National Park Centre Thy

Kystkulturens hus

Titlepage

Ajanthan Alex Sivapatham

Kristine Anine Vammen Ørsnæs

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Main supervisor:	Tenna Doktor Olsen Tvedebrink Adjunkt Pædagogikum Department of Architecture, Design & Media Technology
Technical supervisor:	Agathe Revil-Signorat Research assistant Department of Civil Engineering

Preface

The following project is a presentation of our Master Thesis Project developed during the 4th semester of the master's program in Architecture and Design at Aalborg University, 2019. The report is a presentation of the project development of the entire design process – from idea to analysis and sketching to detailing of the finishing project – of a national park visitor centre in Nørre Vorupør, Thy.

Initially the project started as a wish to explore the relation between sustainability, nature and people, and therefore the idea of creating a visitor centre in one of Denmark's unique areas was created.

A special thanks must go to our supervisors Tenna Doktor Olsen Tvedebrink and Agathe Revil-Signorat for engagement and knowledge which have contributed to the result. Also, a warm thanks must go to the Breakfast Utzon which have, Friday after Friday, contributed to motivation and reminded us that we are all in this together.

Abstract

The master thesis represents the process towards a proposal of Thy National Park visitor centre situated in Nørre Vorupør. The project focuses on the dissemination of the national park to unfamiliar visitors and functions as a stepping stone into the national park. The thesis aims to create a centre that both accommodate the user, visitors and locals. The project work towards the focus of the participatory and the vision of a low-tech environment.

Ill. 01 View from the top of the site

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Introduction

Invitation to tendering

The creating of a visitor centre in National Park Thy have been a vision for many years. When starting at the project we had found the tendering material targeted consulting engineers which have been a great help forming the wishes and demands of the centre.

However, with approximately 2 million DKK left for financing the project we did not quit grasp how far they were in the process of realising the project. In April the project was won by Loop Architects. However, we have throughout the whole project avoided the winner project and the many proposals to not be coloured by their vision and ambitions.

Reader's guide

The report is separated into a number of chapters going from analysis to sketching and detailing of the project. A theoretical framework sets the approach for a sustainable and tourist orientated direction, creating the base for the analysis chapter. The analysis goes from focusing on the national park on a more general level to more specific analysis of the site, which have resulted in a program for the centre.

Following the analysis and program, the design phase is illustrated. As the process has been very iterative going back and forth between sketches and detailing, we have tried to present the most logical route through the process.

The presentation has been placed in the end of the report showing the result of a long process, following a conclusions and reflection of the project and process.

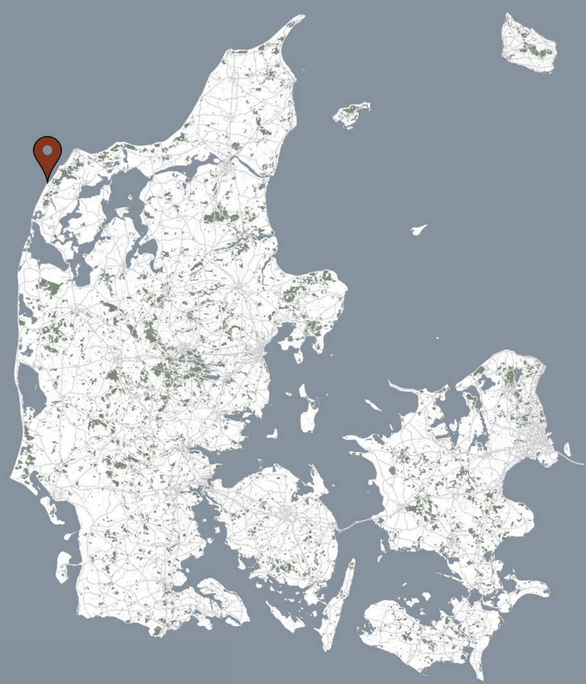
The list of literature and illustrations are based on the Harvard referencing style.

In addition to the report is found a drawing folder, supporting the presentation material with measurable plans, elevations and details.

Ill. 02 Shelter behind Lodbjerg Fyr

Ill. 03 Nørre Vorupør landing ground

Motivation



Ill. 04 Denmark

Overpopulation, pollution, plastic in the oceans, destruction of nature and natural resources is just a short list of human influences on the Earth and for many years the human kind have ignored the warnings about global warming, and only smaller global initiatives have been made.
Furthermore, we spend hours indoor, disconnected fron the reallity, not knowing the potentials of the outdoor places surrounding us and thereby forgetting the identity that unites us.

10 years ago, the first Danish national park was created in Thy on the west coast of Jutland in Denmark and now they aim for a centre (ill. 04).
Places like Thy is a symbol of areas that have not been infiltrated by technology and sky-high buildings of concrete, yet. Places like this are spots where "original" landscape, people and trades like fishery can still be found.
But why is it important to protect a unique location like Thy and why is it important to make people care about the nature in general? Should Thy become a medium of communication about the climate changes or is it simply to preserve a historic area of Denmark? Or Both?

Our intention with the centre is not to find a universal solution on the climate changes, but simply to create something "genuine" and simply become a small contribution in a wider context. Though economic, environmental and social sustainability are essential to the project, the intention is to somewhat go against the trends of the time where everything must be high-technological and automatized. As the Danish farmer and "Bonderøv", Frank Ladegaard Erichsen, says: "It is not an attempt to go back to the Stone Age, not at all, it is simply an attempt to make it more simple" (Erichsen, 2008).

National Park Thy

A short description

The National Park Thy covers an area of 244 square metres and spans from Agger in the south to Hanstholm in the north (ill. 05). The national park has a unique nature only found at this location in Denmark – as well as in Europe – and is therefore visited by many, both locals and tourists.
The unique nature of national park Thy consists of sand dunes, dune hearth, wetlands, lakes, calcareous coasts and dune plantations with conifer. Marked tracks for riders, hikers and bikers are found throughout the park, and at some locations it is possible to stay overnight in shelters. Likewise, observatory towers are placed around the park and it is possible to fish and bath in lakes or in the North Sea (Nationalpark Thy, 2011).

However, the area can somehow seem very foreign and the scale very unmanageable to many people. As a response to this a visitor centre is to be placed, with exhibitions for tourists and space for the park administration, in the town Nørre Vorupør, centrally located in the national park.

The advantage of placing the centre in Nørre Vorupør is first and foremost the central location in the national park. From this point there is only about half an hours drive to both Agger in south and Hanstholm in north which make it easy for tourists to make short one day trips.
At this point, only two houses with information about the national park is already found at Svaneholmhus, near Agger, and at Stenbjerg landing ground. The information centre at Stenbjerg is the smallest of the two - approximately 35 square metres - and at the same time the only one which is staffed throughout the summer season (Nationalpark Thy, 2011). The centres location in Nørre Vorupør therefore creates a natural line of information stations along the west coast.
Bike and pedestrian paths are found throughout the whole national park. A continuous path, for both pedestrians and bikers, is placed on the west side, going though all the towns in park. As seen later, this path also goes directly past the site of the project, which makes it possible for people to stop by and recieve information or just to take a rest or it would be possible to start a journey into the national park form this point.

Another and very important advantage of placing the centre in Nørre Vorupør is, that it is placed where the tourists are. People can easily stop by when visiting the town and seek information and do not have to drive out to a remote location in the national park. To support this a visitor centre, not far from the national park, for windmills in Østerild, is placed so remote that people do not visit it. This have created negative influence on the finances (Hansen, 2019). This have shown how important it is, that the centre should come to the tourists and not let the tourists come to the visitor centre.

Project site

National park Thy border

Pedestrian path

Bike path

Café / Restaurant

Good surfer conditions

Overnight stay

Toilets

Shelters

Bird observatory

Lunch pack facilities

1. Bunker museum
2. Hanstholm lighthouse
3. Isbjerg
4. Vorupør landing ground and Norsø Aquarium
5. Vorupør Museum
6. Stenbjerg landing ground and rescue museum
7. Faddersbøl mill
8. Lodbjerg lighthouse
9. Svaneholmhus

Ill. 05 National Park Thy

History

The landscape in Thy is formed by a series of changes since the Ice Age. A result of the advance and melted ice from the Ice Age a moraine landscape covers the most of Jutland. Released from the pressure of the ice, the land raised leaving large hills in the landscape (Naturstyrelsen, n.d.).
Until the Stone Age the sea level rose and fell many times. The mild climate melts the ice in the northern Scandinavia, which causes the sea level to rise and leaves the area as a cluster of islands surrounded by the Arctic Ocean. The uplift of the land continued leaving drained sea floor as a naked and unprotected land. The Northern Jutland becomes one continuous landmass (Jensen, 1993). The steep cliffs found along the coast from Lodbjerg to Hanstholm are former coastlines (Naturstyrelsen, n.d.).

During the Middle Ages sand drift causes a lot of trouble creating large drifting dunes which destroyed many fields and forced people to move further inland. The damage coursed by the sand were a result of geological conditions, but also by removal of vegetation. Forest and brushwood were used as fuel, fodder and building materials, leaving nothing to hold back the sand (Jensen, 1993).
The sand drift forces people to move. Legislation is made to prevent the drift, people continuous to use it unchanged, though the punishment is compared with theft. Not before the end of the 1700's, 100 years after the first initiatives, plantation became an active tool for dune management (Jensen, 1993).

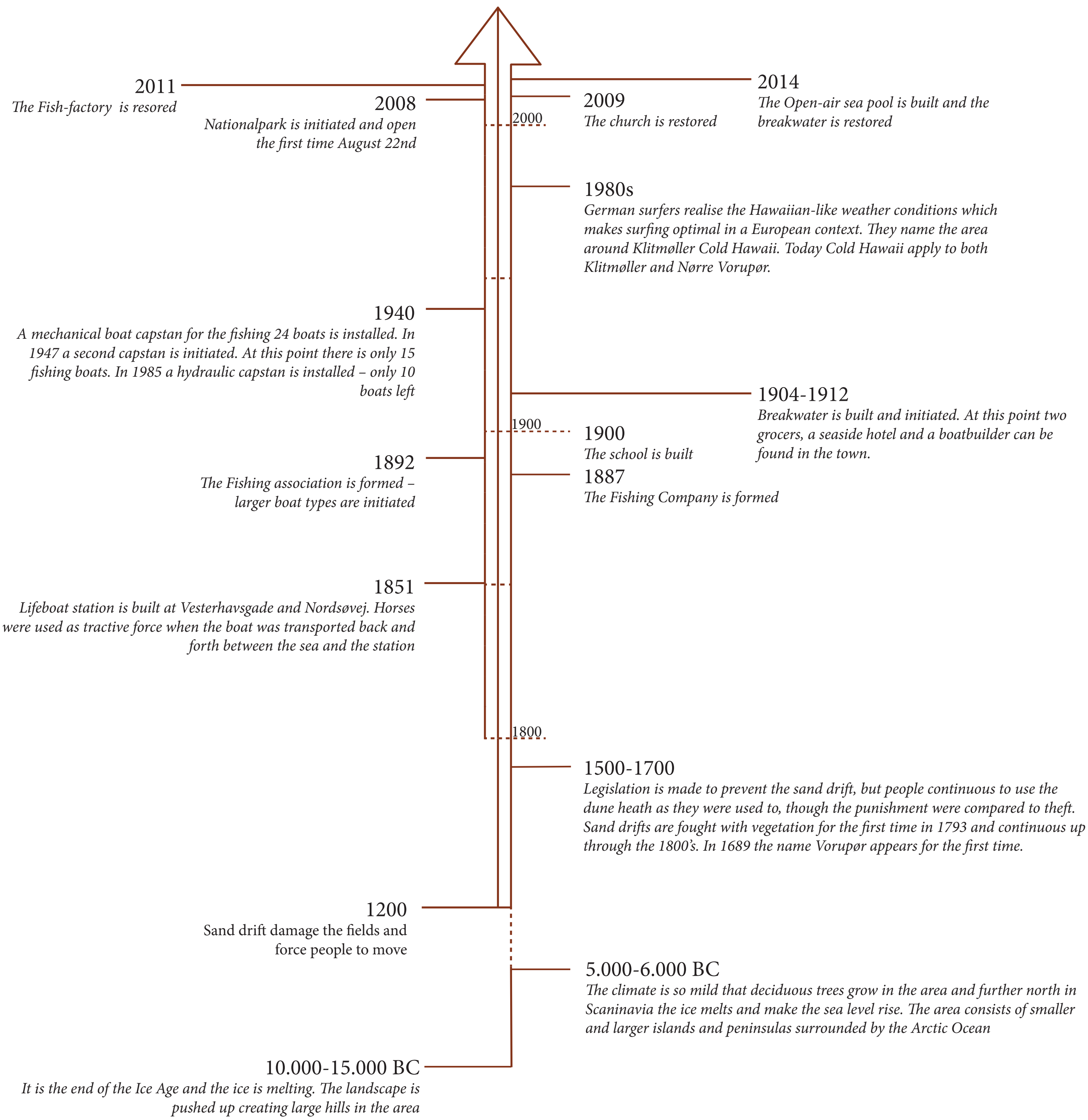
On the west coast of Jytland, 20 kilometres from Thisted, lies Nørre (northern) Vorupør. In the late 1600s the area is known as "Klitten" (the Dune) and consists of seven houses. Farming is impossible and fishery is the only possible income. But it is a dangerous and hard job, due to small boats, in a merciless environment, and the income is small (Jensen, 1993).

Throughout the 19th century it is the poorest part of the area, though the population have grown. In the 1850s the fishery is organised and in 1978 they export further inland and later to Germany (Jensen, 1993). Information states 75 household's dependant of fishery, in 1880, of these approximately 90 fishers in 14 boats (Rasmussen, 2000).

In 1887 the Fishing Company is formed. It is a union of 33 evangelical fishers who shared everything – beliefs, export and income. The company were cause of many improvements. They developed better boat types, initiated the lifeboat service and the organisation of treatment and export of the capture, along with mechanical capstans to pull the boats from the water. The fishery were still a dangerous occupation and they ask the state for the establishment of a breakwater that would create safer conditions when leaving and arriving at the landing place. As it finished in 1912 the fishing season were expanded, it prevented fatal accidents and attracted young fishers (Rasmussen, 2000).

When the harbour in Hanstholm were established in 1967 the days with fishery in Nørre Vorup were numbered. From 1967 to 2000 the number fishing boats fell to 15 to 9 and 40 to 19 fishers (Rasmussen, 2000). In 2010 the last fishing boat stopped and only three boats are left. Two sails with anglers and one is left on the landing place as a museum (Realdania, 2007).

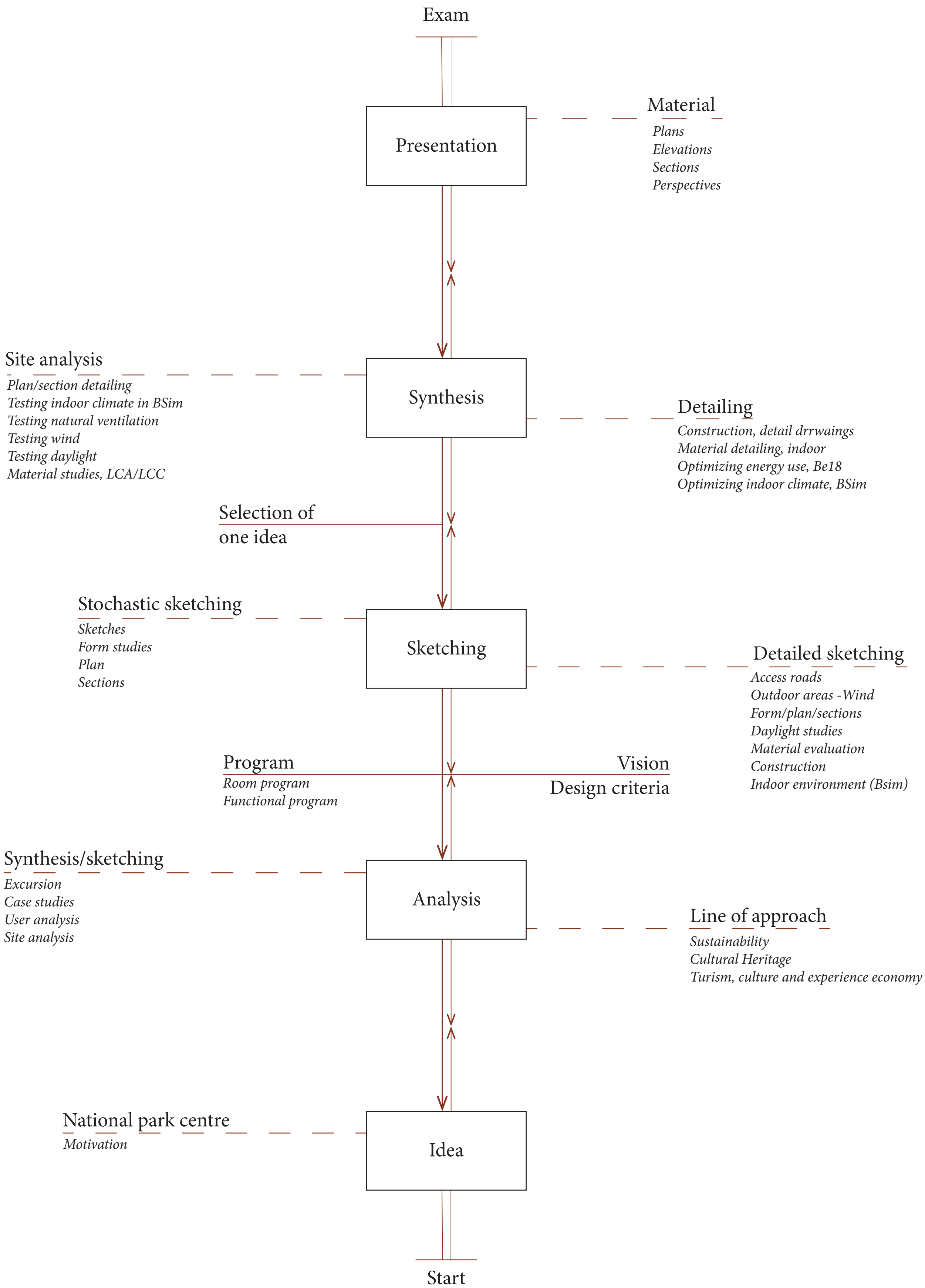
As the fishery died as a fulltime trade the town became a very worn town with decreasing population. In the beginning of the 2000s the tourism started to desert and a reinterpretation of the cultural values of the town was needed. At this point German surfers have named the area around Klitmøller and Vorupør 'Cold Hawaii' due to Hawaii-like weather conditions. Promotion of Cold Hawaii and initiative to renovate the old fishing cabins close to the landing place have slowly turn the negative loop. A renovation of the church, the fish-factory, the breakwater and the establishment of an open-air sea pool came along (Realdania, 2007). On the side line of these initiatives the Danish Ministry of Environment selected Thy as the first Danish national park in 2007, because of the unique nature. The park is supposed to preserve both natural and cultural heritage, promote possible outdoor life and strengthen educational research (Nationalpark Thy, 2019).
The area is slowly learning to live of the potential confined to the specific location. It has created a strengthened community with a renewed faith for the future.



Ill. 06 History

Methodology

The importance of a holistic approach have increased for the subject of sustainable architecture and architecture in general. To accommodate the issue of the significant emission of greenhouse gasses and new legislative demands to reduce the energy consumption, a method close connected to the Integrated Design Process (IDP) would be applied in the development of the project. Integrated Energy Design (IED) focuses more on the integration of sustainable solutions in the progress of a project. IDP revolves around the involvement of, the field of architecture and engineering to overcome complicated issues connected to the development of buildings. The method functions as a foundation for the project, and the implementation of the different phases of IDP - problem formulation, the analysis -, sketching -, synthesis and presentation phase - applies structure into the development. The iterative process enables a holistic project, because multiple solutions and parameters are considered, revisited and tested in the process of designing. (Knudstrup and Hansen, 2005). The IED supplement the IDE, and aim to reduce energy consumption and design buildings with high energy-efficiency. An iterative process ensures a holistic optimal design though programming and energy-efficient strategies – primarily passive strategies and secondly active strategies – to achieve as much comfort as possible (Andresen et al., 2009). The IED present a comprehensive guideline for the achievement of optimal sustainable solutions. The method assure the principles for a low energy building are implemented in the initial phase of the project. During the phases different tools will be used to communicate visions, e.g. in the analysis phase analysis of site and climate will be mapped in diagrams. In the sketching phase simple tools as hand drawings and Sketch-Up models may be used to create quick visualisations of initial ideas. Also, either a deductive or inductive method will arise during the sketching phase based on experiences from the analysis phase, i.e. literature or observations on site. In the last part of the sketching phase an onto the synthesis phase simulation in e.g. LCA, LCC, Bsim and Be18 will be made to ensure environmental, economic and social considerations. From the synthesis phase onto the presentation a detailed 3D model and detailed information about the building will be carried out.



Ill. 07 Methodology

Line of approach

Ill. 08 Stenbjerg landing ground

The main focus of the project is the design of a sustainable visitor centre in Nørre Vorupør

To ensure the design is lead in the right direction theoretical studies of sustainability, cultural heritage and turism and experience economy are investigated are made.

Sustainability

For more than three decades scientists have warned and talked about the consequences of global warming. Though the human species is self-proclaimed the most intelligent species on earth, warnings about global warming have been ignored and only smaller global initiatives have been made (Rees, 2010; Berardi, 2013). Solutions like 'green building', as *Council House 2* in Australia, and *Shanghai Tower* in China, and 'zero energy buildings' as *Yannell Residence* in Chicago, gains ground. But a core issue is the fact that no global acknowledged definition of sustainable development exists and as the awareness increases, so does the number of terms like *source reduction*, *cleaner production* and *life cycle assessment* (Peter Glavič and Lukman, 2007).

This section is an attempt to specify why it has taken the broader population such a long time to realize the problem about climate changes though continuous warnings. Furthermore, the goal is to identify the sort of sustainability that is suitable for the context of the site and, in that way, create a sustainable direction for the project.
Because a worldwide definition of sustainable development has not been clarified the concept is continually clouded by new additional definitions. In 1987 the Brundtland Report tried to assemble a universal definition of sustainable development and thereby unite the worlds countries to engage in a common goal. The report states that *"sustainable development is development which meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987).
The report place focus on environment, economy and society, which considers procurement of resources, growth and needs, respectively, as the three fundamental components of sustainable development.

It is now more than thirty year since the Brundtland Report was written and for many of these years we have seen images, addressed to people's emotions, of thin polar bears on melting icebergs and disformed turtles trapped in plastic, but even those who believe in climate changes have failed to make necessary change. According to Rees (2010) *"Humanity is a deeply conflicted species"* because we are torn between the ability to reason and judge and emotions and instincts. The general population on Earth have denied the problem for so long, that it is almost too late to change a catastrophe on the long run. This tendency to denial is a significant role in human behaviour and is the reason why Rees calls the human species *"naturally unsustainable"*. No matter how severe the environmental problems becomes people's commitment towards solving them depends upon the way they are presented and not how critical they are. The development of people realizing the problem have slowly grown, but a lack of support for a more defined policy is caused by ignorance, the lack of caring and disbelief (Rees, 2010; Guy and Farmer 2001).
New definitions and interpretations are often put forward and discussed, but still a concrete universal definition has not been accepted as the content seems to depend very much on the topic.

The building sector is generally one of the foci where energy consumption of materials and structural elements carries a large responsibility of energy use and emission of greenhouse gasses – not only during the operation phase, but from the early production to the final demolition. According to Berardi (2013) the terminology *"sustainable building"* has increased and is often abused, which has led it to become unclear and biased. Based on different interpretations Berardi proposes the reason for a missing definition as specific factors that is cause for uncertainty. These factors contain time; location; people; and domain (environment, economy, society). I.e.

- Time: The lifespan includes not only the operation period, but the whole lifespan, which can be difficult to determine in the long run.
- Location: The capability to interaction with the surrounding environment is very individual for every building.
- People: Because people's perception is so individual it can put a constraint on the development and spread of sustainable buildings. Stakeholders priority and point of view often also have an influence on the result.
- Domain: The economic aspect is essential as it is dependent on both time, context and people.

Opposite Berardi (2013) who searched for a more coherent definition, Guy and Farmer (2001) have *"abandoned the search for a true or incontestable definition"*. As Berardi they point out the variety of approaches and interpretations. They state that different individuals, groups and institutions are the reason for different perceptions, though they might have the same commitment to sustainable design. Based on completed buildings and reviews they have listed, what they call six environmental logics: Eco-technic, eco-centric, eco-aesthetic, eco-cultural, eco-medical and eco-social. The six logics frame different ideas and concepts in the environmental discussion. I.e.:

- Eco-technical: Believe technical solutions can solve future environmental problems on a global level.
- Eco-centric: Believe that nature dictates human responsibility toward environmental issues and the way human kind must manage and take care of it. Generally, buildings are unnatural forms that interrupt the natural cycles.
- Eco-aesthetic: Believe architecture to be of societal values and must inspire to identification through building arts. The logic has focus on individual creativity and a romantic view of nature. Architecture is prioritized above physical performance.
- Eco-cultural: Believe in preservation of existing cultural values and in relearning a sense of place. It is about the responsibility for protecting a place from intrusion and destruction of ecosystems on a local level.
- Eco-medical: Believe human health is threatened by technology and therefore buildings must radiate a heathy environment to meet the human physical, biological and spiritual needs.
- Eco-social: Believe democracy to be the key to a sustainable society. Human domination and social patterns are the reason to natural degradation. Environmental responsibility is created through self-reliant societies, which operates on a local economy.

Looking into Guy and Farmer's logics the eco-cultural and eco-social logics are the most interesting categories, in our opinion, when seen in the context of a visitor centre in Nørre Vorupør as they focus on local materials, low-tech technology, flexible solutions and vernacular, but participatory focus. In our beliefs these factors are important because they create buildings which are true to their environment and the local history. The fact that the building is not built because it is possible with modern technology, but because it explores the opportunities in local resources, makes it more in sync and connected with nature. Likewise, the building should reflect local building traditions and represent the local community which state of mind are considered very down to earth.
The eco-cultural logic focuses on the preservation of existing and diverse cultures and its genius loci (sense of place). At each location a unique identity evolves from nature and must be protected from disturbance. The aim is to take a distance from a universal and technically based design method, because these often fails to correspond with specific values of a location and the community. Passive strategies are in this case of great value to the building, as it reflects an understanding of the site conditions, whether it e.g. is the wind or the sun.
The eco-social logic focuses on the society rather than the individual and see the democracy as a key to ecology. Through common goals and needs humans will be able to live in coherence with nature without dominating it. The aim is among others, to take responsibility for the local environment and create buildings with a feeling of home and belonging. This approach is as much technical as it is aesthetical and social (Guy and Farmer, 2010).
Guy and Farmer's logics can be combined in many ways and interpreted very individual. Combined with more technical knowledge about e.g. passive as well as active strategies and let them interact in order to solve very complex problems in the design of a building, the project moves towards a more holistic project.

During the last few years sustainability has to some degree become a hyped and trendy word. Though it in the beginning might seem superficial or effortless the focus could slowly lead to significant changes on the long run. Already, many building companies, clothing and food industries marks themselves as sustainable, because the tendency is accredited and acknowledged.
The degree of sustainability will be evaluated based on recent knowledge and data of a given subject. In relation to

Berardi's (2013) factors, they will be evaluated with the aid of programmes which ensure an informed decision. I.e. the time uncertainty of the project will be evaluated on material lifespans in relation to the embodied energy in the program LCAByg. Furthermore, investigations of the economic aspect, as a solution for the domain factor, must secure the ability to overcome and support direct and indirect costs without neglecting other essential needs in the program LCCByg. A global, common social expectation to the building's expression might not be solved during this project, but never the less the user needs must be respected and fulfilled. Passive strategies are investigated in BSim to maintain indoor comfort for the users as well as the special arrangements are organised in the most optimal way for both staff and visitors.

At last, Berardi's (2013) location factor leans towards Guy and Farmer's (2001) eco-cultural logic that intentionally secures an authentic sense of locality and place. This logic or uncertainty uses a more phenomenological approach, that can be perceived differently from individual to individual.

To be able to live up to Guy and Farmer's (2001) eco-cultural and eco-social criteria it is important to preserve the rooted culture and authenticity of the place. The centre must create a sense of responsibility towards protecting local values, traditional buildings and the surrounding nature. Regardless of the location there will always be constraints as well as possibilities, but both must be respected to create truly eco-cultural sustainable buildings. Overall, it is important that the unique identity, tradition and individuality of the site is expressed and reflected through e.g. building typology or construction techniques.

Through the eco-social logic, the design approach must express the formation of society and the link to the natural locality. It must symbolize a sense of community not only for the inhabitants, but especially for the visitors, as this will create a more unified need to protect Thy. The centre must function as a communicator of knowledge and history of the surrounding environment.

Cultural heritage

The 22nd of August 2008 a political decision was made, based on empirical questions of the site's inherent values and preferences, to initiate the western part of Thy as the first national park in Denmark.
The term "national park" resonates with the word heritage and the perception of a national identity. A national self-image rooted in the rough and wild part of the Danish landscape, were the reason for the public's' favour of the nature situated in Jutland to become the first National Park.

But what defines an area to become a national "heritage"? A common perception of the word heritage relates to the word extinction of a specific tangible species (fauna and flora) and the fear of their extinction. To label the landscape situated at the west coast of Jutland as a national heritage must have a regional and national desire for preservation and conservation of the site.
To elucidate the question for the landscape around Thy to be classified as a "heritage" the actual word heritage will be examined.

The definition of heritages have been look upon at the Oxford English Dicitionary to have a simple foundation of the word (to understand the specific explanation of the specific word). Pursuant to the dictionary, the term heritage have multiple descriptions in the use of heritage and the definition of heritage. The second definition mentioned, comprise the notion of denominate the area as a national heritage park. The description from the Oxford English Dictionary (2019) are as followed:

"Denoting or relating to things of special architectural, historical, or natural value that are preserved for the nation".

The quotation seen above, emphasis on the relation to an objective, and the value of preservation. The preservation must connect the inherent to the past of specific memories and histories. The heritage site implies that the cultural value of the area are owned and related to the nation, the world and not the only the local habitants.

"Heritage tourism should be understood based on 'the relationship between the individual and the heritage presented and, more specifically, on the tourists' perception of the site as part of their own heritage (Poria et al., 2004)" (C. Knudsen and E. Greer, 2019).

The question to be answered is why the western landscape have been preferred, compared to the eastern. The north of Zealand has been ranked low in spite of its potential, and the closeness to the dense and popular capital of Denmark, Copenhagen. If use value were important it must have been expected that the location situated close to a larger population hub would have been valued higher than an area located further away (Bredahl Jacobsen and Jellesmark Thorsen, 2019).
The preservation of the nature located at west of Jutland derives from its appearances in the Danish Golden Age literature and paintings. The northern and western landscape became an identification of the Danish landscape and erected as a focal point for the national heritage (C. Knudsen and E. Greer, 2019).

Turism, culture, and experience economy

For many decades the migration from rural areas to larger cities has have had a negative effect and made a disproportion in population and working capacity. Especially the outlying areas farthest off the larger cities can feel the pressure (Realdania, 2017). From 2006 to 2018 the population has fallen with almost 5% while in Nørre Vorupør it has fallen with approximately 13% (Statistikbanken, a-b, 2018). It is often young people who move away from the area, for educational reasons or to find work. This means a majority of elderly is left behind (Realdania, 2012).
The spiral is very negative and is difficult to turn around because the bigger cities have a broader variety of activities and benefits. It might not be possible to turn the migration completely, but it is important to stop it and keep the younger generations, who grew up in the areas, or make the area attractive enough to come back to after education.

The outlying areas have always been dependant on tourists and now maybe more than ever. From this need the term *'culture- and experience economy'* have arose. It covers the financial benefits from specific experiences inherent in nature or made by human resources. I.e. the content of the experience, which is to be facilitated or sold, is based on local nature, landscape, commodities, trade, buildings, history or culture (Manniche and Jensen, 2006). Every area is different and though the challenges might seem the same in the rural areas the solution might not. It is important to promote the identity of the place, so they might become a steppingstone to a more positive development with focus on life quality and not necessarily economic growth alone (Naturstyrelsen, 2017).

Nature have always been a key attraction for tourists (Fredman and Tyrväinen, 2010) and the national park in Thy takes its starting point in natural resources as the coastal area, dune, heath, forest, flora and fauna along the west coast of Jutland is only to be found on this exact location in Denmark. The national park has an area of 244 square kilometres and can for some people seem impossible to get an overall view of and the wild nature can seem impassable (Thisted Kommune, 2018).
Since the opening of the national park in 2008 events like seal safaris, berry picking, mushroom collection and taste of regional dishes have evolved (Naturstyrelsen, 2018). But the nature alone is often not enough to attract tourists and create commercial success (Manniche and Jensen, 2006). Therefore, experiences related to cultural heritage like guided hikes and bus tours to architectural buildings and storytelling at specific sites can also be found around the national park's towns (Naturstyrelsen, 2018). Characteristics for these events are the on-location experience where history and heritage about otherwise invisible and intangible aspects of landscape and architecture are passed on (Manniche and Jensen, 2006). Furthermore, more active activities include cross triathlons and mountain bike routes as well as children activities like boat building and workshops with natural materials (Naturstyrelsen, 2018).
Besides the national park's public activities, the phenomenon and brand *'Cold Hawaii'* is a good example of how the identity of a place, as the surfers' utilization of the areas weather conditions can be found nowhere else in Denmark. Based on an increasing interest for surfing initiatives to surf shops and schools have flourished in Klitmøller and Vorupør and help to promote and create identity in the area for young newcomers.

Local engagement and community are as much attractive as imposing landscapes and nature. Over the past years many initiatives have been made and many local enthusiasts work hard in cooperation with local companies, to show the identity of a place, to change the physical worn-out environment and buildings and make qualified services and experiences for tourists (Realdania, 2017).

Passion can still be found among the local enthusiasts who wants to turn the trend around. Though they might not have stopped the migration yet, approximately one million people visits the national park annually (Pedersen and Immersen, 2013).
The national park in Thy and the local enthusiasts have understood to exploit the cultural and experience economic activities in their specific geographical location to promote both natural and human made resources through storytelling around the national park on guided hikes or bus tours. The stories take its starting point in specific locations like lighthouses and birdwatching towers, churches, bunkers

from the 2nd World War, burial places for Vikings and monuments, but also in the dune hearth and drifting dunes (Naturstyrelsen, 2018).
Although it will take a long time for the cultural and experience economic activities to replace the traditional trades as fishery it is on its way and on the long run it could help to turn the negative migration around and contribute to growth in the local population (Manniche and Jensen, 2006).
Nature, environment, involvement, authenticity and traditions is characteristics and qualities that create the frame around the rural areas and a complete contrast to the larger cities, which is characterised by pace, dynamic, technology, and changeability (Manniche and Jensen, 2006).

All the above-mentioned activities are already a part of the experience of national park Thy, many of them lead by museums, nature guides or volunteers who pass on knowledge and engagement about the area. The farther out this knowledge comes the less foreign and inaccessible the area becomes.
The centres job is neither to replace nor take over the existing activities. It should simply create a base for some of the activities and perhaps assist the museums with larger facilities for activities. Furthermore, the centre should become a steppingstone or a gate to the rest of the national park for those who are unknown in the area and those who think the park is too complex to deal with by themselves.

Subconclusion

The three main subjects investigated: Sustainability, cultural heritage and tourism and experience economy very much focus around the same subject: The local environment and spirit of the place.

Looking into the problematic field of sustainability Guy and Farmer's (2001) eco-cultural and eco-social criteria is the main foci throughout the project to ensure the centre is rooted in a local authenticity. At the same time the centre must communicate a sense of responsibility towards protecting the nature and the rooted culture of the location. It is important that the unique identity and individuality of the site is expressed as well as it must symbolize community, not only for the inhabitants but also for the visitors to create a more unified needs to protect and explore the area. However, decisions cannot be made on a phenomenological approach alone. Therefore, to ensure informed decisions several assessments must be made on lifespan in relation to the environmental impact as well as economic aspects must secure the ability to overcome and support direct and indirect costs. In relation to this, passive strategies must be the focus and high-tech technologies must be avoided to secure a healthy building and to show people, that environmental problems not have to be solved though technology.

The cultural heritage is of great importance in the area and apparently also in the rest of Denmark as it has been nominated the first Danish national park. A combination of a unique landscape and a romanticization of the area have led to this need for preservation of something that can be lost forever if we do not protect it. Again, this leads to focus of the spirit of the site.

But despite this romanticization of the area locals have been moving away to the larger cities which have a broader variety of activities and benefits. The spiral is very negative. So therefore, to catch the interest of tourist, and maybe to turn or at least stop the migration, 'culture and experience economy' could slowly help to turn the interest in the area around. The term connects an experience to a product. I.e. an attractive product is often based on local materials, trades, buildings, history and culture among others, but with the experience added the attraction becomes more attractive. Therefore, it comes as no surprise, that guided hikes and storytelling can be found all around the national park.

Though the national park centre is intended to be free of charge to enter, it already creates, along with the well-established brand of Cold Hawaii, a frame for many local products just by being the *first* national park centre in the *first* Danish national park.

Site analysis

Ill. 09 View from the top of the site

This chapter includes phenomenological analysis of Nørre Vorupør and the site along with an investigation of the local climate conditions.

This will contribute to the understanding of local issues which must be considered in the design process.

Nørre Vorupør

The project site is found in the old fishing town of Nørre Vorupør which is surrounded by the national park on three sides and the North Sea on the fourth. Nørre Vorupør have 581 citizens out of 43.716 citizens in Thisted municipality (Statistikbanken, a-b., 2018). As mentioned earlier fishery have been the main income for centuries and, as the years have passed, formed the culture and the history of the town. But a recently dying fishing industry called for changes and now the town mostly lives of visitors who wants to get a glint of their heritage (Realdania, 2017).

Though the town is small and cannot be compared with the larger cities, the characteristics of Nørre Vorupør have been marked on illustration 10 inspired by Kevin Lynch' *Image of the City* (Lynch, 1960). The method creates the concept of legibility which describes the ease to understand the layout of a city. It is based on Kevin Lynch' five elements known as: Path, edges, districts, nodes and landmarks, which is characterized by:

- Path: Any road or trach the observer moves along – potentially or occasionally – and it can appear as both streets, canals or railroads. It is around this element the other categories are arranged. In this case the paths are marks as roads – asphalted as well as gravel-paved. Likewise, the most marked tracks through the sand dunes can be paths (Lynch, 1960).
  The main path runs along Vesterhavsgade which meets Hawblink, Norsøvej and Fiskervej along the way. Besides the smaller summerhouse roads connected to the main roads hundreds of smaller paths for pedestrians emerge. It is mainly along these paths closest to the city centre the permanent habitation is found.
- Edge: A linear element and a natural boundary like the shore, railroads or definite walls. The barrier can be penetrated and possible to break through (Lynch, 1960). In this case the North Sea is a very defined edge. Similarly, is the former coast line of steep sandhills which at some places are impossible to climb and the smaller streams through the dune heath.
- Districts: Zones with a recognizable identity. This identity can be very individual for the given area and can be typology or building density in cities (Lynch, 1960) or in this case the sudden change from town to dune heath. In some areas it is possible to separate the all-year residence from the summerhouses, but in most of the town they flow together and cannot be identifies as districts.
- Nodes: Strategic spots like junctions, concentrations of users or the foci of a district (Lynch, 1960). In this case the nodes mark trafficable cores and intensive focus areas with a concentration of shops. At these points it is possible to arrive with car, bus, bike or as a pedestrian. Especially, the northern node seems to be a point of attraction for activities.
- Landmarks: A landmark is typically a static and close object like a store, building or sign, but it can also have a larger distance to the observer like a mountain, which can be seen over the top of smaller objects (Lynch, 1960). The landmarks of the town are only visible from specific points and is characterised as elements everyone can reference to – even a one-day tourist.

The image of a city can be interpreted and understood very individually. In the case of Nørre Vorupør only the very dominating elements are pointed out for the reader to get an understanding and an overview of the layout of the town. There appears to be a clear movement directed towards the landing ground (3) and the shops and activities concentrated near it. Moving south away from the landing ground there is a mass of buildings, while moving to either north, west or east one is met by the large scale of North Sea (1) or dune heaths (4).

Project site
Paths
Edge
Town
Dune heath
Beach
Nodes

Landmarks
1 The North Sea
2 The pier and open-air sea pool
3 Landing ground
4 Dune heath
5 Campsite
6 Vorupør church and the grocer

Ill. 10 Map of Nørre Vorupør (Map: SDFE kortviser, 2019)

What is a landmark?

As the centre is supposed to attract visitors it has been discussed in what degree the centre should stand out from the context. As mentioned Nørre Vorupør is surrounded by nature, and the centre should represent this nature inspiring people to explore it even more. Therefore, in this section it is discussed exactly what a landmark is, how it can be interpret and to what degree we aim for.

According to the previous section, Kevin Lynch speak of a landmark as an external type of point-reference, like a building, sign or mountain. In our case, this could be the camping place, church or grocer, but also elements like the North Sea, landing ground or the dune heath. In other words, it varies very much in shape and size. Two "rules" however apply for an object to become a landmark. First, it should either be placed in the city or second, it must be of such a scale that it can become a reference point which can be seen over the top of smaller elements. Common to the two is that should symbolize a constant direction. Therefore, even the sun can also be named a landmark, as it set a point of direction. This also make North Sea and dune hearth valid landmarks (Lynch, 1960).

Reflecting upon this, both the North Sea and dune heath is of such a scale that it should be internally understood exactly which point of reference is mentioned. A landmark therefore depends on how local one is to the area. The more local one is the more specific reference points appear, as smaller object become landmarks. When people saying: "We'll meet at the ice cream shop" everyone knows of which ice cream shop is mentioned. But as a foreigner the larger scale as the beach or landing ground is more suitable.

Intuitive the centre must stand out in some degree. If a foreigner search for the centre it does not help if it is located at a remote place where it is difficult to find. However, as seen later in this chapter, the architecture of the area of Thy is very modest and homogeneous. Therefore, simple features would make it possible for the building to stand out from the broader context. And maybe the centre automatically will become a landmark, though reflecting the cultural heritage, only based on the fact that it is the only of its kind in the area. This means it is not a bad thing that the building blend into and respect the context, as just little thing – as materials or shape – stands out from the context.

Ill. 11 Lodbjerg lighthouse

Site observation

The project site is a part of the dune hearth east of Nørre Vorupør. To the south the site is cut off by the road "Hawblink" which leads north to Klitmøller. On the other site of the road lies the Westwind clothing shop along with a newly opened surf shop and the VØ-pizza bar. West of the site is a large parking place which in periods is used by the local community for gatherings and town parties and the Nordsø Aquarium. North of the site is "Røgeriet" (smokehouse) which is a part of the Fishing Companies buildings. Behind this is the landing place and the North Sea where surfers are seen all year around.

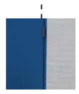
At this point the site is an essential and characterizing element in the town image. It sneaks its end into the town placing a very visible part of the national park close to the centre of the town. In other words, the site is a part of a larger area which is appointed as protected dune heath and included in the Protection of Nature Act. Though this means, the area is protected from any harm, the municipality have made an exemption with the national park centre (Beskrivelse Nationalparkcenter Thy, 2018).
The site consists of two parts - 1 and 2. Part 1 is not intented to be built upon, but to function as a forecourt to the centre. Part 2 is the area meant for the visitor centre (ill. 16).

Ill. 13 South 1:500

Ill. 14 West 1:500

Ill. 15 North (backside) 1:500

Site



Ill. 16 East 1:500

Ill. Site surroundings

Ill. 16 Map of site

Material observations

The context surrounding the project site consist of one common material, and a few house are cladded in wood. The brick is an attractive material at the site, and reference back to the rebirth of the region in the start of 1900. The brick dominate the area and occur on most of the houses at Nørre Vorupør. A common characteristic for the houses are the finish on the brick walls. Plaster, chalk and untreated bricks are the three solutions that resonate around the site. The white colour on the façade reflect the finish on an old chalked farmhouses.

The doublet-pitched roof occurs on all houses, from the small shacks near the pier to the old auction houses. It is evident that the consistent use of a specific material and façade expression formed a homogenous picture of the town. The original use of material on the roof was often concrete roof tile sor galvanized tiles, today replaced with roofing felt.

A contrast to the dull material and monotonous architecture, however, occurs on the level of detail. The houses distinguish form each other in the detailed material or colour on the windows.
Copper frequently occur on the houses at the site. The corrosion of the copper forms a fine contrast to the simple white colour and give the houses character. The use of copper differs from house to house. The majority had cobber gutters or window frames, and a few covers the roof.
The wooden structure and façade are not as dominant as the brick in the area.

At the west end of Nørre Vorupør, near the landing ground, a complex of wooden summerhouses has been built within the current years. The houses are situated a few meters behind the wooden shacks that are located alongside the pier. The wood façade at the site are coloured in a variety of colours.

The urban plan of the shore contain a lot of concrete. The concrete at the site has become a dominant material at the shore and on the pathways. The material does appear on the trial towards the water, and frames some of the project site. The material functions well in the in local climate, and has been integrated in a manner where it prevent the sand to drift.

Ill. 17 a-j Details from the national park

The buildings in Nørre Vorupør

The fishers buildings
These buildings are often made of white painted brick or limewased stone with roofing felt on top.
Originally the roofs were covered with galvanized tile, but have been, as mentioned, over the years been replaced with roofing felt.
The building type is very small, simple and humple and can be found in all the towns like Klitmøller and Stenbjerg landing ground, along the west coast.

Ill. 18 Fishers building

The all-year residence
This type of building are traditionally made of brick and have the same simple expression as the fishers buildings. They are symmetrical, some with white facades as seen on illustration 19, or merely as red brick and often with tiles.
Traditionally the gables are placed facing the west and east and the south or north facade facing the street. This have resulted in a very long main road from the landing ground to the grocer in the other end of the town


Ill. 19 All-year residence

The summerhouses
Many summerhouses are built either in wood or porous concrete, plastered with a matching material. The newest summerhouses are often made of wood, however, as seen on illustration 20.
The oldest houses are found to the north and south of Nørre Vorupør hid behind tall coniferous trees shielded from the weather.


Ill. 20 Summerhouse

Ill. 21 Locals in Nørre

Site analysis

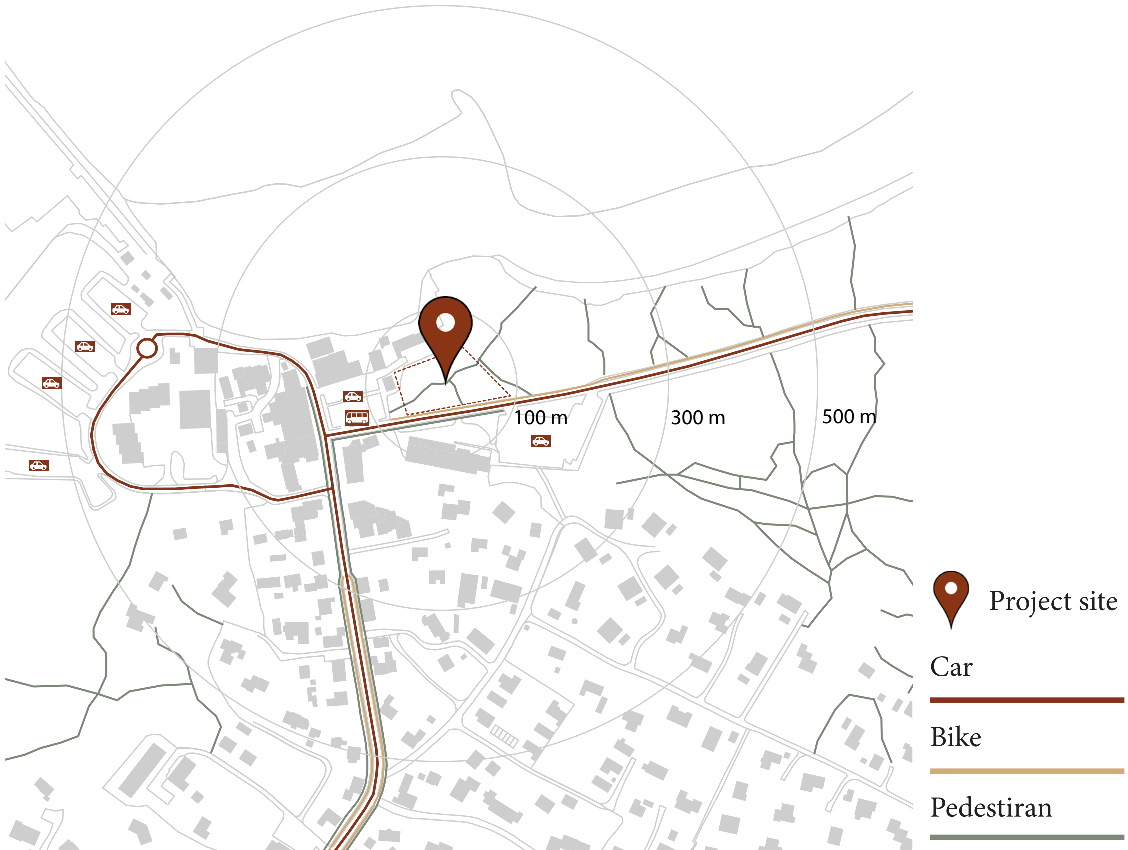
Infrastructure
South of the site is the road Hawblink. A bicycle path runs along it and lead bikers through dune heath and forest to Klitmøller. Along with Vesterhavsgade, Hawblink is the road leading people in or out of Nørre Verupør. The area is therefore very trafficked during the summertime and likewise very quiet during the wintertime.

On the other side of Hawblink and on the western side of the site is a large parking space. From the western parking place there is easy access to a bus stop. Dependent on the time of the day it either goes to Thisted or Stenbjerg.
As a pedestrian there is only about 100 to 200 metres to the most facilities, 300 metres to the beach through the dune heath and 500 metres to the pier and open-air sea pool and more parking places.

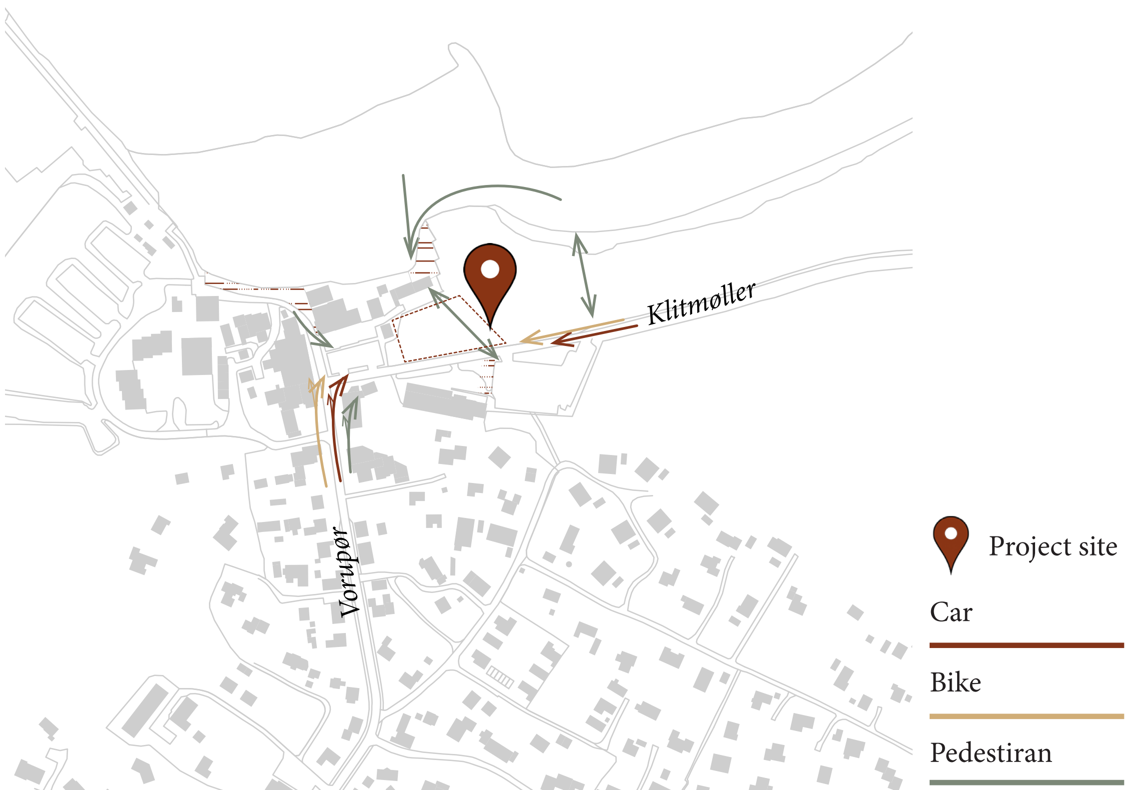
Approaching the site
When walking around the site it is clearly seen where people move through the sand dune. Large tracks through the lyme grass have been formed by pedestrians moving from the parking spaces to the south to the beach in the north.
It is expecially the movement across the site that is interesting, as the sand dune is very steep and unmanageable when carrying surf boards or just blankets and baskets to the beach. A respond to the way people move through the site is therefore very important, because it confirm how ”lacy” people are taking this shortcut instead of walking the short way around the site. Such an approach could also help integrating a newly made wooden terrace north of the site. At this point it is very hidden and only a few people moves in this direction.

As mentioned people mainly approaches from the southwest on Vesterhavsgade, but driving, biking or even walking from the north of the national park one will approach the site on the road Hawblink. Therefore it is also important to catch people approaching from this side.

1:5000



Ill. 22 Infrastructure



Ill. 23 Infrastructure

Functions
As mentioned within 500 metres of the site is the largest concentration of facilities in the town. Shops, public facilities as the Nordsø Aquarium and surf school, ice-cream kiosks, cafés and restaurants are all places close to the site. The area bears the impress of being dependent on tourism. In the winter period a few shops and restaurant are open during the weekends, other are closed all week from mid-October to Easter. To the south the all-year residence and summerhouses are the primarily typology. The aim is not to compete with the existing facilities, but to support them.

Vegetation
The vegetation in area is primarily dominated by dune heath with lyme grass. Only a few coniferous trees and bush areas are found in between the building. The weather as well as the sandy ground makes it very difficult for vegetation to grow. The site is placed on a large dune, which reaches first floor heights, covered with no vegetation except for lyme grass. Standing on top of the site, the dune heath covers the area as far the eye reaches and is only interrupted by buildings in the town.

1:5000

Project site

Shops

Cultural- / public facilities

Fishery

Café / Restaurants

Housing

Ill. 24 Functions

Project site

Ocean

Beach

Dune heath

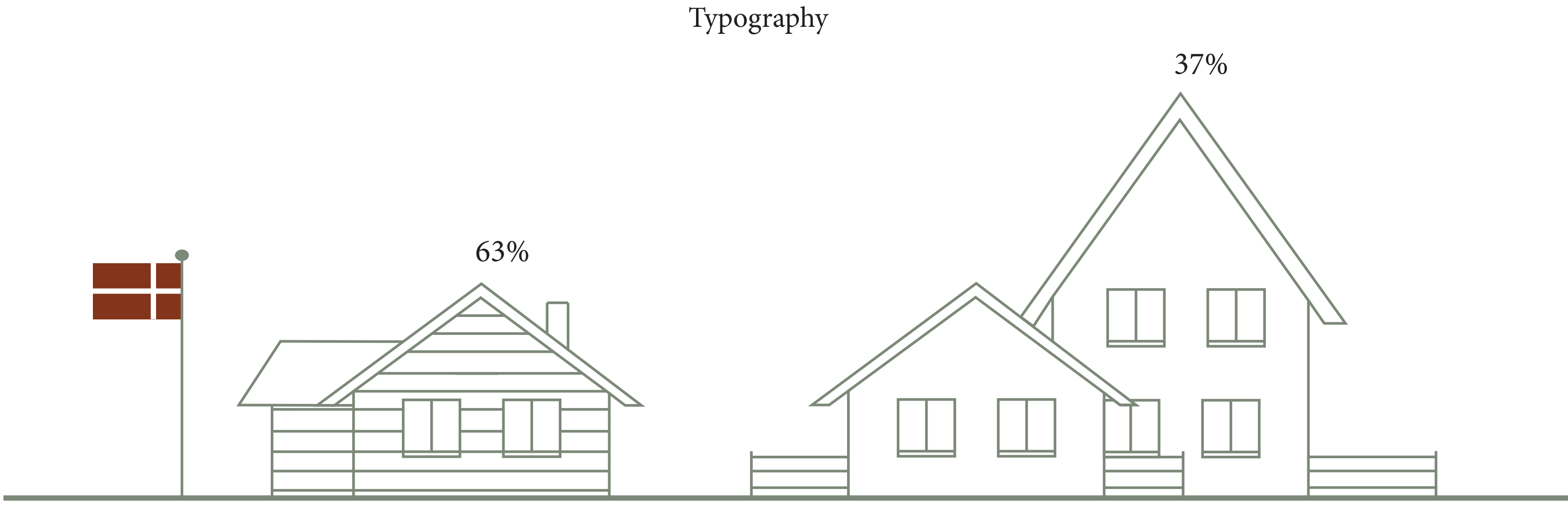
Tree

Ill. 25 Vegetation

Facts about Nørre Vorupør

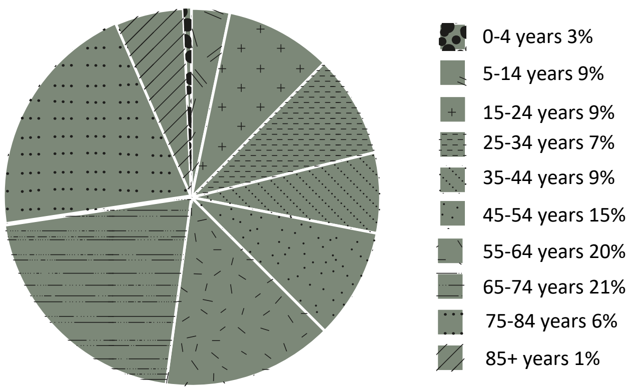
According to many Danes a great quality of Denmark's outlying areas is the coastlines, beaches and the closeness to the ocean and many spends weekends or holidays there, before returning the everyday life closer to larger cities in Denmark (Realdania, 2012). Despite this fascination of the outlying areas the population of Nørre Vorupør have decreased with 13% over the last 10 years despite the opening of the national park in 2008 (Statistikbanken, a.-b., 2018). However, over the last six years many initiatives have been initiated and over 68 million DKK have been invested in the town and according to Bramsen, Kolstrup and Ellersgaard (2016) local shops and traders have experienced economic progress assumable because of the renewed town and the attention in connection of this, though changes in the demographic development might not be visible yet.

There is 383 all year residence and 665 summer cottages. Of the inhabitants the distribution between men and women are almost equal though there is a majority of people over 45 years. A part of the summer cottages located in Nørre Vorupør are used as rental housing with lodgers especially coming from Denmark as well as the neighbouring countries Norway, Sweden and Germany. Their primary reasons for visiting the area are the beaches and coastline and special scenic areas (Bramsen, Kolstrup and Ellersgaard, 2016).



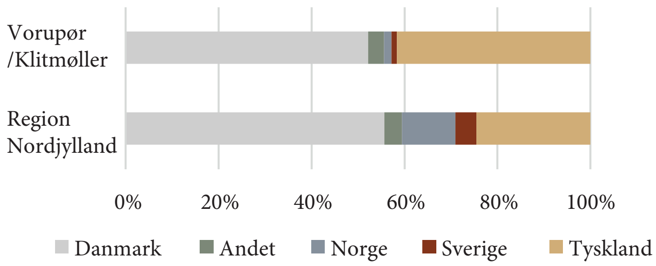
Ill. 26 Typology

Age distribution



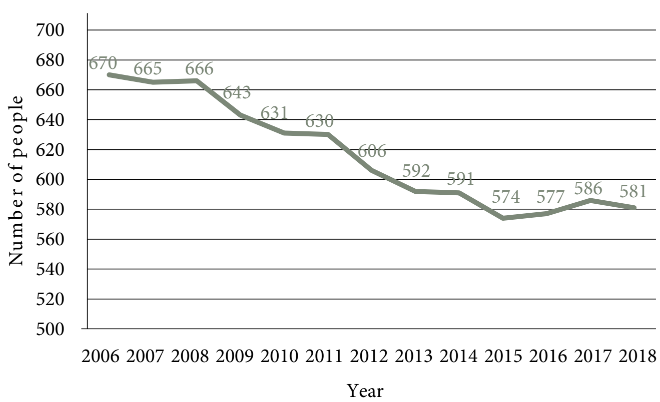
Ill. 27 Age distribution

Tourists nationality



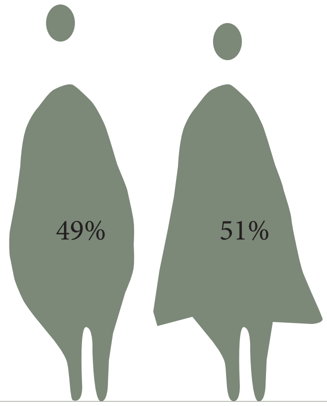
Ill. 27 Tourits nationality

Population progression



Ill. 28 Population progression

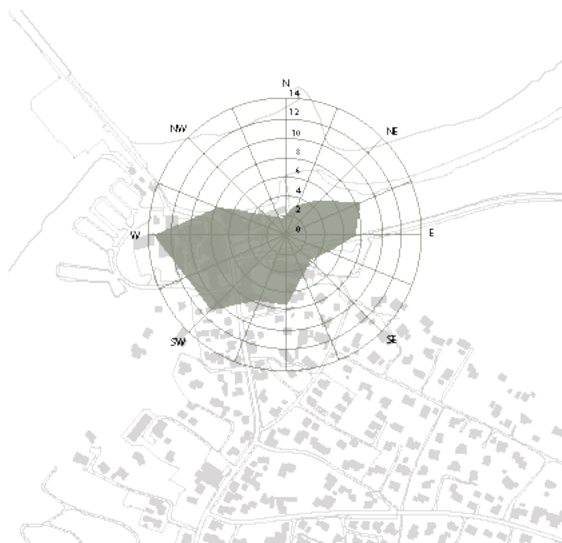
Gender distribution



Ill. 29 Gender distribution

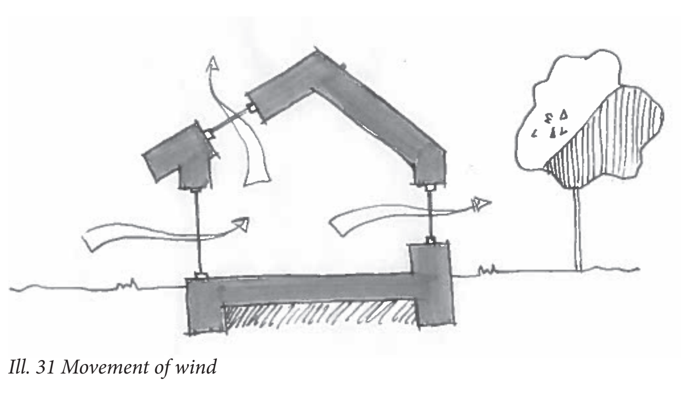
Local climate analysis
Wind analysis

The wind direction is based on observations from the weather station at Silstrup/Thisted, which is the station closest to Nørre Vorupør. Dependant on the season the wind direction mostly comes from West and Southwest (Windfinder, n.d.).
Wind is a very dominating factor at the Westcoast. It is clearly seen at the surrounding landscape where trees and larger vegetation have a hard time to grow on the heath. Due to the strong western wind and open landscape near the cost the site is very exposed to the constantly moving sand from dune and beach and salt in the air. Consequently, the façade and building materials must be very robust to resist the hard wind. A greater focus might be placed on the material patina and aging when the design is considered.
Another important factor to be aware of along the coast is the windchill. This means high wind speeds must be avoided, as the perception of the wind can seem cooler than the actual temperature. The height and shape of surrounding buildings and landscape can influence the wind direction towards the site and must be considered. Normally, additional vegetation could help to this problem as well, but due to the hard climate this might have a distant prospect and other solutions must be considered.
Natural ventilation strategies depend on the wind conditions and can inform the building design about placement and size of openings and by this help to cool and remove indoor air pollution.



Ill. 30 Windrose, Anually

A wind analysis has been made in Flow Design to reach an understanding of the current conditions at the site. According to weather data collected, the average wind direction arrive from west, with a wind speed of 7,0 m/s.
The simulation made in Flow Design, indicate a problem regarding the wind. The existing buildings at the location, does not influence the wind due to the low placement in the landscape. Shielding for the West and Southwest should be considered in the development, as it has a high risk of direct wind and therefore should be reduced greatly to secure a pleasant environment at and around the site


Ill. 31 Movement of wind

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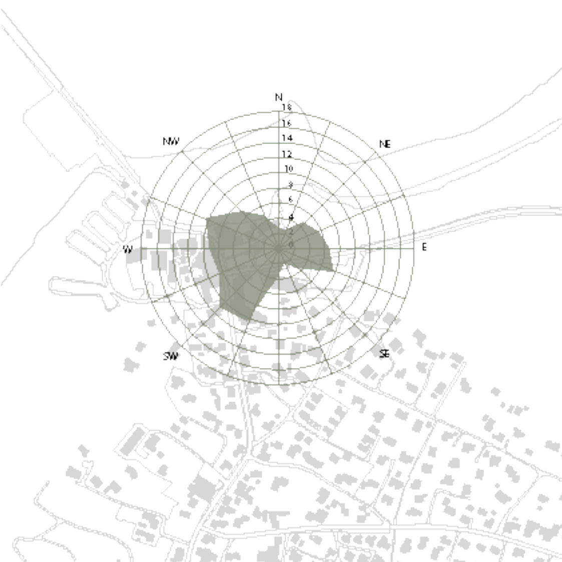
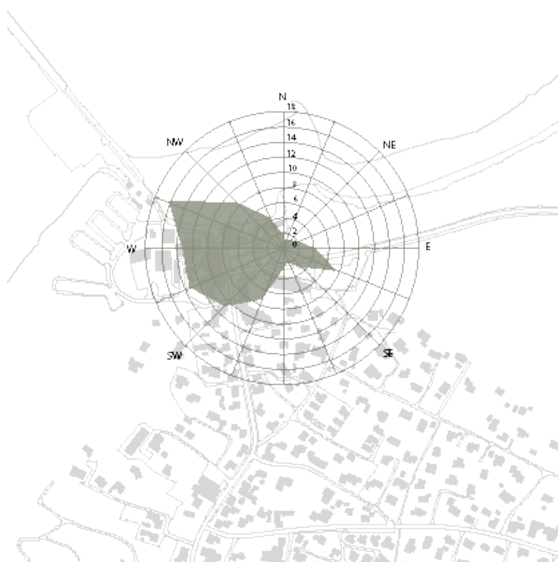
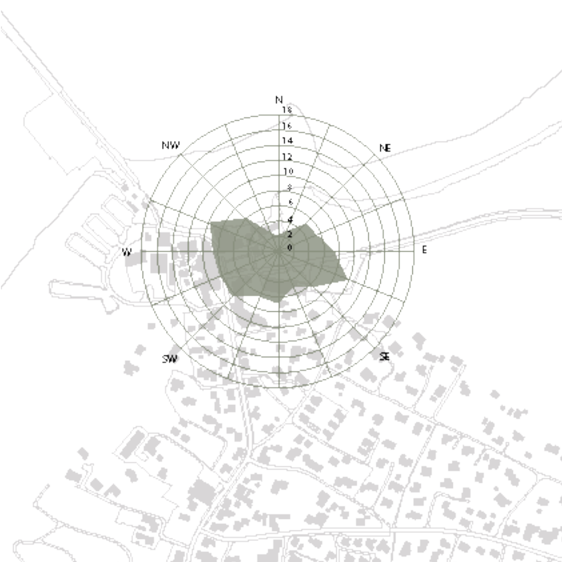


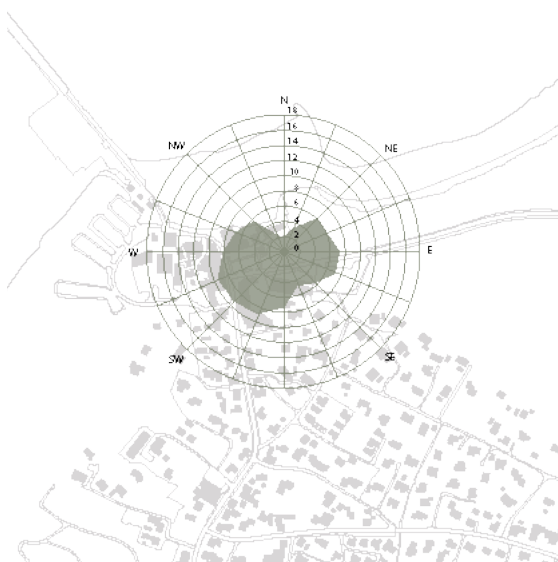
Ill. 32 Windrose, Spring



Ill. 33 Windrose, Summer



Ill. 34 Windrose, Fall

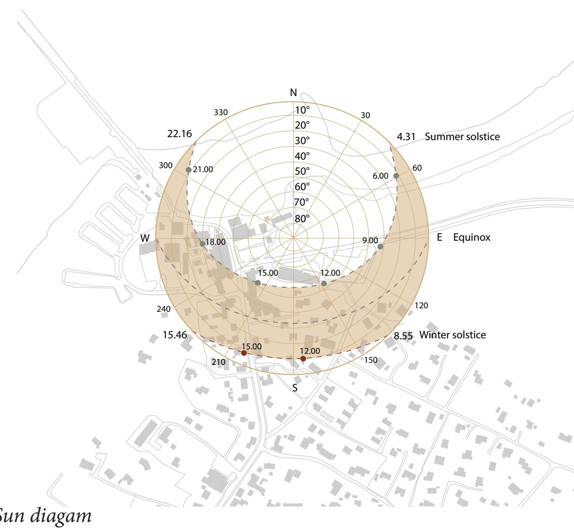


Ill. 35 Windrose, Winter

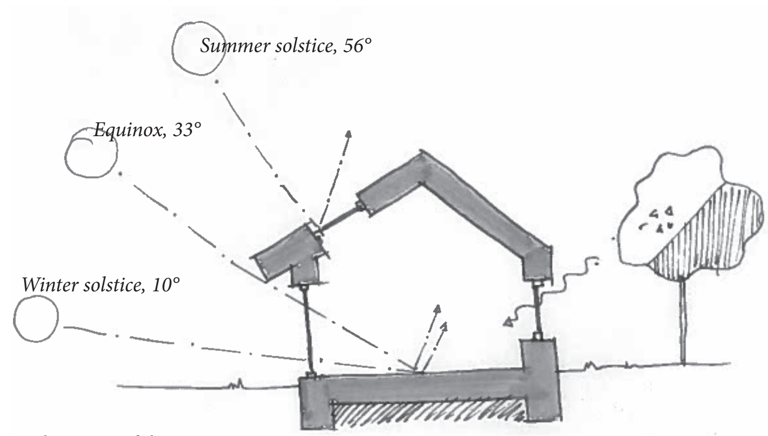
Sun analysis

Denmark is in the tempered climate zone on the northern hemisphere. This means the length of the day vary very much from the summer period to the winter period. The difference is especially seen from summer solstice to winter solstice on the west coast where the sun rises at 4.31 and 8.55, and sets at 22.16 and 15.46, respectively. A consequence of Denmark's location is short winter days while the long summer days gives a possibility to have activities late in the afternoon and early evening. Cloudy weather is also a consequence and exploration of the sun exposure and shade therefore becomes important.
Solar heat can have a very positive effect on both passive and active strategies in the built environment. Solar angles are important when the active strategies are applied. Passive strategies influence the building orientation as well as the envelope and material choice. The buildings indoor environment must make efficient use of the solar energy and take advantage of the free heat it delivers through multiple analysis during the design process.

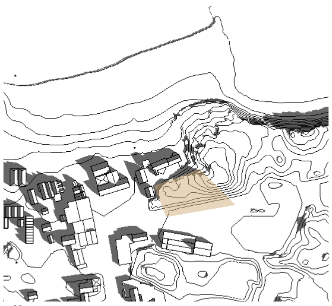
A sun/shadow analysis has been formed in Revit to determine the areas on and around the site that are affected of shadow. The sun has a significant impact on the physical perception of the indoor environment and the outdoor areas. The high location of the project-site ensure the surroundings does not affect the site. The analyze have been done for summer-, winter solstice, spring -and autumn equinox.



Ill. 36 Sun diagam

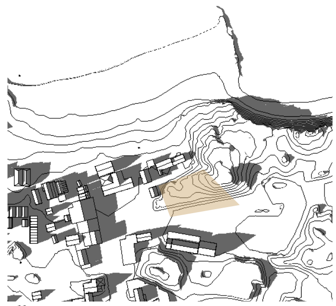


Ill. 37 placement of the sun


Ill. 38 Spring equinox, 09.00


Ill. 39 Spring equinox, 12.00


Ill. 40 Spring equinox, 15.00


Ill. 41 Spring equinox, 17.00


Ill. 42 Summer solstice, 09.00


Ill. 43 Sommer solstice, 12.00


Ill. 44 09.00, June 21^{st}


Ill. 45 09.00, June 21^{st}


Ill. 46 09.00, June 21^{st}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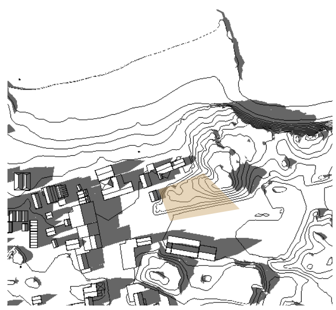
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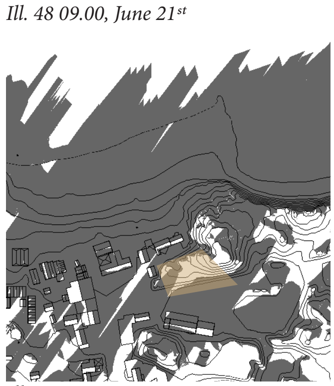
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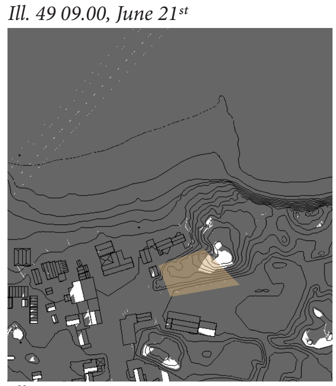
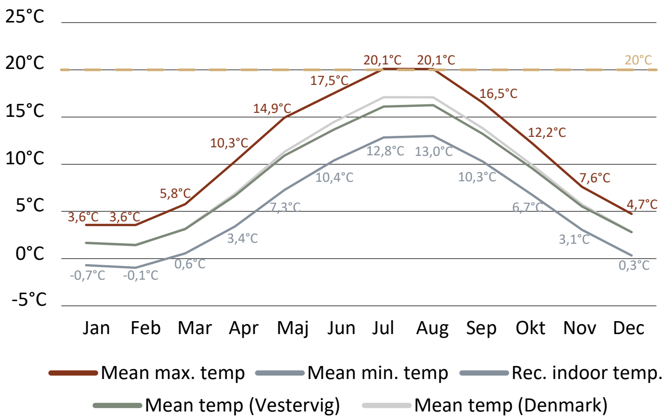

Ill. 53 09.00, June 21^{st}

Temperature analysis

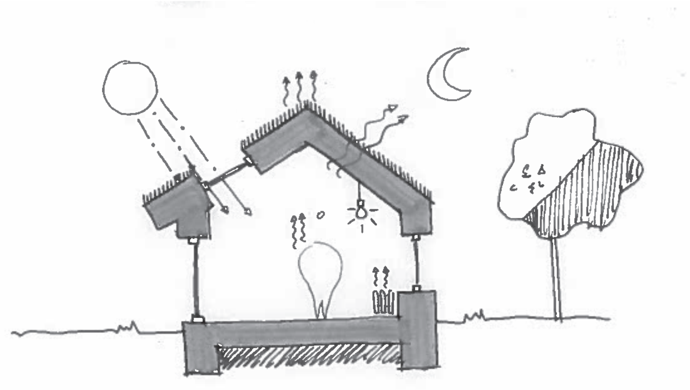
The chart shows the monthly mean temperature for Vestervig and Denmark as well as the monthly mean for daily maximum and minimum temperatures, covering the period from 1981 to 2010 (Cappelen, 2011). The winter months follows the country norm but is slightly cooler in the summertime. The span in which the temperature fluctuates is greater in the summer period (July: 7,3°C), than in the winter period (January: 4,3°C). The warmest period is likewise found from June to August as the coolest period is found in December, January and February.

The site is very much affected by the coastal climate, where the wind carries the mild weather from the sea and prevents temperatures from changing drastically over winter and summer periods as well as day and night.

The recommended indoor temperatures for landscape offices and conference rooms are 20°C. (Danish Standards, 2007). Most of the year the average temperature is below this and heating is needed. In this case the sun can become a useful strategy to reach the aimed temperature and choice of material can help restore the heat over a shorter period. However, using the sun as passive strategy a risk of overheating is possible. Therefore, it is important to secure no more than 100 hours above 26°C and 25 hours above 27°C – corresponding to the demand of an office building (Bygningsreglementet, 2018).



Ill. 54 Temperatures



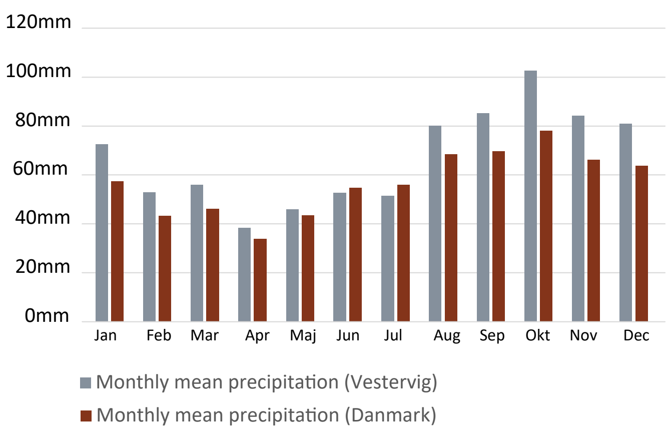
Ill. 55 Temperature diagran

Precipitation analysis

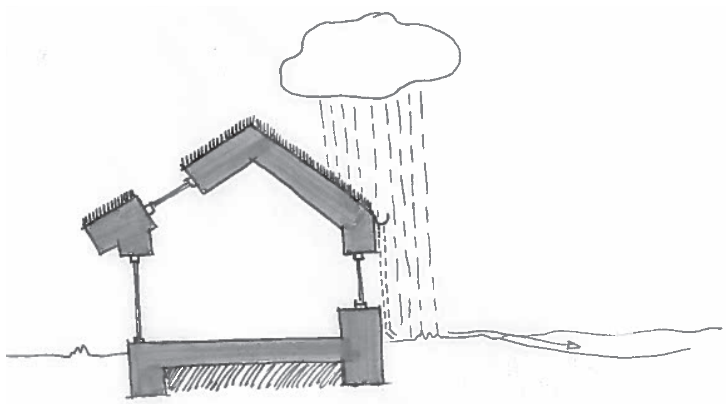
The chart shows the average monthly precipitation in Vestervig (about 20 kilometres south of Nørre Vorupør) compared to the average monthly precipitation in Denmark covering the period from 1981 to 2010. In general the monthly precipitation in Vestervig is above or equal to the country norm. Most of the annual precipitation falls late in the year from August to December. In late spring to mid summer the precipitation generally follows the average (Cappelen, 2011).

The rain has great influence on the quality of outdoor spaces and affects the way people uses and interact with them. Likewise, the weather has a big impact on the attractiveness of outdoor activities which is a key factor for the national park. Therefore, it is important to take e.g. covered or semi-covered outdoor spaces in mind or facilities that would make it possible to move an activity indoors.

Strategies like green roofs are often seen as integrated features on buildings as a help to hold back rainwater, preventing surrounding areas of flooding. The closeness to the North Sea leaves an advantage of letting superfluous rainwater from a green roof seep directly into it, instead of loading the local sewer systems.



Ill. 56 Precipitation



Ill. 57 Precipitation diagram

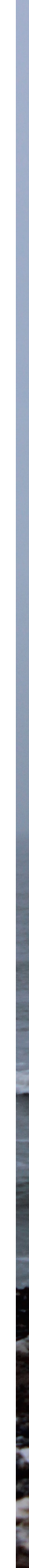
Subconclusion

The project site lies on the edge of the national park and the town of Nørre Vorupør on a sand dune connected to the larger dune heath east of the town.
The building tradition is very simple and homogeneous with white painted or raw brick facades with pitched roofs. The detail however stands out on many buildings in the form of gutters, window frames or along the edge between the roof and wall. The level of detail also varies depending on the type of house. The mentioned features are primarily found on all year residence and the old fisher's buildings. The summer houses stand out a little from the traditional building form, as they often are made of wood. But at the same time, they are often hid away behind shielding vegetation, where the buildings closest to the sea is directly exposed to the hard climate.

The site is easily accessed, both by bike, car or as a pedestrian, from the two main roads, Hawblink, on which the site is located, and Vesterhavsgade, which goes through the whole town from the grocer south to the landing ground in the north. These two roads are especially important because it is from here people needs to be caught and let into the building. Many pedestrians go through the site as it is at this point to the beach, but as it is very unmanageable and steep the intention is to accommodate this movement, including the terrace to the north in the town image.

Many different functions are placed around the site, and the intention of the centre is to support these functions and not compete with them. In continuation of the experience economy this means, it does not make sense to create a surf-school when it is found just across the street. Instead it would be great to include renting of bikes as the bike path lies just next to the site and is not found anywhere else in the area.

The local climate is a very important factor to investigate. It is seen that the wind is very strong and mostly comes from West and Southwest. Wind is a very dominating factor at the Westcoast and as there is no e.g. high vegetation to shield the site, it is very exposed. Therefore, it would be good to accommodate this situation when creating the outdoor areas.
The missing vegetation and large distance to southern buildings ensure that the whole site is covered with daylight during the year. As passive strategies are in focus, the solar heating is very important for the building and must be exploited as much as possible without causing overheat in the building.
The temperatures also confirm how the wind and coastal weather affect the area, as it is slightly cooler than the country norm. Therefore, the implementation of passive solar heating has even a bigger importance for the building.



Ill. 58 Surfer in Klitmøller

Program

Ill. 59 View over Stenbjerg landing ground

The program is based on the previous analysis around the National Park Thy and Nørre Vorupør.

In this chapter case studies and an investigation of the target group will help to form the wishes and demands for the building.

The spacial program along with the functional diagram will set the frame for the building layout.

Case studies
Vadehavscentret

Due to the admission to UNESCOs' World Heritage List, the purpose of the centre is to inform visitors of the qualities found in and around Vadehavet, and thereto functions as the GATE to "Vadehavet".
The elements from "Vadehavscentrets" that we would prefer to implement in the development of the "national park-center Thy are numerous. The national park Thy contain a various of functions that are of different levels of volume and to overcome the problem, the architect have spread the location of the different functions. The plan solution has been developed in a close cooperation with the exhibition architect to achieve the optimal placement of the windows and the overall form.
The windows are placed limited towards the surroundings, and those windows that occur are placed according to the specific installations or views.
The concept does reflect on the previous shape of the centre in the preservation of the outer walls, the inner steel construction and the form. The most visible connection to the old centre does appear in the west oriented house. The west oriented construction has been cladded in a pre-patinated list of the wood species "robin" to accentuate the section as the older part.
The northern part of the "firelænget gård" has been cladded in a local material that has a historical use on older farmhouses that are located close to low-levelled water. The architect have revisited the purpose of the straw, and viewed it in a different perspective. The common perception of the material have been, to use it as a thatched roof. To emphasis, the strict form the straw embellish the façade and the roof. The composition of the wood and straw projected the desired form. The material assure a sustainable mindset of a prolonged lifespan, despite the exposure of salt in the air.

Ill. 60 Vadehavscentret (Gundersen, n.d.)

Ill. 61 Vadehavscentret (Gundersen, n.d.)

Ill. 62 Vadehavscentret (Gundersen, n.d.)

Tirpitz

The functions that Tirpitz contain are permanent installations that inform the visitors of the cultural heritage at and around the site. The “invisible museum” that melts into the landscape and disappear. To integrate the museum into the landscape and form a natural transition between the impact of the human and the natural constructed landscape had been a focal element in the development. The museum functions as the portal to the Danish west coast trove of hidden stories.

The museum consist of four volumes that erects from the soil, and cuts into the preserved dunes. The four volumes form a sheltered court that protect the visitors towards the wind and a look into the installations of the museum, due to the six-meter tall curtainwall that assure a good indoor lighting.

The materials applied are a reference to the old WWII bunker and Czechish hedgehog located at the site. The material that cover the balustrade and cantilevered roof surface is corten steel. The material does fit well into the natural landscape of the dunes.

Concrete has been applied to the structure of the museum and the method of in situ cast reflect in the surface, and references back to the built of the bunker. The solution of in situ have made it possible to have a “floating”-roof.

Ill. 63 Tirpitz (Gundersen, n.d.)

Ill. 64 Tirpitz (Gundersen, n.d.)

Naturcenter Amager Stranspark

Naturcenter Amager Strandpark has not been chosen for its architectural "marvel", however for its spatial program. The centre strives to form a focal point for a dissemination of activities associated to the nature at Amager Strandpark and the local associations. The centre contain three separate constructions. All three forms are cladded in an untreated douglas spruce. The untreated spruce patinate into a silver tone that complement the sand and forms a visual connection to the context. In addition the sheltered outdoor patios is uninfluenced by sunlight and the warm colour of the wood remains.
The strict rhythmical pattern of the wooden cladding counter the twisted form of the construction. The roof has been covered in sedum as an evocative reference to the dune plantation that surround the area.

The spatial program of the centre contributes to activities close connected to the area. The centre has a close collaboration to the primary school and accommodate their educational needs.
The functions in the centre are flexible and oriented in the direction of active functions. The centre have a transparent profile, and contain several of small sheltered outdoor pockets that accommodate the vision of an active outdoor lifestyle. The repository for canoes and equipment are incorporated in the form and does affect the concept.
The functions are divided according to a few simple parameters and functions a complete unit. The functions that require an indoor setting are located in one of the three forms and the functions connected to the outdoor activities are placed in a third accommodation. The segregation ensure a clean and quiet environment for the educational dissemination.

Ill. 65 Naturcenter Amager Strandpark (JJW Arkitekter, 2014)

Ill. 66 Naturcenter Amager Strandpark (JJW Arkitekter, 2014)

Ill. 67 Stenbjerg landing ground

Target groups

The target group can be separated into three categories: The tourists, the local and the staff. Each category has several subcategories as seen on illustration 68. With an area in growth the wish is to embrace as many of the users' needs as possible in the centre (Beskrivelse Nationalparkcentre Thy, 2018). However, with a limited space on the site, the centre must be very flexible to embrace all the users wishes (Andersen, 2019). In this project the most dominating users from each target group have been pointed out to let the building form itself around their needs. I.e.: Summerhouse owners and tourist foreign to the area, surfers; school classes and local associations; the national park management.

Overall the local, both residents and shops, have a great influence on the visitors in the area and therefore plays a big part in the creation of a visitor centre in National Park Thy e.g. the sales personnel in the local shops – fish shop, clothes shop, cafés or grocer – have time to talk with customers and pass on positive information and tips about the area, though their motivation is primarily based on economic outcome they also focus on the visitors desire to come back and expand their stay the next time (Wisnes and Gudiksen, 2017). Beside the opportunity of selling their products the shops will not become a main user of the centre.

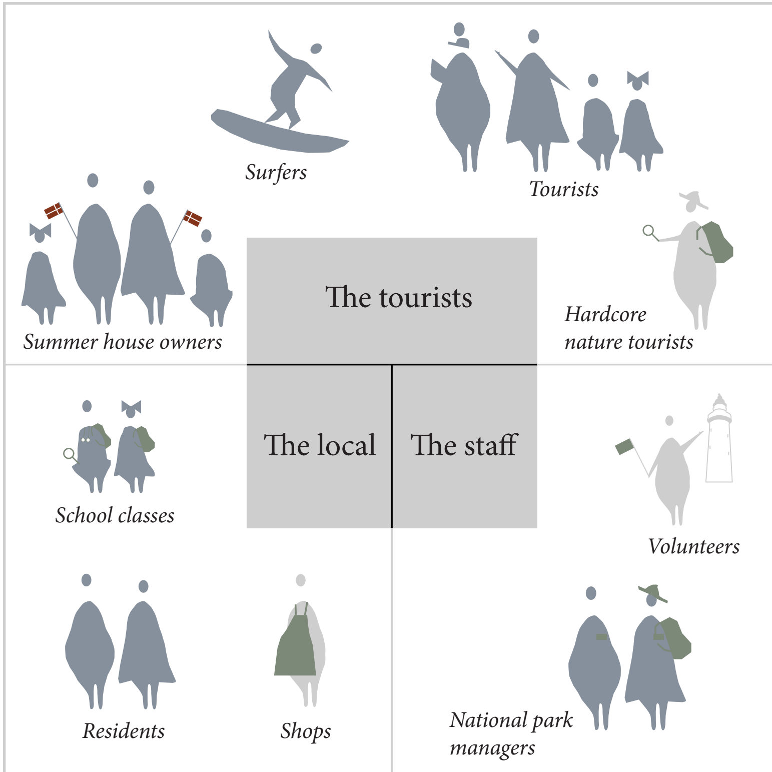
On the other hand the local primary school students are expected to become a large part of the centre, as they can use it as a intermediate stop on their way to explore the national park, and as an educational environment to learn about the flora and fauna in the national park (Andersen, 2019).

The residents are a tricky subcategory to deal with, because it seems they have difficulty pointing out attractions and objects of interest, as they miss the overview of possibilities in the national park. On the other hand, they are happy and proud of the area (Wisnes and Gudiksen, 2017). Like a typical tourist they might need information from nature guides, who can tell them e.g. where to take walks. Opposite the tourists, they are not pressured by a limited vacation, but can use the park when they like. For the centre not to stand empty during the wintertime it is very important that it is used throughout the winter period. To be able to let the residents or associations use the facilities for private arrangements or events, like concerts, receptions and local exhibitions, would create life throughout the year.

As mentioned, tourists are often limited to the length of their stay. Therefore, they seek information about activities or events matching the length at the specific time they are visiting – talking to a nature guide, volunteers would help them organize their time (Andersen, 2019). The centre should orientate itself towards the tourists who are unfamiliar with the area and not the hardcore nature tourists who knows where the attractive locations are placed (Andersen, 2019).

Likewise, are the surfers who come with one intention in mind – to surf. However, the surfers are a big part the areas brand and image and to accommodate simple needs as outdoor bath and toilet facilities would perhaps attract even more. These facilities could furthermore be a supplement to the beach guests during the summertime.

The summerhouse owners are lying on the edge of the local and tourist category, as they often visit the area repeatedly – also outside the tourist season. Therefore, they might exploit events in the wintertime as well as the summertime, though they overall have the needs of a typical tourist.



Ill. 68 Target group

The staff

National park managers

A place to eat lunch.

A place to have meetings.

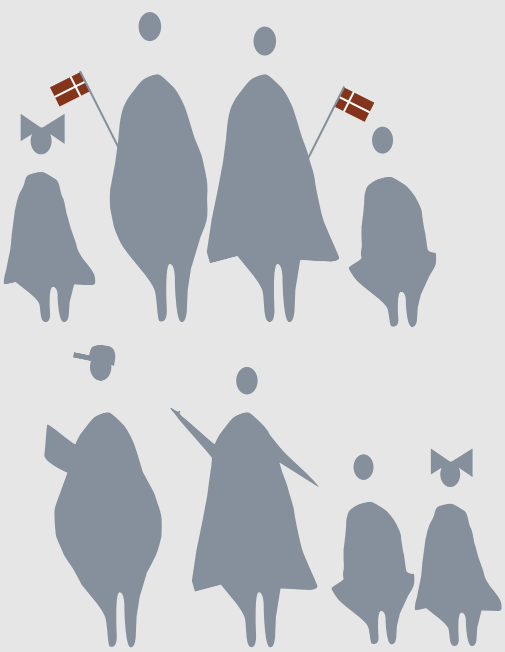
Access to meet the tourists.

Good work conditions.

A place to drop of bags and to change clothes from visits to the National park.

Ill. 69 Staff

The tourists



Ill. 70 Tourists

Summer house owners and tourists

- A place to talk with nature guides or volunteers - to get tips about where to go.
- To get an overview over the national park.
- Get access to reference books, seek information and learn about the national park.
- To be able to borrow equipment as field glasses, magnifiers or handbooks.
- A place to rent bikes.
- A place to drop off bags before entering the national park.

Ill. 71 Surfer

Surfers

- To get information about weather conditions.
- To get access to toilet and bath facilities

THE LOCAL

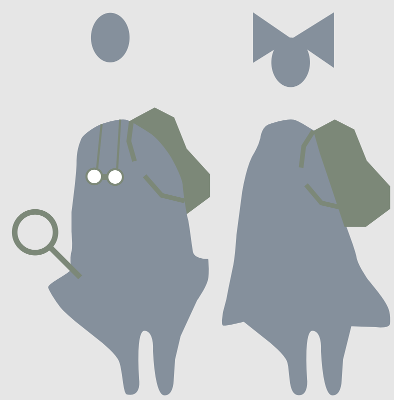
School classes

A place to talk with nature guides or volunteers - to get tips about where to go.

Get access to reference books, seek information and learn about the national park.

To be able to borrow equipment as field glasses, magnifiers or handbooks.

A place to drop off bags before entering the national park.



Ill. 72 School students

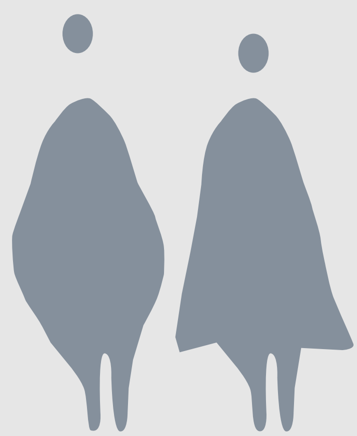
Local associations or residents

A place to have meetings.

Be able to use the centre facilities outside the tourist season for privat arrangements, gatherings or cources.

Get access to reference books, seek information and learn about the national park.

To get access to cultural arrangements or events outside the tourist season.



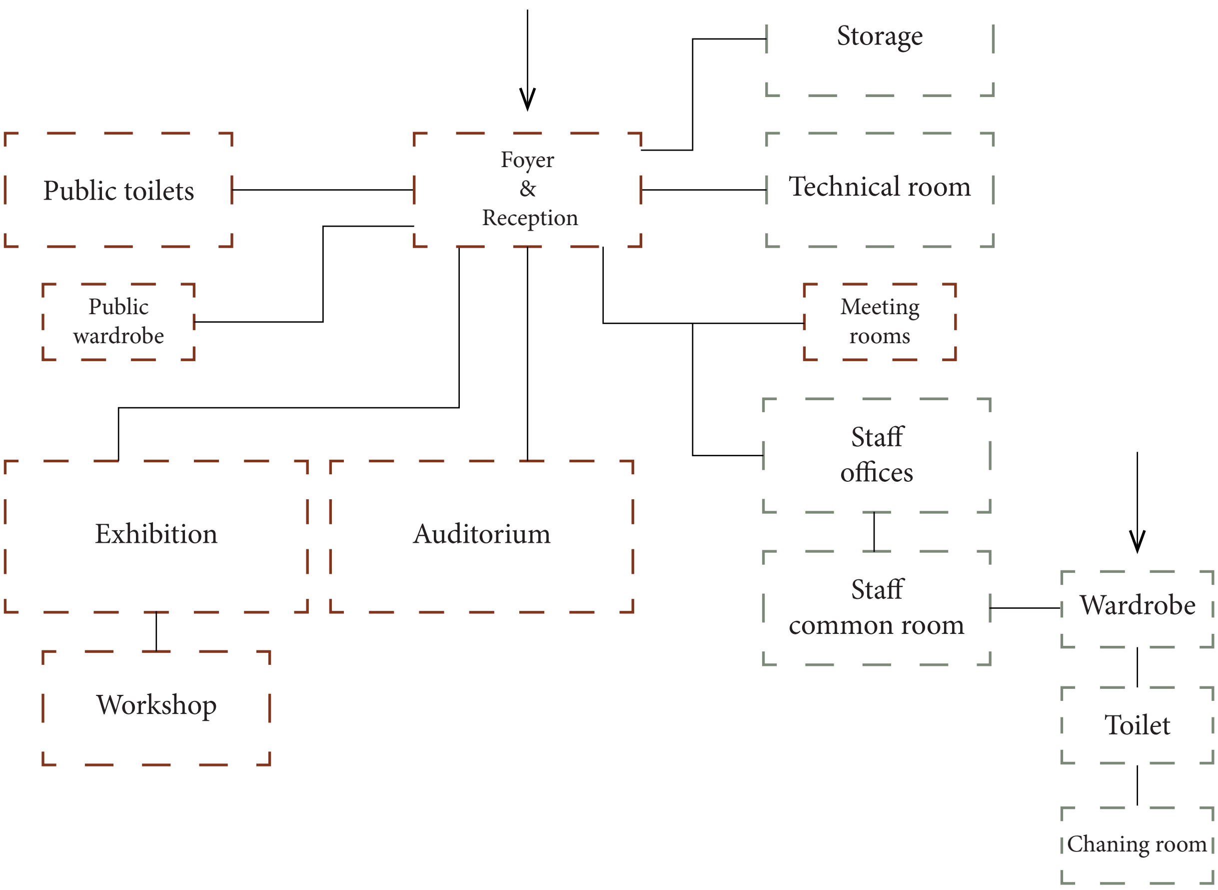
Ill. 73 Locals

Spacial program

Function	Size	Functional demands	Ligting	Ventilation
Public functions				
Foyer / reception	135 m²	*Opportunity to meet staff or volunteers. Including wardrobe to guests*	*Artificial / Natural*	*Mechanical / Natural*
Public toilets	58 m²	*Incl. disabled toilet and cleaning room*	*Artificial*	*Mechanical*
Exhibition	145 m²	*Must be flexibility - Opportunity to change layout*	*Artificial / Natural*	*Mechanical / Natural*
Workshop	66 m²	*Able to occupy 30 people (class)*	*Artificial / Natural*	*Mechanical / Natural*
Auditorium	96 m²	*Opportunity to become an auditorium. Should be able to occupy 100 people. A movable chair-layout is needed*	*Artificial / natural*	*Mechanical / Natural*
Technical room	28 m²	*Opportunity to access with a pallet jack.*	*Artificial*	-
Storage	34 m²	*Opportunity to access with a pallet jack.*	*Artificial*	-
Private functions				
Lanscaped office	105 m²	*Incl. storage of office supply and copy room. Room for 12 staff members*	*Artificial / Natural*	*Mechanical / Natural*
Common room	48 m²		*Artificial / Natural*	*Mechanical / Natural*
Meeting rooms	37 m²	*Must be able to be seperated into two smaller meeting rooms*	*Artificial / Natural*	*Mechanical / Natural*
Toilet	8 m²		*Artificial*	*Mechanical*
Changing room	6 m²	*Incl. bath*	*Artificial*	*Mechanical*
Wardrobe	9 m²	*Lockers for storaging field equipment and bags*	*Artificial / Natural*	-
Outdoor functions				
Outdoor toilets and baths	44 m2	*Seperated in men and women. Incl. disabled toilet*	*Artificial*	*Mechanical / Natural*
Outdoor kitchen	*27* m²	*Must be able to be shut off during the*	*Artificial / Natural*	*Natural*
Bike storage	*61* m²	*Incl. storage for bike equipment*	*Artificial*	-

Table 01 Spacial program

Functional diagram



Public functions

Private functions

Ill. 74 Functional diagram

Vision

The National Park Centre Thy should function as the stepping stone to national park, communicating the nature and activities to visitors who are unfamiliar with the area. Furthermore, the centre should strengthen the collaboration with different actors within the field of education, open-air activities, tourism, local artists and associations through knowledge and dissemination of nature and cultural heritage.
The centre should strive towards implementing passive strategies and aim to avoid high-tech solution.
At last the centre must create a connection between and fluent transition from the town of Nørre Vorupør to the National Park Thy.

Ill. 75 View from around Lodbjerg lighthouse

Design Criteria

Architectural

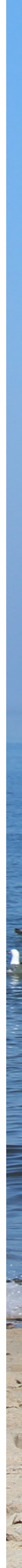
- Integration of building and sand dune on site
- Create transitions and places between town, building, bike path, parking place and the dune heath.
- The building should be recognizable through the choice of materials
- Create a coherent connection between the town and landscape.

Tehcnical

- Materials should be able to withstand the hard local climate
- The main construction material should be chosen based on an environment assessment and detailing from an economic assessment
- Sufficient and adequate natural light in the different educational area and work environments
- Secure a good indoor environment for visitors and staff with the use of natural ventilation as the primary source
- Secure the energy frame and an energy friendly building with the main focus on passive strategies

Functional

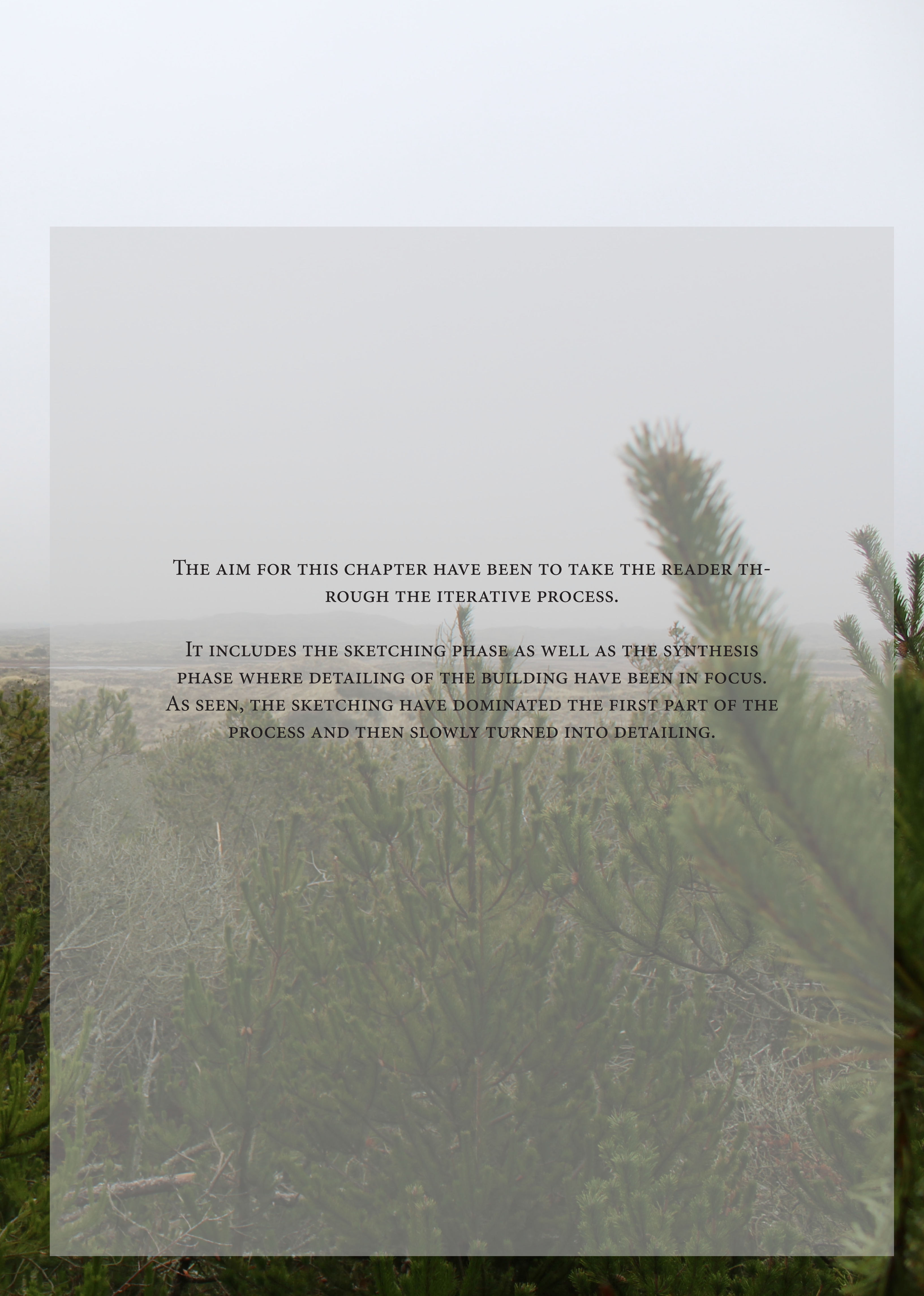
- The aim is to create a flexible programme where changes and renewals is easy in the exhibitions areas
- It should be easy, as a visitor, to get contact with a nature guilde/volunteer when entering the building
- Access to meetingrooms and auditorium outside openings hours
- Integration of bikepath south of the site as well as accommondate people movement through and around the site



Ill. 76 Local fisher

Design process

Ill. 77 View from around Lodbjerg lighthouse



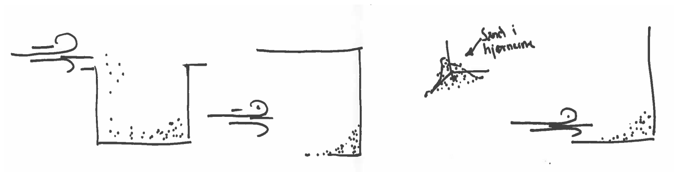
The aim for this chapter have been to take the reader through the iterative process.

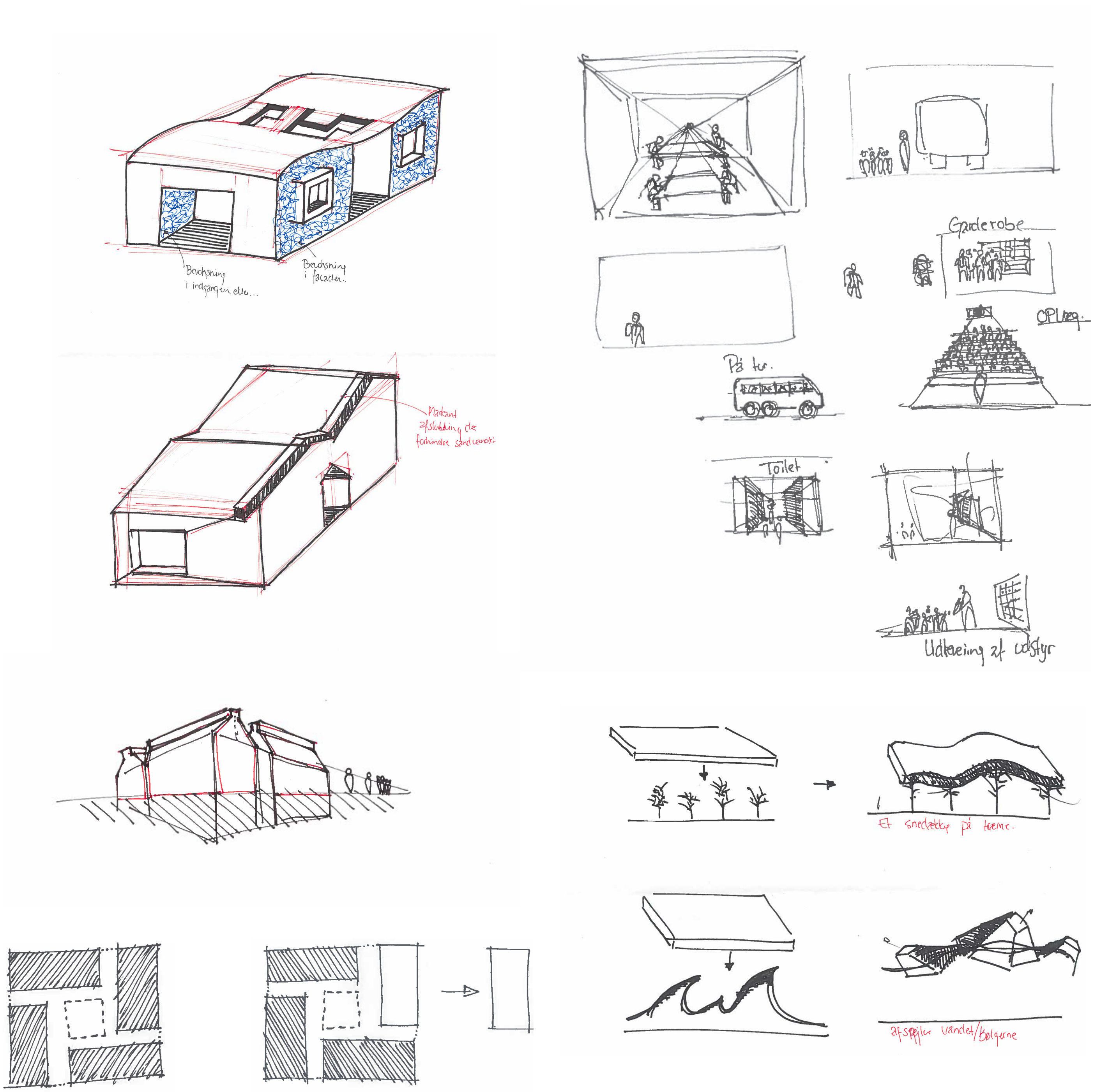
It includes the sketching phase as well as the synthesis phase where detailing of the building have been in focus. As seen, the sketching have dominated the first part of the process and then slowly turned into detailing.

Initial sketching

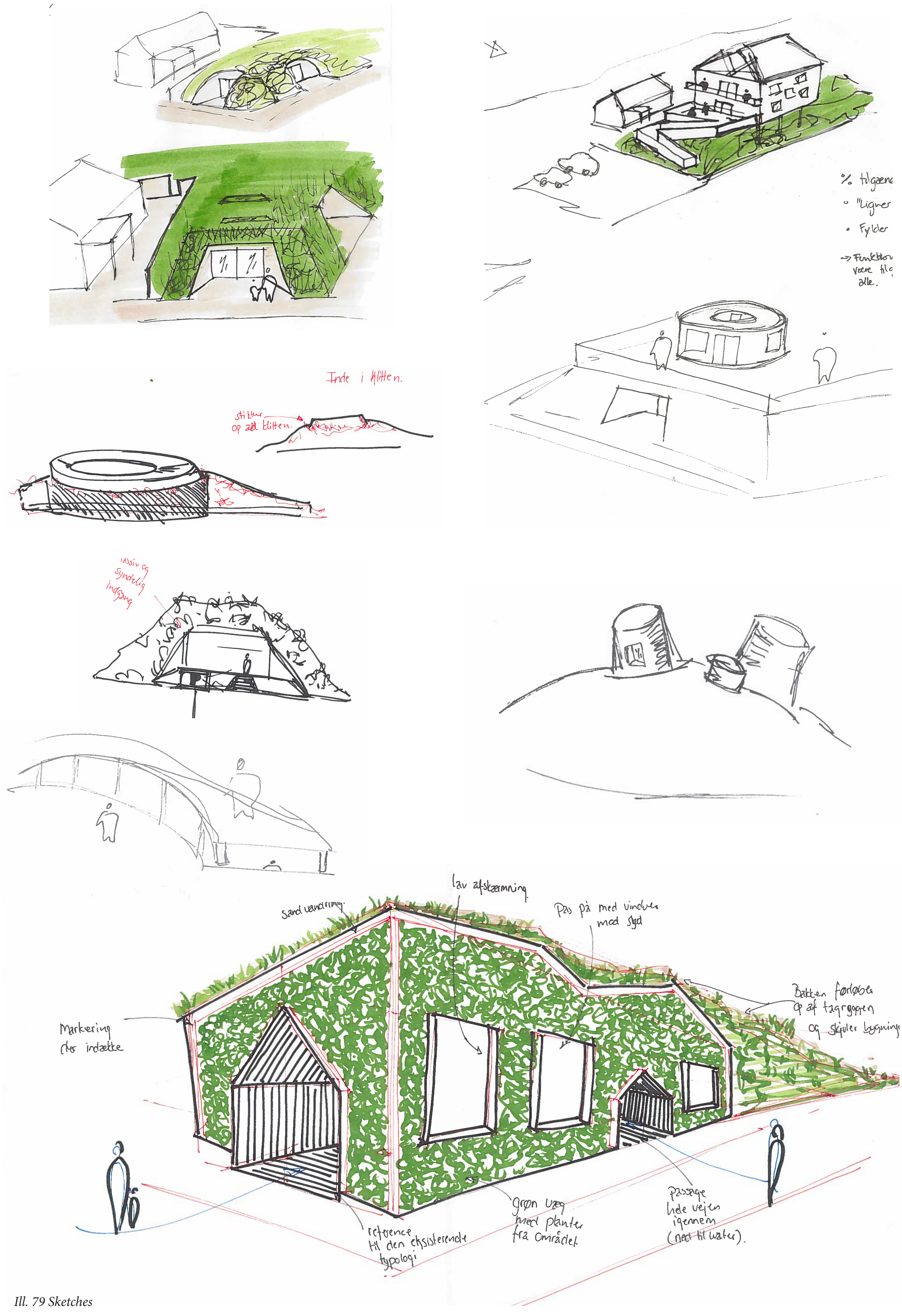
The design process started as a brainstorm of sketches. Different focuses, as *building into the dune*; *wakling on the roof (the 5th facade); flow; outdoor area; seperated and assembled volumes* among others, were chosen to see where the ideas went. During this stage, there where no limits, whatsoever, about squaremetres, heights or form.

At this page a selection of the many drawings are shown. They vary a lot - from being simple conceptual ideas of the interior to the experior shape.



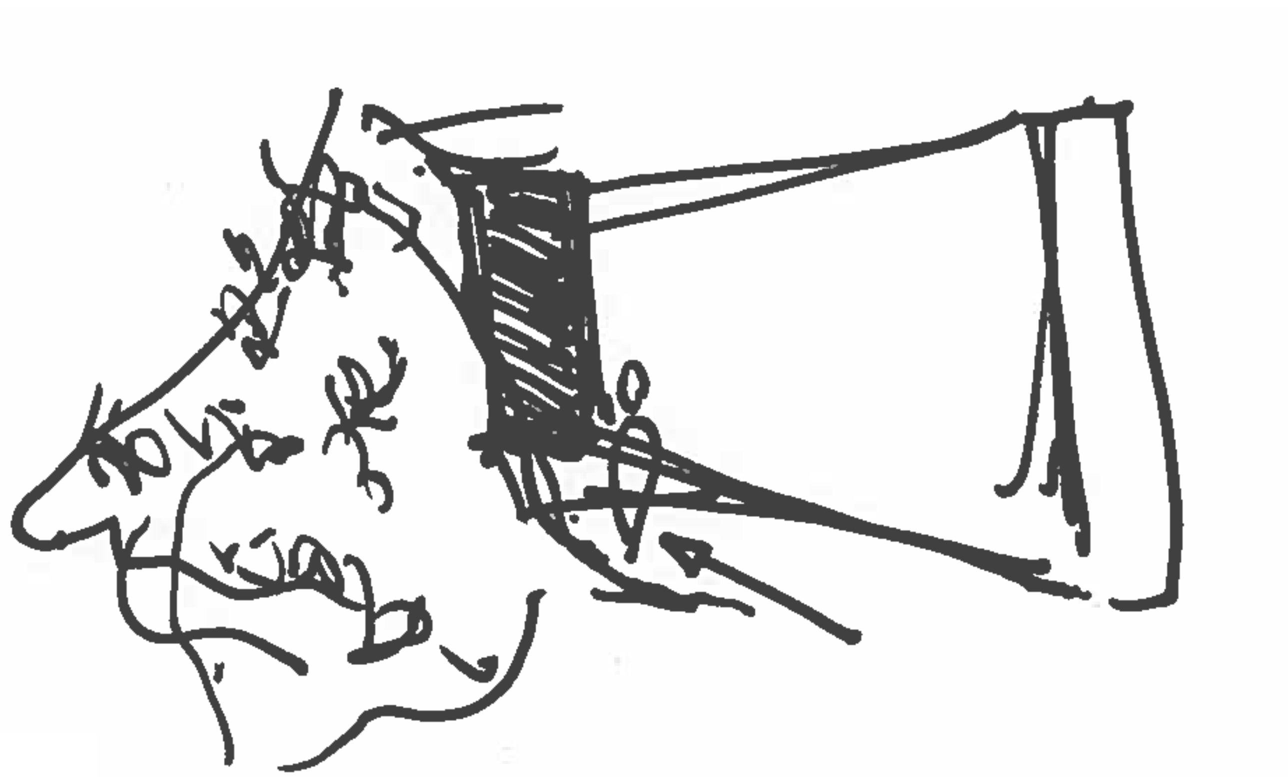


Ill. 78 Sketches



Ill. 79 Sketches

Sand dune



Ill. 80 Sketches of sand dune

After the steching phase, Several focus areas arose. The site is very narrow and as a headland in the ocean, it reaches from the national park's dune heath to the town.

To ensure the building lives up to the wishes, demands and vision of the project, several evaluations have been made, throughout the different design stages.
First of all it was important to figure out, how the building would connect to the sand dune which covers the entire site. Furthermore, it was important to figure out how the connection between the town and the dune heath should be formed.

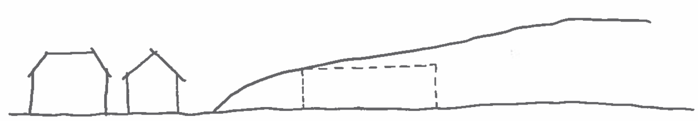
Through the 'dune stage' it was evaluatet how the building should relate and respond to the sand dune. The evaluation is seen on the right side where four different scenarios have been lined up.
The first covers the building completely, hiding it away from the surroundings. The second removes the sand dune completely and cut off the dune heath from the town. The third lifts the building over the sand dune, creating an overview of the context. The fourth integrates the the building into the sand dune.

Advantages and disadvantages have been made for the four suggestions, but a few factors made the choice really simple.
The centre should be for everyone - old and young. Therefore, the access have been a great contributor to the placement. Technical aspects as daylight conditions and the possibility of natural ventilation have been important as well. The centre should represent the natur and to be able to see and feel the surrounding nature have been crucial.

Based on these factors the fouth suggestion have been selected. It is wished, that the sand dune should be a part of the building, but at the same time it should relate to the town of which it is a part.
For turists to be able to recognize the building, further development of the building must ensure it stands out either in form or material.

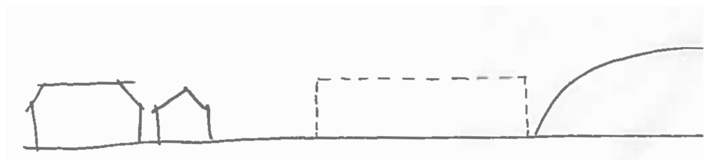
Underground

+ Integration in sand dune + Easy accessibility is possible for disabled + Not dominating the landscape	- Not visible for visitors - Problems with adequate daylight - Natural ventilation is challended (depth) - Relation to town



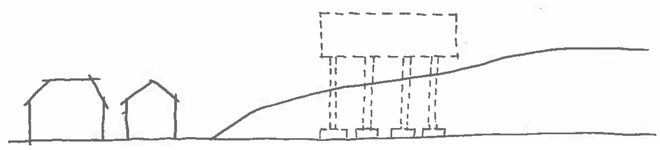
Sand dune removed

+ Good daylight conditions + Visible for visitors + Natural ventilation is possible + Easy accessibility is possible for disabled	- Relation to the National park - Dominating the landscape - No integration with sand dune



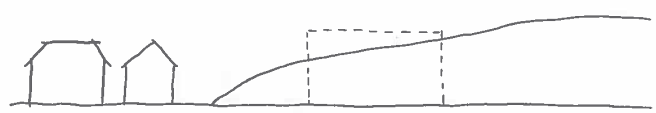
Above ground

+ Adequate daylight + Visible for visitors + Natural ventilation is possible	- Dominating the landscape - Accessibility is challenged - Not integration with sand dune



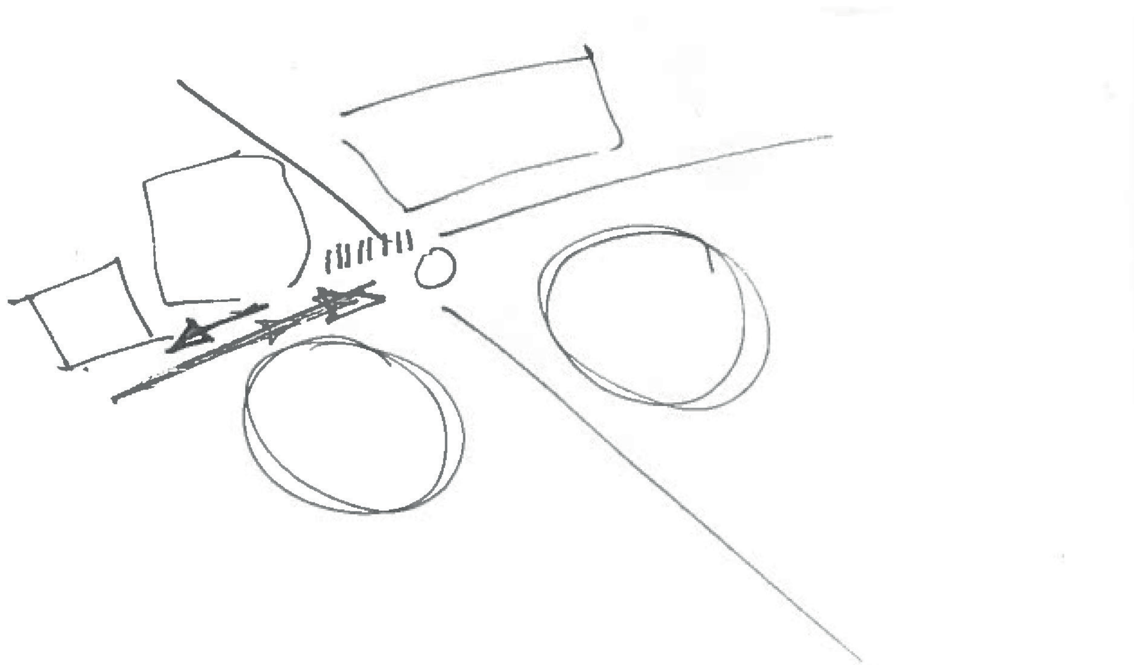
Integrated

+ Visible for visitors + Integration with sand dune + Easy accessibility for disabled + Natural ventilation is possible + Not dominating the landscape	- Impact on dans dune - Adequate daylight conditions is challenged, but possible



Ill. 81 Evaluation

Building layout



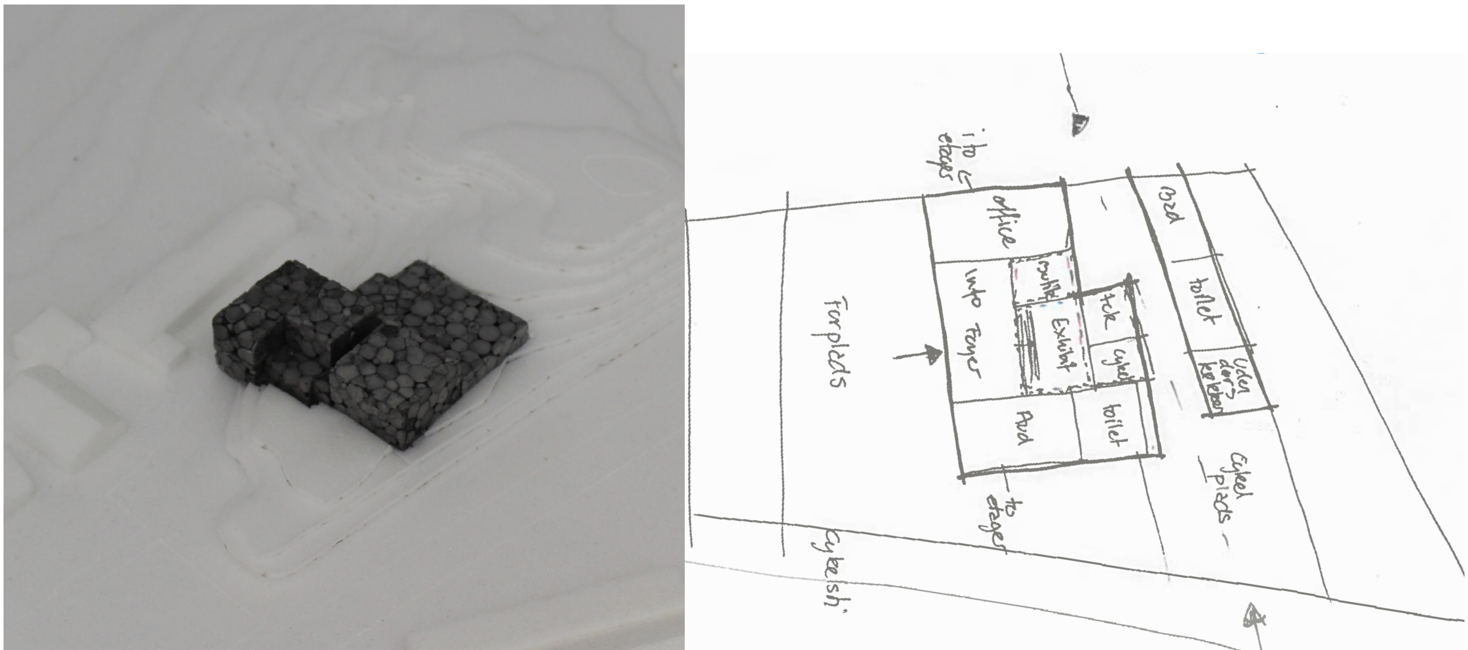
Ill. 82 Sketch

The building layout have played a major part in the project. Many functions - private and public - and wished about flexibility in both indoor and outdoor areas have been a puzzle. Two layouts where quickly formed after each other. They can be seen on the next page Illustration 83-85.

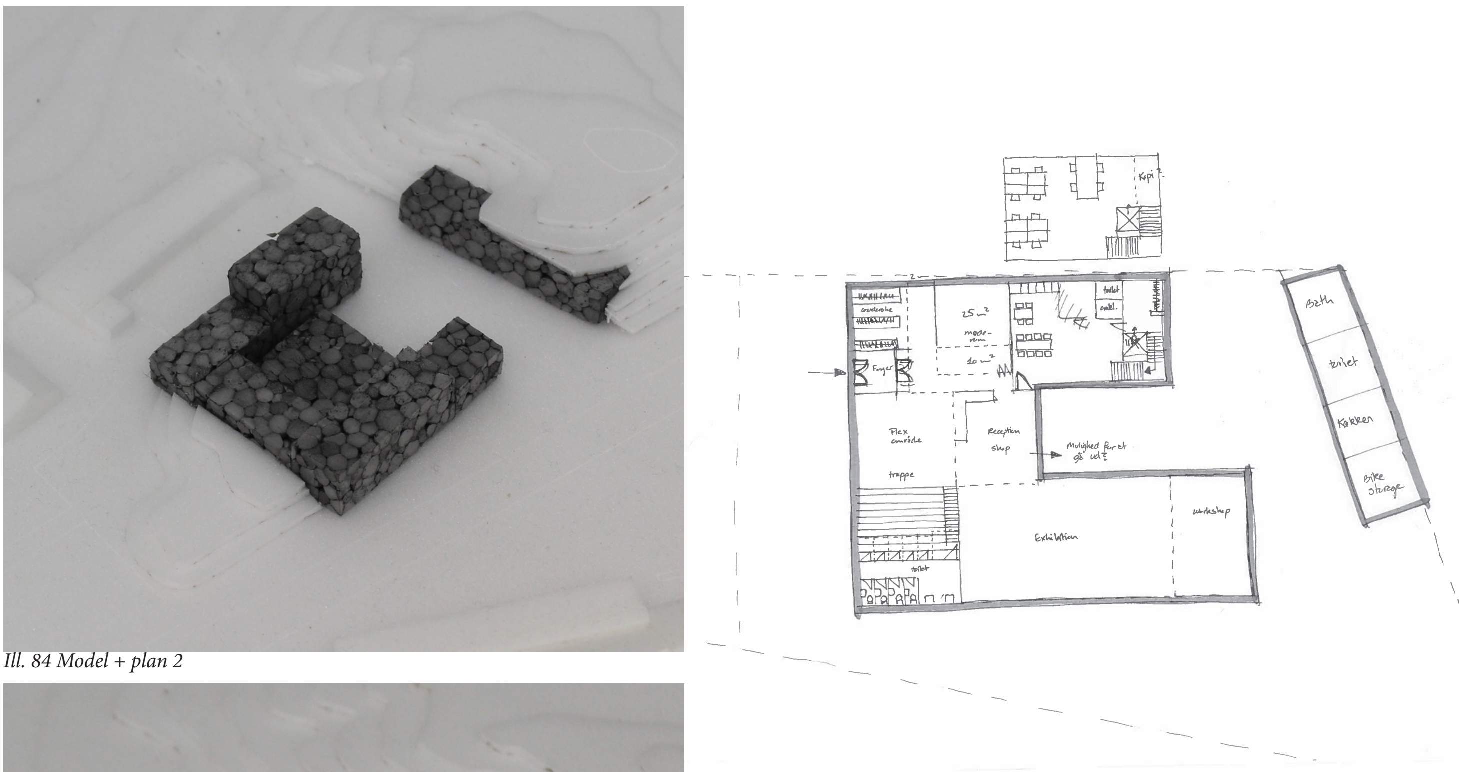
The first suggestion (ill. 83) was a very compact building which piled up through the landscape, dominating it. To make the building a bit lighter in the landscape and to create a more atmospheric experience, the idea of hiding the exhibition in the ground arose. One of the whished for the centre was to create some outdoor spaces, where people can relax and seek shelter, but the area initially reserved for this, by the Nationalparkfond Thy, is facing west and will in periods be very windy. By hiding the exhibition in the ground an outdoor courtyard is formed above it, shielded by the building itself.
However, thinkting about the most important purpose of the building, that it should promote the national park, and become a stepping stone for visitors to explore the national park on their own, it did not make sense to hid away the most important feature - the exhibition. Technical solutions also made the hidden exhibition difficult, as it was hard to ensure enough daylight and natural ventilation in the room.

The second solution, seen on illstration 84, has its origin in the idea of the courtyard and therefore it became this three-winged building. But the narrow site made it difficult to ensure both dune heath and building, when access roads were added through the site, and glimpse to and from the exhibition and indoor activities were created. Another challenging factor is, that the building have no "backside". It is surrouded by either the dune heath or the town and people potentially moves throught the site from three out of four directions.
The advantage of the building orientating itself in all directions is, that it *catches* all kind of people and send them out in again in another direction. A disadvantage is, that funktions as toilets and the technical room must become a central part of the building, as it cannot be hid away in the most unattractive area of the building.

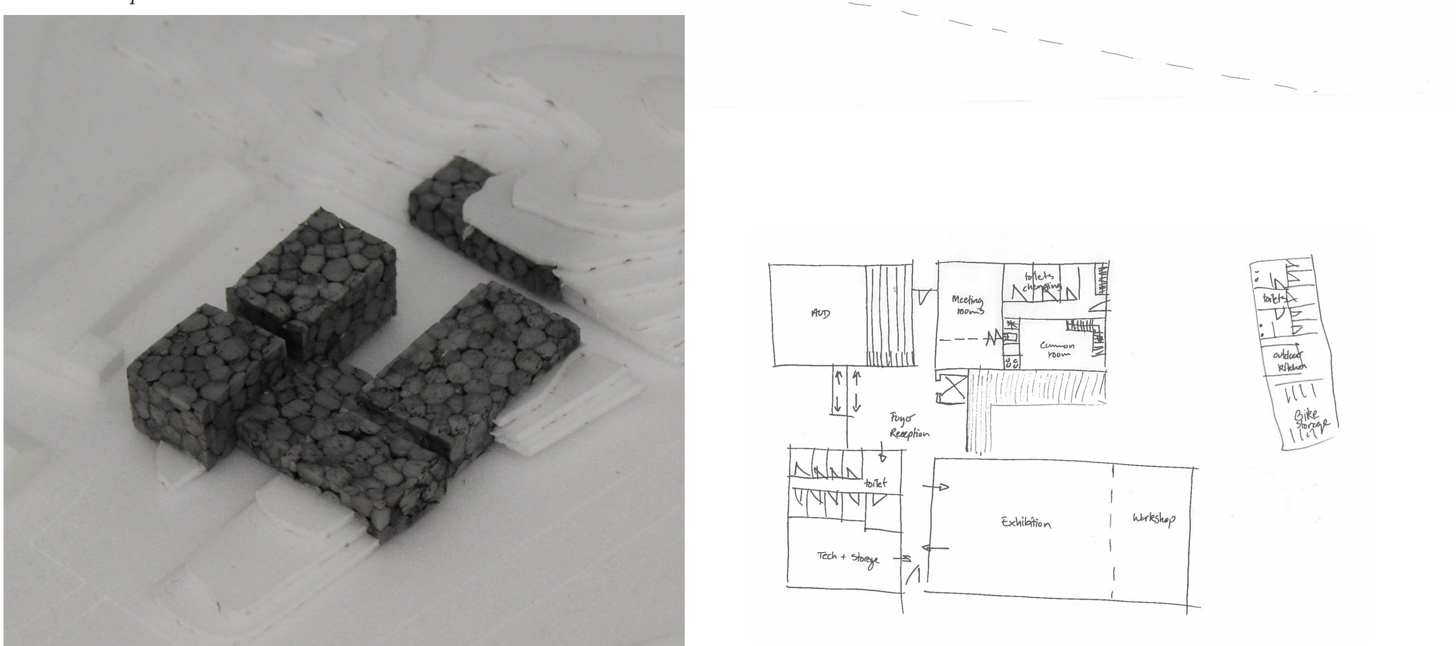
After working with the second plan for a long time realizing it was too locked, the idea of splitting the functions, and connecting them again through the foyer and reception arose. This idea is seen in illustration 85.
The functions have been layed out so the staff is placed in the north-east corner, away from the noicy road and the exhibition and workshop is placed in the south-east corner, catching the eye of the people passing by. Due to overheating the auditorium have been placed in the north-west corner, away from the south and the toilets and technical room have been placed closest to the main road, Hawblink. This create four corners of with either active or quiet zones.



Ill. 83 Model + plan 1



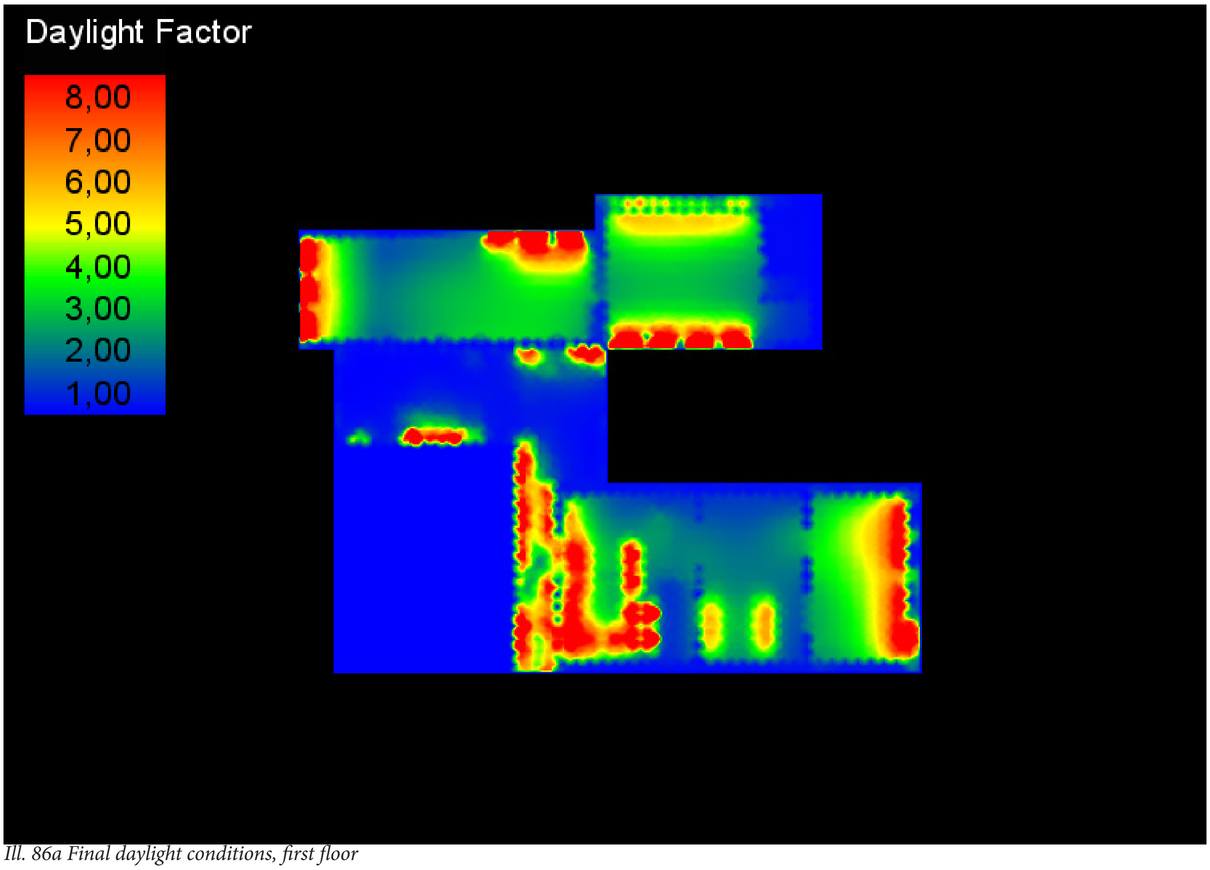
Ill. 84 Model + plan 2



Ill. 85 Model + plan 3

Daylight conditions

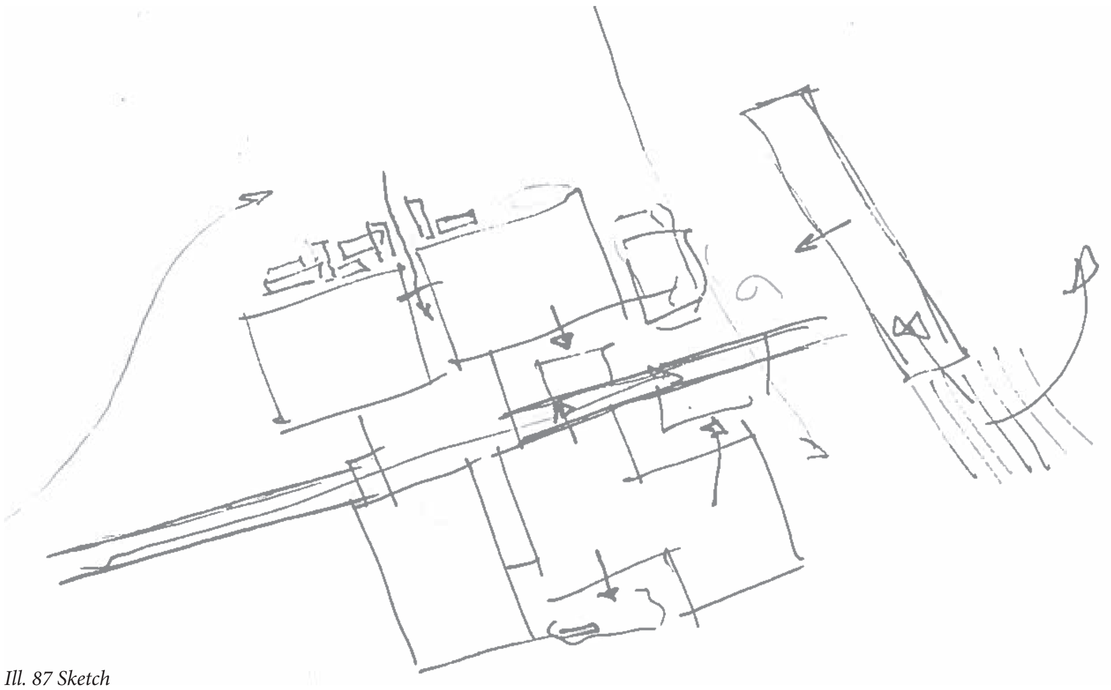
Studies of the daylight have been formed from the point of equinox and the conditions of overcast. The reason for simulating in these conditions are because the centre also should achieve an adequate daylight distribution on the most critical period of the season and day.
Velux has been a vital part of the process of the developing the centre. Velux has both worked as a tool for reaching the required daylight conditions, and the comparison of havehow well the interior material reflect and distribute the light.
In the initial phase of the project, Velux have had an important role in the decision-making of the amount of integrating the centre in the dune heath. The centre was investigated in Velux to see if it was possible to cover the complete centre underneath the dune and comply with the Building Regulation to fulfil the minimum daylight factor of 2%. The model formed and placed in Velux indicated the areas located in a short distance from the placement of the windows did not reach the requirement.
The form had to be dissolved and made more narrow so the rooms in the centre that required a minimum of 2% of daylight factor would have it, hence the implementation of the courtyard.
The rooms that have been investigated and simulated for the most; are the exhibition, auditorium and office. The office area is placed on a level above the rest of the functions, due to their need of a good work condition related to the amount of window area. The view towards the water and the diffuse light have had an important role in the amount and size of the windows.
The exhibition and auditorium require a significant amount of window area, and above the mentioned the rooms have a high internal heat-load. The value of the internal heat-load does affect the amount of window area, the placement(orientation) and the solar transmittance. Velux have been used in correlation with BSim to place the required windows. The large window areas are placed towards north, smaller windows are placed towards east and west and a small amount of skylight are integrated in the roof to have an adequate distribution.



Ill. 86a Final daylight conditions, first floor

Ill. 86b Final daylight conditions, ground floor

Placement of the building



Ill. 87 Sketch

With a layout and vision for the plan, it was important to figure out exactly where on the site the building should be placed. Because the site it so narrow the and the courtyard makes the building quite wide, it is almost not possible to have the dune surrounding all of the building.

To the right is seen an evaluation of the placement of the building on the site. Besides the placement in the dune, the evaluation also takes the access paths into consideration. As mentioned earlier people access and pass by the site from many directions, which have resulted in several access paths. Beside the western access path three others have been placed around the building, one on each side. These three entrances have been evaluated as well on the plans.

The first suggestion have placed the building in the middle of the site leaving a small peace of the sand dune on each side. With all four accesses preserved, this creates leftovers of drops of the original sand dune.

The second suggestion have moved the outdoor functions close to the main building, erasing the path between the parking lot, the courtyard and the beach. Though it gives the sand dune the opportunity to embrace the building more, it removes a very dominant factor from the site, removing the opportinity of connecting the bikepath with a bike-storage for renting.

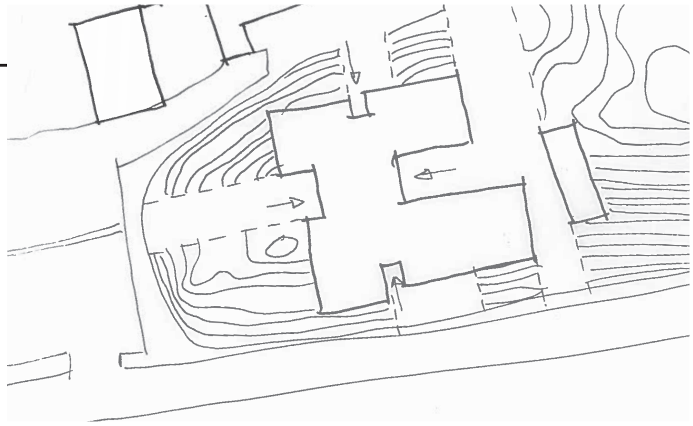
The third suggestion places the building furthest to the North. This placement gives the opportunity of covering the most of the building in the sand dune as much as possible. Accesses can be found to the west, noth and east and the crossing path have been preserved. Though the path cuts through the dune, the rest of the building is covered, and is able to break through the top of the sand dune, maintaining an interesting peak to the building's top.

The fourth suggestion places the building furthest to the south. In this way the people passing by can get a directly view into the exhibition. However most of the building will be uncovered, removing the illusion of a building breaking through the dune.

Though the third suggestion removes a potential entrance to the building, it is the best option, as it covers most of the dune. Though cutting through the dune with the small passage, graduation from dune heath to the town is intact. And despite the missing view to the exhibition from the road, it is possible to see the building break throught the dune, creating an interesting and in new view in the town.

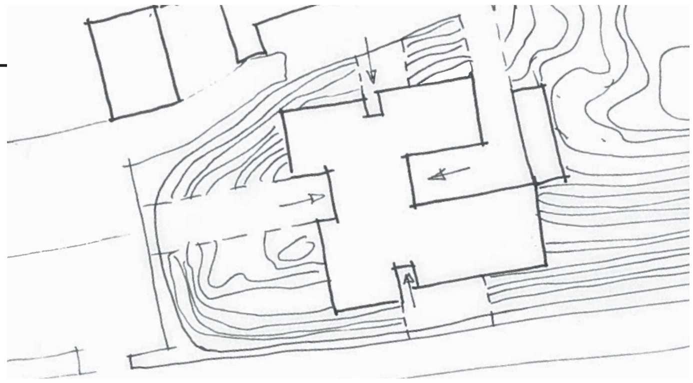
In the middle, four accesses

+ Views into the exhibition	- Entrances seperates the sand dune too much
+ Multible entrances	- Enclaves of sand appear random
+ Passage secure easy access to beach	- passage disconnect the sand dune from continuation
+ Adequate daylight secured	



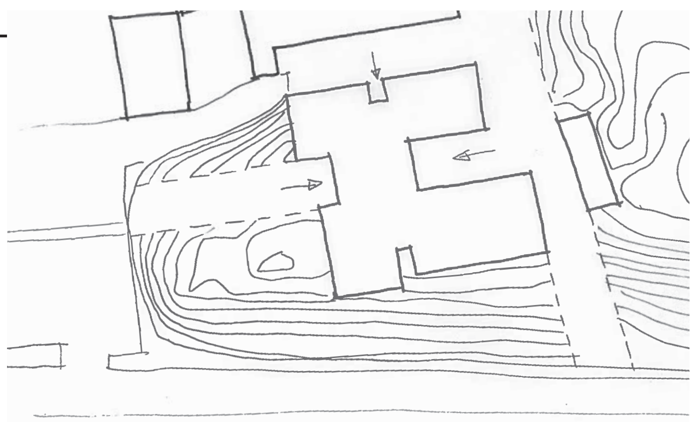
In the middle, path removed, three access

+ Views to the exhibition	- Disconnected to the main road
+ Multible entrances	- Bike-storage is disconnected from bike path
+ No passage secures continuation of sand dune	- Missing passage prevent access to beach



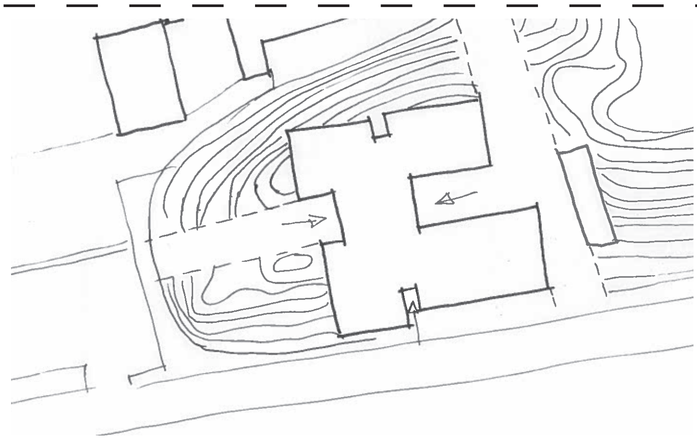
To the north, three accesses

+ Sand dune works together with the building	- No direct views to the exhibition from road
+ Bike storage close to the bike path	- passage disconnect the sand dune from continuation
+ Town graduates into dune and vice versa	
+ No access from south creates more homogenius flow	
+ Front of the site is covered in sand dune	



To the south, three accesses

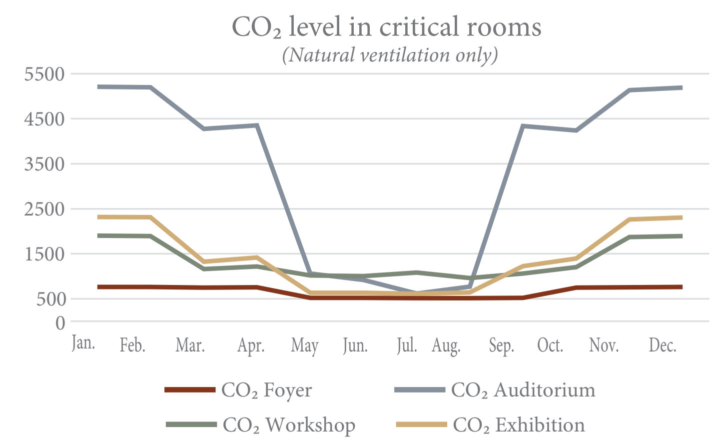
+ View to the exhibition	- The sand dune does not enclose the building
+ Bike storage close to the bike path	- Poor graduation from town to sand dune and vice versa
+ Passage secure easy access to beach	



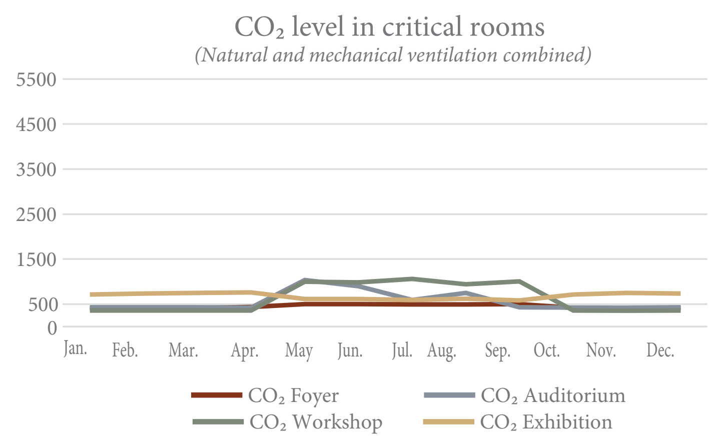
Ill. 88 Evaluation

Indoor climate conditions

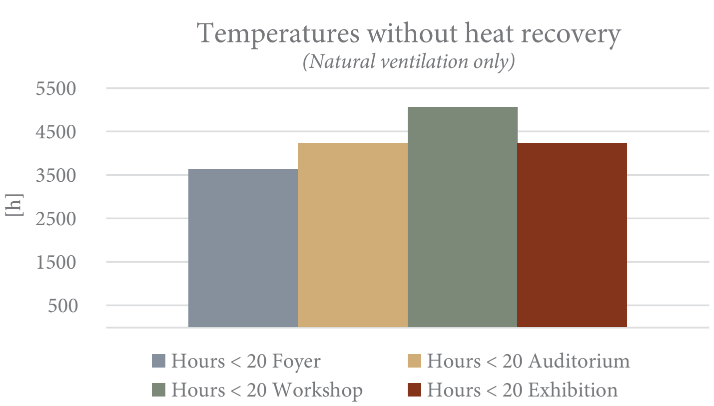
To ensure an optimal indoor environment that support the vision of our centre the aim have been to optimize the experience of a centre with that focuses on passive solutions and therefore work towards a natural environment for the users. To assist the choice of direction the Danish Building Regulations (DBR) have been considered and used to achieve an optimal thermal and atmospheric comfort. The regulation dictates the temperature cannot exceed no more than 100 hours above 26 degrees, and no more than 25 hours above 27 degrees. Thereto the DBR does not allow the atmospheric comfort to exceed a CO_2 concertation above 1000 ppm.
To overcome and meet the DBR, we have alternated between Revit, BSim, Be18 and Velux to work towards the focus of the participatory and the vision of a low-tech environment. In Revit the form and desired area of windows have been placed and thereto the Velux simulations have been used to support and verify an adequate daylight distribution in the centre. To understand the flow of the wind around and in the centre, FlowDesign have been used in correlation with Revit. Furthermore, BSim have been the main tool for continually examine the centre and reaching the desired thermal and atmospheric comfort.
Four rooms have been formed and simulated for in BSim and are a representation of the actual rooms in the centre. The rooms are divided into different thermal-zones to investigate and understand the impact from the internal heat supply and the external solar radiation.
The auditorium, foyer, exhibition and workshop area are all chosen for examination due to their difference in orientation, required window area and the internal heat load.
The auditorium has been investigated due to the desire of a substantial amount of window area and the impact from the solar radiation on the total heat-load. The auditorium was first placed towards the south but the correlation from the internal heat-load (people-, equipment-load) and the external transmittance led to a relocation of the room, from a its original placement in the south of the site to the far north.
The Workshop and exhibition were both chosen because of the placement to the south and the combination of a significant amount of internal heat-load and external heat transmission due to the original orientation of the windows towards south.
To achieve the requirements from DBR, specific parameters have been adjusted. The parameters that have been adjusted are Natural ventilation, reduce of window area and adjusting the g-value according to a fabricated window. All elements have had a significant impact on the indoor thermal and atmospheric comfort (Graph. 05-12)
The process of reaching the requirements started with Adding natural ventilation, so the size of the openings and placement(height) in correlation with the orientation and was settled. The natural ventilation reduced the CO_2 level in the summer period and had and an impact on the thermal comfort.
To further minimize the thermal comfort, the window towards south had to be reduced to minimize the external heat-load. This did affect the temperature in summer, so to overcome the issues of a significant solar transmission in summer and heat-loss in winter a change in the g-value was made. The change in the g-value did influence the daylight condition but the rooms did still fulfil the requirement of a daylight factor of 2%.
The initial assumption and supporting theory that formed the project mentioned, the path back to nature and avoiding mechanical solutions. To comply with the theory and avoid mechanical-ventilation, the natural ventilation was optimized and placed as the main focus to decrease the hours above 26 and 27. The natural ventilation did function well, but a problem occurred in the winter. The level of CO_2 and the hours below 20 degrees was substantial in winter and had to be minimized through mechanical ventilation. The graph still indicate a certain amount below 20 degrees and the reason behind that are because the heat are turned off in the period of closing hours. The heating does start and turn off one and a half hour before opening- and closing hour. The heating does work four hours more one day every week, to accommodate lectures outside opening hours (Graph 01-04).



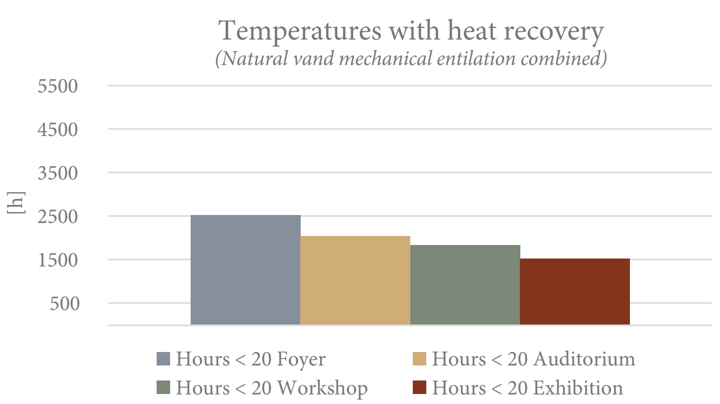
Graphs 01 CO_2 level



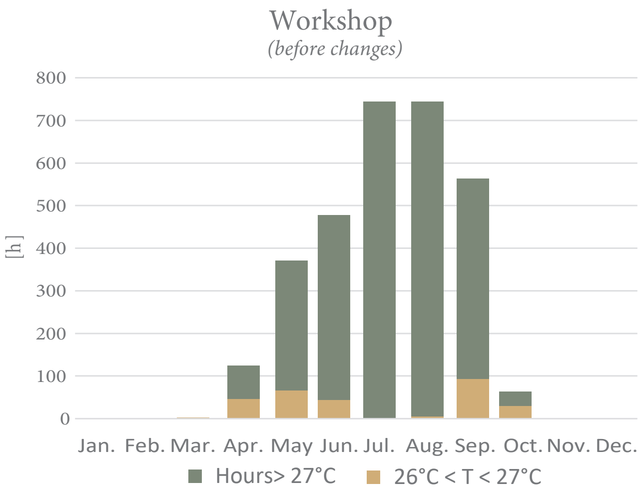
Graphs 02 CO_2 level



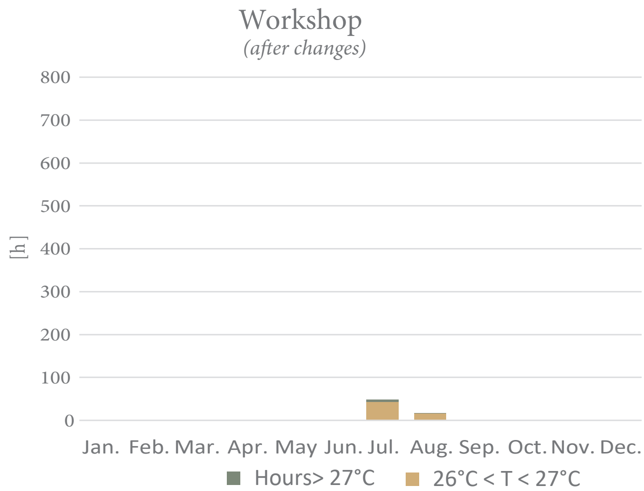
Graphs 03 Temperatures



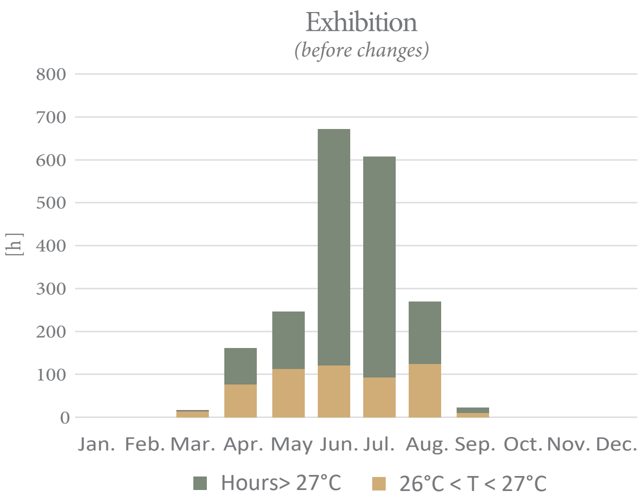
Graphs 04 Temperatures



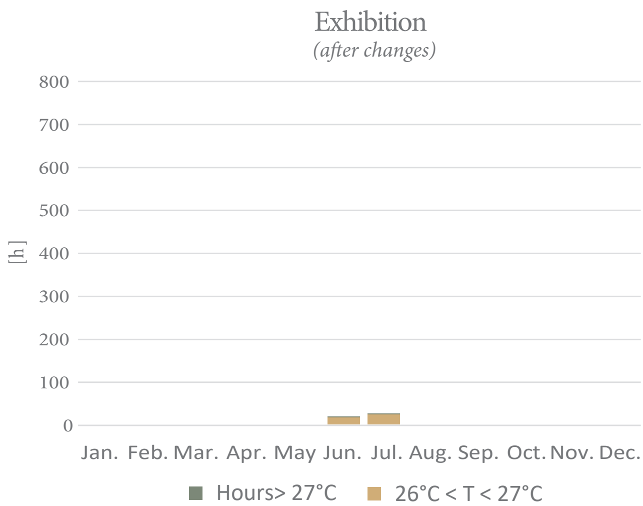
Graphs 05



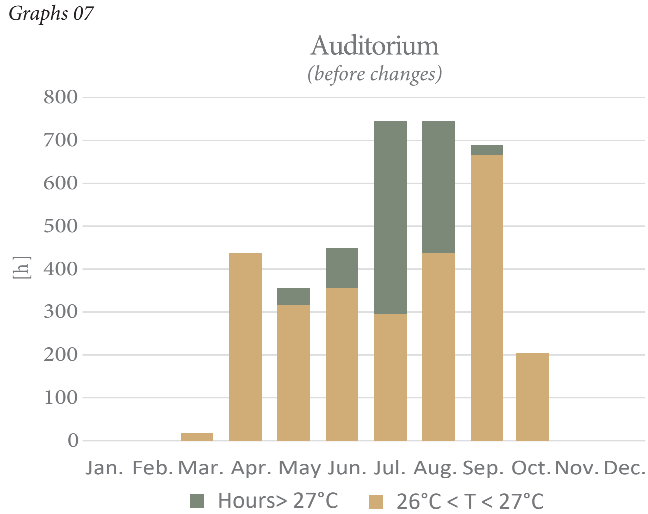
Graphs 06



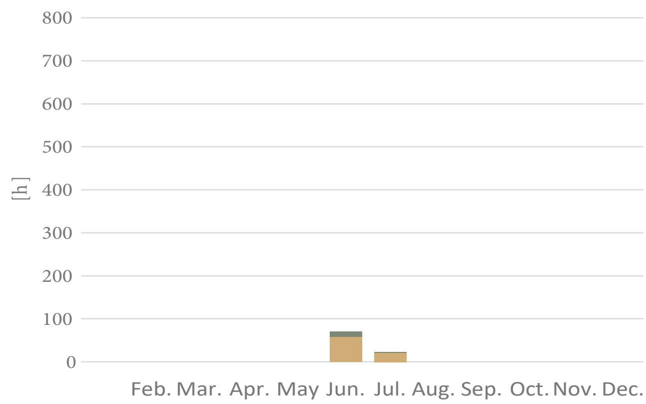
Graphs 07



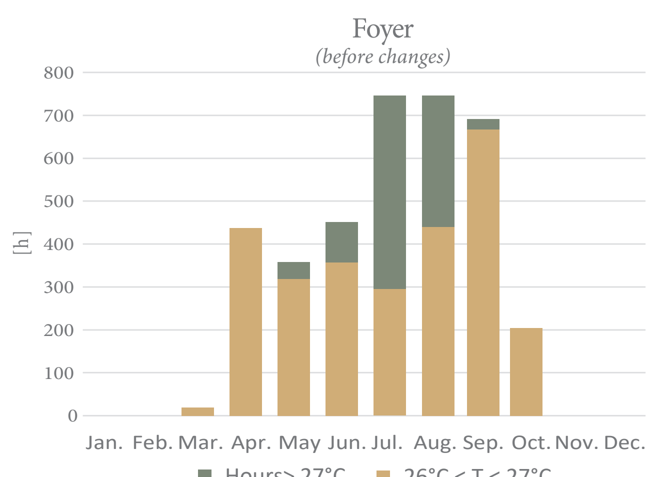
Graphs 08



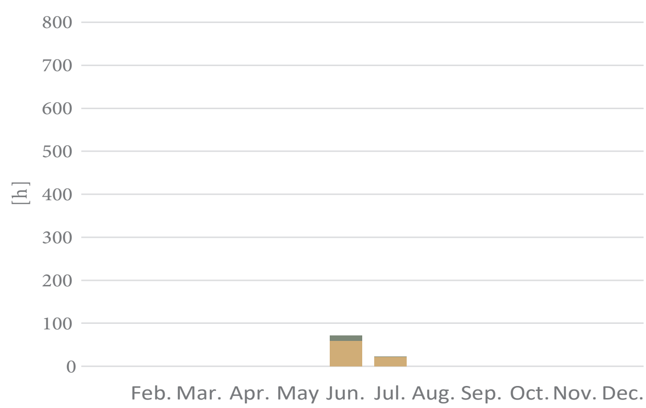
Graphs 09



Graphs 10



Graphs 11



Graphs 12

Ill. 89 Surfer in Nørre Vorupør

Material evaluation

Introduction

A buildings expression is very much a result of the interaction between the building form and the choice of material, both through performance and aesthetical parameters. To evaluate a possible design solution and to choose the right material for the final building it is important to investigate many different properties and characteristics, e.g. heat insulation, load bearing capacity and durability, for each material.

All materials are exposed to physical and chemical influencing factors. In most cases the influence is negative, but the breakdown might happen fast or slow depending on the sort of material and the environment in which it is exposed (Gottfredsen and Nielsen, 2015).

With a site located at the Westcoast of Denmark it is clearly seen that the environment has a great impact on the materials lifespan. A strong and hard wind along with the salty sea air has a great influence on the breakdown of materials used for the marine constructions as well as buildings found along the coastline.

Three aspects have been important to take in mind when selecting the materials used for the construction and façade: The load bearing capacity, lifespan and the environmental impact.

Material comparison

As mentioned earlier in the report the traditional building material have been brick though many summerhouses later have been built in wood. The marine constructions as the 115-year-old breakwater and newly built open-air sea pool have been constructed in concrete. Therefore, these materials have been investigated for comparison in table 02.

The centre is intended to be partially covered by the sand dune which is already found on the site. This means the constructing material must be able to withstand the pressure from the dune. Though brick was a very desired choice of material, due to its relation to the context, it has been deselected based on its structural ability to carry the load from the sand dune. It might be possible to strengthen the brick with rebars, but it would demand a more complicated approach. Likewise, wood have been counted out for some the same reasons as brick, as it would take a more complicated approach to ensure the ability to withstand load from the sand. Furthermore, the durability of wood has been observed to very poor in the area. The summerhouses with wood construction and façades are placed further into the landscape, shielded by vegetation, and is far less exposed than those located close to the coast. Furthermore, contact with sand and driving rain will cause moisture absorption in the material leading to decay.

This mean concrete has been chosen as the most optimal material for the construction. Several positive properties as lifespan, and structural abilities are highly valued as well as its ability to withstand the hard climate.

		History /identity	Aesthetic	Technical	Functional
Brick	+	Traditional building material in NP Dominating facade material in NP	Tactility is warm	Able to withstand the local climate Strong material in vertical compression Environmental impact is better than concrete	High lifespan Recyclable
	-		Form can become very monumental Tactility is rough	Load bearing capacity is not good in horizontal compression Environmental impact is worse than wood	
Wood	+	Traditional building material for ships Dominating building materialfor summer houses in NP	Form can seen less monumental Tactility is warm Create inviting atmosphere, as facade cladding	Strong material in vertical compression ???? Environmental impact is better than brick and concrete	
	-			Not able to witstand the local climate (over a longer period) Load bearing capacity is not good in horizontal compression	Low lifespan Not recyclable
Concrete	+	Traditional marine construction material (breakwater, open-air sea pool) Material relates to new urban context	Tactility can vary depending on treatment Able to stand out in the context (less dominant building material)	Able to witstand the local climate Loadbearing capacity is good in both vertical and horizontal compression	Ling lifespan Precast elements are recyclable
	-		Form can become very monumental Tactility is cold	Environmental impact is worse than wood and brick	In-situ cast elements are not recyclable

Table 02 Material evaliation

Life cycle assessment

Environmental investigations
The third aspect to be considered is the environmental impact. Generally concrete has a high environmental impact. However, previous considerations have led to a comparison of the environmental impact of two concrete walls, where to different cast method is in focus – precast and in-situ cast concrete.

The investigation has been carried out through a life cycle assessment (LCA) in LCAByg. The assessment is a method to estimate potential environmental impacts and the resource consumption of products used in the building throughout its whole lifetime. The essential about the LCA method is, that it includes all building process in the life cycle instead of focusing on the finished building alone. The life cycle of a building can be separated into five stages: Product stage; construction process stage; use stage; end-of-life stage, and benefits and loads beyond the system boundary.
All stages are included in the assessment - from the raw material supply, to the manufacture of construction products, to the demolition and disposal or reuse of materials and all the exchanges with the environment, which happens through the life cycle stages, will be added up (Birgisdóttir and Rasmussen, 2015).

Illustration 90 shows the two walls compared, though the only variating factor is the concrete elements used. The amount of inulation is the same and therefore both walls have a thickness of 556 milimetre. Table 03 and 04 shows the information about the amount of material, lifespan for each material and u-value.

Initially, both wall consisted of two layers of concrete, where the interior wall was the load bearing wall - precast and in-situ cast - and lightweight concrete were introduced as a facade cladding. The advantage of the lightweight concrete is, that it contains more air voids than the heavyweight. The air voids are anti-capillary and hinder the concretes ability to absorb fluids as rain water and prevent entry of moisture and the resistance to frost becomes higher (Gottfredsen and Nielsen, 2015). Results from this assessment can be found in Appendix 01.
However to introduce yet another type of concrete on the facade would influences the results. Furthermore, the in-situ cast wall consisted both of an in-situ cast element and a a precast facade element which conflicted with the idea of comparing the methods.
In this context the two walls were yet again reviewed. The first consideration were to use the same casting method on the two concrete element, but because the facade element only works as cladding the funcional purpose were questioned. From an environmental perspective one concrete wall is better than two. Therefore, the load bearing structure is moved from the interior to the exterior and the insulation is placed on the interior side. In this way a layer of concrete is saved and the only difference now lies in the cast method.

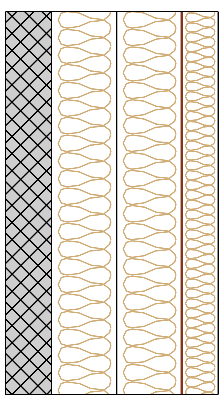
For the walls to be compared it is important to ensure the same u-value, in this case 0,09 W/m^{2}K, as it secures the same transmission loss through the walls and the 'operations'-phase can be left out in the calculation. Therefore, the calculations have been made for one square metre of external wall, as it is representative for the whole wall construction.

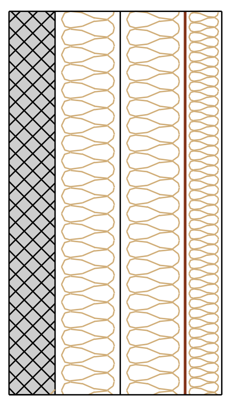
Results

Precast concrete wall

U-value 0,09 W/m²K

Precast concrete - 120 mm
Insulation - 170 mm
Insulation - 170 mm
Vapour barrier - 0,001
Insulation - 95 mm





In-situ cast concrete wall

U-value 0,09 W/m²K

In-situ cast concrete - 120 mm
Insulation - 145 mm
Insulation 145 mm
Vapour barrier - 0,001 mm
Insulation - 45 mm

Ill. 90 Precast concrete wall vs. In-situ cast concrete wall

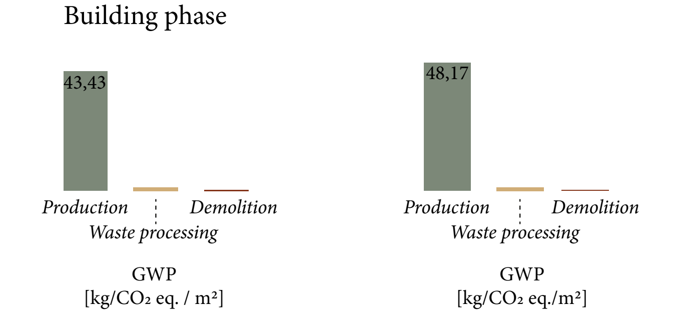
Material	Info	Amount pr. m²	Lifetime [year]	Uvalue [W/m²K]
Concrete	*Prefabricated concrete, C20/25*	288 kg	120	0,09
Insulation	*Mineral*	0,17 m³	80	
Insulation	*Mineral*	0,17 m³	80	
Vapour barrier		0,001 m²	80	
Insulation	*Mineral*	0,095 m³	80	

Table 03 Precast concrete

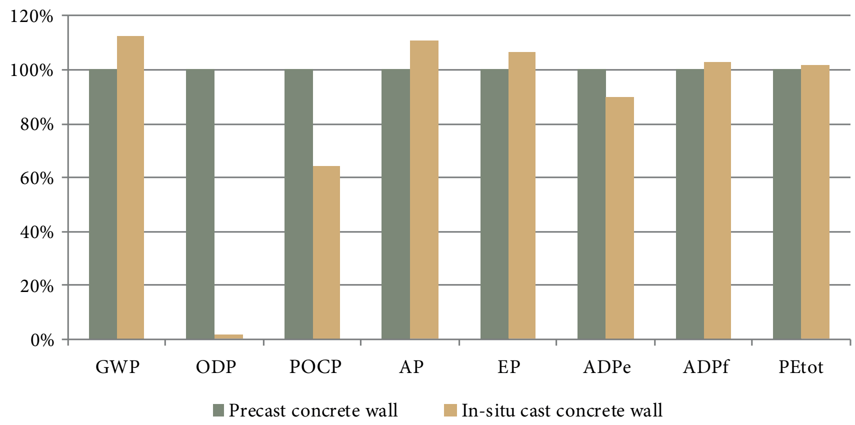
Material	Info	Amount pr. m²	Lifetime [year]	Uvalue [W/m²K]
Concrete	*Self-compacting concrete, C20/25*	288 kg	120	0,09
Insulation	*Mineral*	0,17 m³	80	
Insulation	*Mineral*	0,17 m³	80	
Vapour barrier		0,001 m²	80	
Insulation	*Mineral*	0,095 m³	80	

Table 04 In-situ cast concrete

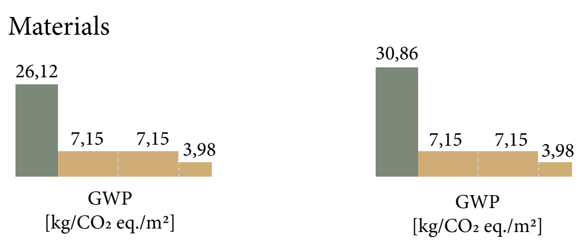
From the result, seen on graph 13, it is clearly to see, that the in-situ cast method and the precast method performs almost the same or slightly worse except ODP, POCP and ADPe.
It is notable that the in-situ cast wall performs very well on the ODP which describes the *Ozone Depletion Potential*. ODP contributes to the destruction of the stratospheric ozone layer, that protects flora and fauna against the suns UV-radiation. The fact that the category is very low at the in-situ cast method compared to the precast method could have something to do with the exclusion of certain steps in the cast procedure. It is unclear whether the LCA includes the precise procedure and therefore it is difficult to say e.g. if the wooden forms used at the site are included or not.
Another reason for the good performance could have something to do with the different phases which the wall elements goes through, through their lifetime. But as seen on illustration 91, *building phases*, almost all of the total environmental impact is used on the production phase. A very small amount is used on the waste processing and demolition. So at least the impact is similar through the building phase.
The POCD, *Photochemical Ozone Creation Potential*, describes the potential for generating smog, which means the precast method breaks down more of the ozone layer in the lower atmosphere.
The ADEe, *Abiotic Depletion Potential for Non-fossil Resources*, is also very important, as it describes the resources which occurs naturally in nature - in this case water, sand and minerals. Something suggest that these elements are lower in the in-situ cast mixture and therefore performs better in this category. But based on the results the precast method overall performs slightly better when it comes to the environmental impact.
Another point of discussion is whether it is an advantage to cast on site. In this case there is no connections between wall elements and therefore no risk of e.g. water infiltration in the structure. Furthermore, the structural wall will appear more even with no deformations and can be used directly as the interior wall. A disadvantage of the in-situ method is that the process is potentially not as controlled as the precast method regarding aspects like temperature difference and tolerances. And a finishing layer added to the precast element will secure an even facade and prevent water infiltration. A potential advantage of the precast method is also that it is possible to disassemble after a period opposed to the in-situ cast method which must demolished completely. A risk is though that the wall is maintained for such a long period, that the structural integrity cannot be guaranteed and therefore might not able to be reused anyway.
Based on the results and following discussion the most optimal solution must therefore be the precast concrete.

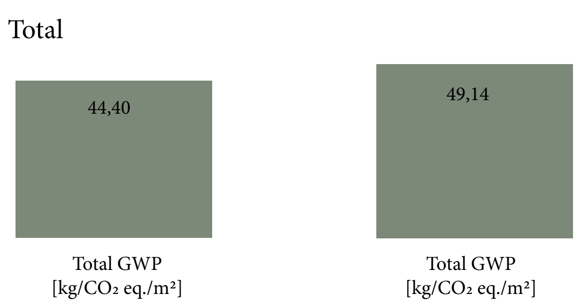


Ill. 91 LCA result_building phase



Graph 13 Comparison of precast and in-situ cast wall





Ill. 92 LCA result_Materials

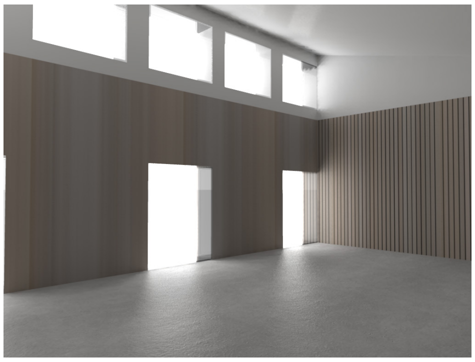
Ill. 93 LCA result_Total

Interior materials

Opposite the exterior the interior cladding is not affected by the weather in the same way and the wish is to have a more warm, light and inviting atmosphere. Therefore, concrete have not been selected, but instead the focus lies on light and natural materials as gypsum and wood, respectively. The tactility and mateirality of these materials differs very much from the exteriror concrete which is raw and well-resistant towards the weather conditions.
Only the walls and roof materials are changing throughout the investitation, because though concrete have been ruled out as wall and ceiling material it is the best material for the floors. Many people will enter the building with sand on their boots and shoes, and concrete simply is the most resistant material to severe wear exposure.

Four situations have been tested, to secure the best experience of the room, but at the same time ensuring proper light conditions.
The investigation of the material works simply works as a guideline for the design of the public functions and the cladding is expected to vary throughout the building.

A combination of wood and gypsym have been put together in the thirst two. The seperation have been placed where the sand dune reaches on the exterior wall. Both situations have an average daylight factor of 3,3 %.
The last two situations are either covered entirely with wooden panels or gypsum. Not surprising the white gypsum boards combined with the polished concrete have the highest daylight factor of 4,3 %, whereas the wooden room have an average of 2,3 %. However, the gypsum create a very steril and empty space.
The first situation have been chosen as a main cladding, as the wood creates the warm and inviting atmosphere where there is room for display, learning and development.

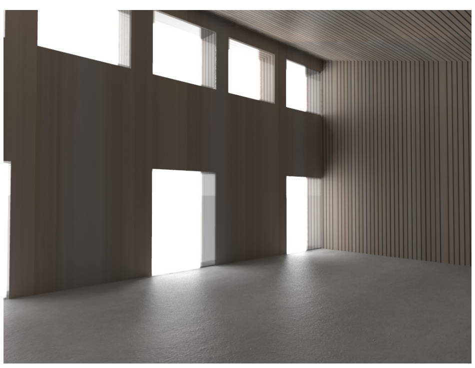


Floor *Concrete*
Walls *Wooden panels*
Ceiling *Gypsum*

Average daylight factor
3,3 %

Floor *Concrete*
Walls *Gypsum*
Ceiling *Wooden panel*

Average daylight factor
3,3 %



Floor *Concrete*
Walls *Wooden panels*
Ceiling *Wooden panels*

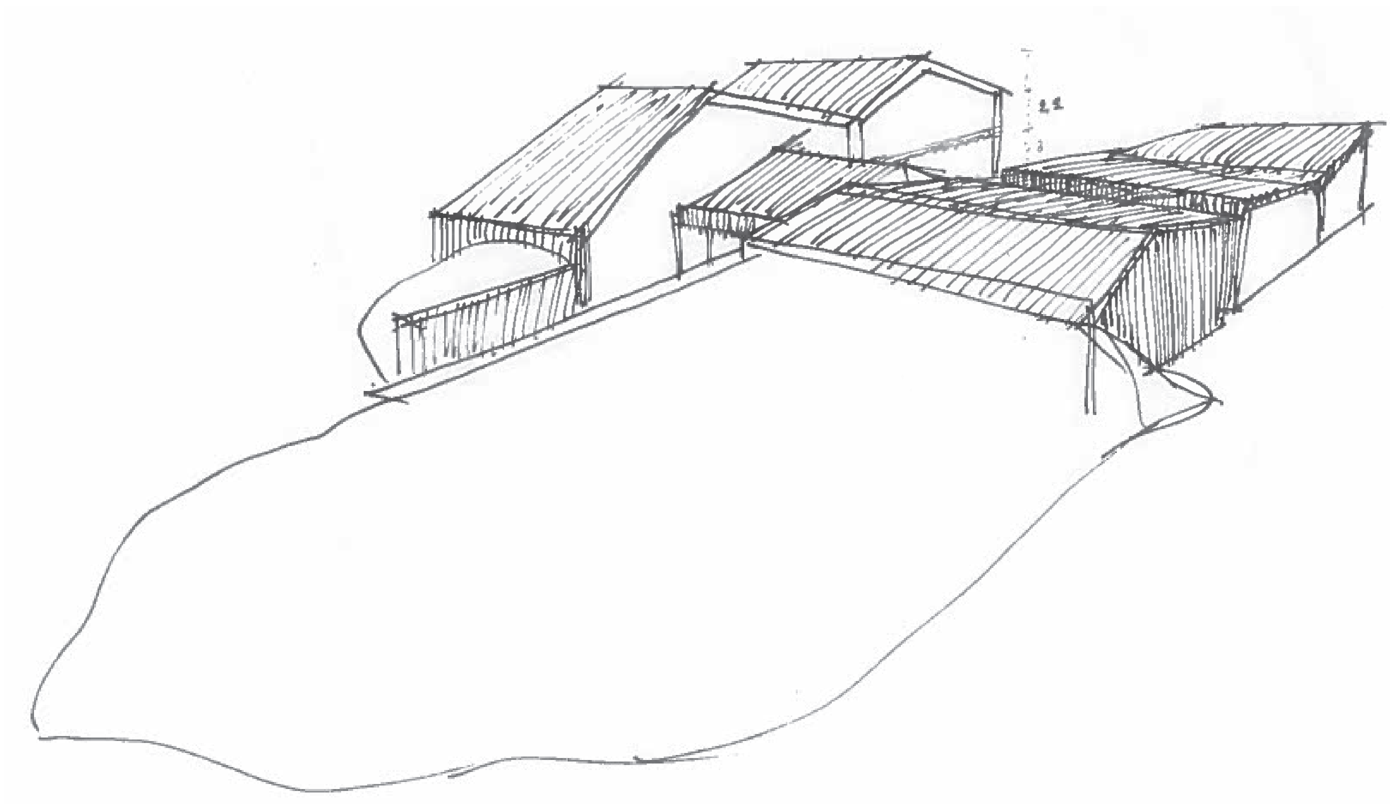
Average daylight factor
2,3 %

Floor *Concrete*
Walls *Gypsum*
Ceiling *Gypsum*

Average daylight factor
4,3 %

Ill. 94 Evaluation

Roof



Ill. 95 Sketch

When choosing to partly hide away the building, the roof becomes a very important factor. It is the element that connects the town with the dune heath and the national park.

To the right is an evaluation of the roof expression. If it should be as simple as square boxes, if it should be organic, blending into the dune heath or if it should have a saddle roof, traditional or interpret.

When creating the roof, the interior functions affect the choice as well e.g. must the pipes for the mechanical ventional be thought of, to ensure a proper room height.
In this case it is very much a balance of creating a visible building, which stands out from the context, and yet, it cannot stand out too much. Therefore, the saddle roof have the biggest advantage, as it relates to the traditional town houses. Having the sand dune surrounding the building it already stands out, which makes the traditional saddle roof good as it draw a referance back to the national park and the people who live there.
The other three solutions removes the focus from what is important, creating a building without a relation to the history of the site surroundigs.

Square roof

+ A monument in the landscape + Ventilation pipes is short (roof)	- Becomes very massive in the landscape (form) - No relation to context - No relation to town

Interpretation of saddle roof

+ A monument in the landscape + Stands out in the context + Relation to town + Able to fall into the lines of the landscape	- Ventilation pipes is complicated (roof)

Traditional saddle roof

+ Relation to town + Able to fall into the lines of the landscape	- Anonymous in its expression - Ventilation pipes can be complicated

Organic

+ Relation to sand dune + Falls into the lines of the landscape	- Ventilation pipes can be complicated - No relation to town

Ill. 96 Evaluation

Material Evaluation
Detailing

Introduction
A very important part of the buildings ability to perform is the system of gutters. It is a system that is often ignored in an architectural context and for a period it resulted in concealed gutters, hid behind the façades. But the hidden gutters can be a great disadvantage as maintenance needs to be made more often to prevent water damage on the construction (Sode, Jensen and Pasternak, 2017). The gutters cannot be denied and is, eventually, a big part of the building expression. As the rest of the centres external building materials, the gutters will have to be made of a material able to withstand the rough climate, because the breakdown of each materials happens faster in this area compared to the climate further inland.

Material comparison
Several materials, as plastic, zinc, steel and copper, are suitable as gutter material, but as most of the façades are made of concrete there is a big difference in the expression when choosing between steel and plastic.
A comparison of gutter materials is listed and valuated in table 05 based on four categories: History/identity, aesthetical, technical and functional aspects.

The comparison favours copper, as it relates very much to the site, the tactility will be a warm contrast to a concrete wall and especially the lifespan and the ability to withstand the local climate is important. The only disadvantage is the expense. Plastic and zinc are the only materials which can be compared to copper. Plastic has the advantage of being much cheaper, but on the other hand it also looks cheap and, in a time, where the material is discussed negatively in a sustainable context, it would not send a good first-hand impression. Galvanized steel is the second most used roof material, after roofing felt, in the area, and is often used for gutters, but a major disadvantage is that it is not able to withstand the local climate and only has a lifespan of 8 years. As zinc, aluminium and steel can look very much alike, zinc has the advantage of having a much longer lifespan (50 years) and the ability to withstand the local climate better than aluminium and steel – though not as well as copper (Bedre hus og have, n.d.).

		History/identity	Aesthetic	Technical	Function
Copper	+	Existing material in the area (gutters, window frames, roof cladding)	Patinates faster in the local climate Tactility is warm and smooth Stands out from concrete wall	Able to withstand the local climate very well (not affected by sea fog) Can be made as one long piece (avoid joints) Can be brazed (hide joints)	Ling lifespan (60-80 years)
	-			Standard sizes in 3 and 6 metres (risk of leakage in joints)	Expensive (approx. 200 DKK/m)
Corten	+		Tactility is warm Stands out from concrete wall	Able to withstand the local climate (not affected by sea fog)	Cheaper than copper
	-	Foreign material in the area	Tactility is rough	Not standard product (needs to be custom made)	Short lifespan (10 years)
Aluminium	+		Same appearance as zinc and steel Tactility is smooth		Cheap (approx. 90 DKK/m)
	-		Tactility is cold Blend into concrete wall	Must be treated/coated to withstand climate Standard sizes in 3 and 6 metres (risk of leakage in joints) Not able to withstand the hard climate (affected by sea fog)	Short lifespan (15 years)
Zinc	+		Same appearance as aluminium and steel Tactility is smooth	Able to withstand the local climate (not affected by sea fog) Can be brazed (no joints)	Long lifespan (50 years)
	-		Tactility is cold Blend into concrete wall	Standard sizes in 3 and 6 metres (risk of leakage in joints)	Expensive (approx. (140 DKK/m)
Steel	+	Existing material in the area (gutters, galvanized roof tiles)	Same appearance as aluminium and zinc Tactility is smooth		Cheap (approx. 90 DKK/m)
	-		Blend into concrete wall	Not able to withstand the hard climate (affected by sea fog)	Low lifespan (8 years)
Plastic	+				Cheap (approx. 90 DKK/m)
	-		Looks cheap Mismatched in the area Do not have a sustainable appearance	Able to withstand the hard climate (not affected by sea fog) Standard sizes in 3 and 6 metres (risk of leakage in joints)	Long lifespan (25 years) Not able to withstand pushes and punches Difficult to repair (cannot withstand preassure from ladder)

Table 05 Material evaluation

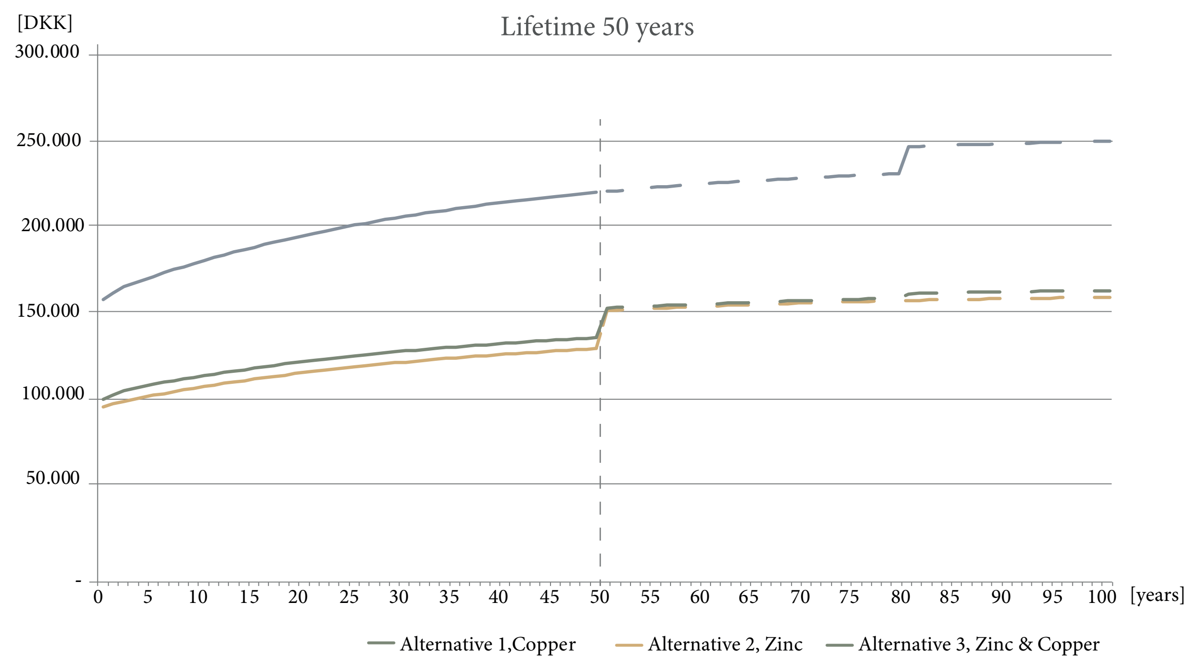
Life cycle costing

Cost investigations
As it is the two most expensive materials – copper and zinc – which are most suitable for the local climate, it is interesting to compare the economic circumstances over a period. The comparison is made as a Life Cycle Costing (LCC) assessment. The assessment can be very comprehensive, and focus is not only at the initial investment costs, but also the costs connected to site management, operation and replacement.
In this case, the site management and operation are left out of the assessment, and only the initial investment and potential repair and replacement are included. Three alternatives have been suggested: One with copper gutters and downpipes; one with zinc gutters and down pipes, and; one with zinc gutters and copper down pipes. The last alternative is suggested in to see the possibility of hiding the gutters behind the facade and only make the downpipes visible.
Key figures are specified in table 08 in appendix 02, along with the initial and management costs of the alternatives.

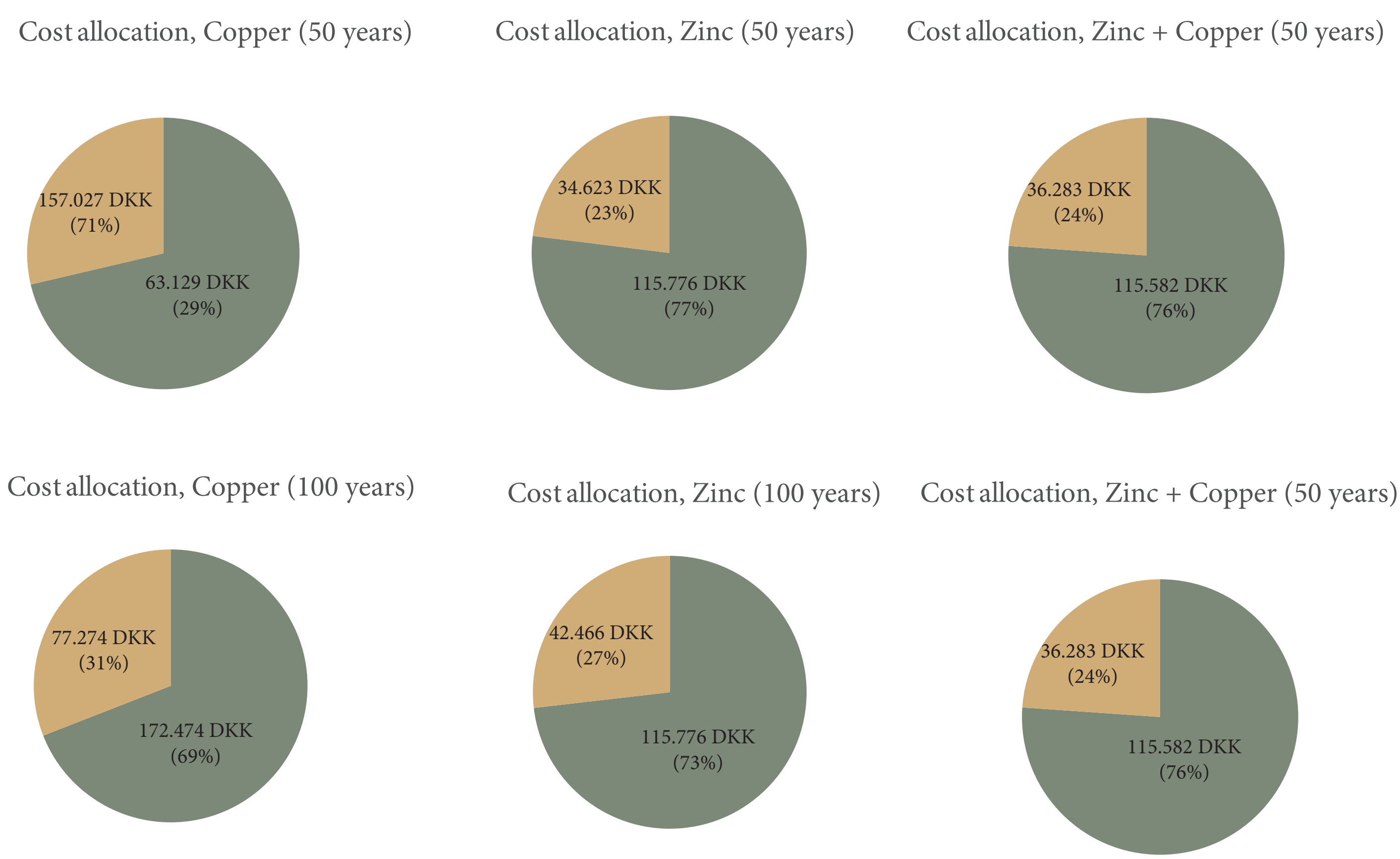
It is important to take the lifespan of the materials as well as the building into account, because the total costs can vary over time. Therefore, to achieve a comparable situation, the *Precent Value* for each alternative will be estimated.
When calculating the LCC the time horizon is very important. For a visitor centre like ours, an average lifespan would be expected to be approximately 100 years. A disadvantage, though, is the changes or alterations that can emerge during this lifetime, because they can be difficult to simulate in a meaningful way and might create greater uncertainties than certainties in the result. According to Haugbølle (2015) a discounted period of 30-50 years would be more solid in terms of taking future uncertainties into account.
However, the two materials investigated both have a lifespan of 50 years or more. When looking at a period of 50 years the alternative with the highest investment, would also be expected to become the most expensive over time, when assuming the maintenance will be equal for the two first alternatives. So, because copper is the most expensive material it most likely will become the most expensive investment and solution to maintain. Therefore, the calculations have been expanded to a 100-year period, to see exactly how big a difference there is between the two alternatives. The advantage of combining the two alternatives in a third is that it might reduce the total cost, but at the same time give the same exterior expression as alternative 1. To place the zinc gutters behind the facade will also protect it from the weather.

Results
As mentioned, the three alternatives have been compared based on the Present Value. The comparison can be seen at graph 14. The Present Value is an expression of the amount of money, which needs to be put aside today to be able to pay the running prices (the future price for a present product with the inflation considered) in the future.

Seen in a sustainable context it would be best to let the materials fulfil their lifespan. But as expected, Alternative 1, copper, is the most expensive, no matter if it is over a 50-years or 100-years period. During a 100-year comparison all gutter systems are expected to be replace at least once. In principle, Alternative 2, zinc, would have to be changed once when looking at a 50-years period, but practically, if the building is expected to be demolished after 50 years, it might not be an included part of the investment.
In the end, it is the building owner and investor who must make the final decision. Though alternative 3 is slightly more exensive than alternative 2, it is much cheaper than alternative 1, but in the end creates the same expression, which make it the most optimal choice for the centre.
An advantage for the national park centre is that it is Nationalparkfond Thy, a private foundation, which is the building owner, and along with other private foundations, who on their own initiative, supports the centre financially. This means they might think in a more long-term perspective, as they only post money into a project of a certain standard and where the values are highly favoured. Public investors might not have the same ambitions and the money prperbly would be fewer and needs to be invested in a shorter lifespan as the 30-50 years.
In an aesthetical context it varies very much on the expression which is wanted from the building. Copper has a slightly better performance in lifetime and resistance against the local climate, but it stands out from a concrete façade – both before and after patination. Zinc has a more anonymous expressions and blends in nicely with a concrete wall. On the other hand, the lifetime is lower and the resistance against the local climate are also lower.
As mentioned in the beginning most of the considerations speak in favour of copper and with the heavy concrete facades, it would create a great contrast to the concrete. The change from light cupper to dark brown to the verdigris green will also be telling a story about how the local climate influences and transform the materials much faster in this area. With some of the gutters hid away alternative 3 is the most optimal solution overall.



Graph 14 Comparison of gutters

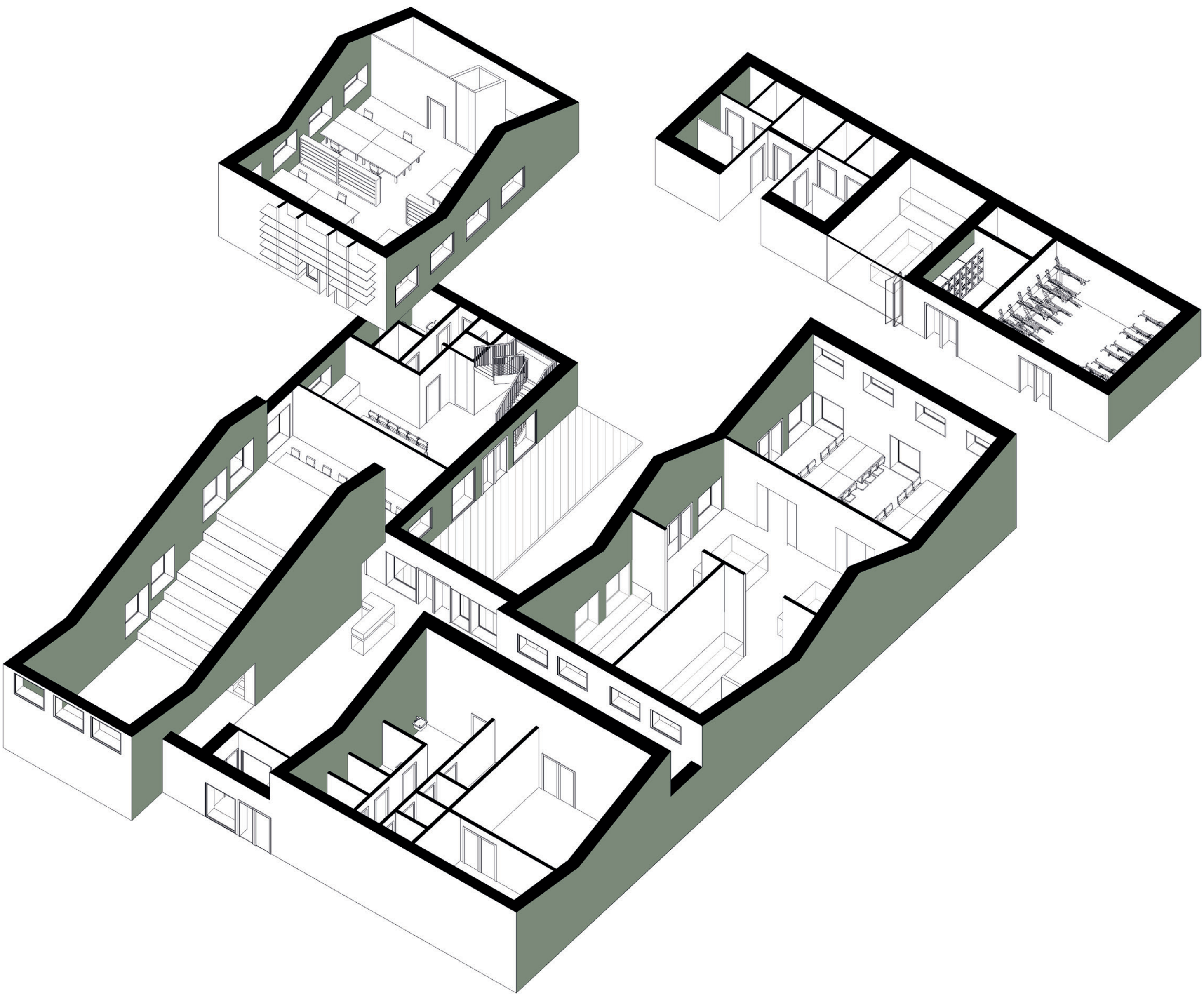


Graphs 15 Investment versus maintainance

Construction

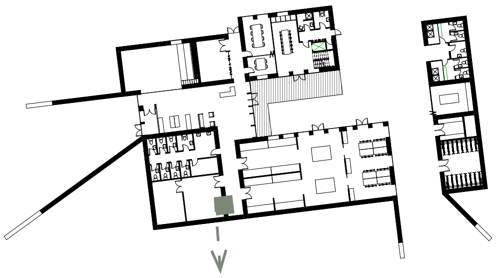
As discussed during the life cycle assessment the need for both an interior and exterior concrete wall where evaluated to be unnecessary. Considering the option with two walls from a constructional perspective it both the interior as well as the exterior wall would have to be load bearing. The interior wall was meant to carry the vertical load from the construction itself and the exterior wall would then have to carry the horizontal load from the sand dune in the areas where it would lean on the wall. This means the lightweight concrete, initial thought of as a façade cladding, would either be reinforced enough to carry this load or be replaced completely with heavyweight concrete. Another option considered for a moment, where a fading wall, with reinforced heavyweight concrete in the bottom, carrying the load from the sand dune, and lightweight concrete in the top. But comparing each of these solutions with reducing the two concrete elements to one, there were more advantages of having one wall carrying the load from both construction and sand dune. First of all the environmental impact where reduced, second the exterior concrete cladding without a function besides being the façade where saved and third the honesty letting people see the construction and the materials of which the building is built, instead of hiding it behind another interior cladding were highly favoured.

The loadbearing walls are shown at illustration 97. The roof elements, carrying the green roof are also made of concrete and rests on the northern and southern walls of the different building units.
With the lowered foyer a critical area arises around the corner where the roof and wall meet. As the exterior concrete façade is continued into the interior space a risk of thermal bridges appears. This have been solved by adding a small layer of insulation to the interior wall, as seen on illustration 98. The wall layers are seen at illustration 99 and the foundation layers are seen at illustration 100.

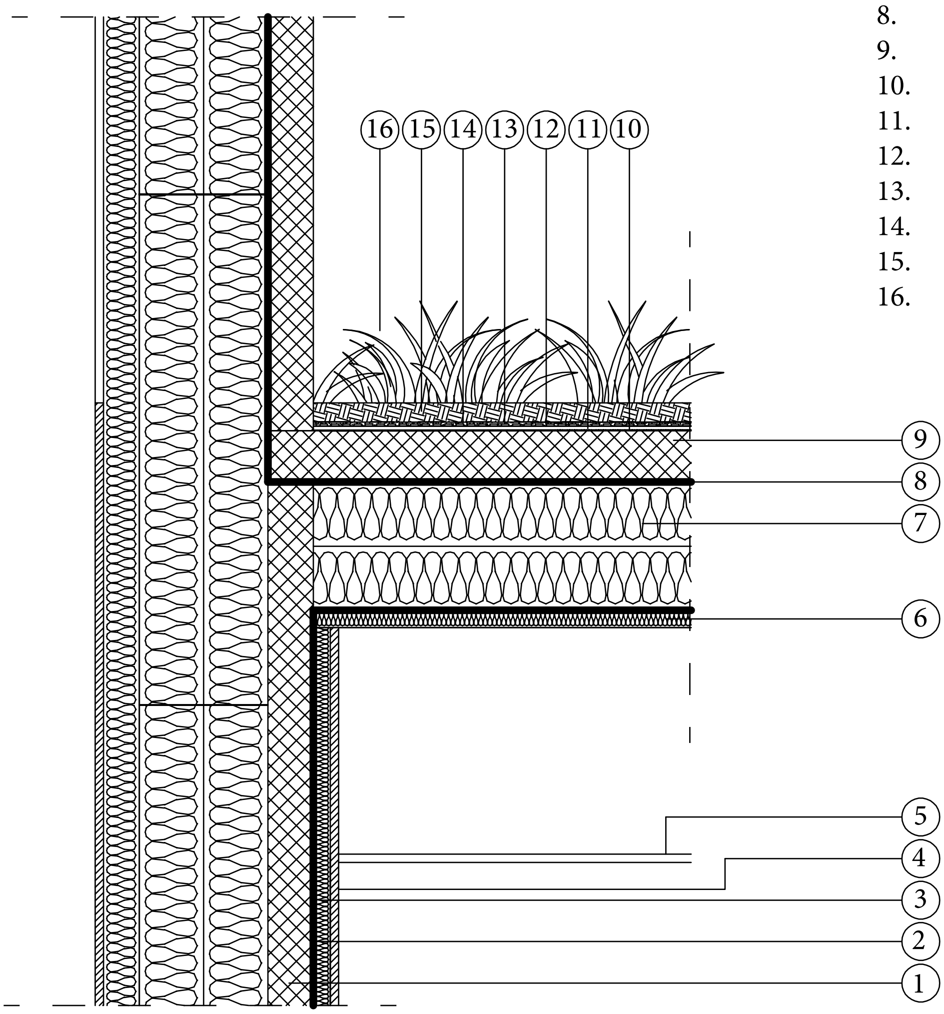


Ill. 97 Construction

Details
Detail 1

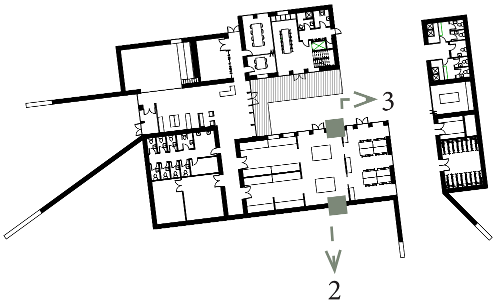


1. Concrete 120 mm
2. Vapour barrier
3. Insulation 45 mm
4. Wooden panel 22 mm
5. Gypsum 22 mm, false ceiling 600 mm
6. Insulation 45 mm
7. Insulation 2x 170 mm
8. Moisture barrier
9. Concrete 135 mm
10. Waterproof membrane 2,5 mm
11. Membrane protection 10 mm
12. Root barrier
13. Drainage layer 10 mm
14. Filter
15. Medium 50 mm
16. Vegetation, lime grass

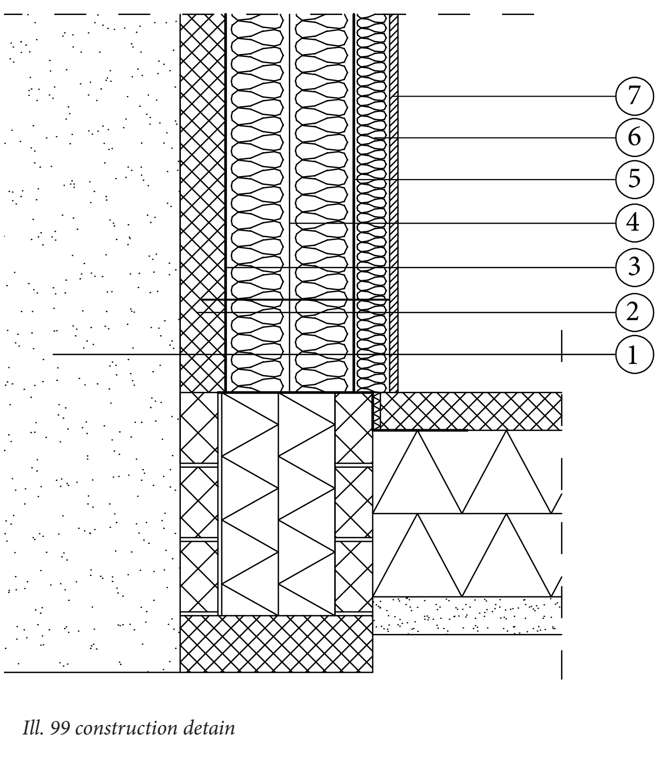


Ill. 98 construction detain

Detail 2



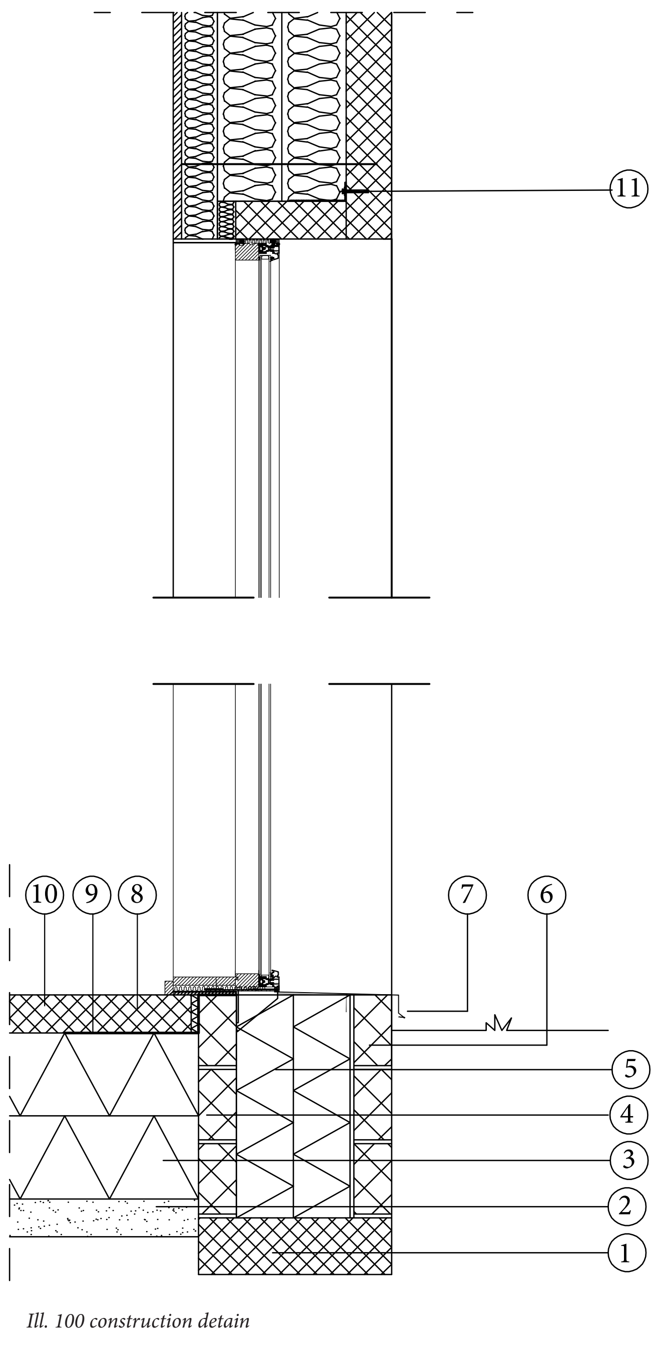
1. Sand dune
2. Concrete 120 mm
3. Moisture barrier
4. Insulation 2x 170 mm
5. Vapour barrier
6. Insulation 95 mm
7. Wooden panel 22 mm



Ill. 99 construction detain

Detail 3

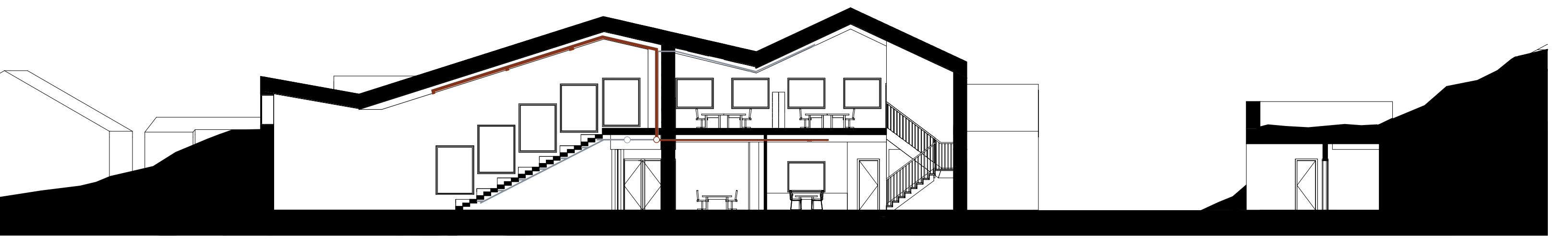
1. Concrete foundation
2. Sand cushion
3. Polystyrene 2x 220 mm
4. Lightweight concrete 100 mm
5. Polystyrene 2x 150 mm
6. Lightweight concrete 100 mm
7. Zinc flashing
8. Insulation 20 mm
9. Moisture barrier
10. Concrete floor 100 mm
11. Brackets



Ill. 100 construction detain

Mechanical ventilation

Ventilation strategy



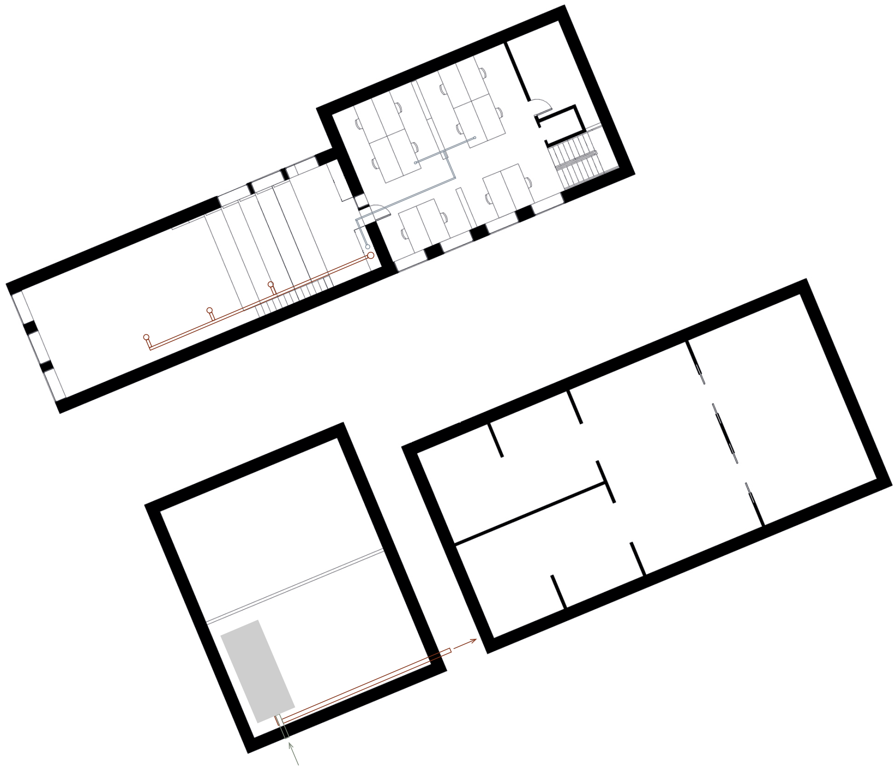
Ill. 100 Mechanical ventilation section, 1:300

As it is not possible to avoid a mechanical ventilation system, the strategy has been to create as simple a system as possible. This means to avoid pipes crossing each other and make the them as short as possible to prevent unnecessary pressure loss. However, due to the different building heights and the movement of ceiling bended pipes have been necessary.

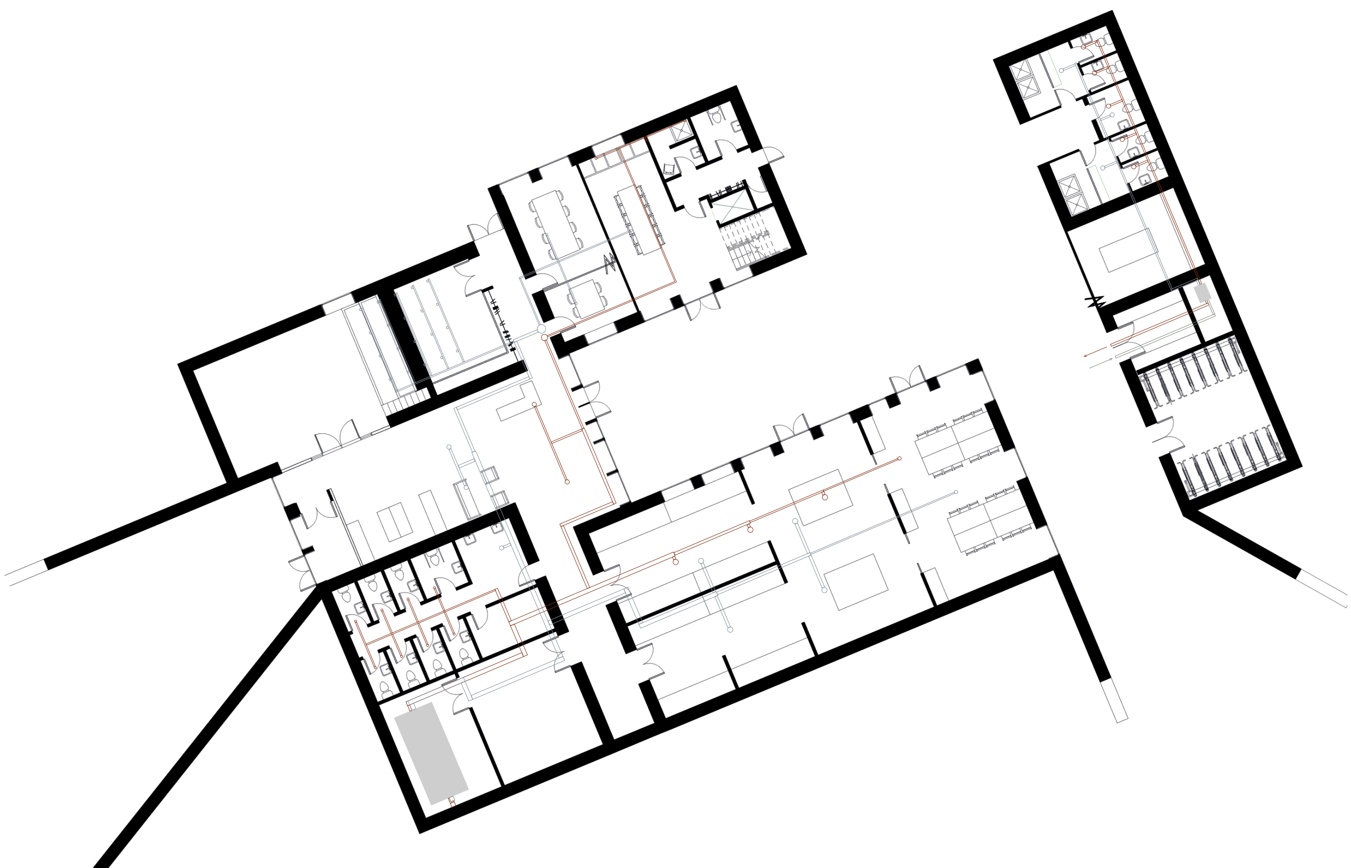
Because of a large variation in the number of people using the different areas of the building, the system relies on a VAV system. The unit is placed in the technical room, in the southwest corner of the building, which is the móst noisy corner of the building, with heard from the road, Hawblink. Assess to the technical room is found through the foyer. In an earlier design proposal, a direct access from Hawblink were planned, but due to the wish of not breaking through the sand dune, to more than the entrances, the location prevented such an assess.

To ensure the correct number of inlet fittings the length of the air flow throw have been calculate. The calculations can be found in appendix 05. The number of inlet and outlet fittings have been calculated with the intension of having as few as possible.
Both disadvantages and advantages can be found when discussing this calculation. The advantages of the having few fittings is the installation time and resources, as well as the material use on each fitting. On the other hand they must be a bit bigger to cover the whole lenth of the room. Furthermore, the same inlet have been used thoughout the whole building. This also contributes to the production, as only one fitting needs to be produced.

1:350



Ill. 101 First floor



Ill. 102 Ground floor

Energy consumption

To achieve the requirements of Building Regulation 18 (Br18), and confirm if the centre follows the requirements, the simulation tool Be18 has been implemented. Be18 allow us to detect the energy consumption of the building.

Parameters, as the roof and walls and the windows, have shown to have a significant influence of the energy demand of the building and all of them had a role in the development of our centre.

The construction of the wall and roof influenced the heat-loss and the solar heat transmission. The u-value started at 1,2 W/m²K due to the desire of a thin wall, but calculations in Be18 and simulations in BSim indicated a substantial heat-loss and therefore the walls was formed to have a u-value of 0,09 W/m²K to accommodate the heat-loss (Ill. 132, Appendix 03).

A second element that had a vital impact on the consumption was the placement, orientation, size and properties of the windows. The windows were initially placed in accordance to the initial analysis and concept, and hereafter evaluated in Be18 and BSim.

The size of the openings in the windows and an improvement in natural ventilation indicated to have an impact on decrease of the overheating. The size and amount of the windows did affect the consumption, so a reduce of size and amount was made, but the consumption was still above the acceptable value (Ill. 132, Appendix 03)

In the initial phase of the project we had agreed that we would avoid having shading if possible, and therefore seek other solutions to overcome the direct solar transmittance. To further minimize the temperature and overcome the problem of overheat the solar transmittance had to be reduced. The g-value of the windows have a major influence on the decrease of overheating in the summer, but it also have an impact on the luminous transmittance and the thermal transmission(u-value). The increase in the u-value comes in our favour in the winter, but the decrease in luminous had to be tested and overlooked in Velux to document an adequate daylight in the different rooms. The change of the g-value and reorientation of windows according to a small redesign, contributed to reaching a low energy building (Ill. 104)

Initial building

Key numbers, kWh/m² year

Energy frame BR 2018

Without amendment	Amendment for special conditions	Total energy frame
42,5	1,6	44,1
Total energy rewuerement		110,2

Energy frame low energy

Without amendment	Amendment for special conditions	Total energy frame
33,0	1,6	34,6
Total energy rewuerement		110,2

Contribution to energy requirement

Heat	106,7
El. for operation of building	10,3
Excessive in rooms	0,0

Net requirement

Room heating	105,7
Domestic hot water	0,0
Cooling	0,0

Ill. 103 Be18 initial building

Change of g-value & orientation

Key numbers, kWh/m² year

Energy frame BR 2018

Without amendment	Amendment for special conditions	Total energy frame
42,5	1,6	44,1
Total energy rewuerement		31,3

Energy frame low energy

Without amendment	Amendment for special conditions	Total energy frame
33,0	1,6	34,6
Total energy rewuerement		31,3

Contribution to energy requirement

Heat	18,6
El. for operation of building	8,1
Excessive in rooms	0,0

Net requirement

WitRoom heating	17,7
Domestic hot water	5,2
Cooling	0,0

Ill. 104 Be18 Final building

Subconclusion

The two phases – sketching and synthesis – have merged together during the iterative design process. Starting with handmade drawing systematically separated into categories an idea slowly started to take form. From the start access points and climate conditions as wind and sun influenced the design a lot. From the beginning of the project the wish was to preserve, and work integrated with the sand dune on the site. However, at some points it seemed very difficult to maintain a proper relationship between the sand dune and building because the site is so narrow.
Based on the need for adequate daylight a dense volume did not work, and the courtyard was formed creating a wind shielded outdoor area, resulting in enhanced daylight conditions on the interior of the building.
Based on the movement towards and through the site two passages are create on the site catching the people passing by. Many evaluations have supported this process, when in doubt, to ensure the right track was kept. This also includes the placement of the building which was evaluated to ensure the relation between the building and sand dune. The strongest relationship was achieved by placing the building in the northern part of the site.

On the sideline of this, discussions about placement and plan layout, the indoor conditions have been influenced by the wish of having natural ventilation for as long a period as possible. Originally it the wish were only to have natural ventilation all year around, but it was quickly realised, though BSim and Be18 investigations, that having natural ventilation all year around would result in a very big heat loss. This means the indoor temperatures drops to temperature beneath 20 degrees and it is not possible to maintain a stable temperature of approximately 21 degrees as mentioned earlier in the analysis phase. This also means heating must be added thoughout the winter period resulting in a large energy consumption.
Therefore, a compromise has been made and natural ventilation is applied from April to October and hereafter supplied with mechanical ventilation.

Furthermore, the movement of the building on the site have been influencing the window placement. The windows are both responsible for having adequate daylight conditions and natural ventilation conditions. Initially the natural ventilation was forced by wind pressure in the exhibition area moving though the room but closing the dune on the southern side of the building it prevented having cross ventilation. Adding windows to the top of the building walls then made thermal buoyancy possible and thereby ensuring adequate air change.

The material evaluation in addition to the life cycle assessment and life cycle costing have resulted in concrete as the main material. The concrete was favoured based on its ability to withstand the pressure from the sand dune. Though wood would have had a better result on the life cycle assessment, it was rejected as a constructional material due to the load carrying capacity and its lifespan in the hard climate. Therefore, an assessment between two different concrete casting methods were made. The precast method performed slightly better than the in-situ cast method and is therefore used as a main construction material for both walls and roof.

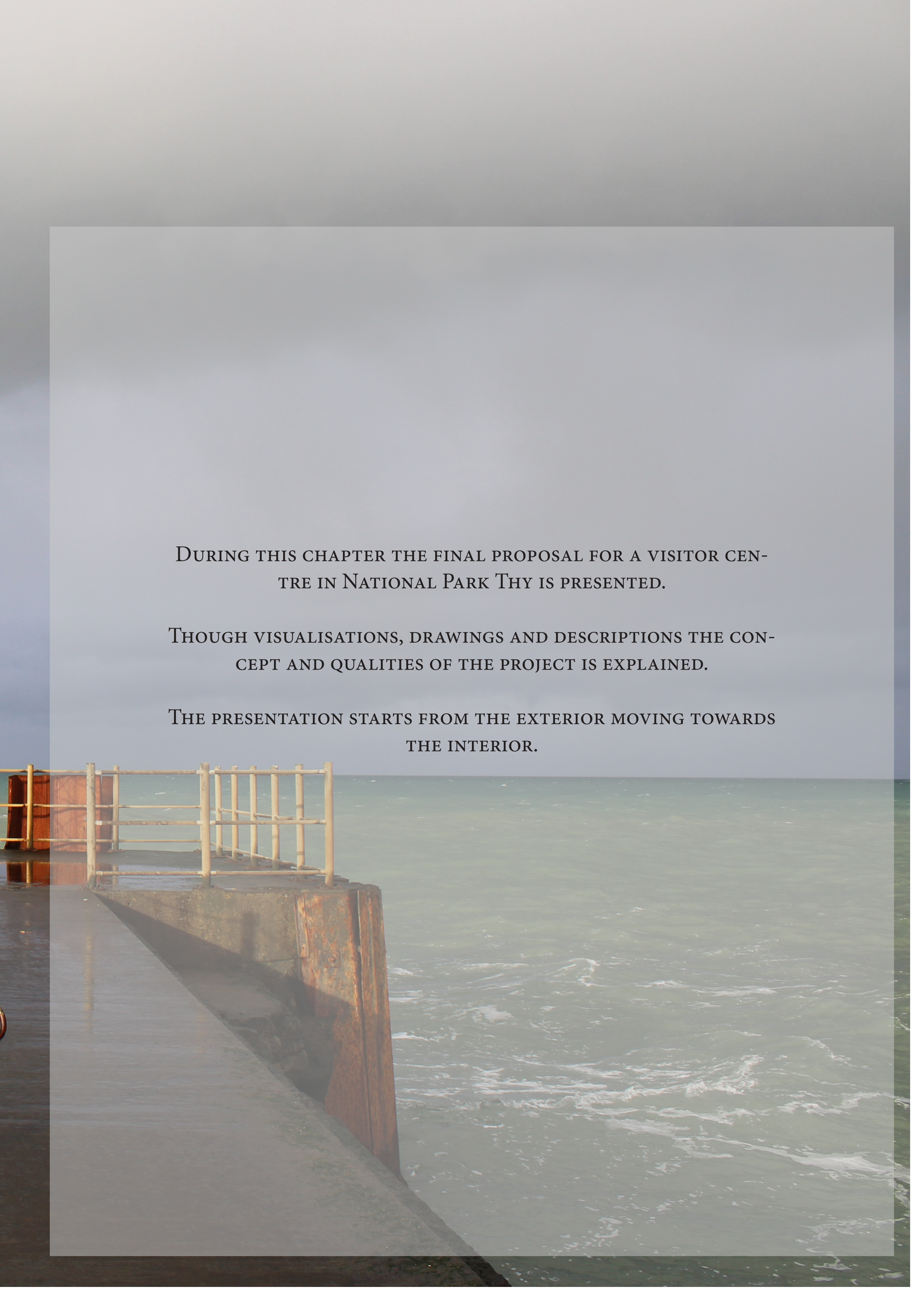
Like the earlier design stages the roof have been evaluated in relation to different parameters. Especially the relation between the town and the landscape have been greatly discussed. With a concrete façade the building already stands out in the context, though partially covered by the sand dune. Therefore, it has been a balance of how much it should stand out. In the end an interpretation of the pitched roof has been chosen as it stands out, but have a relation to the town, as well as it is possible to form the roof in the lines of the context.

The mechanical ventilation is very much influenced by the shape of the roof. Due to the wish of maintaining the shape on the interior. On the other hand the number of fittings have been reduced as much as possible to save the installation time and material used for each fitting.

Ill. 105 Klitmøller

Presentation

Ill. 106 Breakwater in Nørre Vorupør

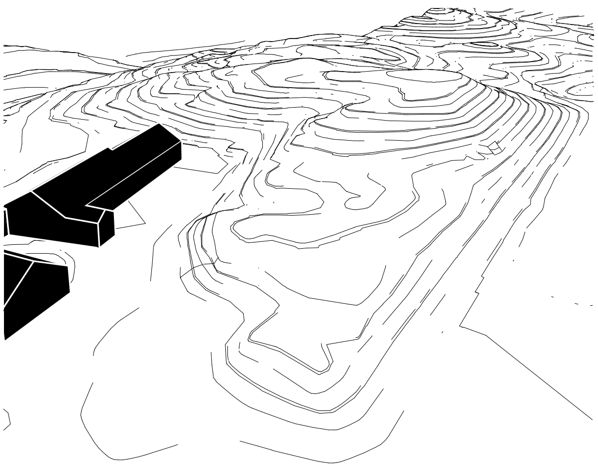


During this chapter the final proposal for a visitor centre in National Park Thy is presented.

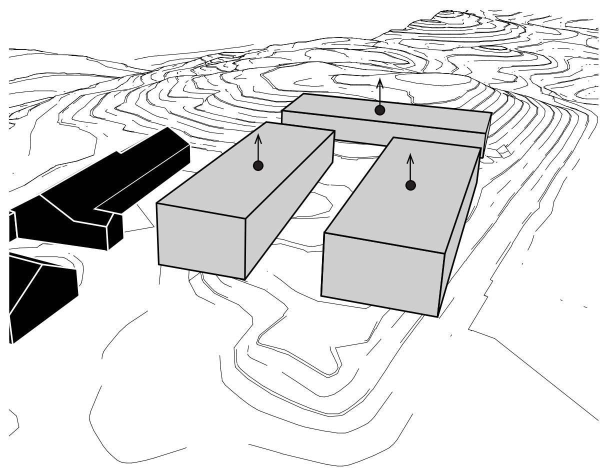
Though visualisations, drawings and descriptions the concept and qualities of the project is explained.

The presentation starts from the exterior moving towards the interior.

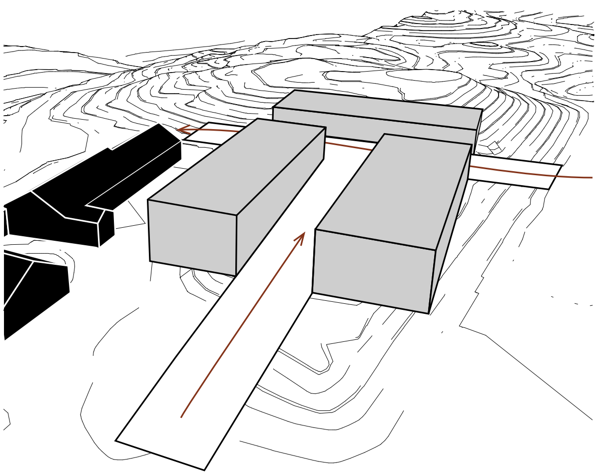
Concept



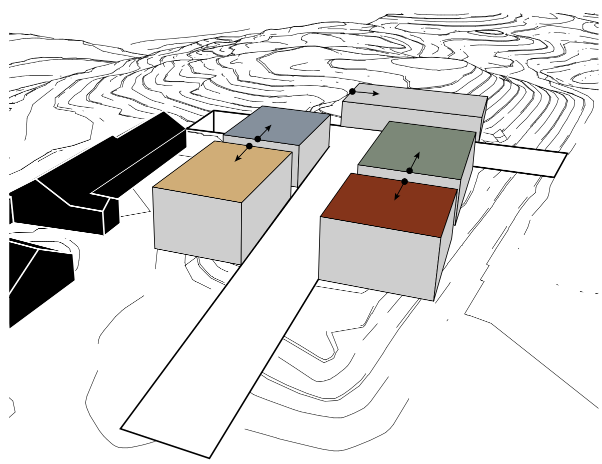
1. The sand dune before the intervention



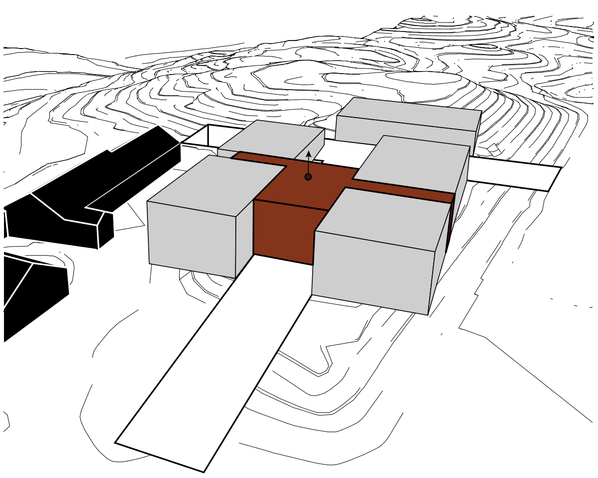
2. Extrusion of volumes



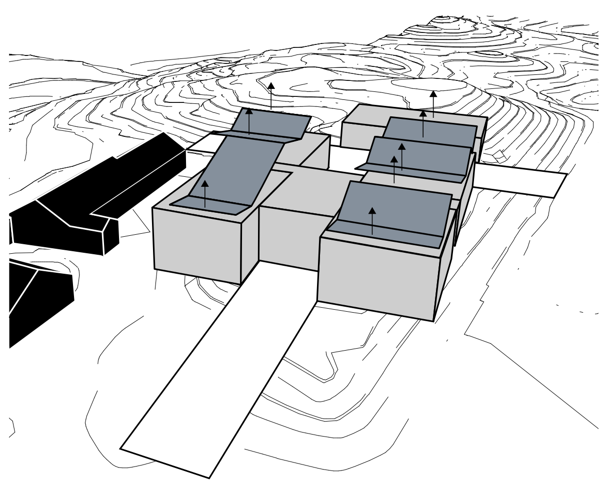
3. Arrangement of accesses



4. Separation of volumes according to functions



5. Connecting the volumnes with centralized volume



6. Forming the roof

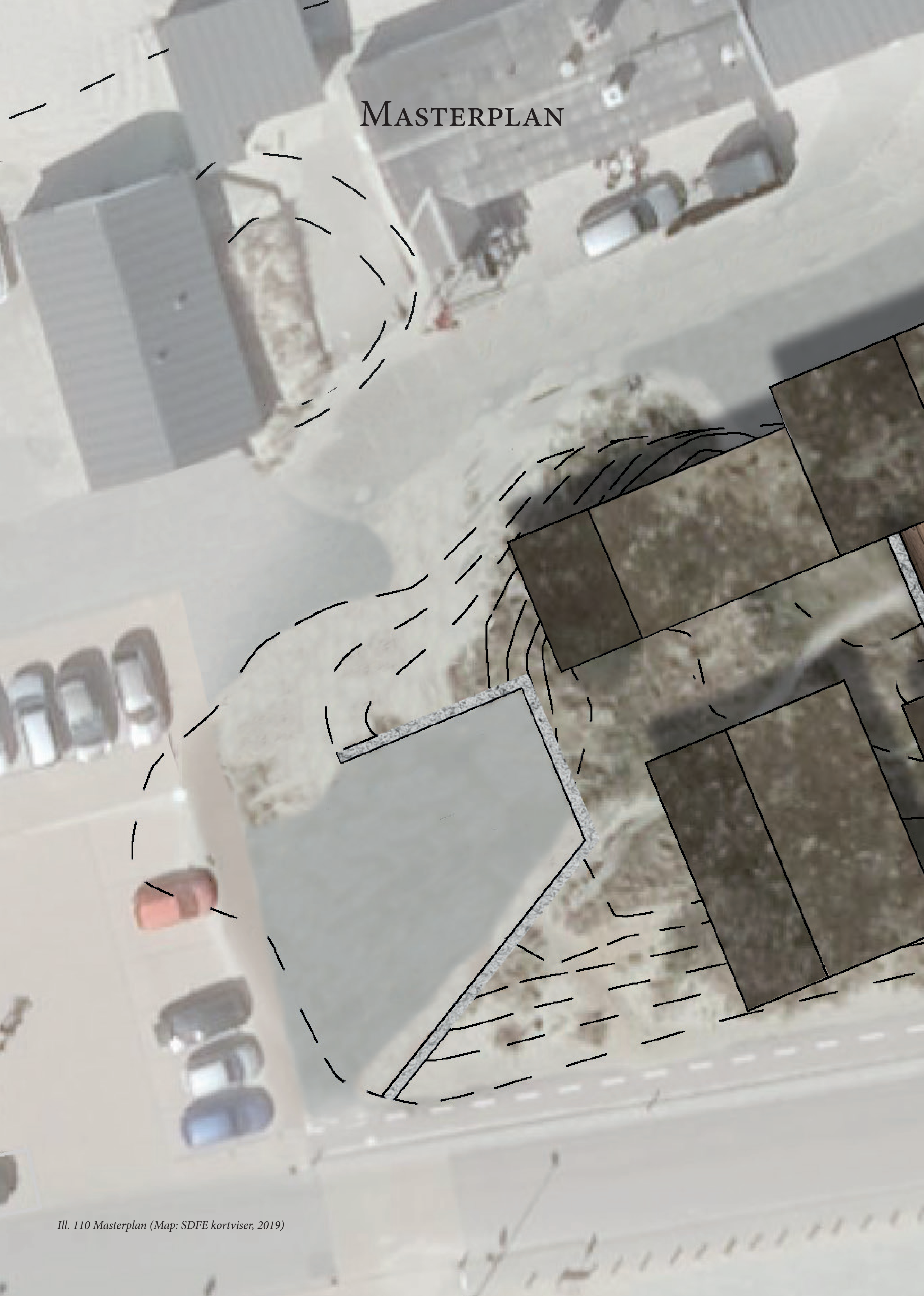
Ill. 107 Concept

Ill. 108

Entrance


Ill. 109 Approaching the site

Masterplan

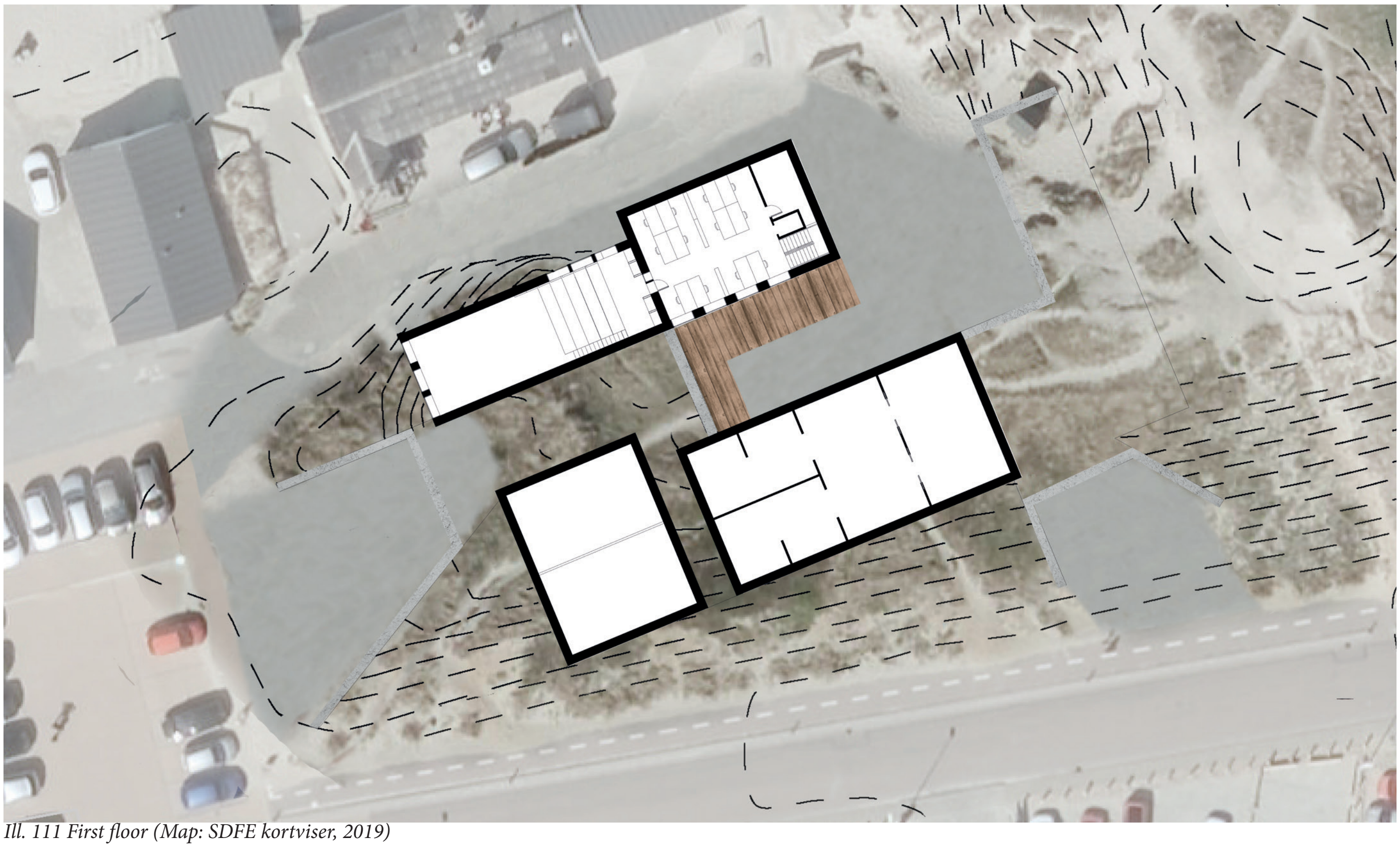


Ill. 110 Masterplan (Map: SDFE kortviser, 2019)

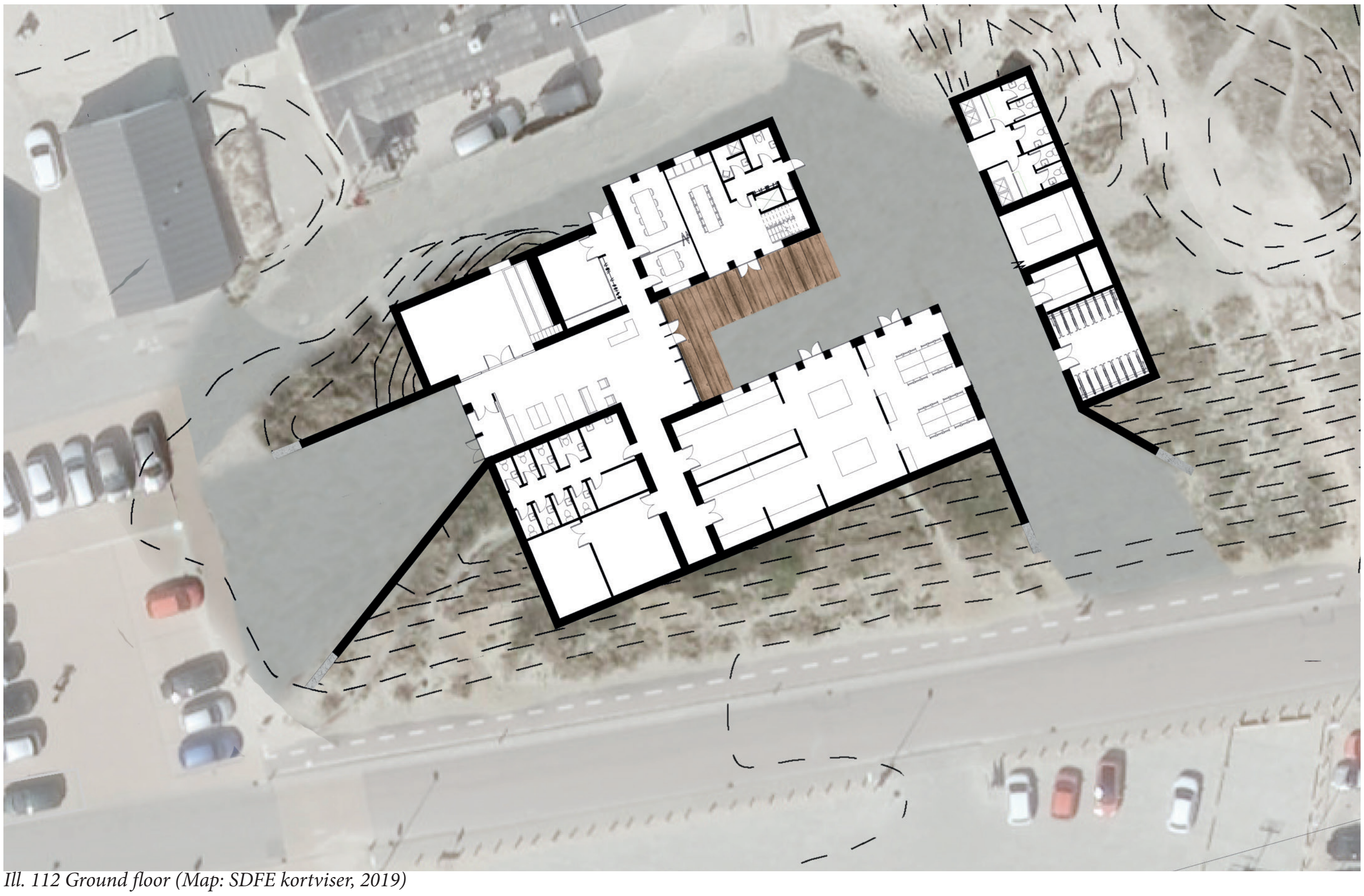

1:200

Plans

1:500



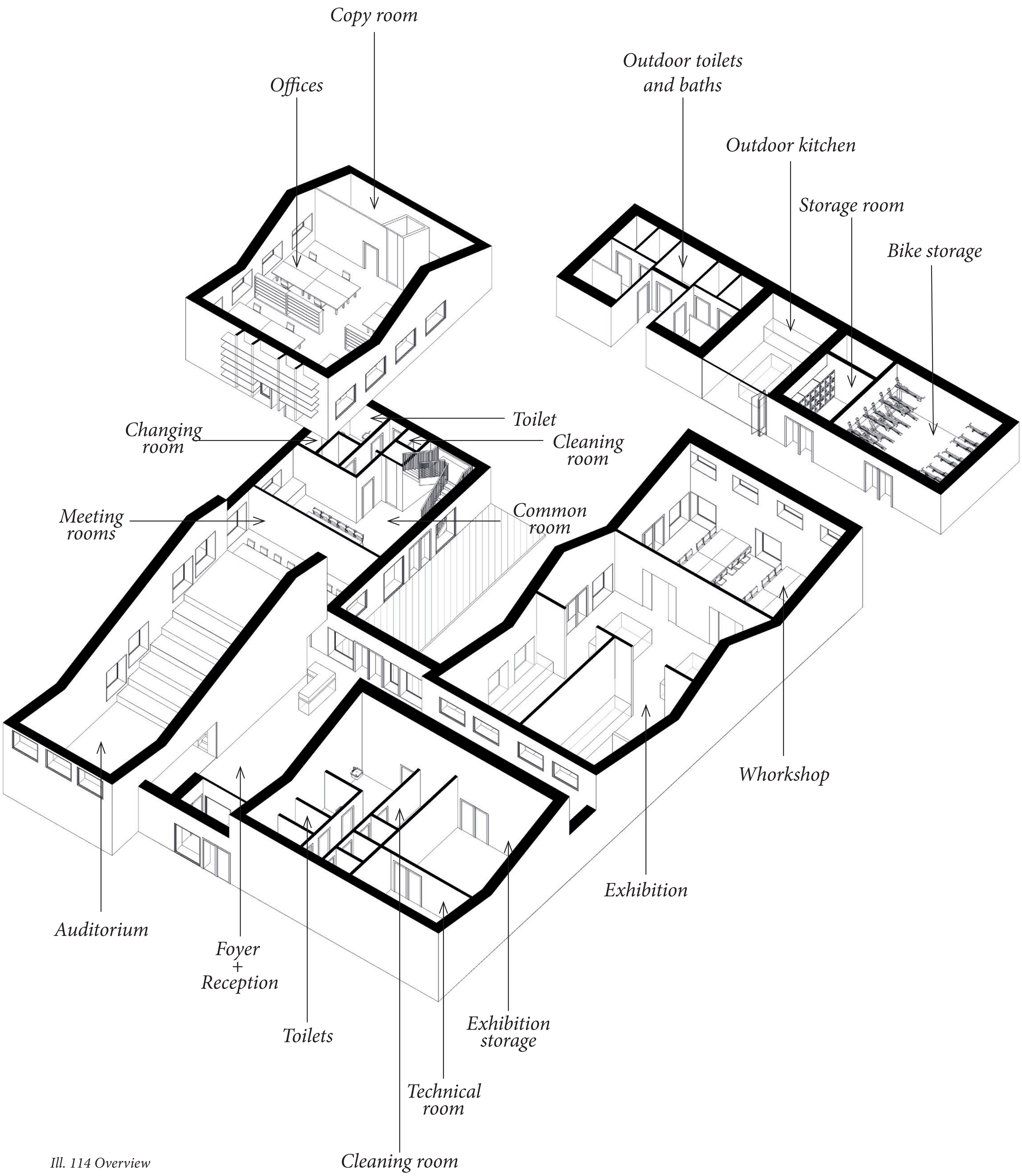
Ill. 111 First floor (Map: SDFE kortviser, 2019)



Ill. 112 Ground floor (Map: SDFE kortviser, 2019)

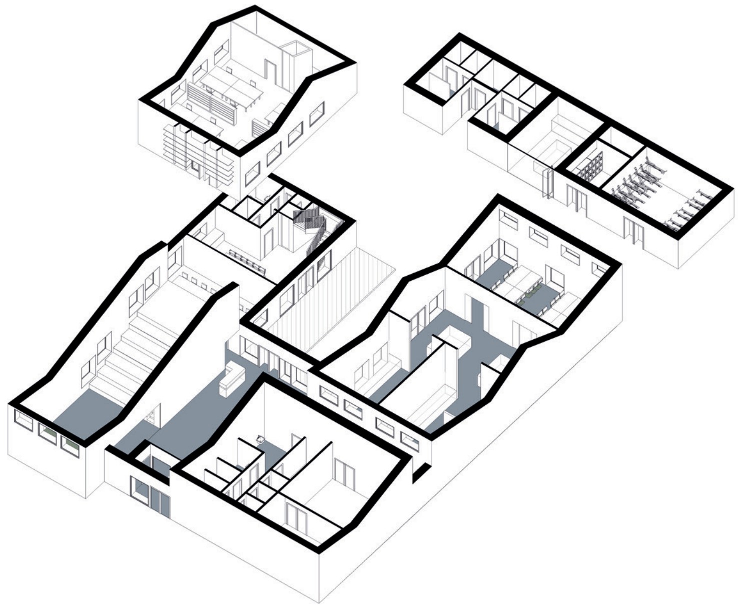
Ill. 113 Auditorium

Overview

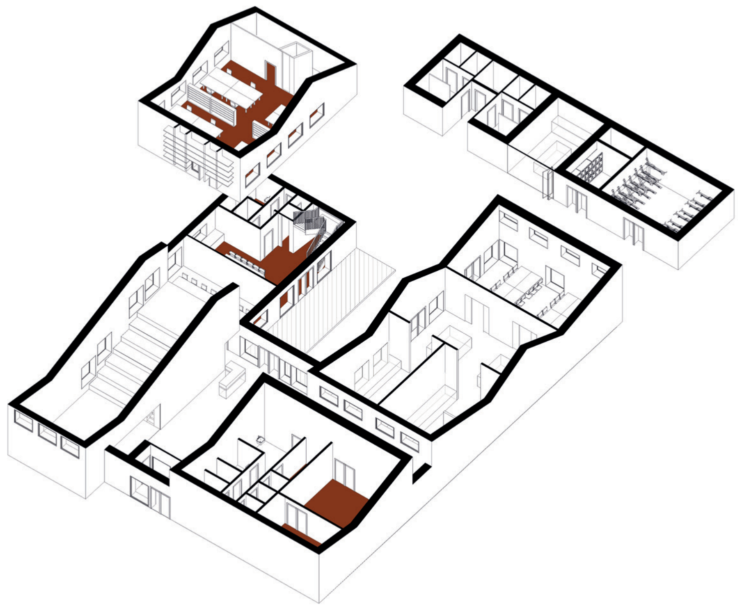


Ill. 114 Overview

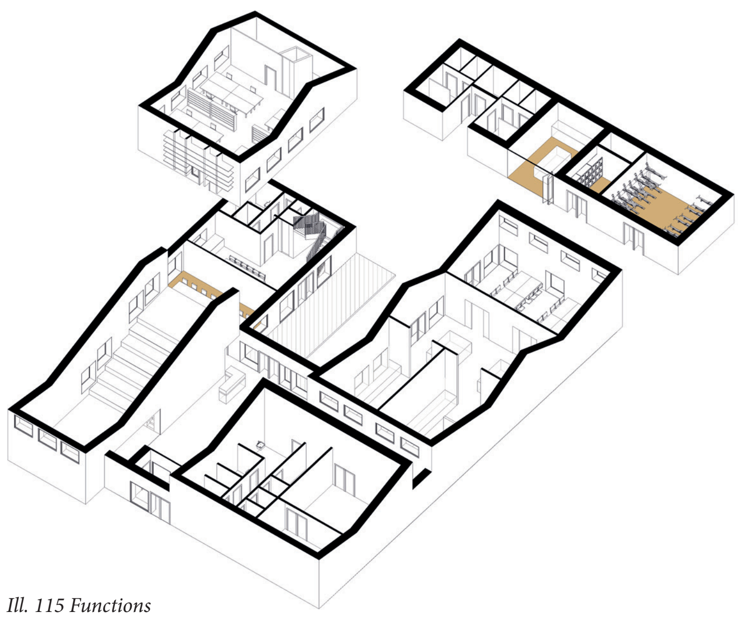
Public functions
The public functions include : Foyer, auditorium, indoor and outdoor toilets and baths, as well as the exhibition and workshop.
The functions are placed diagonally in the building to ensure movement and activity throughout the centre. The first room people enters is the foyer and recepion. Here it is possible to meet and talk with nature guides or volunteers to get information about the national park. From here there is also very easy access to the outdoor functions on the eastern side of the building
All rooms are very flexible in the layout e.g. it is possible to accomondate approximately 50 people on the stair in the auditorium, but there is room for adding another 50 chairs on the floor in case of leactures, information before a bus trip to the national park, and the like. Likewise, is the exhibition. At this moment seperation of the room have been proposed, but as the outer walls is the carrying walls, it is poosible to move the interior walls around.



Private functions
The private functions mostly include the staff facilities: Office, common room, changing facilities and a private wardrobe. It have been important to place the private functions in the most quiet area of the building, because the staff is a central part of the centre. Opposite visitors who only stay for a short period, the staff comes to work every day and therefore needs the most optimal work environment.
Though they have been placed at the first floor there is easy access through the auditorium to the foyer. In this way, they are connected to the everyday life of the center, however shielded from most of the noices.
The technical room and storage have been placed diagonally to the staff, in the most noicy spot on the site. It is facing the road where many cars pass by during the day in the summertime. At the same it is placed close to the exhibition which makes it easy to change and more exhibition material back anf forth when needed.



Semi-public functions
This category includes functions ith different purposes. Basicly the functions are not possible to access, as a visitor, without a staff member. This especially apply to the bike storage, which visitors can rent. The outdoor kitchen is imagined to be open during the opening hours of the centre, so people is able to wash their hands after entering the national park or just to get a drink on a warm day. However, when e.g. local hunting or school cources are running they are able to borrow the outdoor kitchen for educational use.
Similarly is the meeting rooms placed close to the foyer. Unless the staff uses the functions it would be open during the opening hours as well. Here it would be possible to settle down and immerse oneself in a book.
Outside opening hours it will be possible for local residents and associations to borrow the rooms for meetings.

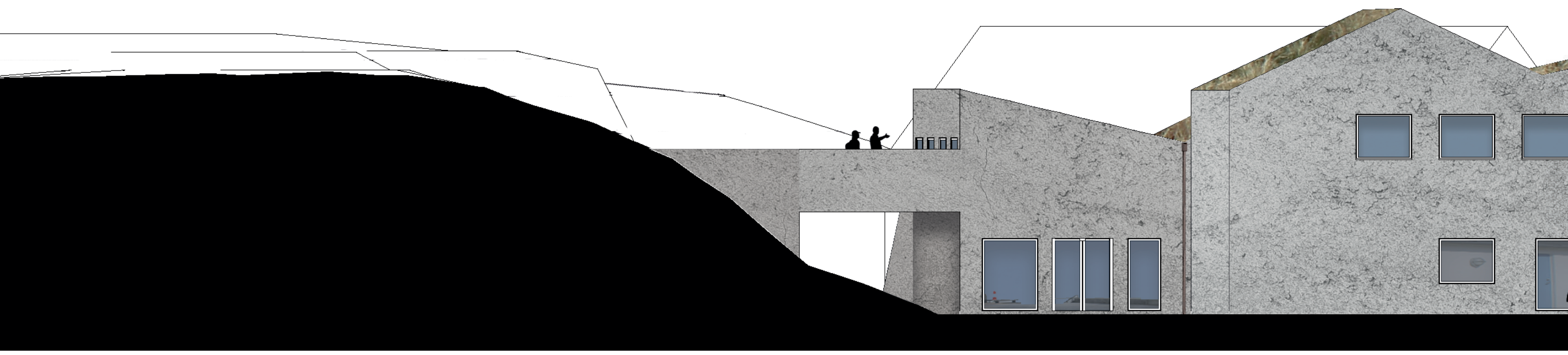


Ill. 115 Functions

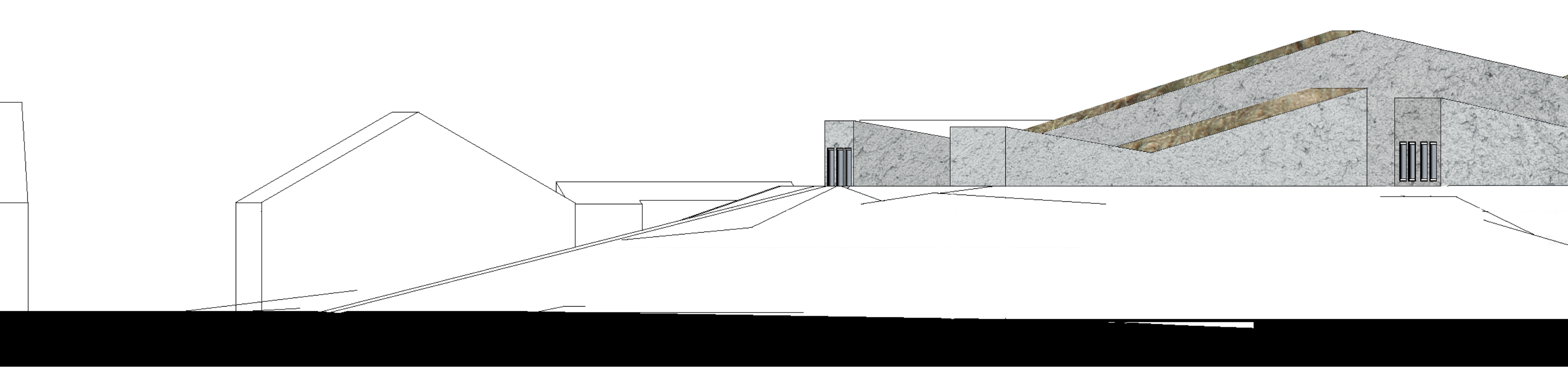
AUDITORIUM

Ill. 116 Auditorium

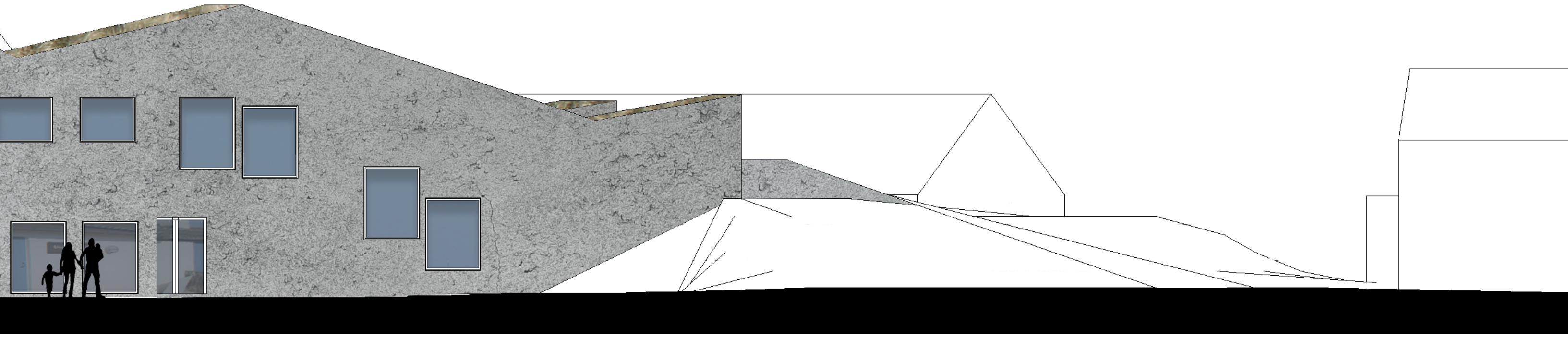
Elevations

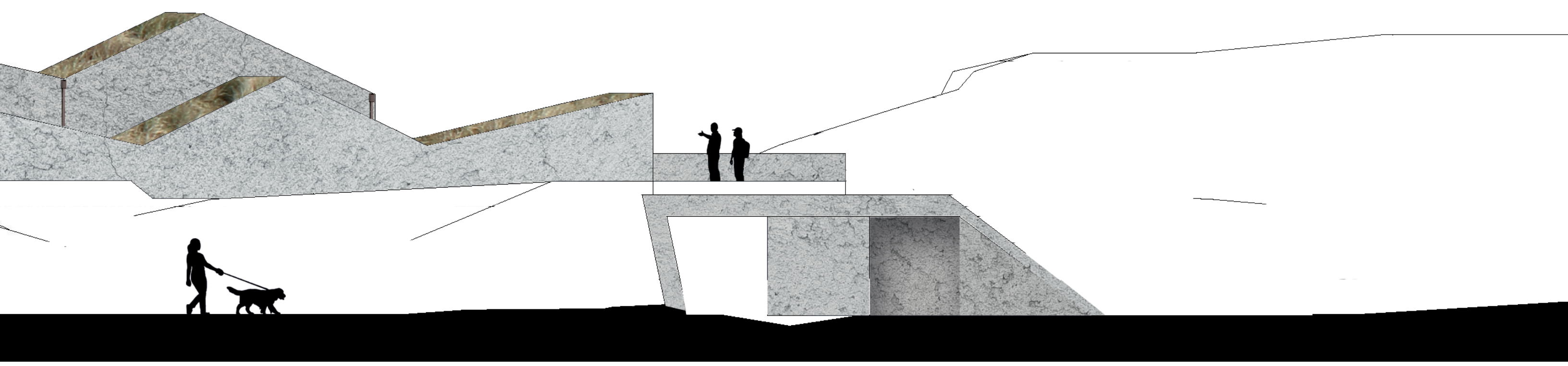


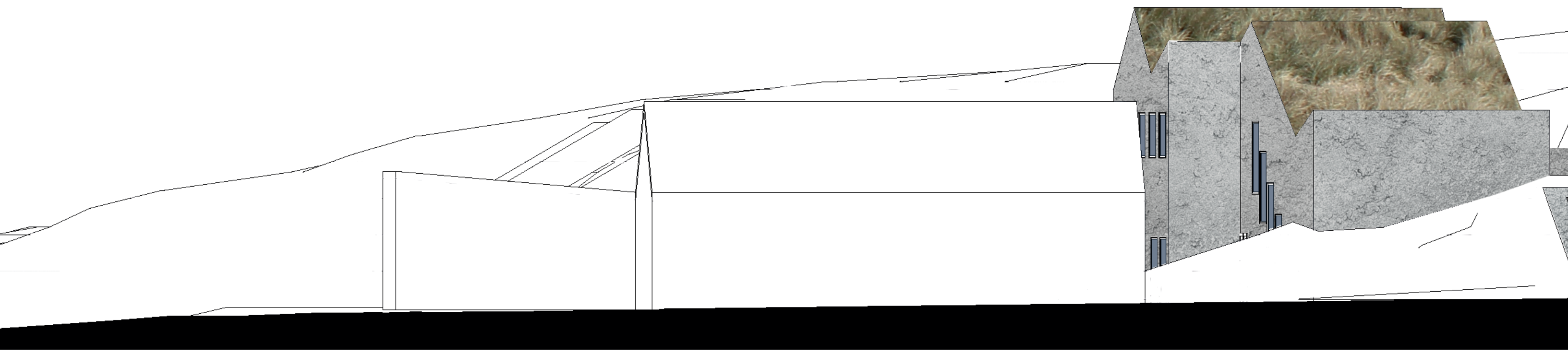
Ill. 117 North elevation, 1:200



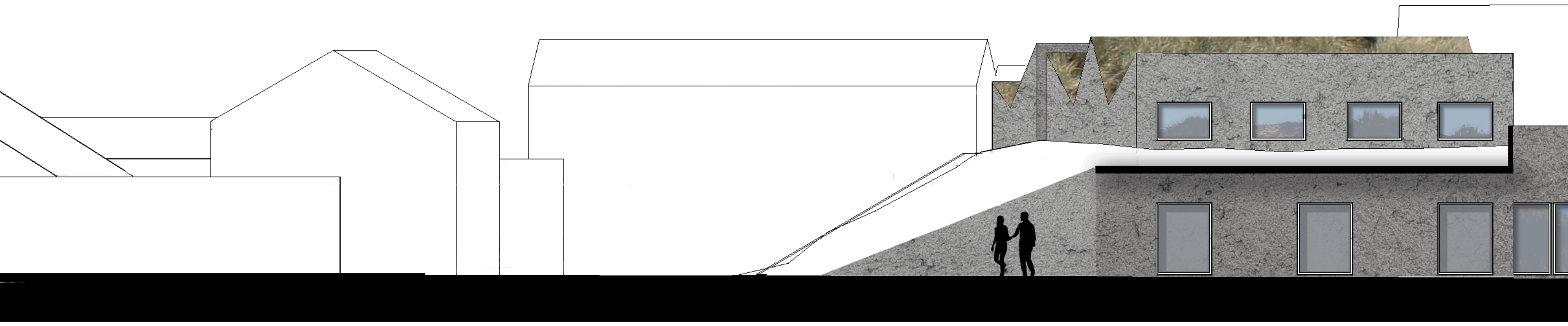
Ill. 118 South elevation, 1:200



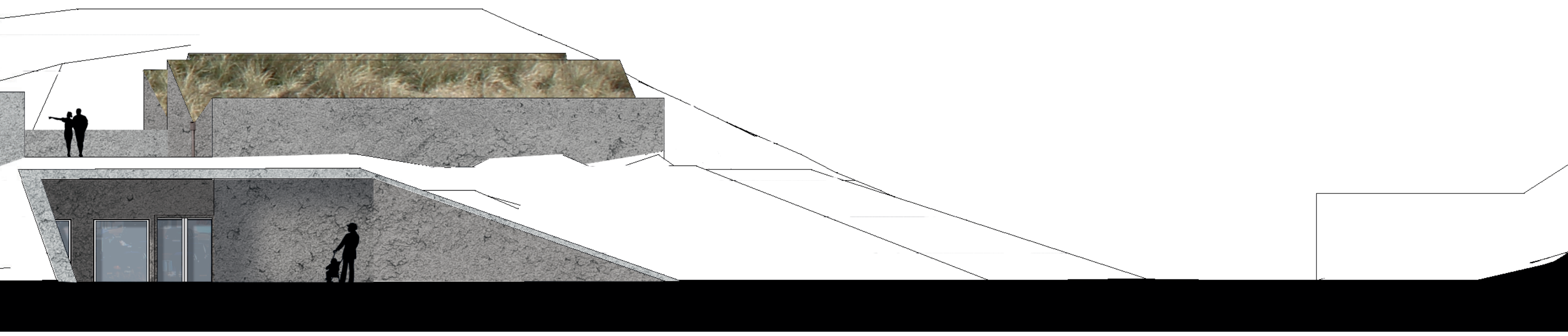


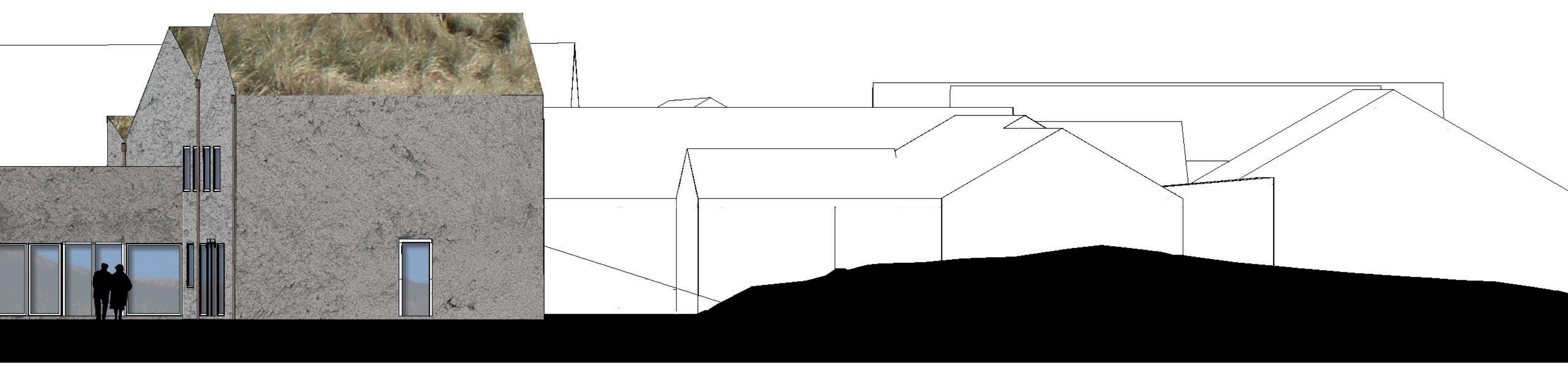


Ill. 119 West elevation, 1:200



Ill. 120 East elevation

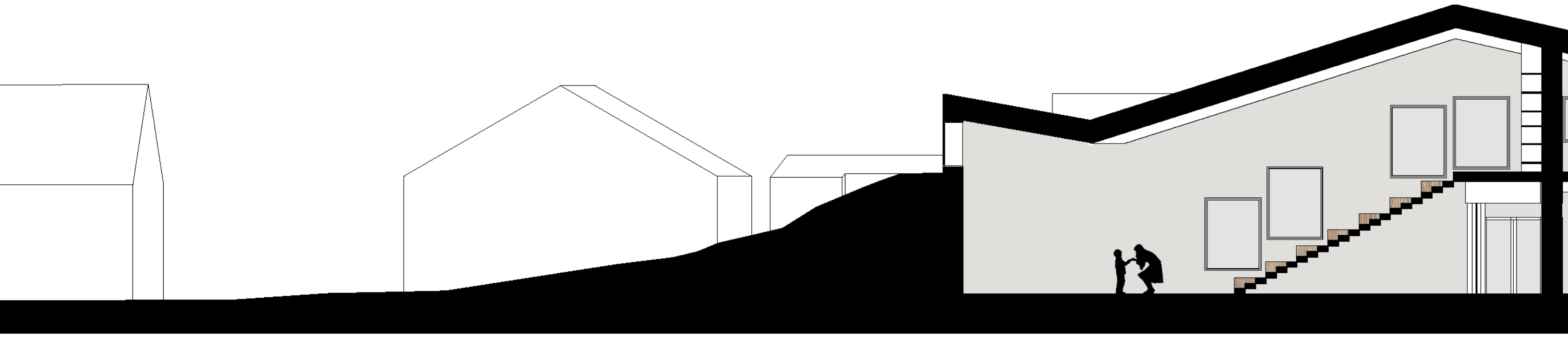


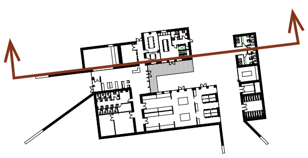


Ill. 121 Workshop

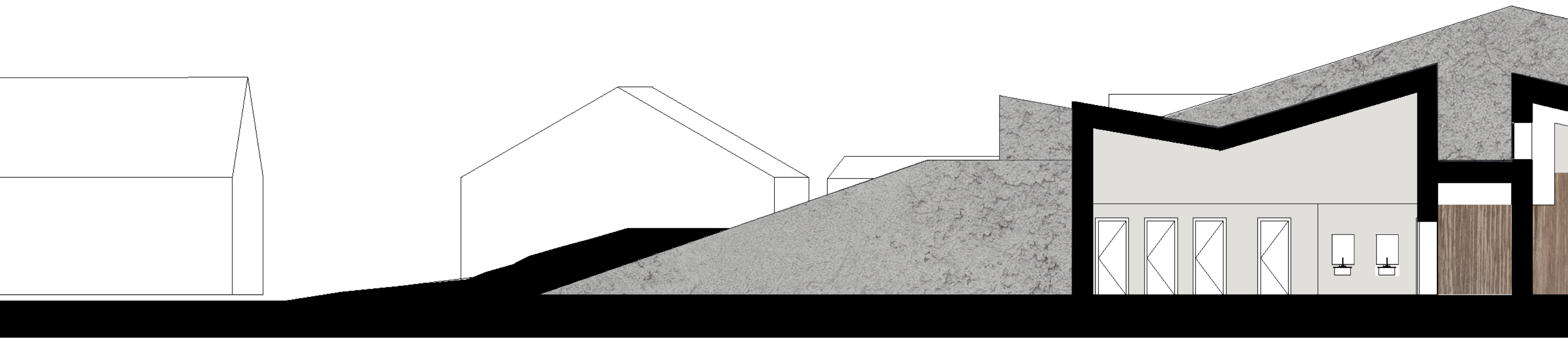
Sections

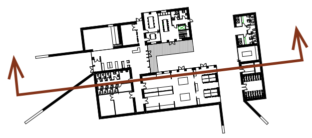
1:200



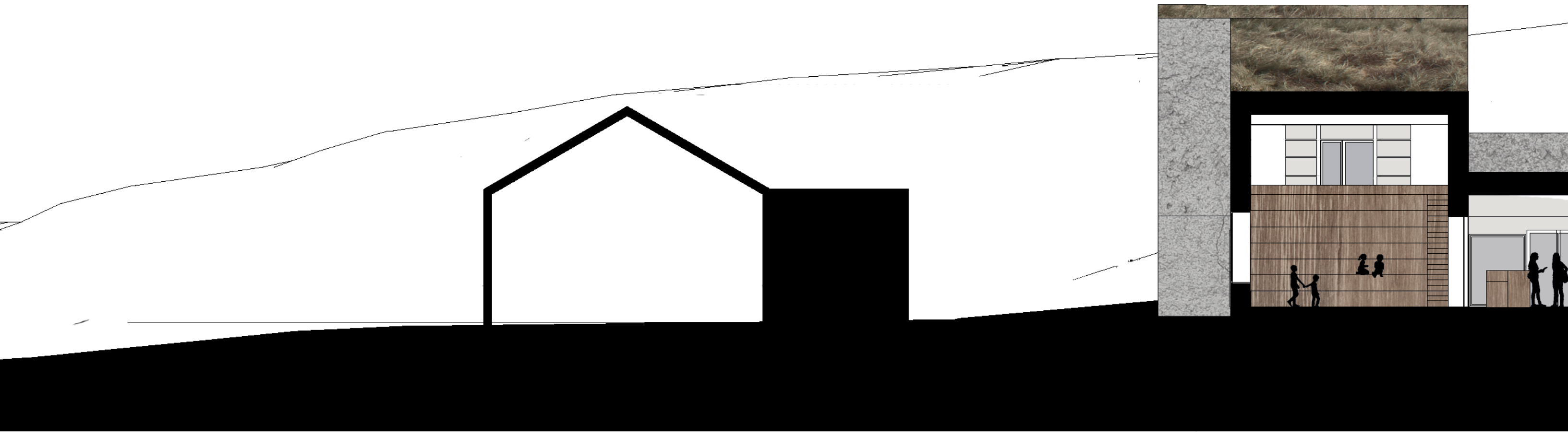


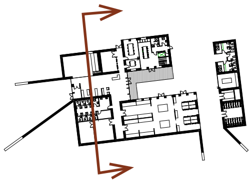
Ill. 122 Section AA



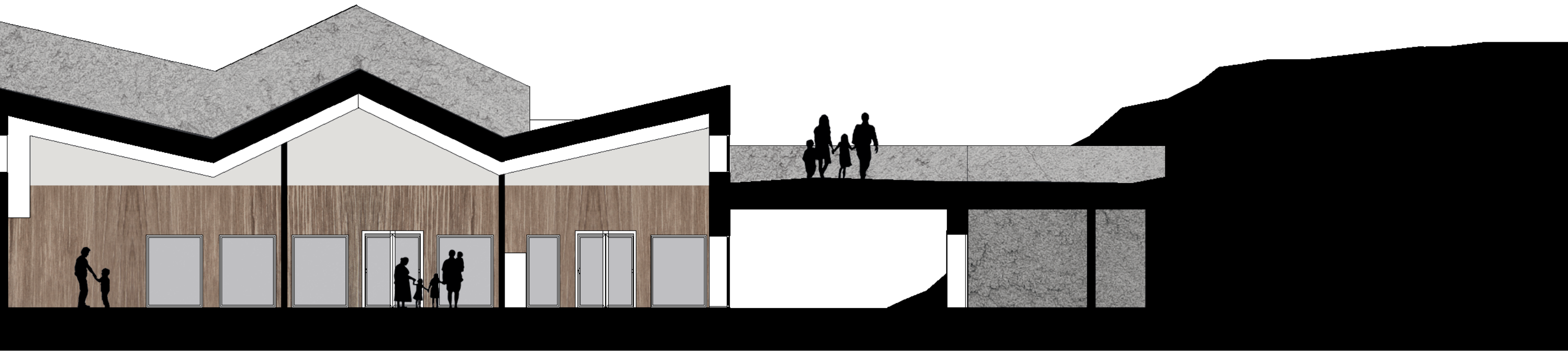


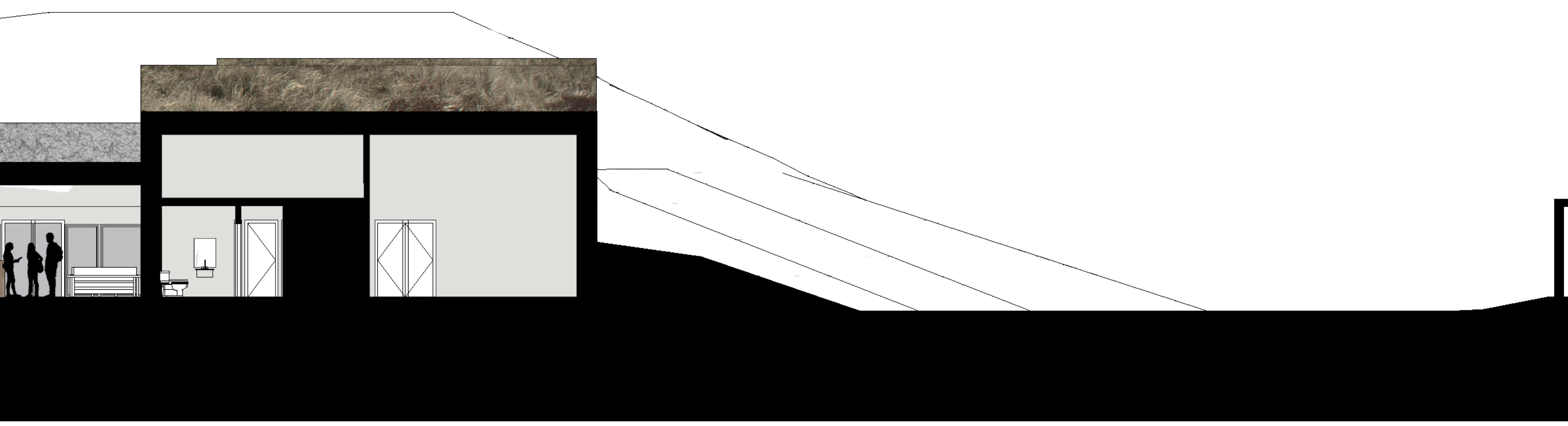
Ill. 123 Section BB





Ill. 124 Section CC





Epilogue

Ill. 125 View from the site

Conclusion

With the focus on developing a centre that functions as a steppingstone to the national park thy and aim to ensure an optimal indoor environment that support the vision of low-tech solutions, have we formed our solution of a centre located at Nørre Vorupør.
The project initiated a lot of restriction and demands of the site. To accommodate the local plan of the area, multiple requirements had to be followed. The site itself is narrow and situated longitudinal the protected park, thus the strict restriction and a main criterion of not exciting the chosen site. To accommodate the vision and communicate the sense of responsibility towards protecting the nature and cultural heritage the importance of implementing the sand dune had been a crucial criteria. The dune claps the centre and form an enclosure around the form as it becomes a part of the national park. The centre erupts from the sand dune and display an interpretation of the original typology found along the national park. The double pitched roof does resonate in the local style of building at Nørre Vorupør. The material embellish the centre, physical connects to the concrete that joins the beach to the dune. The implementation of concrete distinguishes the building from the simple and homogeneous limewashed facades around the site and makes it recognisable for unfamiliar visitors at the site. The mobility has had a significant influence on the form and the adapting of the dune, due to the "cow path" that runs across the sand dune, from Havblink to the water have formed a significant impact on the final concept.
The two focal point from the west and east allows a direct transition from the parking lot, bus stop and bike parking to the centre. The separation of the volumes form a half closed courtyard that promote a protected area and allow local, cultural and nature related events to form outside. The functions that are close connected to the outdoor activities are all placed in close relation to the path that runs from Havblink to the water.
An important criterion for the centre has been to create a place that orientates towards the local and accommodate the different actors. The centre allow private and public organisations to take use of the house outside the opening hours. The inner layout of the centre does reflect a logical distribution to the different functions of the centre. The functions that are public accessible, are all situated in their own volume and can therefore be locked independently.

Reflection

Looking back at the process of the project many aspects have been considered. Especially the relation between the sand dune, building shape and roof have been the cause of many frustrations at times. The fact that the building has no backside seemed to be solved when implementing the courtyard and the passage through the site seemed for a long time as a good idea as it accommodates how people move through the site and create a more fluent movement around the building. However, the passage cuts off the building and the sand spit from the rest of the dune heath and the landscape of the national park as well as the many entrances for a period also slit the rest of the sand dune into smaller pieces which seemed very random. The passage still stands as a strong element of the project and the connection of the sand dune have been preserved on the first floor where it gives people the opportunity to walk across it and moving in and out through the building units.

This leads to yet another challenge in the project – the roof. For a long period, the wish was to reflect the town through the town's dominant pitched roof. Many shapes, sizes and interpretations have been made, but for a long period of time it each volume seemed disconnected to each other and to the rest of the building as well. When the decision was made to let people walk on the sand dune alongside of the building, we wanted to prevent people from crawling up the roof. This resulted in the final proposal. By changing the position of the pitch of the roof leaving the high side at each end made it possible to prevent an enormous and out of proportion roof height. Though the final suggestion lowers the roof height and prevent people from climbing it, discussions are still going on whether the displacement is an advantage for the building or not, because it seems slightly aggressive with the high ends also leaving a challenge with the ventilation pipes on the inside. On the other hand, seeing the building in the context, the roof shape alone might not seem so foreign anyway.

Another focus, which have made us realise that a completely sustainable building is difficult to reach without the compromises. First, the dune made it necessary to choose concrete as a constructional material, at it is the most suitable for carrying the load. But seen in the context of a life cycle assessment concrete will always perform worse than e.g. wood. But if every decision were to be made as the most technical beneficial, we would only build one type of building made from wood.

At last, and in relation to the above, the most energy optimal solution might not always be the best solution. The aim from the beginning were to reach the building regulations energy demands of 2018 and not a zero-energy building, because this would demand active solutions in addition to the passive. However, trying to reach the low energy demand would need further changes of e.g. u-value, to an already well performing building, just to make it perform even better – or is it better? Because lowering the u-value making the walls insulate better, also prevents the building from breathing and the risk of overheating and too high CO_2 values are high. It is such a fine balance, which in the end succeeded for us, but it took time from other assignments which were just as important to focus on. Therefore, tightening the energy frame might not be the best solution for a sustainable building in the end.

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Appendix

Ill. 126 Fishery at the landing ground in Nørre Vorupør


FORD

Appendix 01: LCA

Precast concrete wall

Material	Info	Height h [m]	Length l [m]	Depth d [m]	Amount		Lifetime [year]	U-value [W/m² K]
Concrete	Prefabricated concrete C25/30	1	1	0,120	0,120	m^3 / m^2	120	0,09
Vapour barrier		1	1	0,001	0,001	m^2 / m^2	80	
Insulation	Mineral	1	1	0,145	0,145	m^3 / m^2	80	
Insulation	Mineral	1	1	0,145	0,145	m^3 / m^2	80	
Insulation	Mineral	1	1	0,045	0,045	m^3 / m^2	80	
Concrete	Prefabricated concrete C25/30	1	1	0,100	0,100	m^3 / m^2	120	

Table 06

In-situ cast concrete wall

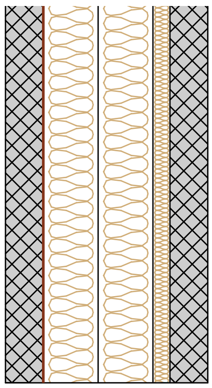
Material	Info	Height h [m]	Length l [m]	Depth d [m]	Amount		Lifetime [year]	U-value [W/m² K]
Concrete	Self-compacting concrete, C20/25	1	1	0,120	288	kg / m^2	120	0,09
Vapour barrier		1	1	0,001	0,001	m^2 / m^2	80	
Insulation	Mineral	1	1	0,145	0,145	m^3 / m^2	80	
Insulation	Mineral	1	1	0,145	0,145	m^3 / m^2	80	
Insulation	Mineral	1	1	0,145	0,045	m^3 / m^2	80	
Concrete	Self-compacting concrete, C20/25	1	1	0,100	240	kg / m^2	120	

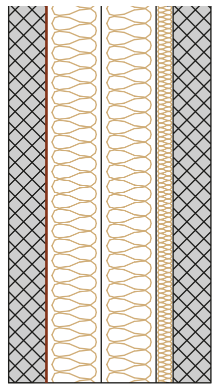
Table 07

Precast concrete wall

U-value 0,09 W/m²K

Precast concrete - 120 mm
Vapour barrier - 0,001 mm
Insulation - 145 mm
Insulation - 145 mm
Insulation - 45 mm
Precast concrete - 100 mm





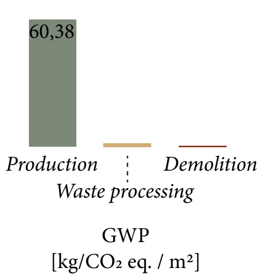
In-situ cast concrete wall

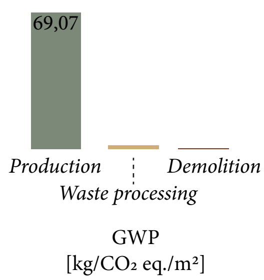
U-value 0,09 W/m²K

Ready-mix concrete - 120 mm
Vapour barrier - 0,001 mm
Insulation - 145 mm
Insulation 145 mm
Insulation - 45 mm
Ready-mix concrete - 100 mm

Ill. 127

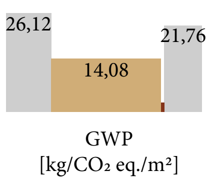
Building phase

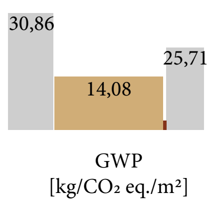




Ill. 128

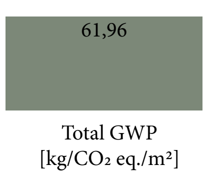
Materials

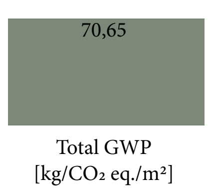




Ill. 129

Total





Ill. 130

Appendix 02: LCC

Key figures

Inflation	
2%	
Discount interest	
5%	

Building design lifetime [years]	
50 -100	

Table 08 Key figures

ALTERNATIVE 1				
Copper				
Lifespan	80 years			
Costs				
Item	**Investment**		**Maintenance**	
Gutter	**Cost pr. m**	**Length**	**Labor cost pr. m**	**Material pr. m**
	[DKK]	[m]	[DKK]	[DKK]
	2316	57	856	1460
Down-pipe	**Cost pr. pipe**	**Number**	**Labor cost pr. pc**	**Material pr. pc**
	[DKK]		[DKK]	[DKK]
	4285	6	340	1157

ALTERNATIVE 2				
Zinc				
Lifespan	50 years			
Costs				
Item	**Investment**		**Maintenance**	
Gutter	**Cost pr. m**	**Length**	**Labor cost pr. m**	**Material pr. m**
	[DKK]	[m]	[DKK]	[DKK]
	1284	57	856	428
Down-pipe	**Cost pr. pipe**	**Number**	**Labor cost pr. pc**	**Material pr. pc**
	[DKK]	[ps.]	[DKK]	[DKK]
	3496	6	340	291

ALTERNATIVE 3				
Zinc gutter and copper pipes				
Lifespan	50-80 years			
Costs				
Item	**Investment**		**Maintenance**	
Gutter	**Cost pr. m**	**Length**	**Labor cost pr. m**	**Material pr. m**
	[DKK]	[m]	[DKK]	[DKK]
	1284	57	856	428
Down-pipe	**Cost pr. pipe**	**Number**	**Labor cost pr. pc**	**Material pr. pc**
	[DKK]	[ps.]	[DKK]	[DKK]
	4285	6	340	1157

Table 09 Info on the three gutter alternatives

Appendix 03: Energy consumption

Optimizing of envelope

Key numbers, kWh/m² year

Energy frame BR 2018

Without amendment	Amendment for special conditions	Total energy frame
42,5	1,6	44,1
Total energy rewuerement		52,4

Energy frame low energy

Without amendment	Amendment for special conditions	Total energy frame
33,0	1,6	34,6
Total energy rewuerement		52,4

Contribution to energy requirement

Heat	36,1
El. for operation of building	8,7
Excessive in rooms	5,1

Net requirement

Room heating	35,2
Domestic hot water	0,0
Cooling	0,0

Ill. 131

Reduce of window size

Key numbers, kWh/m² year

Energy frame BR 2018

Without amendment	Amendment for special conditions	Total energy frame
42,5	1,6	44,1
Total energy rewuerement		41,0

Energy frame low energy

Without amendment	Amendment for special conditions	Total energy frame
33,0	1,6	34,6
Total energy rewuerement		41,0

Contribution to energy requirement

Heat	24,9
El. for operation of building	8,5
	3,7

Net requirement

Room heating	24,0
Domestic hot water	0,0
	0,0

Table 132

Appendix 04: Air flow

Table 10

ROOM INFORMATION

Nationalpark Centre Thy	Net area	Number of people	Room height	Volume	Activity Level	Air pollution
	[m^2]	-	[m]	[m^3]	[met]	[olf pr.
Foyer, reception + wardrobe	104	15	2,5	260	2	3,11
Public toilet	57	4	2,5	142,5	1,2	1,87
Storage + technique room	59	0	3	177	2	3,11
Exhibition	144	60	3,5	504	1,6	2,49
Workshop	60	15	3,5	210	1,2	1,87
Flexroom + auditorium	87	50	3,5	304,5	1,2	1,87
Meetingrooms	33	6	2,5	82,5	1,2	1,87
Staff common room	38	4	2,5	95	1,2	1,87
Staff toilets	13	2	2,5	32,5	1,2	1,87
Staff landscaped office	96	8	2,5	240	1,2	1,87
TOTAL	691					
				Met til olf faktor		1,56

RESULTS

	Air flow	
	CO_2	Senory
	[l/s]	[l/s]
Foyer, reception + wardrobe	215	408
Public toilet	34	94
Storage + technique room	0	42
Exhibition	687	1170
Workshop	129	243
Flexroom + auditorium	429	729
Meetingrooms	52	104
Staff common room	34	80
Staff toilets	17	36
Staff landscaped office	69	175

CALCULATIONS

Source: 6. semester, Lektion 1

Dilution equation	c	=	$(q/V_L) + c_i$	[ppm]
	V_L	=	$q/(c-c_i)$	[m^3/h]
	q	=	People + interior pollution	
	V_L	=	Air flow	
	c	=	CO_2 concentration above outdoor	[ppm]
	c_i	=	CO_2 Concentration	[ppm]
	A	=	$\pi*r^2$	[m^2]
	r	=	kvrod(A/π)	[m]
Pipe diameter	d	=	$r*2$	[m]
		=	kvrod(A/π) *2	[m]
		=	kvrod(($V_L/3600/V_{max}$)/π)*2	[m]

Source: 6. semester, Lektion 1-2

Comfort equation for indoor quality	$q_{v,u}*(c_i-c_u)$	=	$10*G*(1/\varepsilon_v)$	
	$q_{v,u}$	=	$10*G/(c_i-c_u)*\varepsilon_v$	[l/s]
	$q_{v,u}$	=	Air flow	[l/s]
	c_i	=	Experienced indoor air quality	[dp]
	c_u	=	Experienced outdoor air flow	[dp]
	G	=	Sensorial load in air	[olf]
		=	$n*p_{people} + A*p_{building}$	[olf]
	n	=	Number of people	[person]
	p_{people}	=	Pollution pr. person	[olf/pers.]
	$p_{building}$	=	Pollution from building	[olf/m^2]
	A	=	Area	[m^2]

ROOM: EXHIBITION

CO_2-calculation

Source: DS-CEN-CR 1752, figur A.5, s. 23 (da)

Category		CO_2 Concentration [ppm]	CO_2 concentration above outdoor [ppm]	Max velocity in channels [m/s]
A	c_1	460	810	
B	c_2	660	1010	5
C	c_3	1190	1540	

Source: DS-CEN-CR 1752, figur A.8, s. 24 (da)

Number of people	n	=			60	
Activity level	M	=			1,6	met
CO_2 production pr. person	$q_{v,CO2}$	=	17*M	=	27,2	l/h
		→			0,027	m^3/h
CO_2 production, total	$q_{v,total}$	=			1,63	m^3/h
Amount of CO_2 pr. m^3 air injected	c_i	=			350	ppm
		→			0,0004	m^3/m^3
		→			0,035	vol%
Air flow	V_L	=			2472,73	m^3/h
					41,21	m^3/min
					0,69	m^3/s
					686,87	l/s
					4,91	h^{-1}

RESULTS

Category	**Airflow** [m^3/h]
I	3547,83
II	2472,73
III	1371,43

ROOM: EXHIBITION

Sensory-calculation

Source: DS-CEN-CR-1752 s. 22-23 (da)

Category		Experienced indoor air quality dp	Dissatisfied %	Necessary l/s * olf
A	$c_{i,1}$	1	15	10
B	$c_{i,2}$	1,4	20	7
C	$c_{i,3}$	2,5	30	4

Source: DSEN 1752 - Tabel A.9

Levels of air quality		**Experienced outdoor air quality** [dp]
Exellent	$c_{u,1}$	0
In towns, good air quality	$c_{u,2}$	<0,1
In towns, poor air quality	$c_{u,3}$	>0,5

Number of people	n	=	60	people
Source of pollution per person	p_{people}	=	2,49	olf/person
Average odor existing buildings	$p_{building}$	=	0,10	olf/m^2
Area	A	=	144	m^2
Ventilation efficiency	ε_v	=	1	-
			4210,29	m^3/h
			1,17	m^3/s
Air flow	$q_{v,c}$	=	1169,52	l/s
			8,35	h^{-1}

RESULTS

Category	**Airflow** [l/s]
I	1637,33
II	1169,52
III	654,93

Appendix 05: Length of throw

Table 11

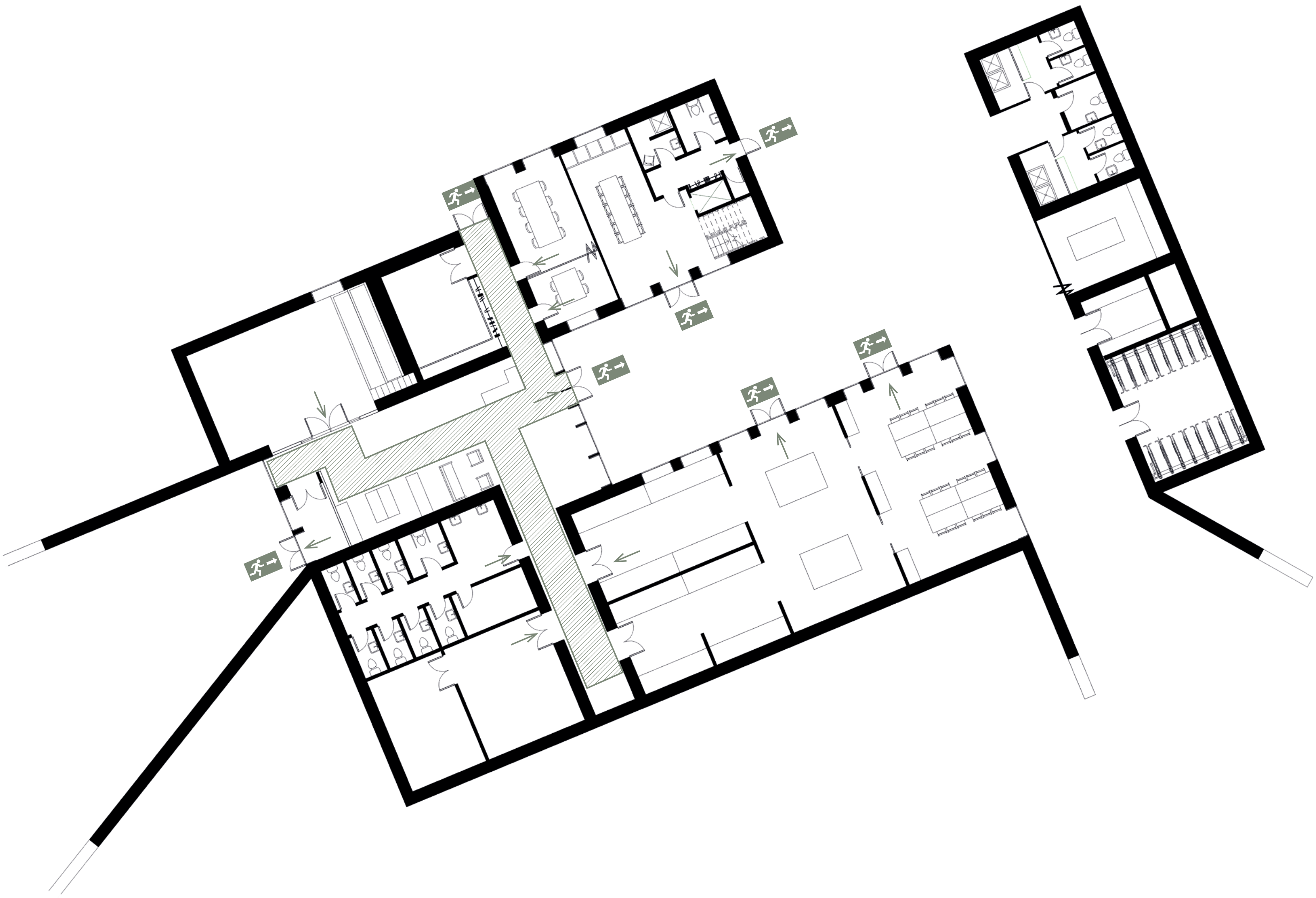
Room type	Number of people	Air flow		Dwelling zone	Dwelling zone distance to wall	Room height	Longest room width
		Inlet total	Extract total	Height			
		[m³/h]	[m³/h]	[m]		[m]	[m]
Exhibition	60	2472,73	2472,73	1,8	0,2	4,8	13,6
Workshop	15	243	243	1,8	0,6	4,8	9,6
Foyer	15	772,73	772,73	1,8	0,6	2,5	11,6
Meeting rooms	6	185,45	185,45	1,8	0,2	2,5	7,6
Common room	4	123,64	123,64	1,8	0,6	2,5	7,6
Staff office	12	247,27	247,27	1,8	0,2	3	8,7

Number of fittings		Number of row	Number of fittings pr. room width
Inlet fittings	Outlet fittings		
ps.	ps.		
4	3	2	2
1	1	1	1
2	2	2	1
2	-	1	2
1	1	1	1
2	-	1	2

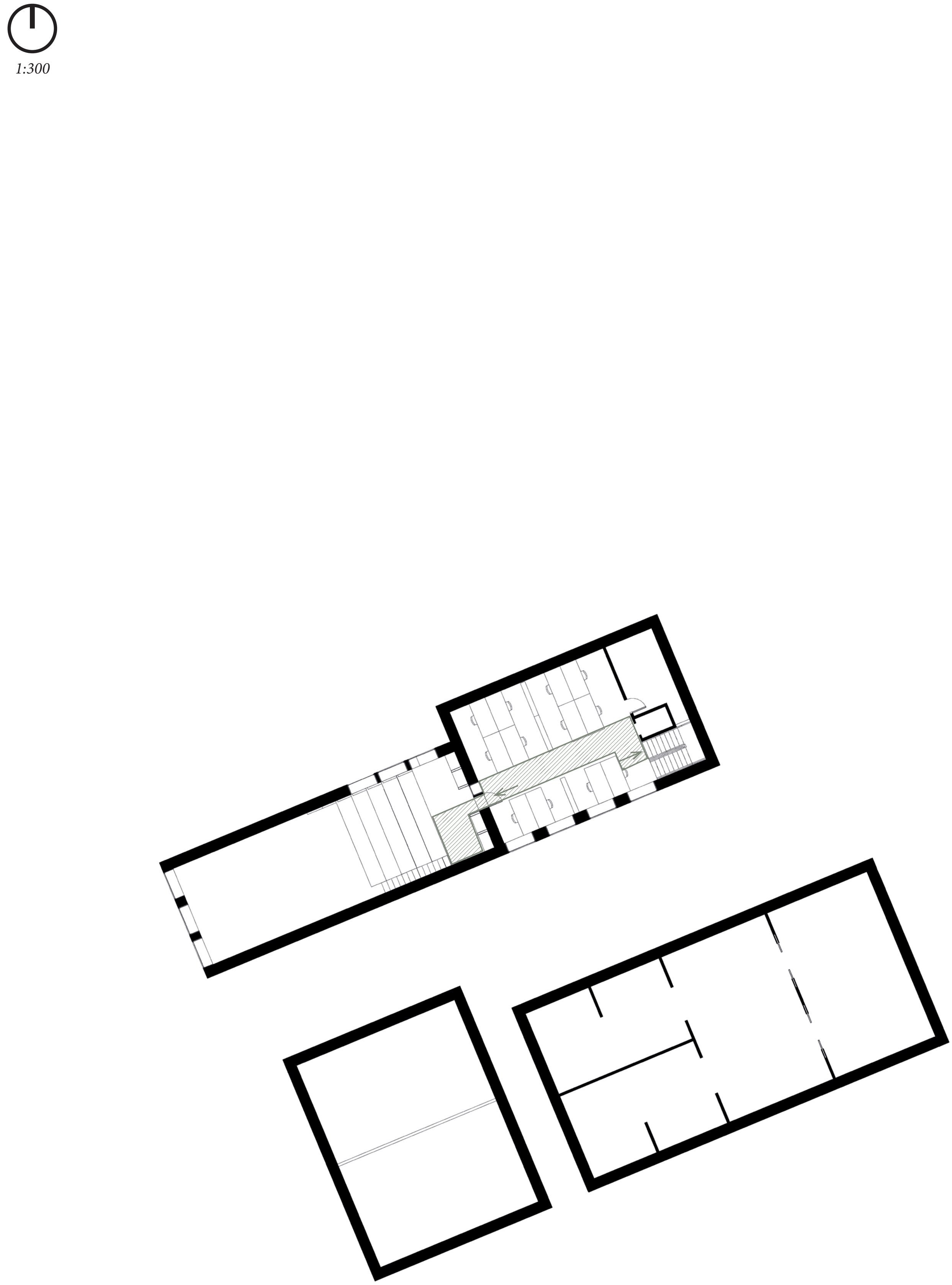
Fitting distance	Fitting distance to wall	Distance to dwelling zone	Length of throw				
A	B	C	0,75*((A/2)+C)	≤	$l_{0,2}$	≥	(A/2)+C
[m]	[m]	[m]	[m]				[m]
7	3	3	5	≤	$l_{0,2}$	≥	6
10	5	3	6	≤	$l_{0,2}$	≥	8
12	6	0,7	5	≤	$l_{0,2}$	≥	6
4	2	0,7	2	≤	$l_{0,2}$	≥	3
8	4	0,7	3	≤	$l_{0,2}$	≥	4
4	2	1,2	3	≤	$l_{0,2}$	≥	3

Fittings							
Inlet pr. fitting	Velocity in channels	Channel diameter	Type	Outlet pr. fitting	Velocity in channels	Channel diameter	Type
[m³/h]	[m/s]	[mm]		[m³/h]	[m/s]	[mm]	
618	5	209	250	824	5	241	250
243	5	131	160	243	5	131	160
386	5	165	200	479	5	184	200
93	5	81	100	-	-	-	-
124	5	94	100	371	5	162	200
124	5	94	100	-	-	-	-

Appendix 06: Fire escape routes



Ill. 133 Escape routes on groundfloor



Ill. 134 Escape routes on first floor