Ilulissat Icefjords Centre

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Ill. 2.1 - Photo by Ingeborg Simoni Leere

Acknowledgement

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Ill. 4.1 - Glacier

Motivation

Now, more than ever, we are feeling the impact of climate change. All over the world the weather are getting more severe, whether it is wind, temperature, flooding, or drought. The future architecture needs to take these conditions into consideration and actively use the weather impacts as a design driver.

To learn how to design buildings fit for these tough conditions, it makes sense to look at how we already are designing buildings in one of the most extreme places in the world.

Greenland is not only one of the places where climate change makes the biggest impact, it's with the majority of its area placed north of the arctic circle, also one of the most uninhabited places in the world. Here the inhabitants need to withstand cold temperatures, tough winds, lack of sunlight during the winter and excessive sun exposure during the summer. Furthermore, it is not possible just to dig into the ground and ride out the storm, because the ground is affected by permafrost, which also causes disruptions when melting.

Although the local building traditions in Greenland have a focus on withstanding the harsh weather, they do not provide sufficient indoor climate compared to modern Nordic standards. This results in several health issues among a population which is already struggling with several community problems. They furthermore do not have a focus of how daylight can affect both the health and the mind, which can also lead to further community problems.

As students from the Architecture & Design education at AAU, we are engaged in modern building standards, in terms of structure, sustainability and aesthetics. To use this knowledge together with research on traditional building culture in an arctic environment, we hope to be able to design a building adapted to the Arctic environment with a modern approach, that focuses both on both technical and aesthetic qualities, that enhances the quality of the site.

Vision

To create a sustainable building with minimal carbon footprint, that is adapted to the arctic environment and is enhancing the story and the experience of the site.

Ill. 6.1 - Glacier

Abstract

This Master Thesis project is written by Kamilla Dodensig Larsen and Mikkel Esrup Steenberg at the 4th semester in the master programme in Architecture at Aalborg University, Denmark. This thesis is based upon the architectural competition brief of the Ilulissat Icefjord Centre in Greenland and includes a design proposal for the brief together with the design process. A light analysis tool has also been developed in parallel through this process, and has been used actively in the design process. The main focuses of this thesis is daylight seen from a human perspective and indoor thermal conditions located in an extreme climate. The design proposal reflects the main focus and the analysis of the site.

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Reading Guide

The following report is divided into six chapters, where the first four is the programme of the project, containing analyzes of the site and its users, as well as different studies relevant for the project. In the fifth chapter the design process is chronologically presented, while the final result is presented through visualizations and plans in the last chapter.
Before the first chapter an introduction to the project approach, method, and motivation is described.
If there is a corresponding page in the appendix a reference is highlighted on the page.

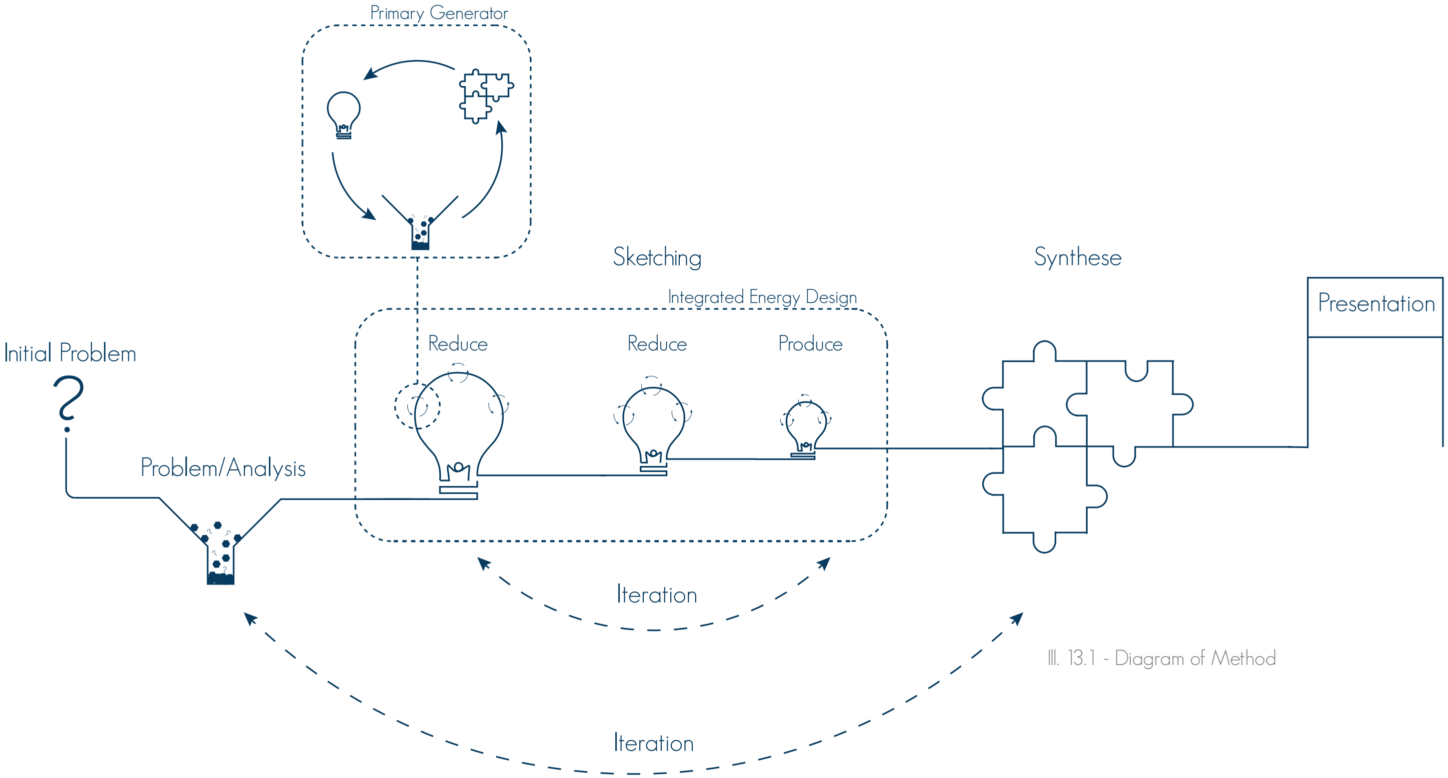
Table of content

Methodology

To design a modern visitor centre for the arctic environment, that meets the latest requirements for energy consumption and indoor climate, it's necessary to combine the architectural and engineering knowledge early in the process and thereby create an integrated design.
The integrated design process is complicated with multiple aspects that all needs to be considered. There are several proven methods which is used to structure this process, - all based on iterative processes. For this project a hybrid model based on Knudstrup's Integrated Design Process (Ring Hansen, H and Knudstrup, M, 2005), is used as the main guidance for phasing during the project period. A problem driven process is chosen, as the project seeks to solve the design in not only a creative way but also in a broad qualitative way as documented by Corinne Kruger in "Solution driven versus problem driven design: Strategies and outcomes" (Kruger, C. and Cross, N, 2006).

The IDP is divided into five phases, in which the first two phases are "Problem" and "Analysis". In this project the two are interwoven as the problem is subject to the results of the analysis and are therefore interchangeable throughout the whole process.
To form a basis for the subsequent design process, the initial phase is analysing the site context in both quantitative and qualitative studies, to give a holistic interpretation of the site. The two initial stages therefore form the basis for the subsequent design process, which are based on the IDP's sketching and synthesis phase. The quantitative methods consist of both data collected by third parties as well as data from environmental simulations, which are based on terrain and location data.
The qualitative studies are based on second-hand studies, as it has not been possible to visit the site. Therefore they consist of impressions made through 360° photography.
To understand what the centre needs to facilitate, a user analysis is essential.
The user group is based on existing competition material, while additional user behavior and wishes are collected through official sources, such as the municipality or government travel information. The room program and how the facilities are distributed is adjusted according to the gathered information, and through a case study of a similar existing building.
Case studies are used in this project to get practical knowledge from existing buildings and thereby build upon the knowledge they were designed with. The case studies are subject to themes such as the building culture in Greenland and how to design modern architecture in an arctic environment.

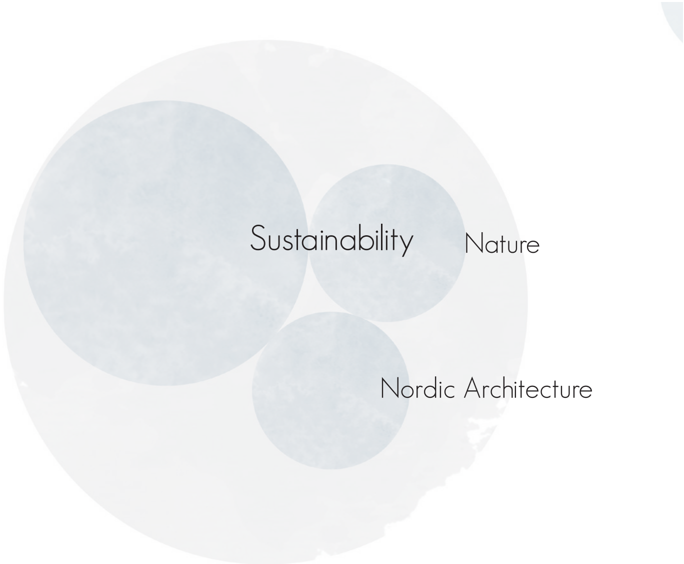
The subsequent phase of the IDP is the sketching phase, which takes its starting point in the data collected from the previous phase and evolves the design upon them. To ensure both aesthetically and technical qualities, a co-evolution method,



Ill. 13.1 - Diagram of Method

Sequential Primary Generator, is used, and thus creates the framework for a design which is not only evidence based, but also allows an open and conceptual-based approach (Foged,I., 2018).
The primary generators are largely based upon the Integrated Energy Design (Kongebro, S. 2012) method, which seeks to reduce the overall energy consumption through Reducing, Optimizing, and Producing, inspired by the Trias Energetica (Kongebro S., 2012).

The next phase of the IDP, "Synthesis", merges the often parallel design solutions into one final form, which is evidentiary analyzed to validate the final design. At this point, all wishes, aims, and programmes are met to achieve a holistic design proposal (Ring Hansen, H and Knudstrup, M, 2005).
The last phase is the presentation where the aim is to highlight the final solution through the technical and architectural aspects of achieving a holistic design. This is made through visualizations, final calculations, detail-, section-, and plan drawings.



Focus of the project

Ill. 14.1 - Diagram of focus

SUSTAINABILITY
The main technical focus is to create a sustainable holistic building design through integrating active and passive strategies from the beginning, and thereby minimizing the carbon footprint.
The focus is to enhance the social environment, through facilities that is designed to embrace the users. One of the tools to achieve this, is the daylight, which will be used as an active design tool. The daylight is divided into three different categories: Vitality, Comfort, and Emotion based on Oculight Research.

NATURE
The project site is situated in the gate of the Ilulissat Icefjord. This area is well famous for its significant nature and should be implemented and embraced through the design proposal.

NORDIC ARCHITECTURE
Greenland has roots in Denmark and the Nordic tradition, however, the main part of the architecture does not have a clear Nordic approach. But through materials and using the daylight in the design, the focus is creating a building design inspired by the tradition of the Nordic countries.


Ill. 15.1 - Photo by Patrick Pluel

Ill. 16.1 - Glacier

1

Greenland

Greenland

The world's largest island, Greenland, is well famous for its significant nature and unforgiving climate. Due to its massive size of approximately 2.180.000 km2, a lot of the nature still remains untouched as up to 85 percent of the land is covered by ice. Until 1953 it was a colony under Denmark, thereafter it became a part of Denmark and in 1979 autonomous, but are however still a part of EU. The building culture has been influenced by the Danish government in a long period of time, but since it's autonomy the Greenlandic government has been working on creating a building culture, where local materials are used, so they don't need to import as many resources from Denmark (Byginfo.gl, 2018). The number of inhabitants is around 55.000 and the settlements are primarily near the ocean due to fishing. The infrastructure is limited to a few roads, so most transportation between towns is only possible by airplane or ship. Within the cities, there are roads for buses and cars (Den store danske, 2018).

Ill. 19.1 - Illustration of Greenland

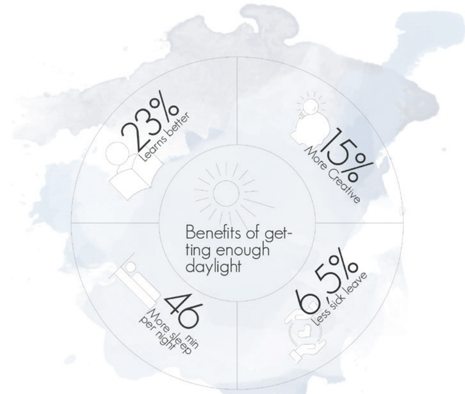
Daylight

VITALITY

Greenland suffers from multiple community problems, in which alcoholism and suicide is often looked at. 54% of Greenland's population are from homes with alcohol problems, (Possible Greenland, 2012).

The alcoholism is not directly related to the daylight, but during the winter months the amount of people with Seasonal Affective Disorder (SAD) is significantly higher above the arctic circle, as it is related to the lack of sunlight people are exposed to (Kegle, M., Dam, H., Bjerregaard, P. and Ali, F, 2009). SAD is also known as winter depression, which is known to be a catalyst to alcohol abuse (Sundhedsstyrelsen, 2007).

Greenland has one of the highest suicide rates in the world and although SAD might be suspected to impetus the suicide, it doesn't correlate to the statistics, as the peak is in July. A study concluded that the high suicide rate might be affiliated with the circadian synchronization, which again is controlled by the amount of daylight the body receives (Björkstén, K., Kripke, D. and Bjerregaard, P. , 2009). The circadian synchronization controls the body's internal clock, via the amount of daylight it receives. If the body doesn't receive enough daylight it starts to expand the day cyclus to 25.2 hours, which affect the body as a constant jetlag (Kongebro, S., Strømann-Andersen, J. and Mandsfeldt, L.,2012) If the body however is overexposed to daylight, the circadian synchronization regulates the body's hormones accordingly, which can lead to insomnia, which again can lead to suicide. (Björkstén, K., Kripke, D. and Bjerregaard, P. , 2009).



Ill. 20.1 - Daylight diagram

EMOTION

In the Nordic countries daylight have always been an important design factor, due to the lack of daylight during winter. Several Danish architects, such as Jørn Utzon and Henning Larsen, has not only recognized its importance but also used it as the main design factor. Similar traditions have not been a part of Greenlands building culture, as a consequence of both building in the harsh environment with outdated techniques, as well as using prefabricated housing which originates from military buildings.

Therefore it's a necessity to look to the Scandinavian countries to understand how daylight can control the perception of a room and it's materials.

There are several ways of controlling the daylight, but when looking at it in a holistic manner, it can be categorized as either a contrasting effect, which often draws the eye, or the opposite which is often soothing.

The motion of daylight is in particular phenomenological, but an attempt to quantify the perception of the light has been done in "Perceptual Dynamics of Daylight in Architecture" by S. F.

Ill. 21.1 - Daylight OCULIGHT dynamics.

Rockcastle, M. Andersen, where the daylight is analysed and gives a quantitative perception based on the light contrast in the space(S. F. Rockcastle, M. Andersen,2017).

COMFORT

Glare is often caused by direct sunlight, or by it's reflection from a reflective surface. While a well lit area can be a comforting experience and is often drawing the attention of the eye, it has the opposite effect if the area becomes too bright. Then the eye will automatically seek away from the light, which results in great discomfort.

During both spring and autumn the sun is low in the horizon, which can cause significant glare in buildings if they are not shielded with shading. Even if the building is shaded from direct sunlight, the reflection from the snow can cause a lot of glare. This is also the case in the summertime, where reflections causes the greatest discomfort as the sun will be too high in the sky to penetrate vertical windows for a majority of it's cyclus.

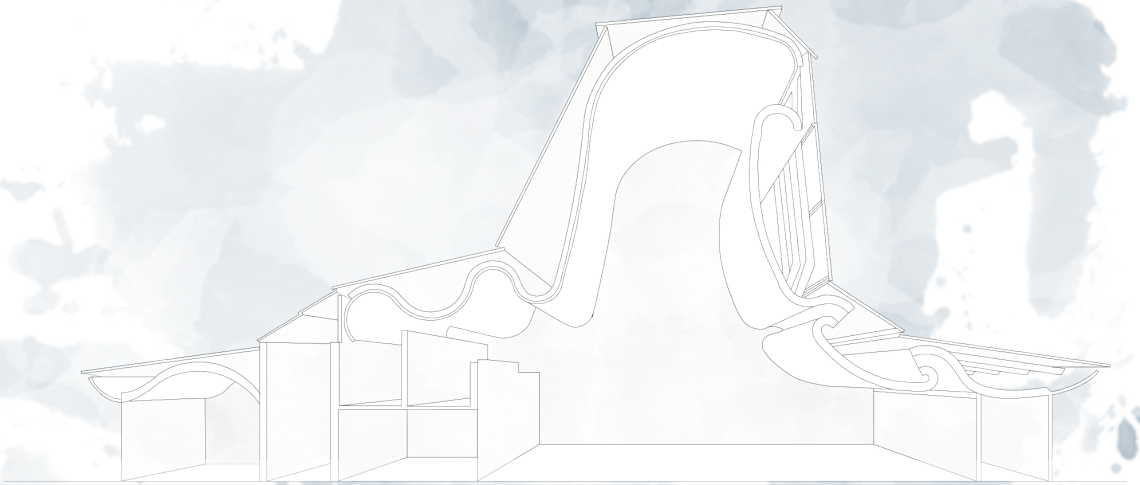
CONCLUSION:

As these studies cannot be measured by 2D analysis it is necassary to compute the light analysis in 3D.

New nordic architecture

Nordic architecture is often defined as honest and natural. Architecture critic Kurt W. Forster, explains in regard to the understanding of the Nordic tradition from the 20th century up until today, that there has been a wave for the past 10 years, where we seek back to the Nordic tradition (Kjeldsen, K., Schelde, J., Asgaard Andersen M. and Holm, M.,2012).
Architect Christian Norberg-Schulz talks about how a place influences the architecture and how it should be shaped and adapted to its surroundings.
Often when Nordic architecture's main characteristics are described, the focus is on how it is humble to nature both in terms of choice of materials and how it's shaped into the landscape.
But in recent times a new trend seems to appear. The tradition of analyzing the sites stills remains, but it is interpreted in a new way. An example is PLOT with their "Maritime Youth House". Here the site was polluted and it would take a quarter of the budget to remove the pollution. But through a different architectural approach, they managed to change the negative problem to a positive design driver by raising the building from the ground and create a distance to the poison. This is another way to interpret the sites and nature, and find the opportunities which before where a problem. (Kjeldsen, K., Schelde, J., Asgaard Andersen M. and Holm, M.,2012)
As mentioned earlier the light is a key factor in Nordic architecture.
The light often occurs in a white luminosity form with white finished walls and from indirect sunlight. This refers to a snow-covered landscape and its beauty. It also utilizes the maximum of the sunlight as it is reflected and brought further into the room (Plummer, H.,2012).

CONCLUSION:
The building should embrace the landscape, take inspiration from its surroundings and use it as a design driver.



The light of Bagssværd Church enhance the play of the textile of the simple materiality chosen for the church and stages the materiality.

Ill. 23.1 Diagram of Bagsværd Church

Case study - Nordic Pavilion

The Nordic Pavilion is formed as a rectangular hall and consists of two completely closed and two open sides. The architect Sverre Fehn drew the pavilion back in 1958 for the competition of designing the Nordic Countries Pavilion for the Venice Biennale, representing Norway, Finland, and Sweden.
The whole construction is made of concrete with timber doors. The materiality of the doors provides the room with a sense of warmness. The only interior of the pavilion is three trees which symbolize/increases the feeling of being outdoors and indoors at the same time and works as a vertical element within the pavilion. Outside the pavilion, a tree is integrated into the construction and underlines the pavilion of being a part of nature. The Nordic Pavilion defines the Nordic tradition of taking the nature in, bright materials, diffuse daylight, and simplicity. The roof is made of two layers of beams organized in each direction. The height of the beams on 1 meter each reflects the light between them and provides the roof with indirect sunlight. The diffuse light creates a space without shadows (ArchEyes, 2018) (Archdaily,2018).

CONCLUSION
The building should be designed with respect of existing sorroundings. The diffuse daylight is a key element, which can be used in the building to create a calm atmosphere.

Ill. 25.1 - Photo by Åke E:son Lindman

Ill. 25.2 - Photo by Åke E:son Lindman

Ill. 25.2 - Photo by Åke E:son Lindman

Material perception

Tectonics are defined in a lot of different ways but tend to focus on a constructions structure, function, and spaces within. The choice of material and how it was produced has a big influence on how the spaces are experienced. The same material can be treated in a lot of different ways for example being polished, drilled, grinded etc. These ways of treating the material can often change its appearances and how it is perceived completely.

As Juhani Pallasmaa writes about in "Eyes of the skin" our buildings today are flat. It is mass produced with a repellent surface for the viewer that does not reveal anything. The textile of materials is not shown as when natural materials is being used which has a debt and a story to tell (Pallasmaa, J,2005). When choosing materials the light has a big impact on how the materials are experienced, which is elaborated in the book "Atmosphere" by Peter Zumthor. In Atmosphere, he talks about light according to material and how the materials light reflection properties should be integrated into the design decision from the beginning (Zumthor, P, 2006).

CONCLUSION

The textuality within the building should enhance the perceptions of light and have a deepness which reveals the materials manufacturing process and age.

Ill. 27.1 - Embossed Hand Gouged Italian Walnut - Photos by Rivadossi

Ill. 27.2 - Hand Carved Italian Walnut - Photos by Rivadossi

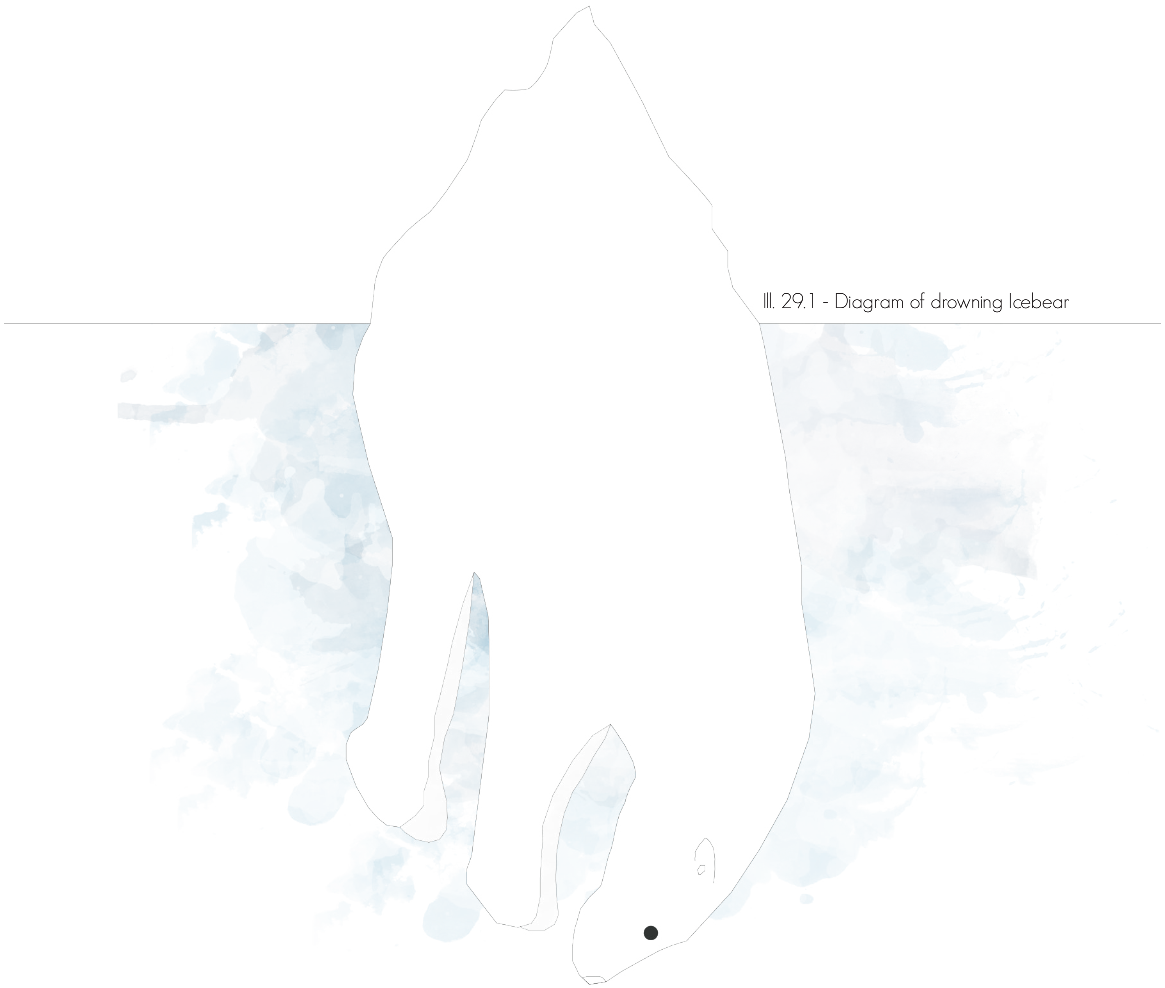
Ill. 27.3 - Hand Planned Italian Walnut - Photos by Rivadossi

Ill. 27.4 - Hand Carved Italian Walnut - Photos by Rivadossi

Climate change

The generel sea level of the world would rise with seven and a half meters if all ice on Greenland melted. Every year the ice cap is reduced and by the year 2050, the sea level is increased by 0,42 centimeters according to scientists. Currently, the ice cap is melting faster than initially predicted. This doesn't, however, decrease the size of Greenland, as a study by DTU shows that even though the raised sea level is flooding all the low land areas, Greenland is actually increasing in size (Dtu.dk, 2018). As the melting ice is being transported out to the ocean it moves stone and gravel with it, which is adding to the existing coastline. When planning future infrastructure, this needs to be taken into account (Dmi.dk, 2018).
With the increasing sea level, the temperatures are also increasing. By 2080 the average temperature is raised by 7-8 degrees, predicts DMI (Dmi.dk, 2018).
The increased temperatures will boost Greenland's florawhich will accommodate a larger quantity of plants.
Today Greenland has a relatively high emission of CO2 per inhabitant compared to other countries. The high emission derives from a higher energy consumption, caused by the arctic environment with the increased need for artificial lighting and heating for the winter which is especially problematic for towns without renewable energy sources. Furthermore, there is a high emission caused by the long distances between the cities, where fuel-driven transport is being used (Climate Greenland, 2018)

CONCLUSION:
The climate change has a significant influence on the future weather conditions to become more extreme and due to the temperature increase the flora of Greenland will also change accordingly. It is therefore important to communicate the importance of thinking sustainable



Ill. 29.1 - Diagram of drowning Icebear

Enviromental impact

SUSTAINABILITY

There's a wide range of aspects which covers the term building sustainable. Overall the meaning of sustainable covers the terms social, environmental and economic. In this report, the focus of a sustainable approach is according to carbon footprint and users comfort and health. Today the primary part of people's time is spent indoors rather than outdoors. This causes a huge responsibility for the indoor environmental quality within the building and the pollution of the building material.

LCA

Life Cycle Assessment is a method which focuses on product's environmental impact from cradle to grave. Here raw materials are taken from the cradle of mother nature through a production process, transformed into a product and after its been used it is put back to the grave. Sometimes the product is being reused, for example, bricks from a demolished building are being reused in a new building. By using the LCA it is possible to evaluate the choice of materials by how much of an impact they make on the environment. A large percentage of the construction material's carbon emission is being released during the transportation (lca-center.dk, 2018).

The only possible way of getting materials from other countries to Greenland is either by air or sea. By air, the Co2 emission is undoubtedly the worst with 1.319 kg CO2e per Tonne-Mile compared to 0.0602 kg CO2e per Tonne-Mile by sea (Carbonfund.org, 2018).

But when comparing the transportation time there is a clear difference between only 4 hours and 24 minutes from Copenhagen to Ilulissat by air and over ten days by the sea (Happyzebra.com,2018).

The transportation time has a big influence on the building culture in Greenland as if you run out of a specific material or have to renovate, it takes a long time for the new material to arrive. The most common way of getting materials transported is by sea, as it is by far the cheapest solution. This demands a highly structured planning process at a building site so all materials are available when needed.

CONCLUSION

The transportation of the materials is causing a high emission of Co2, so the most efficient transportation is by ship. This also provides some logical problems, as the building materials needs to fit into a container.

Ill. 31.1 - Designed by Freepik

Renewables

Renewables are based on energy sources which are naturally replenished during a human lifetime. As mentioned earlier in the report Greenland, has a high energy consumption per person due to the arctic environment. This increases the need for producing energy from renewables to decrease the emissions. The primary part of renewables in Greenland comes from hydropower plants, solar energy, waste heat, and fish oil.

The total energy consumption is 67 % produced by renewables.

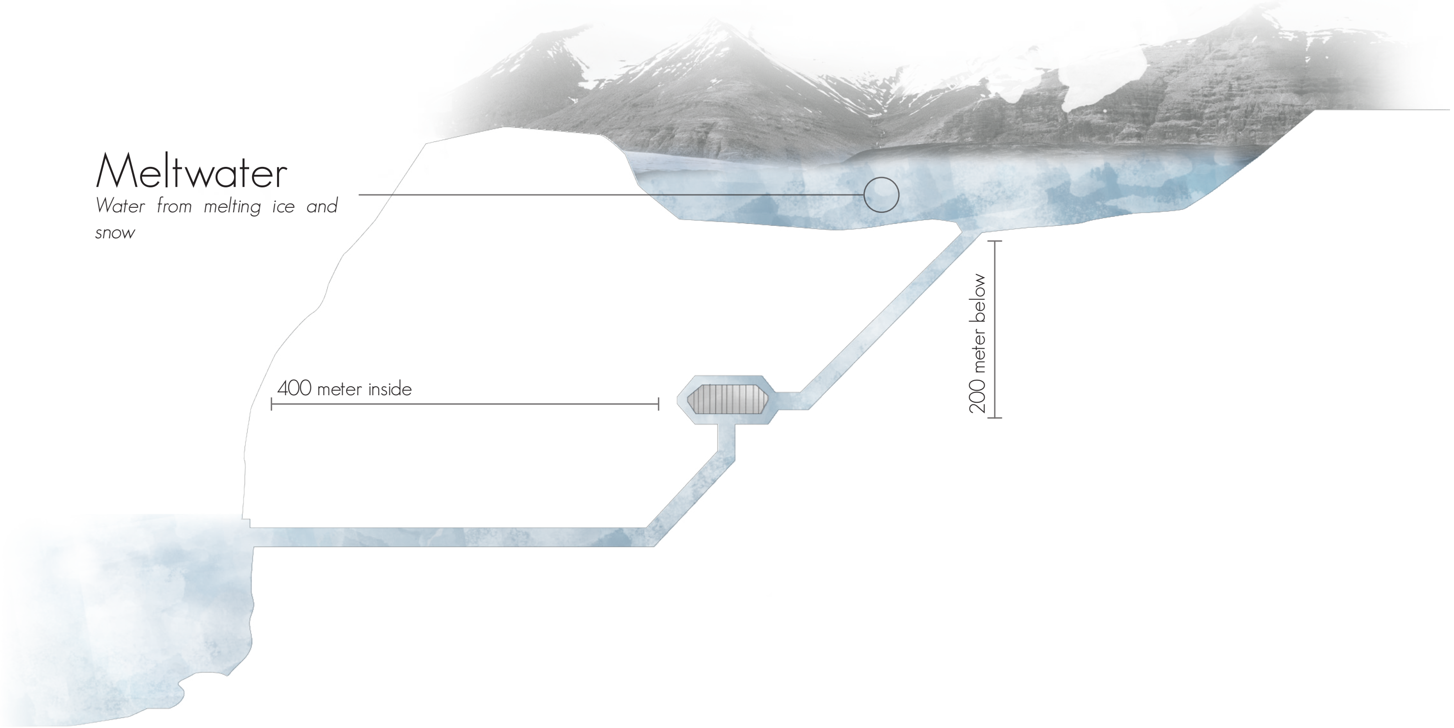
The solar energy is very limited and is only produced in private installations. The waste heat comes from burning non-biodegradable waste which generates a high level of heat. Denmark is well known for using windmills as a part of the strategy to become more environment friendly, but Greenland is only powered by a few windmills, as they are not as profitable as other renewable sources. The primary renewable energy sources are from the hydropower plants, which can be placed both as small local plants that are drawing its energy from their melting water channels, and larger, which is buried under the permafrost approximately 200 meters under the surface and is unmanned (Abb-conversations.com, 2018). The turbines of the system utilizes the kinetic forces of the meltwater through channels underground.

There are five power plants in all of Greenland and the latest established is in Ilulissat in 2013. The hydropower plant produces electricity, heat and hot water supplies for the nearby town Ilulissat and the energy is transported 50 kilometers on a power line. The long distance between the energy source and the cities is the biggest problem of using the hydropower plants. They are expensive to construct but have low operating costs.

It is difficult to create a nation-wide grid of electricity in Greenland, due to the towns being spread over a large area (Climate Greenland, 2018) (Stat.gl, 2018).

CONCLUSION

Greenland have a high amount of renewables which are based on energy sources which are sustainable. This means that the energy consumption for the building is not critical.



Ill. 33.1 - Climate Greenland, 2018.

Building culture

GREENLAND BUILDING CULTURE

Greenland's building culture has until 1950 consisted of four different building types: peat wall houses, stone houses, stick work houses and half-timbered houses. These types are sometimes combined and made by self-builders. In the 1800's the Greenlanders' housing habits where seasonal. In winter, the inhabitants lived in peat wall houses which didn't have any regular entrance, but instead a long hallway with a low ceiling that made it impossible to stand up. The houses were often shared by several families so they could use their body heat to help heating the house. Most of the winter period was spent indoors, except when the men was out hunting. While hunting, the men often build an igloo near the good hunting sites, to protect them from the weather. In summer, they moved out of their houses and lived in tents they could move around to the different campsites (Uldall Jensen, M., 2000).

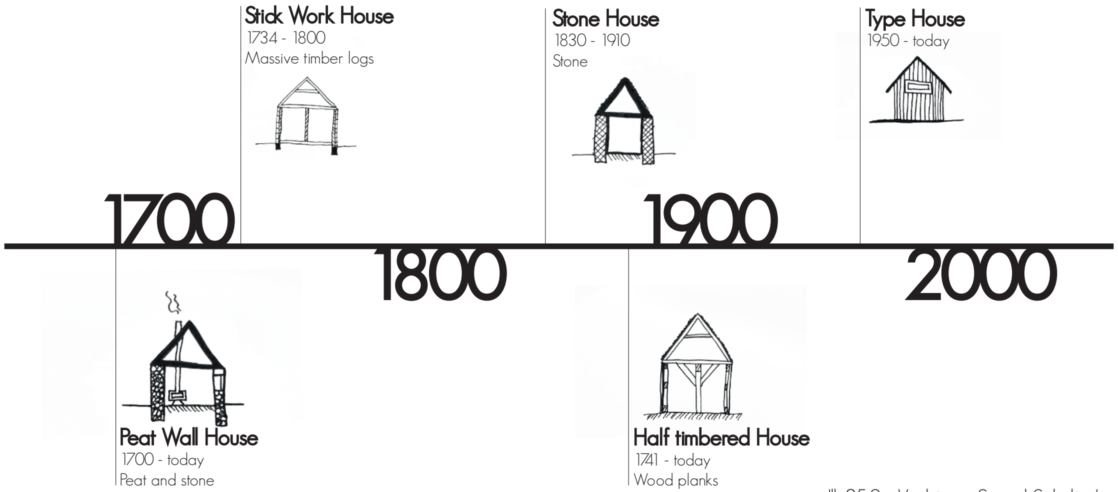
In 1953 the government began to supply Greenland with prefabricated housings from Denmark, which heavily influenced the building culture. Later on, two architects, Viggo Møller-Jensen and Tyge Arnfred developed a type-house series known as " 67- Typehouse". The houses span from 35 m2 up to 120 m2 and came in different colors. Today most of the Greenlanders are living in towns or districts, in which the houses are constructed mostly of wood or bricks. The people who can't afford their own house are living in concrete blocks of flats, which are varying in quality, but most newly build blocks are of Danish modern standards (Vadstrup, S. and Schultz-Lorentzen, H., 1993).

PEAT WALL HOUSE

This building type contains a mix between peat and stone. It originates from the Eskimos, in the beginning of 1700. The houses are built into the surrounding terrain, which limits the number of directions where they need to shelter themselves from the weather. The building style is still in use today, although in a smaller extent as they are known for having a bad indoor climate (Vadstrup, S. and Schultz-Lorentzen, H., 1993).

STONE HOUSE

Similar to the building type of the Peat wall house, but the peat wall is replaced with a stone wall. There is only a limited number left in Greenland as most have been demolished(Vadstrup, S. and Schultz-Lorentzen, H., 1993).



Ill. 35.2 - Vadstrup, S. and Schultz-Lorentzen, H., 1993.

STICK WORK HOUSE

This building type consist of massive timber logs which are placed vertically together to obtain a closed climate envelope. The benefits of this construction principle are that it is easy to disassemble and transport to a new location. Furthermore, the material has a high durability and could be reused in later buildings (Vadstrup, S. and Schultz-Lorentzen, H., 1993).

HALF-TIMBERED HOUSE

This building type replaced the Stick work house and contained a layer of up to three wooden planks, which obtained a more closed envelope. This building type is still in use today, although it's been modified several times since the original(Vadstrup, S. and Schultz-Lorentzen, H., 1993).

CONCLUSION

Building materials should be disassembled and reusable for future use. Also be aware of bad indoor climate, caused by the closed envelope.

Case study - The Blue Church

In 1771 the citizen of Sisimiut ordered The Blue Church due to their economic success on hunting in the seas. The church was made in Denmark as a building kit and transported by ship to Greenland, where it was raised in 1775. Until 1926 The Blue Church functioned as a church, but after a new church was established, the function of the building changed to be a school and storage.
The construction is made as stick work and the fundament is placed on the terrain. After central heat was distributed in the town near the roads of the church, the church's fundament began to sink due to the melting of permafrost in the ground. The fundament has since undergone a renovation and the church is now placed on metal beams. In 2016 the church went through a total renovation and is now under the Sisimiut museum. The centre now offers cultural facilities. Although it is over 200 years since its erection it is still an important part of the community and is today still in function with a lot of the original materials still intact (Byggefilm.dk, 2018).

Ill. 36.1 - Photo by Thomas H. Jørgensen, Faglig Museumsassistent, Sisimiut Museum/Kangerlussuaq Museum

CONCLUSION
The Blue Church has been able to adapt to new functions over the time. The reuseablity of the centre should be considered for the future. Futhermore it is important to consider the permafrost which will change the fundament dramatically if heated up.

Ill. 37.2 - Photo by Thomas H. Jørgensen, Faglig Museumsassistent,
Sisimiut Museum/Kangerlussuaq Museum

Case study - Svalbard Science Centre

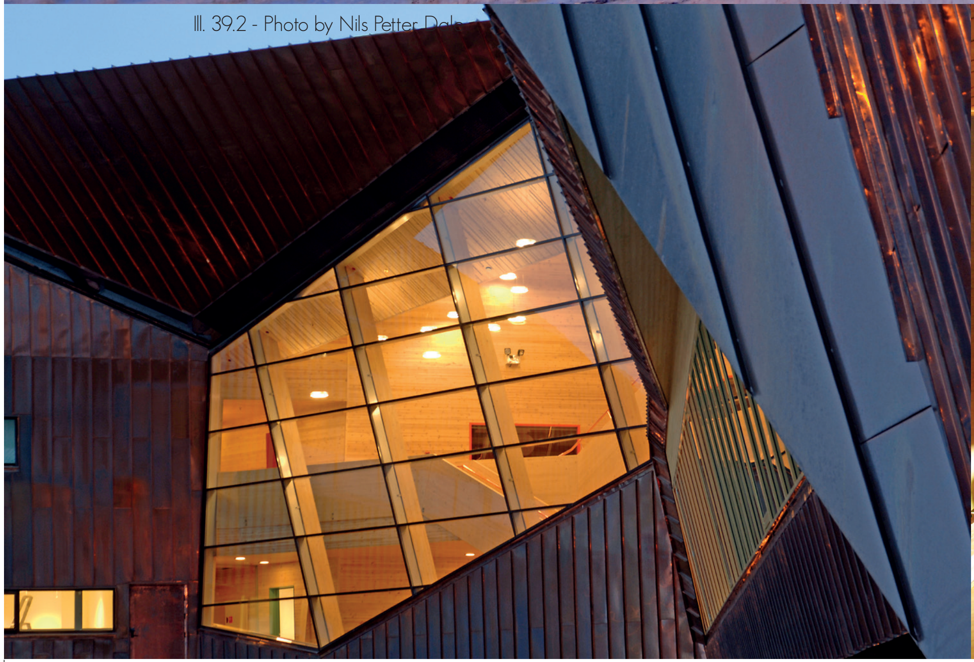
The Svalbard Science Centre by JVA architects is situated in a Norwegian island group in the arctic climate. The centre is an extension of the existing university and research building. The architect's vision was to create a common public space where people would stop by and relax.

The outside of its envelope has a copper clad skin which is formed to lead the snow away from window and doors. The shape is based on CFD analysis, that could predict the accumulation of the snow as used as a design parameter to avoid snow in unpleasant places. The envelope of the building is raised on pillars, so the heat from the building doesn't melt the permafrost and thereby disrupting the surrounding ground. The interior of the centre is clad with timber, and all materials within the building are chosen with the purpose of creating a warm atmosphere (ArchDaily, 2018) (designboom | architecture & design magazine, 2018).

CONCLUSION

The centre should be inspired of Svalbard centres material use for creating a warm indoor atmosphere as a contrast to the outdoors cold and dark climate. Also the fundament needs to be consider regards the permafrost.

Ill. 39.1 - Photo by Nils Petter Dale



Ill. 39.2 - Photo by Nils Petter Dale

Ill. 39.3 - Photo by Nils Petter Dale

Building practice

Snow, rain, sun, and wind is climate aspects to consider when building in Greenland. These aspects is of course the same to consider in other countries but due to the arctic environment these aspects can have significant influence. The roof is exposed to all of the factors and in the Greenlandic building regulations it is pointed out, that a roof pitch should have a minimum pitch of 7 degrees. This is due to the amount of snow and heavy rain. The rain is especially important to consider due to the low temperatures, as it can cause ice formations on the roof. In Denmark, gutters are often used to lead the rain. This is however not a normal practice in Greenland because of the temperature variation which destroys the gutters(Byginfo.gl, 2018). The current building regulation is from 2006 and is, due to the climate variation from north to south, divided into different zones which regulates the energy frame to the different zones. Ilulissat is located in zone 2 which allows a higher amount of energy pr. m2, than zone 1. The minimum U-value requirements for the envelope is equal to the ones from the danish BR18, while the requirements for windows and external doors are not as strict as in the danish BR18 (Bygningsreglementet.dk, 2018) (Byginfo. gl. ,2018).

Keyfactors

7°
Minimum pitch

Low
Temperatures can
cause ice formations on the roof.

Gutters
Are usually not used in Greenland

Foundation
Should not heat up the terrain if would
cause an unstabil fundament

Ill. 41.3 - Photo by Thomas H. Jørgensen, Faglig Museumsassistent, Sisimiut Museum/Kangerlussuaq Museum

Ill. 42.1 - Glacier

2

Visitor centre

Competition brief

This thesis is based upon an architectural competition brief for an Icefjord centre in Ilulissat from 2015. The competition project partners and clients are the Government of Greenland, the municipality of Qaasiutsup and Realdania.
The purpose is to develop a centre which communicates the effects of the global warming through exhibitions. Furthermore, it should accommodate conference rooms, tourist information, cafe and research facilities.
The location of the project is placed between Ilulissat and the Icefjord in an attempt to bring the nature and the town closer together.
The architecture should be humble to the surrounding nature and create only a small footprint on the earth, achieved by a sustainable approach. Furthermore, the architecture should be of high aesthetic value on an international level. The centre should enhance a wide range of people all from locals to tourists of all kinds. It should further bring development to Ilulissat by increasing the amount of tourists and by creating a local gathering place (Realdania, the government of Greenland and Qaasuitsup municipality, 2015).

Ill. 45.1 - Photo by Jens V. Nielsen, Courtesy Realdania

Case study -Wadden Sea Centre

The centre opened in 2017 with a new extension to the former centre. The new centre contains exhibitions, administration, shop, cafe, and more. The centres vision is to be the gate pass for "The Wadden Sea" which is on the list of Unesco World Heritage sites and also Denmark's largest national park with a very flat terrain. The architect behind the centre is Dorte Mandrup. She won the competition back in 2004 over four other pre-qualified participants (Arkitektkonkurrencerdk.dk,2018). The exhibitions communicate information about the surrounding nature and animals through both interactive and passive displays. The architecture of the centre is humble to the surrounding landscape and provides, by means of a centre courtyard, a shelter against the wind.

The thatched roof and walls, enhance the colors of the surroundings and provides a long life span despite being exposed to the high amount of salt in the air. In the exhibition area, a wide range of skylights are implemented to offer the rooms indirect daylight. The brightness of the artificial light combined with the daylight and bright white walls contributes a well-balanced amount of lighting, that makes the room pleasant and don't take the attention away from the exhibitions. The artificial lights are mostly used as subtle, reflective lights on the walls, but some are also a part of the exhibition and are placed so they mimic birds sitting on branches. The lights are also used to create contrasts around the different displays, for the visitors eyes to be drawn towards them. In 2017 the "The Wadden Sea Centre" was the winner of the Danish Lighting Price due to its sensitive storytelling and incredible light setting(Visit Ribe) (Dansk Center for lys, 2017). There is however a lack of focus on the arrival and the café area, which clearly has been budgeted. You do not feel welcomed at the arrival, as you are immediately crammed between the sliding doors and the counter. This also results in restricted access to the café area and the shop, which deflects the customer base who are only there for the café.

CONCLUSION:
The visitors centre reflects the surrounding landscape through the architecture as well as its intermediary. The arrival area needs to be considered in the center so the cafe area can be used without entering the exhibition.

Ill. 47.1 - Photo by Adam Mørk ,Vadehavscentret, Dorte Mandrup.

Ill. 47.2 - Photo by Adam Mørk ,Interiør Vadehavscentret, JAC studios.

Ill. 47.3 - Photo by Adam Mørk ,Vadehavscentret, Dorte Mandrup.

Ilulissat Icefjord

Ilulissat Icefjord is on the list of UNESCO's World Heritage sites as one of the three sites that were first to be accepted in Greenland. The site is approximately 4,000 km2 and is a protected area to conserve its unique nature and glaciology. Within the site is the Sermeq Kujalleq which is the largest and most producing glacier in Greenland. Sermeq Kujalleq is moving 19 meters a day and is accountable for 10 percent of the icebergs that are produced from the ice cap. The icefjord is ideal for hunting and fishing due to the high amount of nutrients which have made it possible for people to live in the area for centuries. The area around the Icefjord has a special value for research work, as the impacts of the climate change are very visible when looking at a year to year study, as the glacier in the last 15 years has pulled more than 12 km back. Furthermore, it is possible to study how the ice has been affected the world events many centuries back (Geus.dk, 2018).

CONCLUSION:
The centre should amplify the already visible climate change.

Ill. 49.1 - Photo by Jens V. Nielsen, Courtesy Realdania

Tourism

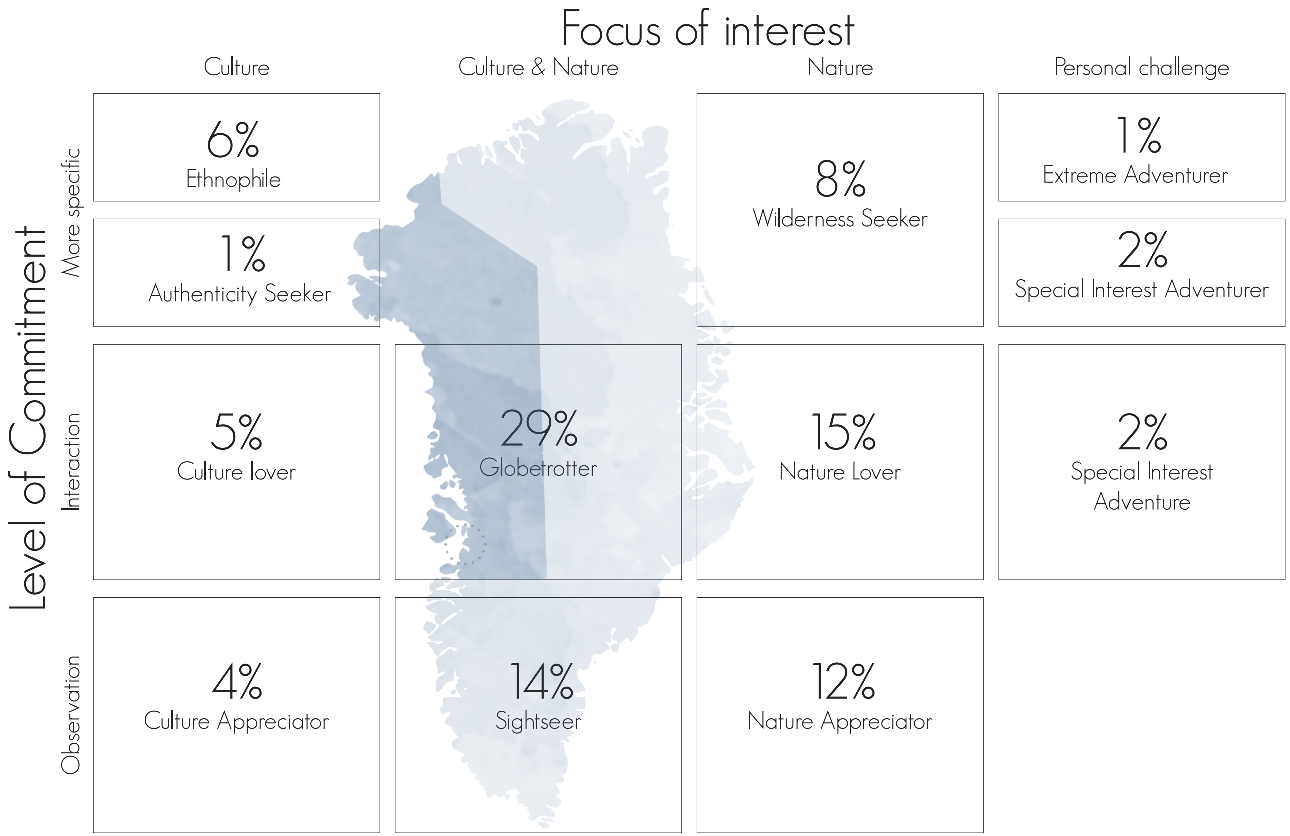
Every year around 120,000 tourists visits Greenland and about 30.000 of them arrives in Ilulissat. From 2008 - 2014 the amount of tourists traveling to Greenland decreased, but is in 2017 peaking with the highest number of tourists ever(Stat.gl, 2018). They typically arrive by cruise ships or airplane, which is often included in a package deal, where the majority is arriving by air. The primary group of tourists are from Denmark and the rest of Scandinavia. The tourists can be divided into different segments:

The primary tourists for the area around Ilulissat is the Globetrotter, Nature lover and Nature appreciator. The globetrotter is one of the most common tourists in Greenland and is used to travel around the world and often wants a little bit of everything Greenland has to offer from local culture to attractions.

The Nature lovers are active every day which is reflected in their holiday activities, where they love to be close and interact with the nature.

The Nature appreciator is traveling with a specific natural wonder in mind, they do not want to actively engage with the site but would rather take a picture from a distance (Tourismstat.gl, 2018).

CONCLUSION:
Centre should accommodate a range of tourist, with different wishes and level of interest.



Ill. 51.1 -Tourismstat.gl, 2018.

Ill. 52.1 - Glacier

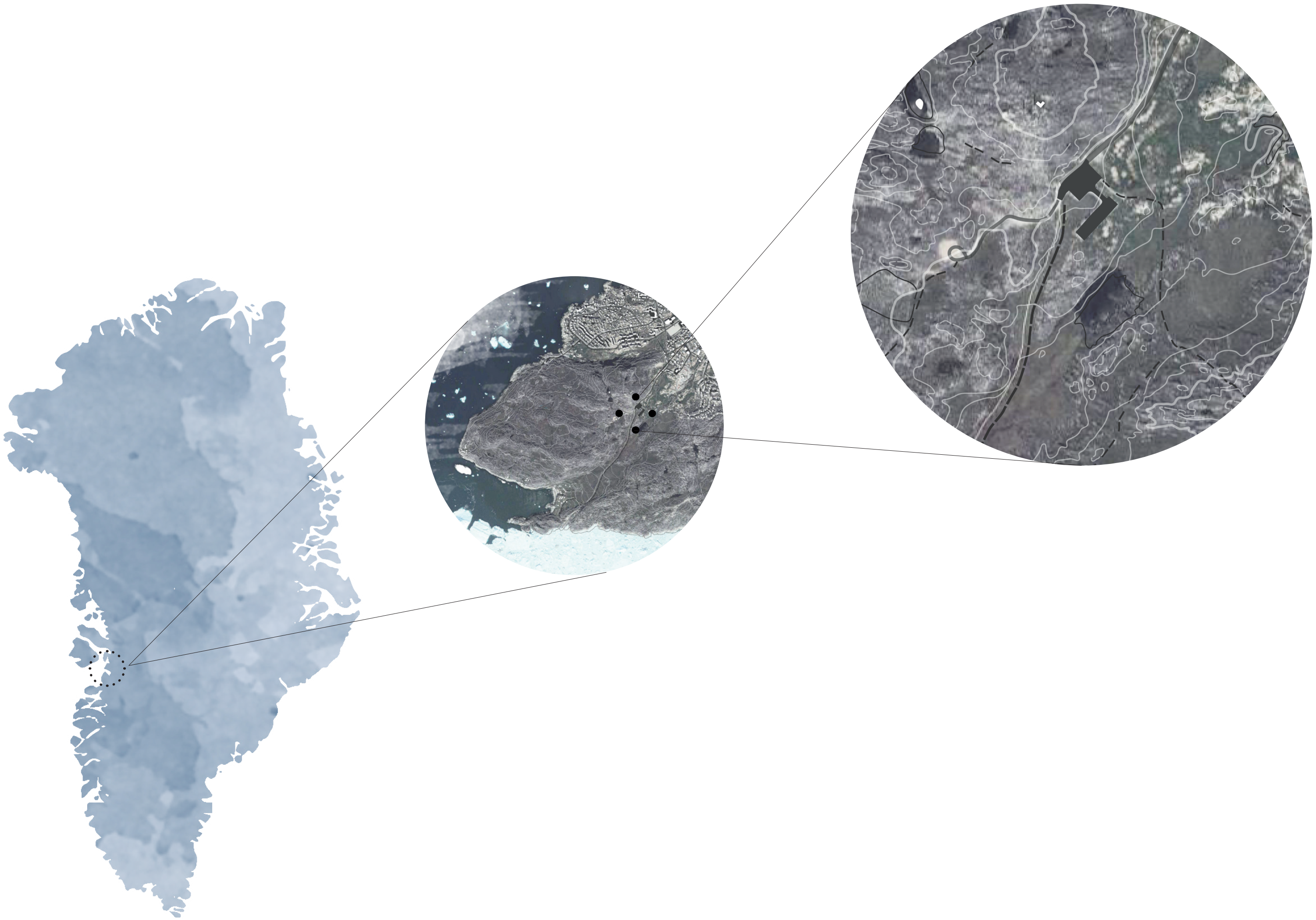
3

ILULISSAT

Ilulissat Town

Ilulissat was established in 1741 and called "Jakobshavn" in Danish. The city is inhabited by approximately 4,500 inhabitants which makes it the third largest city in Greenland. Ilulissat is a part of the Qaasuitsup municipality which is geographically dispersed and is the world's largest municipality in terms of area. However, most of it is covered by the ice cap(Qaasuitsup.gl, 2018).

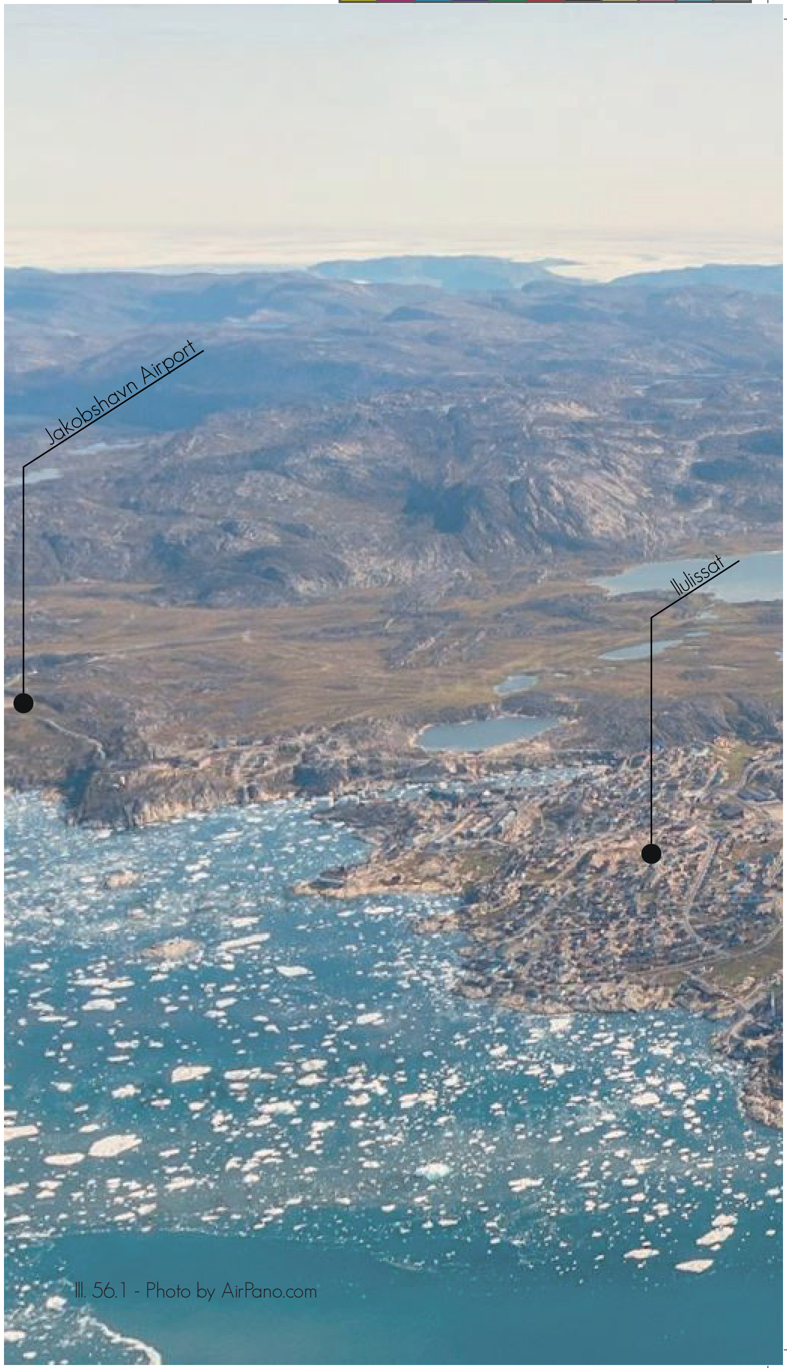
The citizen's income is primarily based on tourism and the fishing industry. Within the city, there are three shops, one hostel, an art museum, a small local museum, two Royal Greenland factories, a cemetery, and a maritime school. The main tourist attraction for the area is the Icefjord, which is reflected in the cities name, as Ilulissat is the Greenlandic term for an Iceberg (Denstoredanske.dk, 2018).



Ill. 55.1 - Diagram of Ilulissat

Infrastructure

Ilulissat can be reached either by sea or by air, as there is a local airport.
From the city centre and out to the airport is approximately 3.5 km. The roads within Ilulissat are simple and without pavement. The inhabitants are primarily moving around by foot but most have access to a car. The other primary transportation method to move through the rugged landscape of Greenland is by sled dogs. The sled dogs are a characteristic form of transport in Greenland. Ilulissat contains approximately 3,000 sled dogs which are almost the same amount as inhabitants in the city (Realdania, the government of Greenland and Qaasuitsup municipality, 2015).



Ill. 56.1 - Photo by AirPano.com


Competition Site
Sermermiut Settlement
Ilulissat Icefjord

Project location

The project site is located at the main arrival to the UNESCO World Heritage site and are used as a buffer zone to ensure that no activities are held too close to the site and thereby secure the views from the protected area. The site is the former heliport access to Ilulissat, and is placed next to a small lake named Sermermiut, which is named after the first settlement in the area inhabited by the Saqqaq people, who were a part of the original inuits. There are still traces of the old settlement near the icefjord.

The Icefjord Centre has been part of the plan for the area for several years, and was published in the local plan for the area in 2009. It was however published with a different sketched project, which was also supposed to be a centre with an exhibition, but not in the same scale as the later international competition set the stage for.

Today the old heliport site is used as the gateway to the 3 official routes that passes through the heritage site. Two of the sites are primarily nature paths, with only small portions which is landscaped to ease the accessibility. The third path is following the glacial valley and is a wood covered path, which is made to protect the fragile environment along the path. The path is leading to the old Sermermiut settlement placed next to the icefjord (Real Dania, the government of Greenland and Qaasuitsup municipality, 2015) (Qaasuitsup-kp.cowi.webhouse.dk,2018).

Ill. 59.1 - Photo by Jens V. Nielsen, Courtesy Realdania

Photographic notation

Photo A Ill. 60.1 - Photo by Google street view

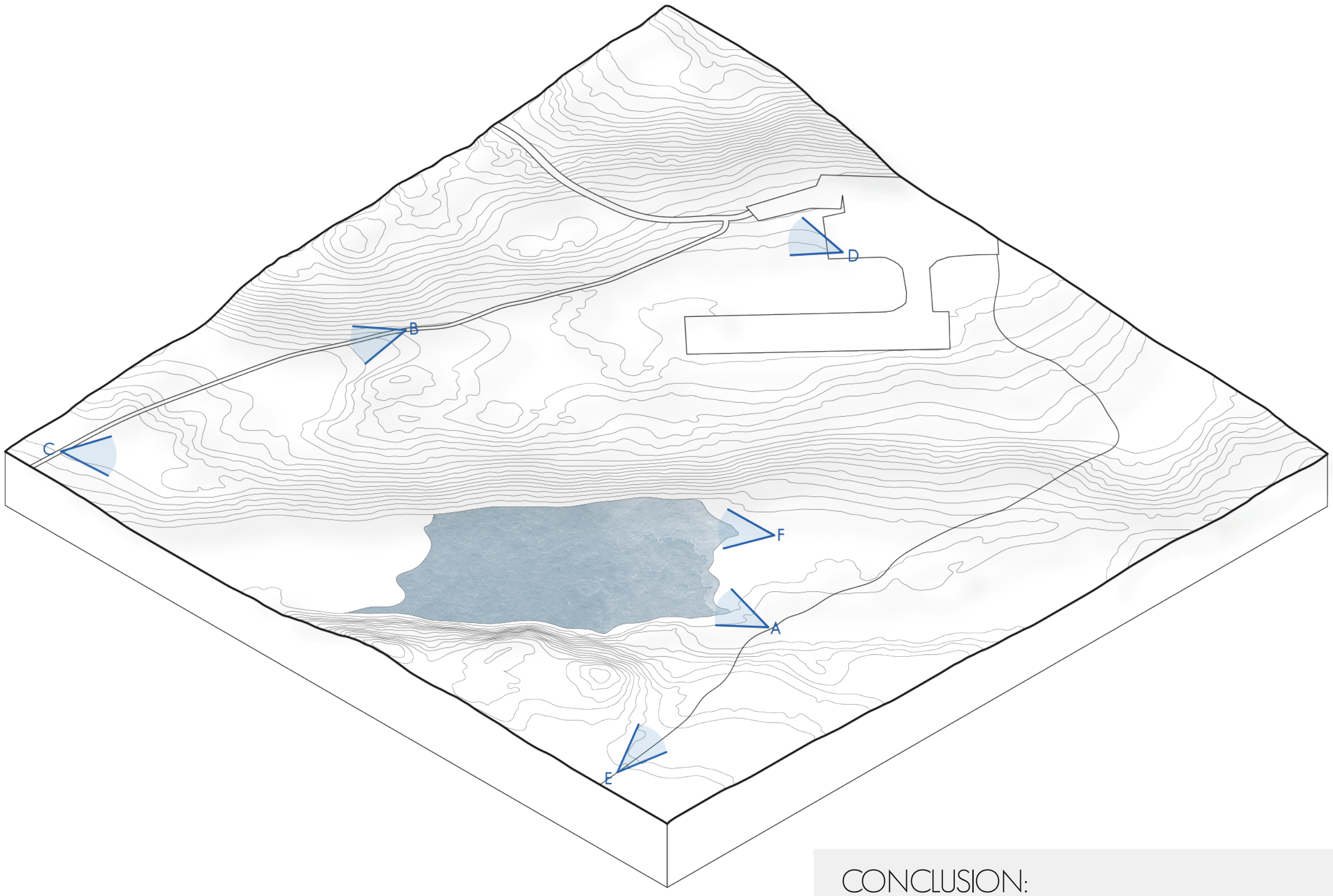
Photo B Ill. 60.3 - Photo by Google street view

Photo C Ill. 60.5 - Photo by Google street view

Photo D Ill. 60.2 - Photo by Google street view

Photo E Ill. 60.4 - Photo by Google street view

Photo F Ill. 60.6 -Photo by Jens V. Nielsen, Courtesy Realdania



Ill. 61.1 - Diagram of site

CONCLUSION:
The building should embrace the natural framing in the landscape.

Terrain & Geology

The surrounding area of the site is mainly consisting of precambrian bedrock, exposed through eradication of former glaciers. The centre of the site is a former glacial valley, which was created because the bedrock in that area was more fragile than the surrounding bedrock. The many glacial striations around the site is a visual reminder of how the site came to be, and can be seen on the spatial bedrock in the valley area. It's glacial past can also be seen by the many boulder ridges which is located between the site and Ilulissat Isfjord (Weidick, A. and Bennike, O., 2007).

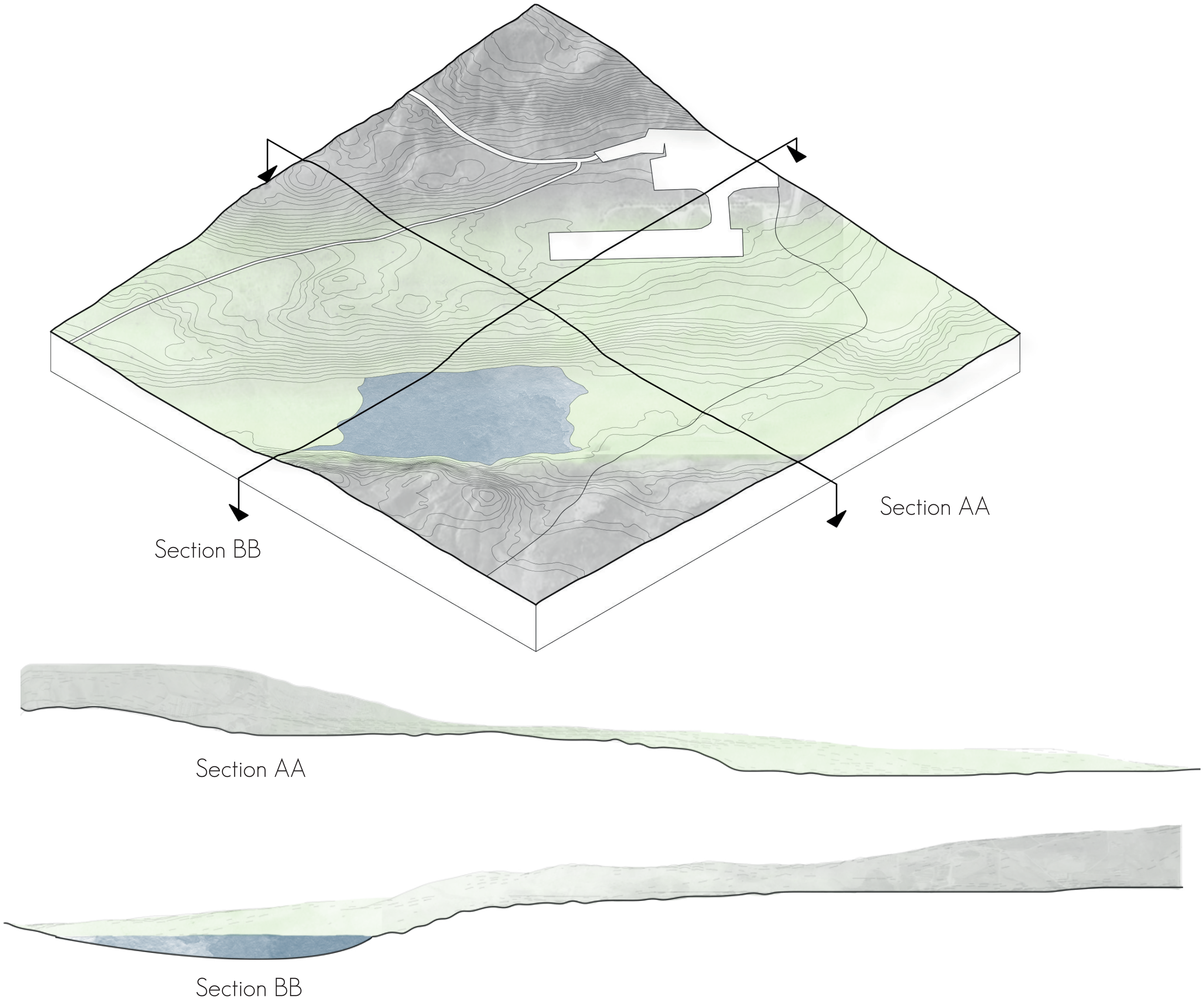
The former glacial valley is today a sedimentary basin filled with a water depot and silt-rich till. The silt-rich till is normally seen as a stable building platform, as it sits firmly on the bedrock (Gravesen, P. and Kelstrup, N,2001). This is however not the case in the arctic environment as permafrost can have a huge impact on the soil. The permafrost in Ilulissat is continuous, which ensures that the whole area is affected by it. The permafrost in silt-rich till, is often containing pockets of ice, which can cause large disruptions on the surface if the ice is melting in the summertime (Ingeman-Nielsen, 2007). This is especially a problem, as the permafrost is melting deeper for each year due to climate change, and are thereby releasing new pockets of ice, changing the landscape each time.

In places similar to the site, buildings are often constrained to the bedrock either directly or by piloting, as the melting of the permafrost doesn't disrupt the rock. Furthermore there are examples of buildings which is piloted a minimum of 15 m into the ground, as the melting of the top layers doesn't affect the permafrost at that depth.

CONCLUSION:

The centre should pursue a foundation which is anchored in the bedrock.

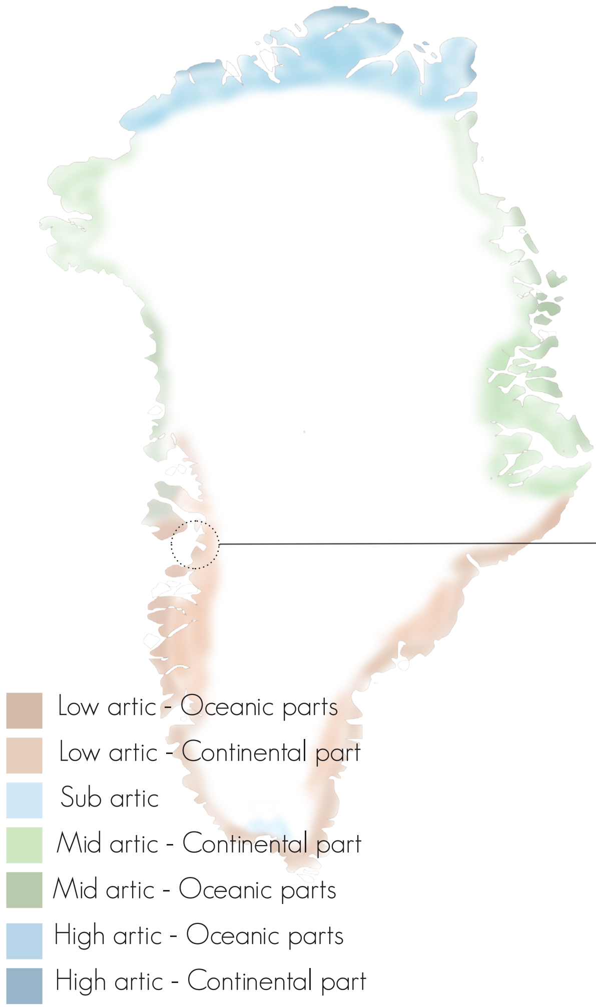
There should be a limited heat transfer between the building and the permafrost.



Ill. 63.1 - Diagram of vegetation

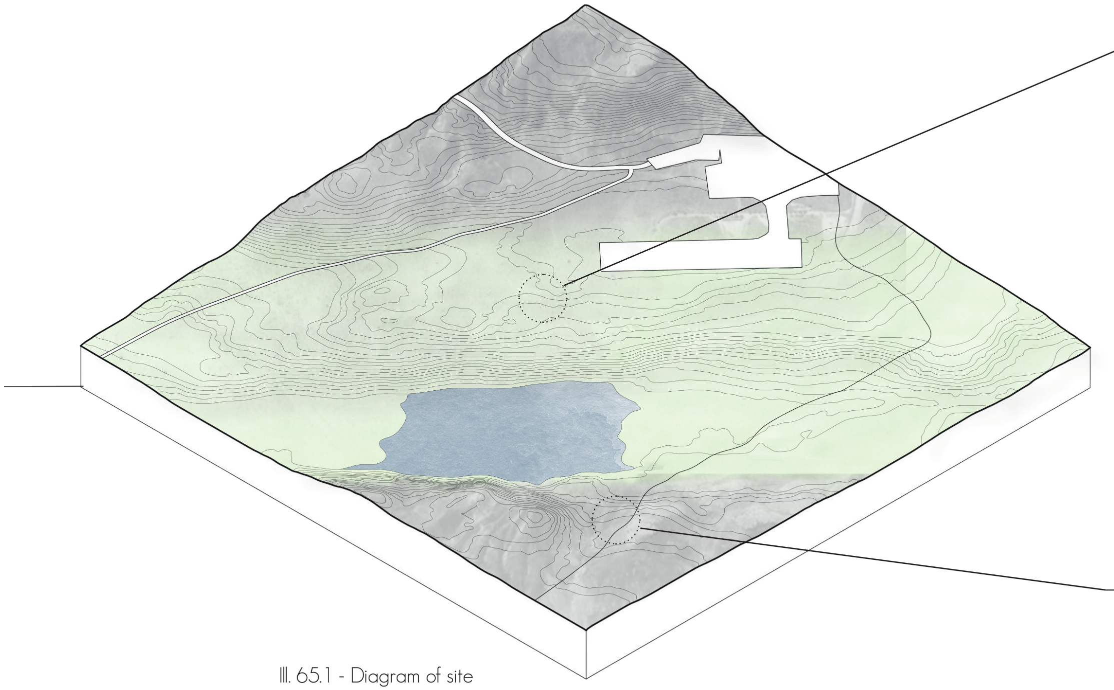
Vegetation

Ilulissat is surrounded by mountains and has a limited vegetation, as it is not possible to grow a forest within Greenland due to the extreme weather conditions. Greenland is in the arctics zone and is subdivided into high artics and low arctics. The area of the project site is located in the mid arctic which influences the amount of plant types which can grow in the landscape. The most plants grow in the river valleys, where more than 160 flowers grow, due to the increased amount of soil. In the rocky areas, it is mostly different species of fungus which grows. The height of the vegetation barely reaches more than a half meter above ground. In most moist environments of the Icefjord, it is, however, possible for the Willow Scrub to grow up to one and a half meter. Some of the plants are been used in the kitchen and served. But today it is not as important than previous because a lot of vegetables and fruit is been shipped from Denmark to Greenland (Velkommen til Ilulissat isfjord, 2018) (Geus.dk,2018).



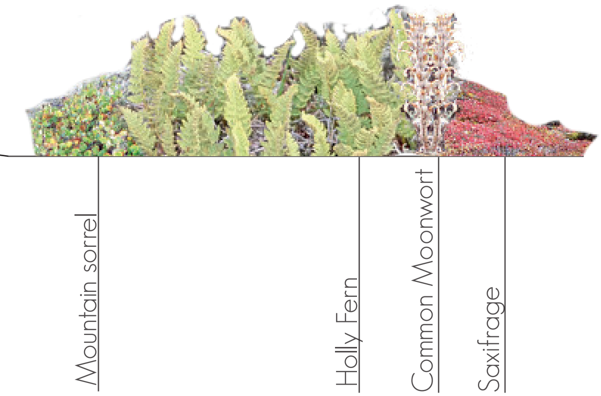
Ill. 64.1 - Geus.dk, 2018.

CONCLUSION:
There is a limited amount of vegetations, so it is important to protect them from the huge amount of visitors visiting the site.

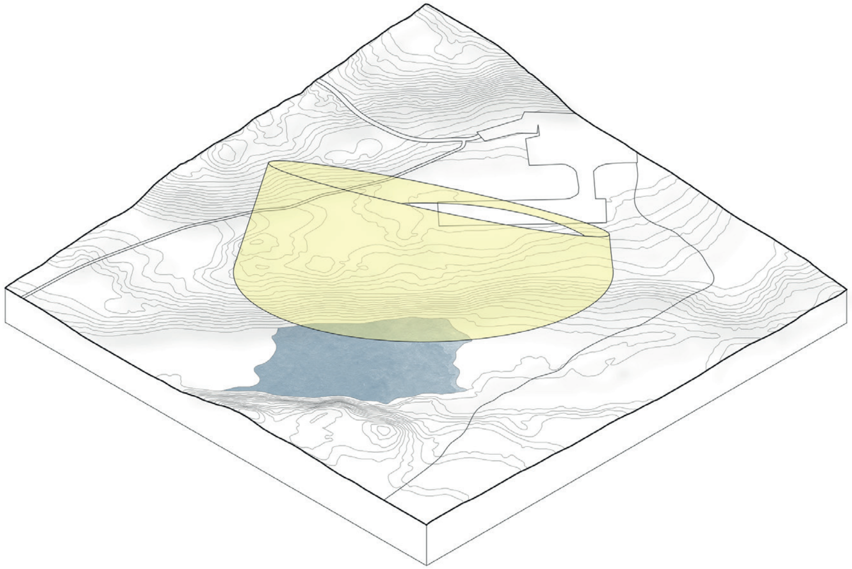


Ill. 65.1 - Diagram of site

Ill. 65.2 - Photos by Jakob Lautrup, GEUS



Ill. 65.3 - Diagram of vegetation



Ill. 66.1 - Sun path

Ill. 66.2 - Yearly sun

Microclimate - Sun

The majority of the Greenland area is placed above the arctic circle, which means that the sun does not rise above the horizon in the winter period (Nov-Feb), contrary to the summer period (May-Aug), where the sun never sets. The roof of the building needs to be designed to avoid complication with shadows causing accumulation for the ice (Byginfo.gl, 2018).

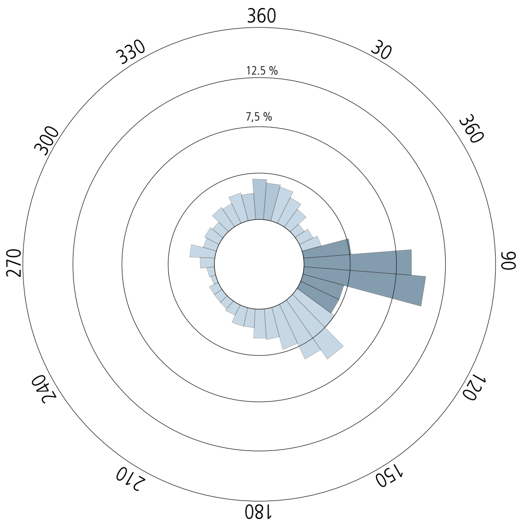
Daylight and the lack of it, is important for the optimal function of the human body, but there is several aspects to daylight, that all affect the human body differently.

In this report they are divided into three different categories: Vitality, Comfort and Emotion.

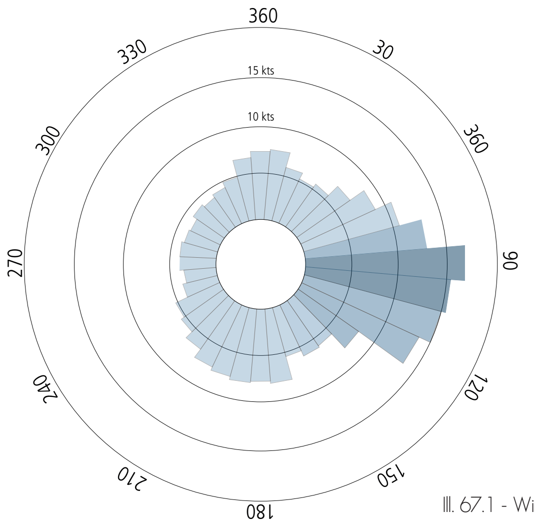
These categories are based on Oculight Research (Daylight OCULIGHT dynamics, 2017).

CONCLUSION:

The building form should not leave an area in full shadow during a day. The building windows should be oriented so they affect the inhabitants most optimal.



Frequency by Direction



Average Speed by Direction

Ill. 67.1 - Windhistory.com, 2018.

Microclimate - Wind

The Greenlandic Ice sheet is the main contributor to the wind in Ilulissat. The cold air from the ice sheet is causing a high pressure over Greenlands inland (Europas-lande.dk, 2018). The high pressure is pressing the wind out to the coastal areas which is why the dominant average wind, measured from a station in Jakobshavn (Ilulissat) airport, is coming from East. The average speed of the wind is above 7,7 m/s (Windhistory.com, 2018), characterised on the beaufort scale as wind where smaller branches would be affected (Dmi.dk, 2018). In longer periods of time it is not unusual that there is no wind. Denmark is generel more windy than Greenland.

In the winter period the high speed of the winds and the low temperatures, can cause a windchill that feels as almost double as cold (Visit Greenland, 2018).

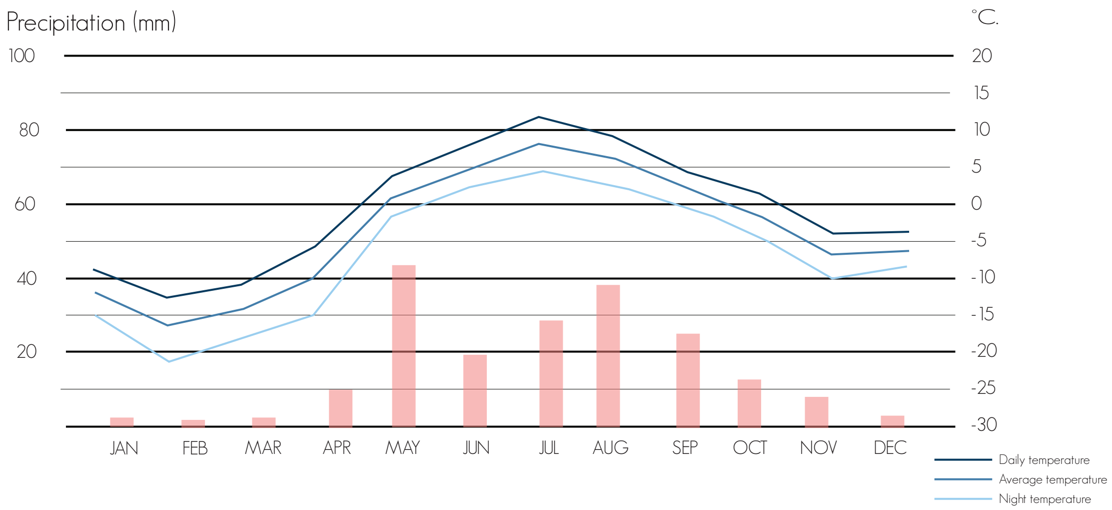
CONCLUSION:
Outdoor areas and building openings should be sheltered from the eastern wind.

Precipitation and temperature

The city of Ilulissat is located in the southern part of the Arctic climate zone, which is defined as the average temperature of the warmest month is below 10°C.
Ilulissat is located on the west coast of Greenland and is therefore highly affected by the temperature of the surrounding sea, which works as a heat accumulator, and is thereby minimizing the temperature fluctuations caused by the arctic sun pattern. The climate is also affected by the ice cap that covers 80% of Greenland, which reflects 90% the sun radiation and thereby keeping it's cool temperature all year (Denstoredanske.dk,2018).
The daily temperature is very static during the winter and summer months, as the sun exposure is almost equal throughout the day. In spring and autumn, the daily temperature is following the sun pattern.

In Greenland the precipitation measurements are limited (Dmi.dk,2018). The precipitation varies greatly throughout Greenland where the south gets the most, while the northeastern part gets almost none.
Ilulissat is receiving an average of almost 250 mm per year which is about a third of the annual precipitation average in Denmark(DMI, 2018).

CONCLUSION:
The daily variation of temperature is quite static, and can in winter time reach under 20 degrees minus.



Ill. 69.1 - Mit rejsevejr & DMI vejrarkiv

Ill. 70.1 - Glacier

4

Programme

Users

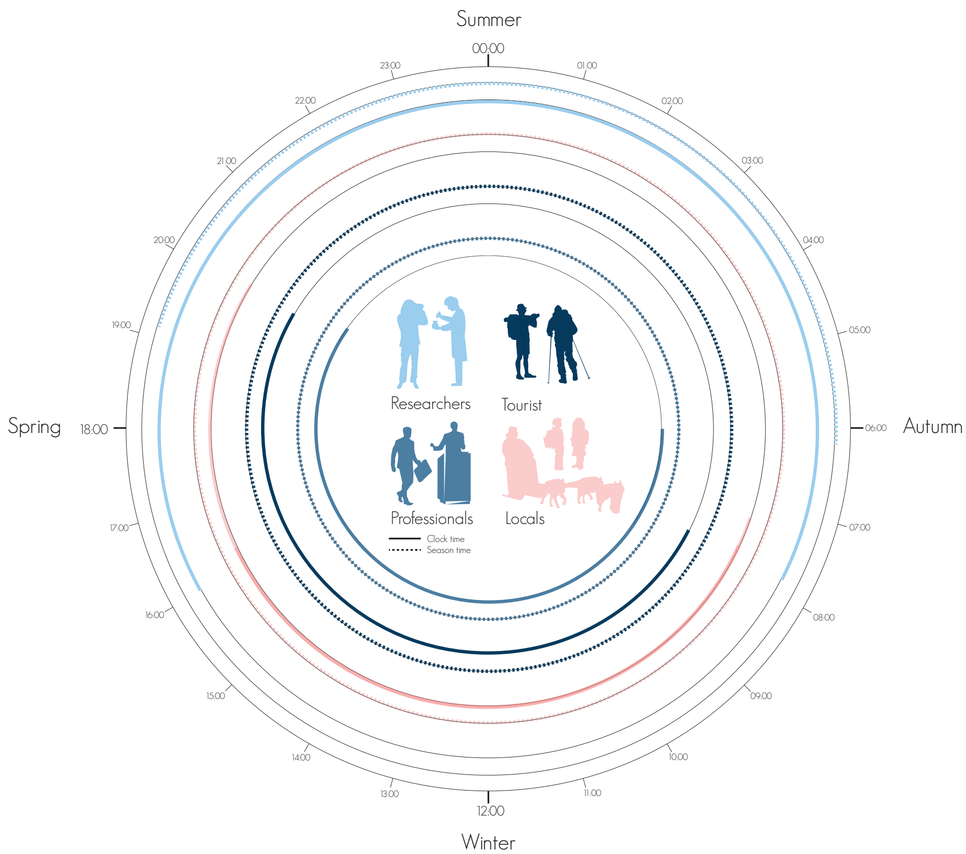
Targets groups/ User Group
The Icefjord centre should accommodate a wide range of users with different purposes and needs.

LOCAL RESIDENTS
Would use the centre as a break stop before visiting the Ice Fjord and use the cafe, facilities and as a meeting place for the local community. The centre is also going to host regular and special events, for both adults and children. Furthermore, it would also have a collaboration with the local's school for activities with a focus on the local nature. The light setting should enhance the feeling of a cozy nest, and thereby impetus the feeling of being part of a group .

RESEARCHERS
Primarily works outdoors in the area and spends a few weeks at the site. The Icefjord centre will contain the field station and provide the researchers with possibilities to accommodation, cooking facilities, workshops area, networking with other researchers, tests, research, and storing equipment.
The field station's focus is to bring all research elements of the area to one primary station.
As most of the researchers come from different countries, it's also an opportunity for them to communicate and share their research with colleagues as well as the other user groups. The research facilities should be equipped with different light settings, in which the workplaces should consist of well-lit spaces in order to increase productivity, while the sleeping quarters should be moody in order to make the inhabitants relax.

PROFESSIONALS
The centre should attract climate debaters, business people and other professionals to enhance the global climate debate in the highly affected area of the Ilulissat Ice Fjord. It should, therefore, facilitate the needs of a small conference centre with both auditorium and meeting room. The conference area should accomodate a wide range of light settings; The presentation area needs to be completely shaded, while the lighting of the informal meeting areas should consist of both cozy and focused light to gather the participants. Furthermore, they need well-lit workspaces, in order to increase productivity.

TOURISTS
The tourists are the primary user group, where the centre is to articulate through its exhibition and work as a resting place before and after they continue to the icefjord. The typical types of tourists are the Scandinavian sightseers, globetrotters, adventure tourists, elderly people and culture tourists.



Ill. 73.1 - User schedule

The centre should enhance all varieties of tourists and offer the needed tourist information. A moody light in the entrance, cafe- and shop- area should lure the tourist inside from the cold. In the exhibition, the light should enhance the different displays, and create an interesting and alluring effect throughout the exhibition.

STAFF

The staff keeps the centre running. The staff needs to be provided with good facilities as private toilets, cloakroom and tea kitchen. All staff of the centre uses the same facilities to strengthen community within the centre. The staff needs well-lit workplaces, in order to increase their productivity. The staff is available in the opening hours of the centre.

Room Programme

ARRIVAL/PARKING
The parking area should contain 20 parking spots and a zone for a bus stop. The arrival should be met with a welcoming atmosphere drawing the visitor into the centre. The arrival should take the disabled into consideration and provide a step-free access to the centre and World Heritage Trail.

ENTRANCE/FOYER
Has to function as a distribution area for facilities such as toilets, cafe, and shop. The entrances should ensure easy circulation between the offices, exhibition areas and the shop for the staff.

SHOP / TOURIST INFORMATION
Here the visitors are being informed of the exhibitions, possible tours in the area, and general tourist information. Furthermore, it might contain a small exhibition, which should serve as a teaser for the bigger exhibition area. The area should also be used as a shop, where souvenirs, books, and merchandise can be bought. It's important that there is a close connection between the shop and the information desk, so one person can operate them both, in low-season.

EXHIBITION AND INTERPRETATION AREA
The exhibition area is to host three different exhibitions, with the possibility to install both permanent and temporary installations. The surrounding site area should contribute to the storytelling of the exhibition. Therefore, it is necessary to provide a flexible exhibition area, so even temporary storytellings can be placed within the right scenery.

CAFE, KITCHEN AND CONFERENCE AREA
The indoor area of the cafe provides the centre with 30 seatings for guests which offers the possibility to relax. The cafe should offer a menu of cold beverages, hot drinks, and meals. An outdoor area is placed in direct connection with the indoor cafe area. The outdoor area should be designed for the microclimate to be comfortable. The Kitchen should have a direct connection to both the indoor as well as the outdoor areas.

RESEARCH FACILITIES
The Research facilities are mainly used in the summer time (May-September) and are to accommodate 4 researchers, each with their own bedroom, toilet, and workstation. As researchers bring their own equipment, there's no need for a dedicated laboratory, but rather a workspace and storage space for both long- and short-term storing. As most of the equipment is heavy and not easily transported, it's important with free space and easy access.

OFFICES, ADMINISTRATION AND MEETING FACILITIES
The existing Icefjords centre will be moved over to the new Icefjords centre. The office should consist of meeting areas for

Category	Room	NO	M_2	Sum M_2 Net	Lighting Temperature K	Diffuse / Direct sunlight
Entrance	Foyer	1	20	20	2700-3000	Diffuse Sunlight
	Shop, Tourist info	1	30	30	2700-3000	Diffuse Sunlight
	Toilet	3	4	12	~3000	Diffuse Sunlight
	Toilet outdoor access	2	4	8	~3000	Diffuse Sunlight
	Cloakroom	1	10	10	2700-3000	N/A
Dining	Cafe	1	30	30	2700-3000	Diffuse / Direct sunlight
	Kitchen	1	30	30	2700-3000	Diffuse Sunlight
	Conference area	1	40	40	~4100	Diffuse Sunlight
	Auditorium	1	50	50	~4100	Diffuse Sunlight
Research	Research facilities	1	70	70	~3500	Diffuse / Direct sunlight
Administration	Offices	4	10	40	~3500	Diffuse Sunlight
	Administration	1	10	10	~3500	Diffuse Sunlight
	Meeting facilities	1	20	20	~4100	Diffuse Sunlight
Exhibition	Exhibition area	1	300	300	~6500	Diffuse Sunlight
	Storeroom	1	80	80	N/A	N/A

Net Sum	750
Net/Gross %	30%
Gross Sum	**975**

small groups, leisure rooms for the staff, and workstations for 3-4 persons.

TOILETS AND CLOAKROOMS

The centre should provide three indoor toilets of which one is for the disabled, and two outdoor access toilets. The cloakroom needs to accommodate winter clothings of up to 30 guests at a time.

STOREROOM AND SERVICE

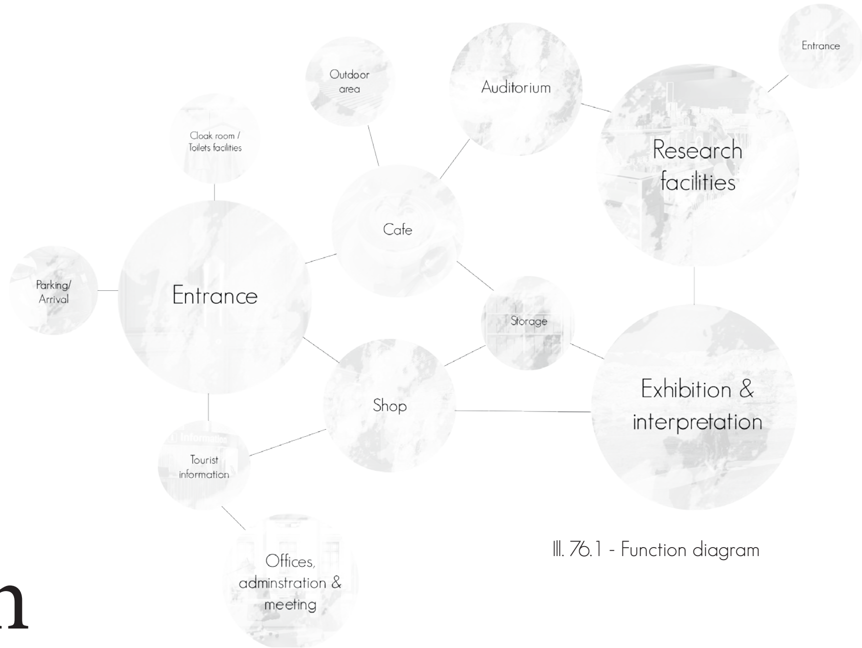
The Storerooms are used for exhibition materials, chairs and tables from the cafe, and research equipment. Everything should be easily accessible, as some might be long-term storage while others short-term.

OUTDOOR AREA

Outdoor areas for relaxation is to be placed near the entrance and the café area, so it naturally extends the two facilities.

AUDITORIUM

An auditorium is implemented in the centre to provide the possibilities for the local school children and conferences to hold lectures.



Ill. 76.1 - Function diagram

Room Distribution

When arriving at the Ilulissat centre, whether it's by car, public transport or on foot, the first welcome will be the centre's entrance.

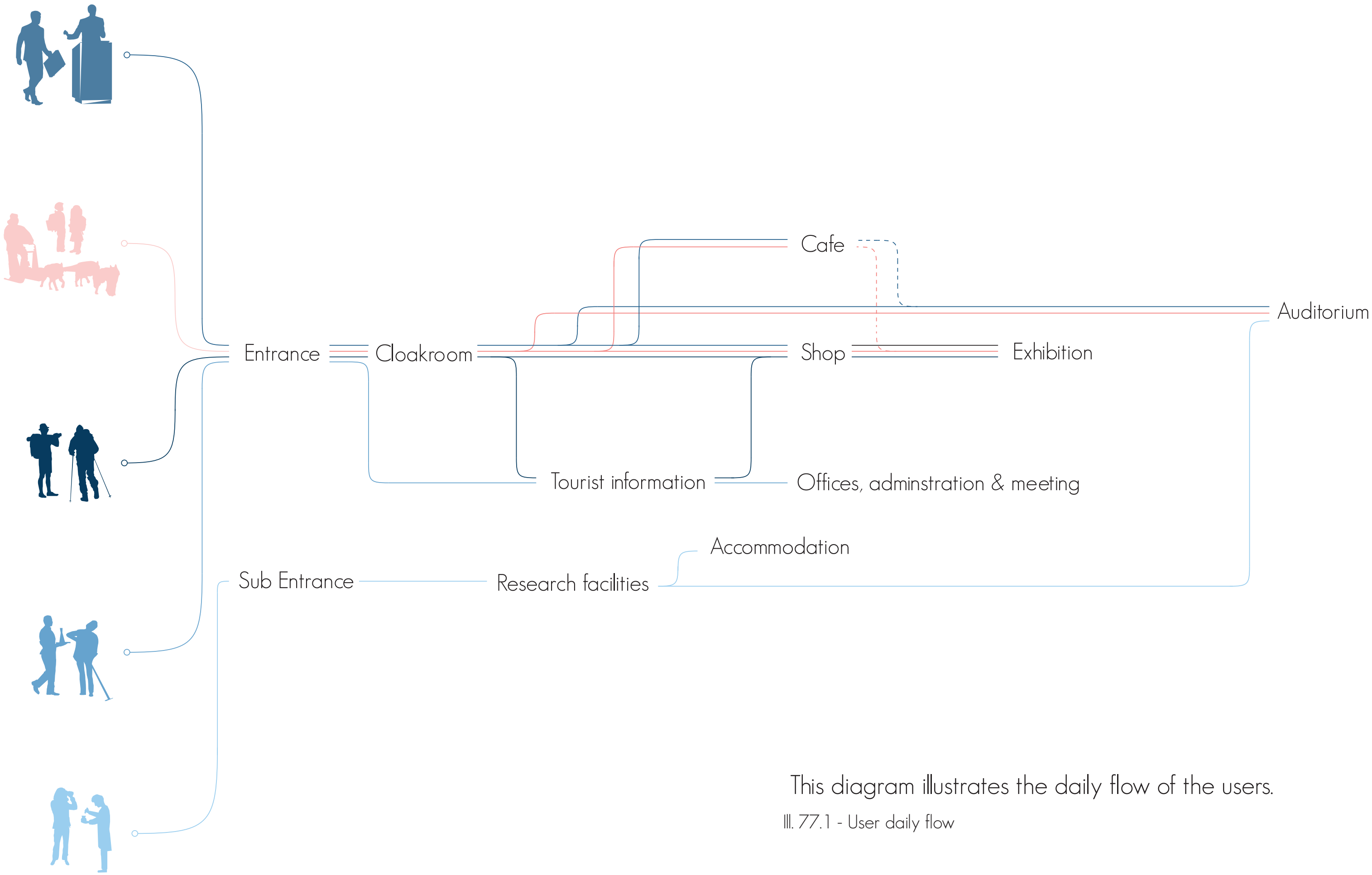
The entrance is the heart of the centre from which all service functions for the visitors are distributed. The entrance should attract the visitors to the exhibition, but it should also invite people to visit the information desk or taking a break in the cafe.

Therefore it is important that the entrance is a spatial place where visitors aren't immediately forced toward the reception.

The storerooms should be placed with easy access to and in connection with the exhibition, the shop, and the cafe.

The auditorium is placed in an extension of the cafe area, so it can be used as a relaxing place in lecture recesses.

The research facilities are connected to the auditorium and exhibition to make it easy to convey the research data. The research department is implemented with their own entrance to create a private zone for the researchers staying overnight and give the possibility of closing parts of the centre off at closing time.



This diagram illustrates the daily flow of the users.

Ill. 77.1 - User daily flow

Program conclusions

A summarization of the program conclusions is listed beneath:

LIGHT
3D light analysis
Diffuse daylight to create a calm atmosphere
Materials should enhance the light perception

CONTEXTUAL PLACEMENT
Embrace nature and its surroundings
Use the site problems as a design driver
The fundament can not be placed directly on permafrost
The fundament should be anchored in the bedrock
The building should embrace the natural framing in the landscape
Protect the existing nature
Orientation of the building should provide adequate daylight
The wind should be sheltered from the eastern wind
The building needs to withstand - 20 degree

FLOORPLAN
Articulate the importance of global warming
The interior materials should provide a warm atmosphere
The entrance area should allow guest to go straight to the cafe
The centre should accommodate the different types of visitors

SUSTAINABILITY
Building materials should fit in a standard shipping container
The building should be reuseable for future use
Energy consumption is not at highest priority

Design parameters

To start the design process, the program conclusions is merged into the following design paramters:

/Create a gathering point for a wide range of people with different interest level.

/Choosing materials based on aesthetics,environmental impacts, and material properties.

/Daylight and materials should collaborate in enhancing the perception.

/Create a 3D light analysis tool, based on Oculight Dynamic research.

/Using Nordic principles to create a building that reflects and embraces the site, its history and its problems.

/Ensure a holistic simplicity, which still fulfills all wishes and requirements.

Ill. 80.1 - Glacier

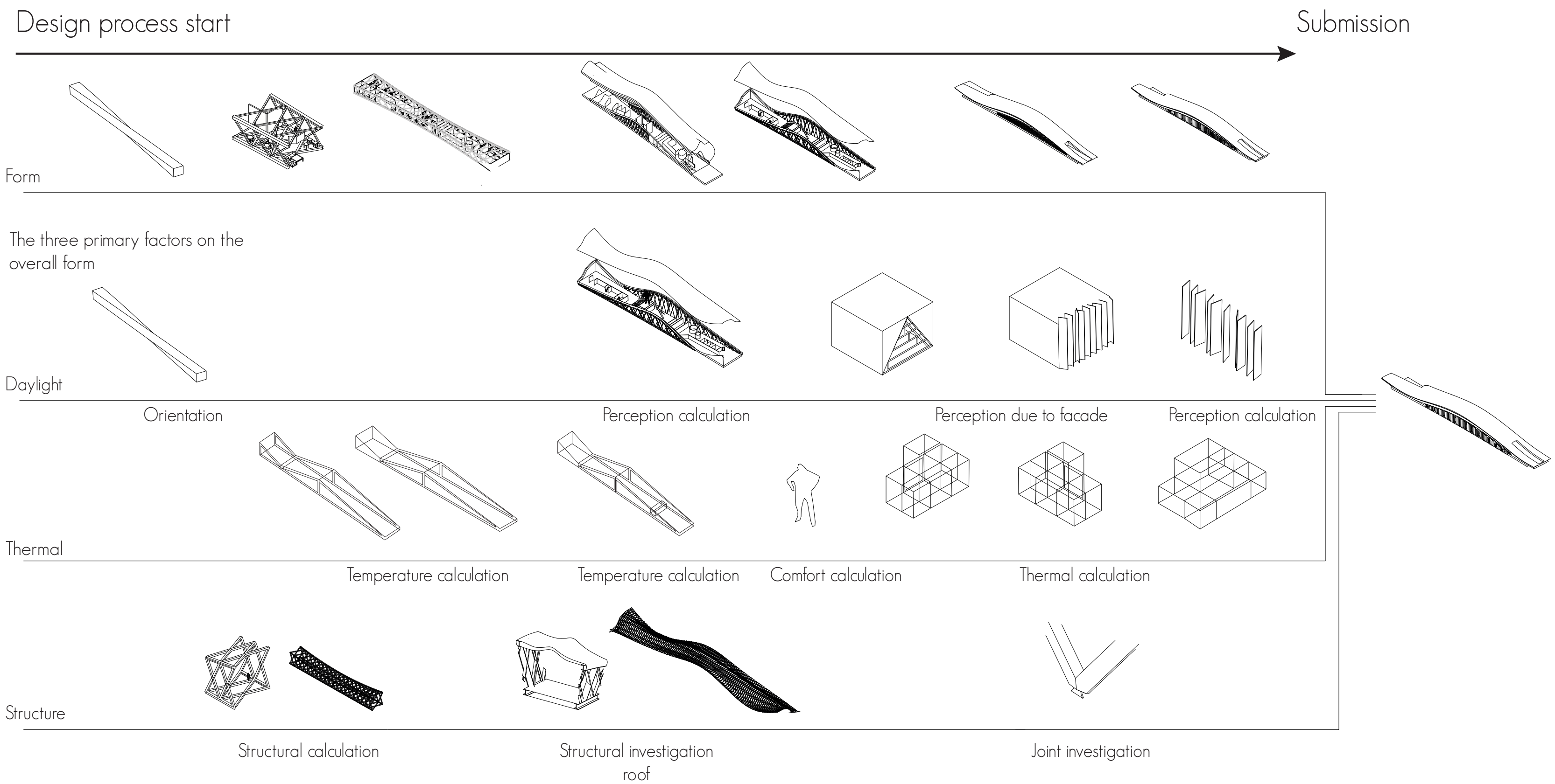
4

Design process

Overview

The design process has been complex due to all the parameters in play. The primary focus points in play are daylight, thermal environment and construction. Here the daylight has been the primary focus to ensure a daylight which enhance the experience when visiting the centre. The process for the different aspects has been in play on different times and as diagram 83.1 intermediary some of the studies have taken place in parallel with others. This complex process shows that it is hard to have a linear process since alot of aspects needs to be in play and affects the others.

Ill. 82.1 - Photo by Kamilla Dodensig Larsen

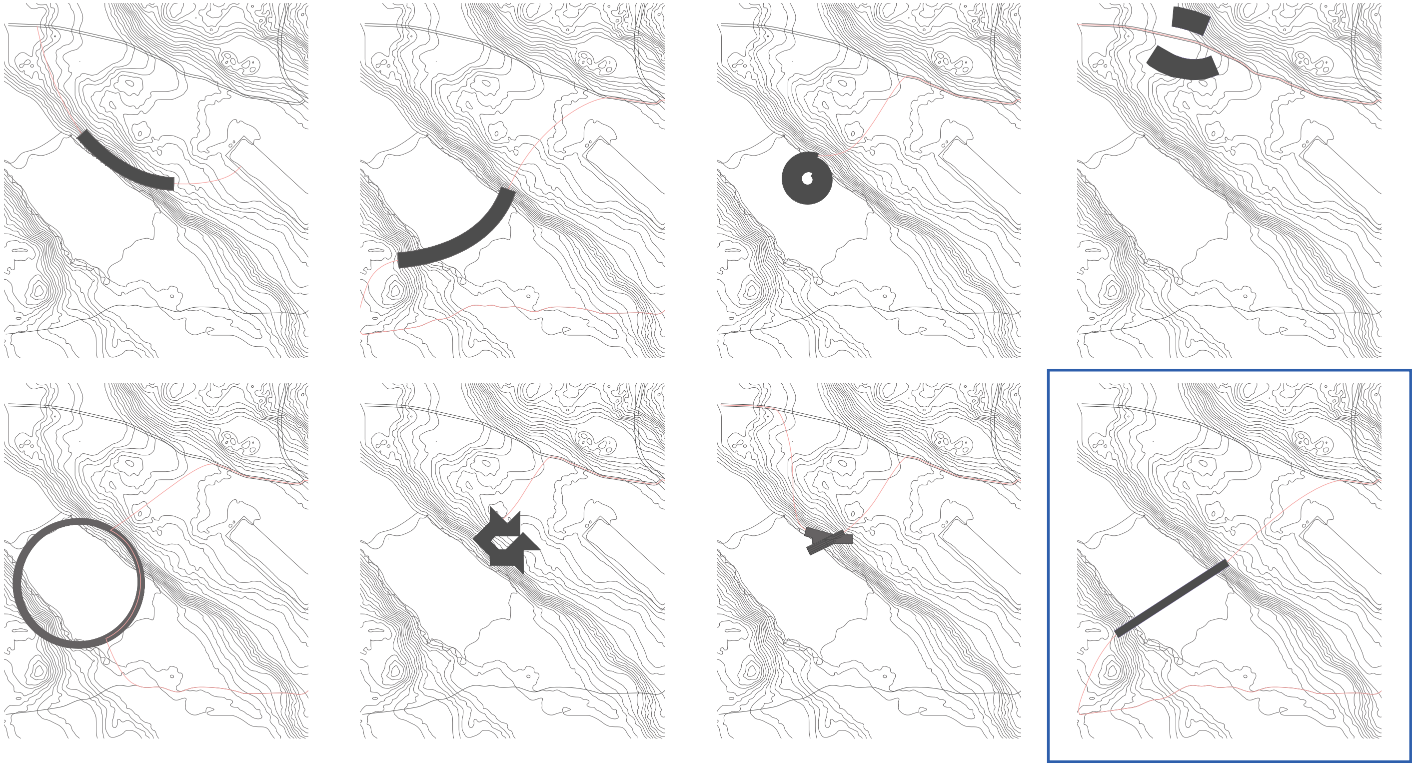


Ill. 83.1 - Diagram of the Design process

Initial form studies

The design process started out with different form- and volume studies and how they each are placed in the landscape. The studies were based on the analysis in the programme and were assessed upon the level of solving the stated challenges within the site. The goal of the form studies was to gather information of the site's possibilities and qualities. The different volumes shown on the page to the left are different in terms of placement, form, and expression. They all however focus on the existing paths on the site and either connects the paths or integrates the path with the centre.

See appendix 01

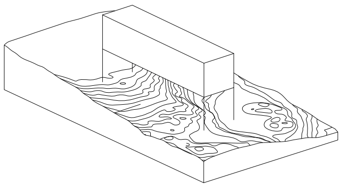


Ill. 85.1 - Diagram of initial form studies

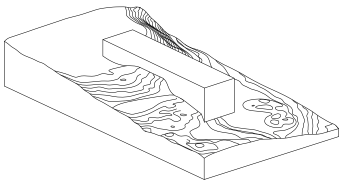
Contextual output

Within the site, a lake called Sermermiut is located. The lake is placed in the glacier valley, and is therefore providing an uninterrupted view towards the icefjord.
By placing the Icefjord centre across the lake, the position will provide the most optimal view towards the icefjord while the bedrock on each side of the lake is in play and functions as the foundation of the centre. The building volume would rise from the landscape as a long line across the lake and into the bedrock on the other side.This makes the centre an attraction in itself due to the unique views that is made accessible. By stretching the Icefjord centre across the lake, it would push the conventional idea of buildings having a solid fundament in the soil, and thereby become an architectural landmark. It questions the standard tradition of placing the whole building volume on solid soil and is rethinking the traditional building typology. It would stand out in the international architecture scene and it would be a journey to visit the Icefjord Centre in itself.

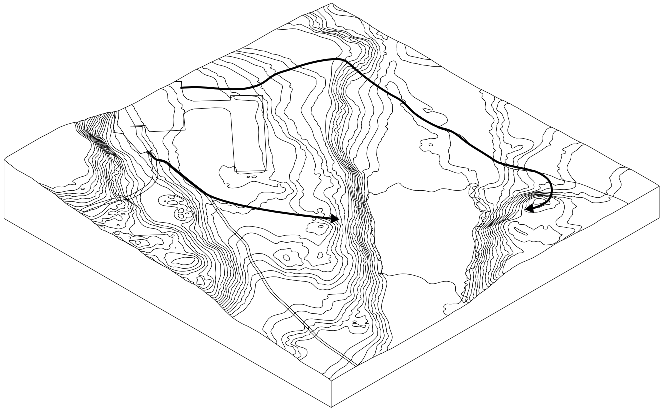
The centre is placed in relation to the existing paths on the site and creates a distributions centrum from the Icefjords centre. The centre can therefore both be a start and an end station for the visitors of the site no matter which path they choose to follow. The main path is elevated upon wooden planks to protect the fragile nature in the glacier valley. Much like that the building is placed to make a minimal impact on the local terrain and flora. The nature path is furthermore redirected through the building and is no longer causing damage to the fauna in the glacier valley.



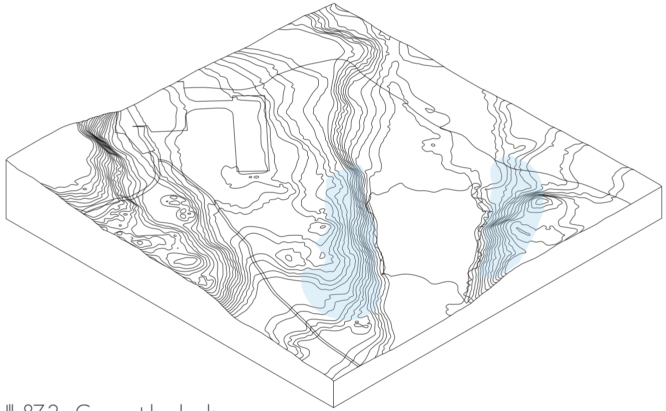
MINIMUM IMPACT
The building volume are lifted above the landscape.
Ill. 86.1 - Diagram minimum impact



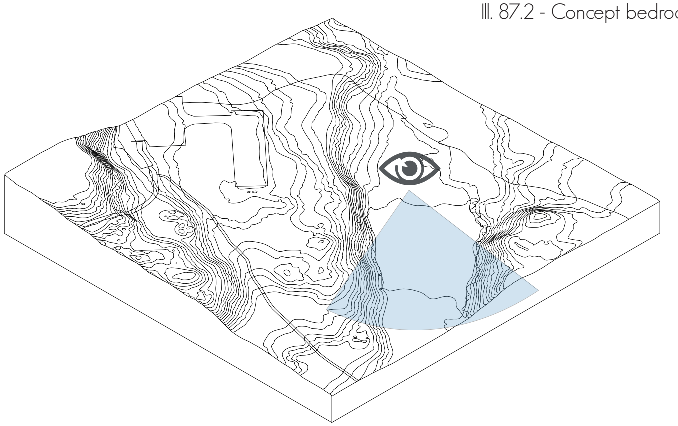
MAXIMUM IMPACT
The building volume involves directly with the landscape.
Ill. 86.2 - Diagram maximum impact



Ill. 87.1 - Concept pathways



Ill. 87.2 - Concept bedrock

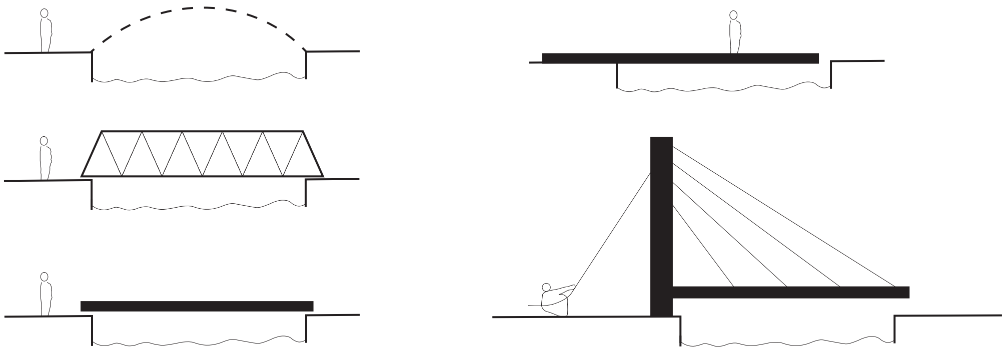


Ill. 87.3 - Concept view

Connection

By spanning the Icefjords Centre across the lake, the typology of the building needs to be assessed. Typically when building over water, the used typology is that of a spanning construction which connects two adjacent elements and combines them into a connection link, whether if it is for cars, bicycles or people. Spanning structures are are often structural architecture, and are therefore optimized to it's specific purpose. They are primarily located within the cities, and are often designed with a highly architectural quality, as they are often easily visible throughout the city.

The visitor centre needs to span approx. 80 meters, and it it's therefore necessary to look for inspiration in spanning construction, to ensure a structural integrity.



Ill. 88.1 - Diagram of bridge structures

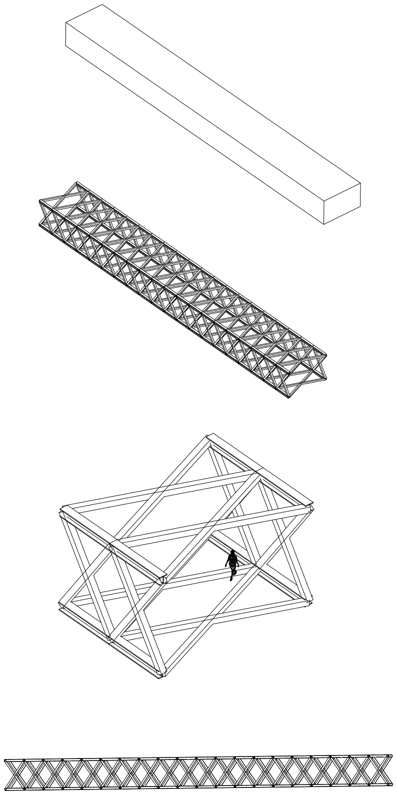
See appendix 03

Ill. 89.1 - Photo by Kamilla Dodensig Larsen

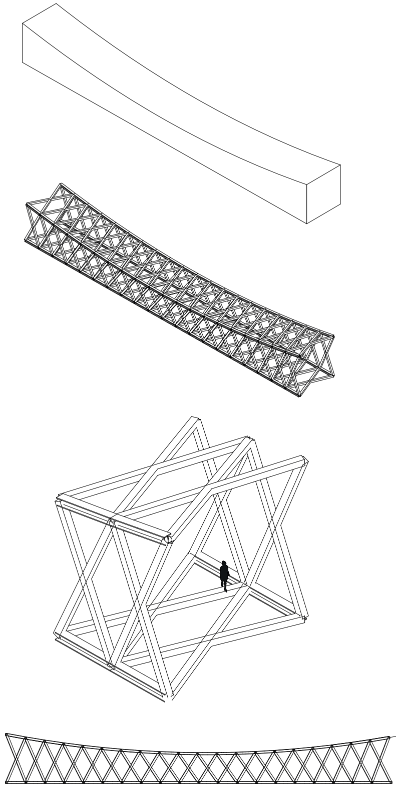
Typology structure studies

To accomodate a span of approx. 80 meters, the structure is an essential part of the final form and volume. Different structural forms based on the classical truss system, has been analyzed through the plugin tool Karamba for Grasshopper, which gave an estimated deflection. The calculations was done with dead load, live load and snow load. The wind low could not be calculated as there were not sufficient data. The design studies was evaluated on their deflection, their ability to shape the building, and enhance the aesthetics value. On the right, three selected studies are presented. The result of the studies showed that an arch is the most optimal in terms of minimal deflection and minimal use of materials.

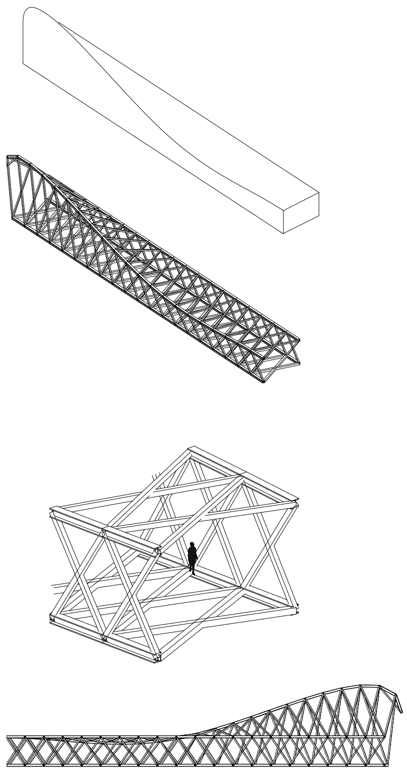
See appendix 02



Name// Figure 1
Deformation// 39 cm



Name// Figure 7
Deformation// 47 cm



Name// Figure 9
Deformation// 49 cm

Ill. 91.1 - Diagram of structure

Conceptual spatial organization

The user diagram for the daily flow (which is shown earlier in the report, under the program page 77), shows a close relation between the main entrance and the sub entrance. By spanning across the lake, a long rectangular volume appears, which questions the functional scheme of the building. The functional scheme has therefore been evaluated and two scenarios has been studied.

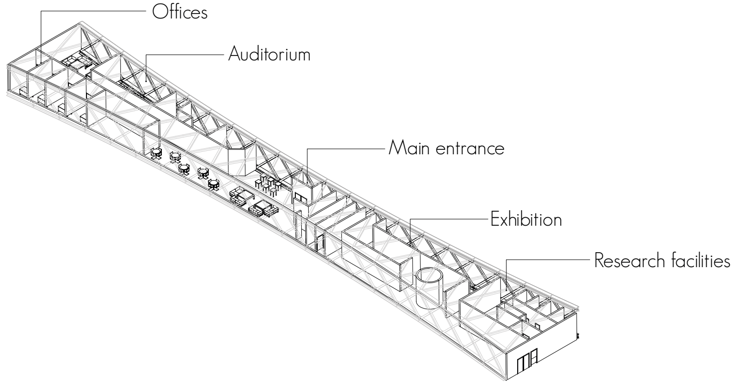
The first scenario is based on the idea of placing the main entrance in the middle, with an entrance pathway on the side, and the sub entrance in one of the ends. This provide the opportunity of creating a central public function and distributing the private functions, such as the office and research facilities, out into the two ends of the building. This however gives the visitors and staff a longer journey before entering the visitor centre.

In the second scenario, the two entrances are placed in each end of the building and provides the visitors and staff the possibility to walk through the building and continue their journey on the other side of the centre. This provides a linear flow through the building but also gives a hierarki towards one of end of the centre.

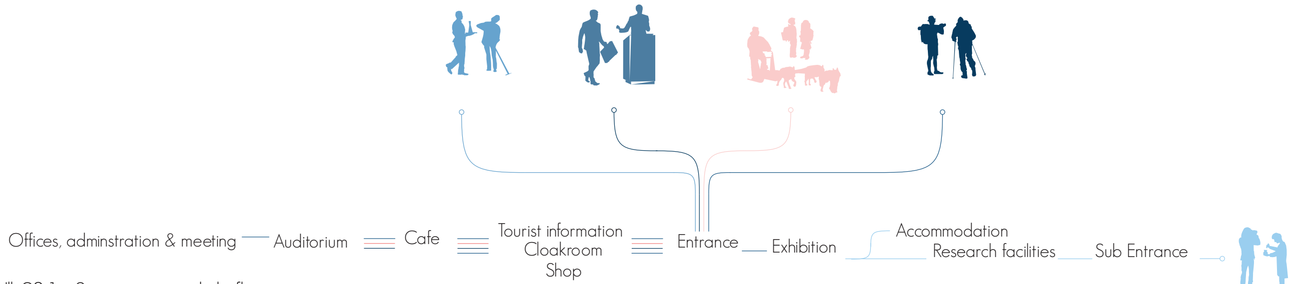
Conclusion

By placing the entrances in each end, it supports the concept of connecting the two paths into one journey and thereby allowing people to move freely.

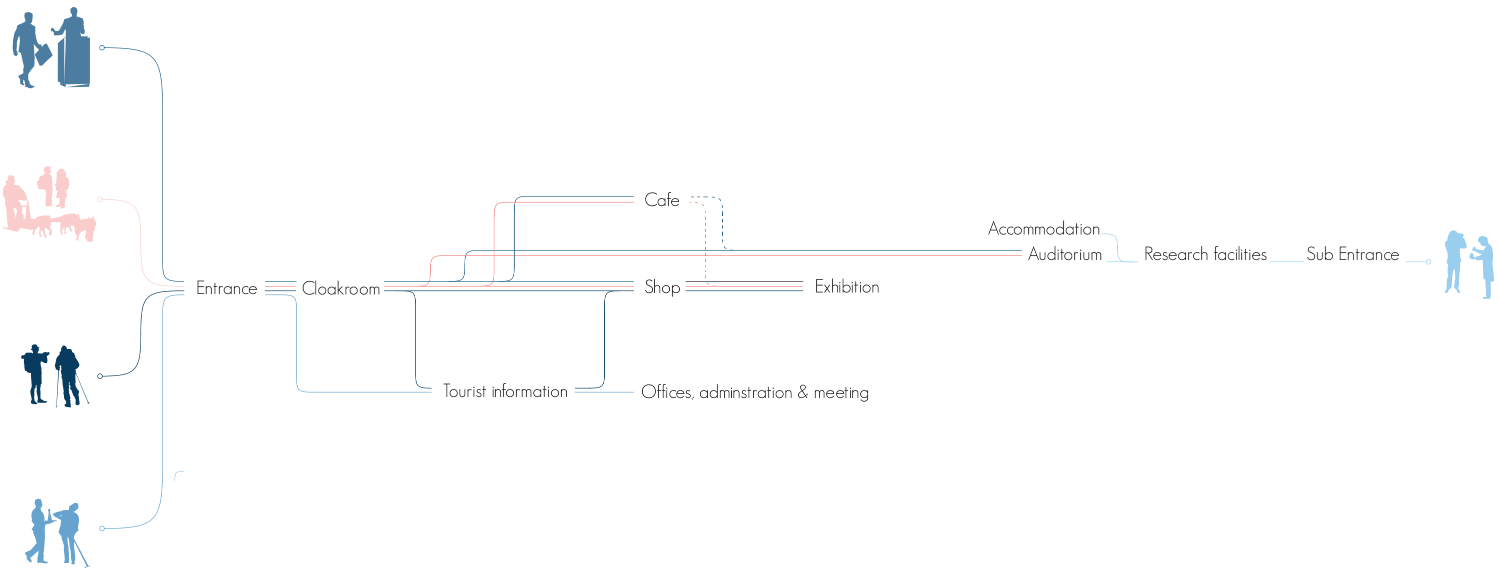
See appendix 04



Ill. 92.1 - Diagram of spatial organization

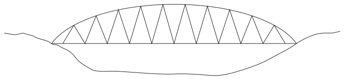


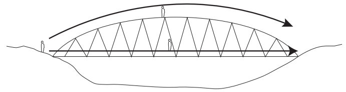
Ill. 93.1 - Scenario one, daily flow



Ill. 93.2 - Scenario two, daily flow

Organic shape



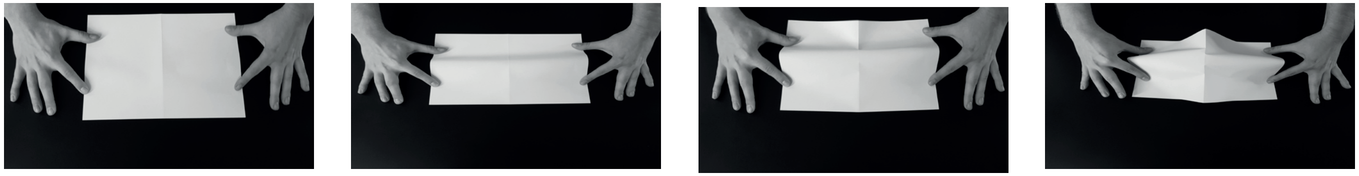


The main part of the structure is inspired by the arch truss system of a spanning structure. This structure however, does not allow people on the roof, and is therefore limiting the flow, to only go through the building. For the roof to accommodate a flow, it's necessary to create a shape, that is not to steep and is inviting visitors to explore the new pathway.

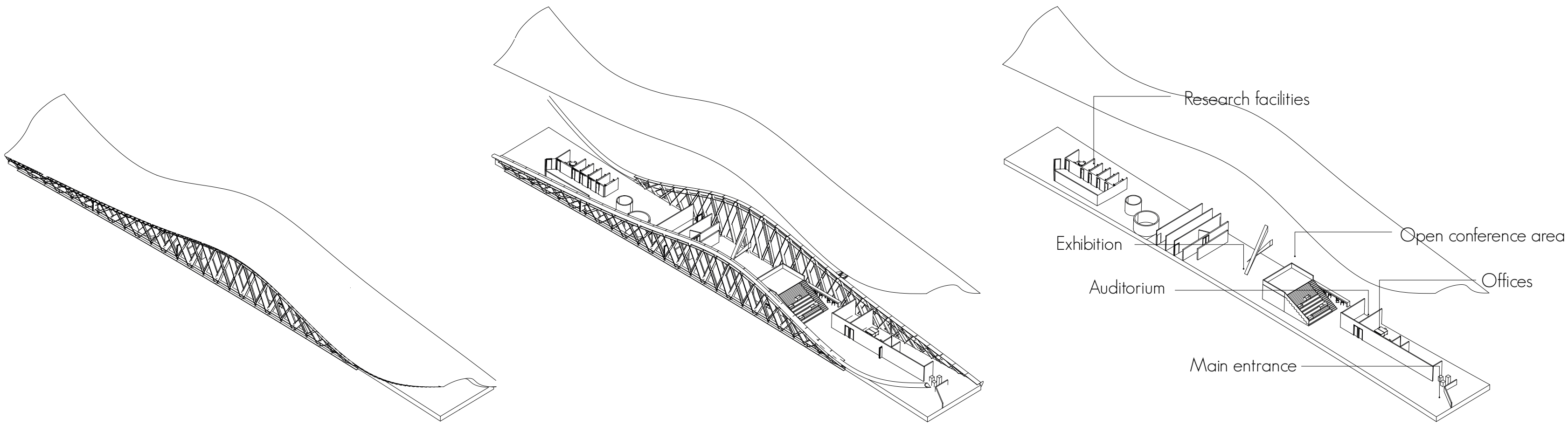
The arch truss structure symbolises a steady and static structure, but by working with an organic shape for the roof, a light and dynamic expression can be achieved.

The organic shape should be formed as an arch, which previously studies on page 90 shows is the ideal form for a spanning construction.

The concept for the roof is based on a folded paper, where each corner is pressed together to create an entrance, but is still allowing for roof access. To mimic the shape of the truss arch, each short side is pressed towards each other, so the forces creates a natural arch.

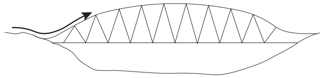


Ill. 94.1 - Photo by Kamilla Dodensig Larsen



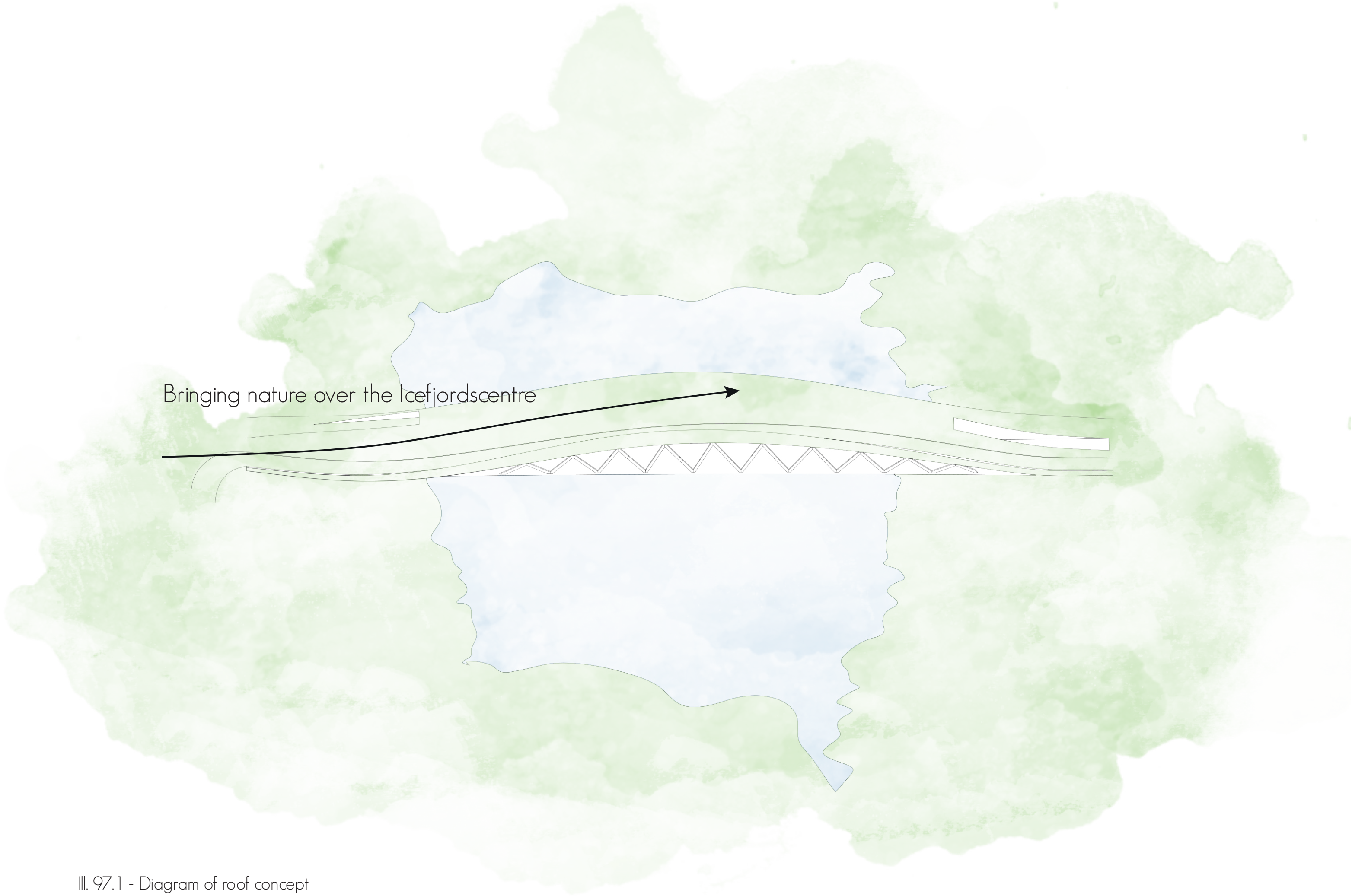
Ill. 95.1 - Diagram of building volume

Landscape extention



A critical problem towards walking on the roof as mentioned in the cluster review. were the often very visual add-on of a handrail.
To integrate the solution into the design, the shape of the side is designed so it creates a natural handrail along the outer edge. To direct the visitors and to integrate the building in the existing path, the wooden raised pathway is continued across the roof, and is therefore directing the visitors. To further allow for a clear division of where to and where not to walk on the roof, the vegetation from each side is continued across the roof, which also gives a smooth transition between the visitor centre and the surrounding nature.

See appendix 09

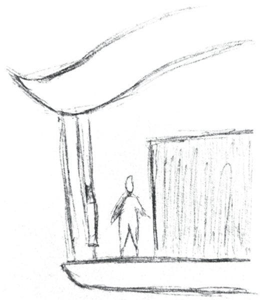


Ill. 97.1 - Diagram of roof concept

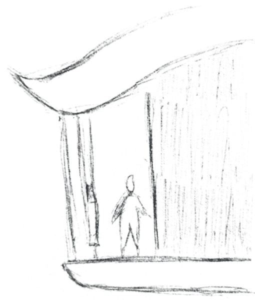
Interaction between inner and outer

The interior walls that separates the functions from the main volumen, has a big influence on how the interior space is being perceived depending on how they meet the outer shell. Two solutions has been investigated. Firstly a solution were the walls is integrated in the overall structure and is meeting both the ceiling and the outer wall. The walls are being perceived as being a part of overall building, but it also creates rooms with high ceilings, that can be intimidating and which does not fit in with the wanted atmosphere. In the other solution a detachment of the interior walls is investigated. This provides a contrast between the organic shaped shell and the interior boxes , which stands out and allows the overall structure to be dominant and staged as a whole. It also creates intimate rooms within in the large volume, both within and outside of the boxes, as they are relatable to the human scale, and is therefore comfortable to be around.

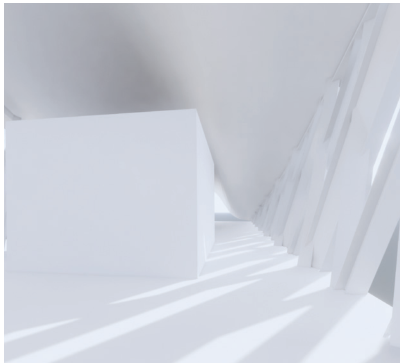
Conclusion:
To proceed the detached interior boxes is chosen to separate the functions and the outer shell. They provide several possibilities such as using the spaces above them for functions which can be more private but is still a part of the big volumen.



Ill. 98.1 - Diagram over interior studies



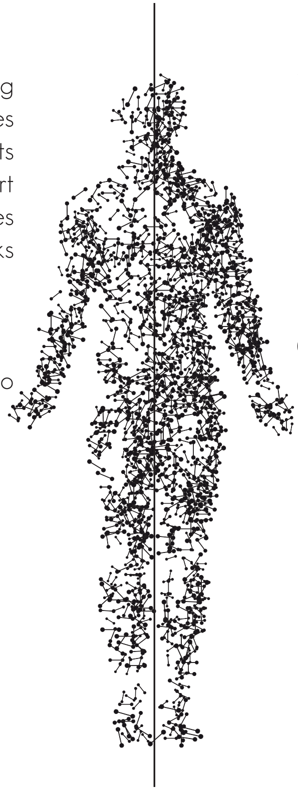
Ill. 98.2 - Diagram over interior studies



Ill. 98.3 - Render over interior studies

Ill. 98.4 - Render over interior studies

Environmental thermal comfort



Ill. 99.1 - Diagram by Freepik

The Icefjords centre is divided into two different thermal zones where the comfort temperature tolerance is variating according to the level of PPD, predicted percentage dissatisfied. The exhibition area and the large main areas should be in category C. This gives the possibilities to have a larger variation in temperature within a span of 19-25 degrees without a high amount of people feeling discomforted. The large variation in temperature is purposely made so it reflects the outdoor climate, which is more comfortable for visitors who are dressed according to the outdoor temperature. But it is also giving a sense of being closer to the nature. The temperature is evaluated with PPD and the category of the function. PPD looks at the activity of people in the given space and the cloth insulation. Example in the exhibition it is assumed the activity of the people is 1,5 mets which match a medium activity and the cloth insulation is 0.95 in winter and 0,7 in summer (See illustration 99.1). which allows a span of 19-25 degrees in category C. See appendix 05 for further temperature span for securing comfort according to temperature. (DS/EN ISO 7730.,2015)
In areas such as the office space and research space it's necessary with a controlled climate, as the workers are spending longer time in these areas.

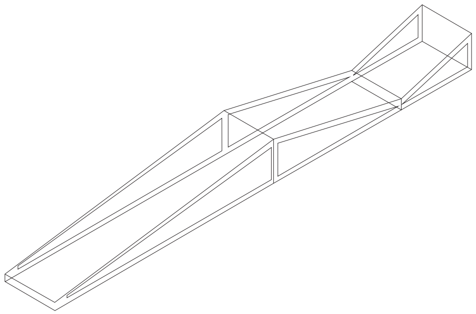
See appendix 05

Thermal performance studies

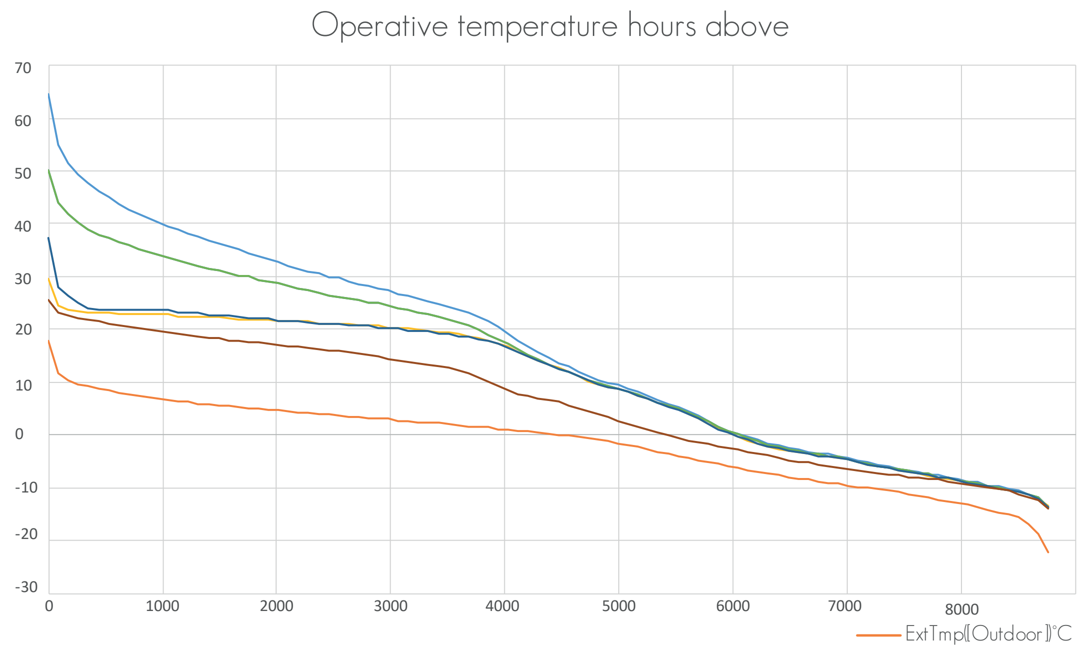
The first geometry that is tested in BSim, is controlled only by the outdoor climate and has no implemented systems to control the level of temperatures within the building. The geometry is a simplified version of the buildings outer shell, with large windows towards southwest and northeast. The analysis was conducted to find the influence of the large window areas in an arctic environment and the possibilities on creating a thermal zone only controlled by the outdoor temperatures. The next iteration had a reduced amount of glass which can be seen on graph 101.1. This reduces the temperature level. In the third geometry, the South Western facade windows is removed, which has a high influence on the temperature level within the building and decreases it significantly. In the fourth iteration it is tested how the natural ventilations influences the temperature level in the summer period. The results show that the temperature levels above 27 degrees is only 138. Inside the building's outer shell, several boxes, with their own thermal conditions, is placed. Their temperature level is dependent on each of their functions, and is controlled by mechanical ventilation.

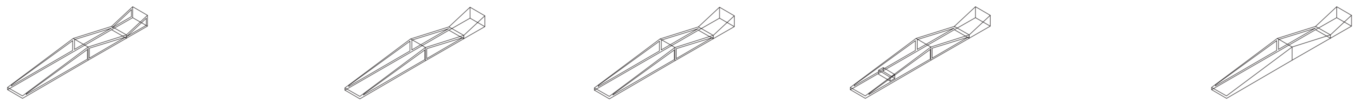
See appendix 05

Conclusion
The building's big room under the outer shell can reach a maximum temperature of 60°+ in the summer period and can reach a minimum temperature of -15° in the winter. It's therefore necessary to apply heating in the winter, and cooling in the summertime. However the results shows that venting during the summertime might be sufficient. Furthermore it's necessary to apply external shading on the southern facade to minimize the solar heat gain during summer.



Ill. 100.1 - Examples of the BSim geometry





Ill. 101.1 - Graph over the operative temperatures of the BSim stimulation

Emotional perception - Light tool

A persons visual perception of a space is driven by season, time of the day and sky type. The interpretation of a space depends on different aspects of daylight coming into the space as the contrast and brightness. The method of calculating a person's perception of a space is based on a doctoral theses " Perceptual dynamics of daylight in Architecture" by Siobhan Francois.

Through 2D renderings in specific times in a specific season the contrast of the renderings is evaluated upon the higher contrast in a space the more exiting the space is perceived by the user. The renderings is set up in a time-series to give an overview of the visual perception effects over a whole day. The illuminance level is depending on strengths of the daylight amount. Each rendering is calculated with a preliminary algorithm with focus on measure contrast and evaluated with a new measure values called modified spatial contrast "MSc". These values range from calming, neutral and exiting and is different from picture to picture due to the amount of contrast in a picture. (S. F. Rockcastle, M. Andersen,2017)

The following method is from the Ph.D. The space that needs to be analysed is build as a 3d model where the floor can be divided into a grid of five meters separation or listed as a specific point in the space, which is to be calculated. The geometry is imported into the program Radiance which is a program for lighting simulation which provides an output of an image in a 180 degree hemispherical format taking from nine views in the 360 degrees circle with simulated light levels in a specific time. The images is saved in a folder and handled in Matlab with an algorithm. (S. F. Rockcastle, M. Andersen,2017)

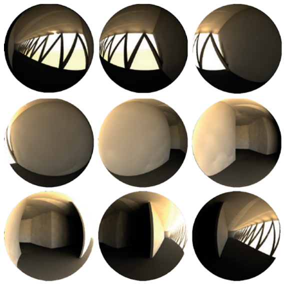
See appendix 06

Each image with an input resolution of 1488 x 1024 is subsampled down in resolution five times with halved resolution each time and thereafter each pixel is analysed for local contrast. The fifth subsampled image represent the eye instant perception of the contrast while the original image is the equivalent to a longer perception of the space. The five subsampled images therefore gives an average interpretation of the perception of the space. (S. F. Rockcastle, M. Andersen,2017)

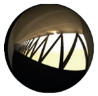
There are several ways to measure contrast, one way is to take the sum of the bright pixels and correlate them to the dark pixels, this however will only tell about the average

deviation, but not give an impression on how much local contrast is in the image.
The local contrast for each pixel is calculated as a matrix which consist of the pixel and its closest eight surrounding pixels, where the local contrast is the difference between the pixels RGB values. The four pixels directly surrounding the pixel is weighting 1 while the rest is weighted as 2/sqr(2) as they are only connected by the corners. The average of all the local contrast on all five images, is called the modified Spatial contrast and is an expression for how the space is perceived by the naked eye.
The value will often be within the threshold of the Ph.D. which found with a MSc below 6,96, 50% percent will find it calming, while with a MSc value above 11,75, 50 % will find it exciting. (S. F. Rockcastle, M. Andersen,2017)

9 image in hemispherical format

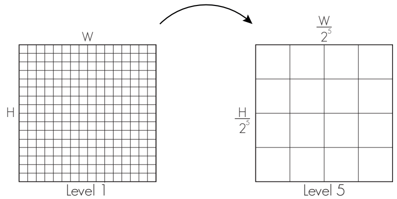


Images handled individual



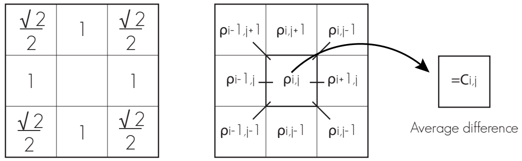
Ill. 103.1 - Light tool

Each image with an input resolution of 1488 x 1024 is subsampled down in resolution five times with halved resolution each time:



Ill. 103.1 - S. F. Rockcastle, M. Andersen,2017

Analyse the contrast of an image:

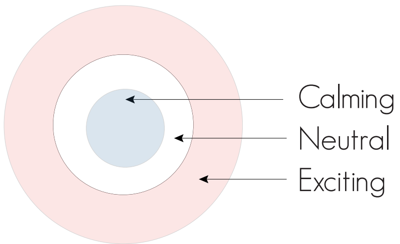


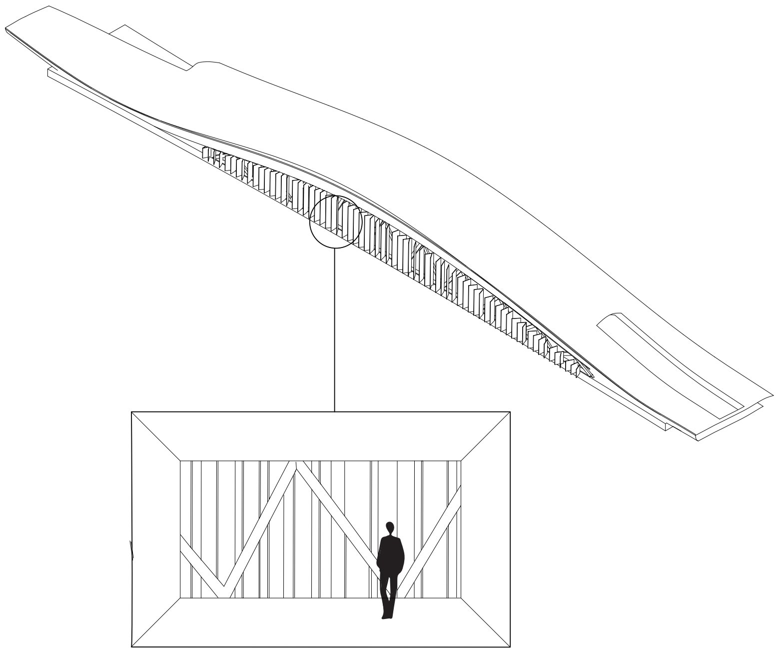
Ill. 103.2 - S. F. Rockcastle, M. Andersen,2017

Emotional perception studies

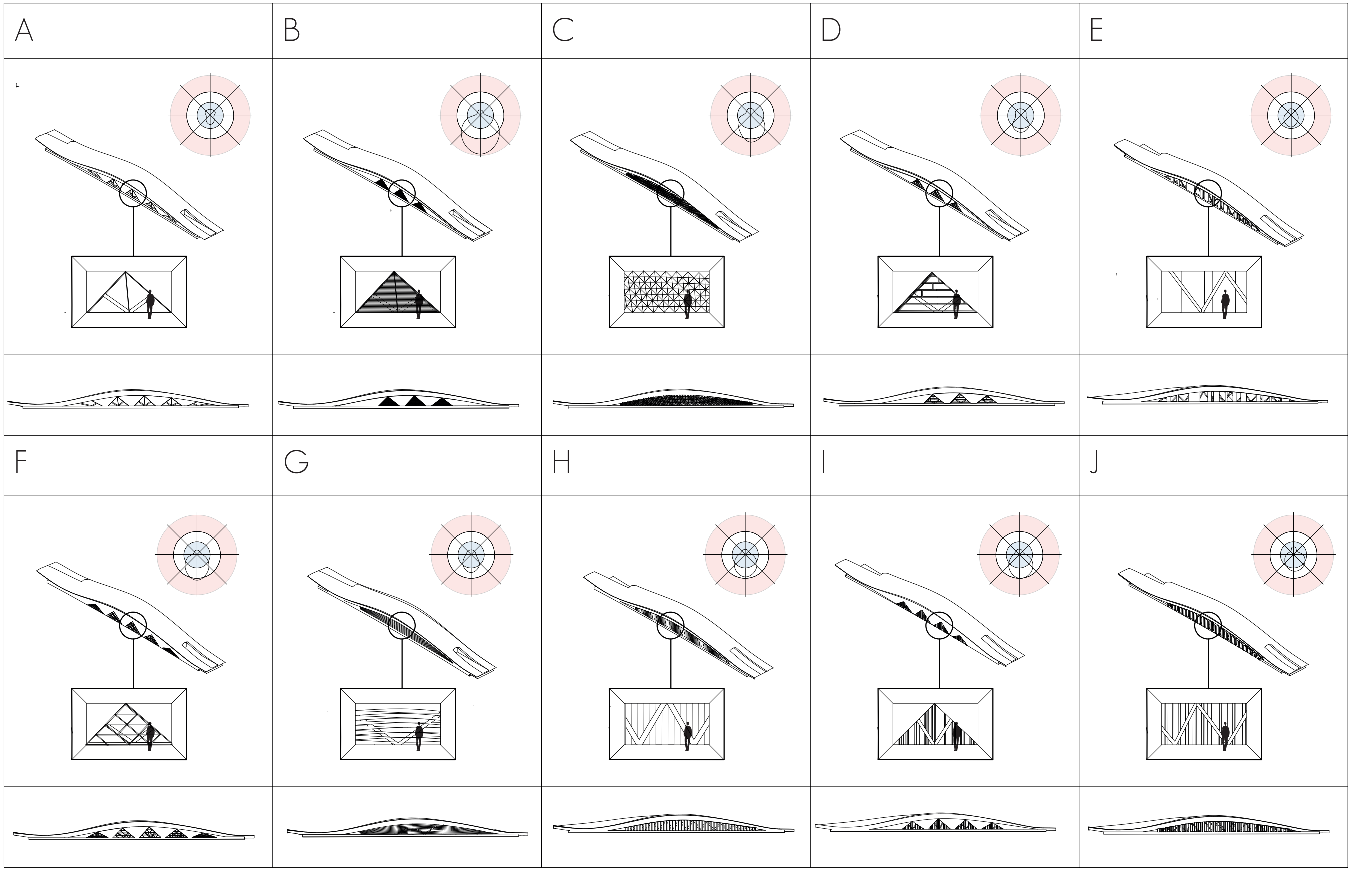
Studies on the facade expression has been made to investigate a system which could enhance the vision of creating different indoor light conditions and experiences. Different facade expressions has been investigated, which either followed the visual expression from the truss system or created an entirely new expression. The main issue was to find a facade system which would work visually inside with the truss system, while working with the outside organic shape of the building. Furthermore the facade system should be able to accommodate several lighting situations indoors. The final solution for the system is figure J. This system solves the given problems and enhance the possibilities to create a new atmosphere in each space by allowing individually angled panels. The outside expression provides the Icefjords Centre with a dynamic flow, and changes the visual connection with the indoor depending on the direction of view.

See appendix 06





Ill. 104.1 - Diagram of perception studies

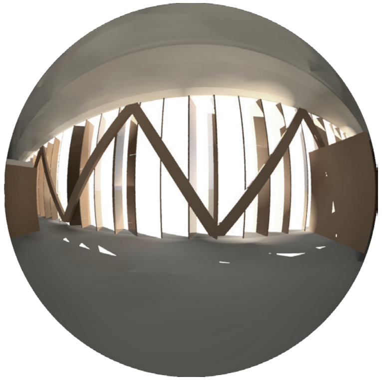


Ill. 105.1 - Diagram of perception studies on facade expression

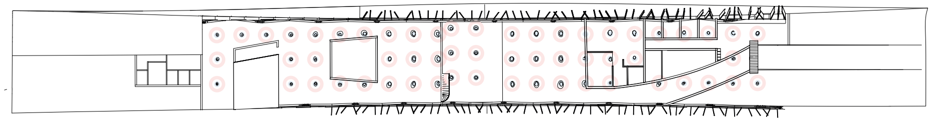
Emotional perception studies

The lamellas of the chosen facade system can be angled independent of each other, and they can be angled to create a specific amount of lighting contrast and therefore a specific perception of the space inside the facade. To design the facade so it achieves the wished atmosphere throughout the centre, several viewing spots was placed to cover the most essential areas. Then 100 lamellars angle iterations was analyzed with the developed lighting tool for each viewing spot. The lamella angles was then chosen for each viewing spot to correlate with the wished atmosphere. The lamellas are therefore angled purposely according to the analysis results and cannot be rotated in the final building. To verify the facade results were used live rendering and virtual reality. The atmosphere throughout the centre is variated between calm and exciting to strengthen the perceived contrast.

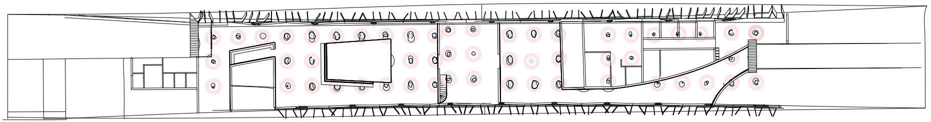
Ill. 106.1 - Low contrast



Ill. 106.2 - High contrast

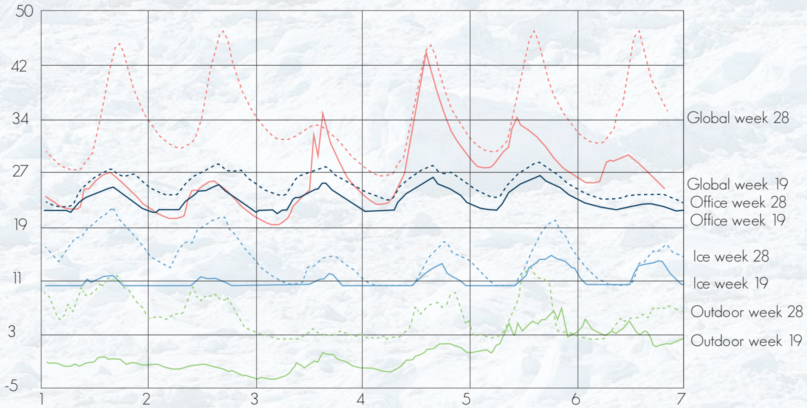


Ill. 106.3 - First results



Ill. 106.4 - Final results

Experienced temperature



Ill. 107.1 - Graph of the operative temperatures of the BSim stimulation

Two of the exhibition rooms are not only giving an experience through their exhibition materials, but also through the physical experience. In the global warming exhibition, a visitor will feel an operative temperature that is significant higher than the rest of the visitor centre. This underlines the consequence of global warming and affects the visitors with a feeling of a temperature discomfort, which is a reference to the statement of the world getting warmer. The global warming exhibition is placed towards the South-West facade to exploit the high sun radiation and thereby reach high temperature levels, as investigated in the first BSim studies on page XX.

The second exhibition room is about ice, and it's history. The physical experience is made by placing the visitor in a cold environment. To lower the temperature levels and the comfortability of the room, natural ventilation was investigated in combination with low sun radiation to avoid passive heating during summer. The low sun radiation was achieved by using windows with low solar transmission, as well as by placing the room towards the Northeast facade.

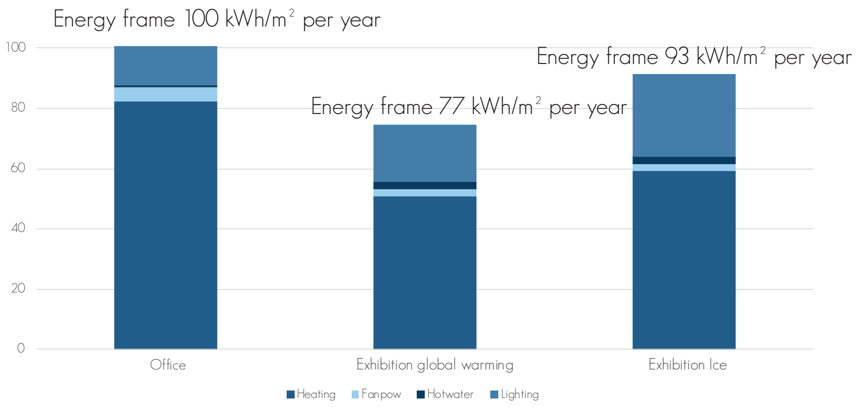
The visitor centre also provides spaces with comfortable temperatures for the visitors and the staff, which has been covered earlier in this report.

Ill. 107.2 - Photo by Jens V. Nielsen, Courtesy Realdania

Arctic energy performance

Greenland is located within the arctic zone, which is subdivided into the high and the low arctics (Denstoredanske.dk,2018). The Icefjord Centre is located in the high artics, where it is assumed that a building requires more energy per square meter to sustain a comfortable and healthy indoor environment. The energy frame for the high arctic environment is 97 kWh/m^2 per year, plus 97 kWh/m^2 per year divided with the amount of floors, plus 4444 kWh/m^2 per year divided with the heated area of building, which for the centre equals 97.5 kWh/m^2 per year (Byginfo.gl,2018).
As a comparison the energy frame for the low arctics is 77 kwH per year, while the danish regulations are significant lower at 41,0 kwH per year plus 1000 kwH per year divided with the heated area
The current building regulation for Greenland is from 2006, and therefore the energy frame has not followed the danish constrictions. To give a better estimate of whether the building is of a modern standard, an assumed reduction of the energy frame for Greenland was made in figure 108.1, based on the danish constrictions from 2006 to 2018.

Ill. 108.1 - Diagram of energyframe



Ill. 109.1 - Diagram of energyframe for calculated spaces

Energy performance

To evaluate the buildings performance according to the energy frame, three rooms energy consumption was calculated. The Greenlandic energy frame only includes heating, ventilation and cooling, while the danish energy frame also includes domestic hot water and lighting. To be able to compare the building with the danish regulations, all five parameters was calculated.

The first room was the office, which is a representative for a controlled indoor environment with a class B atmospheric and thermal indoor environment. The results, which was calculated in BSim, showed that the energy consumption was above the estimated Greenlandic energy frame, but was highly affected by the lighting which is not a part of the regulations. The energy consumptions was regulated by the energy factors, determined by danish building regulations.

The energy factors however are not representable in Greenland, as the electricity, which has an energy factor of 2,18, is produced by renewable sources as mentioned earlier in the report page 32 (Bygningsreglementet.dk, Energifaktorer, 2018).

The second room calculated, was the global warming exhibition, which purposely are warmer than the comfort temperatures. As the room is placed so it receives a high amount of solar radiation, the energy consumption towards heating is lower than the other rooms.

The third room was the ice exhibition, which is kept cooler than the comfort temperatures by venting.

Ill. 110.1 - Glacier

5

PRESENTATION

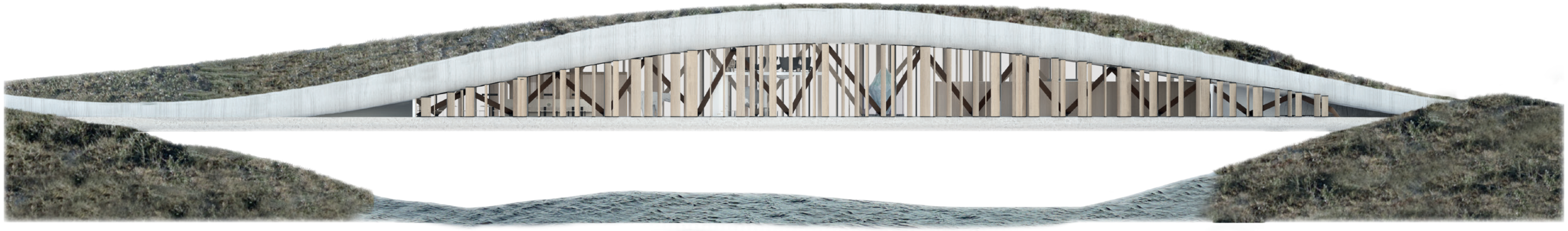
Masterplan

At arrival the first view is of the Icefjord Centre stretching over the lake connecting the two landscapes. The vegetation on the rooftop underline the appearance as an extension of the landscape. The wooden paths is turned towards the Icefjords centre, to underline it as the distribution centre for the three paths leading out to the UNESCO site. This allows the visitor to visit the centre both in the beginning and the end of the tour. The rooftop is inviting the visitors to explore already early in their tour, as it immediately provides a unique view through the glacier valley to the icefjord.
The old helicopter area is used as a parking lot, which can accomodate 20 vehicles and a few busses.

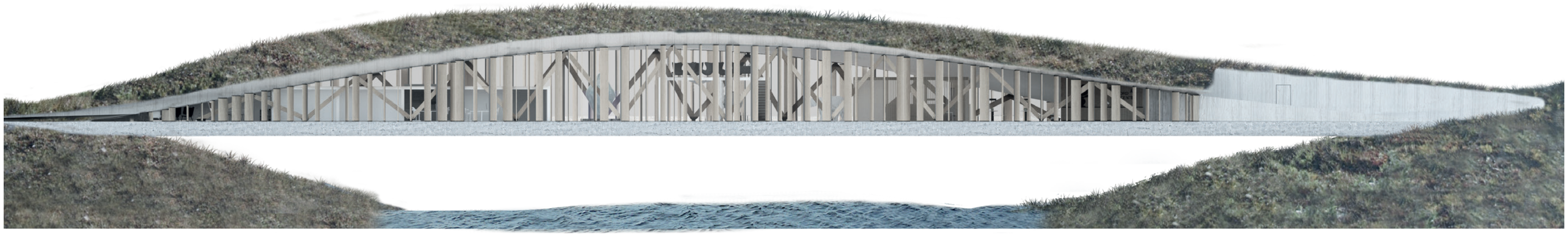
Ill. 112.1 - Masterplan 1:1000


N

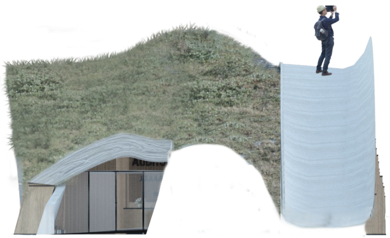
Ill. 114.1 - Visualization outside



Ill. 115.1 - Elevation South west 1:500



Ill. 115.2 - Elevation North East 1:500

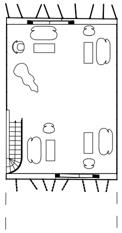


Ill. 115.3 - Elevation South East 1:200

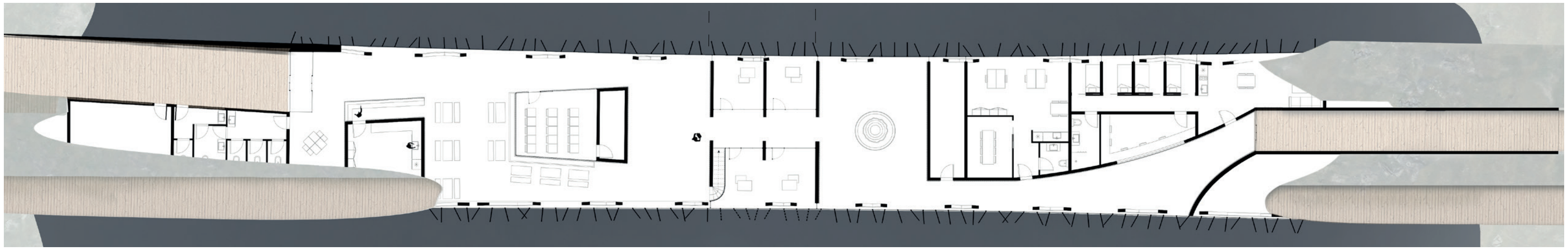
Ill. 115.4 - Elevation North West 1:200

Plandrawing

In the floorplan its visible how each function are placed inside a correlating box. The public functions are primarily placed near the main entrance, and consist of the café, shop, tourist information etc. The private functions are placed near the secondary entrance, and are placed with no visually contact for the visitors, contrary to the two semi-private/public rooms, the research office and the auditorium, which has a visual connection with the visitors, which creates a transparency into what other functions the centre is hosting. To secure future use of the building, its possible to remove all interior boxes without compromising the structure, so if needed the building can be used for other purposes.



Ill. 116.1 - Plandrawing Mezzanine 1:500



Ill. 116.1 - Plandrawing Groundfloor 1:500

Ill. 117.1 - Visualization arrival

Ill. 118.1 - Visualization cafe

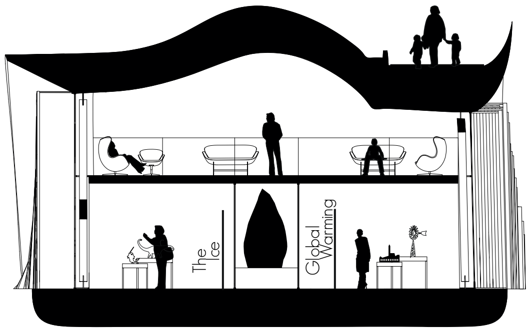
The cafe is located right after the entrance between the kitchen and the auditorium, which allows it to be a catering place for both tourists and people attending seminars.
The large windows provides the visitors with a view towards the icefjord which is framed by the glacial valley where the visitor centre is placed.The ceiling height changes significantly through the cafe, but by placing lamps in a lower setting it creates an intimate atmosphere while sitting at the tables.

Ill. 119.1 - Visualization arrival

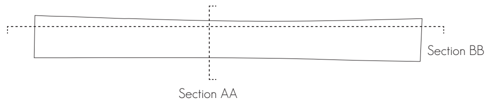
To enter the Icefjord Centre the visitor is first lead through a buffer zone, which is helping to keep a steady temperature. The initial meet will be the reception, which provides tourist information for visitors both to the centre and the icefjord. Next to the reception a small souvenir area is placed. Wardrobe and toilets are also placed next to the reception.
The cafe is also immediately visible from the entrance, and is therefore inviting visitors to settle down for a cup of coffee, even though they were only there for the tourist information.

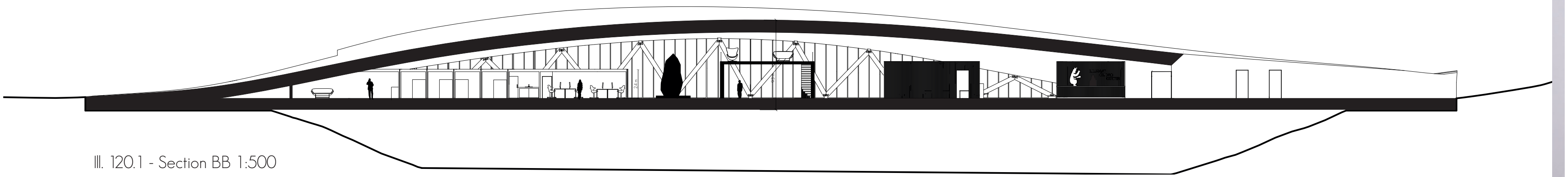
Section

In section AA three different spaces is shown, each with their own atmosphere. The Global warming exhibition is located in the room to the right. Through passive strategies the space is heated above the comfort level of the visitor, which underlines the theme and makes the room a physical experience. The space to the left is the exhibition "The Ice", where the visitor will feel cold due to lack of heating and drag. This is also an addition with a physical experience, which underlines the exhibition theme.
Above the two exhibition rooms, is the conference area located, where the visitors or people attending seminars can retreat and relax.
In section BB it is illustrated how the boxes contrasts the large room and create intimate atmospheres.



Ill. 120.1 - Section AA 1:200





Ill. 120.1 - Section BB 1:500

Ill. 121.1 - Visualization Global warming exhibition

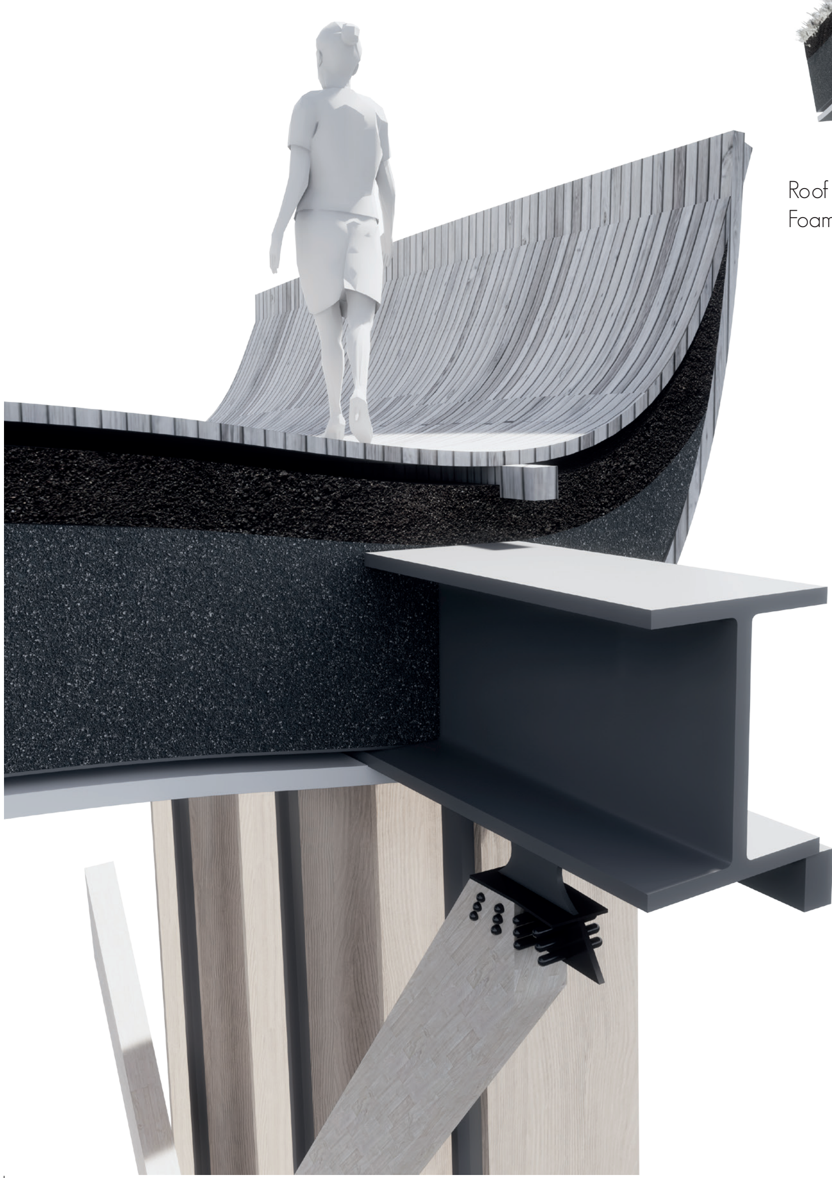
Materiality

From early in the process wood was the prefered material choice for the Icefjord Centre as it could provide a warm interior as a contrast to the harsch arctic climate.
Accoya wood was chosen due to its durability in the arctic environment, and is usable in both furniture and construction, inside and outside. Accoya has an outdoor durability of 50 years above ground and 25 years in ground, which is why the wooden path towards the icefjord is also constructed out of Accoya (Keflico,2018).
The wood is kept in light colors to reflect the daylight into the Centre. The columns is glulam accoy while the beams are of construction wood class 24 (Keflico,2018).
The floor of the centre is made of slate tiles and refers to the solid bedrock which the building is leaping from. It also provides a steady and stable feeling, which can counteract the small movements that might occur in a long span building. The textility of the slate is unique in each tile, which gives it a depth and a story to tell, relating to the old hunting weapons which was made of slate as it is naturally occuring in the area(D., geologien ,2018).
The boxes are covered in wooden panels which amplifies their detachment from the floor and the ceiling.

See appendix 15

The facade glass is three layered energy glass with a low value to minimize the transition loss. The glas solar transmission is kept as high as possible to maximize the solar heat gain.

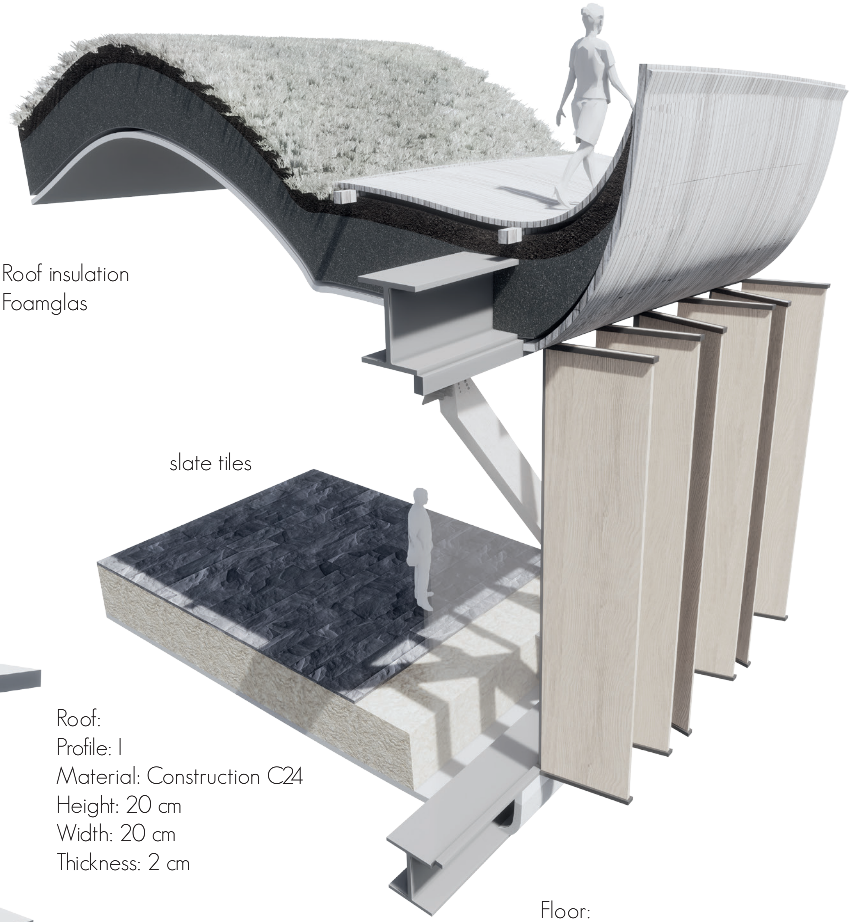
Ill. 122.1 - Visualization materiality



Roof:
Profile: I
Material: Construction C24
Height: 20 cm
Width: 20 cm
Thickness: 2 cm

Columns:
Profile: Solid square
Material: Accoya
Height: 40 cm
Width: 10 cm

Ill. 123.1 - Render detail roof



Roof insulation
Foamglas

slate tiles

Frame beams:
Profile: I
Material: Steel
Height: 80 cm
Width: 60 cm
Thickness: 5 cm

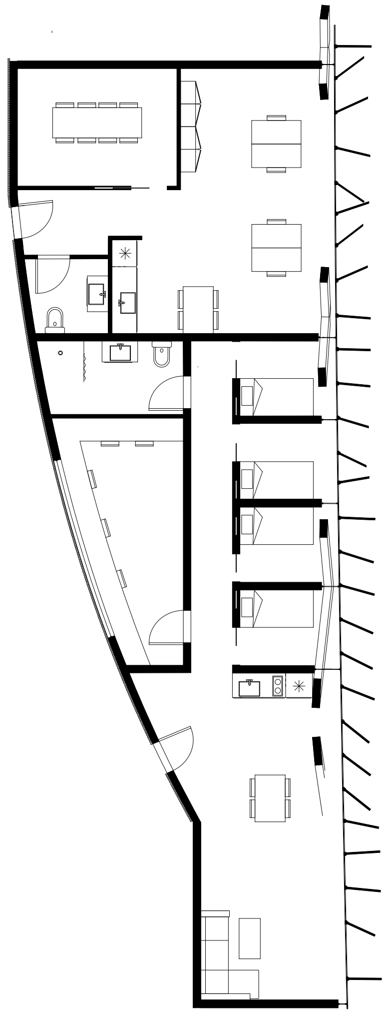
Floor:
Profile: I
Material: Construction Wood C24
Height: 80 cm
Width: 60 cm
Thickness: 5 cm

Ill. 123.1 - Render detail construction

Research facilities

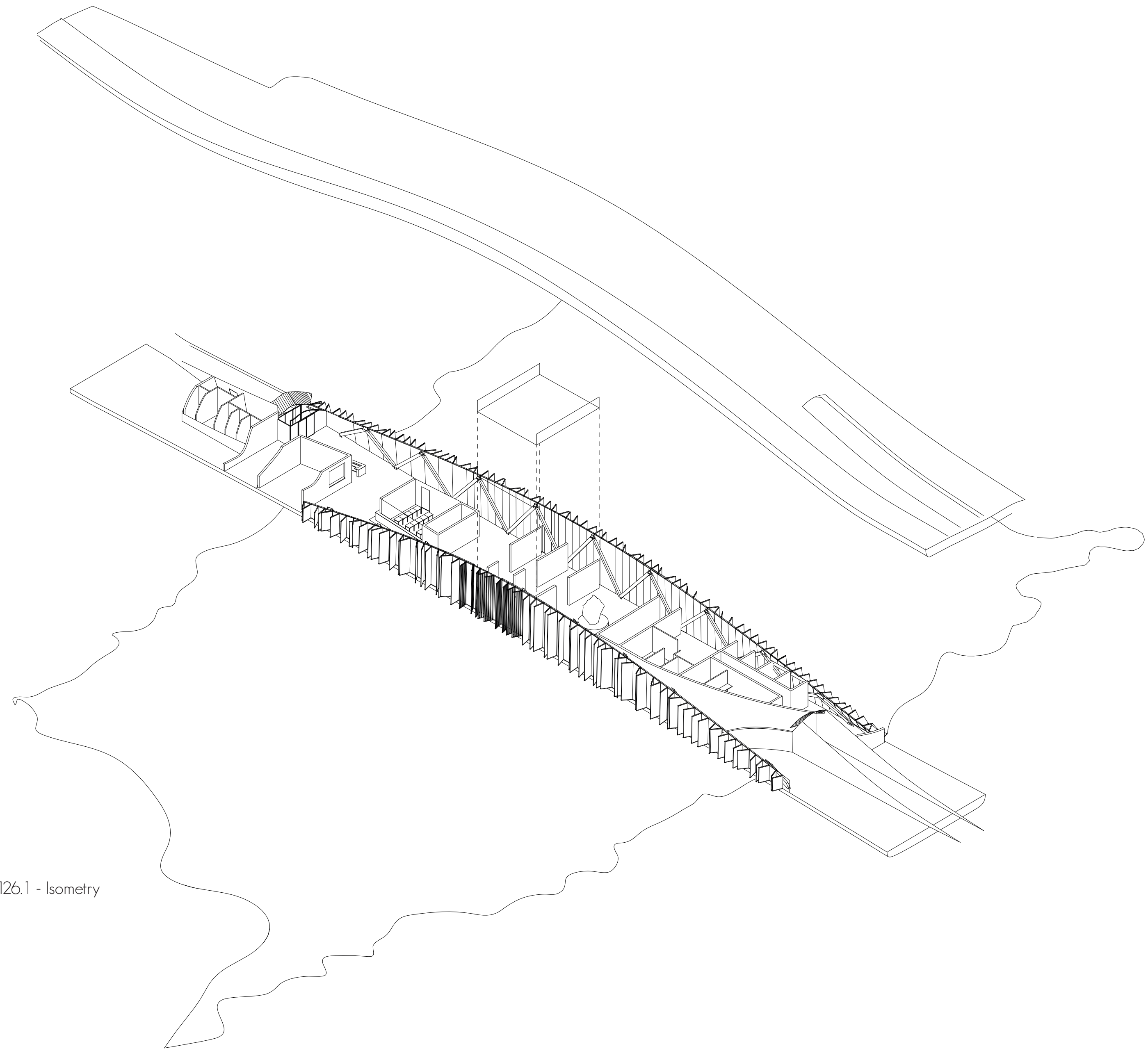
The research facilities can accommodate 4 researches at a time. Each researcher is provided with a private bedroom with storage space, to ensure that they have a private retreat where they can relax. The bedrooms and the shared kitchen/ living space is placed towards the northeastern facade to have a view of the landscape and Ilulissat, which makes the rooms comfortable and relaxing, which increases the social gathering.

The workshop is placed with a window towards the exhibition area, to ensure a transparency between the visitors and the field work. The workshop area gets no additional daylight, as some studies can be light sensitive work, and require controlled lightning.



Ill. 124.1 - Plandrawing 1:200 Research facilities

Ill. 125.1 - Visualization Research facilities



Ill. 126.1 - Isometry

Ill. 127.1 - Visualization Outdoor

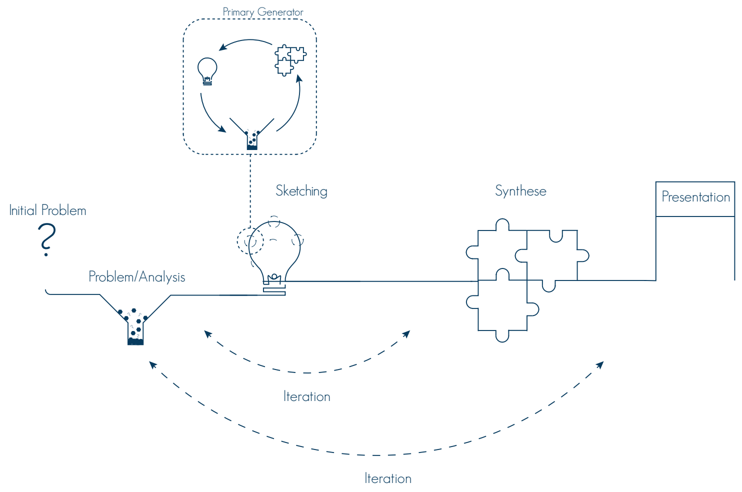
Ill. 128.1 - Glacier

6

EPILOGUE

Methodology - reevaluvated

Through the design process a methodology, as mentioned in the programme, has been used. This method has continuously been assessed and cut to be more simple and focused on certain aspects of the project.
The programming of the 3D daylight analysis tool had a high focus, as well as the implementation of it in the design process. The methodology aspect of the Integrated Energy Design has been irrelevant for the design process, as it did not take the renewables in Greenland into consideration. So the methods used throughout the design process has been the Integrated Design Process and the Sequential Primary Generator. The Integrated Design Process has been used as the overall structure for the process.
The Sequential Primary Generator has been used throughout the process to design facades, structures etc.



Ill. 130.1 - Diagram of Methodology reevaluvated

Reflection

PREPHASE
As the project was located in an unfamiliar climate and culture, a lot of time went into research. A visit to Greenland at that point would have been preferable, to explore the climate, the culture, and the building traditions. Furthermore it would have allowed a more phenomenological approach towards the site analysis as it would have been possible to experience the sites genius loci.

PLACEMENT
To place the Icefjord centre across the lake has its consequences, and the building cost and the material use is therefore larger than if the centre were built directly on top of the bedrock.
It will also require a different technique of assemble as the cranes are limited to each side of the building.

METHOD AND PROCESS
During the design process, the primary sketching tool has been 3D software, VR and parametric modelling, supplied with hand drawings. There's been a lack of physical models except for a site model, during the design process, which might have helped with understanding the scale of the building volume, as well as the structural elements.
Digital tools such as live renders and Virtual Reality, has been used in the progress which helped to understand the scale and how the different rooms and views were perceived. It however could not give a physical interaction, which can be important when generating ideas.

LIGHT DESIGN TOOL
The analysis tool has been developed simultaneously with the building design, and it therefore has not been possible to explore and evaluate, how the tool could be used in the initial design process. It could however have been used to evaluate initial form studies in terms of orientation and shape and size of openings.
The tool was used for the first time during studies of the floorplans. It was not fully developed at the time and could only give a result one point at a time which was very time consuming. The result was used to evaluate on a few of the floorplans, to see if the designs gave the same perception as anticipated. As it was a slow progress at the time, it could not be used on the overall floor plan, but based on the few

results it was clear which designs worked as intended and which didn't.
This helped us to understand that it was important to optimize the tool to give results faster and without much manual interaction.
During the design of the facade, the tool was further developed so each point could be calculated in a 360° degree direction, in less than 10 minutes. At this point several different facades was designed according to building concept, shape, and sun conditions. The tool was then used to evaluate on which perception each facade provided, and how well the light could be controlled according to which perception was wished. To validate the results each design was further tested via live rendering and virtual reality to compare the objective with the subjective results. The results showed as expected that the tool is predicting the atmosphere of each facade but, it did not take the view and if the facade was welcoming or not into account, which means that the tool does not eliminate any current ways of evaluating the design, but is a supplement to get a better understanding.
The chosen facade could be angled in different ways, which would control the amount of inlet light and thereby control the perception of the space. The tool was used to run a hundred iterations with different facade angles in primary locations in the building, after which it was possible to choose facade angles based on which perception was intended for the different locations.
This part of the process showed that the tool could be used as an optimization tool, which was particularly helpful in the design process as it would be difficult to do manually, as there is a lot of variables affecting the result.
The tool was at this point in the process developed so it could calculate multiple points, which meant that the whole building could be analysed in approximately 2 hours. This allowed us to evaluate the flow of perception through the building, both before and after the optimization on the facades. The result showed that the perception throughout the building was more aligned to the wished storytelling. There was however several unanticipated results which was caused by small changes to the floor plan, which had a significant impact on the perception.

Throughout the design process the tool was used in different ways, which all helped to understand how different variables all had an effect on the perceived space. The tool however can not be used to deliver the end result, but as a guideline that needs to be validated by the architects subjective opinion.

OUTPUT

The primary lessons learned from the design process, has been not to rely on everything we have been taught, but rather to remember to think critically on both information and method. An example was the sustainable focus from the beginning, which turned out to be misplaced as there were no need to focus on the conventional aspects such as renewable energy on site and extremely strict indoor environment, due to the different climate.

It has also been a valuable lesson to get to work in a different landscape, climate, and building culture than we have been used to, as they all affect the building design heavyly.

SUMMARIZATION

The reflection has been with a critical point of view, as the final result fulfils the design parameters, and does not only create an architectural landmark but is also build with respect to its surroundings and is articulating the important aspect of Global warming, both through its exhibition, but also through its research department and conference facilities.

Conclusion

APPROACH

One of the main focuses of the thesis was to design with daylight as perceived by the human eye, and not by using the traditional daylight factor which is a requirement in the building regulations, which should ensure good daylight. A tool based on the works of S. F. Rockcastle was developed to analyze the daylight from the user's perspective and evaluate their predicted perception of the space. The Icefjord Centre has been designed in parallel with the tool, and the tool has been repeatedly used to design the centre, which is a journey on its own and caused by its unique architecture.

PLACEMENT

The Icefjord Centre needs to be established close to Ilulissat Icefjord which is on the UNESCO's world heritage list. The Icefjord Centre is therefore a gateway to the icefjord, which provides information, catering, and facilities for research, administration, and seminars, where the discussions about climate change can take place. To be aligned with it's functions, the centre is designed with an sustainable approach.

The Icefjords Centre is stretching across the lake connecting the two landscapes on each side. This pushes the conventional typology of a building, being erected on either a solid fundament in soil or on poles, which underlines the appearance that the building is an extension of the landscape.

CONSTRUCTION

The construction is inspired by traditional spanning structures, which are capable of supporting high weights across great spans. The materiality indoor and outdoor is primarily wood, which supplies a warmness and textility, in the otherwise harsh environment. The floor is made of slate tiles and refers to the solid bedrock which the building is leaping from. It also provides a steady and stable feeling, which can counteract the small movements that might occur in a long span building. The textility of the slate is unique in each tile, which gives it a depth and a story to tell, and relates to the old hunting weapons which was of slate as it is naturally occuring in the area.

ORGANIZATION

The Icefjord Centre is designed as one big open space, which hosts several functions and experiences. This makes the main

roof a dominant experience throughout the building, where it creates both high and low spaces under the ceiling. The ceiling does not provide intimate areas, and the experience can quickly exceed the human scale. Boxes was therefore implemented with different functions, which was kept at the same height, so the scale was not lost in the building. It furthermore created intimate spaces in, around, and on top of the boxes.
The boxes works as a contrast to the roof, which allows the visitors and users to get different experiences throughout the building.
The flow through the building is linear, as the visitors can exit the building on the opposite side of the entrance and come back to their starting point by crossing the roof.

Reference

Abb-conversations.com. (2018). ABB Conversations > Building an unmanned hydropower plant beneath Greenland’s glaciers. [online] Available at: https://www.abb-conversations.com/2012/12/building-an-unmanned-hydropower-plant-beneath-greenlands-glaciers/ [Accessed 20 Feb. 2018].

ArchDaily. (2018). AD Classics: Nordic Pavilion in Venice / Sverre Fehn. [online] Available at: https://www.archdaily.com/784536/ad-classics-nordic-pavilion-in-venice-sverre-fehn [Accessed 17 Apr. 2018].

ArchDaily. (2018). Svalbard Science Centre / JVA. [online] Available at: https://www.archdaily.com/3506/svalbard-science-centre-jva [Accessed 21 Feb. 2018].

ArchEyes. (2018). The Nordic Pavilion in Brussels for the World Exhibition of 1962 / Sverre Fehn ArchEyes. [online] Available at: http://archeyes.com/norwegian-pavilion-in-brussels-world-exhibition-sverre-fehn/ [Accessed 22 Feb. 2018].

Arkitektkonkurrencerdk.dk. (2018). Vadehavscentrets Jury. [online] Available at: http://www.arkitektkonkurrencerdk.dk/konkur/vadehav_judge.pdf [Accessed 14 Feb. 2018].

Björkstén, K., Kripke, D. and Bjerregaard, P. (2009). Accentuation of suicides but not homicides with rising latitudes of Greenland in the sunny months. BMC Psychiatry.

Bridgesdb.com. (2018). Chapel Bridge or Kapellbrücke - Facts and History Information. [online] Available at: http://www.bridgesdb.com/bridge-list/kapellbrucke-chapel-bridge/ [Accessed 20 May 2018].

Byggefilm.dk. (2018). Den blå kirke. [online] Available at: http://www.byggefilm.dk/Videoklip%20Dokumenter/Den_Blaa_Kirke_faktaark_2017%20-%20final.pdf [Accessed 16 Feb. 2018].

Byggefilm.dk. (2018). byggefilm.dk. [online] Available at: http://www.byggefilm.dk/Pages/MovieDetail.aspx?MovieID={71D5B0D4-1671-44D3-A6E1-59D6693C8CA7} [Accessed 16 Feb. 2018].

Byginfo.gl. (2018). Anvisninger fundering. [online] Available at: http://www.byginfo.gl/Portals/0/Publikationer/Anvisninger/fundering.pdf [Accessed 21 Feb. 2018].

Byginfo.gl. (2018). Anvisning tage. [online] Available at: http://www.byginfo.gl/Portals/0/Publikationer/Anvisninger/anvisning_tage.pdf [Accessed 20 Feb. 2018].

Bygningsreglementet.dk. (2018). BR18. [online] Available at: http://bygningsreglementet.dk/Bilag/B2/Bilag_2 [Accessed 21 Feb. 2018].

Bygningsreglementet.dk. (2018). Energifaktorer. [online] Available at: http://bygningsreglementet.dk/Tekniske-bestemmelser/11/BRV/Energiforbrug/Kap-1_1 [Accessed 14 May 2018].

Byginfo.gl. (2018). BR2006 [online] Available at: http://www.byginfo.gl/Portals/0/pdf/love/BR2006DK.pdf [Accessed 21 Feb. 2018].

Climate Greenland. (2018). En grønlandsk virkelighed - Climate Greenland. [online] Available at: http://climategreenland.gl/borger/en-groenlandsk-virkelighed/ [Accessed 20 Feb. 2018].

Carbonfund.org. (2018). How We Calculate - Carbonfund.org. [online] Available at: https://carbonfund.org/how-we-calculate/ [Accessed 21 Feb. 2018].

D., geologien. (2018). Menneskenes land ved isfjorden. [online] Geus.dk. Available at: http://www.geus.dk/udforsk-geologien/laering-om-geologi/viden-om/viden-om-ilulissat-isfjord/menneskenes-land-ved-isfjorden/ [Accessed 16 May 2018].

Dansk Center for lys, (2017). [ebook] Dansk Center for lys. Available at: https://centerforlys.dk/wp-content/uploads/2018/01/PRESSELyspris2017efter.pdf [Accessed 12 Feb. 2018].

Daylight OCULIGHT dynamics. (2017). Daylight | Lausanne | OCULIGHT dynamics. [online] Available at: https://www.oculightdynamics.com/ [Accessed 9 Feb. 2018].

Denstoredanske.dk. (2018). albedo | Gyldendal - Den Store Danske. [online] Available at: http://denstoredanske.dk/Geografi_og_historie/Geografi/Naturgeografi/Vejrf%C3%A6nomener/Nordlys,_elektriske_f%C3%A6nomener_og_str%C3%A5ling/albedo [Accessed 30 Mar. 2018].

Den store danske. (2018). Grønland Geografi og historie. [online] Available at: http://denstoredanske.dk/Geografi_og_historie/Gr%C3%B8nland/Gr%C3%B8nlands_geografi/Gr%C3%B8nland [Accessed 06 Feb. 2018].

Denstoredanske.dk. (2018). Indlandsisen | Gyldendal - Den Store Danske. [online] Available at: http://denstoredanske.dk/Geografi_og_historie/Geografi/Naturgeografi/Glaciologi/Indlandsisen [Accessed 16 Feb. 2018].

Denstoredanske.dk. (2018). Ilulissat | Gyldendal - Den Store Danske. [online] Available at: http://denstoredanske.dk/Geografi_og_historie/Grønland/Grønlands_geografi/Ilulissat [Accessed 24 Jan. 2018].

Denstoredanske.dk. (2018). Grønland - klima | Gyldendal - Den Store Danske. [online] Available at: http://denstoredanske.dk/Geografi_og_historie/Geografi/Naturgeografi/Klimatologi_og_klimatyper/Grønland_-_klima [Accessed 16 Feb. 2018].

designboom | architecture & design magazine. (2018). jarmund/vigsnaes arkitekter: svalbard science centre. [online] Available at: https://www.designboom.com/architecture/jarmundvigsnaes-arkitekter-svalbard-science-centre/ [Accessed 22 Feb. 2018].

Dmi.dk. (2018). Grønland klimaforandringer. [online] Available at: https://www.dmi.dk/fileadmin/user_upload/Groenland/Klimaforandringer_Groenland_pixi.pdf [Accessed 16 Feb. 2018].

Dmi.dk. (2018). Grønlands fremtidige klima: DMI. [online] Available at: https://www.dmi.dk/laer-om/temaer/klima/iskapper/indlandsisen-paa-groenland/groenlands-fremtidige-klima/ [Accessed 16 Feb. 2018].

Dmi.dk. (2018). Vejrarkiv: DMI. [online] Available at: https://www.dmi.dk/groenland/arkiver/vejrarkiv/ [Accessed 14 Feb. 2018].

Dmi.dk. (2018). Vindstyrketabellen: DMI. [online] Available at: https://www.dmi.dk/hav/danmark/farvandsudsigter/vindstyrketabellen/ [Accessed 24 Jan. 2018].

Dmi.dk. (2018). Rapport Qaasuitsup. [online] Available at: http://www.dmi.dk/fileadmin/user_upload/Rapporter/SR/2015/15-04-05_qaasuitsup.pdf [Accessed 21 Feb. 2018].

Dtu.dk. (2018). Smeltevand skaber nye områder med land ved Grønland - DTU Space. [online] Available at: http://www.dtu.dk/Nyheder/Nyhed?id=9baca933-f671-437a-883d-d2fc71b1d602 [Accessed 16 Feb. 2018].

DS/EN ISO 7730. (2015). Danish Standards Foundation.Ergonomi inden for termisk miljø - Analytisk bestemmelse og fortolkning af termisk komfort ved beregning af PMV- og PPD-indekser og lokale termiske komfortkriterier

Foged, I. (2018). Integrated Design Process by Sequential Primary Generators.
Journal of Problem Based Learning in Higher Education

Geus.dk. (2018). Den nærende isfjord - dyr og planter - Viden om Ilulissat Isfjord. [online] Available at: http://www.geus.dk/DK/popular-geology/edu/viden_om/ilulissat/Sider/voii07-dk.aspx [Accessed 12 Feb. 2018].

Geus.dk. (2018). Kvik-guide til Ilulissat Isfjord - Viden om Ilulissat Isfjord. [online] Available at: http://www.geus.dk/DK/popular-geology/edu/viden_om/ilulissat/Sider/voii02-dk.aspx [Accessed 19 Feb. 2018].

Gravesen, P. and Kelstrup, N. (2001). Grundlæggende geologi og grundvand. København: Miljøstyrelsen.

Happyzebra.com. (2018). Copenhagen to Ilulissat: time difference, distance and flight duration time. [online] Available at: https://www.happyzebra.com/timezones-worldclock/difference-between-Copenhagen-and-Ilulissat.php [Accessed 21 Feb. 2018].

Hyldgård, C. (1977). Grundlæggende Klimateknik og Bygningsfysik. Aalborg: Aalborg Universitet Instituttet for Bygningsteknik, p.10.

Keflico (2018). Accoya træ. [online] Available at: https://keflico.com/produkter/trae/accoya/accoya/ [Accessed 16 May 2018].

Kegle, M., Dam, H., Bjerregaard, P. and Ali, F. (2009). CrossRef citations 0 Altmetric Original Article The prevalence of seasonal affective disorder (SAD) in Greenland is related to latitude. [online] Available at: http://www.tandfonline.com/doi/full/10.1080/08039480902799040 [Accessed 9 Feb. 2018].

Kjeldsen, K., Schelde, J., Asgaard Andersen M. and Holm, M. (2012). New Nordic: Architecture and Identity. Humlebæk: Louisiana Museum of Modern Art. pp. 18- 33, 84 -89, 100- 115 and 134- 155.

Kongebro, S., Strømann-Andersen, J. and Mandsfeldt, L. (2012). Hvad med dagslys?. 1st ed. [S.l.]: Dagslysrenovering.dk and Henning Larsen Architects, pp.28-31.

Kongebro, S. (2012). Design med viden. Copenhagen: Henning Larsen Architects, pp.14-17.

Kruger, C. and Cross, N. (2006). Solution driven versus problem driven design: strategies and outcomes. Design Studies, 27(5), pp.527-548.

lca-center.dk. (2018). Hvad er LCA | LCA Center. [online] Available at: https://lca-center.dk/hvad-er-lca/ [Accessed 21 Feb. 2018].

Maerskline.com. (2018). Dry Cargo. [online] Available at: https://www.maerskline.com/en/shipping/dry-cargo [Accessed 16 May 2018].

M. Luca, K., Kotol, M. and Lading, T. (2016). Energy-efficient Building in Greenland: Investigation of the Energy Consumption and Indoor Climate. Kongens Lyngby: Procedia Engineering. (PDF).

M. L. Ámundadóttir, M. Andersen and S. W. Lockley (Dirs.).(2016) Light-driven model for

Reference

identifying indicators of non-visual health potential in the built environment. Thèse EPFL, n° 7146

M. Sarey Khanie, M. Andersen and J. Wienold (Dirs.).(2015) Human responsive daylighting in offices a gaze-driven approach for dynamic discomfort glare assessment Thèse EPFL, n° 6660

Pallasmaa, J. (2005). The eyes of the skin. Chichester: Wiley Academy.

Plummer, H. (2012). Nordic light. London: Thames & Hudson. pp. 6-20, 73-80, 146-153, 175-189, 203-209 and 227-233.

Possible Greenland. (2012). [ebook] DAC - Dansk Arkitekur Center. Available at: http://borisbrorman.dk/web/wp-content/uploads/2012/02/Possible-Greenland_Catalogue_2012.pdf [Accessed 9 Feb. 2018].

Qaasuitsup.gl. (2018). Fakta om Kommunen. [online] Available at: http://www.qaasuitsup.gl/Emner/Om_kommunen/Fakta%20om%20Kommunen?sc_lang=da [Accessed 12 Feb. 2018].

Qaasuitsup-kp.cowi.webhouse.dk. (2018). List of town plan addendums and local plans. [online] Available at: http://qaasuitsup-kp.cowi.webhouse.dk/en/vision_and_main_structure/planning_forecast/list_of_town_plan_addendums_and_local_plans/ [Accessed 23 Feb. 2018].

Real Dania, the government of Greenland and Qaasuitsup municipality, 2015. Ilulissat Competition Brief. [pdf] Available at: https://realdania.dk/-/media/Realdaniadk/Publikationer/Projekter/Ilulissat-Konkurrenceprogram/Ilulissat-konkurrenceprogram.pdf [Accessed 2 Oct. 2017].

Ring Hansen, H and Knudstrup, M, (2005) The integrated design process (IDP) Aalborg: Architecture and Design, Aalborg University.

S. F. Rockcastle, M. Andersen (Dir.). (2017) Perceptual Dynamics of Daylight in Architecture. Thèse EPFL, n° 7677

Sundhedsstyrelsen (2007). Referenceprogram for unipolar depression hos voksne. Afsnit 5.3.5.1. [online] Available at: http://www.sst.dk/~/media/6F9CE14B6FF245AABCD222575787FEB7.ashx [Accessed 12 Feb. 2018].

Stat.gl. (2018). Grønlands Statistik. [online] Available at: http://www.stat.gl/dialog/topmain.asp?lang=da&sc=TU [Accessed 15 Feb. 2018].

Stat.gl. (2018). Grønlands Energiforbrug. [online] Available at: http://www.stat.gl/publ/da/EN/201703/pdf/Grønlands%20energiforbrug%202016.pdf [Accessed 20 Feb. 2018].

Tourismstat.gl. (2018). Greenland Tourism Statistics. [online] Available at: http://tourismstat.gl [Accessed 14 Feb. 2018].

Uldall Jensen, M. (2000). Fangerliv i Grønland. Skoletjenesten National museet.
Vadstrup, S. and Schultz-Lorentzen, H. (1993). Bevar Grønlands bygningskultur og bygnings historie. [ebook] Available at: http://www.tidsskriftetgronland.dk/archive/1994-6-Artikel01.pdf [Accessed 5 Feb. 2018].

Vadstrup, S. and Schultz-Lorentzen, H. (1993). Bevar grønlands bygningskultur og bygningshistorie. [online] Tidsskriftetgronland.dk. Available at: http://www.tidsskriftetgronland.dk/archive/1994-6-Artikel01.pdf [Accessed 17 Feb. 2018].

Velkommen til Ilulissat isfjord. (2018). Dyr og planter i verdensarvsområdet. [online] Available at: http://www.kangia.gl/Fakta%20om%20isfjorden/Dyr%20og%20planter%20i%20verdensarvsomraadet?sc_lang=da [Accessed 12 Feb. 2018].

Visit Greenland. (2018). Vejr og klima i Grønland - [Besøg Grønland!]. [online] Available at: https://visitgreenland.com/da/om-groenland/groenland-klima-vejret/ [Accessed 26 Jan. 2018].

Visitribe. (2018). Vadehavscentret | Porten til UNESCO Verdensarv | Ribe. [online] Available at: https://www.visitribe.dk/vadehavscentret-porten-til-unesco-verdensarv-gdk610542 [Accessed 12 Feb. 2018].

Weidick, A. and Bennike, O. (2007). Quaternary glaciation history and glaciology of Jakobshavn Isbrae and the Disko Bugt region, West Greenland. Copenhagen: Geological Survey of Denmark and Greenland.

Windhistory.com. (2018). Prevailing historical winds. [online] Available at: http://windhistory.com/station.html?BGJN [Accessed 24 Jan. 2018].

Zumthor, P. (2006). Atmospheres . Basel: Birkhäuser Verlag gmbH

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