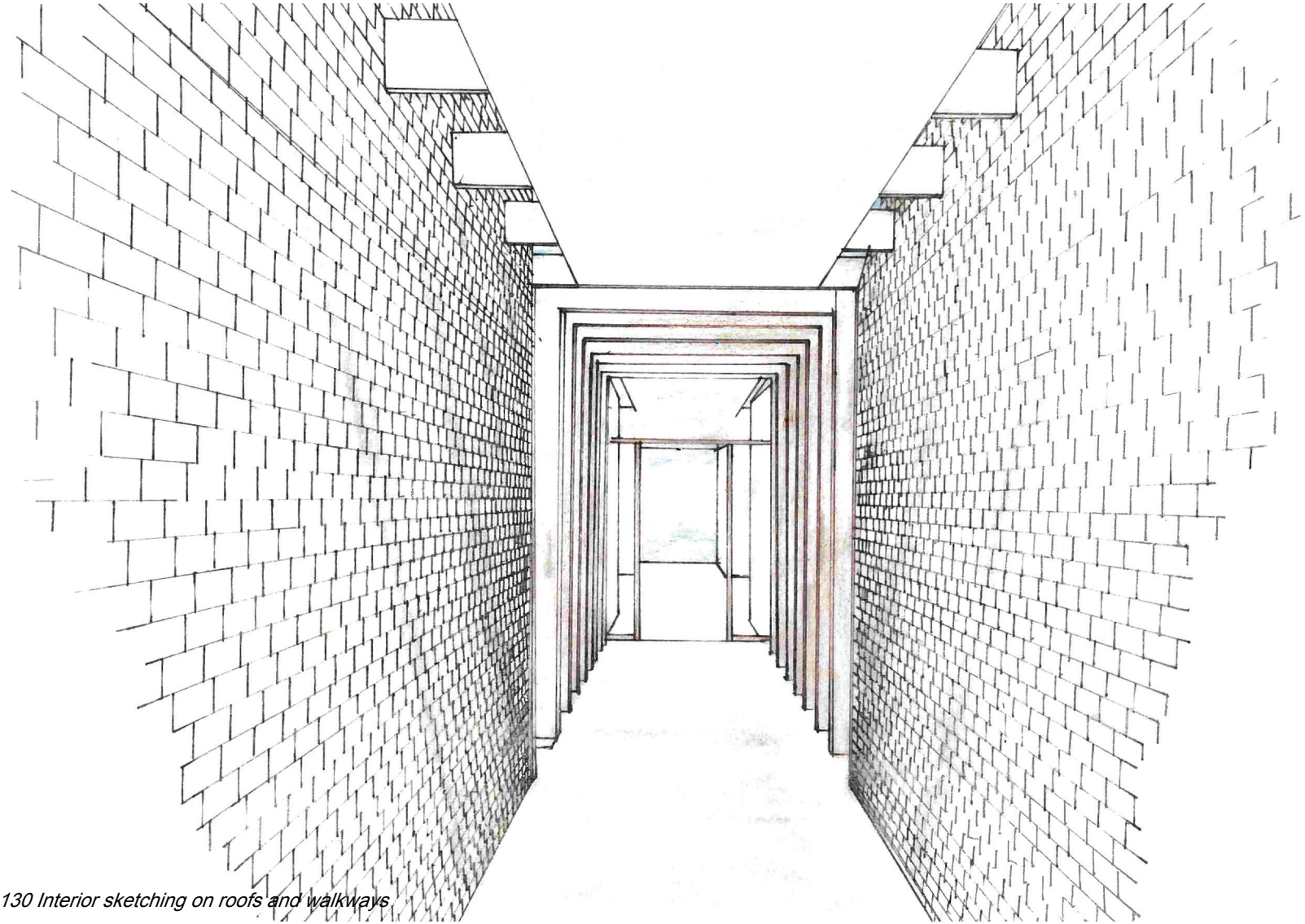
Sketching on roofs

The idea of creating a building which has a strong relation to its context was taken in to account in the sketching phase as to create an expression which symbolized the diversity of the target group and also refers to the diversity of the family housing in the area. This comes across both in the way the plan has been organized with grouping the facilities and creating a roof structure which corresponds with an expression telling the story of the diversity.

Ill. 128 Outdoor sketching on roofs and facades



Ill. 129 Outdoor sketching on roofs and facades



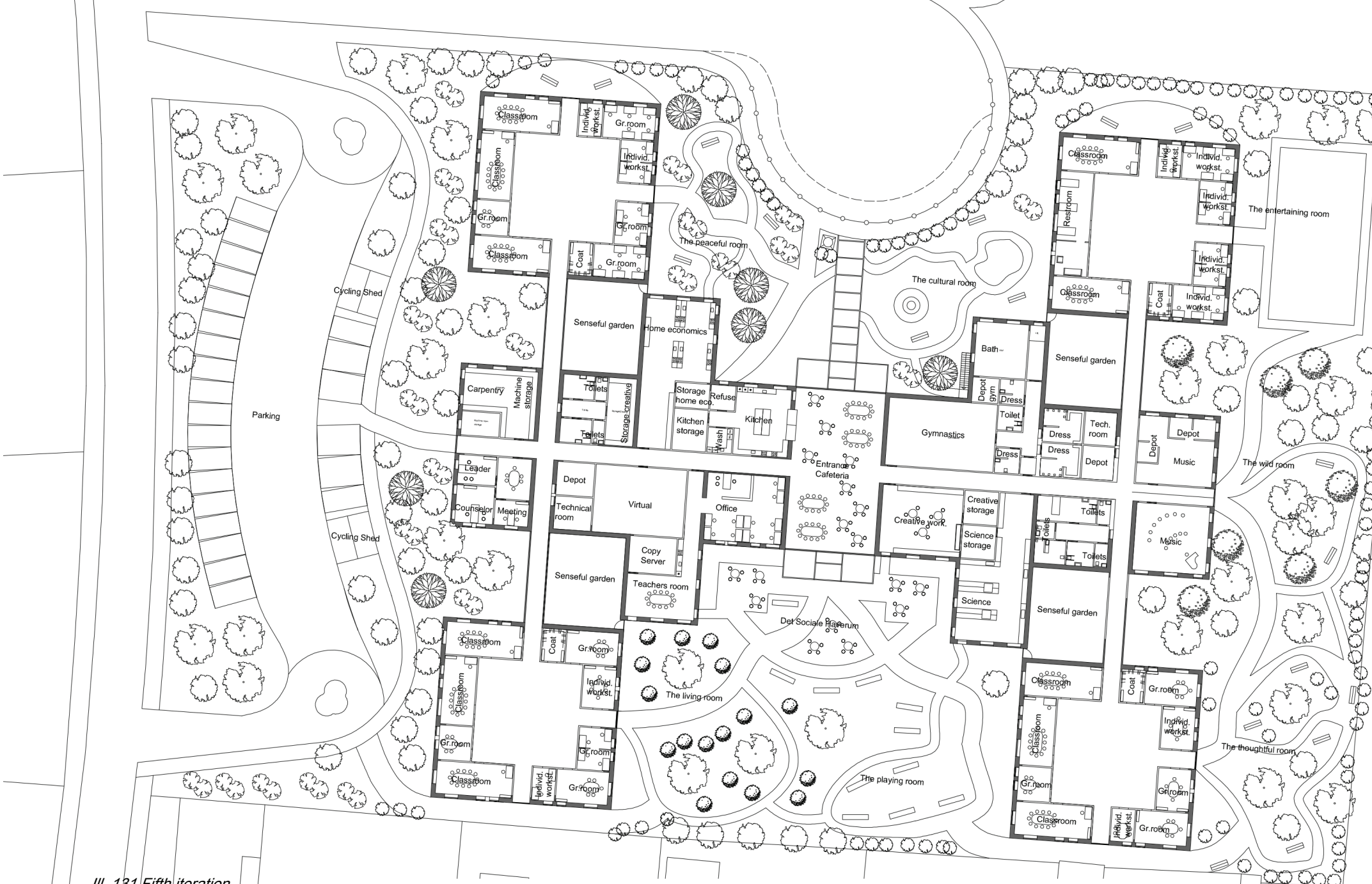
Ill. 130 Interior sketching on roofs and walkways

Function - iteration 5

In the last iteration the internal walkways was removed except in gymnastics and the Pool area where it was preferable, due to changing rooms not being in direct connection with the central lane. Stock delivery is possible in direct connection from the outside to the rooms which are in strongest need of large deliveries such as carpentry, Home Economics and the kitchen. The storage spaces have become better integrated with the facilities which they have to lodge. The kitchen have been made larger and the dining area have been established in the large common area. The kitchen and home economics have been placed towards north because of a high amount of internal heat gain from equipment. The creative workshop, the staff offices and science have been situated towards south due to less internal heat gain.

Concluson

The outside expression is not corresponding properly to the calm environment which is of great importance to the concept for the design. The roofs need more order and a simpler expression. The stock delivery is made so that it accommodates the kitchen, home economics and carpentry directly from the outside and close to the entrance or the secondary entrance at the parking area. Stock deliveries for science and the creative workshop have to be done by walking through the main entrance and then entering the rooms. The reason for this is that it has been estimated that the kitchen, home economics and carpentry have deliveries more often and are in greater need for larger products in general.



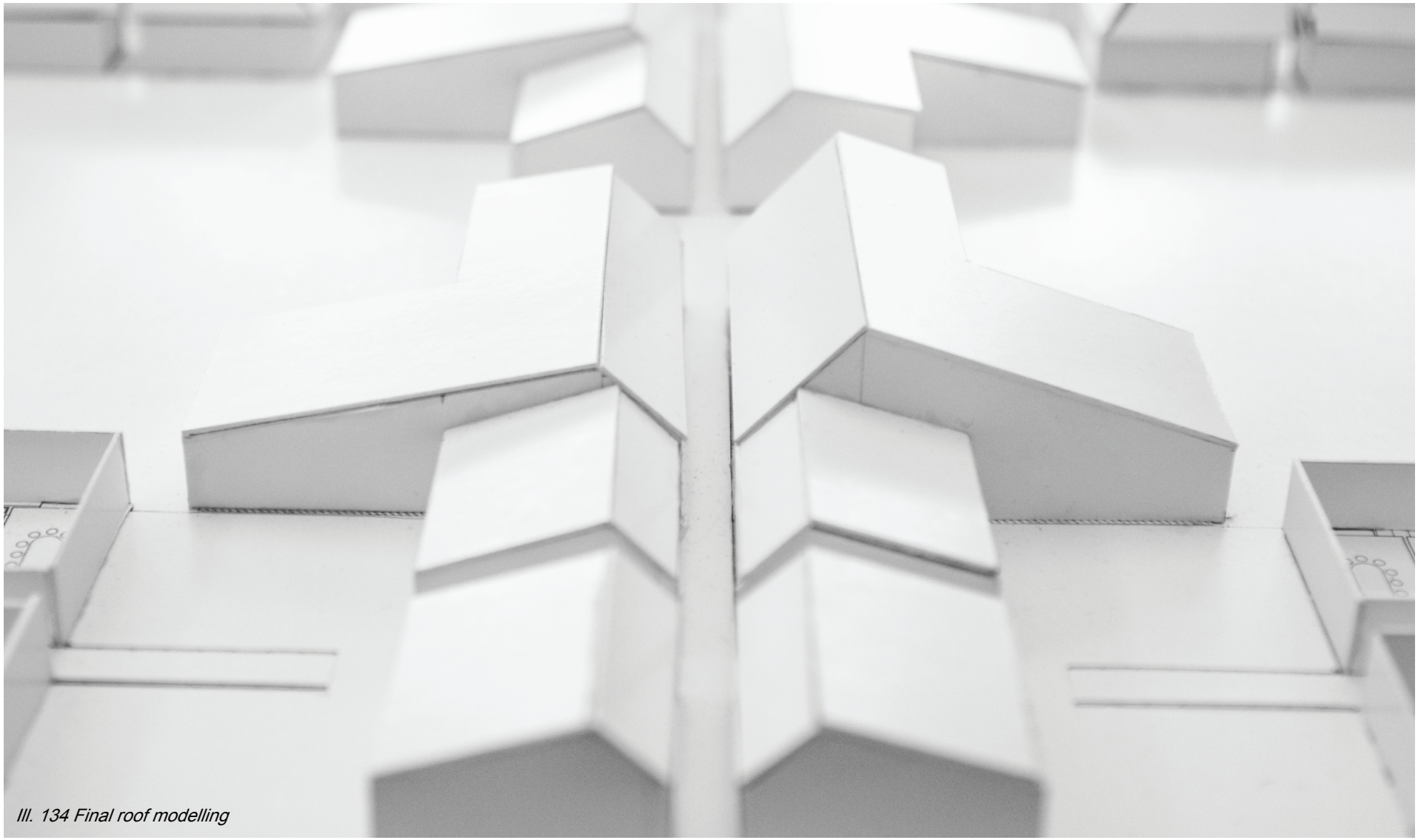
Ill. 131 Fifth iteration

Sketchingphase

The roofs have been readjusted to create a calm and simpler expression. The amount of different sized window have been decrease and placed in accordance to each other and the functions in the rooms. The windows have been placed and design from analyzing the amount of daylight within the room to accommodate a wish for a daylight factor of three percent especially in the workstation areas and in the classroom. This is further investigated in the next section “light and energy”.

Ill. 132 Final roof modelling

Ill. 133 Final roof modelling

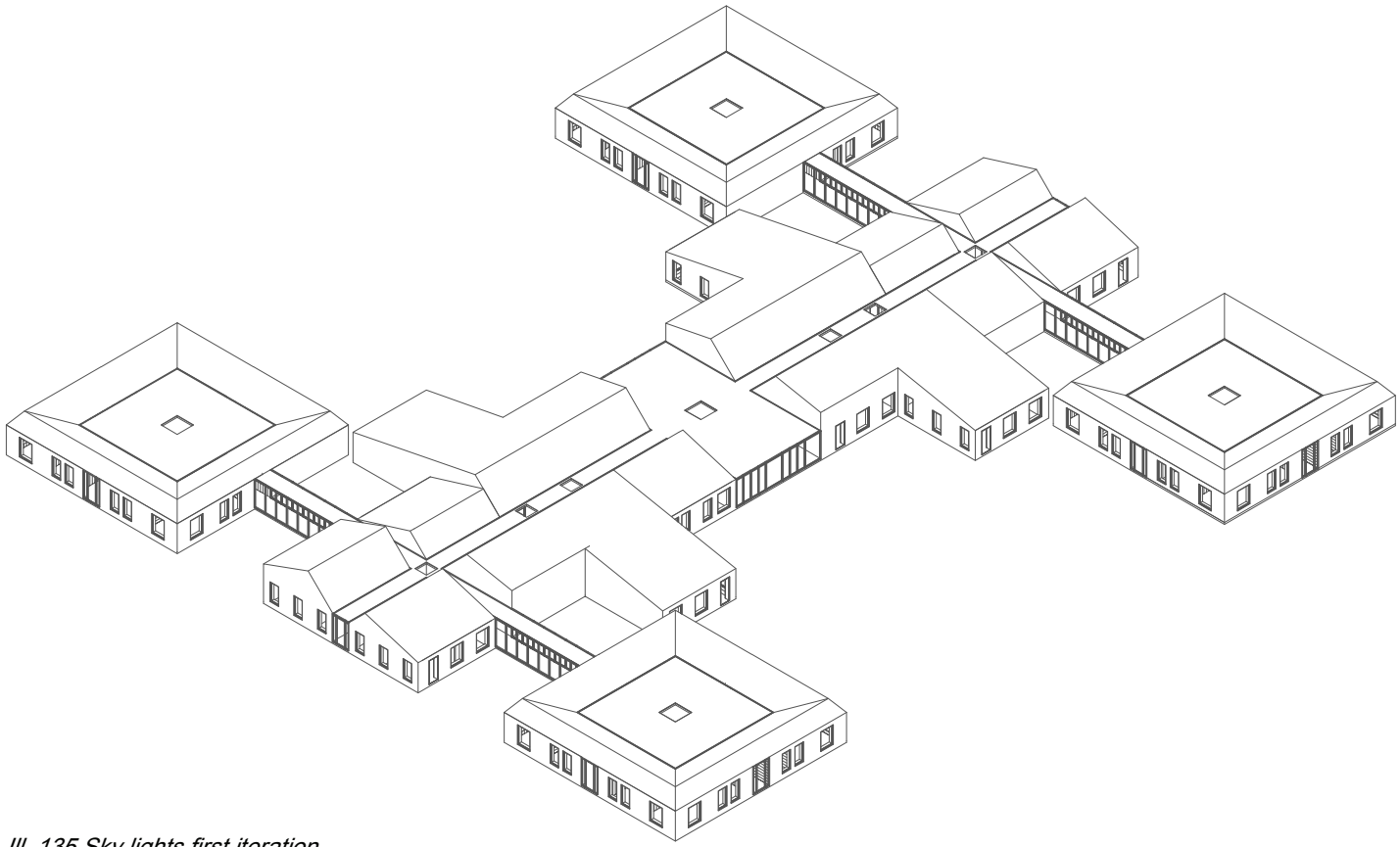


Ill. 134 Final roof modelling

Light & energy

Version 1

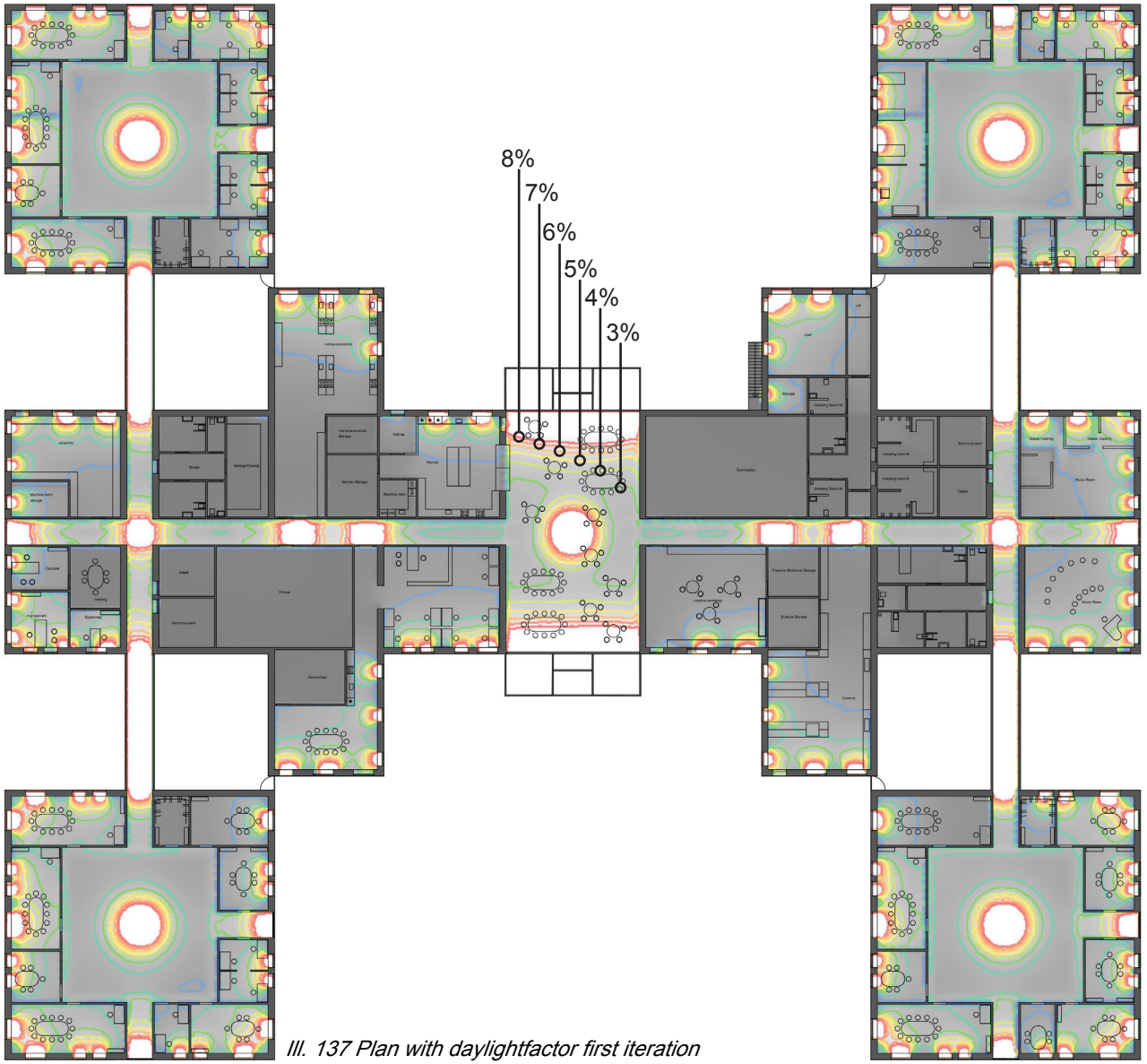
The first plan shows how the light penetrates the façade. In this plan there is not sufficient light in many places. In the individual workstations, and the group rooms, all seated scholars will not gain proper light conditions. Furthermore there are challenges in most of the common facilities in the middle of the building. The primary difficulty seems to get light deep into the different rooms and no lighting at all in the gymnastics. As a mean of wayfinding skylight have been added in the walkway whenever an interconnection is visible. The common area in the middle of the building is also well lit up. The energy demands are fulfilled to BR2010 and BR2015, but not BR2020, which is the goal. The daylightfactor can get larger by placing windows higher on the façade but since the windows are placed in the maximum height, to able wheelchair users to gain a proper view, skylights can be the solution. According to how many, how big and where these skylights will be placed a sufficient daylight factor can be reached. Furthermore these roof lightings might be beneficial to the energy consumption of the building, but they will also contribute to over temperatures.



Ill. 135 Sky lights first iteration

BR 2010	[kWh/m2]
Energyframe	71.7
Energydemands	44.6
BR2015	
Energyframe	41.3
Energydemands	39.9
BR2020	
Energyframe	25.0
Energydemands	32.4
Energy contribution	
Heating	23.3
Power for service	4.2
Overtemperature	10.9
Lighting power	3.1
Ventilators power	1.0
Energy demands (netto)	
Heating	18.0
Hot domestic water	5.3
Cooling	0
Loss from installations	0
Loss from hot domestic v	0

Ill. 136 Energy results first iteration, Be10

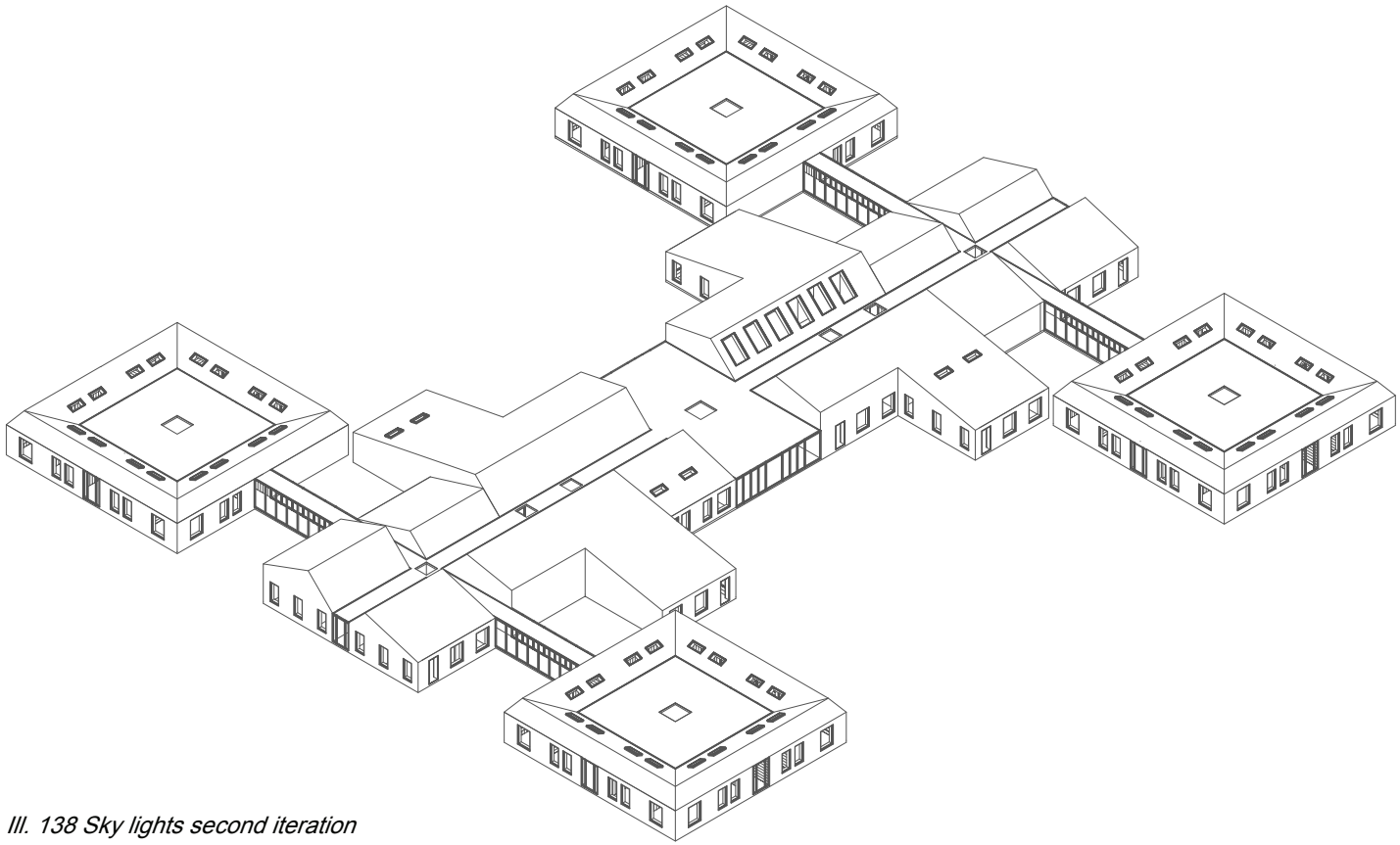


Ill. 137 Plan with daylightfactor first iteration

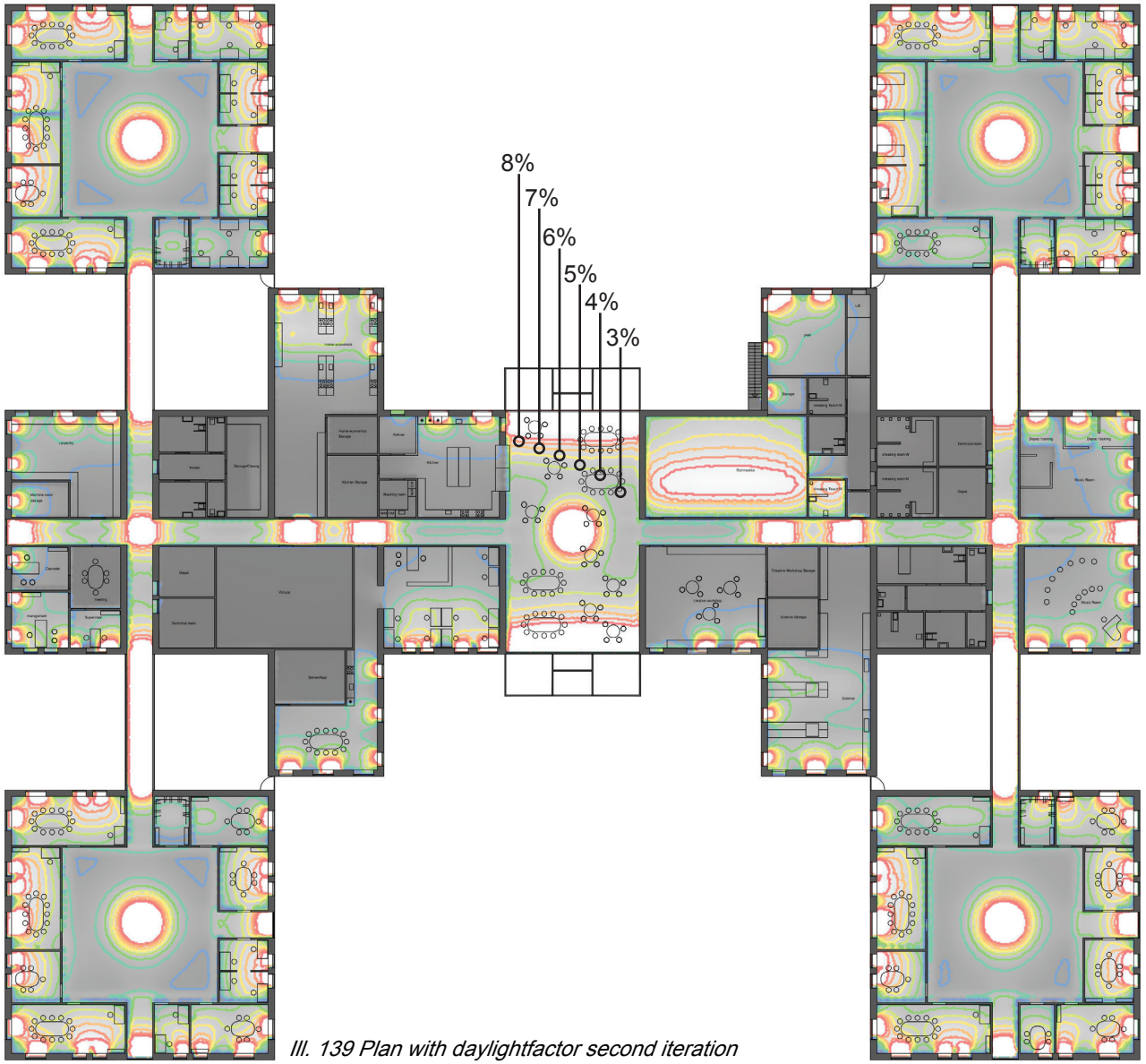
Version 2

To accommodate the need for more daylight deeper inside the rooms, skylights have been added in the group entities and in the practical workshops. Do to the analysis made in Bsim which shows that Gymnastics use a high amount of energy to heat up the large space; a skylight to increase solar gain has been added.

The illustration shows that there still are a lot of problems in the Creative Workshop, Home Economics, the staff room and offices. The daylight in Gymnastics has increased drastically which could create problems with glare. The group entities all have a daylight factor of three percent at the workstations.



Ill. 138 Sky lights second iteration

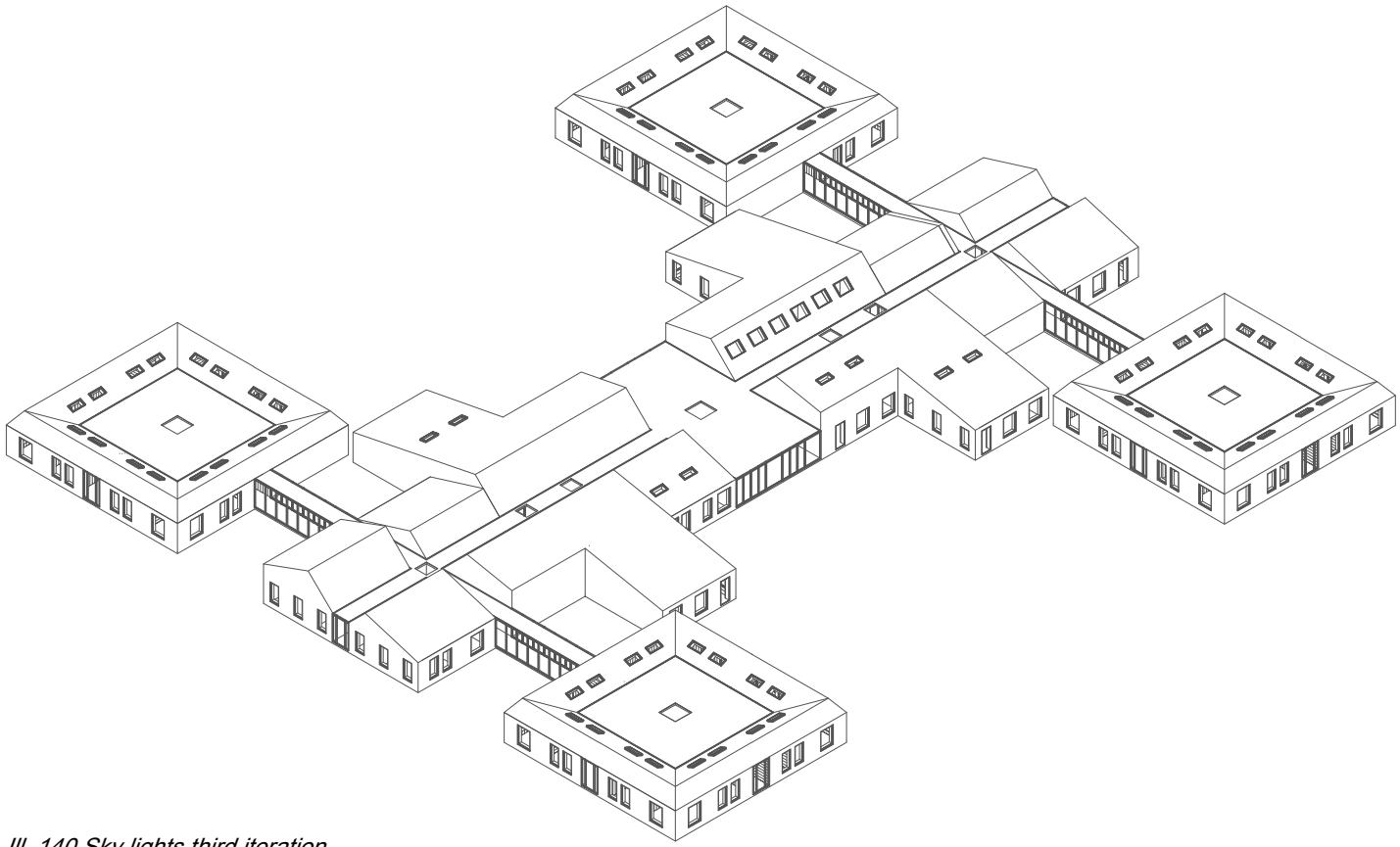


Ill. 139 Plan with daylightfactor second iteration

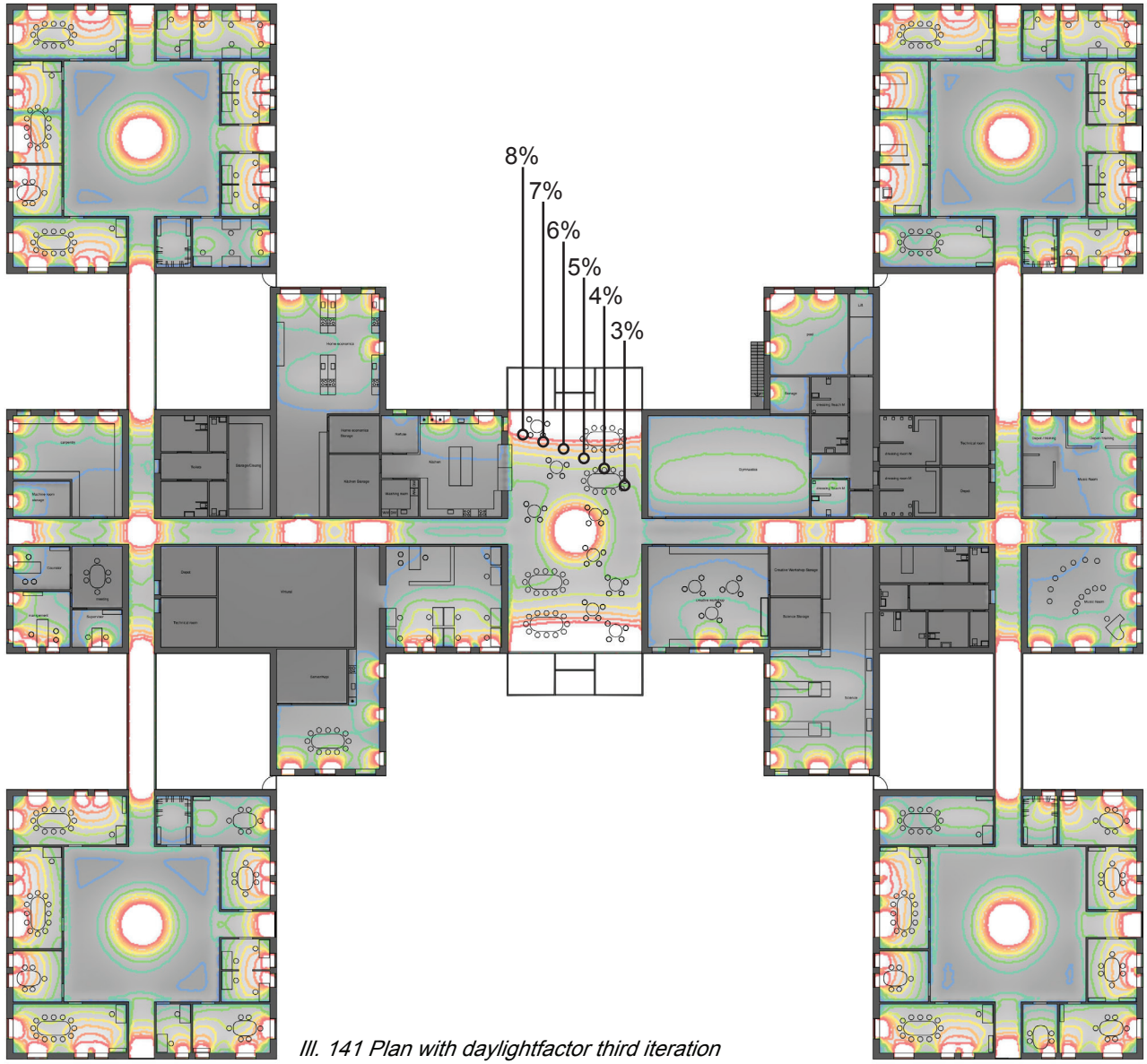
Verison 3

Additional skylights have been added to home economics and the creative Workshop to increase the daylight factor even further and more evenly distributed. The skylights in the staff offices have been readjusted to make sure all the workstations have a proper daylight factor of three percent. The windows in gymnastics have been readjusted and reduced to allow for solar heat gain but still disallow the possibility for glare.

The daylight in gymnastics has become more evenly distributed. There is still a slight problem with the light being distributed evenly in the staff offices, the kitchen and the creative workshop.



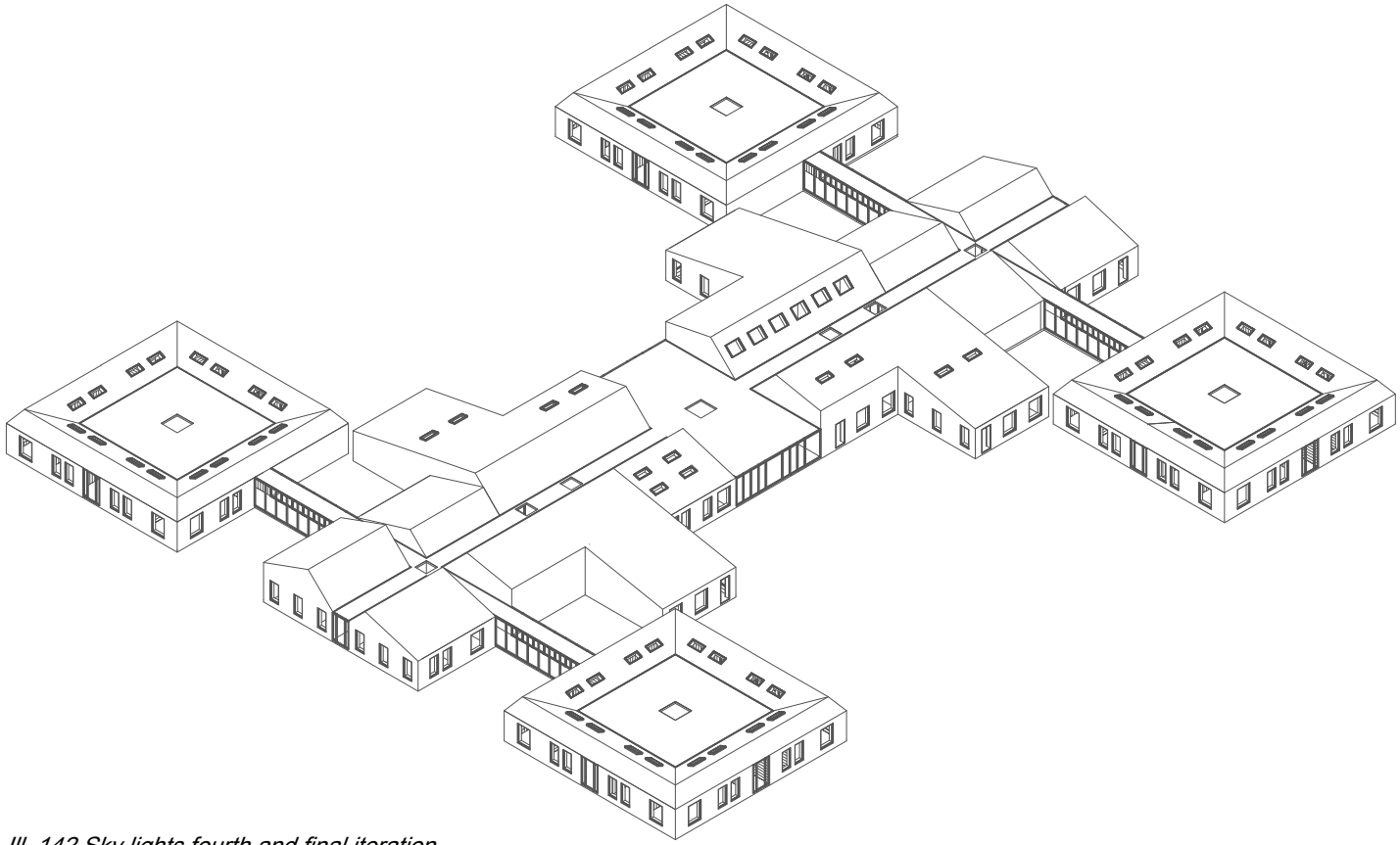
Ill. 140 Sky lights third iteration



Ill. 141 Plan with daylightfactor third iteration

Version 4

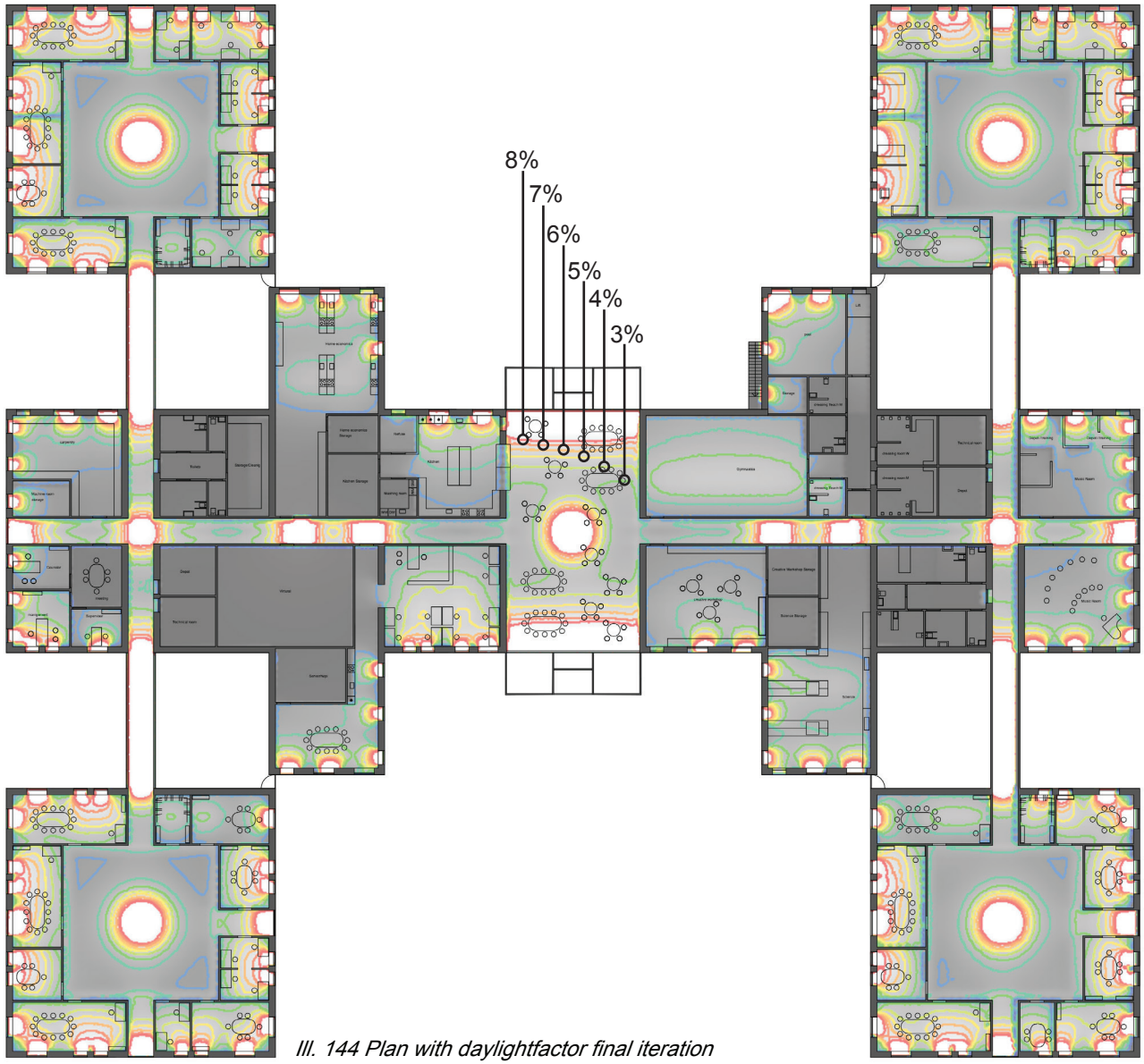
The daylight factors in the rooms are now almost sufficient, and the contrasts between the daylight in the walkways are satisfying. To look at the Energy consumption after these changes gives an indication of where the next initiatives shall be taken to get a good indoor environment. As seen the energy consumption is a little more than wanted. The building now performs to reach BR2010, but not BR2015 and BR2020. But it is considered that solar shading and night cooling can reduce the over temperatures and therefore eliminate the use of energy for automatic cooling.



Ill. 142 Sky lights fourth and final iteration

BR 2010	[kWh/m2]
Energyframe	71.7
Energydemands	47.5
BR2015	
Energyframe	41.3
Energydemands	42.9
BR2020	
Energyframe	25.0
Energydemands	35.3
Energy contribution	
Heating	23.2
Power for service	4.2
Overtemperature	13.9
Lighting power	3.1
Ventilators power	1.0
Energy demands (netto)	
Heating	18.0
Hot domestic water	5.3
Cooling	0
Loss from installations	0
Loss from hot domestic v	0

Ill. 143 Energy results final iteration, Be10



Ill. 144 Plan with daylightfactor final iteration

Improving indoor environment

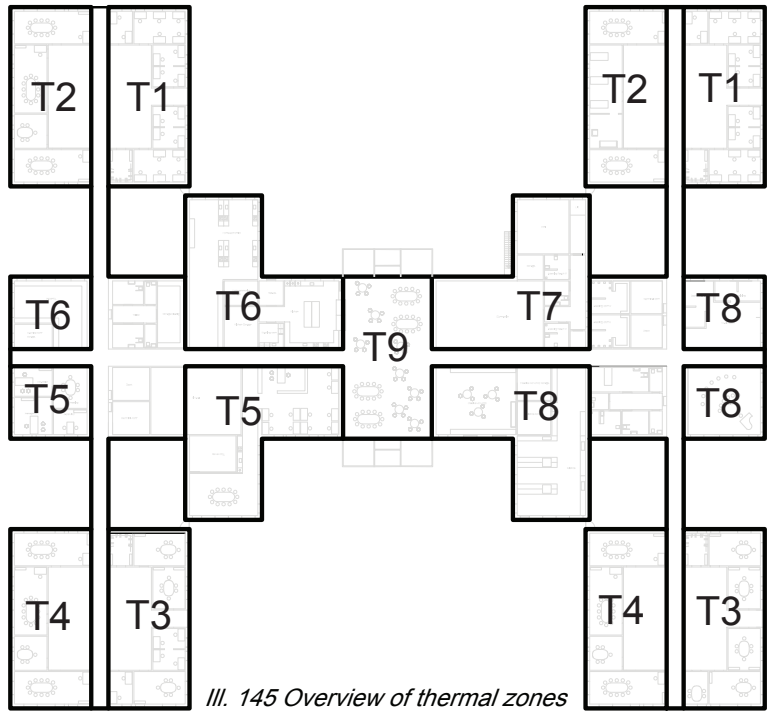
General energy calculations have already been made in Be10 to investigate the buildings performance according to its facades.

But that method does not tell anything about how the specific indoor environment performs. Therefore a BSim model is made with different thermal zones that take different temperature and other indoor environmental conditions into account. Initially this model is used to check for over temperatures in the different zones. There is many hours with over temperature in all zones, but the worst case scenario, thermal zone 3, is investigated further to observe the over temperatures, and if it is to be solved in the worst case scenario it is assumed it can be solved in the other thermal zones as well.

As seen on the diagram the thermal zone three has 429 hours above 26 degrees in the day schedule from 9-15, and 364 hours above 27 degrees in the day schedule from 9-15.

The tolerances according to the building regulations 2020 are to have maximum 100 hours above 26 degrees and 25 hours above 27 degrees.

Thermal zone 3 is the worst case due to; south windows without shadow and skylights in all directions. Thermal zone 3 is used for scholars without restraints which is assumed from previous investigations to be an energy consuming zone.

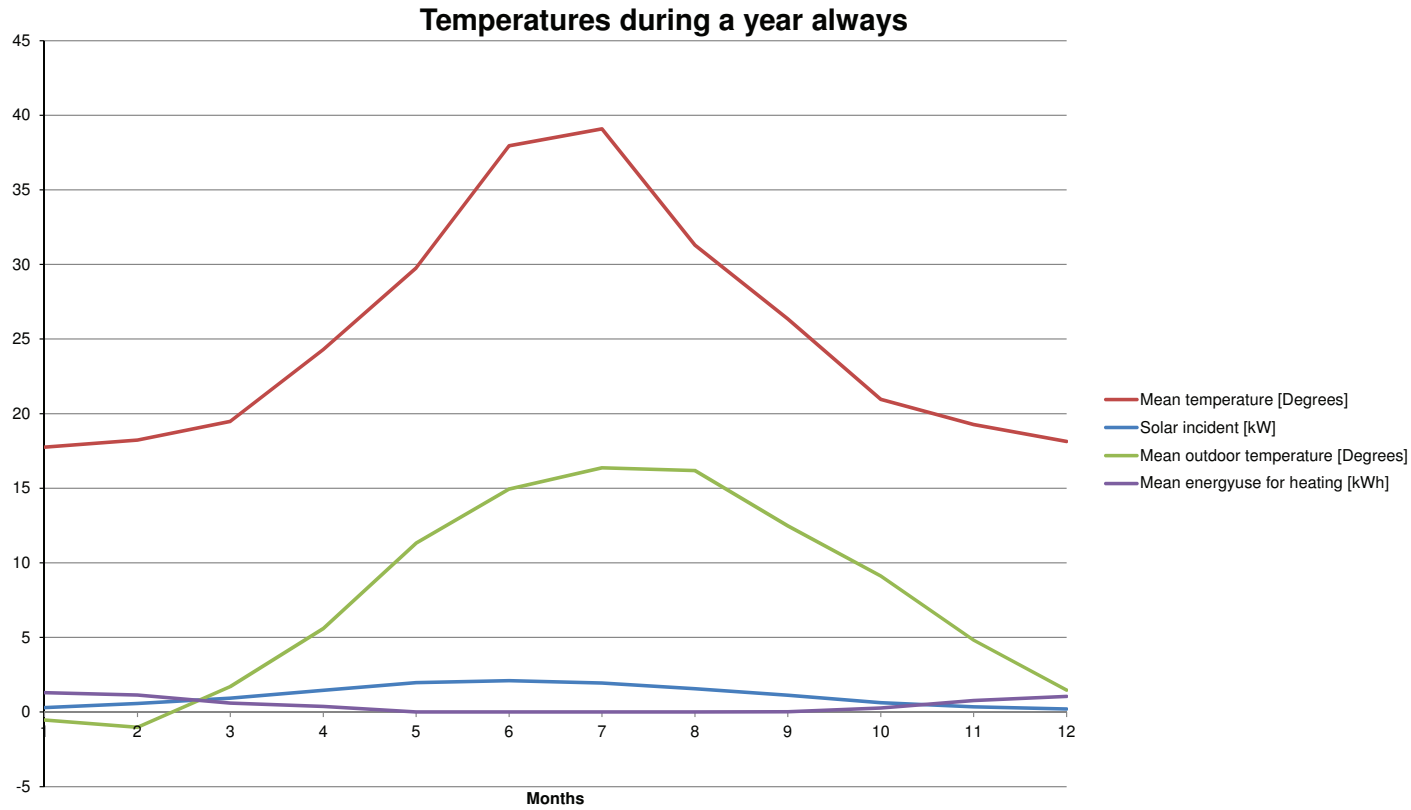


Ill. 145 Overview of thermal zones

Bsim data Version 12 % sunshading %nightcool	Overtemperatur 9 to 15 [Hours > 26]	Overtemperatur 9 to 15 [Hours > 27]	Energy use Yearly [kW]	Energy use Yearly [kW/m2]	Energy from sun Yearly [kW]
T1	364	338	6769	13,6	2
T2	325	273	8917	17,9	1,9
T3	429	364	8520	17,1	2
T4	390	325	9217	18,5	2
T5	338	247	7755	24,0	1,3
T6	52	26	6471	20,0	0,7
T7	13	13	7829	32,2	0,4
T8	104	65	5878	14,5	1,6
T9	494	468	18500	28,4	8,1
Total			79856	20,8	20

Ill. 146 Over temperature results BSim

On the first graph of thermal zone 3 it can be seen the over temperatures occurs in the summer period where the solar incidence are at its highest, and the outdoor temperatures are high. At the same time there is no need for heating in this period.



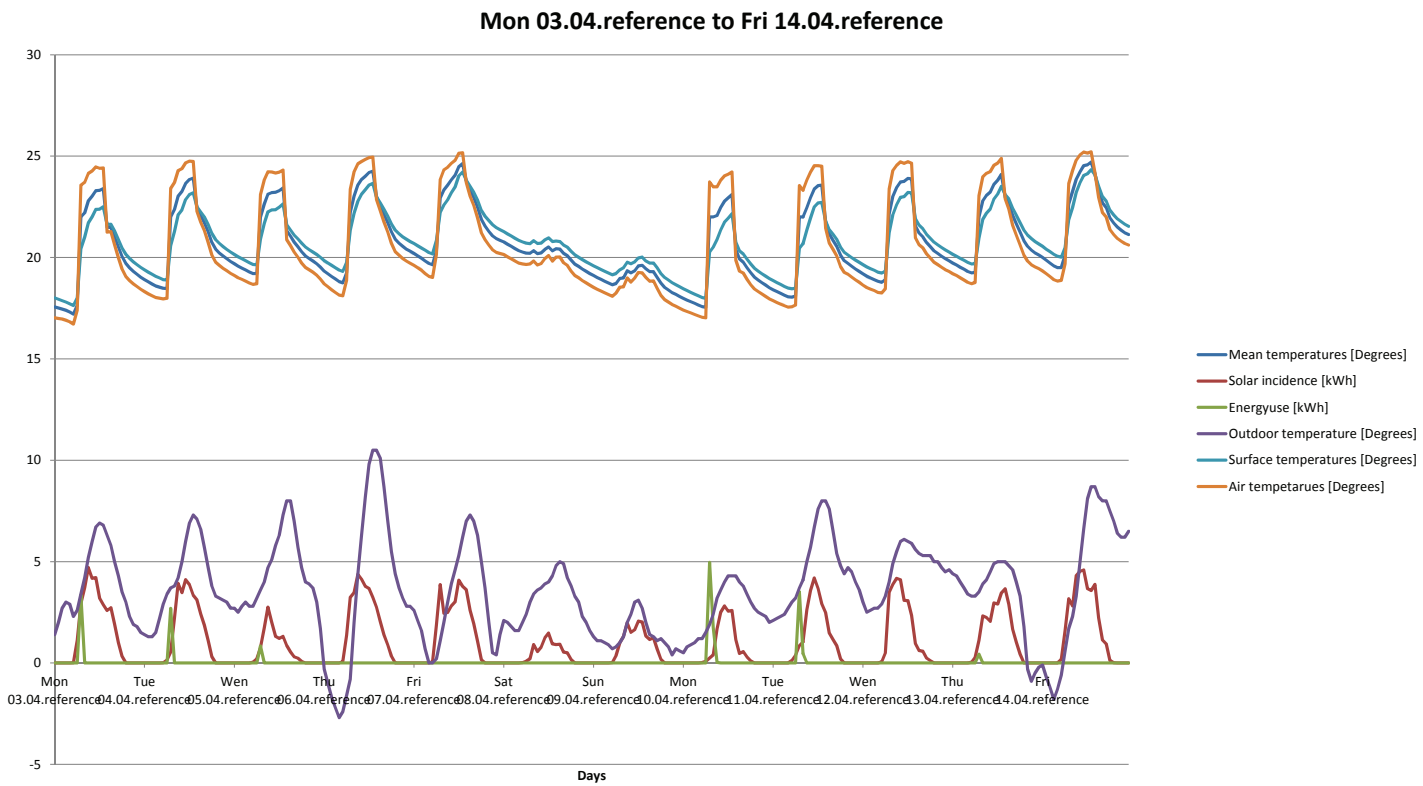
Ill. 147 Overview of energyconsumption during a year

Bsim data Version 13 % sunshade %nightcool	Overtemperatur 9 to 15 [Hours > 26]	Overtemperatur 9 to 15 [Hours > 27]	Energy use Yearly [kW]	Energy use Yearly [kW/m2]	Energy from sun Yearly [kW]
T3	429	364	8520	17,1	2
Total			8520	17,1	2

Ill. 148 Thermal zone 3 data

To investigate the issue further a 14 days graph is made, where it can be seen how the surface temperatures, air temperatures, mean temperature, the solar incidence and outdoor temperatures act according to each other.

It can be seen that the temperatures lowers outside the time of use. Here is the weekend a special case, since the heating is turned off and the temperatures falls during the weekend. When monday morning comes, the temperatures rises, and the zone does not manage to cool down to the same level over the night.

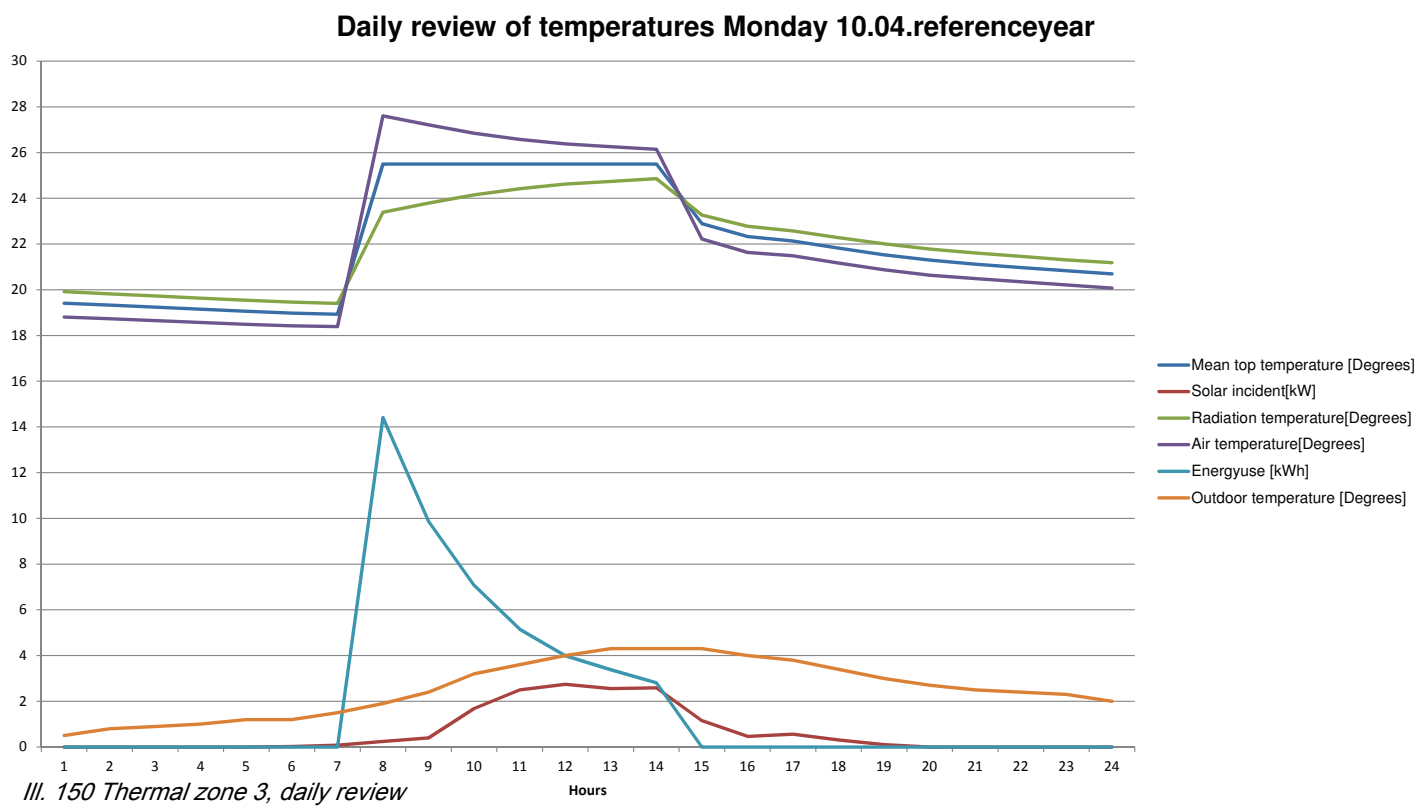


Ill. 149 Thermal zone 3, 14 days review

A weekday schedule is made for monday the 10.04.referenceyear. This graph gives a better insight in the how the surface temperatures and the air temperature have differences.

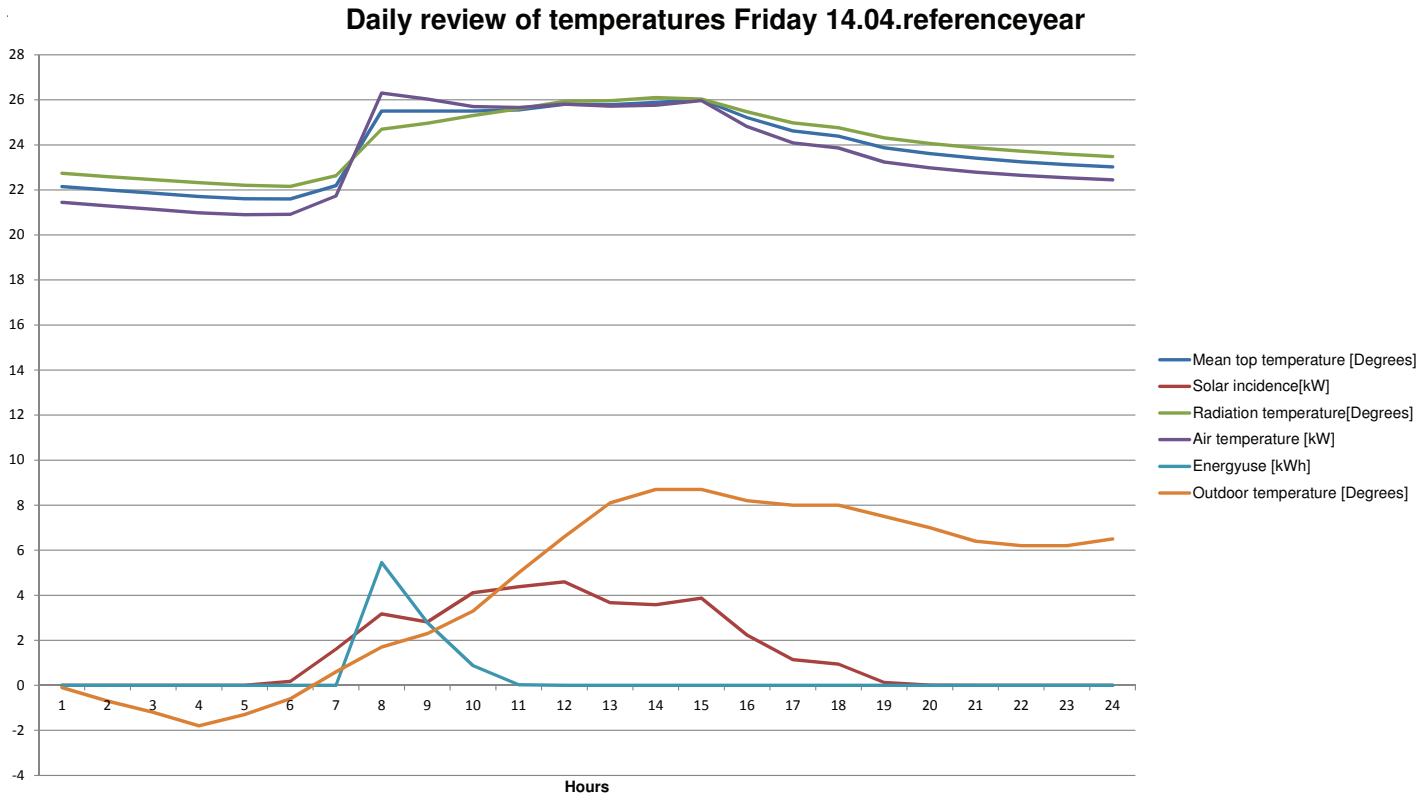
The differences are high monday morning due to the lack of heating during the weekend.

it can be seen the surface temperatures has dropped to about 23 degrees, and the air temperature is about 27.5 degrees. This gives cold surfaces into the zone, and the instability will create a worse experience of the zone. According to restrained scholars it is very important to keep a constant environment during the whole week and day.



Ill. 150 Thermal zone 3, daily review

At Friday in the same week the same time the temperature differences are more even. The surface temperature is about 25 degrees and the air temperature is about 26 in the morning, which means the optimal temperature +/- 0.5 degrees. This variation is caused by the people load and the heating during the week. The environment reaches an optimum at friday afternoon, where the weekend again will interrupt the steady thermal environment.

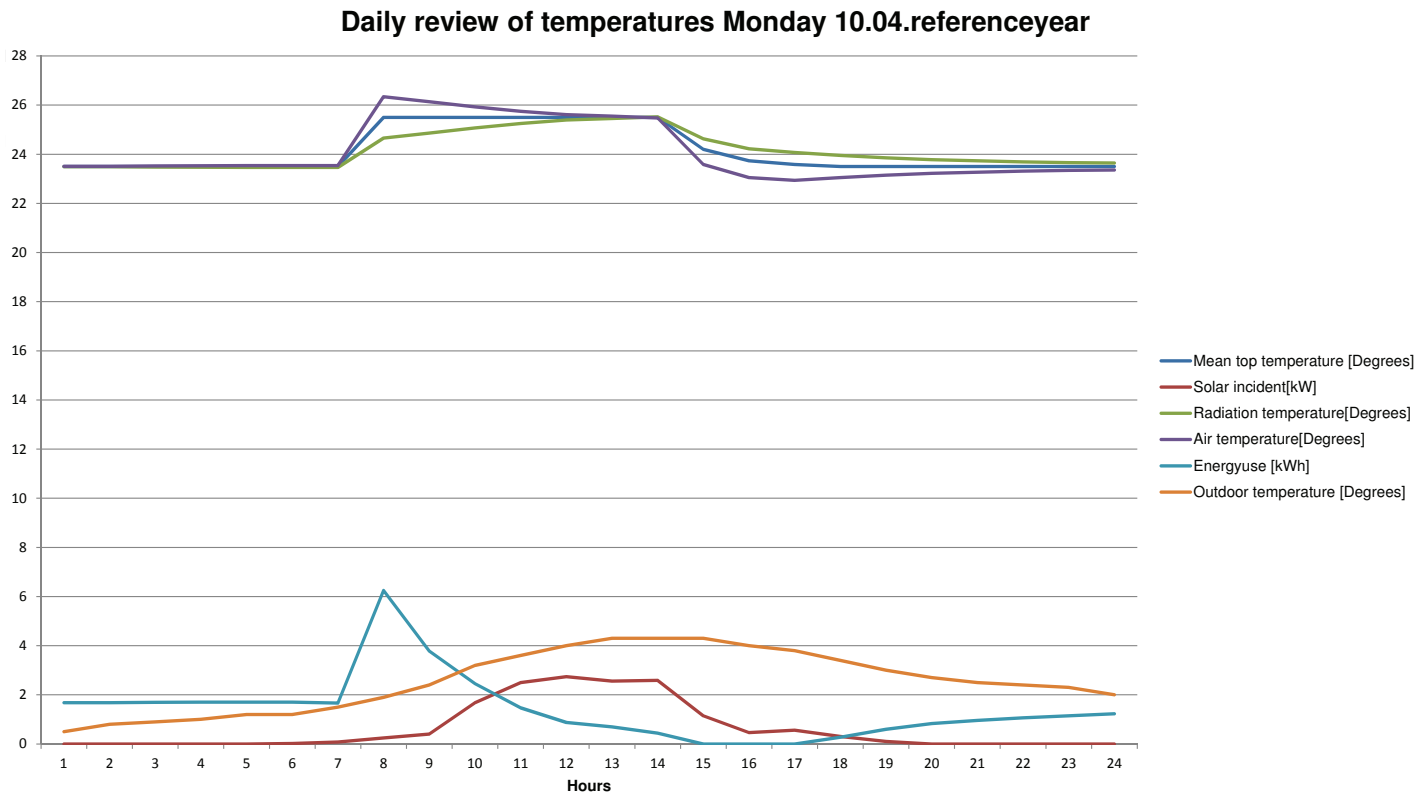


Ill. 151 Thermal zone 3, daily review

To prevent this deviation, heating is activated outside day schedule to maintain the heat of the zone. After activating the heat outside day schedule, the energy consumption raises 0.2 kWh/m^2, but it certainly improves the indoor environment. The temperature differences Monday morning are +/- 0.5 degrees, which means it is the same as Friday afternoon without heating outside day schedule. The temperature differences are almost 0 at Friday with heating outside the day schedule. Friday can be seen on the next page.
This initiative does not affect the over temperatures in the zone, but it improves the experience of using it.

Bsim data Version 13 % sunshade %nightcool heating outside daytime	Overtemperatur 9 to 15 [Hours > 26]	Overtemperatur 9 to 15 [Hours > 27]	Energy use Yearly [kW]	Energy use Yearly [kW/m2]	Energy from sun Yearly [kW]
T3	429	364	8650	17,3	2
Total			8650	17,3	2

Ill. 152 Thermal zone 3 data second iteration

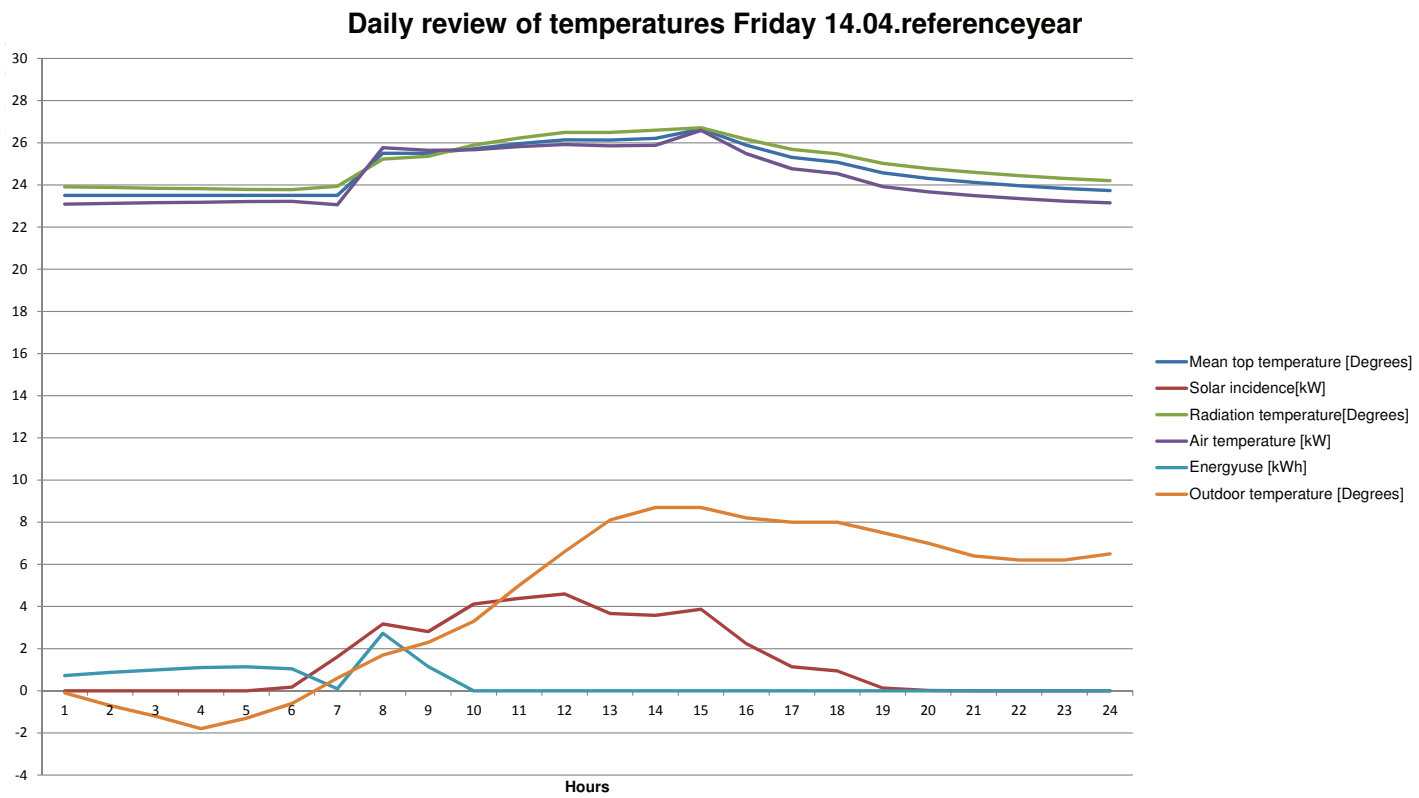


Ill. 153 Thermal zone 3 daily review second iteration

To reduce the over temperatures in the thermal zone, solar shading is used. Solar shading is used, because it is seen on the last graphs that the solar incidence affects the thermal indoor environment during the summer period, where solar incidence is not recommended. The solar shading is constructed as exterior shading with a shading effect on 2/3, when fully used. This gives the opportunity to grant the most possible energy when it is necessary. The first iteration of solar shading is made on the façade, to investigate if it is necessary to make solar shading on the skylights. The effect of this solar shading is a reduction of hours with over temperatures as seen in the graph.

It is concluded that solar shading on the skylights are necessary and they get the same kind of solar shading as the façade, and this again reduces the hours of over temperature, mostly the hours above 27 degrees.

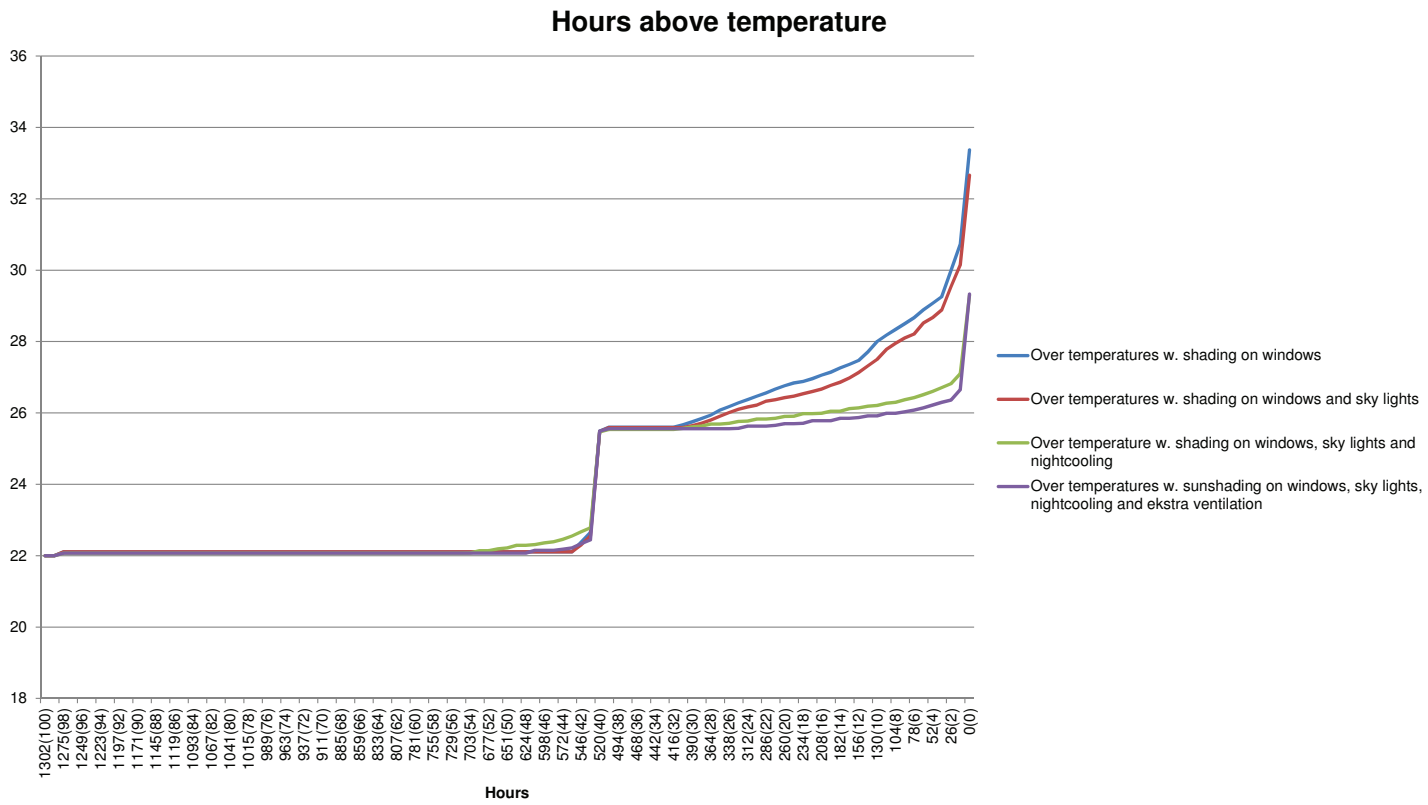
To reduce the over temperatures even more, initiatives must be made. As seen on the first iteration the thermal mass gets heated and cannot accumulate as much heating in the end of the week according to the start of the week. To enhance the thermal mass' heat accumulation night cooling



Ill. 154 Thermal zone 3 daily review second iteration

is added. Night cooling will consist of natural ventilation outside the day schedule, to cool down the building with extra ventilation. As seen on the scheme the over temperatures are slightly reduced. There is now only 195 hours above 26 degrees and 13 hours above 27 degrees. This means the first rule of the thermal indoor environment is fulfilled.

To reach the necessary goal of having less than 100 hours 26 degrees, another active solution must be made. More ventilation is added to the thermal zone to make a quicker air change rate in the zone. This step results in 91 hours above 26 degrees and 0 hours above 27 degrees as seen in the scheme.

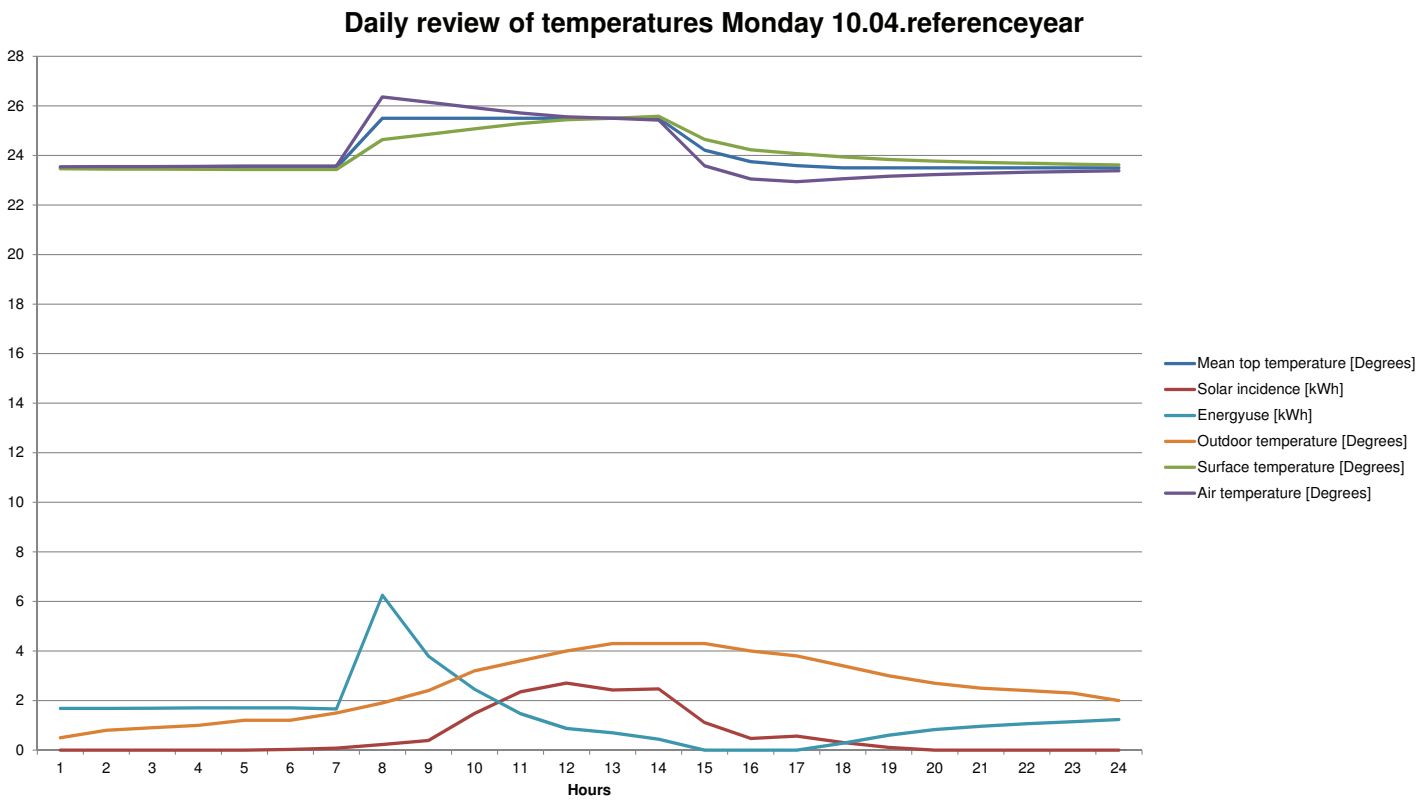


Ill. 155 Thermal zone 3 over temperatures, initiatives

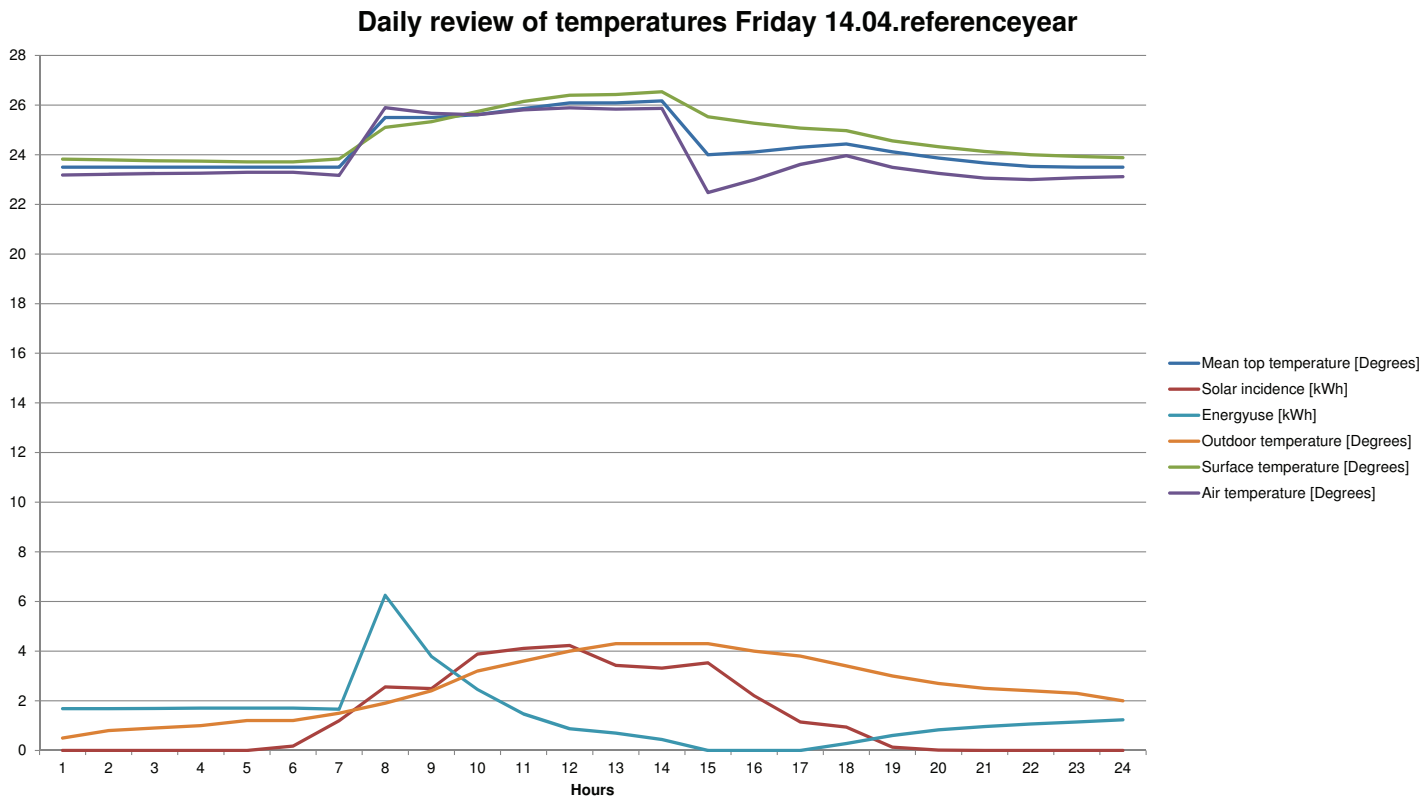
Bsim data Version 13 Sunshade and nightcooling heating outside daytime Ekstra ventilation 0,9 -> 1,8 m3/s	Overtemperatur 9 to 15 [Hours > 26]	Overtemperatur 9 to 15 [Hours > 27]	Energy use Yearly [kW]	Energy use Yearly [kW/m2]	Energy from sun Yearly [kW]
T3	91	0	8650	17,3	2
Total			8650	17,3	2

Ill. 156 Thermal zone 3 data last iteration

At last the surface temperatures and the air temperatures are calculated to see If the temperatures are still within a decent range, and it is +/- 1 degree from the optimum temperature at 25.5 degrees monday morning at 9 PM, and improves as the room gets heated during the day of internal and external heat load.



Ill. 157 Thermal zone 3 daily review last iteration



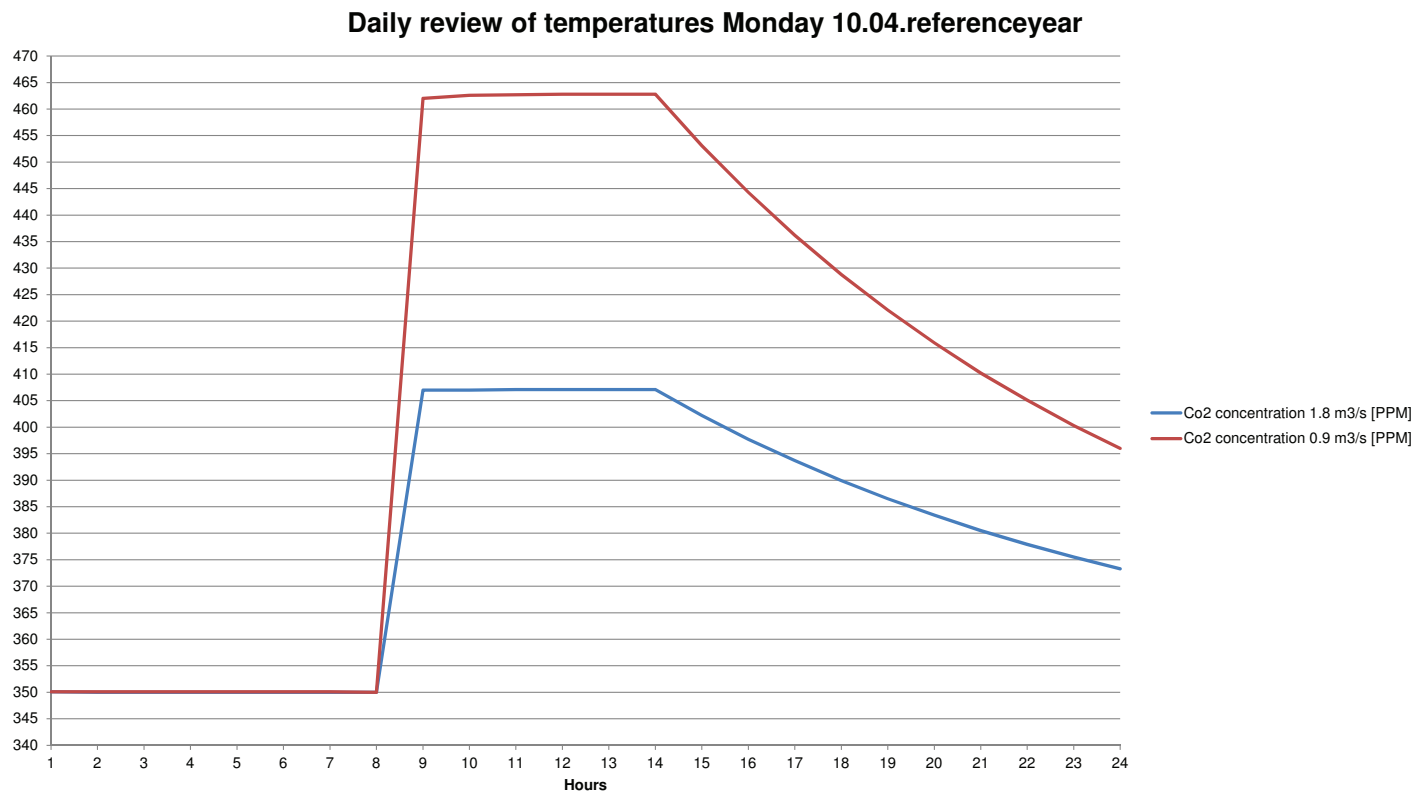
Ill. 158 Thermal zone 3 daily review last iteration

Conclusion

The indoor environment is now tested and verified. The over temperatures are handled to exceed the goals of 100 hours above 26 degrees and 25 hours above 27 degrees. Furthermore are the temperature differences between surface and air in a range of the acceptable differences of 1 degree.

The most extensive initiatives were to apply exterior solar shading and adding night cooling in regards to reduce over temperatures and the increase of ventilation is used to reach the goal at last.

By doing these initiatives the atmospheric indoor environment becomes good aswell.



Ill. 159 Thermal zone 3 Co_2 concentration

Conclusion

During an aesthetic and technical process the functionality, light, temperature differences, over temperatures, and energycalculations have been investigated.

The aesthetics of creating a unity, that is built from the same important means of creating a calm and simple composition has been solved both during the facade and the roof structures. Furthermore the entities gets a distance to make sure the entity is more of a private space, and as one moves closer to the main entrance, the spaces becomes more and more public.

The surroundings that consists of having gardens according to the activity has been solved, to enhance the neighbouring activities inside the building. Here there is a gradient from private to public, since there is a private sensing garden that both distances the common facilities but also creates recognizable views, to improve the navigation throug the building.

The interior has been placed according to the facade, and the facade has afterwards been reworked to fit the interior. Desktops that are to be used during the day has a daylightfactor on about 3%, which fulfills the Building Regulations 2020 requirements. At the same time the building does not fulfill the energy requirements of 2020, but it is assumed to be solved due to nightcooling and sufficient exterior sun shading. A room is tested according to the indoor environmental conditions - both atmospheric and thermal indoor environment.

The thermal indoor environment has been tested according to surface temperatures and air temperatures inside the worst case scenario. Due to too high differences in surface temperature and air temperature heating outside daytime was added, to maintain the temperature, and keep a more consistent environment. The calculation shows a temperature difference on about 1 degree from the optimum temperature.

The overtemperatures were tested, and several initiatives, were made to lower the hours above 26 and 27 degrees. Herein external sunshading, nightcooling and extra ventilation. The zone reached the goal to have 91 hours above 26 degrees and 0 hours above 27 degrees. This was the worst case scenario, and it is therefore assumed the rest of the zones can be solved by the same means.

Presentation

This presentation aims to describe the building design and which initiatives there have been made drawing inspiration from the program, the analysis phase and the process. The project idea was to design a school which could provide a safety zone for the scholars and create a community which adapts to both individual and social offers. The scholars suffer from a variety of different handicaps which has been taken into account throughout the whole process and the initiatives draws inspiration from “Universal Design” and “Helende Arkitektur”.

Reading guide

The presentation should be read as the more aesthetic and functional principles first, where the technical parameter is to be presented as the last subject. A conclusion and reflection upon the project will follow the technical solutions as an end of the presentation.

Contents

Ill. 160 Sketch

Site - Master plan

The Masterplan shows how the eight therapy gardens have been placed around the building surrounding it like a green carpet which creates a sense of security when entering the premises. The main entrance is placed towards north where a roundabout, made for both parking and driving through without prohibiting other drivers. It is meant for the scholars and the primary entrance. These initiatives have been made to ensure that the traffic can pass through quickly in the morning when the scholars arrive. It is also important for some of the scholars suffering from physical handicaps to have a short distance to the school. Upon arrival they travel through the Cultural Garden under a pergola towards the schools entrance.

A secondary entrance is placed towards west. This is primarily meant for the staff since they arrive, unlike the scholars, in either their own car or bicycle. The parking area has gravel pavement and asphalt and has two entrances to ensure the traffic travels easily through. It has large trees and bushes surrounding the cars and screening the building from the outside traffic. This has been done to ensure a sense of calmness around the building and in the therapy gardens.

In between the building components is the therapy gardens placed so that they have their own little private area to able them to appear and be used as individual spaces. The scholars can use the garden which they prefer or could benefit from, depending on the specific stimulation, the individual gardens can offer.

The design draws inspiration from the surrounding context which is primarily single-family housing with small unique gardens and a diverse expression with different housing typologies.

Ill. 161 Reference photo to parkingspot

Ill. 162 Reference photo to trees by kiss & ride

Ill. 163 Master plan

Plan

The plan is made with no elevation and has only even surfaces with bright linoleum flooring to accommodate the walk restrained and wheelchair users. The building is centered on a central lane which is in direct connection to the practical workshops to create an environment with few inter-connections in terms of making better way-finding abilities to assist vision restrained and growth restrained individuals. There has also been made four Sensing Garden in between the group entities and the central lane to create a recollecting image in connection to each of the four groups. The central lane is meant as a common space which could encourage spontaneous meetings and social interaction between the scholars when traveling through to class. The cafeteria is placed in the center as the heart of the school where all of the scholars can meet and interact with one another. The entrance is also situated in this common area which also works as a distributor. The whole complex has drawn inspiration from “Universal Design”. One initiative have been done making the plan parallel around a central axis; this means the rooms in the group entities are identical. This has been done to accommodate a flexible solution that takes a change in number of scholars each year in to account, which also ensures the abilitiy to swap places only by changing the furniture. To make sure that everyone are able to move around freely no matter their physical handicaps, there are always possibilities of turning around in a wheelchair with a minimum turning radius of 1,7 m in all the rooms. All of the doors are 1,07 m wide and are sliding doors which can open with either a button next to it, to accommodate hand restrained or a button specially made for wheelchair users, which is situated just above the floor and can be pressed by a foot or with the wheelchair itself.

The scholars have been divided into four different groups in accordance to their requirements. In these groups there are group rooms, classroom and individual workstations in accordance to the individuals who are to use them. In the center of each group there is a semiprivate common area, this is to create an opportunity for the scholars from each group to connect at recess and to make sure that they benefit from being among equals. The groups towards north are group A and group U and the groups towards south are group B and group E, D, Q. this has been done in accordance to energy consumption.

When walking towards the practical workshop from a group entity, toilet facilities appear. They have been placed at each end of the building in close relation to both the practical workshop and the groups to ensure a short distance to accommodate walk restrain and to create an organization which is similar at each end of the premises for recollection purposes. Right next to them are a storage room and a technical room at each end which is to decrease the size of the ventilation tubes throughout the building.

Ill. 164 Reference photo of door contacts

Ill. 165 Reference photo of sensing garden

Ill. 166 Reference photo of text writing

Ill. 167 Plan solution

Ill. XXX Plan solutoin

Facades

The facades are designed to have a strong visual connection to the context. The complex is designed with an expression to have small entities symbolizing the diversity of the people and the use in the school. The design draws inspiration from the family-house typology with its pitched roofs and small gardens.

Ill. 168 Reference photo of exterior facade material

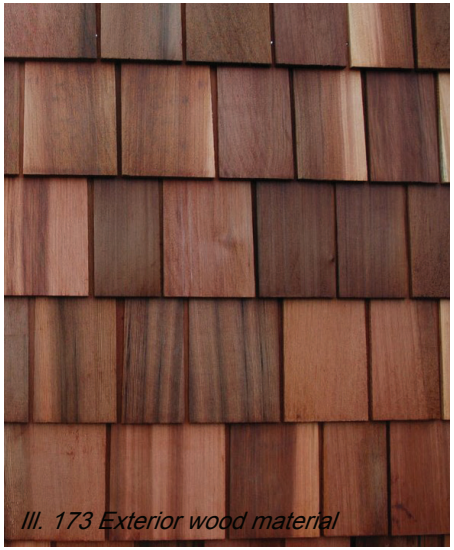
Ill. 169 Reference photo of exterior facade material

Ill. 170 North facade

Ill. 171 South facade

The materials that is used draws inspiration from nordic architecture with the use of naturalistic materials. To indicate the diversity within the house different materials have been used. The group entities where the scholars have their class lessons and their workstations are made in wood, which has been impregnated with an ecological method making the wood chestnut colored to give them a warm and homey expression. The practical workshops are in grey toned brick which is in contrast to group entities in order to inflict a visual connection to the different parts of the complex from the outside. The materials are naturalistic in order for the building to be tucked in between the greenery from the gardens. The solarshading do not inflict the facades. The solar shading is thought as a simple exterior blind in the window frame, that can make sure the solar heat gain does not create over temperatures during the summer period.

Ill. 172 Brick material



Ill. 173 Exterior wood material

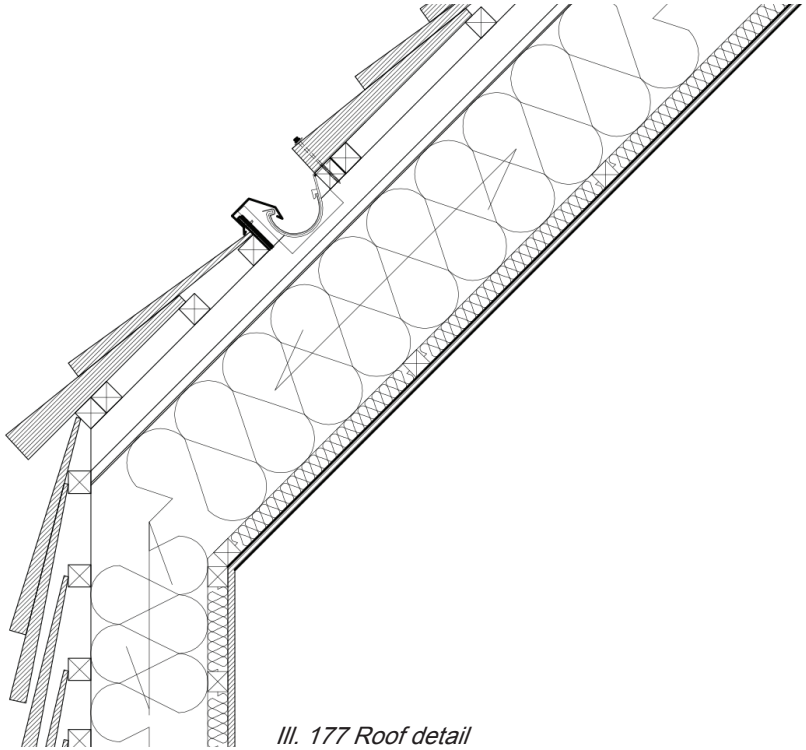
Ill. 174 Exterior blinds

Ill. 175 East facade

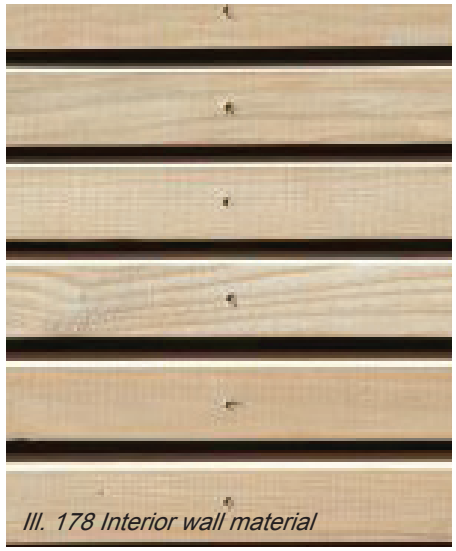
Ill. 176 West facade

Sections & Details

The sections show how the materials from the outside are reflected on the inside. In the group entities the material is wood cladding with a lighter tone, and a more soft expression compared to the wood on the outside, to give a better experience of the interior. In the practical workshops the material is brick on the inside when it is an outer wall deifining the room. When it is an interior wall it is the same wood material as in the group entities. The naturalistic materials are meant to create a calm expression which draws inspiration from nature and is in close contact with the outdoor gardens and the atmosphere within them.



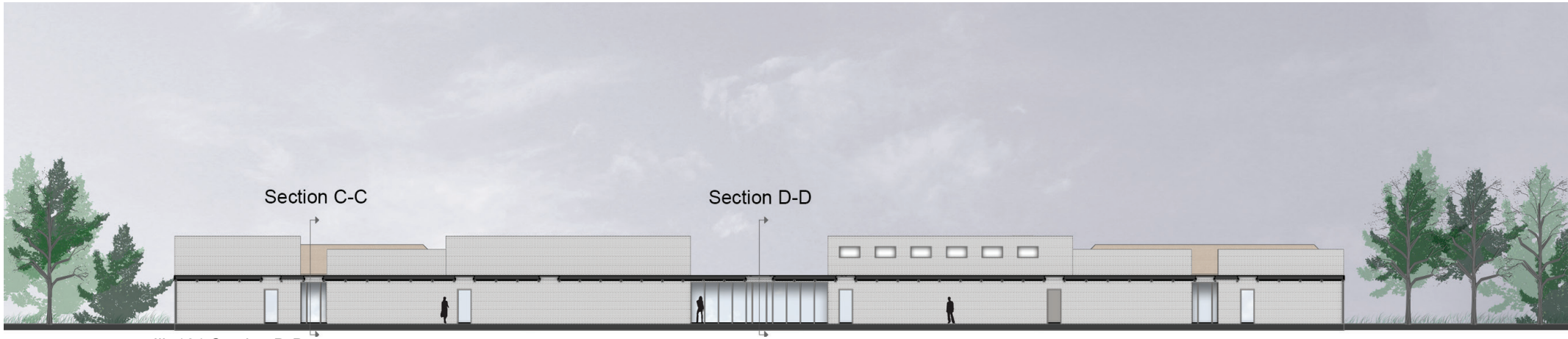
Ill. 177 Roof detail



Ill. 178 Interior wall material

Ill. 179 Exterior gutter in facade

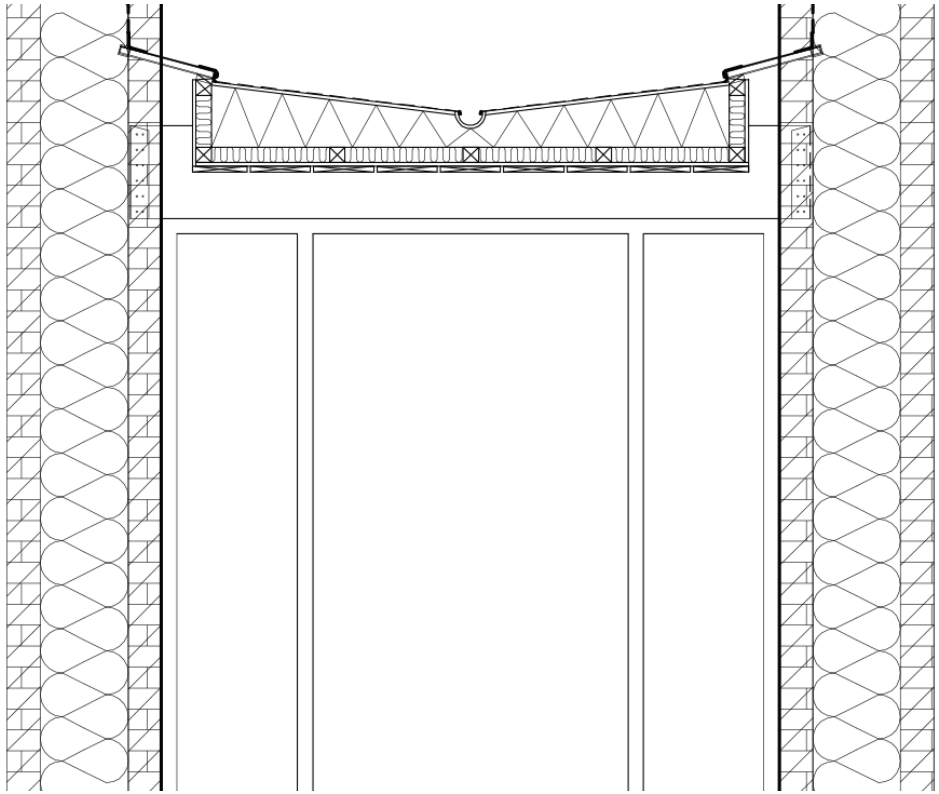
Ill. 180 Section C-C



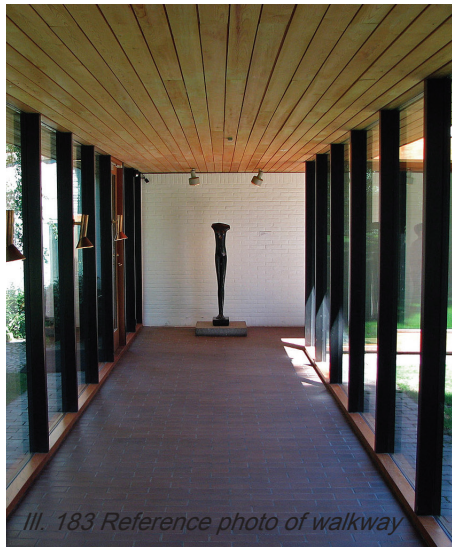
Ill. 181 Section D-D

The contrast between the materials can create a visual connection and help the visual restrained to better move around and find their way inside and outside the building. Furthermore there have been made skylight at each inter-connection to create a contrast in light to indicate a change and a possibility to change direction. This has been made to create an attention field with light instead of tactility change in the flooring to not conflict with walk restrain or people in wheelchairs ability to move at ease. To lit up the walkway in general a small light slit have been made on each side of the wall, which able light to penetrated down through the walkway and thus emphasizing the tactility of the brick material.

The wooden interior is made as wooden boards with small spacing in between, as seen on the detail of the walkway in the ceiling. This has been done to ensure good acoustics and assist the hearing restrained. This initiative both breaks the sound rays and implements acoustic boards underneath.

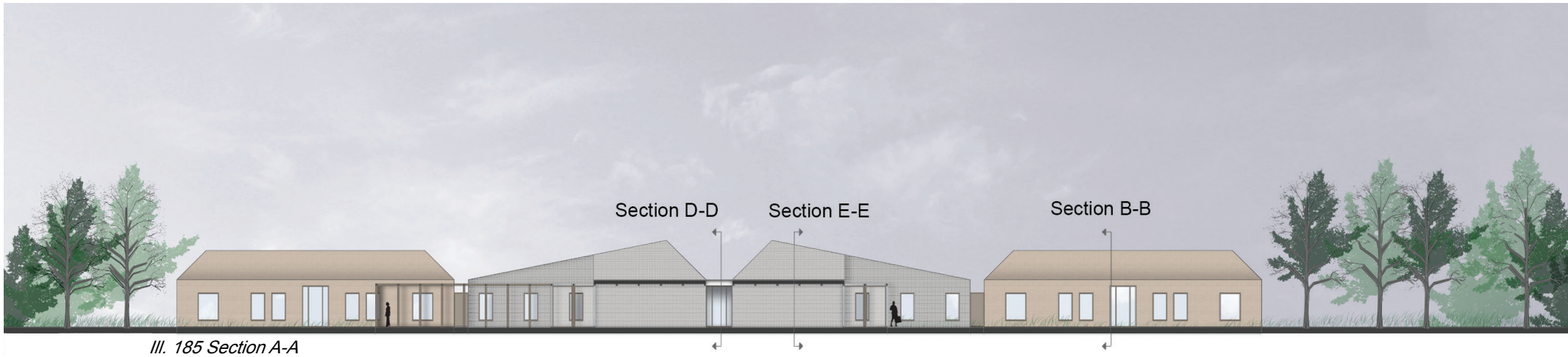


Ill. 182 Walkway detail



Ill. 183 Reference photo of walkway

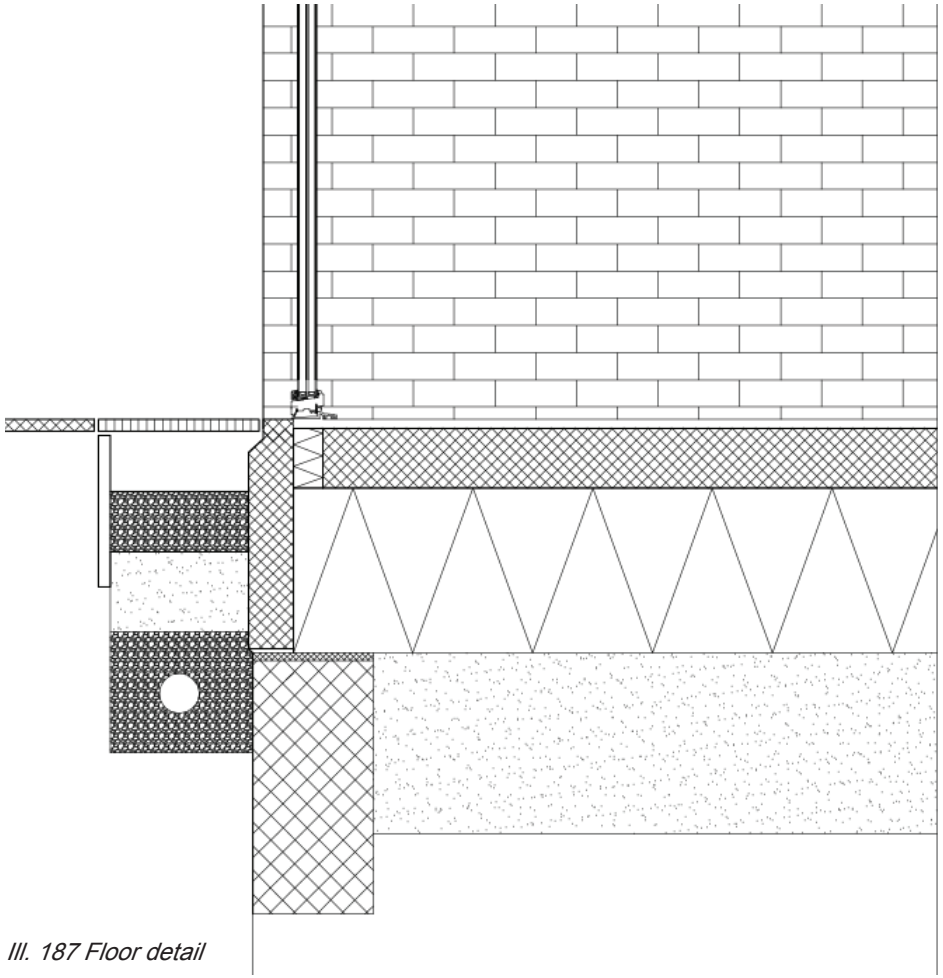
Ill. 184 Reference photo of interior walls and acustic boards



Ill. 185 Section A-A

Ill. 186 Section B-B

To ensure a “Universal Design” solution have all of the exits and entrances been made level free to decrease nervousness for walk restrained and people in wheel-chair who have to enter.



Ill. 187 Floor detail

Ill. 188 Reference photo of brick meeting wood

Ill. 189 Reference photo of level free entrance

Ill. 190 Section E-E

Main entrance

Upon arrival the scholars are met with a composition which opens up and invites them in. The trees in front of the roundabout are open at the tree trunks and closed and overgrown at the tree crowns making merely the entrance visible and sheltering the building tucked neatly in-between the vegetation.

Ill. 191 Main entrance

Parking, secondary entrance

The parking area is embedded in greenery sheltering the building which pecks through the trees emphasizing the colors with it naturalistic materials. The contrast between the timber material and the brickwork makes the building component stand out on their own and create a connection to the context with single family-housing and coherence between the diverse functionality within.

Ill. 192 Secondary entrance

The living garden

In the Living Garden the trees and bushes are home for insects and small animals. The playful garden is slightly visible with its flower beds which able all to partake in growing plant and experimenting with small science projects. The social garden appears as well in connection to the cafeteria. This makes it possible to walk outside and enjoy lunch but also to grow and enjoy herbs and vegetables from either the small green houses or the flower beds in the Playful Garden.

Ill. 193 Living garden

The thoughtful garden

The thoughtful garden is in close connection to one of the group entities which makes it possible for them to easy access the garden. The garden is full of different plant with different colors which able the mind to drift away in wonder.

Ill. 194 The thoughtful garden

Sensing garden

The walk from the central lane and the practical workshop towards the group entities reveals a Sensing Garden which has its own unique expression for each of the group entities. The Sensing Garden is based on strong elements in nature and draws inspiration from Japanese gardens with stone, vegetation and water emphasizing nature's tactility and effects the senses.

Ill. 195 Sensing garden

Walkways

In the walkways light is traveling down from above visualizing and emphasizing the tactility of the brick material. The ceiling reveals timber beams which are creating a rhythm when traveling through. In between the timber beams are there wooden boards which indicate flow and give direction.

Ill. 196 Walkways

Music

In the practical workshop the material is mostly brickwork to create coherence to the outside. It is brick when the wall is an outer wall when it is merely an interior wall or ceiling the material is wooden boards. The wooden boards on the ceiling are resting lightly upon the solid robust brick wall.

Ill. 197 Music interior

Group entities

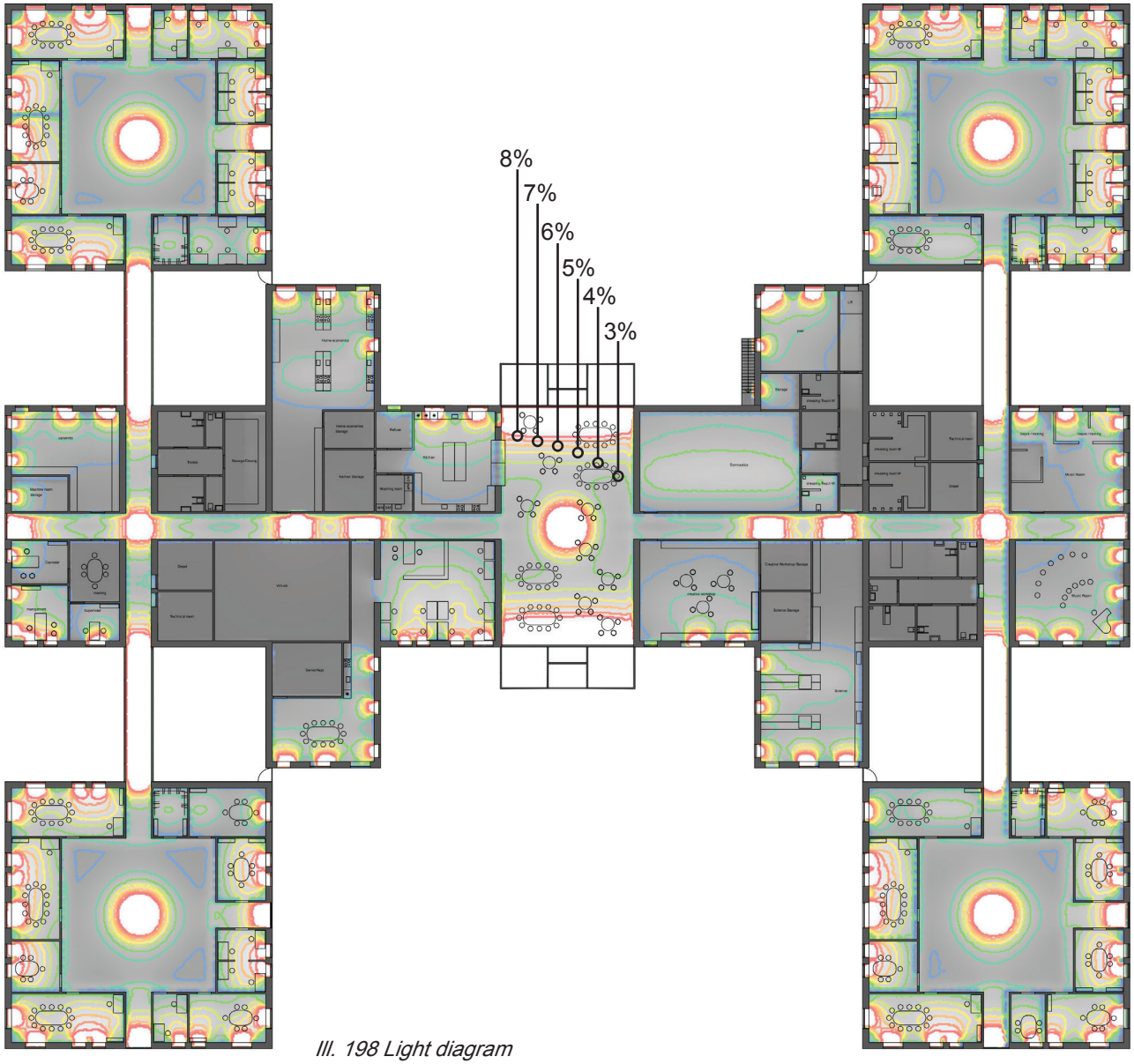
In the group entities the material is only wooden boards. This is to create a warm and peaceful atmosphere with a homey feel to create a safety zone where the scholars can enjoy the common facilities among equals and receive class lesson or work in groups or individually in a calm environment with view towards the gardens outside.

Ill. 197 Group entities

Light

To create a sufficient level of light, the facade has been optimized according to a daylightfactor of 3% on the various workstations. The contrasts between the options in the walkways also works very well according to the calculated daylightfactor. The skylights are placed above the entrances to the common functions, and there by creates the contrasts between . These contrasts are also used in the walkways between the entities and the common functions, that in itself creates a visual barrier to a more of a private area in the entities. The individual workstations and grouprooms has a great daylightfactor, and have windows in more directions to create diverse light conditions.

The skylights are primarily used where there is not a sufficient level of light. They are placed in a system according to the facade, to create a holistic exterior expression.



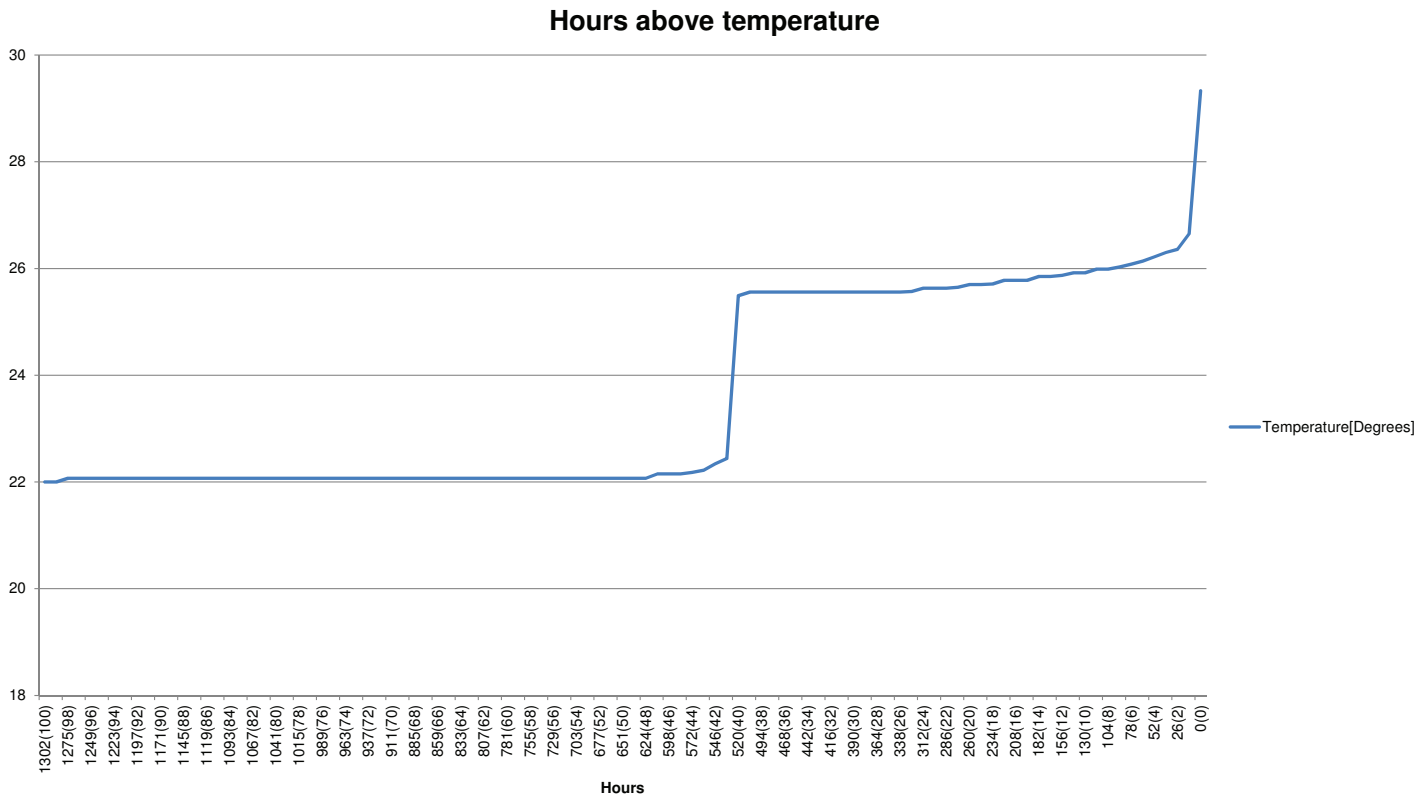
Ill. 198 Light diagram

Over temperatures

The over temperatures has been solved, by creating a facade with exterior solar-shading.
Beside that nightcooling is used during the summer, where the construction will gain more heat than the material has capacity for. This nightcooling happens outside the day schedule from 9-15. At last extra ventilation has been added to create a greater airchange rate in the room. This helps when the temperatures outside is not above 26 degrees.

The building performs 91 hours above 26 degrees, and 0 hours above 27 degrees - this fulfills the Building regulations 2020. The data is taken from calculation of the worst case scenario in the building; Thermal zone 3.

III. 199 Thermal zone



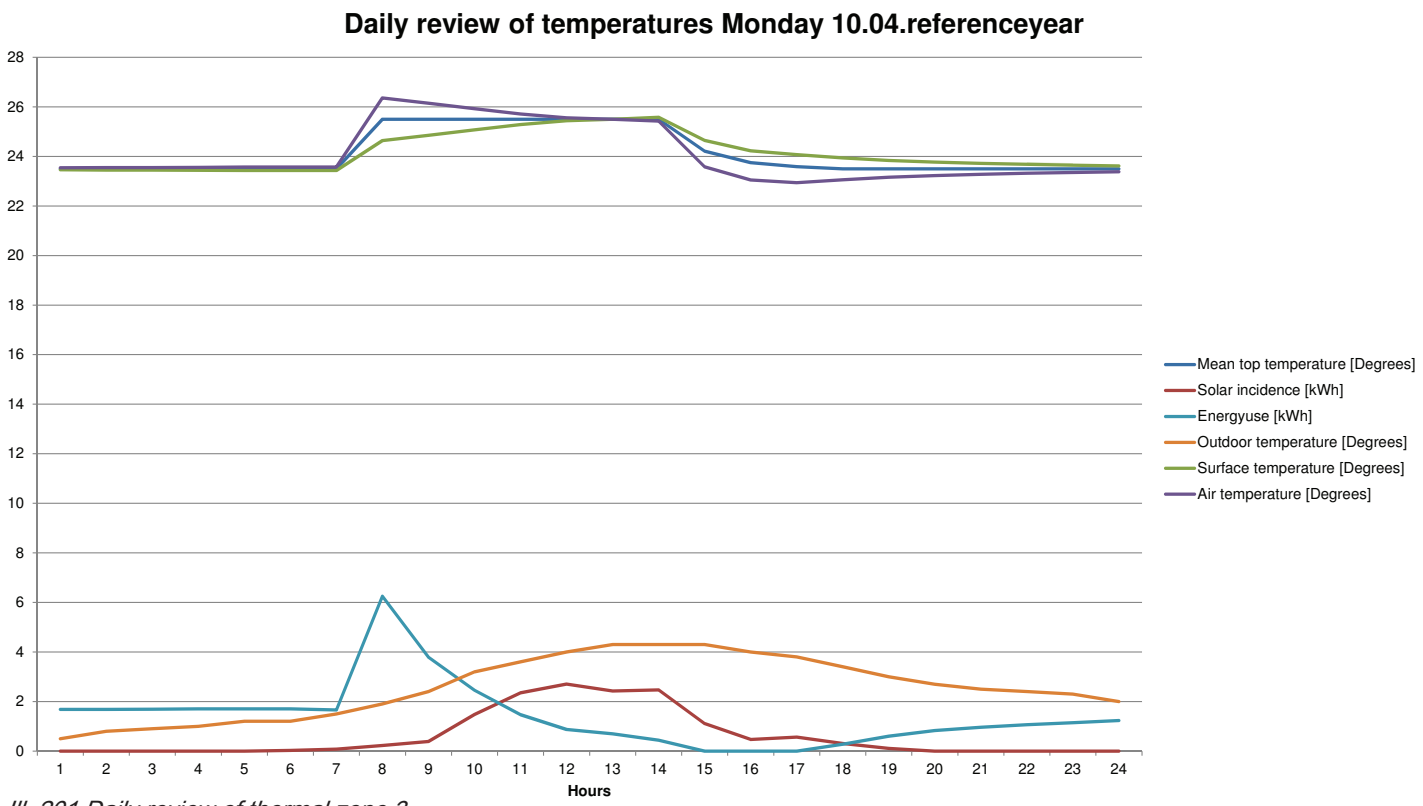
III. 200 Over temperatures

Temperature differences

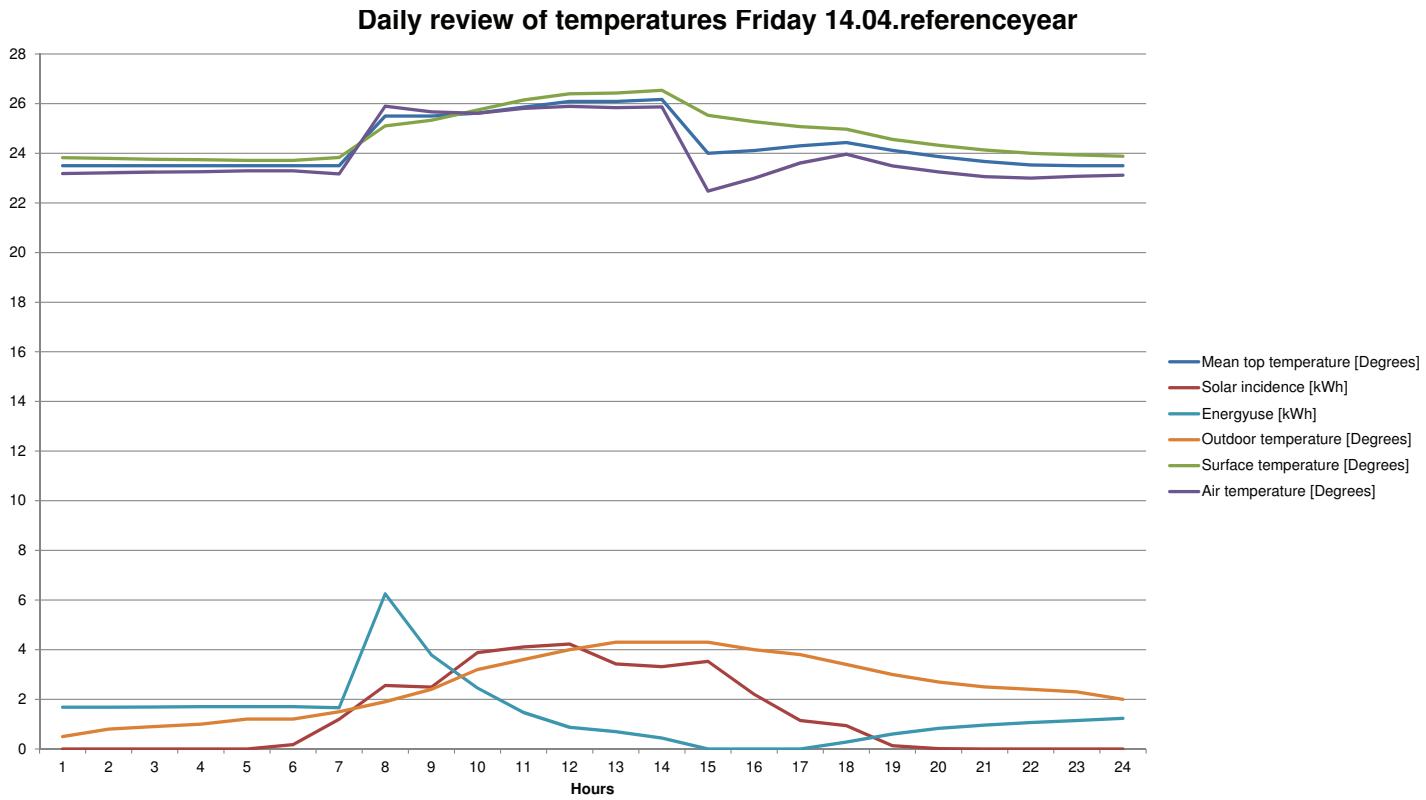
Due to the multihandicaped scholars temperature differences between the air and surfaces are to be minimized.
To make the heating continue outside the day schedule with a 2 degrees lower temperature, the surfaces will not cool down during the night in winter. Due to the little difference the optimal temperature will appear earlier, and the temperature differences, never exceed the category A level of having +/- 1 degree.

As seen the critical part is monday morning, where the people load, and equipment contributions is gone during the weekend, and the temperature therefore falls because of the longer period without use.

At Friday where the building has been used all the week, the temperature differences are almost gone.



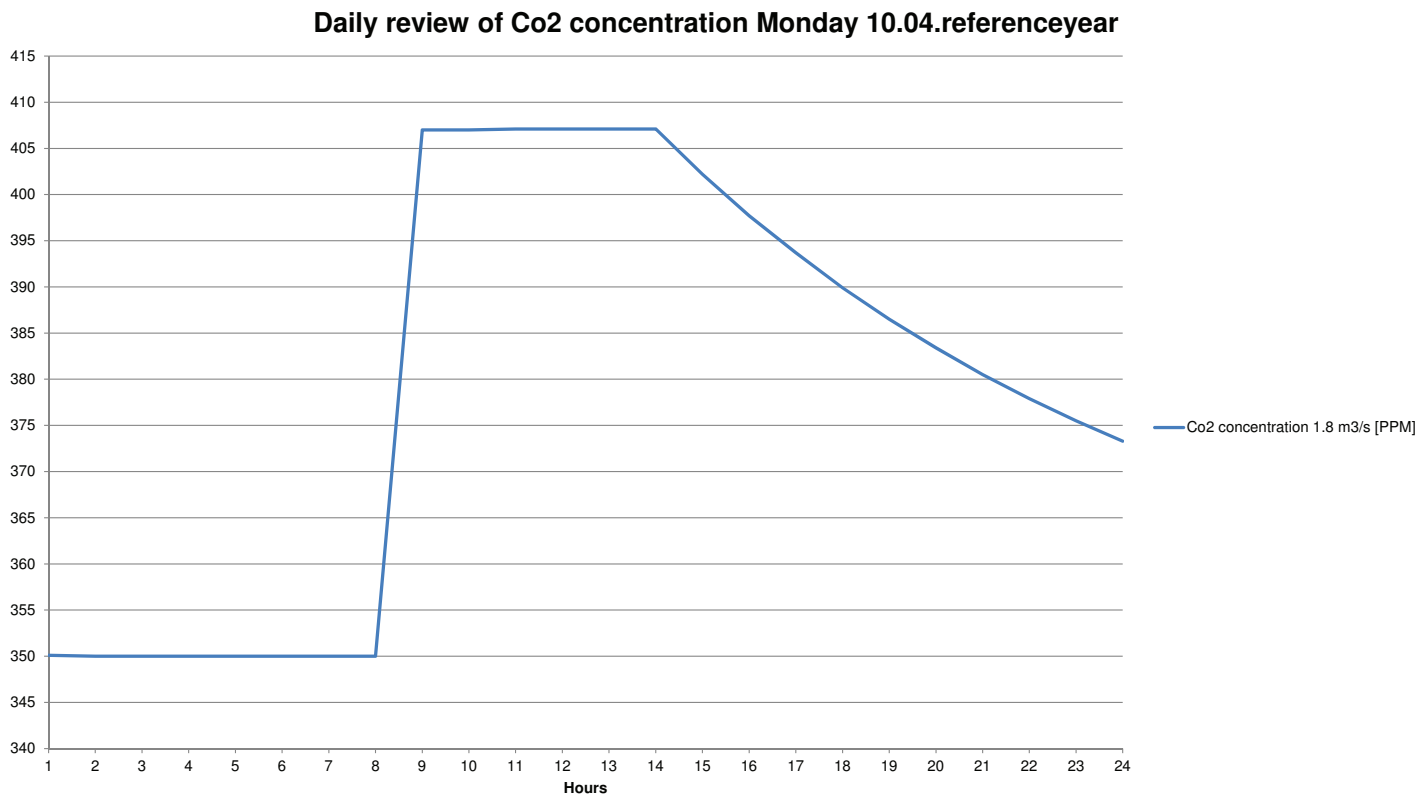
Ill. 201 Daily review of thermal zone 3



Ill. 202 Daily review of thermal zone 3

Co_2-Concentration

Due to the barely hight rate of ventilation the concentration of Co_2 meets a balance on 407 ppm during the daytime which ensures a good atmospheric indoor environment to maintain health and comfort.



Ill. 203 Daily review of Co_2 concentration

Energy calculations

The goal was to reach the Building Regulations 2020 requirements. Solely by the use of passive means the energy frame of 2020 has been reached, and to create a building that has as little energy consumption as possible, active energy contributions has been added. The active means are added solely according to the architecture and aesthetics.
These solar panels are placed inside the roofs on the south facade, where they cannot be seen. They are placed in an optimal angle of 45 degrees, according to the roof structure in the entities.

With the active energy solution the building consumes 13.1 kWh/m^2, which fulfills the Building Regulations 2020 requirements by far.

As the energycalculations takes energy factors into account another energy calculations in BSim were made to make a more realistic view of the energy consumption. This model gives a more precise due to the more specific schedules and data. Here the building uses 32.2 kWh/m^2.

BR 2010	[kWh/m2]
Energyframe	71.7
Energydemands	32.1
BR2015	
Energyframe	41.3
Energydemands	27.8
BR2020	
Energyframe	25.0
Energydemands	20.5
Energy contribution	
Heating	21.9
Power for service	4.2
Lighting power	3.1
Ventilators power	1.0
Energy demands (netto)	
Heating	16.5
Hot domestic water	5.3
Cooling	0
Loss from installations	0
Loss from hot domestic w	0

Ill. 204 Be10 calc. without photovoltaics

BR 2010	[kWh/m2]
Energyframe	71.7
Energydemands	21.9
BR2015	
Energyframe	41.3
Energydemands	17.5
BR2020	
Energyframe	25.0
Energydemands	13.1
Energy contribution	
Heating	21.9
Power for service	4.2
Lighting power	3.1
Ventilators power	1.0
Energy demands (netto)	
Heating	16.5
Hot domestic water	5.3
Cooling	0
Loss from installations	0
Loss from hot domestic w	0
Photovoltaics	4.1

Ill. 205 Be10 calc. with photovoltaics

Bsim calculations	[kWh/m2]
BR2020	
Energyframe	25.0
Demands without primal factors	
Heating	20.9
Lighting power	0.8
Fan power	5.1
Hot domestic water	5.3
Power for the building	4.2
Hot domestic water	5.3
Energy contribution	
Photovoltaics 160m2	4.1
Total energy demands	32.2

Ill. 206 BSim calc. with photovoltaics

Conclusion

The project has been undergoing several processes to complete a holistic design. Through initial analysis of the more general subjects of creating a school for disabled scholars, a problem statement was made. This statement says as the following:

How is it possible to create an educational institution for a wide spread of scholars, that fulfils the special requirements each individual user may demand; and still create functional and aesthetic architecture that is social and environmental sustainable by using the Integrated Design Process?

The problem statement leads to a deeper analysis of the target group. The target group consists of various scholars who suffers from a wide spread of disabilities. This makes all of them particular important to take into consideration when designing a new school specially made for them.

To understand what necessities each individual has, it was important to look at, what can be implemented at the desktop, and what can be taken account for in the architectural solution. Every scholar has today his/her own individual space, with different kind of technologies connected to this desktop. It was therefore a general guideline to create a universal building, which had the possibilities to contain each individual's requirements at every workstation to create a flexible solution which could adapt to a change in number of students or in environment.

Suffering from a disability has a great effect on ones well-being. Since all from the target group has a kind of disabilities, it was investigated, how to optimize the individuals surroundings to shape a safe and calm learning environment.

There are several different parameters that affect an individual's well-being, here in; daylight, temperature and physical surroundings in general have great effects on the human body.

But as a good way of providing a better environment according to safety, calmness, comfort, mood, distress, anxiety, distraction and concentration, nature is a good solution to meet the wide spread of feelings in a positive way. Therefore nature was further investigated according to; how to create surroundings, that enhances these matters. Herein Nordic architecture, therapy gardens and sensing gardens were further investigated. In addition technical parameters have been taken into consideration. The building was to be designed for the building regulations of 2020 aspects and for category A of indoor environment. This is to able good daylight factors, temperature differences and energy requirements.

Ill. 207 Music

Therefore the building is based on principals from all these analysis, to create a holistic design that has taken the individuals' needs into account such environmental and social sustainability will be present.

The concept of the building was to create a universal building, which draws inspiration from Nordic architecture that further draws inspiration in the surrounding society. The building has therefore taken inspiration in the surrounding garden city, and how they use the outdoor spaces, to create private and intimate spaces.

The functionality of the house is closely connected to a universal, flexible and calm design. It is important for the individual that suffers from a disability to have the opportunity to choose what kind of work environment is best suited. There have been created private spaces within the group entities, where some have their individual workstations and some have their

smaller group rooms. This is the most private space of the building, and as one walks towards the cafeteria, the spaces become more and more common. On the way to the most public common area, one interacts with the outdoor nature between the public facilities and the group entities. There is furthermore access to a private outdoor garden. So both interior and exterior spaces have the gradient of privacy. The group entities and the common facilities are pulled away from each other to give a further sense of privacy when one is in the private spaces. This furthermore gives the possibility to use the common facilities outside the day schedules without using the private spaces in the entities.

The walkways between the numerous functions are created to give an experience of tactility and light in terms of the small skylight between the roof and the brick wall.
The composition of the plan solution furthermore gives the opportunity to use contrasts as navigation through the walkways. The skylights, therefore visualize where there is an option to change direction or go into a room. This gives a diverse and expressive aesthetical experience, which stimulates the individual in a positive way.
The windows in the facades are generally designed in regards to daylight, solar heat gain, and the outdoor expression. Due to the horizontal design, vertical window are chosen. This means the facades are made in collaboration between energy consumption, functionality and aesthetics. The energy calculations were therefore a part of the process, which also results in a building that fulfills the building regulations 2020 requirements with merely passive means.
The active energy contribution is placed such it is not visible on the facades, and it has therefore never been a goal to reach 0 kWh/m^2 but to create a building with as low energy consumption as possible without compromising the architectural expression.
The temperature differences in the thermal zones have been adjusted according to schedules, heating capacity and windows. This has led to a very steady indoor environment of little variations, which is good according to the ones sitting still and not being able to move on their own.
Overall the building has been designed according to the individuals needs both in terms of indoor environment and aesthetics. The target group's needs has therefore been the center of the design during the whole process, but without compromising the wish to create a holistic building in terms of plan aesthetics, light aesthetics, expressions, experiences and materials.

Reflection

The project can still be improved in numerous ways. Many iterations has been made to improve the expression and its performance in regards to daylightfactor, energy consumption, over temperatures. And from the first sketch it has already changed shapes many times.
The project can still be complemented by more detailed solutions, and undergo several more iterations than it has already gone through to create a more holistic and finished project.
To understand the process for such building it is important to take into account that every factor is connected to each other.
Light conditions is one of the things that could be investigated further, and detail it in such way, that every workspace get a proper daylightfactor on 3%. As it seems now there are some who face challenges to reach a daylightfactor on 3%. This inflicts the work with the facade expression and the energy consumption, and are therefore to be investigated simoultaneously, as the light conditions can be improved.
Detailing the building further would give the chance of creating a more holistic design. There were a focus upon creating parallel lines, and these lines could be improved in a way such a constructiongrid could appear. This would give a better rythm in the construction, and the rythm would furthermore be visualized by the visible beams in the walkways.
The walkways which are alle connected to the heart and the most public area of the building: The cafeteria, can appear fairly long to a restrained person, and this will bring the flow in the building into discussion.
Will the cafeteria be the heart, or will the building by time get more and more open to each entity, such scholars will enter the entity and not the cafeteria to move further into the building? The many door opening is of course to make sure the exits are close, and the connection to the outdoor nature will appear with short distances.
The many openings further inflict the indoor environment, that must be kept stable according to the more fragile scholars inside. This of course has something to do with how the building is going to be used, but maybe more weather porches are needed, since cold air travel great distances. Especially in the entities where there are two direct exits to the outdoor gardens more weather porches might be an option. The entities is not the only place, where weather porches might be added. There might be a need for them in each end of the central lane. Even though they are secondary entrances, they will get used by the staff, and maybe also the scholars.
Weather porches is not the only doors that might be a necessity, also fire doors could be another point of view to implement in further iterations of the building.
The building is fairly large, but to cut off the common areas with doors, would be crucial to the idea of creating a greater community with coincidental interaction in the walkways, and common areas.

Only the latest iterations in this project were done with more precise and productive BSim calculations on the indoor environment. These calculations could be used for further improvements of the indoor environment.
Many results of how the indoor temperatures acted accordingly to the heating strategy were extracted during the last iteration. Therefore the indoor environment could have more benefit by using cooling coils, thermal masses, optimized the heating schedules and so on. All these factors affects the indoor environment in a positive or negative way, and could be important to considerate to reduce air speeds, temperature differences and noise.
The ventilation is not precisely detailed, only guiding calculations of size has been made. Therefore this could affect the size of the roof thikness. But as two greater technical rooms are planned in the current building it is assumed that it should be sufficient to contain the necessary ventilation units.

Overall the building still contain some technical challenges that should be more detailed and solved further in the planning of the design, but the assumptions made, from general calculations and experiences, a good foundation of further projecting has been made.
The architecture and the aesthetics has many good characteristics, and many ideas, from the research material. Here in there are still more detailing to be made for a furthergoing process.
The functionality of the building has been solved by the use of research material about the target group. Every individual has been taken into consideration in the project, which means “Universal Design” has been made.

This project is made as a fusion of aesthetics, functionality and technical has created a foundation for the further works has been made to accomodate the needs of the user, without compromising on either aesthetics or functionality.

Appendix

The appendixes contains the secondary data that is not included in the report. Furthermore the initiative project description appears in the appendix.

Reading guide

The appendixes should be written as secondary data. Only Appendix B and C have a connection to each other.

Contents

Appendix A

The intelligent classroom is the foundation of the project idea. This project is a real ongoing project.

AALBORG KOMMUNE

Projekt
Det intelligente
klasseværelse

Det intelligente klasseværelse

som ramme for undervisning til fremme af kompetencer og selvstændighed for elever med svære funktionsnedsættelser

VUK Aalborg 2011

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Det intelligente klasseværelse

som ramme for undervisning til fremme af kompetencer og selvstændighed for elever med svære funktionsnedsættelser

Projekt Det Intelligente Klasseværelse tager udgangspunkt i de elever med svære funktionsnedsættelser, der modtager undervisning i gruppe A på VUK i Aalborg Kommune.

Aalborg Kommune bygger sin børne- unge og handicappolitik på FN's Børnekonvention og FN's Handicapkonvention. Politikken skal sikre indhold og kvalitet i børn og unges liv med respekt for den løbende udvikling af evner hos børn og unge med handicap og retten til at bevare identiteten hos børn og unge med handicaps.
I projekt Det intelligente klasseværelse arbejdes der i den forståelsesramme for handicapsyn, som WHO fastlagde i 1980, hvor fokus flyttes fra individets fysiologiske forudsætninger - til samfundets sociale og fysiske barrierer, som definerende for handicap og individets udfoldelsesmuligheder[1].

Undervisningen på VUK er under lovgivningen om STU – Særlig tilrettelagt undervisning for unge.
Eleverne er i gruppe A er såvel kørestolsbrugere som gående, der anvender andre hjælpemidler for at bevæge sig. Få af elever har et verbalt sprog og kommunikerer derfor via alternative kommunikationsredskaber. Deres fysiske og psykiske handicap bevirker, at de har svært ved selvstændigt at være opsøgende - og derved svært ved at få indflydelse på eget liv. Eleverne modtager særlig tilrettelagt undervisning, der tilrettelægges efter deres potentialer, behov og læringsstile.

Til brug for undervisningen i gruppe A er der arbejdet målrettet på at udvikle IKT baserede undervisningsmaterialer, da IKT baserede undervisningsmaterialer gør det lettere at formidle undervisningens indhold og understøtte elevernes muligheder for at lære at lære (Kommunikationsmiraklet 2008[2]). I undervisningen benyttes computere, specialudviklet software og digitale undervisningsmaterialer (Projekt Kan selv- Vil selv 2008[3]).
VUK's IKT baserede undervisningsform giver eleverne mulighed for at vise, at de kan og forstår mere, end de kan vise gennem traditionelle undervisningsmaterialer. Via specialkontakter til computere, kan eleverne ligeledes selv benytte computere og derved arbejde selvstændigt med deres undervisningsmaterialer.

VUK's undervisningsmaterialer og dets udformning er langt fremme i forhold til IKT, nytænkning og udvikling.

CEPRA (Videncenter for evaluering i praksis ved University College Nordjylland[4]) har i 2008 foretaget en praksisevaluering af effekten af VUK's IKT baserede undervisningsmaterialer, og har vurderet, at det er læringsfremmende og kvalificeret undervisningsmateriale til elever med svære funktionsnedsættelser.

De fysiske rammer matcher derimod ikke elevernes formåen i forhold til selvstændighed og kompetencer. Man kan sige, at de fysiske barrierer og udfordringer i klasseværelset hæmmer elevernes reelle muligheder for tilgængelighed og selvstændighed, hvilket betyder, at de fysiske rammer gør eleverne mere handicappede end de er.

I gruppe A's nuværende klasseværelse forefindes der er to former for hjælpemidler: Loftlift og arbejdsborde, der kan reguleres i højde.

Lyskontakter, vinduer, døre, vandhaner med mere kan kun betjenes af personalet. Lysforhold og farver på inventar understøtter ikke elevernes synshandicap (CVI). Der er intet i lokalet, der fremmer udforskning og kreativitet. Deres mulighed for bevægelse (i kørestol) er begrænset.

Disse forhold sammenholdt med, at vores elever **kan** være selvstændige og aktive, såfremt de får de rigtige rammer og udstyr, giver baggrund for et ønske om at skabe det ideelle og intelligente klasseværelse til gruppe A's elever.

Projektets mål
Målet med projekt Det intelligente klasseværelse er at bygge en unik bygning, der skal danne ramme om moderne specialundervisning for unge med svære funktionsnedsættelser.

Projektet opbygges omkring et fleksibelt nationalt videns- og implementeringscenter til mellem 10 og 20 elever. Et videns- og implementeringscenter, hvor produkter og teknologier løbende kan implementeres, testes og evalueres – således, at deres effekt kan fastlægges og vurderes indenfor fokusområderne:

- Det fysiske miljøs betydning for selvstændighed, ligeværdighed og fleksibilitet
- Samspillet mellem det fysiske miljø og brug af nyeste teknologi betydning for læring

Brug af velfærdsteknologi betydning for omkostreduceringer

Et byggeri, der bygges på baggrund af indsamlet viden om de nyeste teknologiske muligheder, materialer samt viden om det fysiske miljøs betydning skal fremmer elevernes udvikling af kompetencer og selvstændighed.

Projektet er et innovativt byggeprojekt og et fyrtårnsprojekt for Nordjylland, hvor design, højteknologi og et holistisk menneskesyn kombineres.

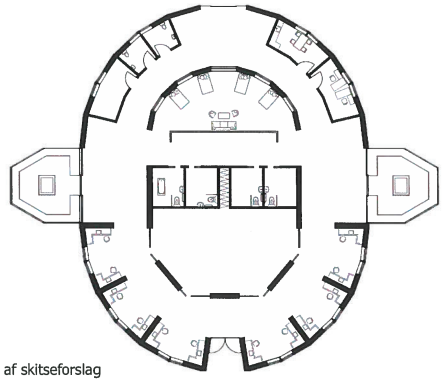
Rum
Projektets mål er, at minimere de fysiske barrierer i klasseværelset, og derved øge den funktionshæmmede elevs mulighed for tilgængelighed og selvstændighed.
Eleverne, der for størstedelens vedkommende er kørestolsbrugere, har behov for rum, der er anderledes indrettet end et rum for personer, der selv kan bevæge sig rundt uden brug af hjælpemidler.

Med moderne byggeteknikker, design og teknologiske muligheder, vil det være muligt at skabe et unikt undervisningslokale, der tager højde for følgende problemstillinger:

- Eleverne er kørestolsbrugere og har brug for meget plads til bevægelse.
- Eleverne sidder ned – hele tiden, derfor bør vinduer, kontakter og materialer placeres anderledes, hvis eleverne selv skal kunne se, nå og betjene.
- Flere af vores elever har synshandicap, derfor bør døre og karme markeres med kontrast farve, så eleverne derved lettere kan orienterer sig (Synskonsulent Karin Rask Institut for Syn og Teknologi).
- Eleverne kan ikke selv åbne døre, derfor ønsker vi døre, som i stedet kan åbne via sensor eller stor kontakt.
- Nogle af eleverne kan ikke selv betjene deres kørestol, derfor bør der være elektroniske køre - og styreinstallationer, der kan betjenes med en kontakt/touch fra en manuel kørestol.
- Eleverne bliver bl.a. undervist i fag som natur og teknik, men har ingen steder, hvor de kan eksperimentere med vand, jord, planter og smådyr. Derfor er der behov arbejdsrum som auqarum og væksthus, hvor der er mulighed for via hæve-sænke borde og robotteknologi at udføre sådanne eksperimenter.
- Eleverne er unge, men har meget lidt mulighed for et ungdomsliv, derfor har de behov for et multifunktionsrum. Et lokale med musikanlæg, computere, smartboard og med plads til fællesskab, hvor eleverne kan lytte til musik, spille spil, se film og være sammen med andre unge. Nogle af eleverne har svære fysiske problemer, der kræver, at deres krop bliver aflastet ved, at de kommer ud af deres kørestol og får et hvil/frikvarter, hvilket kan forgå i samme rum.
- Eleverne har brug for ro, når de skal arbejde med deres digitale undervisningsmaterialer og andre undervisningsmaterialer; derfor har de brug for arbejdspladser/hjørner, der indrettes med en særlig form for smartboards, hvor elevernes elektroniske talemaskiner integreres. Dette vil muliggøre at eleverne har adgang til opgaver/lektier kombineret med deres kommunikationshjælpemiddel.
- Elevernes individuelle arbejdspladser skal kunne tilpasses den enkeltes elevs arbejdskomfort
- Eleverne bruger digitale bøger i deres undervisning. I klassen forefindes en samling/bibliotek af digitale bøger. Klassens samling af digitale bøger vokser støt og omhandler ikke kun undervisningsmaterialer, men også bøger til oplysning og underholdning (kultur). Derfor er der behov for et biblioteksh jørne, hvor eleverne kan vælge og opleve digitale bøger efter eget ønske.
- Projecter til fremvisning af visuel dias-temaer i fællesrummet.
- Toiletterne skal indrettes på en måde, der giver tilgængelighed og en højere grad af selvhjulpenhed (Japansk model)

Som et første bud på udformning af bygningen, der skal rumme Det Intelligente Klasseværelse, er der udformet et skitseforslag, hvor de fælles aktiviteter foregår i rummets kerne og de forskellige individuelle tilbud ligger i bygningens ydre zone.

Set i fugleperspektiv er bygningen udformet som en ellipse med de to arbejdsrum-aquarummet og væksthuset som håndtag.



Plantegning af skitseforslag

Miljørigtigt byggeri
Valg af konstruktionsprincipper og materialer baseres på anvendelse af de mest miljø- og allergi venlige produkter. Byggeriet skal endvidere som et minimum opfylde BR 2010's krav til lavenergiklasse 2015.

Projektorganisering og -forløb
Idegrundlag for Projekt Det Intelligente Klasseværelse er forankret i en arbejdsgruppe bestående af:
Lærer og Kommunikationsvejleder Britta Husted VUK.
Arkitekt m.a.a. og tilgængelighedsrevisor Peter van Hauen fra Thorslund dk ApS.
Byggeøkonom MDB Kim Fihl fra arkitektfirmaet Christensen og Rottbøll A/S.

Arbejdsgruppens opgave er, at uddelegere opgaver, opsamle viden og muligheder - samt i samarbejde med styregruppen at koordinere projektets ideer frem til færdigt byggeri.

Endvidere er følgende eksterne samarbejdspartnere tilknyttet projektet:
Arkitekt Preben Rottbøll, firmaet Christensen og Rottbøll Aalborg
Danmarks Teknologiske Institut Center for Robotteknologi
Synskonsulent Karin Rask - Institut for Syn og Teknologi..
Programmør (endnu ikke navngivet)
3D animation Rene Frandsen og Brian H. Sørensen. Arkitektur og Design AAU.
Projekts forløb rapporteres løbende til Aalborg kommunes skoleforvaltning.

Økonomi
Projektet forventes gennemført inden for en anlægsramme på 25 millioner eksklusiv moms bygningen, der skal rumme Det intelligente klasseværelse samt 25 millioner eksklusiv moms for udvikling og implementering af ny teknologi i bygningen.

Tid/ proces

Ide og finansieringsfase	2011
Udvikling og projekteringsfase	2012
Udførelsesfase	2013
Testfase	første halvår 2014
Ibrugtagning	august 2014
Evalueringsfase	andet halvår 2014
Driftsfase	fra 2015

Finansiering
Der ansøges fonde og offentlige midler til projektering og byggeri.
På nuværende tidspunkt har vi modtaget 100.000,- kr. fra Bevica fonden til forundersøgelsesfasen Vi er i dialog med Real Dania fonden og A.P. Møller og Hustru Chastine Mc-Kinney Møllers fond vedrørende støtte til projektet.
De teknologiske løsninger til huset deles op i selvstændige enheder og finansieres til dels af fondsmidler og -dels af virksomheder, der udvikler og tester teknologi i Det Intelligente Klasseværelse.

Evaluering
Projektet evalueres af Videnscenter for praksisevaluering CEPRA ved University College Nordjylland og Arkitekturevaluering ved Center for Idræt og Arkitektur, Kunstakademiets Arkitektskole i København

Evaluering vil foregå i 3 niveauer:

- Observationer af elevernes muligheder for selvstændighed og synlighed af deres kompetencer i nuværende rammer
- Observationer af elevernes muligheder for selvstændighed synlighed af deres kompetencer i de ny rammer
- Observation af elevernes tryghed og trivsel i de nye rammer
- Arkitektonisk evaluering omhandlende samspillet mellem mennesker og rum

Forankring
Denne projekt beskrivelse er oversat til engelsk og formidlet til vores internationale kontakter i blandt ISAAC.
Projektet vil blive gennemarbejdet og sammenfattet i en rapport. Rapporten vil blive oversat til engelsk, så det vil være muligt at formidle projektet på den internationale ISAAC konference 2014.
Projektet formidles løbende gennem vidensdeling med faggrupper, interesseorganisationer og videnscenter.
Projektets resultat formidles via Videnscentret VIKOM Servicestyrelsen hjemmeside, ISAAC Danmark, handicaporganisationen LEV og Specialskolens egen hjemmeside.

Britta Husted, Peter van Hauen og forstander Jan Arnbjørn.

VUK Aalborg 2011

Kildehenvisninger

[1] Tilgængelighed – udfordringer, begreber og strategier. Ryhl Camilla. Statens Byggeforskningsinstitut. 2009

[2] Britta Husted, Preben Kirkegaard og Sinne Andersen. Kommunikationsmiraklet. Skipper Clements forlag 2008.

[3] Britta Husted og Sinne Andersen. Projekt Kan selv – vil selv. I samarbejde med UCN støttet af Satspuljerne 2008.

[4] Evalueringsrapport vedr. projekt Kan selv- vil selv. Cepra 2008.

Billedserie af skitseprojekt
Foreløbig skitseprojekt af rumforløb uden tekniske løsninger.

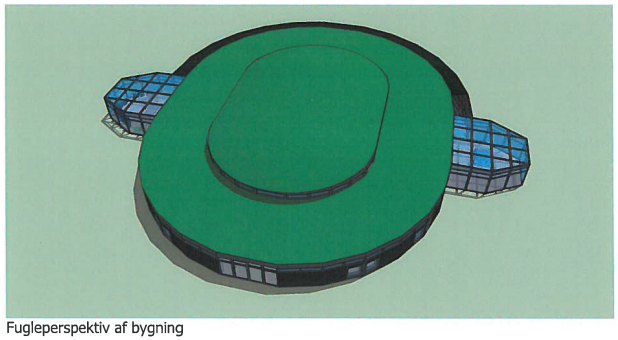
Elevarbejdspladser

Garderobe

Gangparti

Væksthus

Cafe og hvilerum



Fugleperspektiv af bygning

Appendix B - calculations of rooms

To calculate the thermal indoor environment and the experienceed airquality from poeple load CR1752[113] is used to find diverse data and formulas.
The project numbers come from the first sketchingphase, where the functionality initially has been solved.

Beside formulas and units are listed and an illustration shows which rooms are calculated.

Units and formulas[114]:

[M] Met: rate of energy production of the body 1 met = 58.2 W/m^2

[clo] The amount of clothes on the body. 1 clo = 0.155 m^2*^oC/W

[olf] Olf is the sensory load on the airquality

[dp] 1 decipol is the sensory pollu tion from 1 olf ventilated by 10 l/s

[ppm] Parts per million describes how puch pollution there is. Parts = ppm * 10^{-6}

[PPD] People percent of dissatisfied is read on tables or calculated

$Q_c = 10[l/s] * (G_c / (C_{c,i} - C_{c,0})) * (1 / \text{Ɛ}V)$[115]

Q_c [l/s*m^2] Necessary ventilation to sustain comfort

G_c [olf/m^2] sensoric load on airquality

$C_{c,i}$ [dp] Wanted airquality

$C_{c,o}$ [dp] airquality from intake

ƐV Ventilation effectivity, under the circumstances when the air is completely mixed the effectivity is 1. The higher number the better ventilation. The lower the worse.

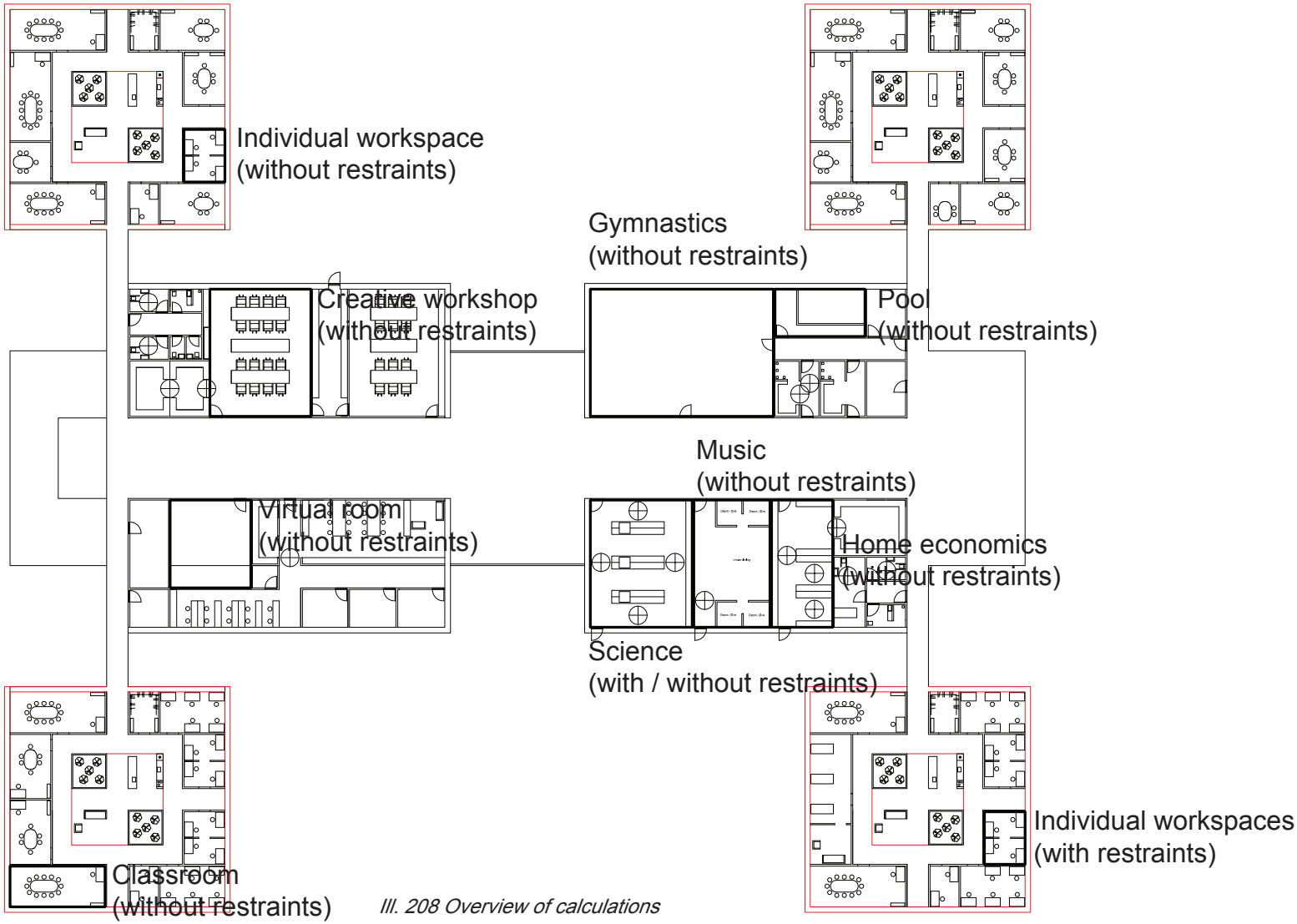
$Q_h = (G_h / (C_{h,i} - C_{h,0})) * (1 / \text{Ɛ}V)$[116]

Q_h [l/s*m^2] Necessary ventilation to sustain healthy air

G_h [l/t] Co_2 load on airquality

$C_{h,i}$ [ppm] Value of chemical

$C_{h,o}$ [ppm] Outdoor concentration of the chemical



Ill. 208 Overview of calculations

Individual workstations (without physical restraints)

Indoor environment readings	
Size of the room	18.2 m^2
Persons:	6 pers
Persons per squaremeter	0.33 pers / m^2
Activity: Seated activities like: Living, school or office[117]	1.2 met
Sensoric load per person [118]	1 olf
Sensoric load from building (new building)[119]	0 olf / m^2
Summarized sensoric load	6 olf
Summarized sensoric load per squaremeter	0.33 olf / m^2
Concentration of Co_2 per person according to activity [120]	19 l / h • pers
Wished airquality; the difference between indoor and outdoor Co_2 concentration (Category A)[121]	350 ppm
Category A for dissatisfied, 15%, with dp 1.0[122]	10 l/s • pers.
Winter clothing: Underpants, singlet, shirt, pants, sweater socks & shoes[123]	0.95 clo
Summer clothing: Underpants, shirt, light pants, socks & Shoes[124]	0.60 clo

By reading tabel A.2 optimal operative temperatures are noted from clothing and activity. By reading the table there has been taken consideration into airspeed where: activity < 1 met counts 0 m/s, where activities > 1 met is calculated by (0.3 • (met - 1)) m/s.[125]

Optimal operative temperature winter, category A (PPD < 6%)	22°C +/- 1°C
Optimal operative temperature summer, category A (PPD < 6%)	24°C +/- 1°C

Experienced airquality is calculated to maintain a reasonable Co_2 and sensoric concentration in the room.

Q_c = 10l/s • (0.33olf / m^2 / (1.0 dp - 0 dp)) • (1 / 1)
= 3.30 l/s • m^2

Q_h = ((0.33pers / m^2 • 19 l/h • pers) / (3600 • 350ppm • 10^{-6})) • (1 / 1)
= 4.98 l/s • m^2

The worst case is used for later calculations.

Individual workstations (with physical restraints)

Indoor environment readings

Size of the room	18.2 m^2
Persons:	4 pers
Persons per squaremeter	0.22 pers / m^2
Activity: Seated relaxed[117]	1.0 met
Sensoric load per person [118]	1 olf
Sensoric load from building (new building)[119]	0 olf / m^2
Summarized sensoric load	4 olf
Summarized sensoric load per squaremeter	0.22 olf / m^2
Concentration of Co_2 per person according to activity[120]	19 l / h • pers
Wished airquality; the difference between indoor and outdoor Co_2 concentration (Category A)[121]	350 ppm
Category A for dissatisfied, 15%, with dp 1.0[122]	10 l/s • pers.
Winter clothing: Underpants, singlet, shirt, pants, sweater socks, shoes & wheelchair (office chair with arms and bag)[123]	1.25 clo
Summer clothing: Underpants, shirt, light pants, socks, Shoes & wheelchair (office chair with arms and bag)[124]	0.90 clo

By reading tabel A.2 optimal operative temperatures are noted from clothing and activity. By reading the table there has been taken consideration into airspeed where: activity < 1 met counts 0 m/s, where activities > 1 met is calculated by (0.3 • (met - 1)) m/s.[125]

Optimal operative temperature winter, category A (PPD < 6%)	22^o +/- 0.7^o
Optimal operative temperature summer, category A (PPD < 6%)	23^o +/- 0.5^o

Experienced airquality is calculated to maintain a reasonable Co_2 and sensoric concentration in the room.

Q_c = 10l/s • (0.22 olf / m^2 / (1.0 dp - 0 dp)) • (1 / 1)
= 2.20 l/s • m^2

Q_h = ((0.22pers / m^2 • 19 l/h • pers) / (3600 • 350ppm • 10^{-6})) • (1 / 1)
= 3.32 l/s • m^2

The worst case is used for later calculations.

Creative workshop (without physical restraints)

Indoor environment readings	
Size of the room	105 m^2
Persons:	10 pers
Persons per squaremeter	0.1 pers / m^2
Activity: Standing mid level activity[117]	2.0 met
Sensoric load per person (own estimate due to activity)[118]	3 olf
Sensoric load from building (new building)[119]	0 olf / m^2
Summarized sensoric load	30 olf
Summarized sensoric load per squaremeter	0.29 olf / m^2
Concentration of Co_2 per person according to activity[120] (own estimate from table A.6)	40 l / h • pers
Wished airquality; the difference between indoor and outdoor pollution (Category A)[121]	350 ppm
Category A for dissatisfied, 15%, with dp 1.0[122]	10 l/s • pers.
Winter clothing: Underpants, singlet, shirt, pants, sweater socks & shoes[123]	0.95 clo
Summer clothing: Underpants, shirt, light pants, socks, Shoes[124]	0.60 clo

By reading tabel A.2 optimal operative temperatures are noted from clothing and activity. By reading the table there has been taken consideration into airspeed where: activity < 1 met counts 0 m/s, where activities > 1 met is calculated by (0.3 • (met - 1)) m/s.[125]

Optimal operative temperature winter, category A (PPD < 6%)	17° +/- 1.5°
Optimal operative temperature summer, category A (PPD < 6%)	20° +/- 1°

Experienced airquality is calculated to maintain a reasonable Co_2 and sensoric concentration in the room.

Q_c = 10l/s • (0.29 olf / m^2 / (1.0 dp - 0 dp)) • (1 / 1))
= 2.90 l/s • m^2

Q_h = ((0.1pers / m^2 • 40 l/h • pers) / (3600 • 350ppm • 10^{-6})) • (1 / 1)
= 3.17 l/s * m^2

The worst case is used for later calculations.

Music (without restraints)

Indoor environment readings	
Size of the room	83.7 m^2
Persons:	10 pers
Persons per squaremeter	0.12 pers / m^2
Activity: Standing mid level activity[117]	2.0 met
Sensoric load per person (own estimate due to activity)[118]	3 olf
Sensoric load from building (new building)[119]	0 olf / m^2
Summarized sensoric load	30 olf
Summarized sensoric load per squaremeter	0.36 olf / m^2
Concentration of Co_2 per person according to activity (own estimate from table A.6)[120]	40 l / h • pers
Wished airquality; the difference between indoor and outdoor pollution (Category A)[121]	350 ppm
Category A for dissatisfied, 15%, with dp 1.0[122]	10 l/s • pers.
Winter clothing: Underpants, singlet, shirt, pants, sweater socks & shoes[123]	0.95 clo
Summer clothing: Underpants, shirt, light pants, socks, Shoes[124]	0.60 clo

By reading tabel A.2 optimal operative temperatures are noted from clothing and activity. By reading the table there has been taken consideration into airspeed where: activity < 1 met counts 0 m/s, where activities > 1 met is calculated by (0.3 • (met - 1)) m/s.[125]

Optimal operative temperature winter, category A (PPD < 6%)	17^o +/- 1.5^o
Optimal operative temperature summer, category A (PPD < 6%)	20^o +/- 1.0^o

Experienced airquality is calculated to maintain a reasonable Co_2 and sensoric concentration in the room.

Q_c = 10l/s • (0.36 olf / m^2 / (1.0 dp - 0 dp)) • (1 / 1)
= 3.60 l/s • m^2

Q_h = ((0.12pers / m^2 • 40 l/h • pers) / (3600 • 350ppm • 10^{-6})) • (1 / 1)
= 3.81 l/s • m^2

The worst case is used for later calculations.

Science (without restraints)

Indoor environment readings	
Size of the room	112 m^2
Persons:	10 pers
Persons per squaremeter	0.09 pers / m^2
Activity: Standing light activity[117]	1.6 met
Sensoric load per person[118]	2 olf
Sensoric load from building (new building)[119]	0 olf / m^2
Summarized sensoric load	20 olf
Summarized sensoric load per squaremeter	0.18 olf / m^2
Concentration of Co_2 per person according to activity (Own estimate from table A.6)[120]	30 l / h • pers
Wished airquality; the difference between indoor and outdoor pollution (Category A)[121]	350 ppm
Category A for dissatisfied, 15%, with dp 1.0[122]	10 l/s • pers.

Winter clothing: Underpants, singlet, shirt, pants, sweater socks, shoes[123]	0.95 clo
Summer clothing: Underpants, shirt, light pants, socks & Shoes[124]	0.60 clo

By reading tabel A.2 optimal operative temperatures are noted from clothing and activity. By reading the table there has been taken consideration into airspeed where: activity < 1 met counts 0 m/s, where activities > 1 met is calculated by (0.3 • (met - 1)) m/s.[125]

Optimal operative temperature winter, category A (PPD < 6%)	20^o +/- 1.2^o
Optimal operative temperature summer, category A (PPD < 6%)	22^o +/- 1.0^o

Experienced airquality is calculated to maintain a reasonable Co_2 and sensoric concentration in the room.

Q_c = 10l/s • (0.18 olf / m^2 / (1.0 dp - 0 dp)) • (1 / 1))
= 1.8 l/s • m^2

Q_h = ((0.09pers / m^2 • 30 l/h • pers) / (3600 • 350ppm • 10^{-6})) • (1 / 1)
= 2.14 l/s • m^2

The worst case is used for later calculations.

Science (with physical restraints)

Indoor environment readings

Size of the room	112 m^2
Persons:	10 pers
Persons per squaremeter	0.09 pers / m^2
Activity: Seated relaxed[117]	1.0 met
Sensoric load per person[118]	1 olf
Sensoric load from building (new building)[119]	0 olf / m^2
Summarized sensoric load	10 olf
Summarized sensoric load per squaremeter	0.09 olf / m^2
Concentration of Co_2 per person according to activity[120]	19 l / h • pers
Wished airquality; the difference between indoor and outdoor pollution (Category A)[121]	350 ppm
Category A for dissatisfied, 15%, with dp 1.0[122]	10 l/s • pers.
Winter clothing: Underpants, singlet, shirt, pants, sweater socks, shoes & wheelchair (office chair with arms and bag)[123]	1.25 clo
Summer clothing: Underpants, shirt, light pants, socks, Shoes & wheelchair (office chair with arms and bag)[124]	0.90 clo

By reading tabel A.2 optimal operative temperatures are noted from clothing and activity. By reading the table there has been taken consideration into airspeed where: activity < 1 met counts 0 m/s, where activities > 1 met is calculated by (0.3 • (met - 1)) m/s.[125]

Optimal operative temperature winter, category A (PPD < 6%)	22° +/- 0,5°
Optimal operative temperature summer, category A (PPD < 6%)	23° +/- 0,7°

Experienced airquality is calculated to maintain a reasonable Co_2 and sensoric concentration in the room.

Q_c = 10l/s • (0.09 olf / m^2 / (1.0 dp - 0 dp)) • (1 / 1)
= 0.9 l/s • m^2

Q_h = ((0.09pers / m^2 • 19 l/h • pers) / (3600 • 350ppm • 10^{-6})) • (1 / 1)
= 1.36 l/s • m^2

The worst case is used for later calculations.

Gymnastic (without restraints)

Indoor environment readings

Size of the room	200.0 m^2
Persons:	15 pers
Persons per squaremeter	0.08 pers / m^2
Activity: Walking 4 km/h[117]	2.8 met
Sensoric load per person[118]	4 olf
Sensoric load from building (new building)[119]	0 olf / m^2
Summarized sensoric load	60 olf
Summarized sensoric load per squaremeter	0.30 olf / m^2
Concentration of Co_2 per person according to activity[120]	50 l / h • pers
Wished airquality; the difference between indoor and outdoor pollution (Category A)[121]	350 ppm
Category A for dissatisfied, 15%, with dp 1.0[122]	10 l/s • pers.
Winter clothing: Underpants, t-shirt, shorts, thin socks & shoes[123]	0.45 clo
Summer clothing: Underpants, t-shirt, shorts, thin socks & shoes[124]	0.45 clo

By reading tabel A.2 optimal operative temperatures are noted from clothing and activity. By reading the table there has been taken consideration into airspeed where: activity < 1 met counts 0 m/s, where activities > 1 met is calculated by (0.3 • (met - 1)) m/s.[125]

Optimal operative temperature winter, category A (PPD < 6%)	19^o +/- 1.2^o
Optimal operative temperature summer, category A (PPD < 6%)	19^o +/- 1.2^o

Experienced airquality is calculated to maintain a reasonable Co_2 and sensoric concentration in the room.

Q_c = 10l/s • (0.30 olf / m^2 / (1.0 dp - 0 dp)) • (1 / 1)
= 3.0 l/s • m^2

Q_h = ((0.08pers / m^2 • 50 l/h • pers) / (3600 • 350ppm • 10^{-6})) • (1 / 1)
= 3.17 l/s • m^2

The worst case is used for later calculations.

Classroom (without restraints)

Indoor environment readings	
Size of the room	33.6 m^2
Persons:	10 pers
Persons per squaremeter	0.30 pers / m^2
Activity: Seated activities like: Living, school or office[117]	1.2 met
Sensoric load per person[118]	1 olf
Sensoric load from building (new building)[119]	0 olf / m^2
Summarized sensoric load	10 olf
Summarized sensoric load per squaremeter	0.30 olf / m^2
Concentration of Co_2 per person according to activity[120]	19 l / h • pers
Wished airquality; the difference between indoor and outdoor pollution (Category A)[121]	350 ppm
Category A for dissatisfied, 15%, with dp 1.0[122]	10 l/s • pers.
Winter clothing: Underpants, singlet, shirt, pants, sweater socks, shoes[123]	0.95 clo
Summer clothing: Underpants, shirt, light pants, socks, Shoes[124]	0.60 clo

By reading tabel A.2 optimal operative temperatures are noted from clothing and activity. By reading the table there has been taken consideration into airspeed where: activity < 1 met counts 0 m/s, where activities > 1 met is calculated by (0.3 • (met - 1)) m/s.[125]

Optimal operative temperature winter, category A (PPD < 6%)	22^o +/- 1.0^o
Optimal operative temperature summer, category A (PPD < 6%)	24^o +/- 1^o

Experienced airquality is calculated to maintain a reasonable Co_2 and sensoric concentration in the room.

Q_c = 10l/s • (0.30 olf / m^2 / (1.0 dp - 0 dp)) • (1 / 1)
= 3.0 l/s • m^2

Q_h = ((0.30pers / m^2 • 19 l/h • pers) / (3600 • 350ppm • 10^{-6})) • (1 / 1)
= 4.52 l/s • m^2

The worst case is used for later calculations.

Virtual room (without restraints)

Indoor environment readings	
Size of the room	61.2 m^2
Persons:	10 pers
Persons per squaremeter	0.16 pers / m^2
Activity: Seated relaxed[117]	1.0 met
Sensoric load per person[118]	1 olf
Sensoric load from building (new building)[119]	0 olf / m^2
Summarized sensoric load	10 olf
Summarized sensoric load per squaremeter	0.16 olf / m^2
Concentration of Co_2 per person according to activity[120]	19 l / h * pers
Wished airquality; the difference between indoor and outdoor pollution (Category A)[121]	350 ppm
Category A for dissatisfied, 15%, with dp 1.0[122]	10 l/s • pers.
Winter clothing: Underpants, singlet, shirt, pants, sweater socks & shoes[123]	0.95 clo
Summer clothing: Underpants, shirt, light pants, socks, Shoes[124]	0.60 clo

By reading tabel A.2 optimal operative temperatures are noted from clothing and activity. By reading the table there has been taken consideration into airspeed where: activity < 1 met counts 0 m/s, where activities > 1 met is calculated by (0.3 • (met - 1)) m/s.[125]

Optimal operative temperature winter, category A (PPD < 6%)	23^o +/- 0.7^o
Optimal operative temperature summer, category A (PPD < 6%)	26^o +/- 0.5^o

Experienced airquality is calculated to maintain a reasonable Co_2 and sensoric concentration in the room.

Q_c = 10l/s • (0.16 olf / m^2 / (1.0 dp - 0 dp)) • (1 / 1))
= 1.6 l/s • m^2

Q_h = ((0.16pers / m^2 • 19 l/h • pers) / (3600 • 350ppm • 10^{-6})) • (1 / 1)
= 2.41 l/s • m^2

The worst case is used for later calculations.

Home economics (without restraints)

Indoor environment readings

Size of the room	67.4 m^2
Persons:	10 pers
Persons per squaremeter	0.15 pers / m^2
Activity: Standing activity[117]	2.0 met
Sensoric load per person[118]	3 olf
Sensoric load from building (new building)[119]	0 olf / m^2
Summarized sensoric load	30 olf
Summarized sensoric load per squaremeter	0.45 olf / m^2
Concentration of Co_2 per person according to activity (own estimate from table A.6)[120]	30 l / h • pers
Wished airquality; the difference between indoor and outdoor pollution (Category A)[121]	350 ppm
Category A for dissatisfied, 15%, with dp 1.0[122]	10 l/s • pers.
Winter clothing: Underpants, singlet, shirt, pants, sweater socks & shoes[123]	0.95 clo
Summer clothing: Underpants, shirt, light pants, socks, Shoes[124]	0.60 clo

By reading tabel A.2 optimal operative temperatures are noted from clothing and activity. By reading the table there has been taken consideration into airspeed where: activity < 1 met counts 0 m/s, where activities > 1 met is calculated by (0.3 • (met - 1)) m/s.[125]

Optimal operative temperature winter, category A (PPD < 6%)	17^o +/- 1.5^o
Optimal operative temperature summer, category A (PPD < 6%)	20^o +/- 1.0^o

Experienced airquality is calculated to maintain a reasonable Co_2 and sensoric concentration in the room.

Q_c = 10l/s • (0.45 olf / m^2 / (1.0 dp - 0 dp)) • (1 / 1)
= 4.5 l/s • m^2

Q_h = ((0.15 pers / m^2 • 30 l/h • pers) / (3600 • 350ppm • 10^{-6})) • (1 / 1)
= 3.57 l/s • m^2

The worst case is used for later calculations.

Pool (without restraints)	
Indoor environment readings	
Size of the room	37.0 m^2
Persons:	5 pers
Persons per squaremeter	0.14 pers / m^2
Activity: Walking 4 km/h[117]	2.8 met
Sensoric load per person[118]	3 olf
Sensoric load from building (new building)[119]	0 olf / m^2
Summarized sensoric load	15 olf
Summarized sensoric load per squaremeter	0.41 olf / m^2
Concentration of Co_2 per person according to activity (own estimate from table A.6)[120]	50 l / h • pers
Wished airquality; the difference between indoor and outdoor pollution (Category A)[121]	350 ppm
Category A for dissatisfied, 15%, with dp 1.0[122]	10 l/s • pers.
Winter clothing: Underpants & singlet (Women clothing estimate)[123]	0.07 clo
Summer clothing: Underpants & singlet	0.07 clo

(Women clothing estimate)[124]

By reading tabel A.2 optimal operative temperatures are noted from clothing and activity. By reading the table there has been taken consideration into airspeed where: activity < 1 met counts 0 m/s, where activities > 1 met is calculated by (0.3 • (met - 1)) m/s.[125]

Optimal operative temperature winter, category A (PPD < 6%) 23^o +/- 1.0^o
Optimal operative temperature summer, category A (PPD < 6%) 23^o +/- 1.0^o

Experienced airquality is calculated to maintain a reasonable Co_2 and sensoric concentration in the room.

Q_c = 10l/s • (0.41 olf / m^2 / (1.0 dp - 0 dp)) • (1 / 1)
= 4.1 l/s • m^2

Q_h = ((0.14pers / m^2 • 50 l/h • pers) / (3600 • 350ppm • 10^{-6})) • (1 / 1)
= 5.56 l/s • m^2

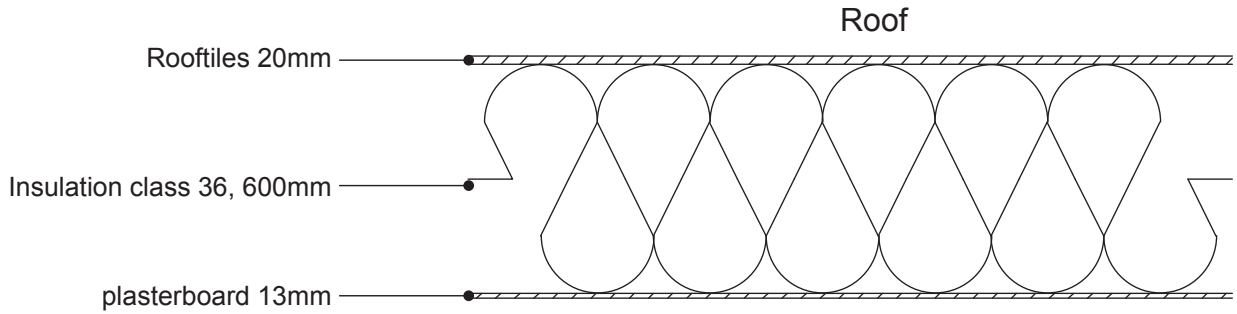
The worst case is used for later calculations.

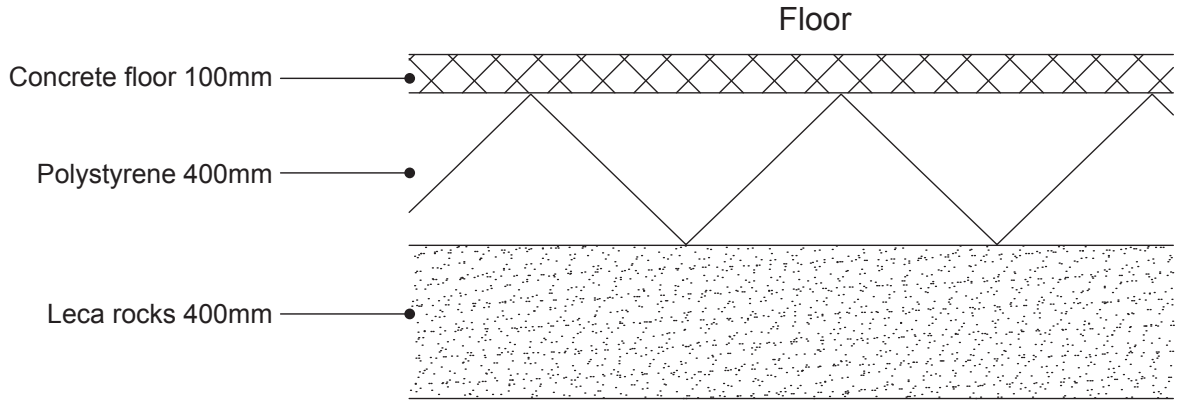
Appendix C - Energycalculations from BSim

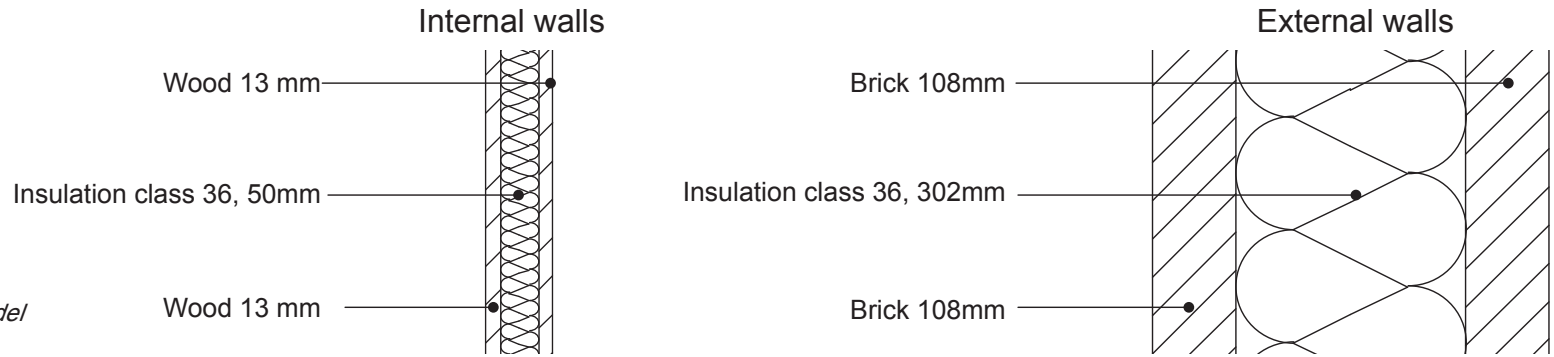
Based upon Appendix B, energy calculations on each vital room is made, to see, which rooms require more energy from the sun. The rooms are without windows, with people load, heating and ventilation to maintain health and comfort.

The calculations are connected to the first sketchingphase as appendix B. The pool, kitchen and home economics are left out, since there are more unknown internal heatgain than people load.

The details are rough since it is an approximation to the finished building.







Ill. 209 Details for BSim model

Based upon Appendix B, more detailed energy calculations on the entire building is made, to see how the building performaccording to energyconsumption and overtemperatures.
The model is divided into nine thermal zones to give a better indication of the location of each group and the difference in activity.The ventilation is calculated for the sensoric load from people.

The BSim models are based on the detail drawings in appendix B.

On the illustrations it can be seen how the thermal zones are divided and what formulas are used to calclulate. Afterwards an example of calculation datacheme isshown which ends in datas and results of the datascheme.

Units & formulas[126]

Qh = (Gh / (Ch,i - Ch,0)) * (1 / Ɛv)

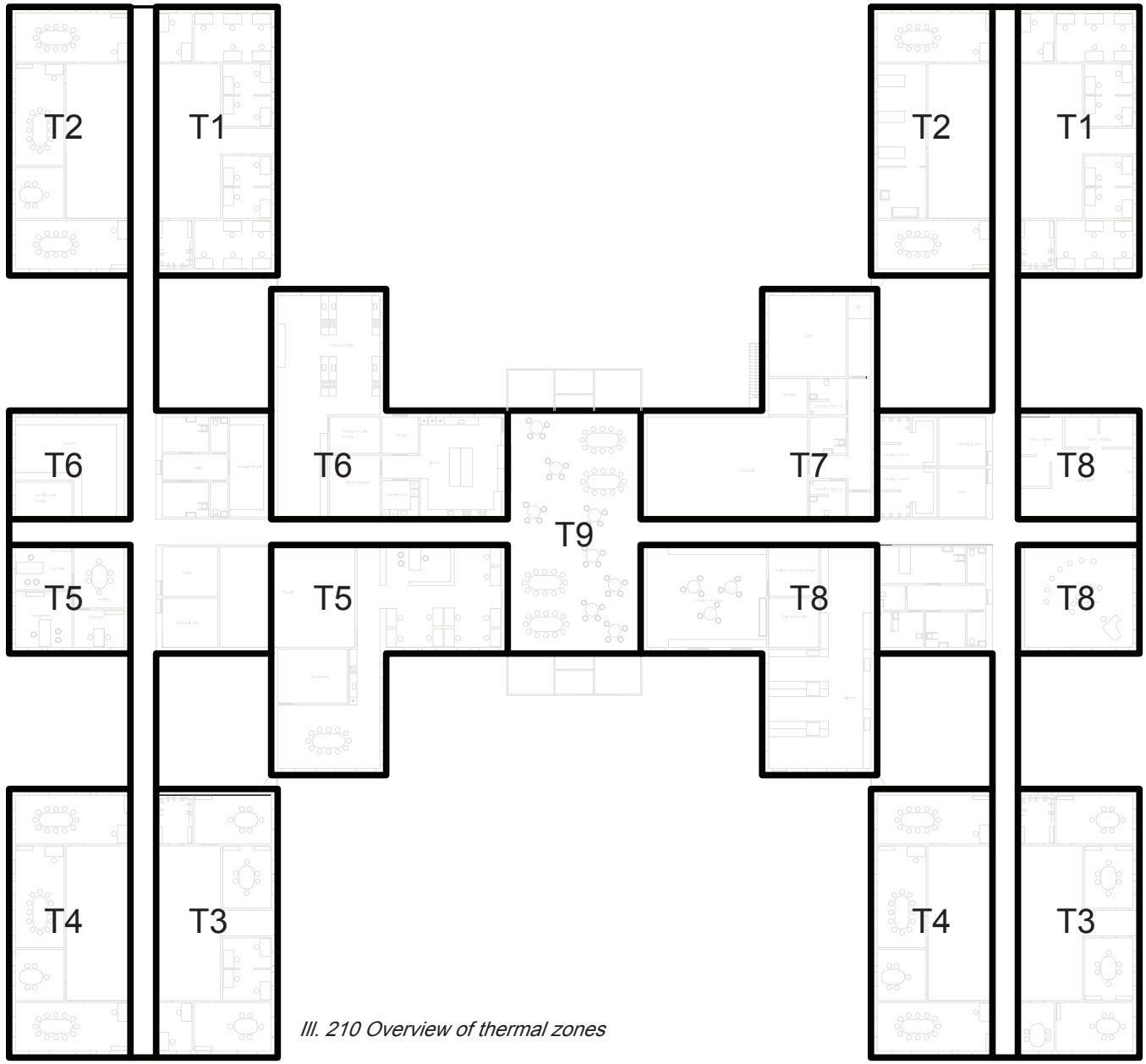
Qh [l/s*m2]
Necessary ventilation to sustain healthy air

Gh [l/t] Co2
load on airquality

Ch,i [ppm]
Value of chemical

Ch,o [ppm]
Outdoor concentration of the chemical

Heat generating
[met] * [58W/m2] * [1.8m2]



Ill. 210 Overview of thermal zones

Thermal zone 1 restrainted East							
Building	Floor area [m2] 499	Ceiling height [m] 3	Floor area [m2] 0	Ceiling height [m] 0	Volume [m3] 1497		
People load	Person load [Pers] 40	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15	Schedule [%] 50% time	People activity [Met] 1	Pollution Co2 [l/h] 19	Heat generating [W] 104,4
Infiltration (Buildingregulations 2020)	Basic airchange [l/s x m2] 0,13 0,09	Time [Weekdays] Mon-Fri Mon-Sun	Time [hours] 9 to 15 1 to 9 & 15 to 24	Schedule [%] 100% 69%	Basic aichange [l/s] 64,87 44,91	Basic airchange [m3 / h] 233,5 161,7	Basic airchange [/h] 0,2 0,1
Heating	Max pow. [kW] 400	Summer temperature [Celsius] 23	Winter temperature [Celsius] 22	Summertime [Months] Apr, May, Sep, Aug	Wintertime [Months] an, Feb, Mar, Oct, Nov, De	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Ventilation	Ventilation sensoric [m3/s] 0,6 Ventilation sensoric [m3/h] 2171,4 Airchangerate [/h] 1,5	Heat rec. [%] 85% summer Te1 [Celsius] -12 Winter Te1 [Celsius] -12	Heating coil [kW] 100 Tinl1 [Celsius] 23 Tinl1 [Celsius] 22	Summertime [Months] Apr, May, Sep, Aug Te2 [Celsius] 22 Te2 [Celsius] 21	Wintertime [Months] an, Feb, Mar, Oct, Nov, De Tinl2 [Celsius] 22 Tinl2 [Celsius] 21	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Lighting	Light [lux] 300	Task light [kW] 0,05	Light energy [W/m2] 10	General lighting [kW] 5,0	Switch [Control] Continous	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15

Thermal zone 1 restrainted East							
Building	Floor area [m2] 499	Ceiling height [m] 3	Floor area [m2] 0	Ceiling height [m] 0	Volume [m3] 1497		
People load	Person load [Pers] 40	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15	Schedule [%] 50% time	People activity [Met] 1	Pollution Co2 [l/h] 19	Heat generating [W] 104,4
Infiltration (Buildingregulations 2020)	Basic airchange [l/s x m2] 0,13 0,09	Time [Weekdays] Mon-Fri Mon-Sun	Time [hours] 9 to 15 1 to 9 & 15 to 24	Schedule [%] 100% 69%	Basic aichange [l/s] 64,87 44,91	Basic airchange [m3 / h] 233,5 161,7	Basic airchange [/h] 0,2 0,1
Heating	Max pow. [kW] 400	Summer temperature [Celsius] 23	Winter temperature [Celsius] 22	Summertime [Months] Apr, May, Sep, Aug	Wintertime [Months] an, Feb, Mar, Oct, Nov, De	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Ventilation	Ventilation sensoric [m3/s] 0,6 Ventilation sensoric [m3/h] 2171,4 Airchangerate [/h] 1,5	Heat rec. [%] 85% summer Te1 [Celsius] -12 Winter Te1 [Celsius] -12	Heating coil [kW] 100 Tinl1 [Celsius] 23 Tinl1 [Celsius] 22	Summertime [Months] Apr, May, Sep, Aug Te2 [Celsius] 22 Te2 [Celsius] 21	Wintertime [Months] an, Feb, Mar, Oct, Nov, De Tinl2 [Celsius] 22 Tinl2 [Celsius] 21	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Lighting	Light [lux] 300	Task light [kW] 0,05	Light energy [W/m2] 10	General lighting [kW] 5,0	Switch [Control] Continous	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15

Thermal zone 2 restrainted West							
Building	Floor area [m2] 499	Ceiling height [m] 3	Floor area [m2] 0	Ceiling height [m] 0	Volume [m3] 1497		
People load	Person load [Pers] 40	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15	Schedule [%] 25% time	People activity [Met] 1	Pollution Co2 [l/h] 19	Heat generating [W] 104,4
Infiltration (Buildingregulations 2020)	Basic airchange [l/s x m2] 0,13 0,09	Time [Weekdays] Mon-Fri Mon-Sun	Time [hours] 9 to 15 1 to 9 & 15 to 24	Schedule [%] 100% 69%	Basic aichange [l/s] 64,87 44,91	Basic airchange [m3 / h] 233,5 161,7	Basic airchange [/h] 0,2 0,1
Heating	Max pow. [kW] 400	Summer temperature [Celsius] 23	Winter temperature [Celsius] 22	Summertime [Months] Apr, May, Sep, Aug	Wintertime [Months] an, Feb, Mar, Oct, Nov, De	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Ventilation	Ventilation sensoric [m3/s] 0,6 Ventilation sensoric [m3/h] 2171,4 Airchangerate [/h] 1,5	Heat rec. [%] 85% summer Te1 [Celsius] -12 Winter Te1 [Celsius] -12	Heating coil [kW] 100 Tinl1 [Celsius] 23 Tinl1 [Celsius] 22	Summertime [Months] Apr, May, Sep, Aug Te2 [Celsius] 22 Te2 [Celsius] 21	Wintertime [Months] an, Feb, Mar, Oct, Nov, De Tinl2 [Celsius] 22 Tinl2 [Celsius] 21	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Lighting	Light [lux] 300	Task light [kW] 0,05	Light energy [W/m2] 10	General lighting [kW] 5,0	Switch [Control] Continous	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15

Thermal zone 3 normal East							
Building	Floor area [m2] 499	Ceiling height [m] 3	Floor area [m2] 0	Ceiling height [m] 0	Volume [m3] 1497		
People load	Person load [Pers] 60	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15	Schedule [%] 25%	People activity [Met] 1,2	Pollution Co2 [l/h] 19	Heat generating [W] 125,3
Infiltration (Buildingregulations 2020)	Basic airchange [l/s x m2] 0,13 0,09	Time [Weekdays] Mon-Fri Mon-Sun	Time [hours] 9 to 15 1 to 9 & 15 to 24	Schedule [%] 100% 69%	Basic aichange [l/s] 64,87 44,91	Basic airchange [m3 / h] 233,5 161,7	Basic airchange [/h] 0,2 0,1
Heating	Max pow. [kW] 400	Summer temperature [Celsius] 25,5	Winter temperature [Celsius] 22	Summertime [Months] Apr, May, Sep, Aug	Wintertime [Months] an, Feb, Mar, Oct, Nov, De	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Ventilation	Ventilation sensoric [m3/s] 0,9 Ventilation sensoric [m3/h] 3257,1 Airchangerate [/h] 2,2	Heat rec. [%] 85% summer Te1 [Celsius] -12 Winter Te1 [Celsius] -12	Heating coil [kW] 100 Tinl1 [Celsius] 25,5 Tinl1 [Celsius] 22	Summertime [Months] Apr, May, Sep, Aug Te2 [Celsius] 24,5 Te2 [Celsius] 21	Wintertime [Months] an, Feb, Mar, Oct, Nov, De Tinl2 [Celsius] 24,5 Tinl2 [Celsius] 21	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Lighting	Light [lux] 300	Task light [kW] 0,05	Light energy [W/m2] 10	General lighting [kW] 5,0	Switch [Control] Continous	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15

Thermal zone 4 normal West							
Building	Floor area [m2] 499	Ceiling height [m] 3	Floor area [m2] 0	Ceiling height [m] 0	Volume [m3] 1497		
People load	Person load [Pers] 60	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15	Schedule [%] 25%	People activity [Met] 1,2	Pollution Co2 [l/h] 19	Heat generating [W] 125,3
Infiltration (Buildingregulations 2020)	Basic airchange [l/s x m2] 0,13 0,09	Time [Weekdays] Mon-Fri Mon-Sun	Time [hours] 9 to 15 1 to 9 & 15 to 24	Schedule [%] 100% 69%	Basic aichange [l/s] 64,87 44,91	Basic airchange [m3 / h] 233,5 161,7	Basic airchange [/h] 0,2 0,1
Heating	Max pow. [kW] 400	Summer temperature [Celsius] 25,5	Winter temperature [Celsius] 22	Summertime [Months] Apr, May, Sep, Aug	Wintertime [Months] an, Feb, Mar, Oct, Nov, De	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Ventilation	Ventilation sensoric [m3/s] 0,9 Ventilation sensoric [m3/h] 3257,1 Airchangerate [/h] 2,2	Heat rec. [%] 85% summer Te1 [Celsius] -12 Winter Te1 [Celsius] -12	Heating coil [kW] 100 Tinl1 [Celsius] 25,5 Tinl1 [Celsius] 22	Summertime [Months] Apr, May, Sep, Aug Te2 [Celsius] 24,5 Te2 [Celsius] 21	Wintertime [Months] an, Feb, Mar, Oct, Nov, De Tinl2 [Celsius] 24,5 Tinl2 [Celsius] 21	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Lighting	Light [lux] 300	Task light [kW] 0,05	Light energy [W/m2] 10	General lighting [kW] 5,0	Switch [Control] Continous	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15

Thermal zone 5 Teacher + meeting							
Building	Floor area [m2] 242,8	Ceiling height [m] 5	Floor area [m2] 80,8	Ceiling height [m] 3	Volume [m3] 1456		
People load	Person load [Pers] 33	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15	Schedule [%] 40% time	People activity [Met] 1,2	Pollution Co2 [l/h] 19	Heat generating [W] 125,3
Infiltration (Buildingregulations 2020)	Basic airchange [l/s x m2] 0,13 0,09	Time [Weekdays] Mon-Fri Mon-Sun	Time [hours] 9 to 15 1 to 9 & 15 to 24	Schedule [%] 100% 69%	Basic aichange [l/s] 42,0615 29,1195	Basic airchange [m3 / h] 151,4 104,8	Basic airchange [/h] 0,1 0,1
Heating	Max pow. [kW] 400	Summer temperature [Celsius] 25,5	Winter temperature [Celsius] 22	Summertime [Months] Apr, May, Sep, Aug	Wintertime [Months] an, Feb, Mar, Oct, Nov, De	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Ventilation	Ventilation sensoric [m3/s] 0,5 Ventilation sensoric [m3/h] 1791,4 Airchangerate [/h] 1,2	Heat rec. [%] 85% summer Te1 [Celsius] -12 Winter Te1 [Celsius] -12	Heating coil [kW] 100 Tinl1 [Celsius] 25,5 Tinl1 [Celsius] 22	Summertime [Months] Apr, May, Sep, Aug Te2 [Celsius] 24,5 Te2 [Celsius] 21	Wintertime [Months] an, Feb, Mar, Oct, Nov, De Tinl2 [Celsius] 24,5 Tinl2 [Celsius] 21	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Lighting	Light [lux] 300	Task light [kW] 0,05	Light energy [W/m2] 10	General lighting [kW] 3,2	Switch [Control] Continous	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15

Thermal zone 6 home economics & carpentry							
Building	Floor area [m2] 242,8	Ceiling height [m] 5	Floor area [m2] 80,8	Ceiling height [m] 3	Volume [m3] 1456,3		
People load	Person load [Pers] 25	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15	Schedule [%] 40%	People activity [Met] 2	Pollution Co2 [l/h] 30	Heat generating [W] 208,8
Infiltration (Buildingregulations 2020)	Basic airchange [l/s x m2] 0,13 0,09	Time [Weekdays] Mon-Fri Mon-Sun	Time [hours] 9 to 15 1 to 9 & 15 to 24	Schedule [%] 100% 69%	Basic aichange [l/s] 42,0615 29,1195	Basic airchange [m3 / h] 151,4 104,8	Basic airchange [/h] 0,1 0,1
Heating	Max pow. [kW] 400	Summer temperature [Celsius] 20	Winter temperature [Celsius] 17	Summertime [Months] Apr, May, Sep, Aug	Wintertime [Months] an, Feb, Mar, Oct, Nov, De	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Ventilation	Ventilation sensoric [m3/s] 0,6 Ventilation sensoric [m3/h] 2142,9 Airchangerate [/h] 1,5	Heat rec. [%] 85% summer Te1 [Celsius] -12 Winter Te1 [Celsius] -12	Heating coil [kW] 100 Tinl1 [Celsius] 20 Tinl1 [Celsius] 17	Summertime [Months] Apr, May, Sep, Aug Te2 [Celsius] 19 Te2 [Celsius] 16	Wintertime [Months] an, Feb, Mar, Oct, Nov, De Tinl2 [Celsius] 19 Tinl2 [Celsius] 16	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Lighting	Light [lux] 500	Task light [kW] 0,05	Light energy [W/m2] 10	General lighting [kW] 3,2	Switch [Control] Continous	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15

Thermal zone 7 Gym & bath							
Building	Floor area [m2] 242,8	Ceiling height [m] 5	Floor area [m2] 0	Ceiling height [m] 0	Volume [m3] 1214		
People load	Person load [Pers] 25	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15	Schedule [%] 40%	People activity [Met] 2,8	Pollution Co2 [l/h] 50	Heat generating [W] 292,3
Infiltration (Buildingregulations 2020)	Basic airchange [l/s x m2] 0,13 0,09	Time [Weekdays] Mon-Fri Mon-Sun	Time [hours] 9 to 15 1 to 9 & 15 to 24	Schedule [%] 100% 69%	Basic aichange [l/s] 31,564 21,852	Basic airchange [m3 / h] 113,6 78,7	Basic airchange [/h] 0,1 0,1
Heating	Max pow. [kW] 400	Summer temperature [Celsius] 21	Winter temperature [Celsius] 21	Summertime [Months] Apr, May, Sep, Aug	Wintertime [Months] an, Feb, Mar, Oct, Nov, De	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Ventilation	Ventilation sensoric [m3/s] 1,0 Ventilation sensoric [m3/h] 3571,4 Airchangerate [/h] 2,9	Heat rec. [%] 85% summer Te1 [Celsius] -12 Winter Te1 [Celsius] -12	Heating coil [kW] 100 Tinl1 [Celsius] 21 Tinl1 [Celsius] 21	Summertime [Months] Apr, May, Sep, Aug Te2 [Celsius] 20 Te2 [Celsius] 20	Wintertime [Months] an, Feb, Mar, Oct, Nov, De Tinl2 [Celsius] 20 Tinl2 [Celsius] 20	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Lighting	Light [lux] 200	Task light [kW] 0,05	Light energy [W/m2] 10	General lighting [kW] 2,4	Switch [Control] Continous	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15

Thermal zone 8 music, science & creative							
Building	Floor area [m2] 242,8	Ceiling height [m] 5	Floor area [m2] 161,5	Ceiling height [m] 3	Volume [m3] 1698,5		
People load	Person load [Pers] 30	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15	Schedule [%] 40%	People activity [Met] 2	Pollution Co2 [l/h] 40	Heat generating [W] 208,8
Infiltration (Buildingregulations 2020)	Basic airchange [l/s x m2] 0,13 0,09	Time [Weekdays] Mon-Fri Mon-Sun	Time [hours] 9 to 15 1 to 9 & 15 to 24	Schedule [%] 100% 69%	Basic aichange [l/s] 52,559 36,387	Basic airchange [m3 / h] 189,2 131,0	Basic airchange [/h] 0,1 0,1
Heating	Max pow. [kW] 400	Summer temperature [Celsius] 20	Winter temperature [Celsius] 17	Summertime [Months] Apr, May, Sep, Aug	Wintertime [Months] an, Feb, Mar, Oct, Nov, De	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Ventilation	Ventilation sensoric [m3/s] 1,0 Ventilation sensoric [m3/h] 3428,6 Airchangerate [/h] 2,0	Heat rec. [%] 85% summer Te1 [Celsius] -12 Winter Te1 [Celsius] -12	Heating coil [kW] 100 Tinl1 [Celsius] 20 Tinl1 [Celsius] 17	Summertime [Months] Apr, May, Sep, Aug Te2 [Celsius] 19 Te2 [Celsius] 16	Wintertime [Months] an, Feb, Mar, Oct, Nov, De Tinl2 [Celsius] 19 Tinl2 [Celsius] 16	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Lighting	Light [lux] 200	Task light [kW] 0,05	Light energy [W/m2] 10	General lighting [kW] 4,0	Switch [Control] Continous	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15

Thermal zone 9 walkways							
Building	Floor area [m2] 651	Ceiling height [m] 3	Floor area [m2] 0	Ceiling height [m] 0	Volume [m3] 1953		
People load	Person load [Pers] 120	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15	Schedule [%] 5%	People activity [Met] 1,2	Pollution Co2 [l/h] 19	Heat generating [W] 125,3
Infiltration (Buildingregulations 2020)	Basic airchange [l/s x m2] 0,13 0,09	Time [Weekdays] Mon-Fri Mon-Sun	Time [hours] 9 to 15 1 to 9 & 15 to 24	Schedule [%] 100% 69%	Basic aichange [l/s] 84,63 58,59	Basic airchange [m3 / h] 304,7 210,9	Basic airchange [/h] 0,2 0,1
Heating	Max pow. [kW] 400	Summer temperature [Celsius] 25,5	Winter temperature [Celsius] 22	Summertime [Months] Apr, May, Sep, Aug	Wintertime [Months] an, Feb, Mar, Oct, Nov, De	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Ventilation	Ventilation sensoric [m3/s] 1,8 Ventilation sensoric [m3/h] 6514,3 Airchangerate [/h] 3,3	Heat rec. [%] 85% summer Te1 [Celsius] -12 Winter Te1 [Celsius] -12	Heating coil [kW] 100 Tinl1 [Celsius] 25,5 Tinl1 [Celsius] 22	Summertime [Months] Apr, May, Sep, Aug Te2 [Celsius] 24,5 Te2 [Celsius] 21	Wintertime [Months] an, Feb, Mar, Oct, Nov, De Tinl2 [Celsius] 24,5 Tinl2 [Celsius] 21	Time [Weekdays] Mon-Fri	Time [Hours] 8 to 15
Lighting	Light [lux] 300	Task light [kW] 0,05	Light energy [W/m2] 10	General lighting [kW] 6,5	Switch [Control] Continous	Time [Weekdays] Mon-Fri	Time [hours] 9 to 15

Litterature

The litterature list gives an insight of the used sources during the project. It furthermore gives and indication of how wide spread the analysis is according to the project's complexity.

Reading guide

The general sources are first listed according to the subject they are connected to. Afterwards the specific source is listed according to the numbers written in the report. At last the illustration sources are listed.

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