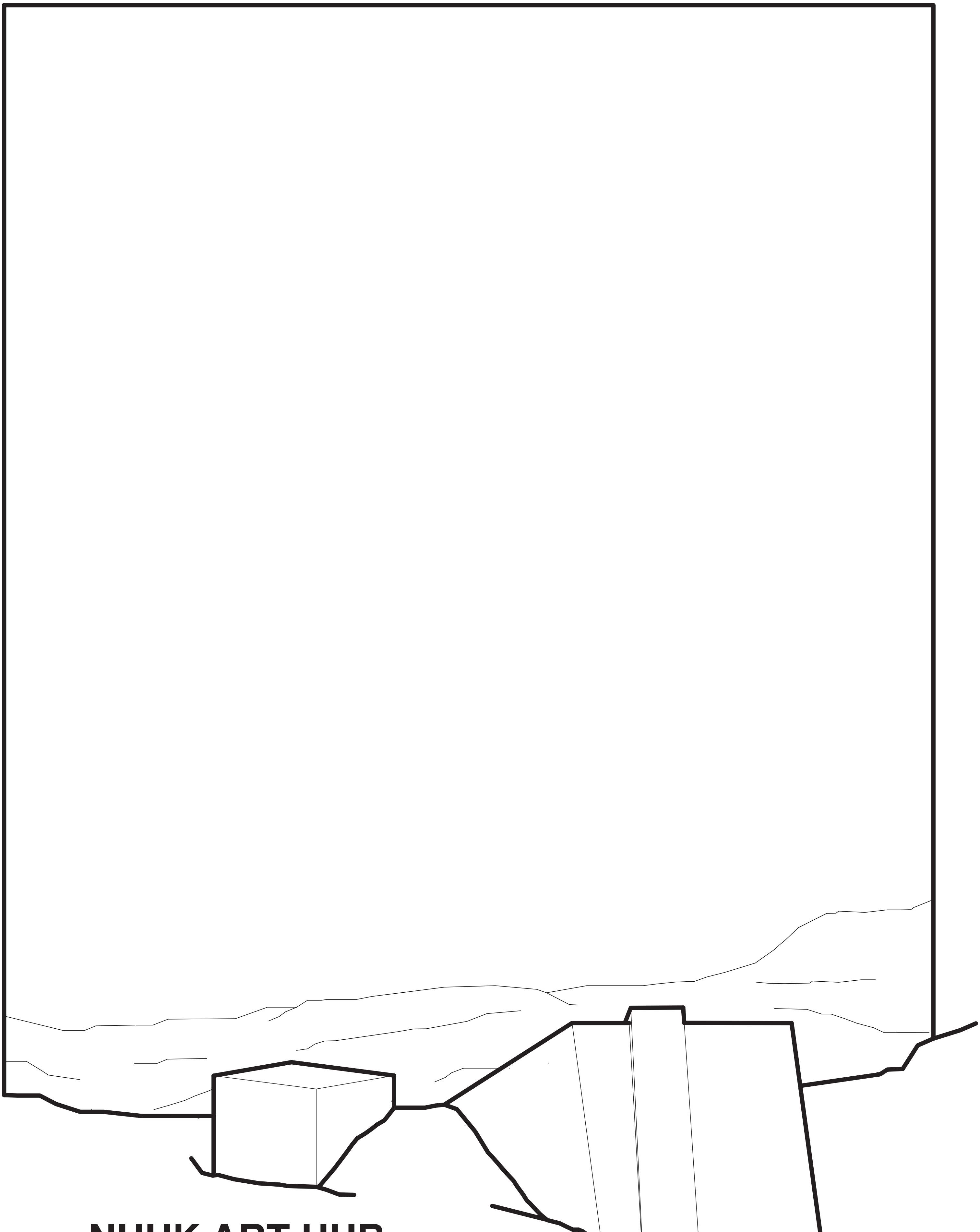

NUUK ART HUB

Master's of Architecture and Design
Thesis by
Inger Hohlweg and Calina Manisor

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Abstract

The presented proposal dwells upon the imminent societal change in the Arctic environment. By means of analysis of the local traditions and present day environment, the proposal aims to house and promote a conscious and integrated social development of the modernizing society of Greenlanders. Therefore, Greenland Art Hub will encompass both The National Gallery of Greenlandic Art as wished by the Municipality, but also a Culture House with classrooms and workshops designed for accommodating the local artistic movement.

From an architectural perspective, the proposal assesses an integrated design approach that focuses on creating a framework that is humble in relation to the existing environment. Moreover, great attention has been given to conscious design, where sustainable features and the architectural intention inform each other in a tectonic way

Contents

The proposal is introduced to the reader through the Abstract. Following this explanation, the Motivation and Methodology of the project are showcased.

Program

Synthesis

Process

Design Development

Epilogue

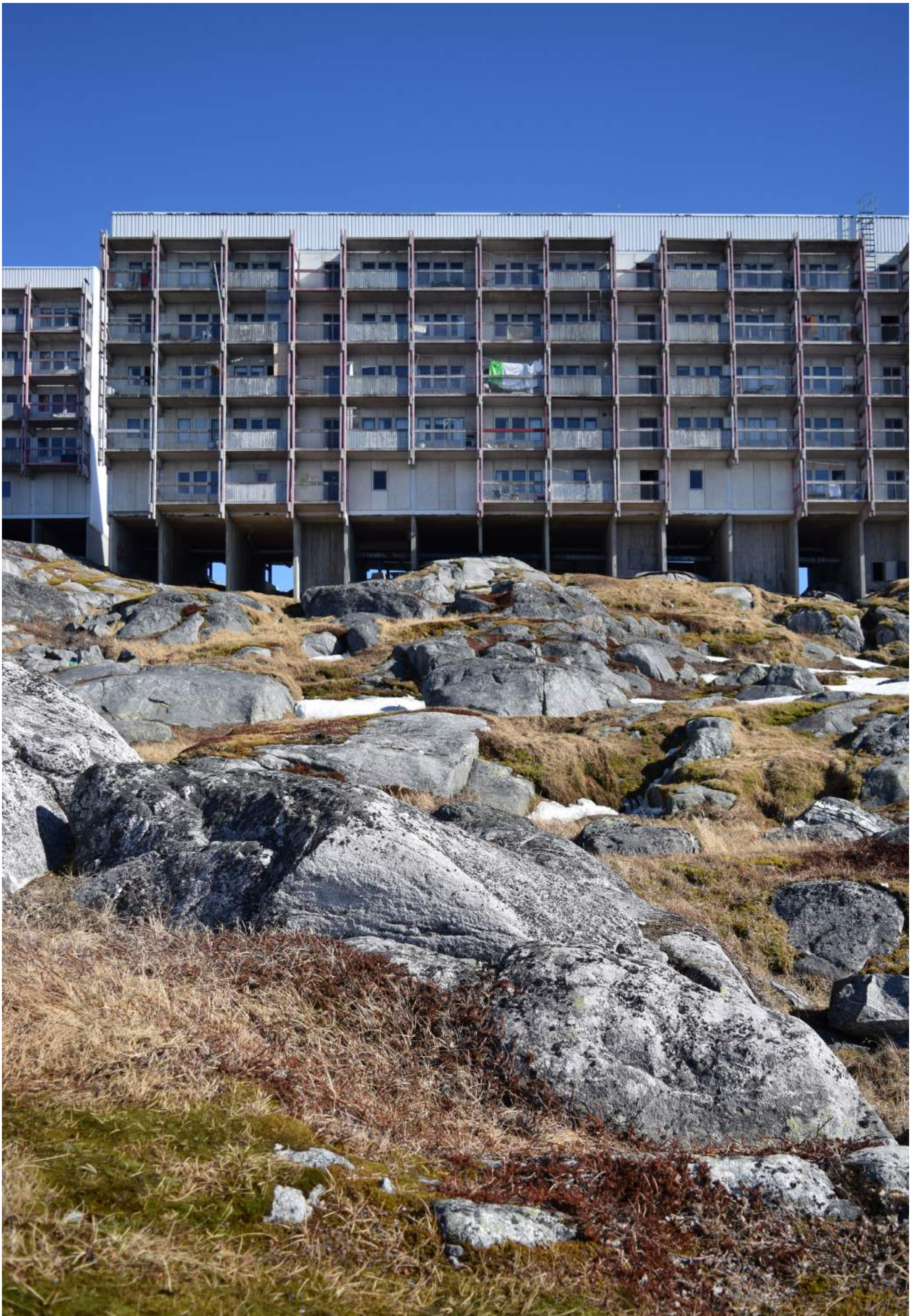


Fig. 1. Radiofjorden Housing Blocks

Motivation

In a world of continuous transition, the greatest quality of men is adaptability. Either because of enforced climate changes, or of geopolitical issues, man has always found a way in which to cope with the given situation.

Why Greenland

Depicting on this premise, Greenland as we know it now, has been undergoing considerable transformation in the structure of their day-to-day traditions. Attesting this narrative stands the desire of the indigenous peoples' of the North to make industrial use of their lands and resources, in order to develop their societies.

> 'Are Greenlanders competent enough to rule their own affairs and can they administer the economic bonanza from the oil.'
>
> [Sejersen, 2015, p.20]

This new direction sets the scene for architectural development as to accommodate the new industrial growth.

However, a main concern for this marginal part of the world is the lack of resources in terms of building materials, as well as the harsh arctic climate. Sustainable building in these conditions is still pristine territory, as not only the climate, but also the resources have different boundaries then in 'continental' countries.

Thus, building sustainably in Greenland presents us with a challenge in terms of determining the confinements of our possibilities. This will enforce us to truly understand not only the potential of modern sustainable technologies and principles, but also learn from the vernacular way of building in order to obtain a successful proposal that is suitable for the local environment.

Why Art Hub

Initially relying on the proposal for the competition led by Greenland National Art Gallery, which supports the opportunity of establishing a National Gallery of Art in Nuuk, we have seen the potential of creating a venue that nurtures and promotes local art, as a means of modern social development.

The initiative is encouraged by the increased interest for the Indigenous traditions, which has lead to a growth in the number of visitors to Arctic countries such as Greenland and Iceland [Visit Greenland, 2015]. However, a main concern of the Inuit peoples, is that their culture is so unique, and so far from modern standards, that it is hard to fully understand and empathize with their traditions. However, it is interesting to compare the attitude of the Inuits with that of other Indigenous people. While Inuits have great pride in their traditions, Mongolians for example render some traditional beliefs as 'for the poor'. Such is the example of the traditional 'ger' house, the dwelling being categorized as deficient by the middle class [Köçümkulkïzï and Waugh 2001]. Seeing this comparison, we strongly believe that the establishment of a venue that promotes local culture and values is essential.

Yet, further research has made us believe that creating a place for the visitors of Nuuk is somehow a non-sustainable solution for the local economy. Given the existing city with a population of approx. 16.000 inhabitants, we felt it essential that, if a venue of such high potential should be erected, then the venue should also give something in return to the local community.

Referencing the typology of the guildhall in such an extreme environment presents us with the unique challenge of responding to demanding social and environmental needs, as throughout the year there are moments when indoor venues are the only place where people can gather [Slavid, 2009, p.58].

Methodology

In order to propose a conscious and empathetic design in an environment placed so far away from the 'known', an extensive analysis that encases different scales and fields needs to be conducted.

Problem Based Approach

The departure point of the project is outlined by using the method concerning problem based learning by highlighting the hypothetical problem of adaptation and integration. By means of research, analysis and testing the programme of the proposal has been outlined. In this sense, a SWOT [Strong/ Weak/ Opportunities/ Threats] analysis has been conducted, from which, based on a phenomenological understanding of the environment and the society, the potential of the given site has been assessed. Therefore, the problem has been formulated as a discontinuity between the traditional and the post-colonial Inuit society, which strives to shape their own future [Sejersen, 2015].

Process

The Integrated Design Process phases as enunciated by Knudstrup [2005]: problem phase, analysis phase, sketch phase, synthesis phase and presentation phase are an accurate narrative of the mechanism of developing an architectural proposal. However, the operation lacks the interplay between analysis, synthesis and evaluation, highlighted in Lawson's writing on *How Designers Think*. This particular negotiation is for our project essential, as the chosen social and natural context are different to what we perceive as 'ordinary'. Therefore, within our process, a constant iteration between Knudstrup's first four stages of design is stressed, as it has been essential for us to propose a informed sustainable design that is contextual in terms of architectural intention, conscious in terms of environmental considerations, and nonetheless iconic.

By using the Municipal plan that considers the erection of a National Gallery of Art as a point of departure, and by analyzing the existing environment, alterations to the initial brief have been made in order to accommodate our findings. Hence, a new program has been made. The program includes the framework for the architectural intention of the Art Hub, as well as the spatial requirements for the rooms housed in the venue.

The draft phase includes a series of working loops synthesized in a way in which the programmed aesthetic, technical, functional and sustainable qualities are met. The final design is completed during the presentation phase, with presentation of the final design through pictures, diagrams, texts and calculations in order to attest the accuracy of the group's proposal. The information about the design shall be included in a booklet, taking the reader through the design process, as well as present him/her with the finalized proposal.

Sewing Architecture and Engineering

Integrated design implies the interweaving of multiple aspects that consider both the architectural expression as well as technical requirements. Following this consideration, these aspects are incorporated in the final solution. The method is a fusion between problem-based learning and professional knowledge, from both architectural and engineering fields, with an emphasis on social and environmental sustainability, achieved in a tectonic manner. Moe [2008, p.6] defines integrated design as a intertwining between a building's spatial, construction, energy and system logics which inform the final design. This approach depicts upon a looping process of constant optimization through iterations.

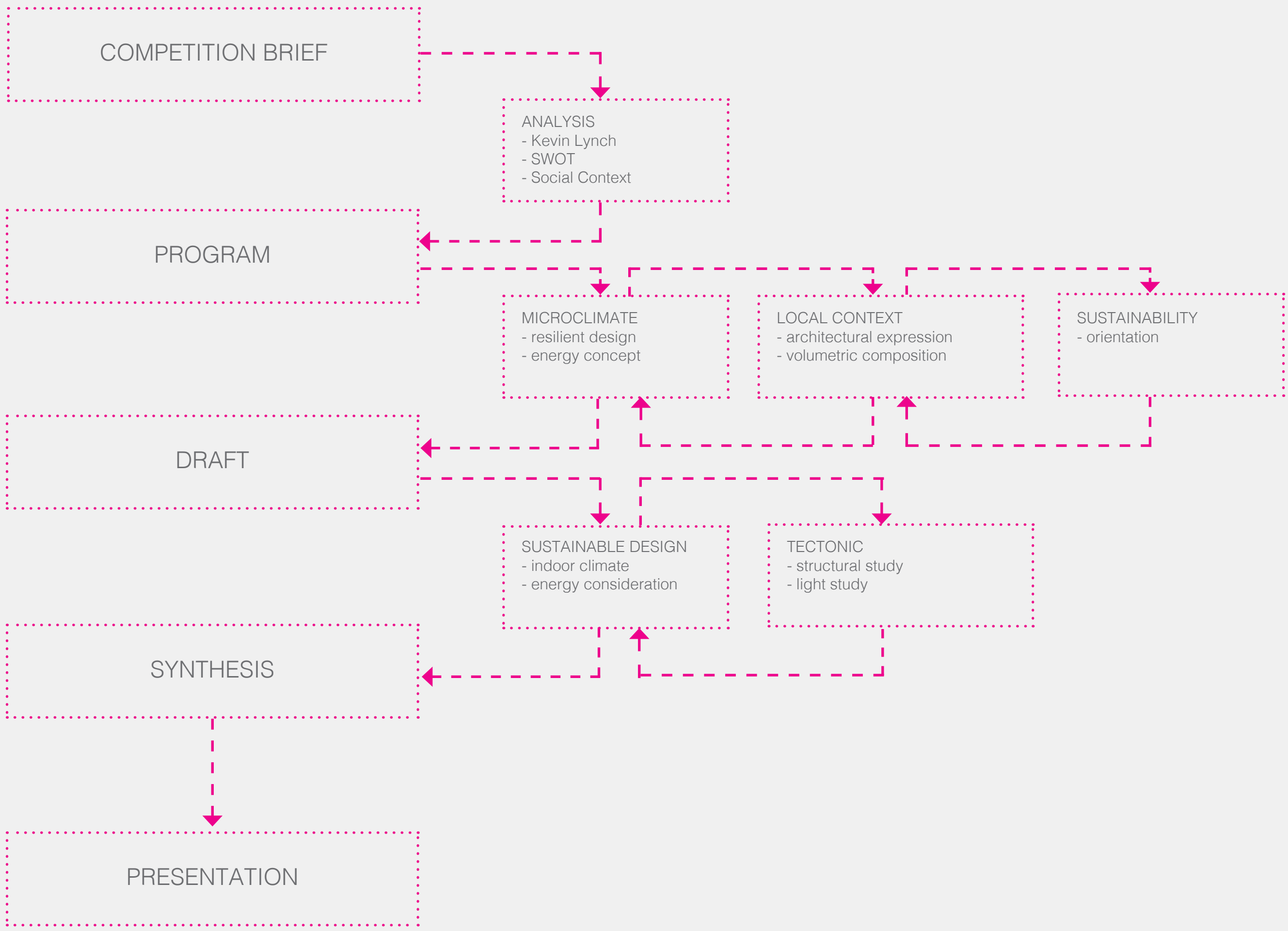


Fig. 2. Methodology

Fig. 3. View in Nuuk


PROGRAM

Fig. 4. Inuit Traditional Wear

Analysis

The Chapter presents the initial considerations used in framing the program of the project. The physical and the phenomenological context have been assessed. The chapter is divided in four areas as follows:

Initial Considerations

The User

The Site

The Place

Initial considerations

While seeking for the challenge of building in an extreme environment, we have depicted upon the brief for the new National Museum of Art in Nuuk, Greenland as a point of departure for our program.

Greenland National Gallery

In August 2010, Greenland's National Gallery of Art committee, together with Vibeke Petersen and Kommuneqarfik Sermersooq Architects' Association have drawn up the brief that addressed the establishment of a museum of art focusing on Greenlandic art and Greenlandic artists.

The intention has been that of organizing an invited design competition where Nordic architecture practices would propose modern, yet empathetic designs for the realization of Greenland's new National Gallery of Art. [Greenland's national gallery of art, 2010].

Municipal Plan

The Board has had a clear vision for the desired proposal: to work for the establishment of an internationally oriented highly professional institution that communicates the continuous project of documenting and development of the Greenlandic national identity through art and culture.

At a morphological level, the National Gallery of Art is intened to be organized into four closely related, mutually illustrative, supplementary departments:

- Department of Greenlandic art
- Department of more recent and contemporary graphic art in Greenland.
- Department of circumpolar art – art from the Nordkalotten.
- Department of international art.

[Greenland's national gallery of art, 2010]

However, the intention behind the establishment of the gallery is not solitary based on the needs of accommodating works of art. By using the gallery's collections as a point of departure, and as the focus of an active program of presentation, the museum will promote and reinvigorate interest in art and artistic expression, by means of special exhibitions and events, therefore having particular relevance to the museum's terms of reference.

> 'We are seeking proposals of high architectural, technical and functional quality. Our aspiration is for the Gallery to be a distinctive focal point for Greenlandic art, and that both residents of and visitors to Greenland will be attracted to and enriched by a visit to the Gallery.'

[Greenland's national gallery of art, 2010, p. 4].

Therefore, we have rendered this discussion into an open invitation to expand upon the intention of an active program of presentation, as mentioned by the brief.

The following pages will frame the importance of creating such a space and place for the community. Moreover, the research has been used to outline the demands of both the society and the environment.

Fig. 5. Culture Centres and Museum in Greenland

the diagram showcases the total number of cultural venues in Greenland. although specialized literature has attested that these types of spaces are the only places were people can gather during winter periods, not many are exclusively designed for such purposes. school gyms are used for social gatherings instead

The User

In order to have a successful 'space and place', it is highly essential to assess the not only the site, but also the potential user and social context in which the venue is placed.

An Era of Change

It is important to understand the social context of the society in order to propose the right use for the designed venue, as our desire is for our solution to be embraced by the community not only at an aesthetic level but also for its function and role. Therefore, the topic *'An Era of Change'* frames the scene of Greenland's modern society and the presents the struggles they are facing.

Sejersen's [2015] book on *Rethinking Greenland and the Arctic in the Era of Climate Change* outlines a profound understanding of Greenlandic traditions and contemporary needs. After a historical legacy of colonialism that linked Greenland to Denmark since 1721 [from being a colony to being endowed as an integrated part of the Danish realm], in 2009 Greenlanders have changed the face of the country's home rule to self government, offering themselves the recognition as peoples with right to independence from Denmark. Greenland is however still depending on Denmark through the block grant of 3.6 billion DKK for areas such as education, health, fisheries, and environment. [Sejersen, 2015, p.28]

Awareness in terms of societal and environmental changes that Greenland is facing, has led to the desire of diversification and strengthening of the nation's economy. This has been achieved by facilitating access to mega-industries such as the placement of aluminum smelters in three of the country's most developed cities. The initiative represents an active way of adapting to natural changes, creating opportunities for future generations.

This adaptation entails however, a '*total transformation of society*' [Sejersen, 2015, p.126]. Nonetheless, the environmental change and the desire of furnishing a new society is also addressed by the ambition of turning the melting ice problematic into a water resource.

Therefore today, after being deeply entangled in colonial and post-colonial projects, the people of Greenland are on their way into modernity. However, the people have become marginal, this marginality being linked in respect to one's own culture, to the environment and to modern culture. Moreover, comprehending 'the local point of view' is not an exercise in representing one's understanding of place or of a diversity of views, but a question of appreciating how place-awareness can be multi-dimensional and can be intertwined in dynamic spatial and temporal scale-making, while simultaneously being deeply embedded in everyday life and prevailing problems.

Geopolitical Context

The concept of '*Indigenous Peoples*' has undergone intensive lobbying in terms of embracing these cultures as stakeholders in the international context. The people's ambition of self-determination and, concomitantly, the rights to continue practicing a specific way of life are being pursued in political institutions on different scales [Sejersen, 2015, p.18]. Moreover, the initiative stressed upon the importance of the collective right to determine a personalized future development. Adequate examples of this phenomena are Greenland or the Nunavut region in Canada, places that have managed to detach and express their own beliefs, taking the form of self-government in Greenland and regional government of Nunavut in Canada.

Climate change

In an era subjected to continuous climate change, challenges such as melting sea ice, receding glaciers, the thawing of permafrost or changes in biodiversity and resource presence, have placed Arctic societies in a tense situation. Now, difficult societal choices have to be made and expectations have to be reconsidered. Sejersen [2015] argues that the speed of environmental change that challenges indigenous peoples' capacity for adaptability is linked with the discourse of the speed of cultural and social changes in the wake of modernization. Hence, indigenous peoples are seen as being unable to adapt quickly enough to the demands of the modern world.

Industrialization
As a result of the shift in natural resources, especially those which concern the fishing industry, unemployment has become an issue. This lack of jobs has forced people to consider emigration, thus resulting in a population shift that can prove devastating to indigenous towns and communities.

For some Inuit groups however, oil and gas development has proven important for their communities and their economy. The uncertainty about the future of the town faced with closing industries and services has made the Greenlandic community welcome the potential establishment of aluminum smelters. Such a decision not only generates job opportunities but also sets in motion a complex process of reinterpreting place [Benediktsson & Suopajärvi, 2007 cited in Sejersen, 2015, p.157]. By embracing aluminum production, the Greenlanders are whirled into the economy that is simultaneously dependent upon, as well as empowering to globalization. Seen from the industry's point of view, Greenland stands out as a suitable prospective site for a smelter. From a Greenlandic point of view, a smelter offers job and tax revenue potentials for a township and for the country as a whole.

Therefore, it is important to keep in mind the problematic of the population shift due to the lack of job opportunities, as well as the frustration of having one's voice being heard. In this direction, our initiative tries to propose a new direction for society, by not only offering them an alternative way in which to express their beliefs, but also by providing a new potential for job opportunities, which can positively influence the migration shift.

VISION
Therefore, this initiative frames the opportunity for a cultural interchange between modern principles and Inuit traditions. Moreover, we aim to address the problem of social adaptability explained in the following texts, and acceptance of these indigenous peoples, as well as propose a sustainable building strategy driven by an overlap of Greenladinc building traditions and modern technology.

The Inuit Community

Sejersen [2015], refers to the Inuit of the Arctic as a culture faced with a nature that demands more from them then any other people of the inhabited world. Hence, this topic outlines the development of the Indigenous peoples of Greenland.

Then

The Inuits of Greenland have been severely affected by climate change leading to a geopolitical marginalization not only when considering social interchange, but also resources due to large travel distances.

Quoted in *Rethinking Greenland* [2015, p.10] Kaj Birket-Smith mentions the struggle of the old Arctic Inuits in their raw fight for food during both winter and summer. This fight is seen as making such great demands on all human energies that it does not leave much time for anything else than to think of how to satisfy the most essential of needs.

Inuit families have a modest life, living in small 2-3 room dwellings, shared between 6-7 family members and relying of fishing and hunting to provide for their primary needs [Vagnby, 2009].

Thus, the Inuit lifestyle has been described as simple, in harmony with the natural environment and relying solitary on natural resources. Today however, a decrease in these natural resources is forcing them to adapt and accept modern industries in order to provide for future generations.

Now

In order to fully grasp and understand the remoteness of this environment, we have compared a number of different aspects related to demographic and societal topic, between Greenland and Denmark. Therefore, where Denmark has a population density [people per sq. km] last measured at 132.91 in 2014, Greenlanders benefit from 37.7 square kilometers per person by only having a density of 0.14 people per square kilometer in 2014 [Trading Economics, 2016].

In terms of economy, Greenland is highly dependent on the fishing industry; contribution in 2000 was reported as 25% of GNI and 23 to 30% of the economy. The sparsely populated villages along the coast, with about 150 inhabitants in each village, are entirely dependent on marine resources of fishing and hunting [Arctic Climate Impact Assessment; Arctic Monitoring and Assessment Programme; Program for the Conservation of Arctic Flora and Fauna; International Arctic Science Committee, 2005].

However, only 1,28 of Greenland's population is part of the fishing industry, while the public administration sector comprehends the majority with a percentage of 36,62 [fig. 6].

A notable fact, relevant for our research, is that the population of Greenland still relies on 20th century communication, while the Internet is something that has not fully been accepted by the society [Madsen, 2000].

Therefore, the research, as well as our visit to Greenland, has shown that the society is indeed in need of a new social typology in terms of leisure. This can also be a conclusion from the overview that placed Greenland at the top of the list for suicide rates. In this sense, our proposal for a 'place' with an active program is integrated in the needs of the community.

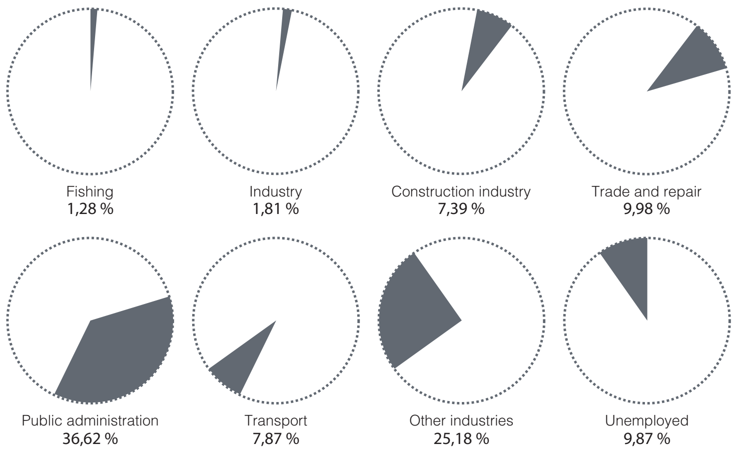


Fig. 6. Industries in Nuuk

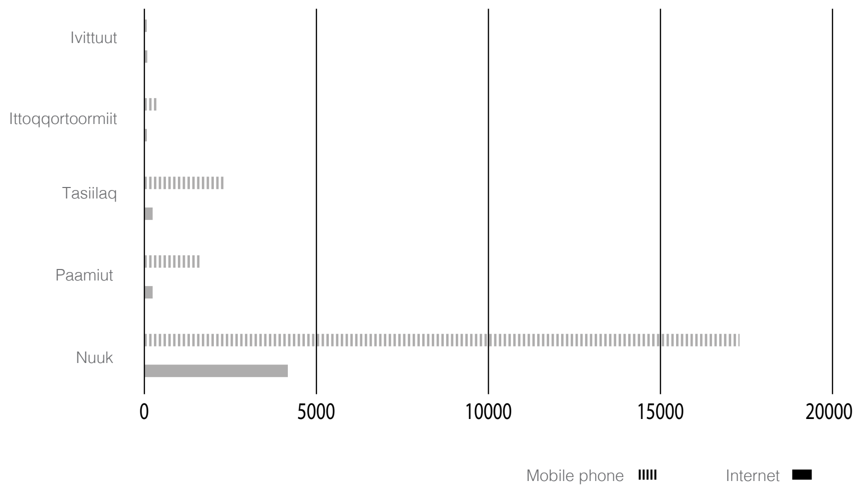


Fig. 7. Communication in Greenland

we have used these diagrams as a starting point in our research, as an insight into the lifestyle of the local community. these studies reinforce the statement that Greenland is undergoing a process of modernization. a shift in occupation which now is centralized on public administration can be noted. it is also relevant for our research to see that not many have access to the internet, therefore access to information is not as easily made

Local Art Scene

By merging together the consideration foran active program for the function of the building and the municipal plan for the development of a venue that accommodated the collections of the existing National Gallery, we have decided to research the local art scene with the intention of assessing the potential of the development of the brief in the direction of creating a space for art and artists.

Our initial consideration has proven unexpectedly successful and accurate for the present day inhabitants of Nuuk. The research has shown that the modern Greenlandic society is using art as a tool for expressing their beliefs. Duprey [2007] talks about the political seventies, which culminated with the introduction of the Home Rule Government in 1979, and when the role of art changes. He underlines how art has been used to display a specific Greenlandic attitude to the outside world. Today, the movement is still supported, and this can be seen in the density of small artist workshops scattered around the city.

Nonetheless, our on-site survey in Nuuk has showed that a great number of small artist workshops and gallery spaces have been blooming along the streets of Nuuk. Hence, the driver towards a society that focuses on the development of the arts and crafts sectors is an existing direction for the locals.

Therefore, it is only natural that the 'active program' of the brief should house functions that relate to the industry of art.

Moreover, a surprising realization was that the majority of artist ateliers are placed within close proximity to our proposed site. This highlights the potential of creating a center for such activities in the given location.

Fig. 8. The Site and The Artist's Street

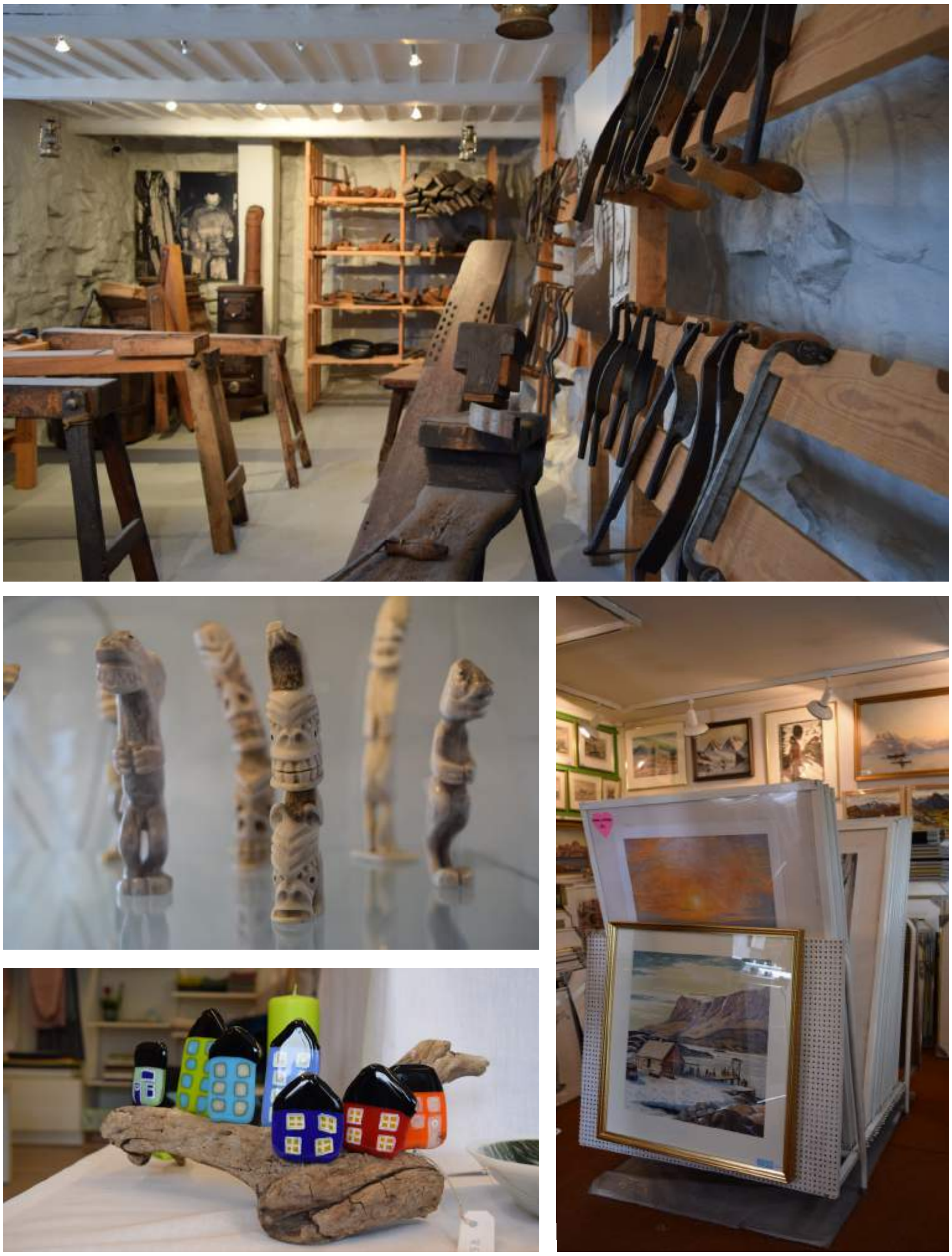


Fig. 9. Local Artist Atelier

the above placed images are photographs taken in local artist ateliers and shops. the art portrayed in these pieces mostly focus on the reenactment of the arctic colourscape

The Site

The section is an overview of the climatic and topographical features of the site, as well as the infrastructure of the city.

Nuuk, West Greenland

Nuuk is Greenland's capital city founded by missionary Hans Egede in 1728. The capital has roughly 16.800 citizens and 'houses 24% of Greenland's population in monumentally ugly housing projects' [Cornwallis, G., Swaney, D., 2001]. Most of the buildings referred to are built by Danish architects that did not understand the Greenlandic culture and building traditions. In an interview with an Inuit woman, she strongly undelines how the earlier relationship between these two countries was manipulated by the Danish half 'This is how it's going to be! This Way!' [Sejersen, F. 2015][Lonely Planet, 2016].

The situation has changed now and the Intuits are getting noticed, a better relationship being established. Although the common housing projects in Nuuk are not monumental, the city offers possibilities in terms of leisure experiences such as gourmet restaurants and modern shopping facilities. The relation and approximation of cultural venues throughout Nuuk is relevant to establish, as the proposal carries a similar function.

Therefore a processional route throughout the city should be highlighted. Centrally placed is Katuaq Cultural Center designed by Schmidt Hammer Lassen, which houses theatrical plays, concerts and art exhibitions. In addition, Nuuk Art Museum and Greenland's National Museum are as well places to visit for art enthusiastic visitors. [Greenland, 2016].

Moreover, in order to set the scene for a successfully integrated proposal, there is a need for analyzing the existing loci of the site. In this direction, the images placed on the following spread capture the phenomenological intention of the site.

The materiality of the site is derived from the rawness of the existing landscape. As a general observation when dwelling upon the natural scape of the place, a tendency towards two atmospheric extremes can be sensed: Gernert's warm redness given by the midsummer sun, competing by Nordic blue winter light described by Fjeld [Sørensen and Haug, 2011]. Human intervention has in addition brought to the site concrete foundations and timber cladding of colorful shades.

Nuuk Stadium
Cathedral of Greenland
Nuuk Kunstmuseum
Katuaq Cultural Centre
Greenland National Museum
National Library of Greenland
Banck of Greenland
Hans Egede Church
Queen Ingrid Hospital
University of Nuuk
Nuuk Prison

Fig. 10. Nuuk

Tuapannguit

The local plan for the proposed plot allocates to the given location the function of a cultural venue.

Dwelling on the social function attributed to the location, the site is positioned within close proximity to the central leisure area of Nuuk [found West of the site]. Moreover, Katuaq Culture House, as well as Nuuk Kunst Museum are placed in reach of a 5 minute walking radius of our site on Tuapannguit street. Within this radius a number of small artist ateliers and boutiques can be seen.

The site can be reach terrestrially via a singular road, Tuapannguit. However, the location is highly exposed towards the fjord, making it part of an important transit area. Therefore, the site can be experienced both from Tuapannguit street, and also from the waterfront.

Fig. 11. The Site as Seen from the Fjord

Mapping

In Greenland, the problematic of marginalization is amplified by the fact that there are no roads connecting the towns and regions. Therefore, traveling is only possible from one place to another by using expensive and unstable means of transportation – namely, by air and by ship [Sejersen, 2015, p.35].

The opposite placed studies showcase how the given site is integrated in its surroundings. An important factor for our study was how the location was perceived in terms of public and private sectors of the city. Nonetheless, this means looking at the functional typology of the surrounding buildings, and at the access to the site, both from the pedestrian as well as vehicle perspective.

The sloping of the site towards the water [south-west, as seen in fig. 12] presents a great opportunity not only for natural daylight considerations, but also for the perspective of creating a landmark for the inhabitants of Nuuk, as the site can be experienced from a variety of different vistas.

Nonetheless, the location encompasses part of the waterfront, making it possible to work with water both in terms of design, as well as a natural resource.

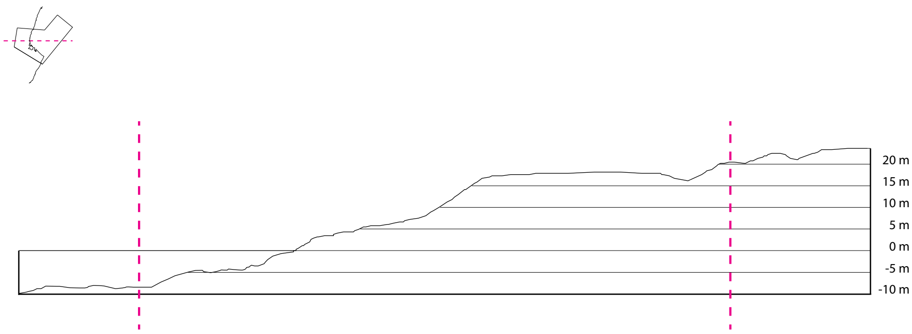


Fig. 12. Latitudinal Section

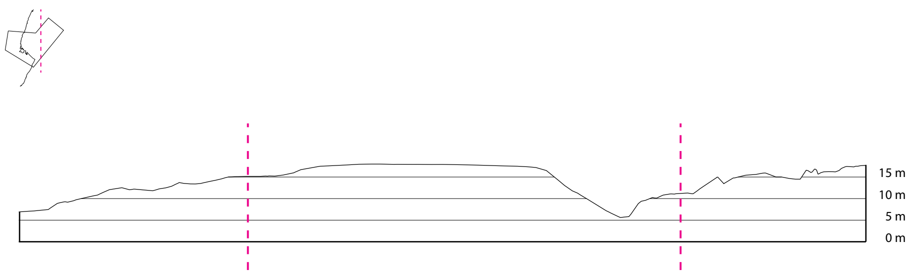


Fig. 13. Longitudinal Section

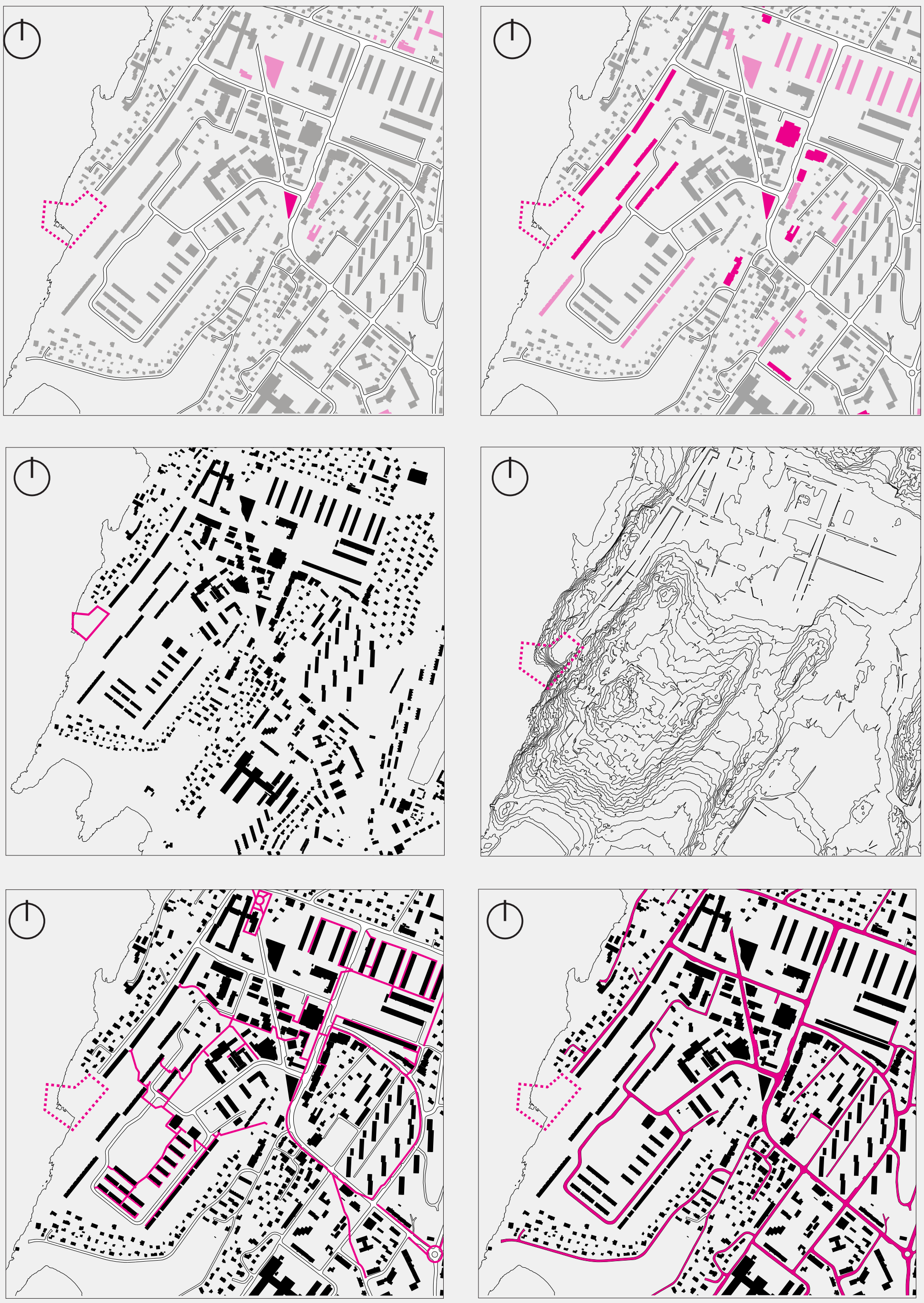


Fig. 14. Mappings of Nuuk

1 roof typology
2 building heights
3 built environment
4 level curves
5 pedestrian paths
6 infrastructure

the topics have been chosen as we have felt that these principles could directly influence our design in terms of placement of the venue on site, and connection to the existing infrastructure

Microclimate

Sun

The average hours of sunshine in Nuuk is 1253. At a first stage, one would be surprised by the number when comparing it to the average 1495 hours in Denmark. [DMI, 2016] [MitRejseVejr.dk, 2016]. However, the number evens out by having 4 hours of sun during winter months, while in the summer, the sunshine can last up to 21 hours. During late April, one can already sense summer sun, as complete darkness never prevails, a dim light being always present, as experienced in our trip to Greenland.

Wind

The wind velocity can differ strongly, as the wind conditions can range from long times without any wind at all with calm waters and no breeze to hight speed windstorms. It is interesting to observe, as architect Peter Barfoed of Tegnestuen Nuuk mentions in his interview with us, that even within the city of Nuuk, microclimates related to wind can be defined. However, during the last years the construction of new housing blocks has been neglectful towards site specific wind conditions. This has resulted in outdoor spaces that can not be populated. However, large fences to capture the wind have been afterwards retrofitted to the sites.

Therefore, in Nuuk, wind conditions can very from calm, windless weather to wild storms that can occur when the cold air has accumulated over the ice cap which pushes high pressure winds out towards the coast.

As an overview, in Nuuk the wind will mainly come from the south in the summer season while it predominantly blows from North/North East in the winter. [EuropasLande.dk, 2016]

Temperature

Temperatures in Greenland range between an average of -10 degrees Celsius in the winter and 10 in the summer. Therefore, we can conclude that heating season is all year round. However, although the temperatures are low, the skies are not as gray as in Denmark. While daylight studies are done in overcast conditions in Denmark, Greenland is evaluated as a mix. This feature will have an influence our design in terms of requirements for daylight studies.

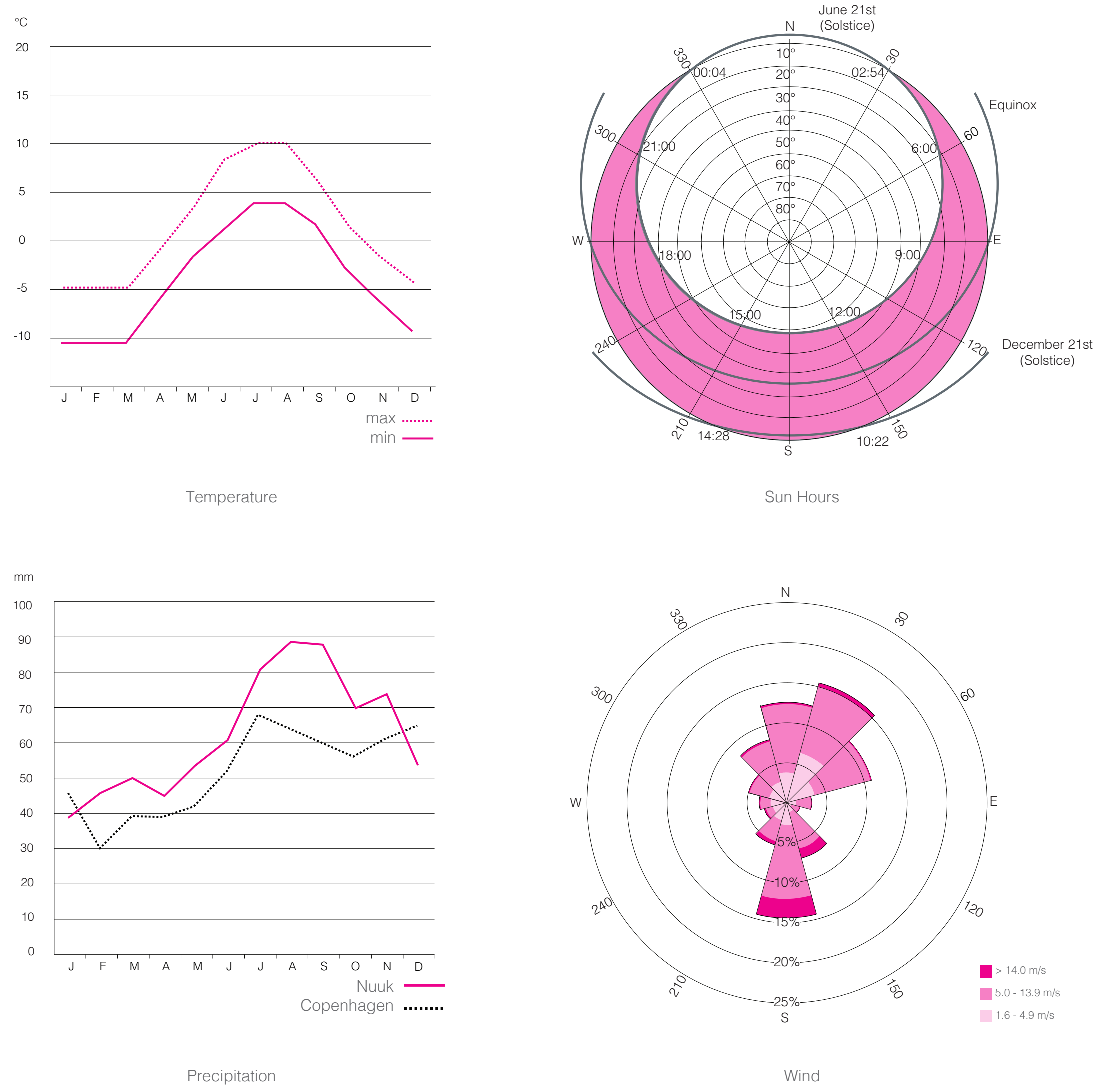
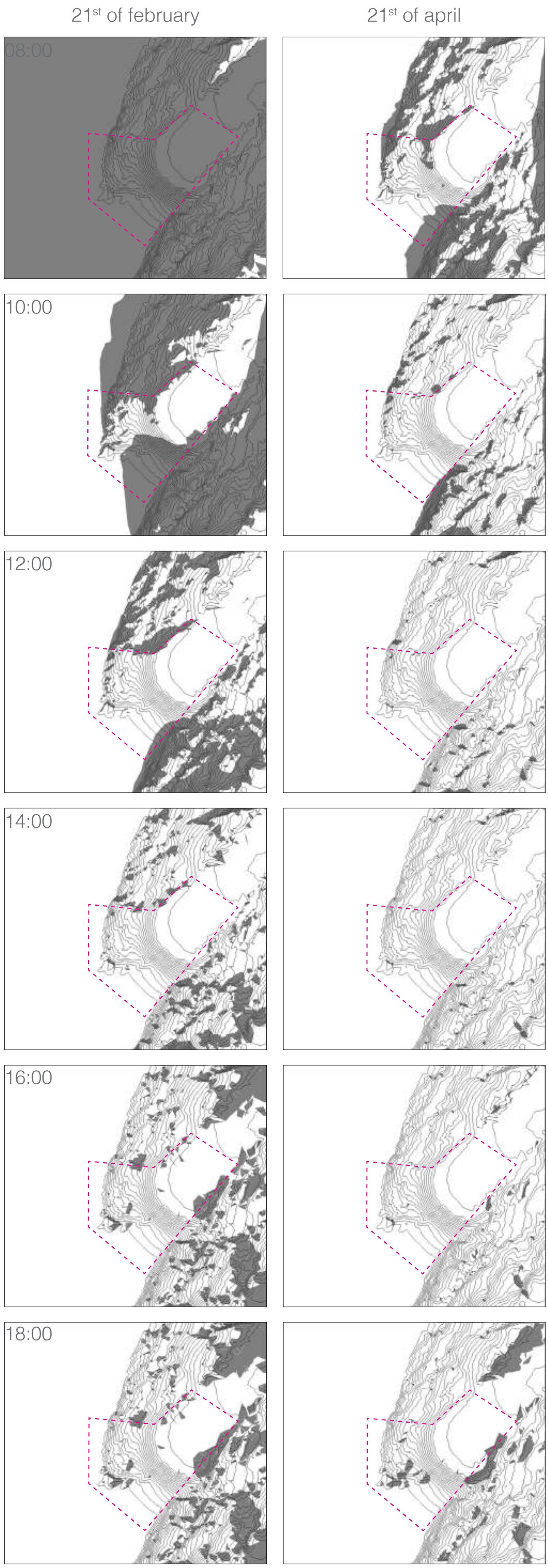


Fig. 15. Local Climatic Conditions

the selected climatic overviews influence the design of our proposal by adopting passive strategies in order to overcome the year long heating season

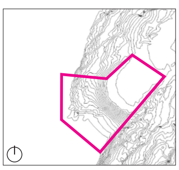


Light Study

The shadow analysis has been conducted by using the REVIT plug-in for shadow study. The study has been done for the 21st of every second month, starting from February. The date of the 21st has been chosen because of the coincidence with the solstice day.

Following this study we can observe that the difference between summer and winter months in terms of daylight is something that needs to be considered. This difference defines two different environments that need to be weighed. Alongside the low angle of the light in the North, during winter months one can experience a shortage of natural illumination in the outdoor environment, compared to the inner continental population of world [Garnert, J. cited in Sørensen and Haug p.6]. However, it is interesting to note the hours inbetween which there is light during December: 12am to 18pm.

With consideration to our proposal, artificial lighting is something that must be integrated in the design in an efficient way, in order to work with both the sustainable and the tectonic architectural intentions.



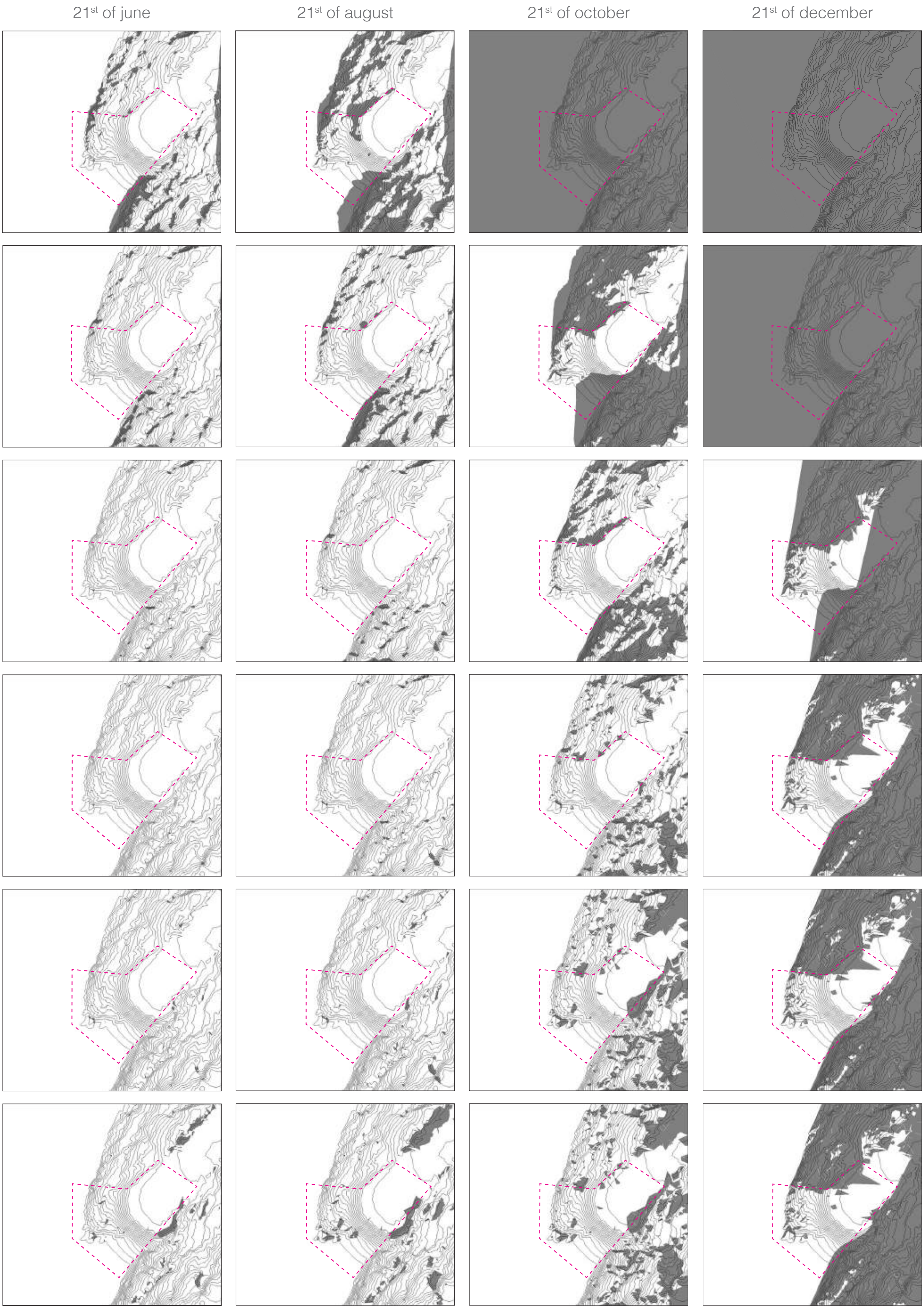


Fig. 16. Shadow Study [Revit]

The Place

In order to fully understand the site, it is essential to assess not only the space but also the place and the metaphysical aspects that come along with it.

Phenomenology

The Light
The low angle of the sun creates a colorful interplay of light. Throughout the seasons, light changes from having long shadows during the winter, to long bright nights or even midnight sun in the summer. Pallasmaa [Sørensen and Haug, 2011] talks of the truly magical and intoxicating night-less summer of the north, contrasted by the scant light in the continuous darkness of the polar winter night, light which seems to emanate from below, as snow reflects the slightest light of the finament.

The Natural Materials
The hue of the waterfront in Nuuk is defined by a raw, natural palette of colours. When the ground is not covered with glowing, white snow, it reveals a rocky edge, sprinkled with dried vegetation of a red and brown apparel.

The sloping of the site towards the water [SW] is ideal not only for light considerations, but also for the potential of creating a landmark within the city of Nuuk, as the site can be experienced from a variety of different vistas.

The Roads to Nothing-ness
As one can experience by looking at a map of Greenland, streets provide circulation only within the city itself, as cities throughout the country are not connected via roads.

Moreover, during our walk through the city, we have continuously perceived the experience of 'open-ness' and 'nothing-ness' as properties merge into one another freely, interweaving harmoniously with the landscape while framing beautiful views in each direction.

Fig. 17. Nuuk Sunset

Fig. 18. Materiality

Fig. 19. The Open View

The Man Made
As a general observation we can outline the existence of a duality between the simplicity of the natural scape, characterized by shades of brown, gray and red, and that of the man made distinguishable by its intense colours.

The traditional Inuit port is still warn today by the locals on national holiday and important events such as weddings.

The Built
Contrasting the natural rawness of the Greenlandic coast, human intervention has in addition brought to the site concrete foundations and timber cladding of colorful shades. The intense tones have been traditionally used in indicating the presence of human settlements, when navigating the sea. Although this approach might be seen as kitsch in modern context, here, the cheerful interplay of colours brings life to the otherwise monochromatic site.

The Intervention
Cornwallis and Swaney [2001] mention monumentally ugly housing projects which shelter more then 50 percent of Nuuk's inhabitants. Most of the buildings referred to are built by Danish architects that did not understand the Greenlandic culture and building traditions. The case of lacking a contextual architectural approach has also been discussed at the 2014 Venice Bienale, where the locals have expressed their frustration towards the Danish approach.

Fig. 20. Traditional Wear

Fig. 21. Colours of Architecture

Fig. 22. Alien Architecture

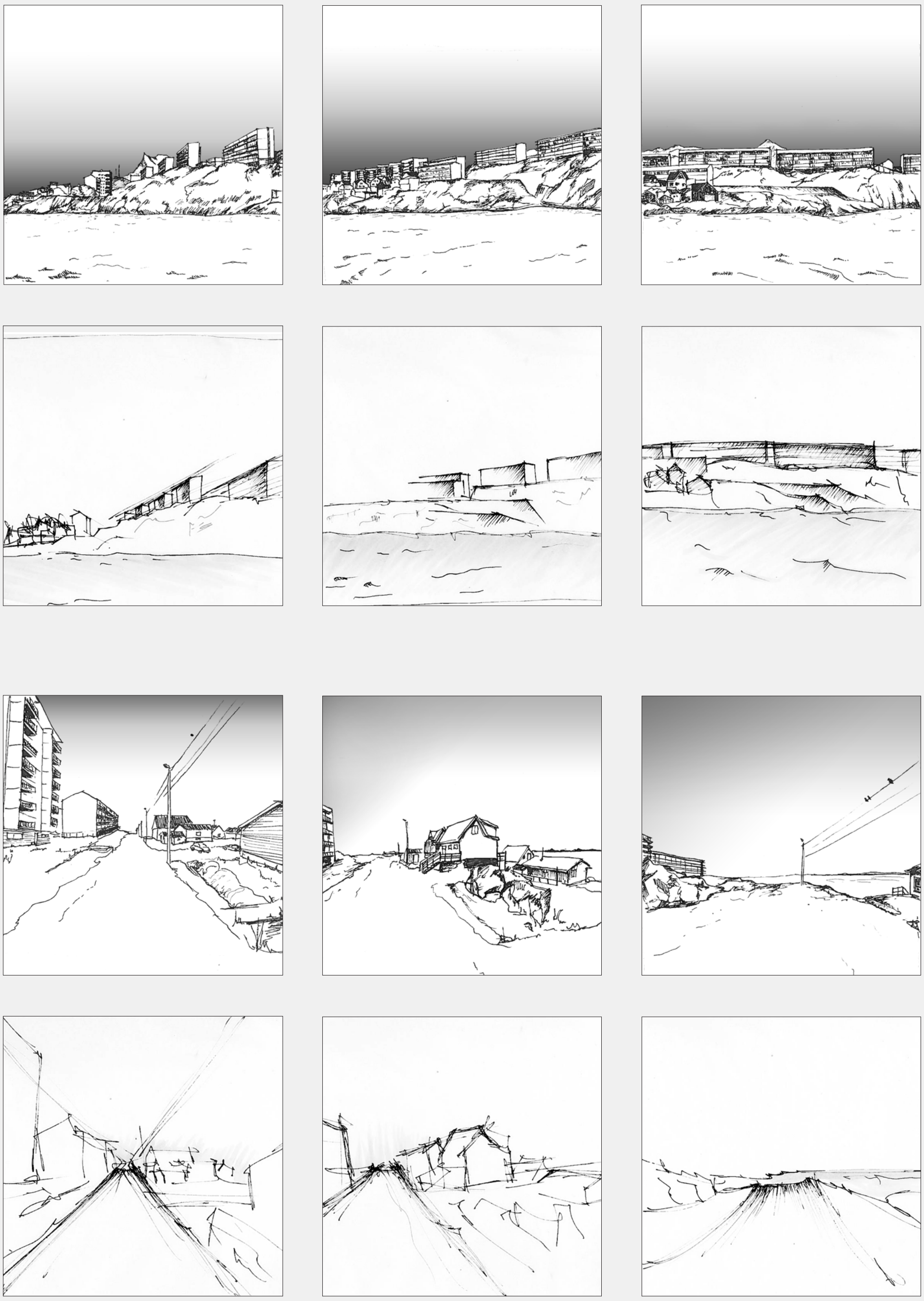


Fig. 23. Serial View Exercise

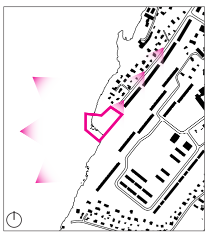
the views emphasize the volumetric compositions placed on the given site, by highlighting the most notable features of the surroundings

Serial View Exercise

Depicting on Gordon Cullen's theories about urban landscape [1961] a serial vision experiment has been conducted. However, instead of showcasing photographs of the 2 approaches to the site, the group has decided to hand sketch the views in order to deeply engage and understand the given site. In this way it was possible to asses which features are most predominant on the given site.

The method of the serial vision has been used in order to frame the site and comprehend the different scales that the design needs to address. A further study will highlight the most expressive characteristics in the narrative of each view.

These considerations will afterwards be introduced in the outline phase as design frames. By having this approach, we stress on the quality of designing in context. Being empathetic to the surrounding architectural environment is a design parameters that is highly important for our design, due to the previous experience of modern building in Greenland has not always been considerate towards the local social and architectural climate, as explained earlier in the study.



Perception of The Site

When dwelling upon the perception of space, several theories describing how people understand their surroundings can be stressed. The most important aspect highlighted in all theories, is that people are indeed capable of perceiving physical objects around them, enabling them to speak about these objects, describe them, and eventually draw a map of such surroundings.

The image placed opposite is an analysis based on Kevin Lynch´s [1960] theory on human perception of urban space. His studies prove the existence of 5 repetitive categories through which people describe an urban space. These are known as Paths, Edges, Districts, Nodes, and Landmarks.

This phenomenological study has shown that the given site of the competition [outlined in the diagram in magenta] is indeed freestanding, surrounded by edges that reinforce the boundary with the existing residential areas placed nearby. This is important for the phenomenological study, as it is essential to understand how locals perceive the site, whether it is considered as part of a larger district or if it is an individual area, which can be rendered according to our architectural desires without creating a threatening impact in the collective memory of the neighborhood.

Moreover, although the area is predominantly residential, as the only public building placed within visual boundaries is the National Museum, it still acts as a recognizable site due to the landmark housing blocks placed to the Est of the given site.

However, our trip to the site has shown that the area of the site is currently undergoing a modernization process, both in terms or architecture and in terms of function. Therefore, adding to the existing residential typology, the site is now home to a number of small creative studios.

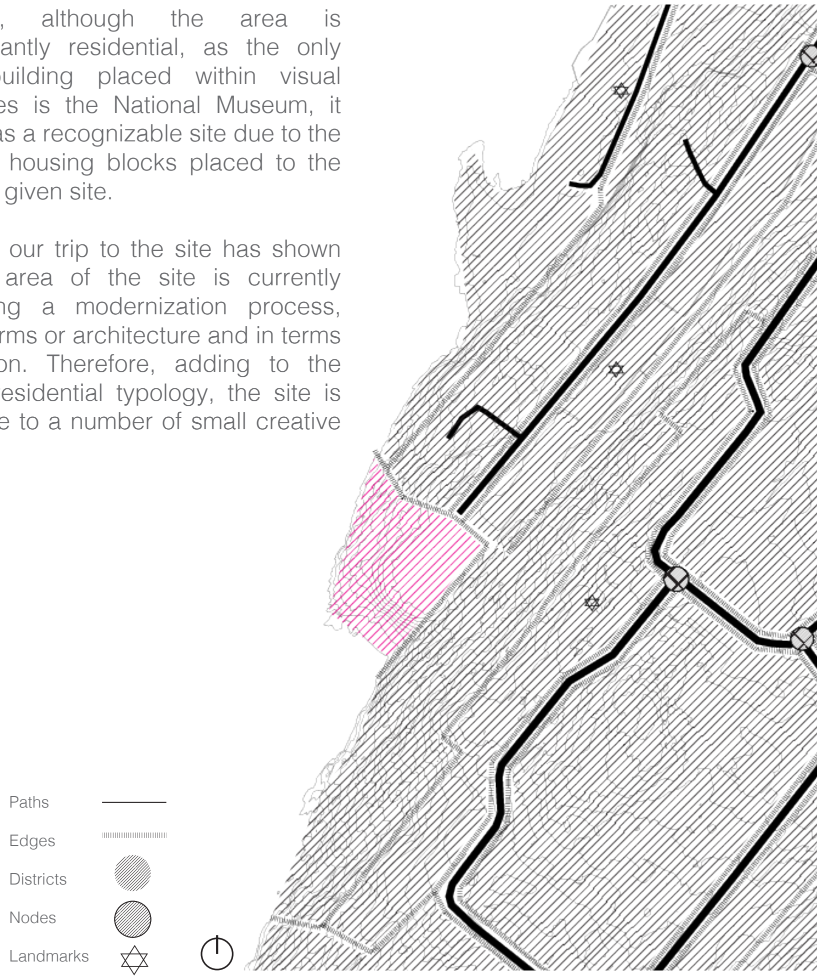


Fig. 24. Kevin Lynch diagram

Potential of the site

The potential of the site has been outlined in a SWOT diagram. The typology looks at characteristics of the site such as Strengths, Weaknesses, Opportunities and Threats. By delineating characteristic features that correspond to each topic, an initial frame for the site can be defined.

STRENGTHS

- good potential for landmark in terms of location
- ideal atmospherical environment that enhances the sensorial experience of a museum
- no shading from surrounding buildings
- no existing architectural limits on site

WEAKNESSES

- placement in residential area. therefore threatening the remoteness of the neighbors
- geology of the site is not ideal in terms of extensive construction
- indoor climate for gallery spaces are challenging when looking at the existing climatic conditions

OPPORTUNITIES

- sloping towards south presents potential in terms of daylight use
- relation to the waterfront
- the site is placed in a an area currently housing creative studios, herefore enhancing the possibility of erecting a venue with a similar function
- economic openness facilitating the opportunity for start up businesses

THREATS

- exposed to extreme climate conditions
- presence of an alternative culture center in Nuuk
- lack of understanding for Inuit traditions
- no existing regulations in terms of sustainable building in Greenland

Fig. 25. Cluster of dwellings in Nuuk

Framework

The Chapter sets the scene for the design of the proposal. Research made at an initial phase has been assessed and formulated as the parameters for the design. In this sense, the chapter has been divided as followed:

Research

Thorough research has been conducted in the direction of understanding the architectural principles with which building an exhibition and learning space in an extreme environment is faced with.

Vernacular Architecture

Most frequently, traditional building design is developed to accommodate the climatically worst time of the year, whether this be the summer heat or the winter cold [Dahl, 2010, p.16]. The climate of Greenland is characterized by harsh winter months that are only balanced by the summer months in terms of daylight, while temperatures remain at an average of 10 degrees Celsius in the summer and -10 in the winter. Considering this, the experience of the buildings will involve a primitive sense of pleasure in the notion of shelter [Slavid, 2009, p.58].

In the extreme climate of the Arctic and Subarctic regions, two classes can be defined: the cold and humid and the cold and dry. The cold and humid climate is characterized by a fluctuation between quiet dry and humid periods with very windy weather. The cold and dry typology is a constant change between extreme cold, long, dark winters and short, bright, cool summers.

The Greenladic building tradition borrows elements from both the cold and humid climate, and the cold and dry. Therefore, within the Greenlandic environment we see the typology of the igloo [cold, dry] standing besides the Icelandic peat house [cold, humid], and the Swedish log house. All three typologies now stand as characteristic building traditions for the Greenlandic environment.

The igloo demonstrates man's ability to develop architecture that provides maximum protection in extreme climatic conditions. Today, after intense studies upon energy consumption of a building, research has shown that circular shaped buildings are the most energy efficient due to a minimum surface to volume ratio. This acts as proof of the profound understanding of nature with which the Inuit people were equipped. Moreover, igloos are constructed by means of snow blocks, which are full of air and therefore insulating [Dahl, 2010, p.20].

The main characteristic of the Icelandic peat house is that it is built down into the terrain, exploiting the earth's moisture, air and thermal absorbing warming qualities through the use of thick peat walls and grass roofs. The house is again an example of conscious design, as internal wood panels on floors, ceiling and walls reduce heat radiation, hence increasing the room's surface temperature and therefore breaking thermal bridges that tend to occur. An interesting tectonic feature of peat houses is that often the furniture is an integrated part of the room's permanent internal fittings. Moreover, when snow falls on a roof, particularly a roof with a low slope, it helps to retain the heat in the interior of the house by acting as an insulating element [Dahl, 2010, p.20].

In Vagnby's [2009] children's book that portraits the Greenladic way of living, Malik, the main character, talks about a new typology embraced by the locals: that of the Swedish traditional log house ironically contrasting the lack of timber resources in the Greenlandic landscape.

With concern to building sustainably in such a remote environment, it is essential to look at vernacular building traditions in order to understand the reasoning behind every architectural decision. These considerations will be further depicted in the design phase of the proposal.

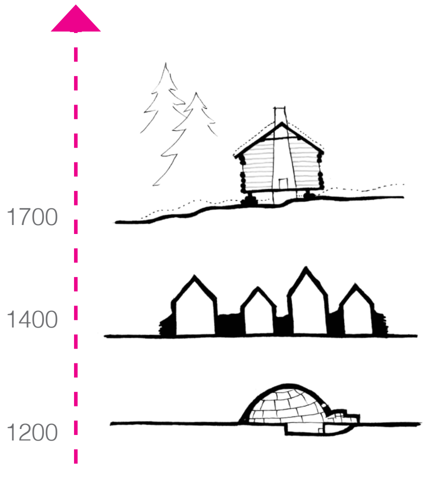


Fig. 26. Development of Architecture

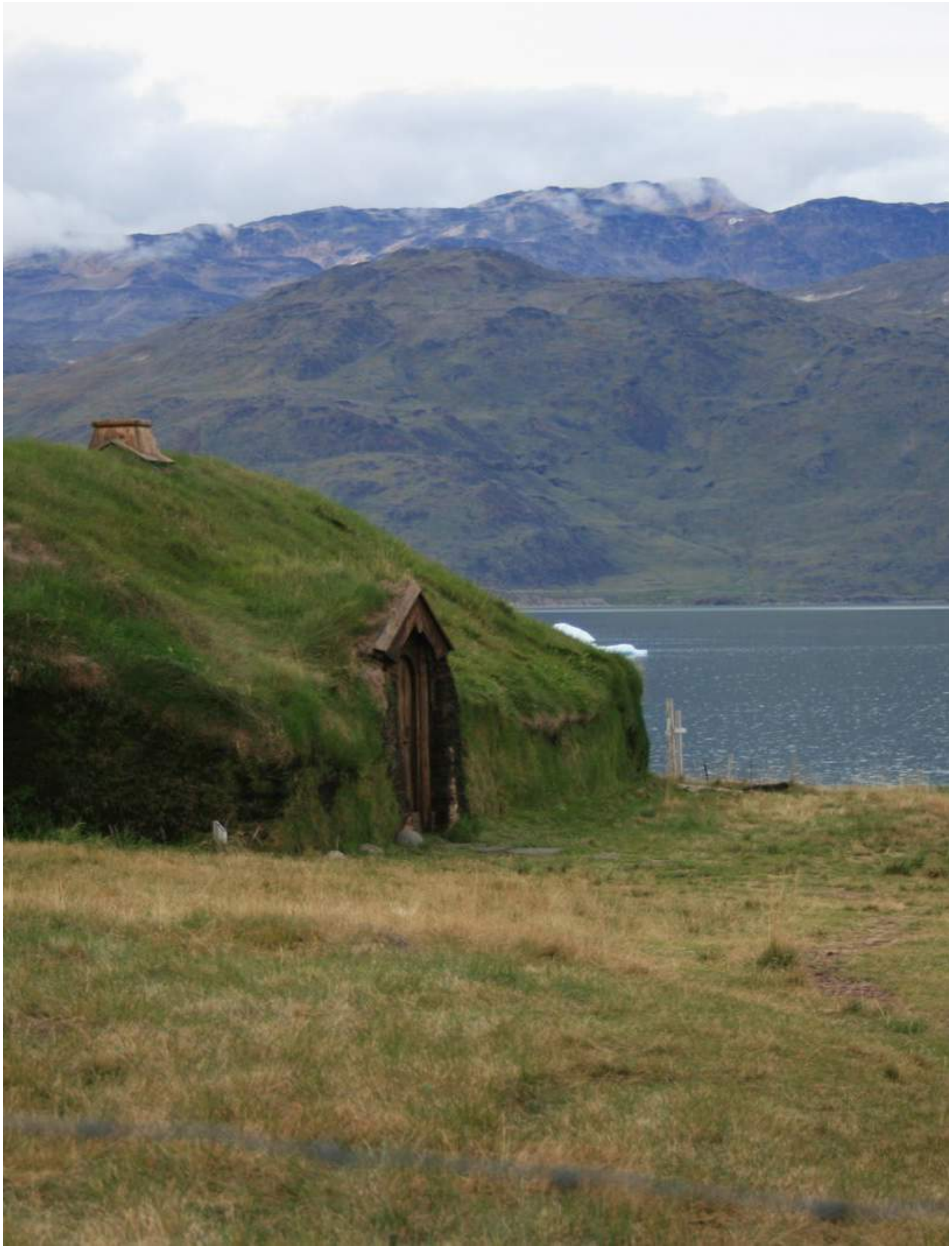


Fig. 27. Turf House

the image illustrates a turf house specific of the local architectural tradition. the typology has provided us with a point of departure in many of the design and technical considerations

Local Building Tradition

Slavid [2009, p.58] defines life in the tundra as incomparably hard, yet with a romantic appeal that some like to imitate today.

When considering vernacular building traditions, most frequently architecture is made according to the worst climatic conditions, this being either the summer heat or the winter cold [Dahl, 2010, p.16]. However, the Greenladic environment, comes with additional challenges. The Greenlanders are geographically marginal not only in terms of distances, but also of resources [Sejersen, 2015, p.20]. Therefore, when building in such an environment, one most pay careful consideration towards local opportunities and local traditions in order to make us of local resources.

Therefore, the choice of materiality and structure which fully satisfy the demands of a building placed in the arctic environment is fundamentally important. Modern technology has now made it possible to have due account of aesthetic values, maintenance requirements, durability and sustainability. However, to the architect, sustainability as such should not only be about finding technical solutions, but also about designing interrelationships and systems [Ibler, 2008].

As an archetype, the Icelandic architectural heritage of few and small openings [Sørensen and Haug, p.99-104] can nowadays be replaced by windows covered with triple layered glass, filled with argon gas for maximum insulation. This solution can be found in the Administration building for the Governor of Svalbard, which is placed in a climate that has temperatures ranging from 20 to -30 degrees [Noal, 2003, p.12-17].

When talking about natural light, the Nordic climate presents a unique opportunity to interplay with the cool light of the northern half of the sky and the warm light of the southern sky in a single space [Pallasmaa cited in Sørensen and Haug, p.27].

However, integrated decision in terms of the envelope of a building also need to be consciously considered. Hence, building walls and overhanging roofs should be angled as to protect entrance areas from both snow and wind. The building envelope requires good insulation and top rate construction if buildings are not to consume energy at a terrifying rate [Slavid, 2009, p.58]. An example of integrated design that involves the exterior and interior structure of a building can been seen in the Echigo Matsunoyama Museum of Natural Science in Japan, steel structure resists high winds and heavy snow loads by groaning as it adjusts itself to the weight of snowfall.

In Greenland however, due to the lack of local construction material and the necessity of import, a sustainable building material as such could not be defined, as mentioned by arch. Peter Barfoed in our interview with him. However, concrete could be assessed as a most sustainable solution for the environment.

Moreover, the architect mentions that great attention needs to be given to the micro-climate of the site in terms of wind and the view.

1. roof
the roof slope should be bigger then 7 degrees. corners should be avoided to prevent snow from piling up.

2. walls
the design should aim for a low energy class 1 [br2015]. this can be achieved by high insulating building envelope, and by building compactly in order to ensures less losses.

3. earth
by building in the terrain, the design can exploit the earth's moisture, air and thermal absorbing warming qualities

4. foundation
foundations should be either a crawlway, a shear wall or a pillar foundation in order to allow melting water to pass under the building

5. piping
piping is idealy placed above ground in insulated channels. pathways keep pedestrians above snow and melting water levels.

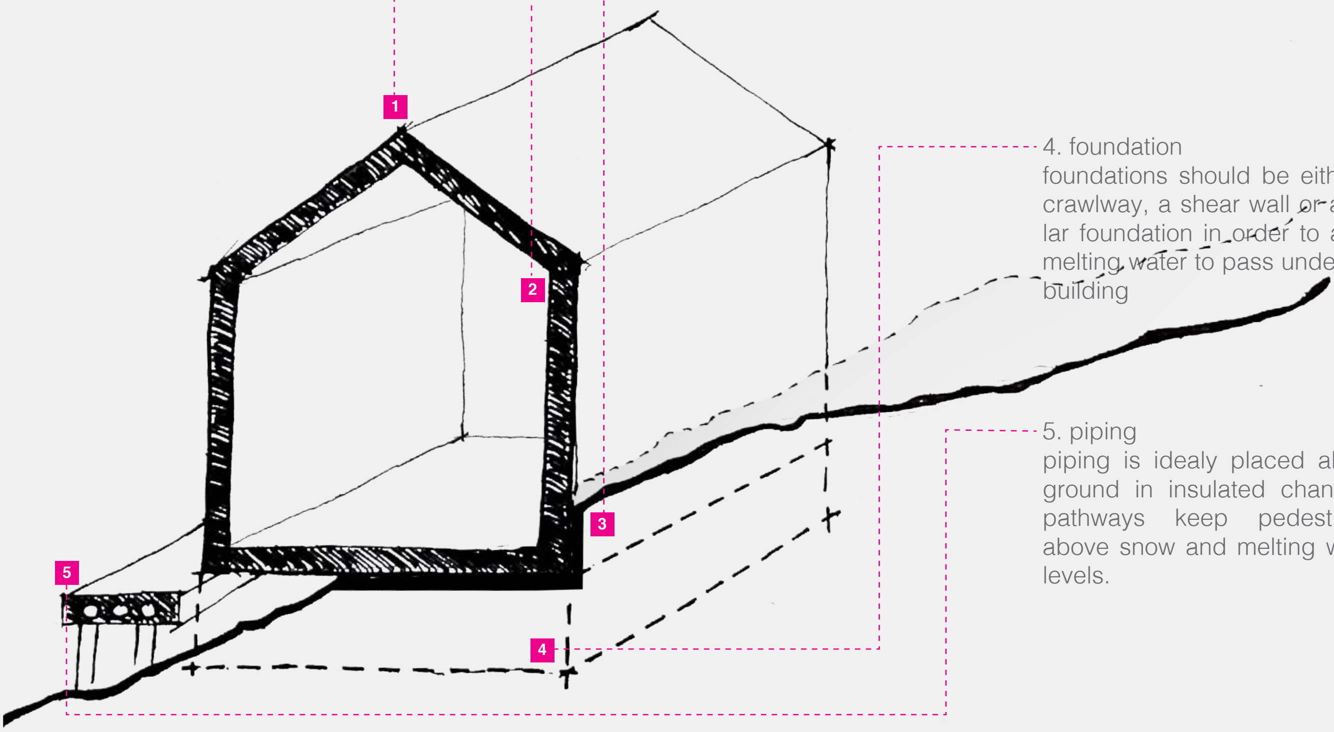


Fig. 28. Local Tradition

Extreme Architecture

The reason for investigating Echigo Matsunoyama Museum by Tezuka Architects + Masahiro Ikeda Co in Japan is because of the unique fusion between technical and aesthetic solutions which promote the project as an example of tectonic as well as sustainable architecture. Here, the detail confirms architectural greatness, by acting on behalf of both the constructing and the construing environment [Frascari, 1984].

The climate of Niigata, Japan is characterized by heavy snowfall that can sometimes reach 7 metres in depth. The industrial appearance of the museum is contrasted on the interior with white plasterboards supported on a lightweight steel framework. The cavity behind the walls is used circulation of warm air in winter, while in summer months the process is inverted, circulating cooling fresh air. The air is injected through long grilles in the floor, and extracted through slots at eaves level. Because the heat passes behind the walls, floors and ceilings, the elements radiate heat [Slavid, 2009, p65]. To sustain the weight of the snow and give the structure a proper isolation, all windows were made of 55 to 75-millimeter-thick acrylic. Additionally, the material provides an extremely high degree of transparency, successfully erasing the boundary between the inside and the outside [Architecture News Plus, 2009].

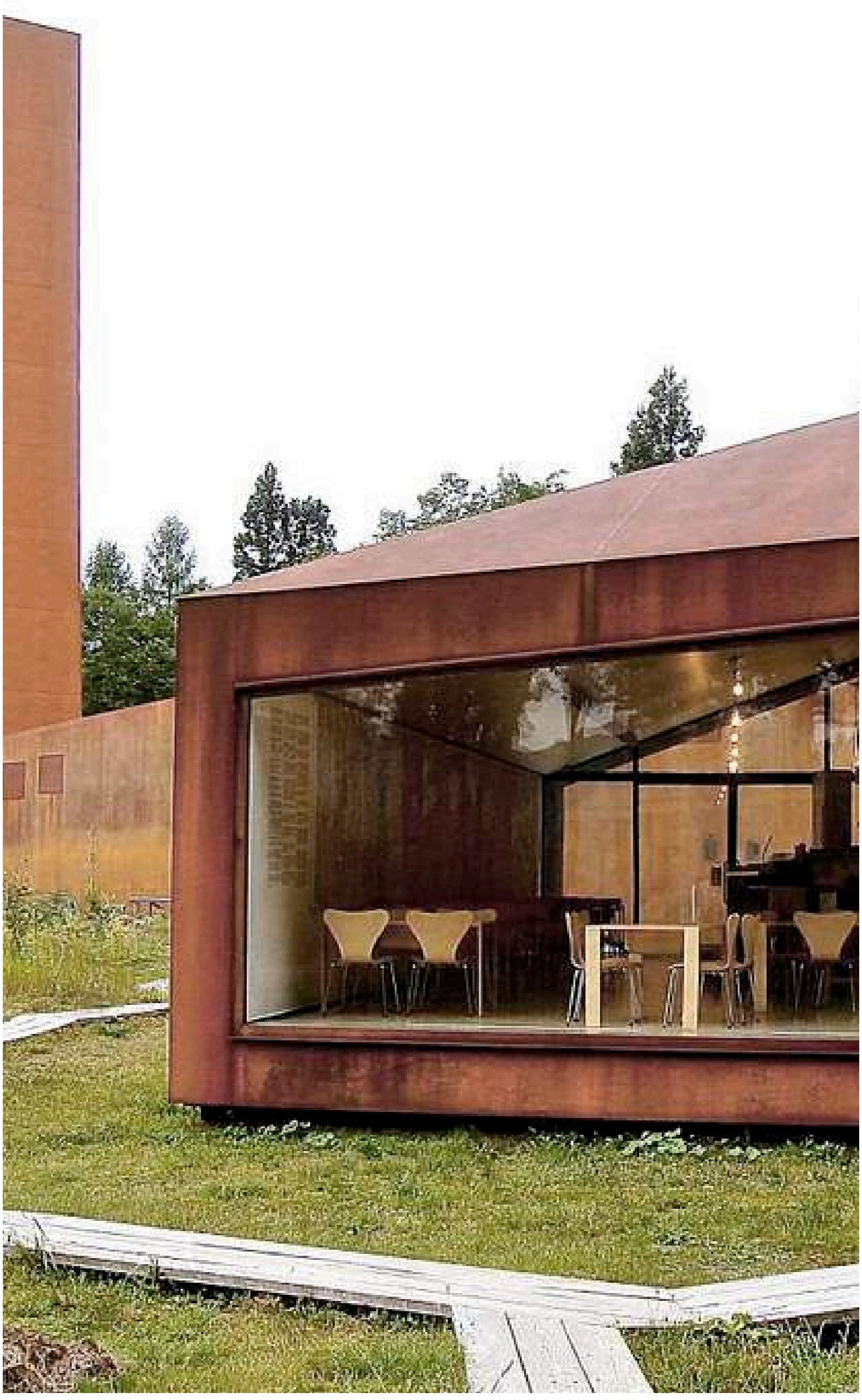


Fig. 29. Echigo Matsunoyama Museum

The Rocky Mountain Innovation Centre by ZGF Architects in Colorado, USA is a successful example of how informed decisions can shape sustainable design without the implementation of active strategies.

The building reaches beyond Net Zero Energy Goals by the implementation of an integrative design. Therefore, the design uses simple and passive design technologies and techniques instead of complex and active systems, which sustain an easy use of the building.

Tectonic design in term of merging together technical and aesthetic qualities are underlined in the presentation of the project by the Rocky Mountain Institute [2016]. Therefore, the roof is angled in order to balance PV power generation while at the same time leave space for an interior volume suitable for the open office in concordance with local height limits. The CLT structural system provides a suitable floor to ceiling height, necessary for achieving good daylighting conditions. Nonetheless, the stone walls are highly durable and worthy of a 100-year building, while integrating with the mountains placed beyond.

Fig. 30. Rocky Mountain Institute Innovation Centre

The Culture House

Within the previous chapters, an opportunity and need of attaching the additional function of an arts and crafts hub to the already defined function of the museum has been outlined. With consideration towards this statement, a short analysis into the typology of the culture center has been conducted. The culture center has been chosen as a typology due to its active program which characterizes our proposal as well.

A sketch by the well known architect Le Courbousier reveals the true nature of the culture center. The sketch portrays the real protagonists of the drawing as the persons themselves, while the place is there to provide a scenic frame for a theatrical piece that portrays architecture not so much as something constructed, but something inhabited [Bione, 2009, p. 7].

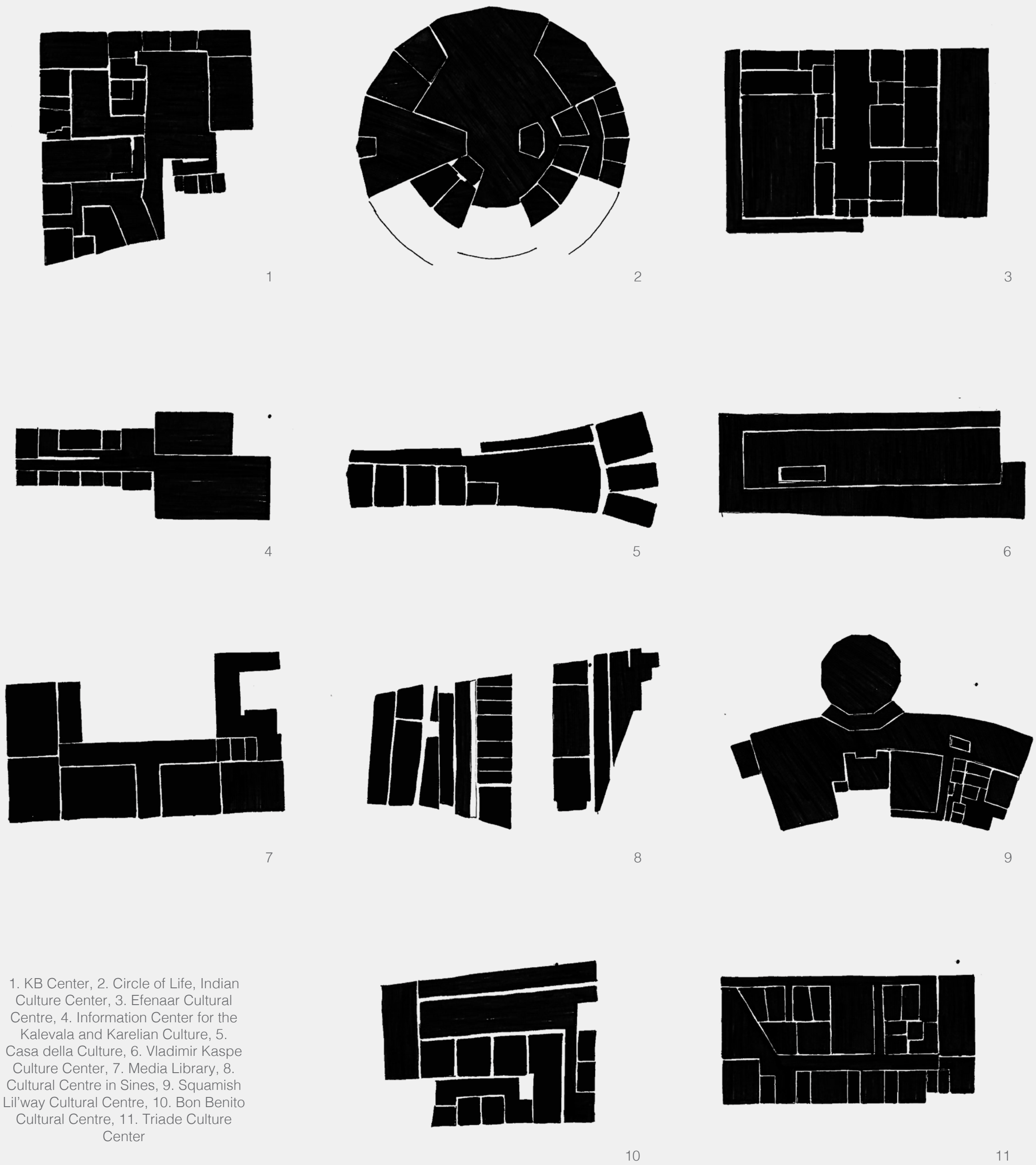
When the concept of the cultural center first started taking shape, the objective behind the initiative was to promote the independence and responsibility of the citizen, with regards to social and cultural entertainment. Nonetheless, the creation and fruition of art have not been presented together until recent times. However, a first instance of a cultural center can possibly be traced back to the renaissance courts when, for the first time, intellectual expression was freeing itself from the religious and the military [Bione, 2009].

Yet, Bione [2009] still refers to the difficulty of defining an architectural typology when talking about the cultural center. This is based on the premise that cultural centers do not follow a specialized function, but are in fact an amalgamate of different experiences. Therefore, when looking into the compositional considerations of a culture center, one has to consider a fragmentary analysis 'which touches upon different disciplines in order to describe this heterogeneous collective experience' [Bione, 2009, p.11].

A common feature amongst modern cultural centers is the common, open space. In an article dated 1970 Alfonso Martinez described Ruben Pesci and Hector Rossi's competing project for the cultural center in Mendoza: 'if we propose to distinguish the dominant parts of this composition, we shall find that they correspond to the non-specified ones: the circular shapes, those spaces without a destination which serve as unifying elements for the areas in which specific functions are carried out' [Corona Martinez, 1987].

Around this central compositional element, the morphology of the spaces can follow different organizational principles. While in some cases, a wide open plan as in the Vladimir Kaspe Cultural Centre designed by Broissin and Hernandez in Mexico City is preferred, other designs favor the approach that dwells on a fragmentation of the plan, offering users the chance to choose between a variety of different scales and different levels of denseness. An example is the De Kunstlinie Theatre and Cultural Centre in Almere, the Netherlands designed by the well-known Japanese architecture practice, SANAA, which hosts spaces from as small as 20 sqm to large multi-purpose rooms.

In either case, the cultural center as such needs to address and fully understand the needs of the users and of the context in which they are placed, such as in the example of the Information Centre for the Kalevala and Karelian Culturem Kuhmo, Finland which has the objective of increasing awareness of local traditions.



1. KB Center, 2. Circle of Life, Indian Culture Center, 3. Efenaar Cultural Centre, 4. Information Center for the Kalevala and Karelian Culture, 5. Casa della Culture, 6. Vladimir Kaspe Culture Center, 7. Media Library, 8. Cultural Centre in Sines, 9. Squamish Lil'way Cultural Centre, 10. Bon Benito Cultural Centre, 11. Triade Culture Center

Fig. 31. Study of Layout in Culture Houses

this morphological study looks at how different cultural centers around the world treat the problematic of the diversity of spaces which characterize this typology. a conclusion is that regardless the diversity and denseness of the individual clusters, they are always united by a larger open plan space

Nuuk Kunst Museum

As mentioned under the *Initial Considerations* section, The National Gallery's collections will be built up with works bought by or loaned over to Greenland's National Gallery of Art. At an organizational level, the brief divides the pieces into four closely related, mutually illustrative departments: the Department of Greenlandic art, the Department of more recent and contemporary graphic art in Greenland, the Department of circumpolar art and the Department of international art [Greenland's National Gallery of Art, 2010].

Therefore, as the driver for the proposal has been the establishment of a National Gallery for Greenlandinc and Circumpolar art as forseen by the Municipality, the group has seen it essential to analyze the existing Art Museum in Nuuk, locally known as Nunatta Eqqumiit sulianik Saqqummersitsivia. The focus of the analysis has been the exhibited art, as well as the morphological layout of the venue and the succession of spaces.

At a morphological level, the plan of the museum is organized by having a succession of spaces through which the visitor must pass twice in order to return to the exit. However, the processional route throughout the exhibition spaces is quite clear, benefiting the viewer's experience of the venue.

As a curious observation, we have highlighted the importance of implementing artificial light within the exhibition spaces. In the visited museum, the only space having natural light has been left unused, as the exhibition architects have considered the light a damaging factor for the existing artifacts.

Moreover, looking at the nature of the exhibited pieces, a number of different typologies can be defined. Therefore, the spaces within the new Museum should be able to accommodate anything from large kayak frames, to small bone sculptures.

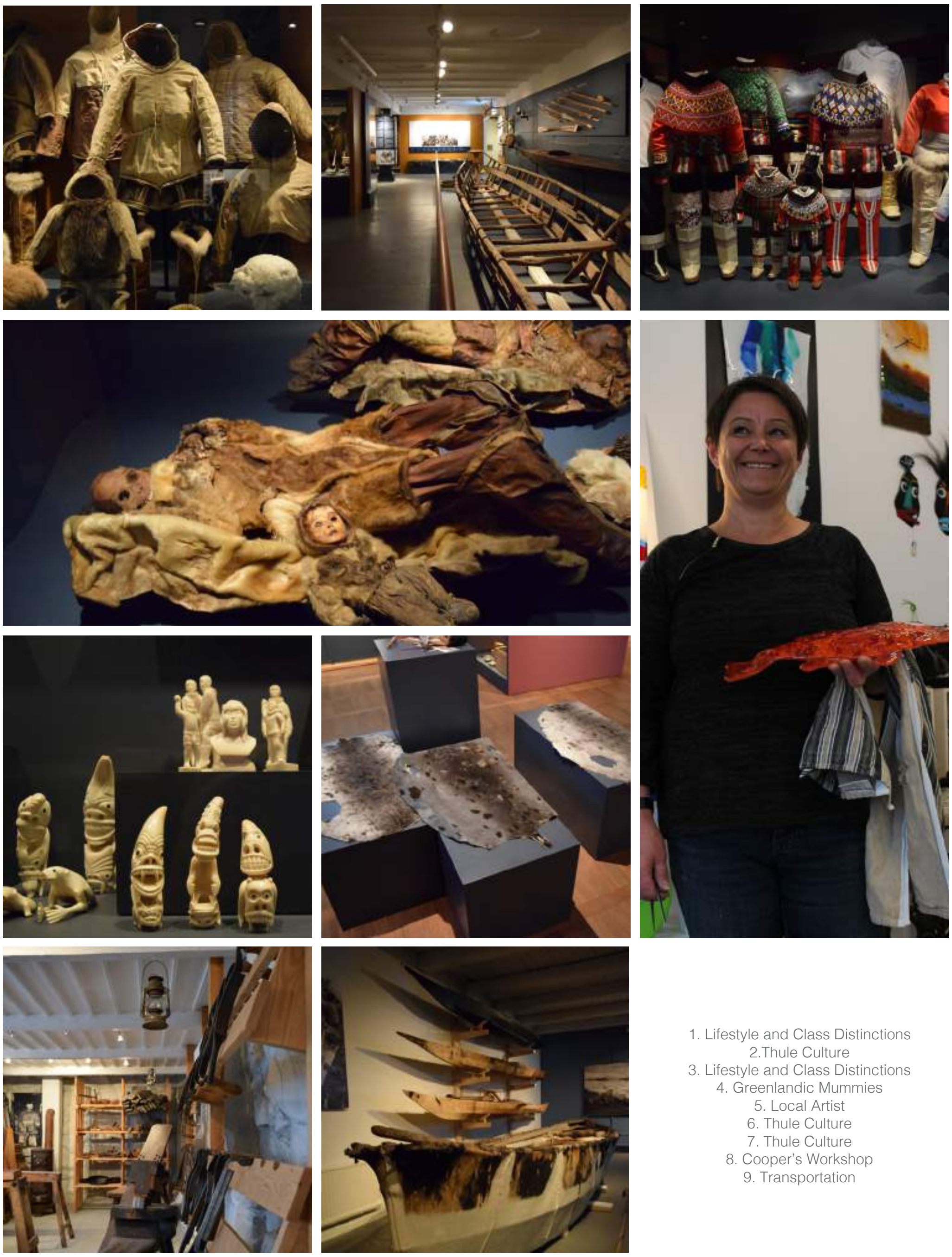
As a plan for future development, the National Gallery of Greenland intends to add to it's portfolio a number of major and minor private collections from all over the world, such as distinguished pieces in wood or bone, or works of embroidery and sewing.

Moreover, the museum's collections will be established by means of a combination of longterm loans, transfers from existing museums and public collections and acquisitions in the form of donations or purchases.

1. Main Entrance
2. Lifestyle and Class Distinctions
3. Special Exhibitions
4> Thule Culture
5. Greenlandic Mummies
6. Means of Communication

7. Cooper's Workshop
8. Transportation
9/ Norsemen
10. Ancient People

Fig. 32. Plan Layout of Nuuk Kunst Museum



1. Lifestyle and Class Distinctions
2.Thule Culture
3. Lifestyle and Class Distinctions
4. Greenlandic Mummies
5. Local Artist
6. Thule Culture
7. Thule Culture
8. Cooper's Workshop
9. Transportation

Fig. 33. Exhibits from Nuuk Kunst Museum

the photographs show a number exhibits, as well as the atmonsphere of Nuuk Kunst Museum. we have looked these features in order to have an overview upon the art that needs to be housed within the museum

Learning Spaces

Today's requirements in terms of teaching spaces stress upon flexible design that accommodates different learning scenarios. Throughout the years, the teaching technique has developed from an outer control discipline, towards todays self control and a self taught methodology, reflected in the way learning environments are now designed. This meaning that the physical environment is used to outline the behaviour within the space, therefore offering the user the possibility of administrating the space to foster their own freedom, imagination and needs [Kirkeby, 2006].

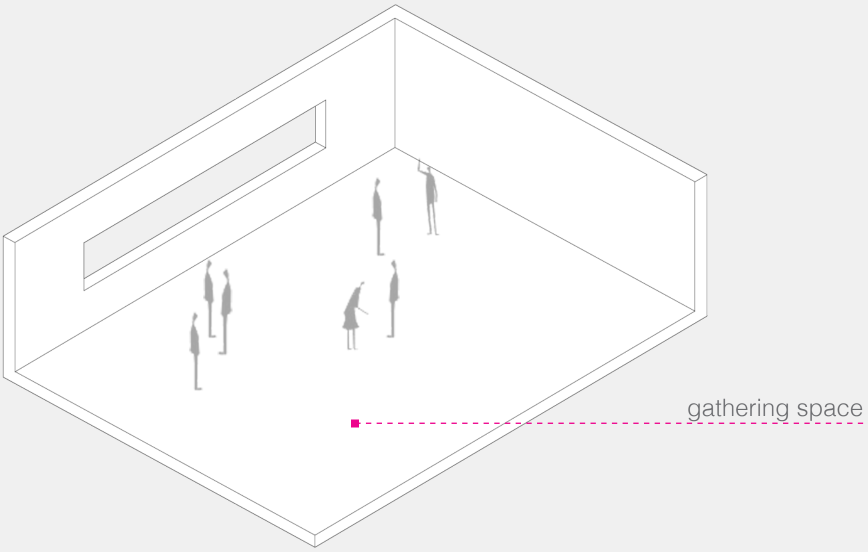
Ricken [cited in Kural, Jensen, Kirkeby, 2010], stresses on the importance of design, arrangement and pedagogic initiatives when dealing with learning scenarios. Fig. 34 reflects the author's theory in a diagramatic way, by stressing on the different use of spaces according to plan layout. An analogy can therefore be made to the cultural center, where a variety of different densities can be seen. However when looking at learning spaces, the variety is a result of the level of privacy which characterizes the space.

Moreover, individuals have different ways of attaining knowledge. Hence a learning environment should embrace differentiated learning and teaching scenarios. However, a space can not teach, but can enable the teacher to facilitate several learning activities, to accomplish a differentiated teaching and therefore a differentiated learning procedure. In this sense, three different scenarios are presented: spaces for gathering, spaces for absorption and space for negotiation.

The gathering space is defined as the focal place for initiating teaching activities. The absorption area is seen as a more individual space, while the negotiation area is seen as the space between gathering and absorption, where the contemplation takes place.

Reflecting on these findings in the process of shaping the interiors of the Art Hub, we have concluded that it is essential to provide adaptable spaces characterized by different levels of privacy in which the artists can contemplate upon all stages of their design.

Moreover, as the venue is designed not only for contemporary artists to carry out their daily routines, but also accommodate the opportunity of using the same spaces for teaching traditional crafts to younger generations, it is all the more important to stress upon the integration of all teaching scenarios within the proposal.



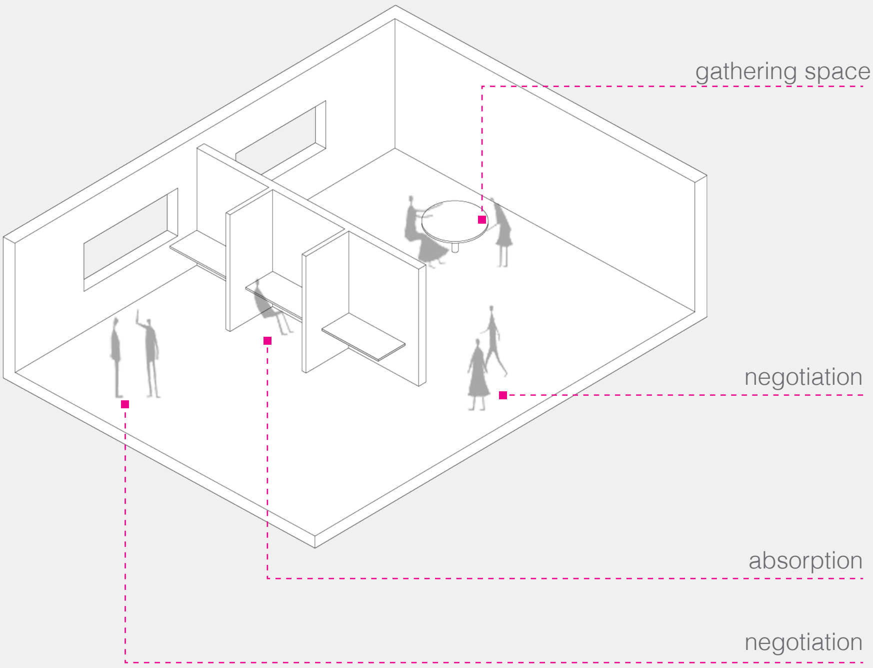


Fig. 34. Study of Learning Environments

within the proposed venue the typologies of the spaces will be represented adequately. therefore, gathering spaces will be defined as classrooms, while absorption and negotiation spaces will be provided within the workshop areas

Design Parameters

Within this section defined parameters for the design will be outlined. Consideration will be given to technical as well as aesthetic aspects.

Sustainable Design

The holistic approach to sustainability presented in the Brundtland-report identifies three major aspects of sustainable development: social, environmental and economic. This stresses on sustainability being viewed as a whole, as the interweaving of social, environmental and economic aspects, underlining the realization that our world is made up of mutual depending elements [DAC, 2014].

Social Sustainability

Social sustainability sustains an empathetic approach that places the needs of the user at the highest level of consideration. In an architectural and urban context social sustainability is about ensuring inclusion and diversity and to create safe and appealing environments which all can benefit from [DAC, 2014].

Given the social context of Greenland, a post-colonial society still depending on a block grant from Denmark [of DKK 3.6 billion] for areas such as education, health, fisheries, and environment [Sejersen, 2015, p.28], a major challenge in adaptation strategies is to raise awareness of the long-term view [Folke et al., 2002]. This involves catering for the foundation for human agency to deal innovatively with developments in the region. Otherwise, these peoples might not be in a position to seize new opportunities, therefore leading to an urban decertification and immense emigration [Sejersen, 2015, p. 52].

Therefore, throughout this proposal, the initiative of framing the opportunity for a cultural interchange between modern principles and Inuit traditions is sustained. In addition, the presented solution stands as a supporting element of this first step towards an empathetic approach on the integration of the North.

This initiative shall be achieved by creating a venue that facilitates and promotes local entrepreneurs, but also offers them the opportunity to learn about the 'modern world' and 'modern traditions'. This way, the fundamental principle of social sustainability, adaptation, is highlighted.

Environmental Sustainability

Environmental sustainability is the most commonly debated aspect of the topic, and is defined as the correlation between construction means and how they interact with the environment.

Kaj Birket-Smith [cited in Sejersen, 2015] talks about the extreme environment of the Arctic region and its close correlation to nature by referring to the Eskimo communities. These peoples live at the world's back door, at the threshold to the empty polar wasteland. They are marginal not only in terms of geographical positioning, but also in terms of resources, as highlighted in the *Analysis* chapter.

In this sense, transportation is a major opportunity for reducing our carbon footprint. Therefore, locally sourced materials shall be considerer, in order to reduce the overall consumption and emissions.

Nonetheless, sustainability also entails the design of a pleasant indoor environment for the user. The psychical perception of a place is influences by physical features. Therefore, by strategical use of physical considerations, one can define a successful environment for in terms of energy efficient design, as well as metaphysical perception

It is all the more essential to built consciously within this environment, and analyze all forms of energy use in the building, relating them to the different needs of individual architectural programs, to see where savings can be made, and at the same time, make the greatest use of natural resources and provide a successful indoor environment [Phillips, 2004].

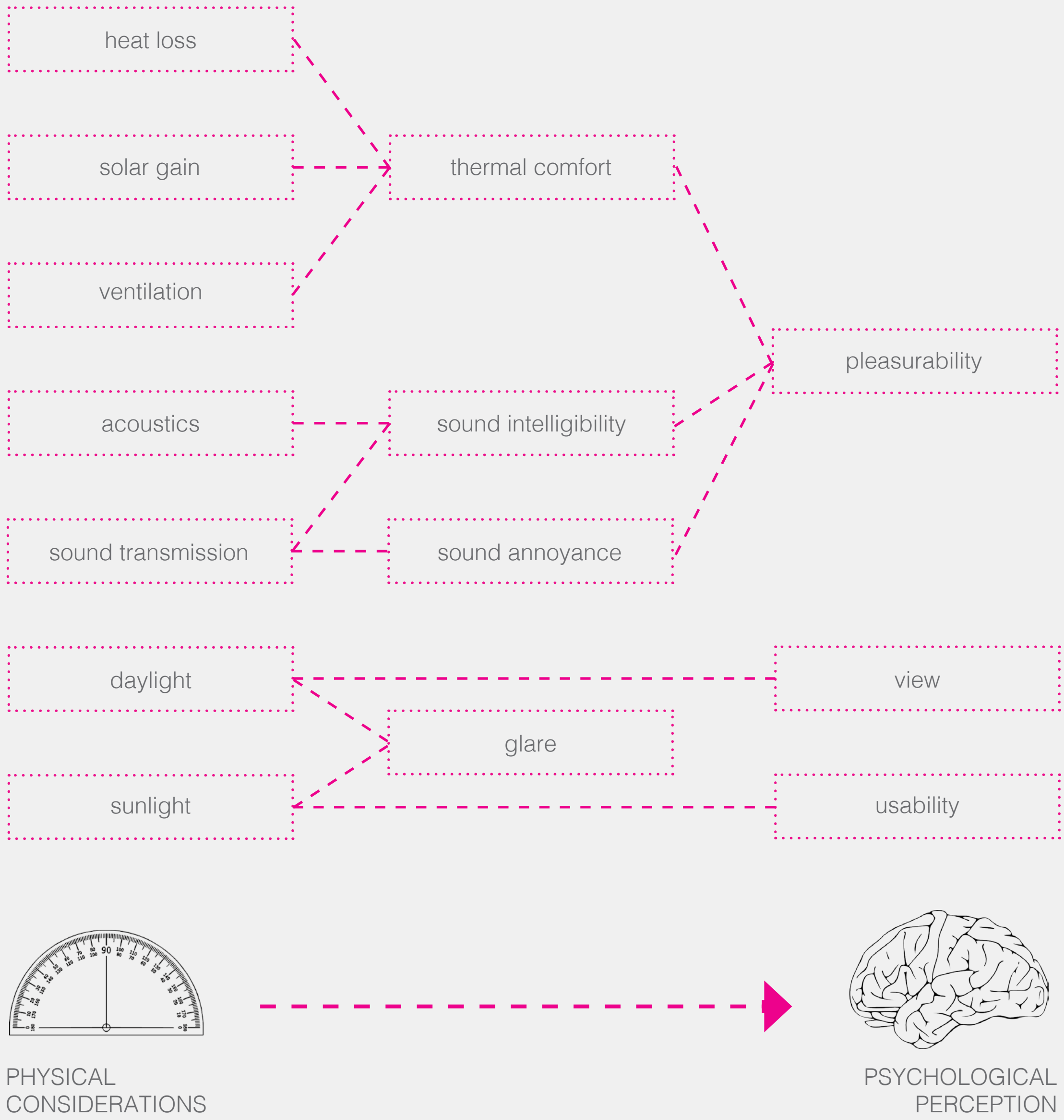


Fig. 35. Relations between physical and psychological attributes
[inspired by lecture slides from Camilla Brunsgaard, 2013]

Energy and Indoor Environment Requirements

Increased awareness in terms of sustainable solutions in museums and art galleries in order to lower energy consumption and carbon footprint can be perceived at an international level. At the same time, the requirements for indoor climate are becoming more strict as the technology develops. This is a challenge as highly controlled environments require greater energy consumption.

Museums and galleries have nowadays become more complex, nesting a wide pallet of different functions - from permanent to temporary, and from ancient to digital exhibitions, workshop spaces, shops and cafés. This wide range of different spatial typologies add extra complexity to the required systems. This, together with the demand for an optimum environment, has rendered it impossible to reach indoor climate regulations without mechanical systems [Museums & Galleries Queensland, 2014; Padfield and Larsen, 2004].

Environmental Damage
Damage to collections because of defective indoor climate is not entirely inevitable, but can be minimized by being aware of the three primary reasons that cause deterioration. To decelerate chemical changes in an object, the climate has to be kept cold and dry. Therefore, to hinder items from biological decay, such as mold, moist an insects, the relative humidity [RH] must have an upper limit of 65%, with a temperature at 20 °C. Moreover, to minimize mechanical decay such as physical stresses in objects, extreme RH and temperature must be avoided. But, having a collection with a wide range of different objects and materials, compromises have to be made [Museums & Galleries Queensland, 2014].

In the proposal, the indoor environment for storage and display rooms will follow a guideline developed by the American Institute for Conservation, for acceptable environmental control for a majority of material types [Museums & Galleries Queensland, 2014]. The set point will be changed within the allowable range according to the seasonal climate conditions in Nuuk. In order to ensure thermal comfort , and at the same time prevent damage of the collections, the temperature of the gallery spaces has to be kept to a constant, of 20^{o}C, with a maximum fluctuation of +/- 4^{o}C per 24 hours. The relative humidity should be 40-60% with a maximum fluctuation of +/- 5% per 24 hours [Museums & Galleries Queensland, 2014].

Thermal Comfort
In the zones where no art is exhibited, the high controlled environment demands are replaced with those of the Danish Standards. The values for the indoor climate in these areas is set to Category II that applies to a normal level of expectations and should be used for new buildings. The temperatures are based on clothing level [clo] and the set point for thermal comfort is 20^{o}C [DS/EN15251:2007].

Atmospheric
The atmospheric comfort is based on the experienced air quality and the air pollution, such as smell from the interior or people in the room, as well as CO^2 levels. Since smell cannot be measured, the set point for the CO^2 level will inform the need for ventilation. CO^2 level should, according to the Danish Building Regulation, not exceed 900 ppm in longer periods which also have to be met in the exhibition spaces [bygningsreglementet.dk,2016].

Visual
Daylight during the winter season in Nuuk is very limited and can therefore not follow normal recommendations. Therefore, the requirements differ from the summer to the winter season. In the summer, the daylight factor in other rooms than the galleries, comply with the Danish Building regulation and have a minimum daylight factor of 2% in working areas

[bygningsreglementet.dk,2016]. In the galleries an average daylight factor of 5% and minimum 2%. (ICAEN, 2004)

Energy
No galleries or museums are the same and therefore it is not easy to predict how much the museum will consume in operation. According to the current regulations in Greenland, the energy consumption for other buildings than residential are not allowed to exceed 290 MJ/m² pr. year, plus 280 MJ/m² pr. year divided with the number of floors plus 13.000 MJ pr. year divided with the footprint area [Direktoratet for Boliger og Infrastruktur, 2006], which correspond to Danish 2016 Building Standards.

However, our proposal sets out to meet more current energy requirements, therefore the design will be made in a way in which optimization will be promoted to the maximum potential. Therefore, the building has been designed to meet 2015 Low Energy Building Standards. However, by placing an extra 110 m² of PV panels, the building will have the potential to meet 2020 goals.

	Display and storage	Workshop, Café, Shop and other
°C	15-25°C +/-4°C per 24 hours	Winter, clo = 1,00: 20-23°C Summer, clo = 0,75: 21-25°C
RH	40-60s% +/-5% per 24 hours	—
CO_2	< 900 ppm	< 900 ppm
DF	—	> 2% on average

	Requirement for the building	Goal for the building
	< 290 MJ/m² pr. year, plus 280 MJ/m² pr. year divided with the number of floors, plus 13.000 MJ pr. year divided with the footprint area	Energy Frame Low energy buildings 2015

Fig. 36. Indoor and Requirements

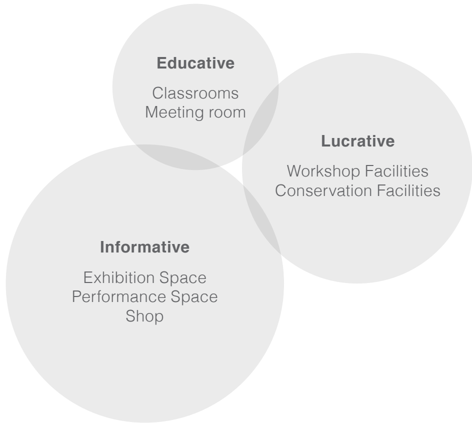


Fig. 37. Experiential Divisions

Room Program

The aim of the proposal housed within the venue is to incorporate the function of a National Gallery, as specified in the brief given by the Municipality. Moreover, the design will also provide spaces for the development of a local arts and crafts movement. Therefore, at a experiential level the venue will branch into 3 sectors: informative, educative and lucrative. At a functional level, the site will be divided into 4 parts, split between two buildings: administrative, public functions, arts and crafts outreach and national gallery.

Research has shown that one of the essential characteristics for all sectors housed within the venue is light. However, a fundamental difference is the nature of the light each of space requires. Good educational and working environments dwell upon the importance of natural light. In contrast, exhibition spaces require artificial lighting as direct sunlight can provoke damages on the existing artifacts.

As both light instances will be enclosed within the proposal's design, a strategy that deals with light in an informed way needs to be defined. Fig. 38 shows an overview upon light requirements in terms of lux, recommended for each type of space. Therefore, the main building, which houses the exhibition spaces and the arts and crafts facilities, will be split in two divisions: the museum, facing North in order to avoid direct sunlight in the exhibition rooms; and the educational facilities, facing Southwards consequently capturing as many daylight hours as possible given the local sunlight conditions.

Kunst Museum and National Gallery
The function of the National Gallery has been placed facing the Northern border of the site, as direct sunlight has to be avoided. The table placed on page 59 offers an overview upon the spacial requirements within the Gallery Outreach. The brief stresses upon the importance of having spaces at different heights, as to accommodate a great variety of potential exhibitions.

Arts and Crafts Outreach
Research into the local artistic scene has revealed that the material required by local artists do no requisite special treatment [see appendix]. Therefore, an open plan workshop, which accommodates area with different levels of privacy and density will be implemented. In order to maintain a pleasant and inspiring environment, it has been rendered essential that each workshop area would be provided with windows facing outwards towards the fjord.

Space	Lux
Foyer/Shop	200
Auditorium	150-200
Cafe	150-200
Kitchen	500
Toilet	200
Exhibition	50-200
Classroom	250-500
Workshop	500
Library	200-500
Storage	100
Office	500
Meeting Room	300
Children's Room	500
Public Spaces	200
Auditorium	200

Fig. 38. Light requirements [*numbers from http://www.noao.edu/education/QLT-kit/ACTIVITY_Documents/Safety/LightLevels_outdoor+indoor.pdf]]

Space	Area	Light	Notes
Public Functions			
Reception	30.5 m^2	⬚	Including staff room
Cafe	182 m^2	☐	Inlcuding kitchen and staff room
Shop	128 m^2	⬚	
Auditorium	84 m^2	■	Seating approx. 80
Reading Room	76 m^2	☐	
Children Playroom	40.5 m^2	☐	
Wardrobe	18 m^2	⬚	
Toilet	24.5 m^2 * 3	⬚	Placed on floor 0, -1, -2
National Museum			
Exhibition Spaces	660.5 m^2	■	Open plan developed on 2 floors
Special Exhibition	173 m^2	■	Inlcuding kitchen and staff room
Performance Space	271 m^2	■	
Conservation	200 m^2	⬚	Including staff facilities and conservation for paper, sculpture, paint, other
Storage	200 m^2	■	Place in administration building
Arts and Crafts			
Classroom	122 m^2	☐	Divided between two classrooms
Workshop	300 m^2	☐	Open plan
Meeting	40 m^2	■	
Lounge	45 m^2	☐	Including tea kitchen
Print Room	7.5 m^2	⬚	
Changing Facilities	37 m^2	⬚	Including shower
Storage	30 m^2	⬚	
Admininstration			
Office	32.5 m^2	☐	Open plan
IT Room	5.5 m^2	⬚	
Lounge	17 m^2	☐	
Delivery Office	37 m^2	⬚	
Archive	29 m^2	⬚	
Plant Room	150 m^2	⬚	Placed on -3 in admin building, and -2 in art hub
Cleaning Room	18 m^2	⬚	
Toilet	24.5 m^2 * 3	⬚	

Fig. 39. Room Program

⬚ No specific light requirement
☐ Essential natural light
■ Essential artificial light

Atmospheres

In the previous sections, the importance of creating a 'place' and not only a 'space' in the given environment has been stressed. Therefore, an essential feature for the design is the atmosphere, the loci of each space.

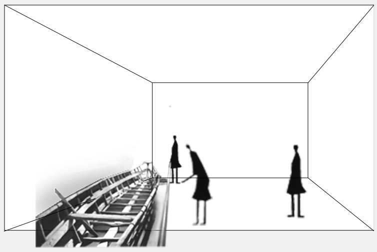
In his book on the Greenlandic Environment, Sejersen [2015, p.158] talks about how the success of reinventing a place for cultural consumption is dependent on the establishment of 'a view', 'a destination' and 'an event'. The function carried out by the proposal [fig.40] foresees the potential inauguration of an event within the local context.

Moreover, the proposed site is enormously generous in terms of capturing a view. Therefore, a parameter when defining the interior spaces has been the framing of the view towards the fjord. By capturing the beautiful view of the fjord, one can enjoy the exterior while being sheltered from the rough weather conditions found beyond. Nonetheless, studies have shown that given the local climatic conditions, large glazed areas are essential in order to obtain as much passive heat gain as possible. Therefore, the placement of large glazed surfaces is justified not only architecturally, but also technically.

Fig. 40. Function Distribution

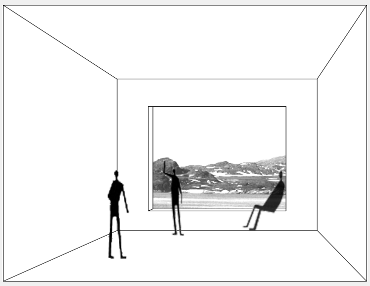
Experiencing the Site

the dramatic declination of the site towards the fjord opens up the possibility of engaging with the site from a different perspective, by informed use of the architecture



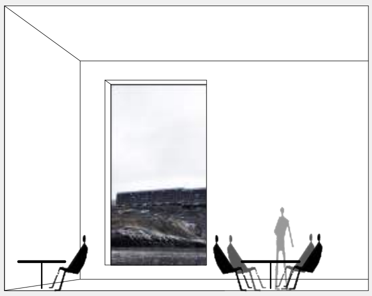
Interacting with the Art

literature has argued that the architecture of a space should not distract the experience of the exhibits, but add to their value



Utilizing the View

the natural settling can be utilized to create a view that connects the interior with the exterior



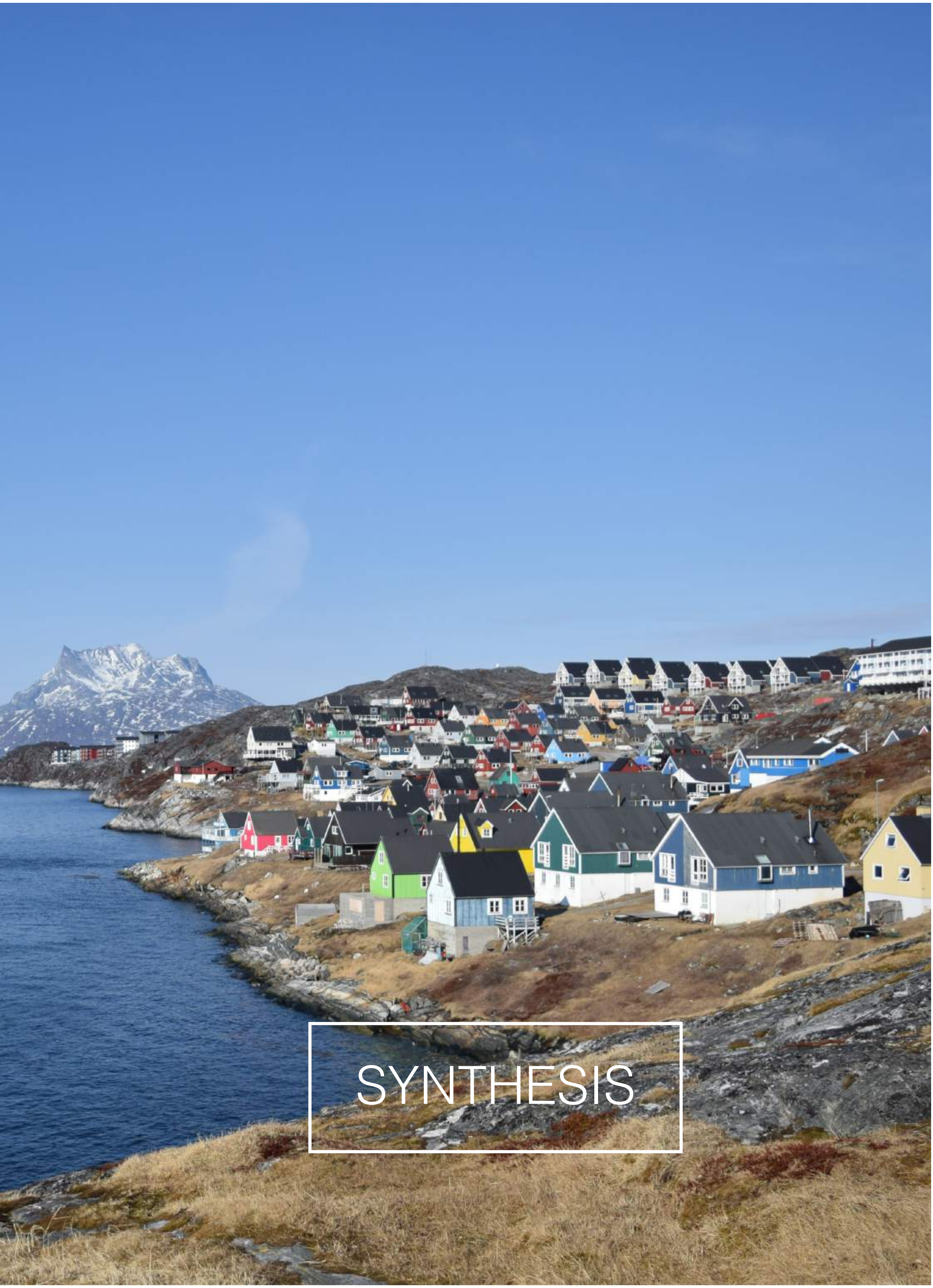
Different Densities

the lucrative unit should be flexible one, with a variation of possible spatial combinations that define areas with different levels of privacy and density

Fig. 41. Perception

Fig. 42. View of Nuuk

SYNTHESIS



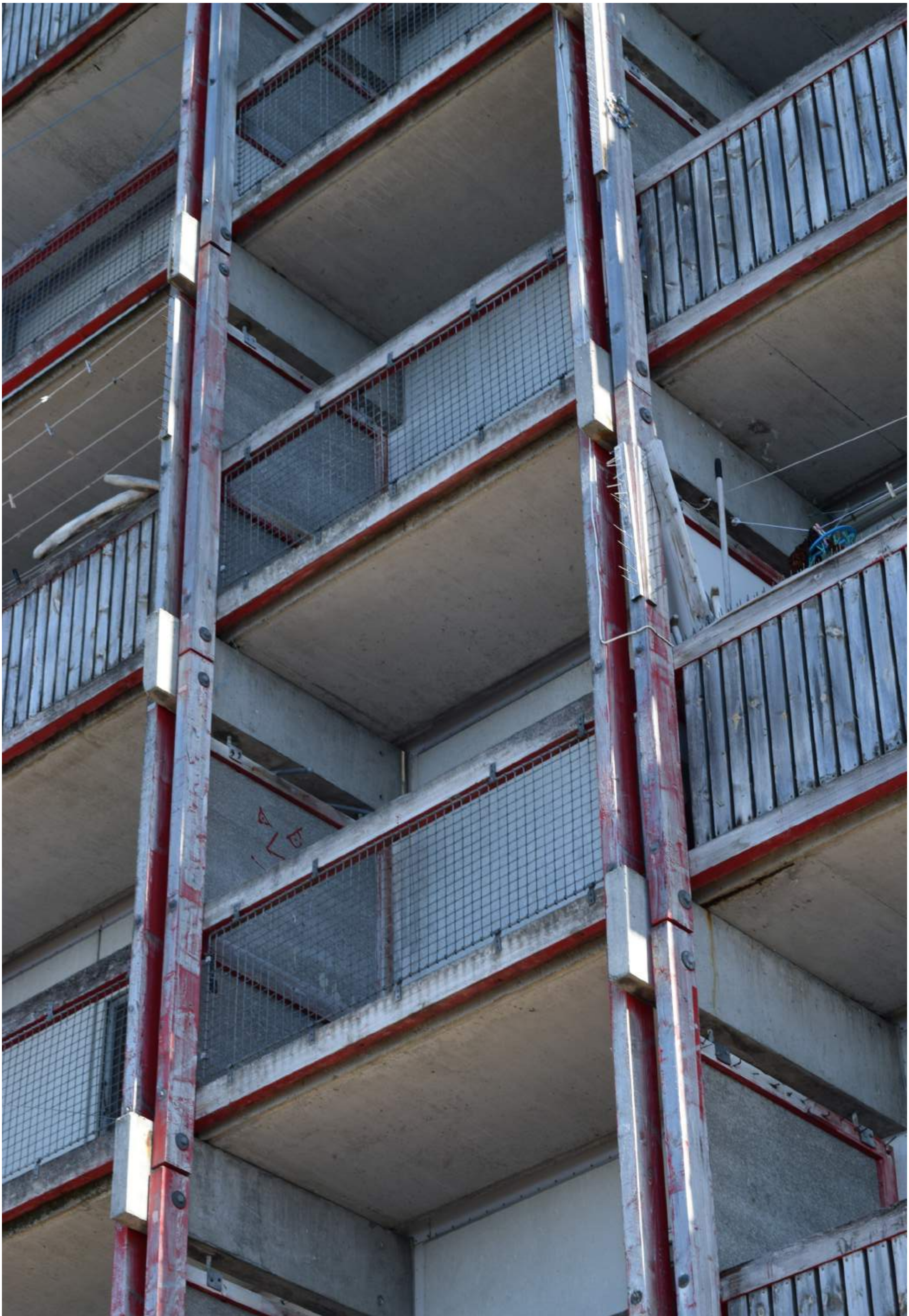


Fig. 43. RadioFjorden Housing Block

The Ambition

The section presents the conceptual parameters which frame the design. The architectural development of the project will therefore be a product of these considerations

The Vision

The vision focuses on the societal implications of the function housed within the proposed venue.

The initiative sustains the development of a cultural interchange between modern and traditional Greenland. The local arts and crafts movement is therefore used as a medium to facilitate cultural consumption, with the purpose of establishing a 'place' for the modern Inuit community. The proposal will house not only a National Gallery of Art that explains the past, but also Workshop facilities that promote a modern direction.

Sejersen [2015] talks about the vulnerability of these marginal peoples of the North in the face of climate change, while dealing with a post-colonial society that strives to shape their own independent future. Therefore, adaptability becomes a central tool in dealing with the marginality that Greenland is confronted with. In this sense, the supreme desire of these peoples is for their rights, their concerns and their interests to be respected and, nonetheless, to play an active role in shaping their future. In essence, Greenlanders are renegotiating the significance of their position within a global context. A way in which they express this ongoing frustration is through art. Therefore, through art Greenlanders express their present experiences. Nonetheless, they see the preservation of these traditions essential as by understanding their traditional and modern art, one understands their culture.

Therefore, the vision behind our proposal is to accommodate the functions that sustain the development of a society that wishes to voice their opinion and shape a future of their own.

The Concept

This chapter outlines the design intentions of the proposal, both in terms of architectural approach, and of social findings.

Fig. 44. The Open View

By using the serial vision exercise as a point of departure, two conceptual approaches that will influence the development of the design have been defined: the narrative throughout the site, and the open view.

THE NARRATIVE
Looking at the unwrapping of the site as reached by Tuapannguit street, a natural built up towards the site can be experienced. The intention is to continue this narrative of the site, by strategically placing the proposal into the storyline.

THE OPENNESS
Although without conscious planning, the planning of buildings within Nuuk is made so that the architecture helps frame the natural environment. The architectural proposal will solidify this perception of the framed view, while at the same time create a landmark for the city.

Conceptual Approach

Having a point of departure in the serial view exercise, where we have accentuated the dominating features of both approaches to the site, from Tuapannguit and the fjord, we have outlined the two concepts that define the proposal: *The Narrative* and the *Open View*.

The Narrative

By making an analogy to the points of a narrative, we intend to define the experience of our site as seen in fig. x.

1. Exposition
2. Rising action
3. Built up
4. Climax
5. Experience
6. Resolution

The building will therefore be placed at the *Climax* point of the story. The narrative will be used in defining the experience of walking on the site. Therefore, the experience of the place will in itself be entangled in the local environment, by telling the story of the site.

The Open-ness

This design intention formulated as *The Open View* maintains the existing phenomenological approach experienced throughout the city. This is achieved by use of the architecture in order to frame the natural scenery. Nonetheless, the existing surrounding will themselves frame the proposed architecture. Therefore, the design will be empathetic towards the surroundings and towards the tradition of the place, and will dwell upon a mutual relationship between the constructed and the natural.

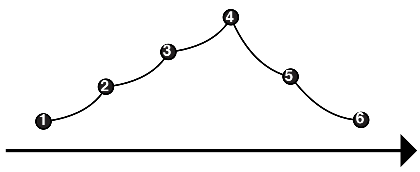


Fig. 45. The Narrative

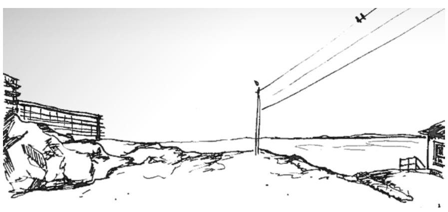
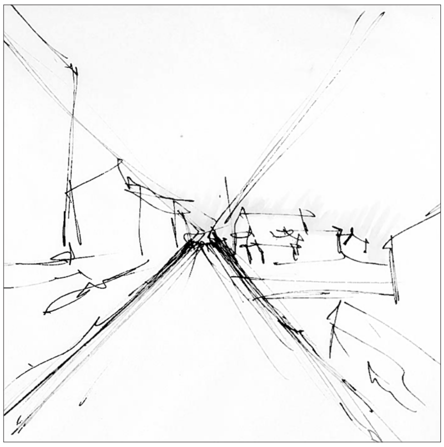


Fig. 46. The Open View



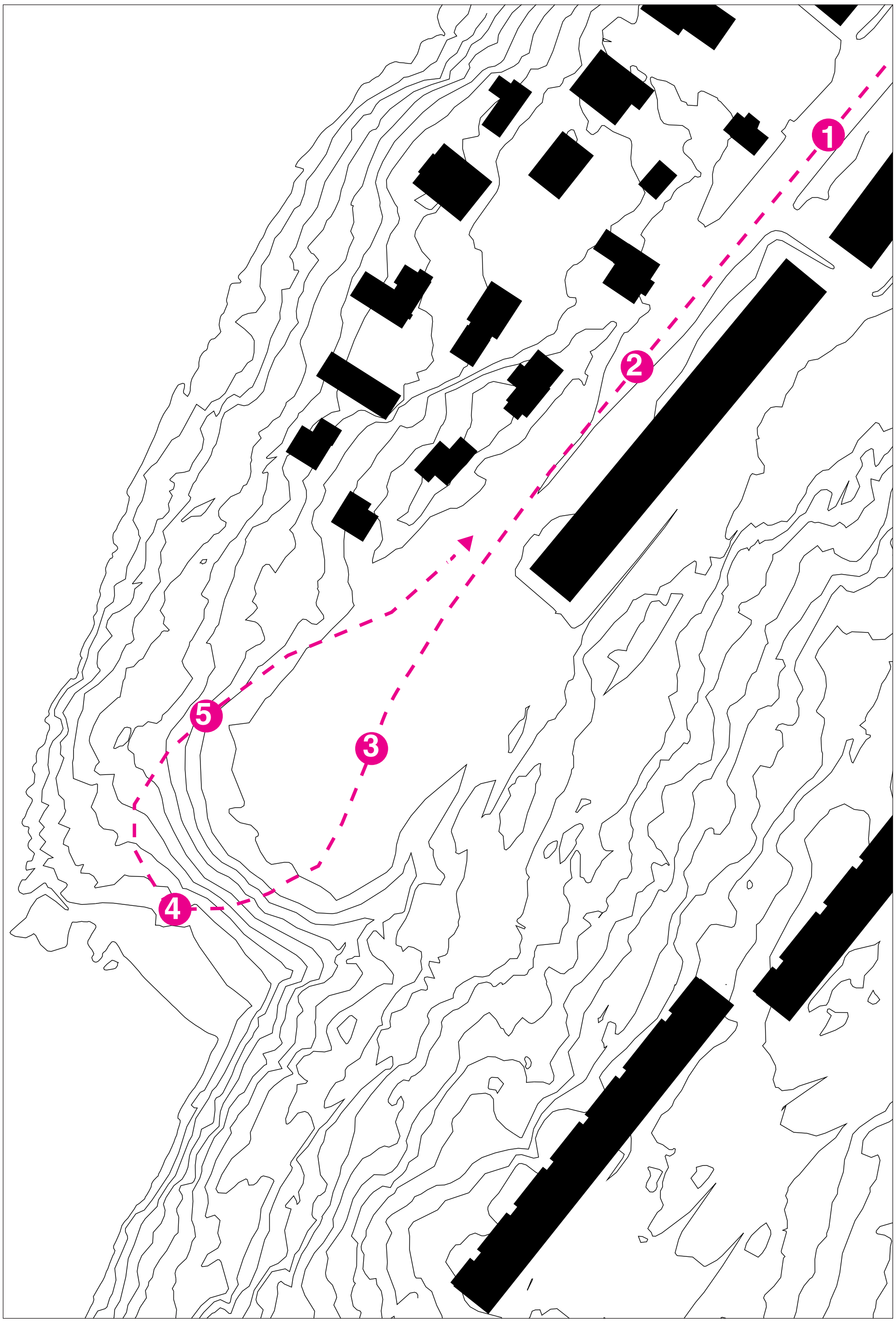


Fig. 47. Conceptual Approach

the diagrams showcase the intention of the narrative throughout the site, as well as highlight the idea of the open view placed in the climax position of the narrative

Fig. 49. View From the Fjord

The Proposal

The Section presents the proposal in a detailed manner. The presentation will showcase the proposal at different scales, ranging from masterplan considerations to detailed design.

Design Apparatus

Aesthetic, vernacular, contextual and sustainable considerations have been considered when shaping the design of the proposal.

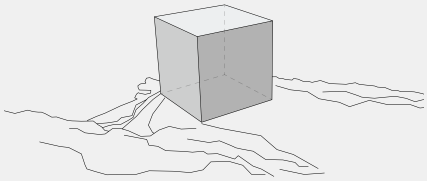
The Proposal

The final volumetric composition of the proposal is comprised of two volumes that house the 4 function of the proposal: national gallery, arts and crafts facilities, public functions and administration. The main building shelters the Art Hub's galleries and associated spaces, while the smaller building has a more administrative purpose, including the administrative quarters and the storage and conservation units.

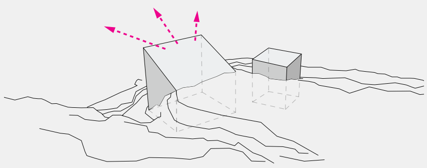
When considering the disposition of the proposal on site, consideration has been given to sun exposure both in terms of aesthetic and environmental consideration. Therefore, by strategically positioning the venues on site, the openings on the facade will showcase the natural scenery, and as well make maximum use of natural daylight use and controlled heat gain through thermal mass.

Moreover, the relationship with the surrounding environment has determined the placement of the smaller volume towards the NW boundary of the site. In this way a relationship with the surroundings can be established by continuing the volumetric framework of the typical Greenlandic dwellings. The volume housing the Art Hub is placed in relation to the concrete residential towers, resembling the scale of these concrete giants.

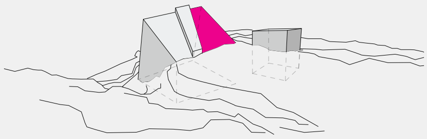
Nonetheless, by building into the site, the proposal carries out the conceptual approach of the open view, using the roof as a culminating point of the narrative. This approach opens the possibility of experiencing the landscape from different perspectives that one could normally do.



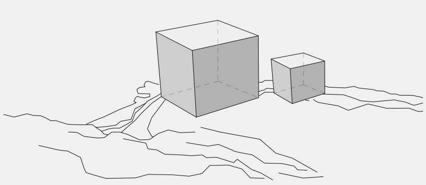
Compact Volume - Energy Efficiency



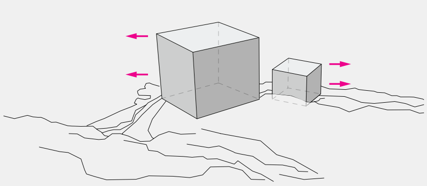
Conceptual Climax of the Narrative - The View



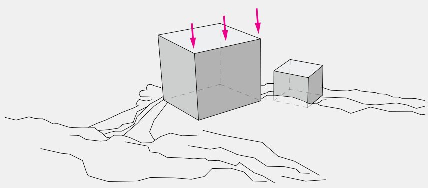
Exhibition Spaces Placed Towards North - No Direct Light



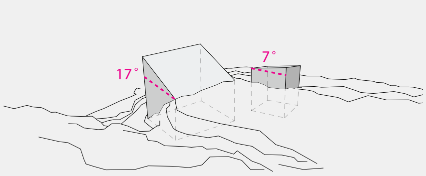
Two Functional Divisions



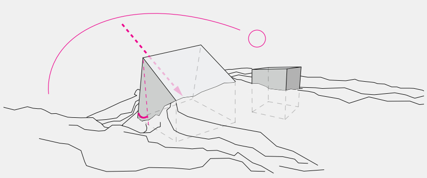
Relationship To Surroundings: Housing Blocks and Family Houses



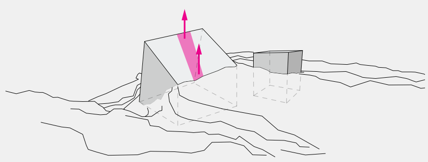
Concealed in Terrain - Less Heat Loss



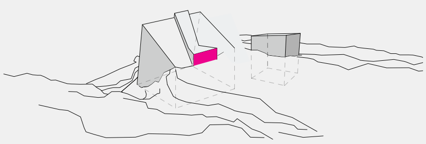
Sloping According to Regulations - Snow Overload Prevention



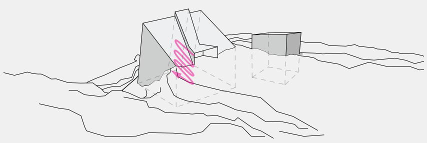
Tilting of Facade Brings Light Deeper Into the Building



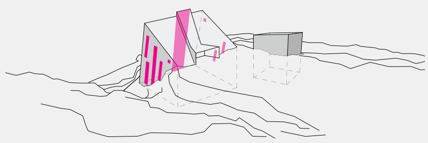
Atrium Defining Two Functional Zones and Facilitating Light Infiltration



Inviting Entrance



Clear Circulation Defined Through Circulation Core



Openings on Facade According to Passive Heat gain

Fig. 50. Development Diagram

A Holistic Approach

The planning for the proposed venue dwells upon a contextual approach, where the architecture can be experienced both from the inside as well as from the outside. The placement on site has been determined by a series of alterations between aesthetic, topographical and environmental considerations.

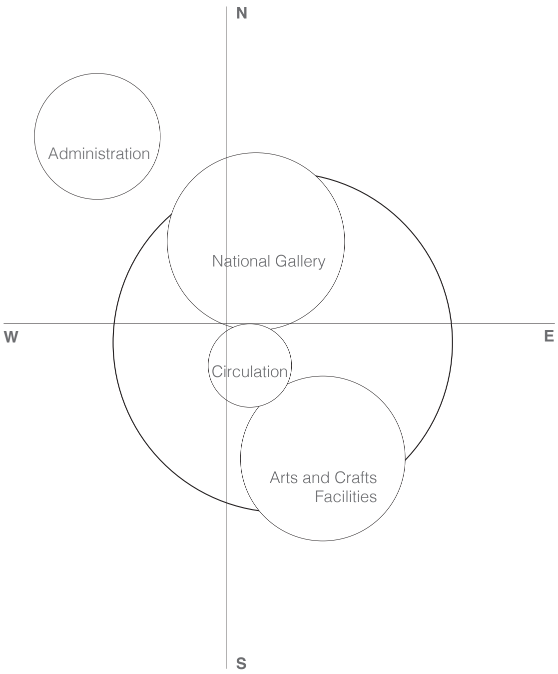


Fig. 51. Morphological Layout

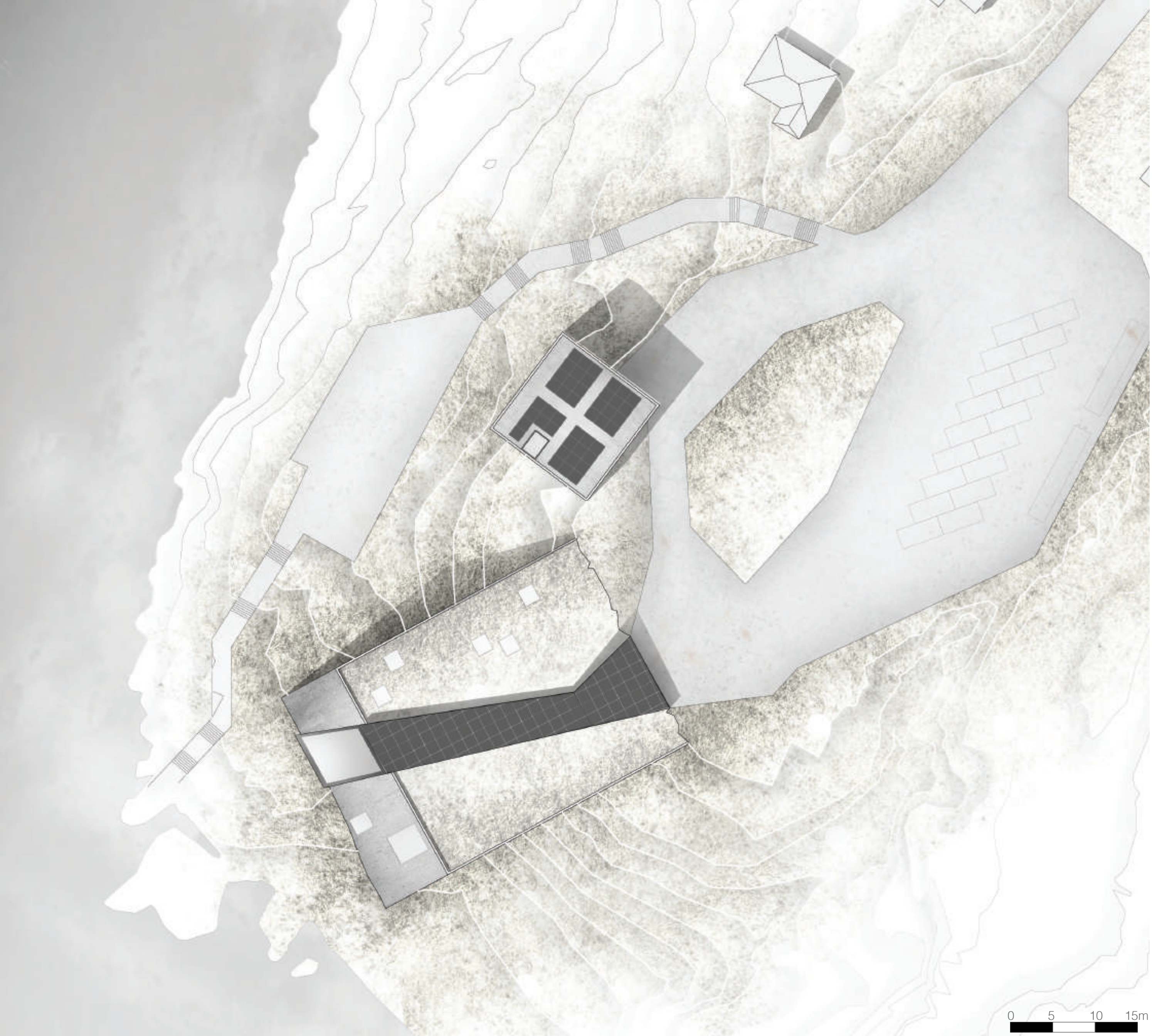


Fig. 52. The Site

Site Considerations

Consideration to factors such as accessibility and microclimate has been given when developing the masterplan.

With emphasis on accessibility in terms of pedestrian access as well as delivery of goods an art pieces, the entrance to both the Art Hub and the Administrative building, which houses the storage units, has been placed at the level of Tuapannguit street. Therefore, access to both buildings is made through the top floor. The parking has been placed at the entrance of the parameter, within close proximity to the main street, however visually hidden from the viewer's perspective when reaching the site, in this way sustaining the idea of the open view. The placement of the parking is also pending on the local plan which suggest a future underground parking on the Eastern border of the proposed site.

Nonetheless, the decision of immersing the volumes into the terrain responds to the local climatic conditions by adopting a vernacular approach. Making this analogy to the local tradition of the turf house, which uses the ground as insulation, the proposal uses the sloping of the dramatic topography as an envelope, therefore reducing the total energy requirement. The exposed facade is strategically orientated, so that maximum light exposure during hours of use can be achieved. Moreover, in order to facilitate sunlight on the outdoor spaces, the buildings leave as minimum shading as possible on the given site.

The placement of the two volumes considers the existing fabric. Therefore, the Administrative building is following the grid of the neighborhood of single family houses on the NW border of the site. The scale of the building replicates that of the above mentioned dwellings. The Art Hub however, represents a transition from the small scale of the dwellings, to that of the large housing blocks placed on the N and E boundaries of the site.

Resilient design has also been a key parameter when developing the site plan. In this sense raising water levels due to the melting of the ice cap has forced us to push the building away from the edge.

The natural layout of the topography outlines the presence of three flat plateaus. These plateaus define public spaces at different heights above sea level, therefore outdoor public areas around the building will be supported throughout time [fig.54].

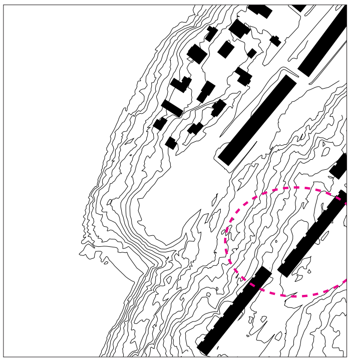


Fig. 53. Future Underground Parking

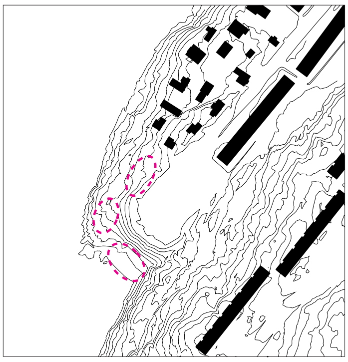
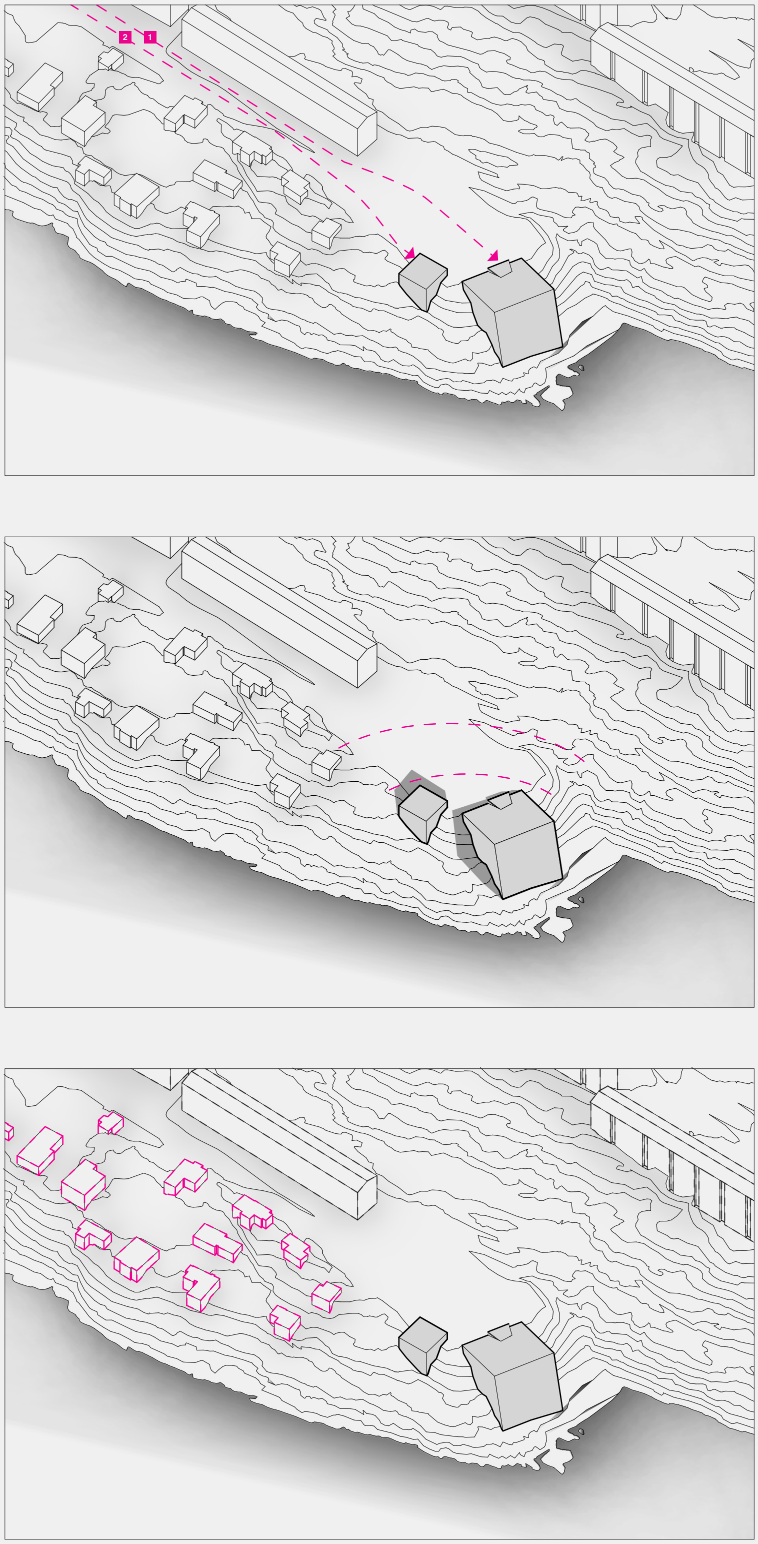


Fig. 54. Flat Plateau



Access
- Delivery
- User Access

Shading
Existing site remains unshaded, together with new protected outdoor space

Surroundings
- Dwellings
- Residential blocks

Fig. 55. Site Specific Consideration

the placement on site and volumetric composition considers three main characteristics, illustrated in the diagrams above:
delivery / access
shadowing
relationship to surroundings

A Holistic Approach

The geometry of the venue and the interior layout of spaces are the result of an ongoing iteration between technical considerations and aesthetic qualities. Therefore through a series of loops the design of the final proposal has been rendered final [fig.56].

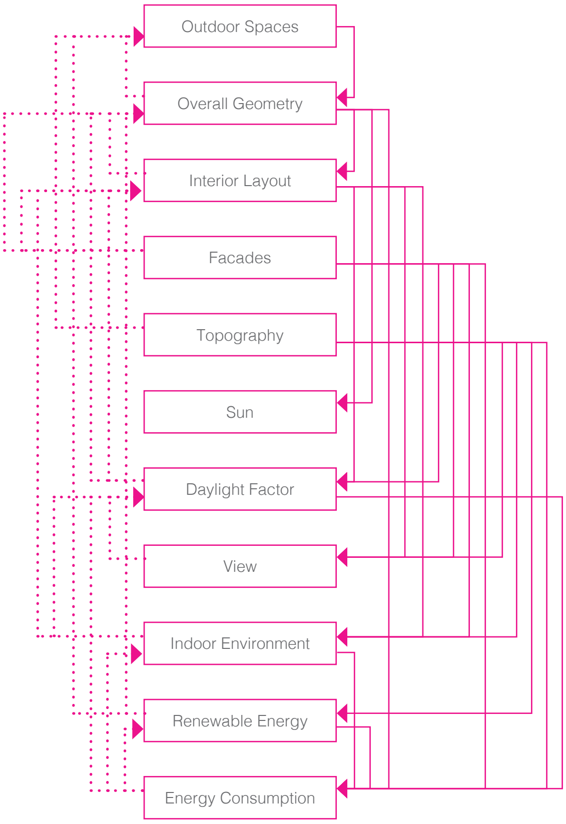


Fig. 56. Integrated Design

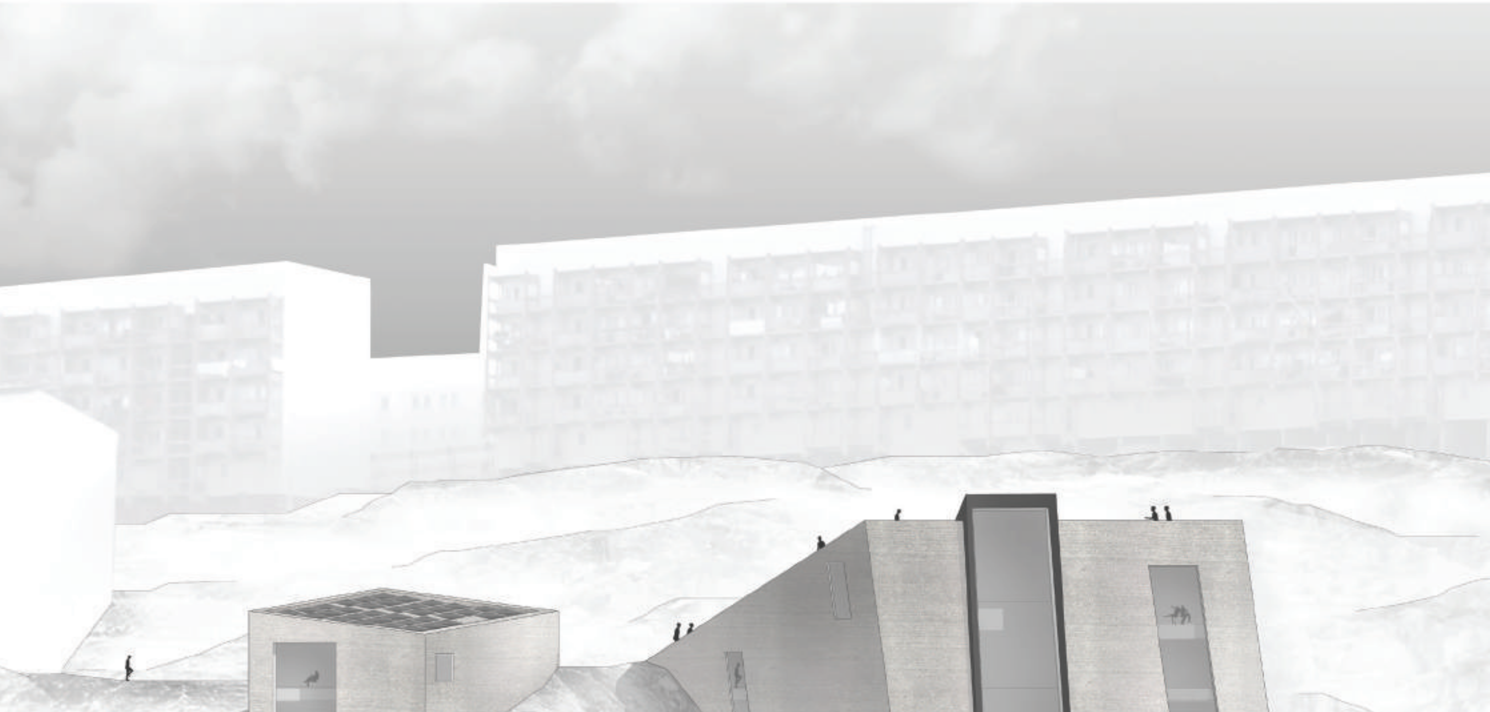


Fig. 57. West Elevation

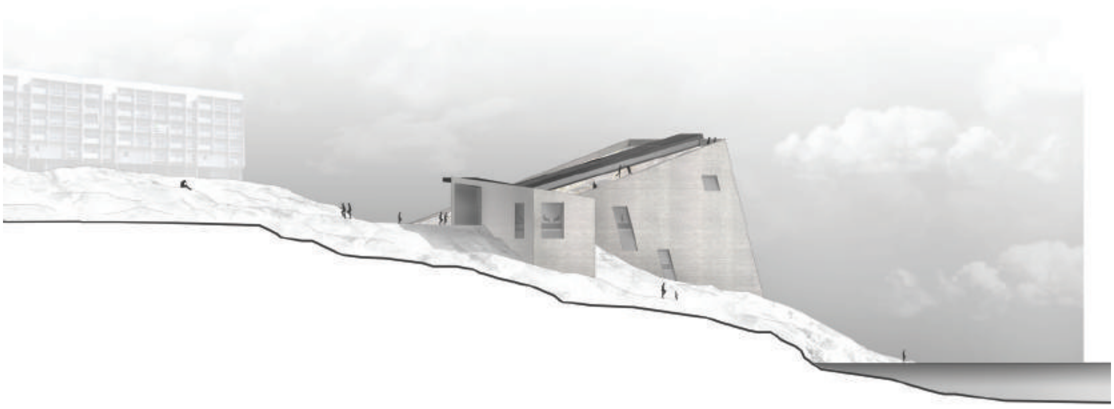


Fig. 58. North Elevation

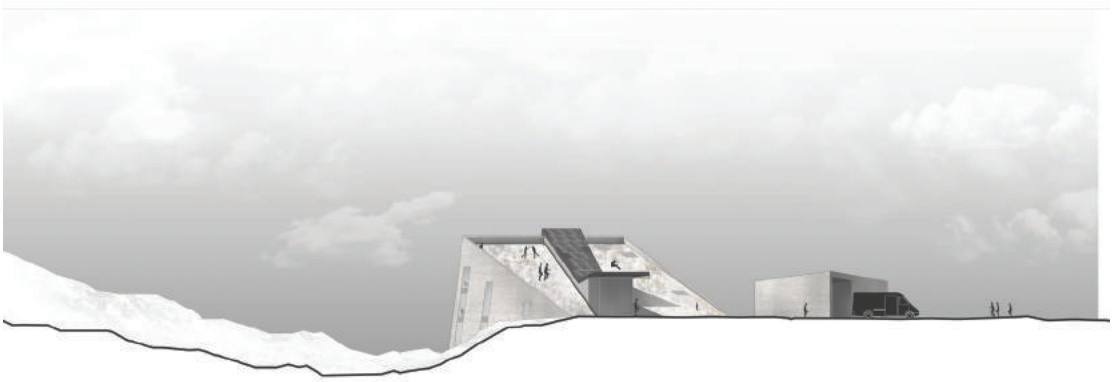


Fig. 59. East Elevation

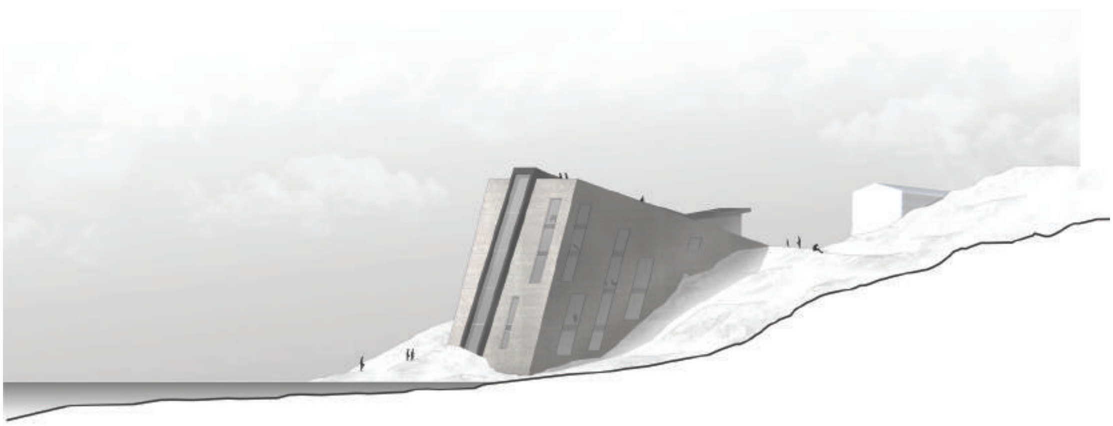


Fig. 60. South Elevation

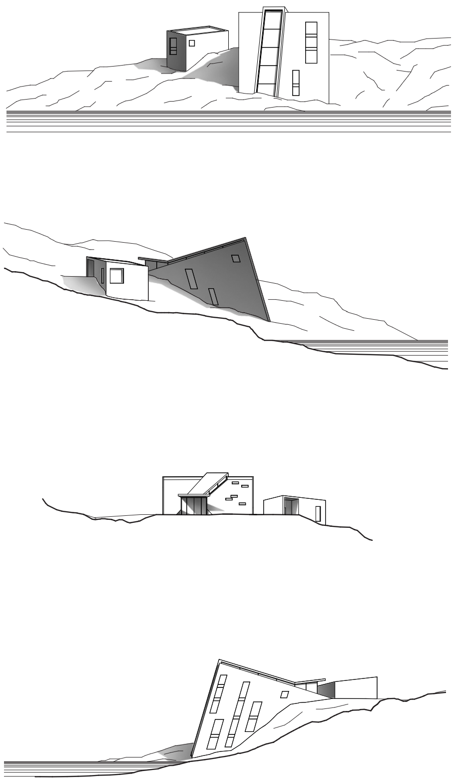


Fig. 61. Art Hub Facades

The development of the proposal has been a result of a continuous interplay between aesthetic qualities and technical considerations. Therefore, each design decision can be justified both through the architectural intention as well as the sustainable scheme.

A key feature of the design is the layout of the plan, which places the Gallery towards the North and the Arts and Crafts Facilities facing Southwards.

The facade is shaped to attain a good interior environment within the spaces placed beyond. Therefore, the openings corresponding to the Arts and Crafts facilities are wide, framing the view outside, while at the same time are utilized to obtain passive solar gain and a suitable daylight factor. Contrarily, the openings of the Exhibition spaces which face Northwards are smaller, in order to prevent heat loss.

At an aesthetic level, the overall geometry of the proposal contrasts the existing natural landscape by having a clear and almost brutal expression. However, the integration in the topography, as well as the materiality and the relation to the scale of the existing surrounding architecture advocate the integration of the proposal within its given context.

Energy Strategy

The calculations for indoor climate have been made on one classroom and the exhibition. The requirements are according to category II in the DS474 and DS/EN15251 standards for human comfort. The Indoor climate for the exhibition spaces meets the guidelines set by the International Conservation Services Stensen Varming. Moreover, the building sets out to reach 2015 Low Energy Building Standards.

Active strategies such as geothermal energy and solar energy have been implemented into the design. However, as the grid relies on green energy, the building will connect to it to the supply for electric water heating [Nukissiorfiit, 2016].

For the calculations in the BSim software, the weather file for Reykjavik has been used as the one for Nuuk did not operate reliably. Hence, the results for the indoor environment are only a guideline of how the building will perform. By having the correct weather file for Nuuk in Be10, excessive heat has been shown to occur [see appendix]. This has therefore been compensated by doing hand calculations for natural ventilation in order to keep the energy consumption for mechanical ventilation down. With outdoor temperatures only reaching a maximum of 10°C in the summer, overheating is assumed to not be problematic with natural single sided stack ventilation in the case of overheating in the Art Hub.

In the exhibition rooms, mechanical ventilation is used due to the demand of a highly controlled environment. Pipes for mechanical ventilation are vertically distributed between the floors and out to the zones under the suspended ceiling.
BSim has been used as a design tool to ensure a good indoor climate by testing different design principles. The calculations have influenced the orientation on the site, the placement of functions and window openings. A more detailed description of the indoor environment corresponding to a classroom and an exhibition space will be provided in the following pages.

Moreover, Be10 has bees used in order to assess the overall energy requirements of the building. The aim has been to reach a Zero-Energy during the summer months, as well as fulfill the energy requirements by the Greenlandic standard 2006 Zone 1. Only relying on passive strategies the building will consume 89,4 kWh/m² per year. After implementing geothermal energy with one heat pump, and place an area of 345m² of PV panels on the atrium and the administration building, the building reaches low energy class 2015 in Be10 with 40,2kWh/m² per year. The energy consumption for the building operation is primarily used on electricity and heating. The heat contribution due to people load, mechanical equipment and lighting is utilized 100% from November to March. In the summer months the utilization goes down to 0,4 which is due to less heating requirement and to a higher incident solar radiation that is 15,76 MWh compared to 0,28 MWh in December [See appendix for more]

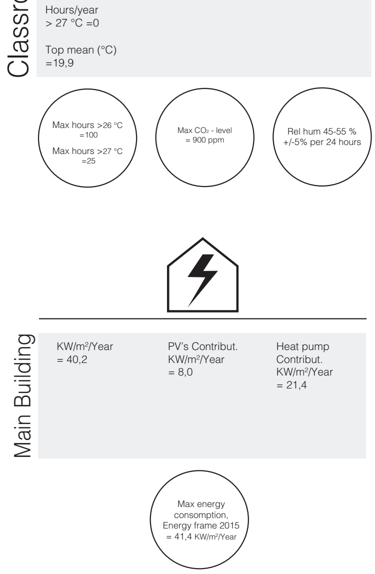


Fig. 62. Building Requirements

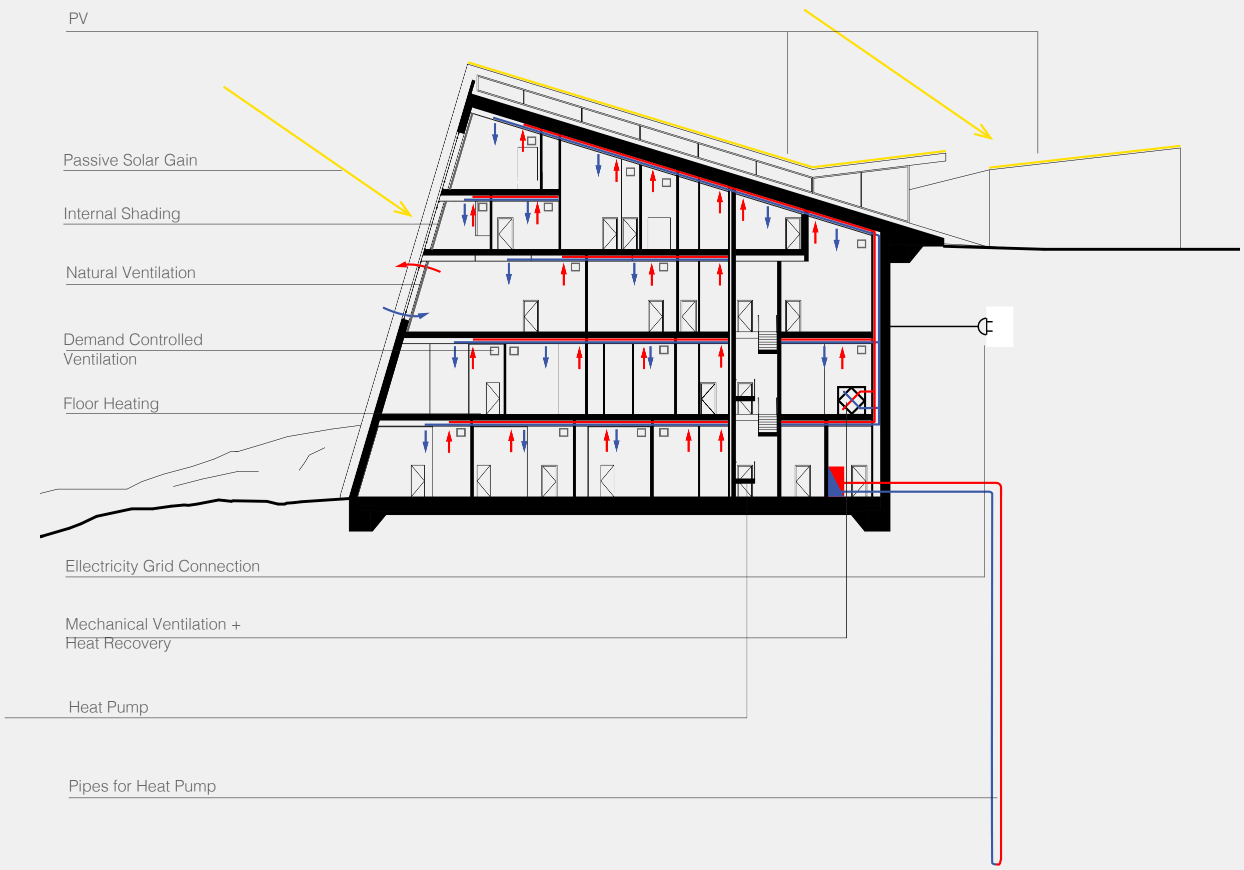


Fig. 63. Energy Strategy Diagram

Main Building	Heated Floor Area	1760 m^2
	Heated Basement	1540 m^2
	Time of Use	54h/week
	Rotation	63°

The Envelope and the Spaces Beyond

The design of the building envelope is the result of an constant debate between the architectural expression and technical considerations.

The overall expression resembles the surrounding architecture, while, at the same time, dwells upon one of the most fundamental features of energy efficient design: the compact shape.

The interior layout of the museum is expressed on the facade. Therefore, dense glazing is placed in correspondence with the active program of the Art Hub. The introverted character of the exhibition spaces is also represented on the facade, as the openings are less dense and less generous.

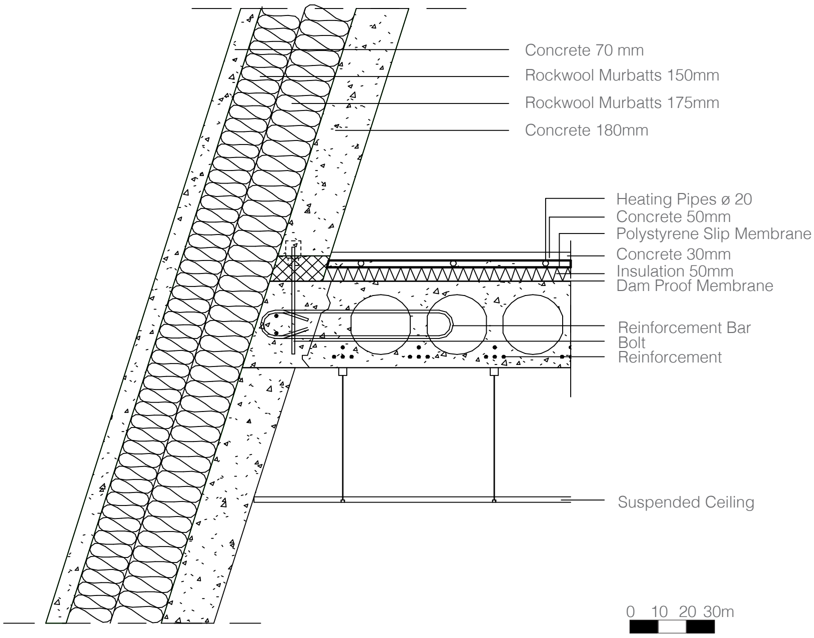


Fig. 64. Facade Detail

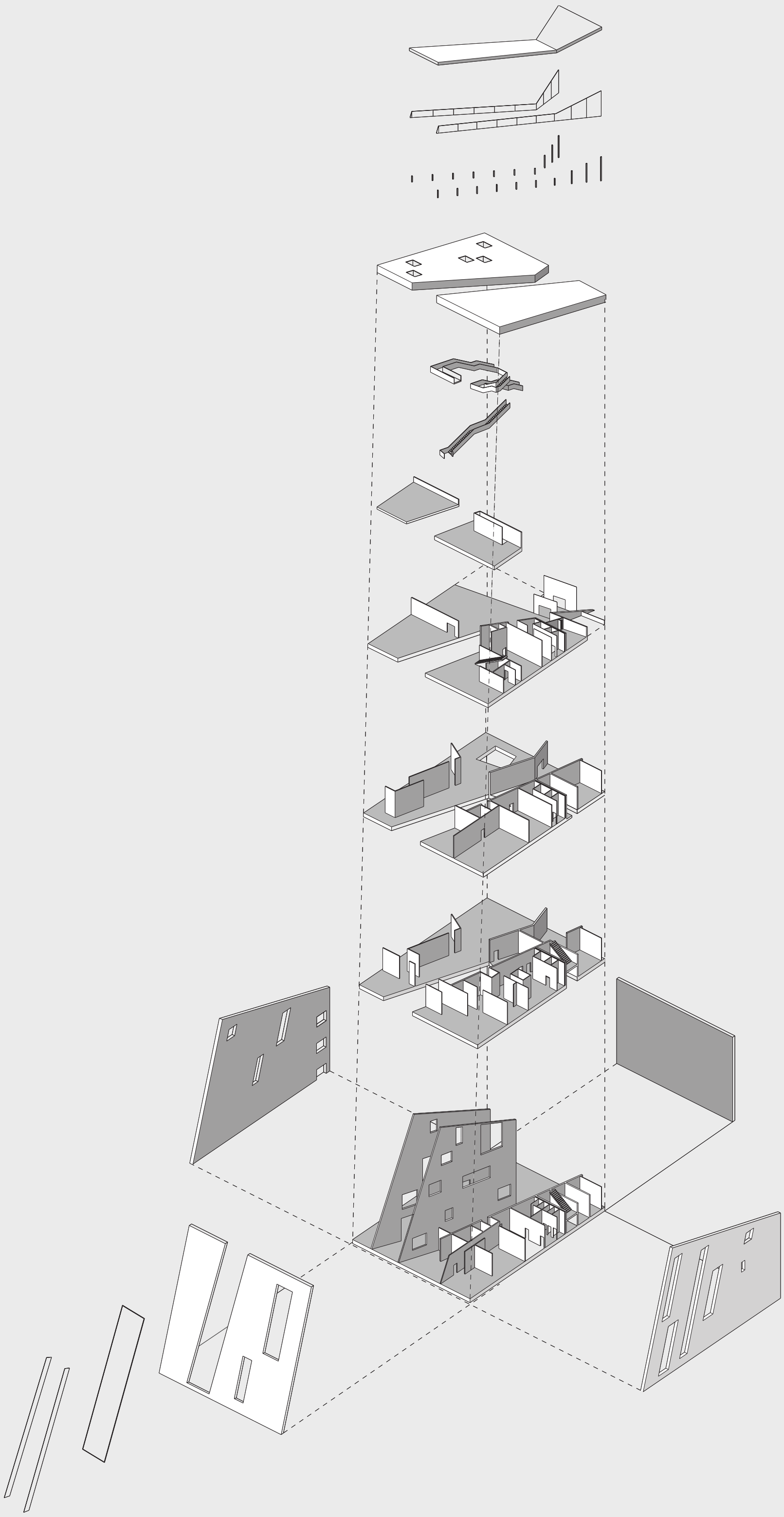


Fig. 65. The Art Hub Exploded Diagram

The Arrival

The municipal plan names Tuapannguit street as being the main approach to the site.

Amidst a picturesque landscape of rolling hills and clear waters, the proposal can be seen as an almost brutalistic intervention into the surroundings. However, the perception is softened by the decision of immersing the building into the ground and turfing the roof with grass, moss and wild flowers. Therefore, the proposal in harmoniously integrated into the natural scene. Upon arrival, the sloping rooftop engages the visitor into the narrative of the site. The path carries the viewer up toward the climax point of the story, placed at the peak-point of the rooftop terrace. From here, one can experience the site from a new perspective, being able to look back, while at the same time experience the beauty of the surrounding fjord from a floating point.

From the perspective of the street, the entrance to the Art Hub is clear. The geometry of the entrance has been angled to sustain a feeling of invitation into the interior quarters of the venue.

Fig. 66. The Arrival

Spaces for the City

The example of the rooftop public space of Moesgaard Museum, building designed by Henning Larsen Architect, has been considered when looking into the typology of the rooftop terrace. The building has become emblematic due to the powerful gesture of a colossal sloped roof structure that erupts from the ground [ArcSpace, 2015; DeZeen, 2014]. The public space place atop the roof has been highly appreciated as one of the most successful public spaces designed of 2014.

Similarly to the given example, the roof of the proposed design acts as a container for all museum functions housed underneath, while at the same time shapes an accessible public space above. The space placed on the top of the roof adapts it's function according to the time of the year. Hence, during the summer months it can be used for picnics, barbecues, lectures and other events while in the winter, the snow-covered slope will provide an ideal site for sledging, without the risk of ending up in the fjord as the slope is facing opposite the fjord.

The detail placed on the side explains the structure of the massive construction of the roof.

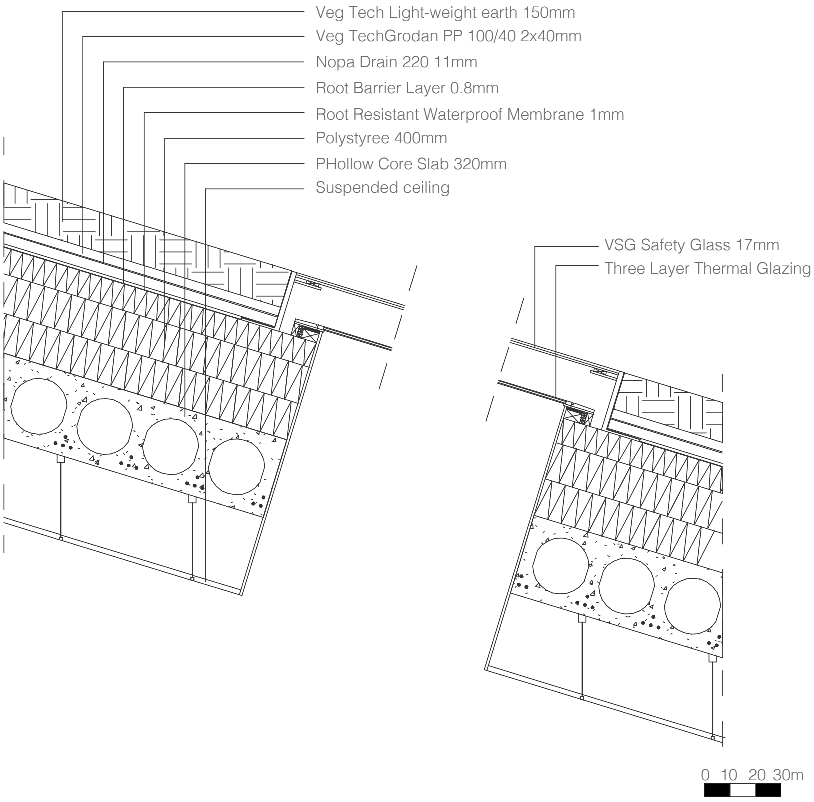


Fig. 67. Roof Detail

Fig. 68. Roof Scenarios

the images showcase the potential uses of the rooftop public spaces. therefore, it can be seen that the roof can be used not only during summer months, but can also provide the locals with a fun attraction during the snowy period.

Layout

The journey through the building is centralized in the atrium, where a dark walnut timber staircase contrasts the simplicity of the venue. Being placed in such a opportune location, on the waterfront of the fjord, emphasis has been made on framing the view of the surroundings while creating different spacial experiences within the interiors. The great variety of spaces and views caters for different social groups to engage in activities housed within the building.

Throughout the building, three different flows can be defined: the flow for the exhibition peaces, the flow for the exhibition visitor, and the flow for the local artist.

The flow of the art passes through the administrative building before ending up in the venue of the Art Hub. The flow for the artist and that of the Hub Visitor however, are intertwined throughout the entire route. The intention behind these fusion of the user paths is to unconsciously address the curiosity of the Art Hub visitor, and determine him/her to proceed deeper into the experience of the venue. Additionally, openings into the massive sheer walls of the atrium supports the previously mentioned concept.

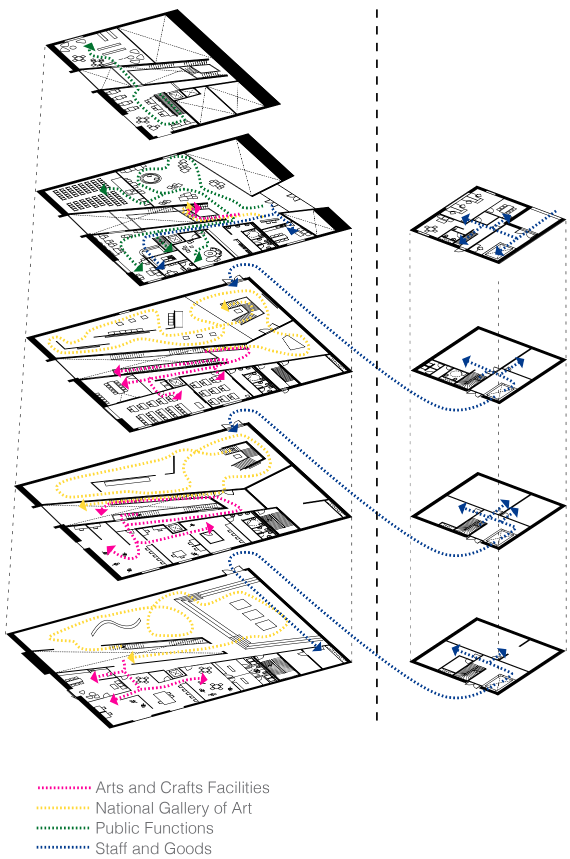


Fig. 69. Flows Within the Building

1 Foyer
2 Reception
3 Staff Room
4 Cloakroom + Toilet
5 Children's Outreach
6 Cafe
7 Facilities for Cafe Staff
8 Shop
9 Auditorium
10 Delivery
11 Reception
12 IT Room
13 Staff Toilet
14 Staff Lounge
15 Office

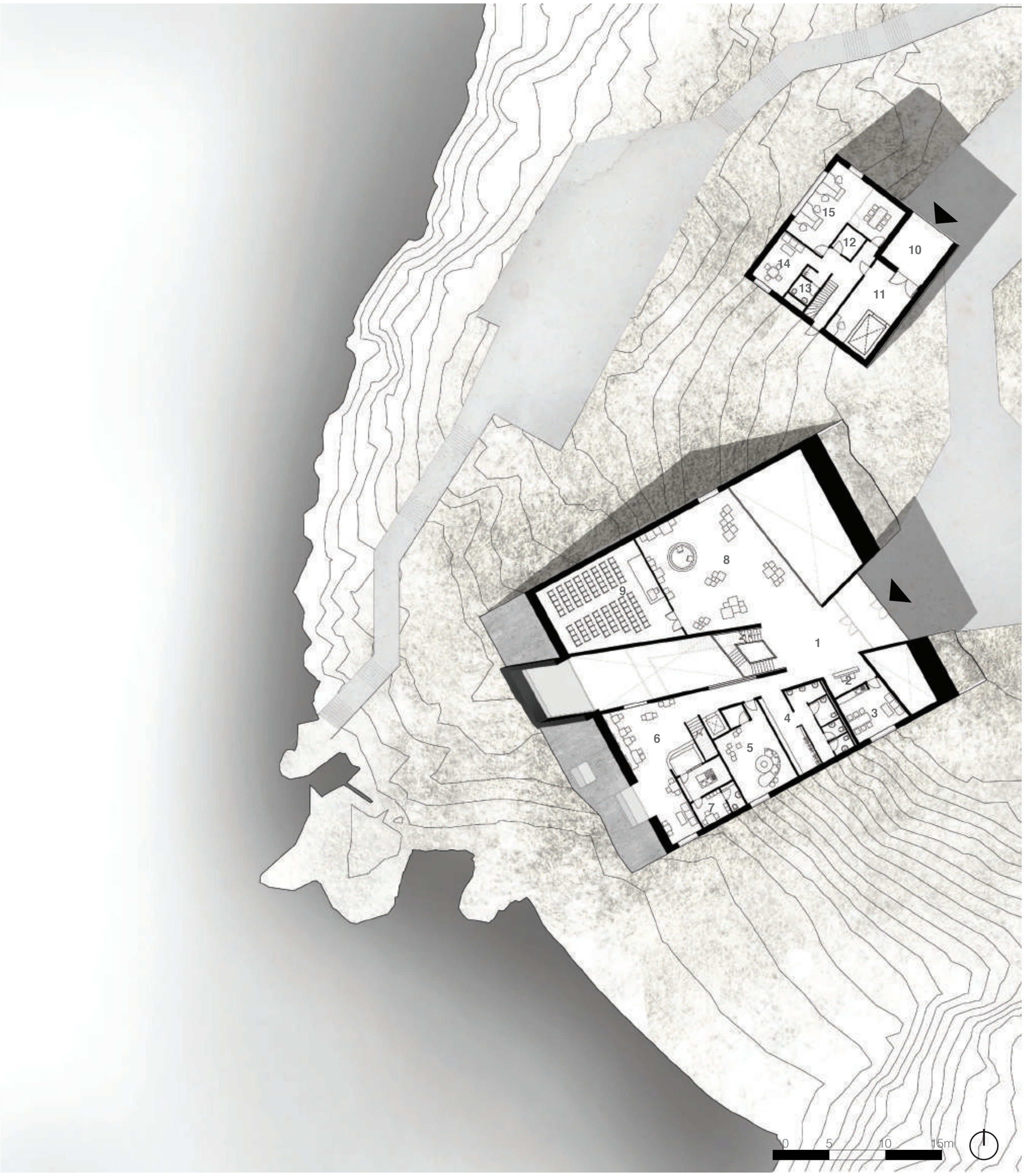


Fig. 70. Level 0

1 Cafe
2 Reading Room

Fig. 71. Level +1

1 Photo Studio
2 Fire Escape
3 Toilets
4 Classroom
5 Classroom
6 Print Room
7 Meeting Room
8 Crossway Point
9 National Gallery
10 Corridor
11 Distribution Hall
12 Archive
13 Sculpture and Paper Conservation
14 Staff Changing
15 Staff Showers

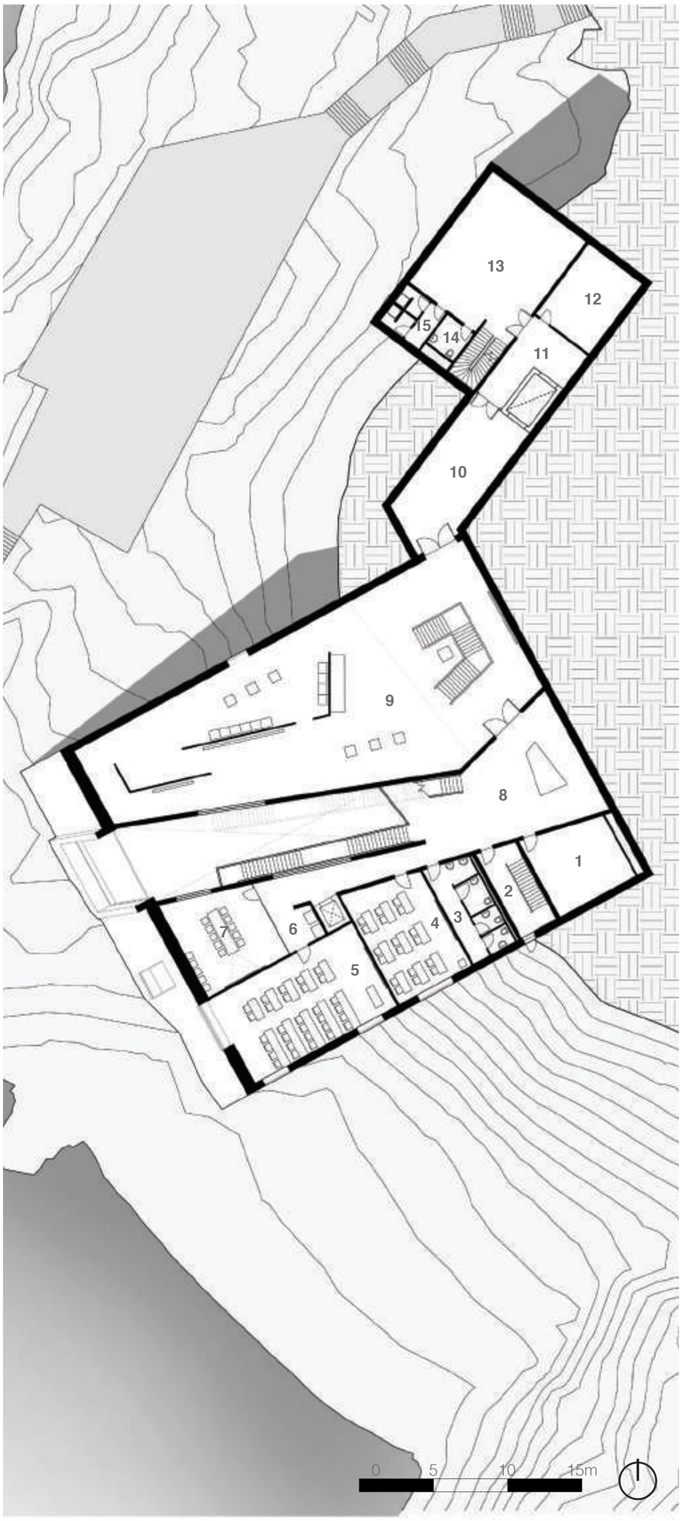


Fig. 72. Level -1

1 Plant Room
2 Fire Escape
3 Toilets
4 Common Workshop
5 Storage
6 Group Spaces
7 Individual Spaces
8 National Gallery
9 Greenlandic Mummies
10 Corridor
11 Distribution Hall
12 Storage
13 Paint Conservation
14 Other Conservation

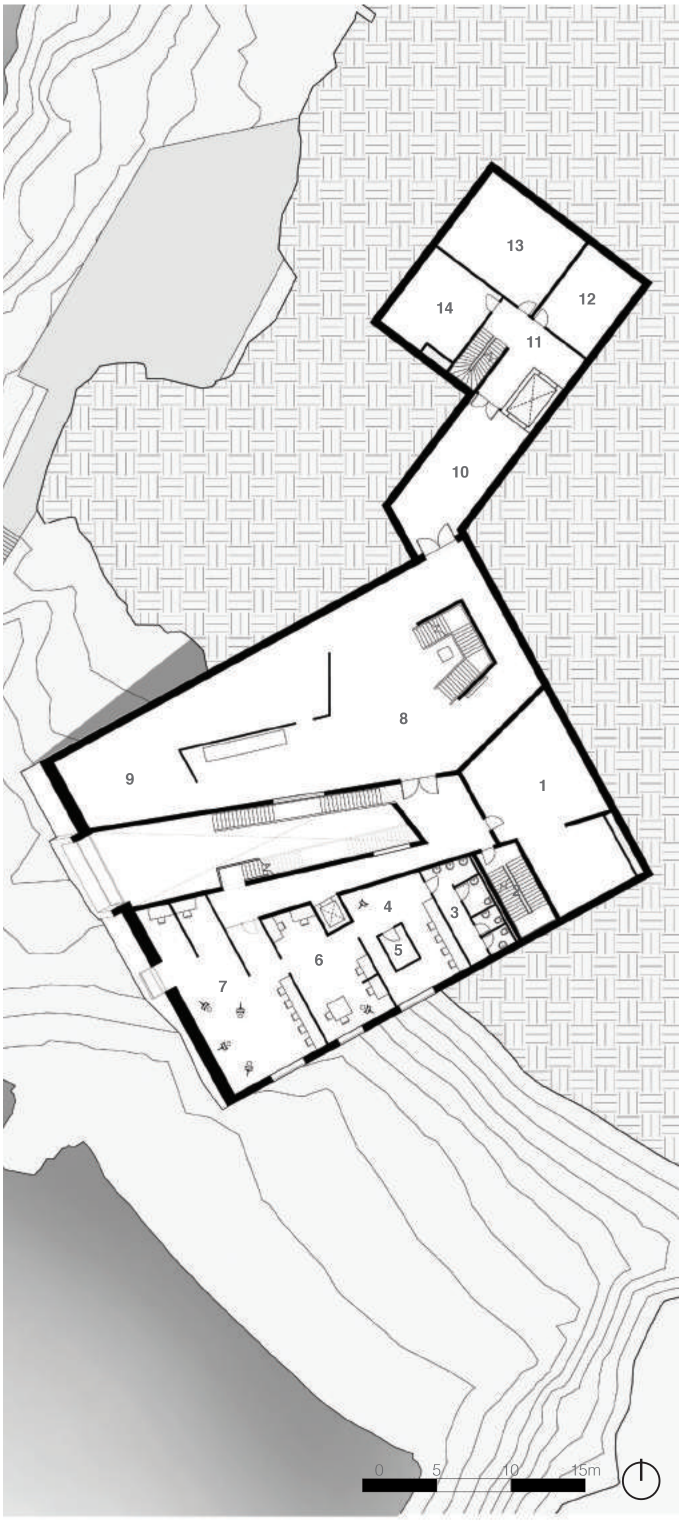


Fig. 73. Level -2

1 Plant Room for Heat Pump
2 Cleaning Storage
3 Fire Escape
4 Womens Wardrobe
5 Mens Wardrobe
6 Dark Workshop
7 Dense Workroom
8 Reflection Workshop
9 Artist's Lounge
10 Atrium
11 Special Exhibition
12 Performance Space
13 Corridor
14 Distribution Hall
15 Open Storage
16 Storage
17 Plant Room

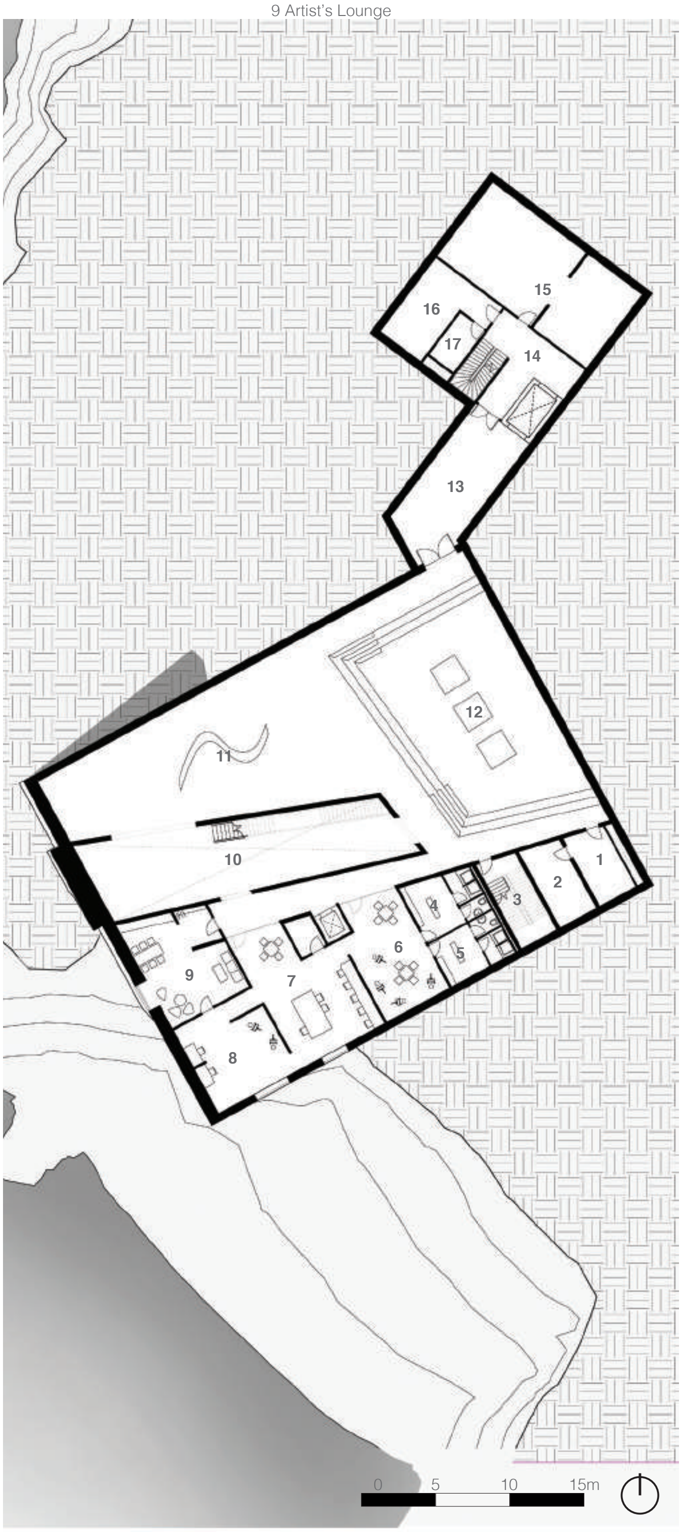


Fig. 74. Level -3

Indoor Environment

Through the atrium, the building captures a piece of the scenic landscape inside the building. This synergy between the landscape and the architecture strengthens the identity of the place and integrates it into the surroundings.

The section placed to the side shows how the roof continues the flat topography of Tuapannguit street and carries the viewer up towards the apogee of the narrative.

The cross section through the atrium explains the circulation in the core, as well as the ideology of the 'peak view' into the exhibition and workshop spaces.

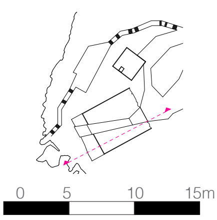


Fig. 75. Section Through Arts and Crafts Facilities

Fig. 76. Cross Section Through Atrium

Fig. 77. Section Through Administrative Building

Overall Light Strategy

Light has been an important feature in the design. The three different quarters that have been defined in the program require very different considerations in term of daylight. Therefore, the administrative and the teaching sectors are dependent on the existence of natural light, whereas in the museum this type is not recommended as it can produce damages to the exhibited artifacts.

Therefore, the Art and Crafts facilities are placed on the Southern facade, with big window openings facing SE. This ensures bright workshop spaces with a view over the fjord, encouraging activity and creativity in the rooms. When the sun is creating glare or the artists want a more diffuse light, internal thin, white curtains can be used, as heat from radiation will still enter the room. Moreover, by using this type of shading devices, a warm atmosphere can be achieved.

The exhibition rooms that form the spaces of the National Gallery are placed towards the North, with only little to no daylight, to ensure good preservation conditions for the art. Here, the diffuse light from the openings facing the atrium will give the visitors a better sense for orientation in the building, while at the same time change the atmosphere when passing through the spaces.

The big opening of atrium, facing South West, brings more light into the space. The tilting of the facade facilitates deeper infiltration of the light into the hart of the building. Moreover, light shall be brought into the atrium through the raised partition.

Nonetheless, the reading room is provided with top lights. Therefore, by making an analogy to Alvar Aalto's Vipuri Library, the light provided in the reading spaces will be controlled, while an oping on the North West elevation will provide the space with a view.

Fig. 78 illustrates the light principle formulated at the beginning of the design process. Further studies have afterwards shown that in the given climate, big openings facing Southwards are beneficial. Therefore, classroom spaces were placed atop workshops, unifying the frame of the windows are creating a single element on the facade. By doing this, the expression on the facade has been simplified, while at the same time, linear losses through the frame have been reduced.

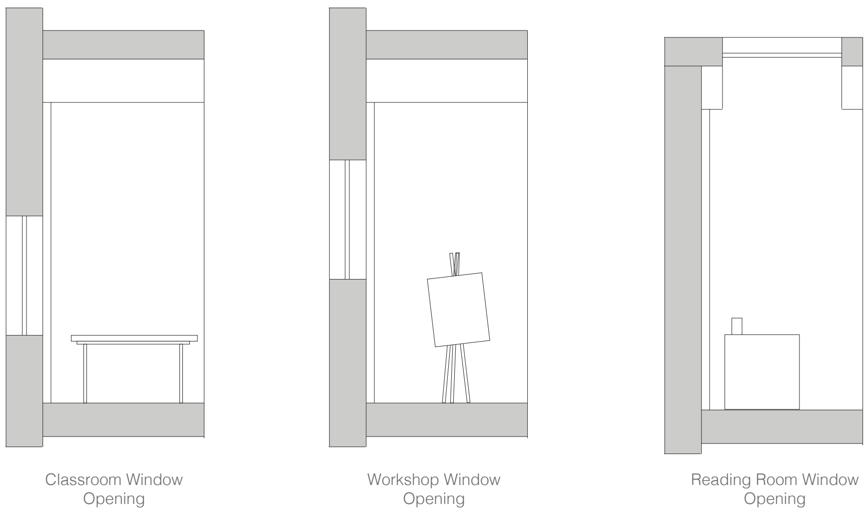


Fig. 78. Window Stratergy

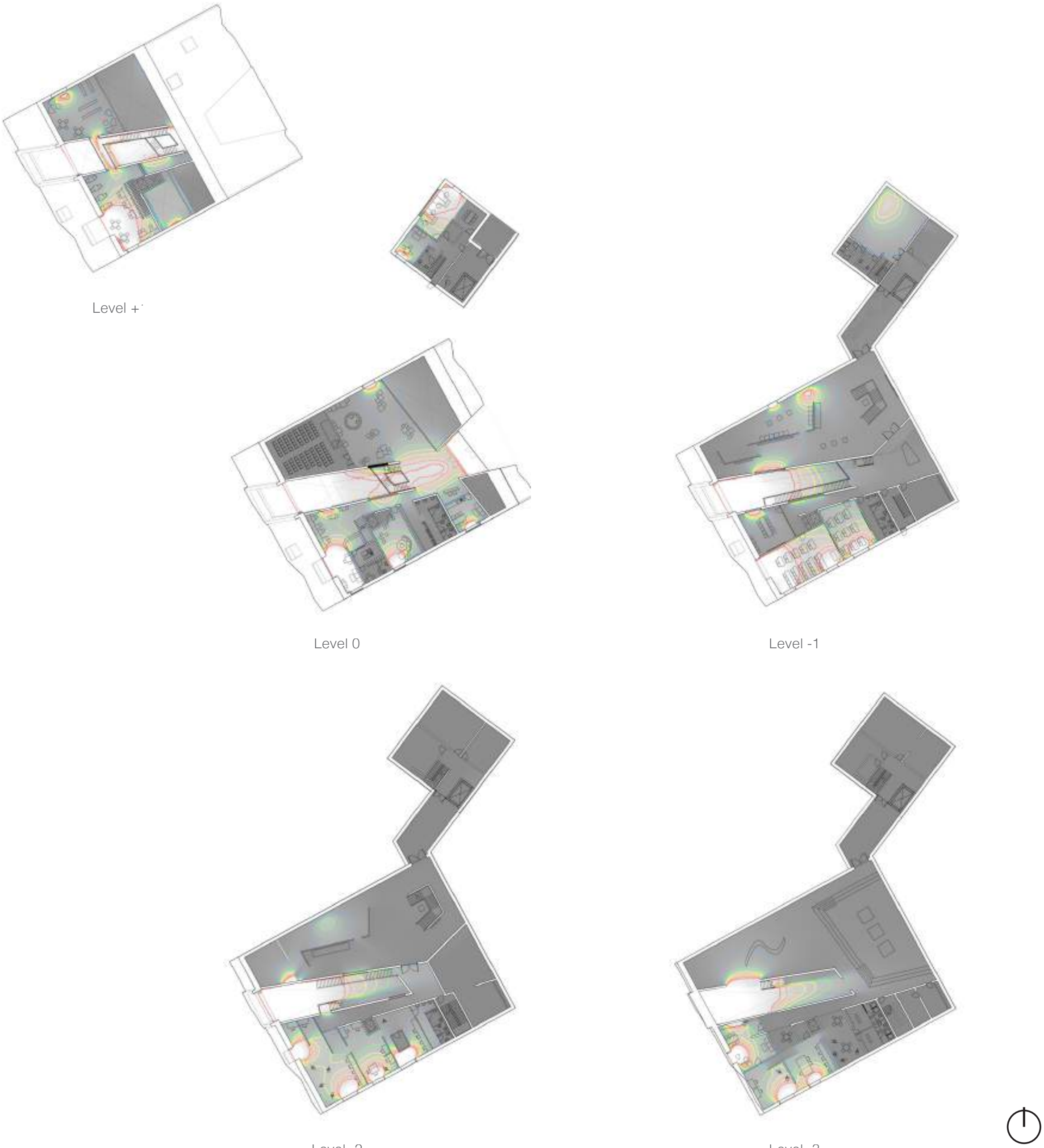


Fig. 79. Daylight Factor

DF

8
7
6
5
4
3
2
1

the study has been made in the Velux Daylight Visualizer Software. again, Reykjavik has been used as the location for the study, as Nuuk has been unavailable

Indoor Climate

The ventilation system used in the building is a variable air volume system, used in order to unable the adjustment of the ventilation rate in accordance to the variable loads in the rooms. This is supplemented by a heat recovery unit, used in order to reduce the energy consumption required for preheating the inlet air.

Mechanical ventilation is used all year rounds, as the heating season in Greenland is all year round, although few days with overheating can occur. Therefore, natural ventilation is possible a strict number of days per year, when the temperature rises above 25°C in the classroom and workshops.

The mechanical ventilation system is split in two, a part that feeds the main building, and one for the administration unit. This split has been established because of the long distance between the two buildings. It is assumes that by dividing the system into two, the energy consumption for transporting the air will be minimized my reducing the length of the pipes.

The central aggregate in the main building is placed on level -2, and from there the pipes are distributed vertically through a duct along the wall and into the suspended ceilings.

In the Administration building the central aggregate is placed on level -3. All Rooms are supplied with inlets and outlets, except for the bathrooms and the kitchen, where inly outlet ducts occur in order to keep a lower pressure and retain from spreading the polluted air into other zones.

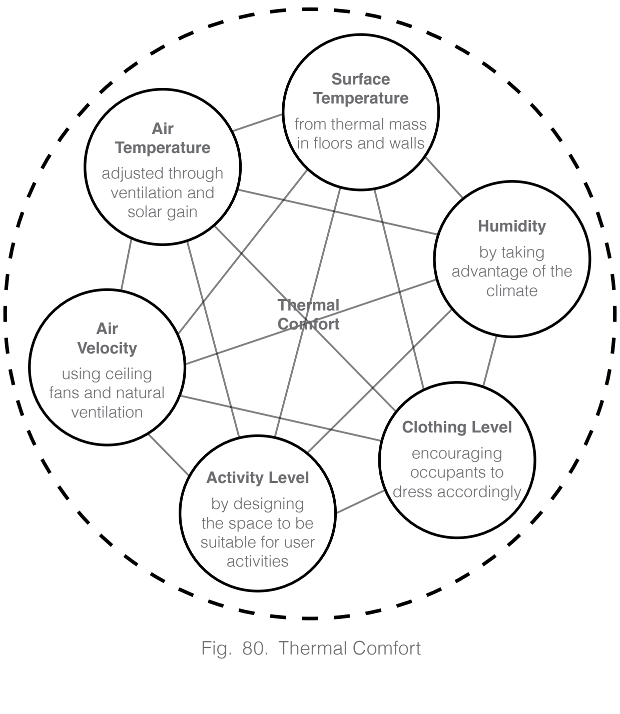


Fig. 80. Thermal Comfort

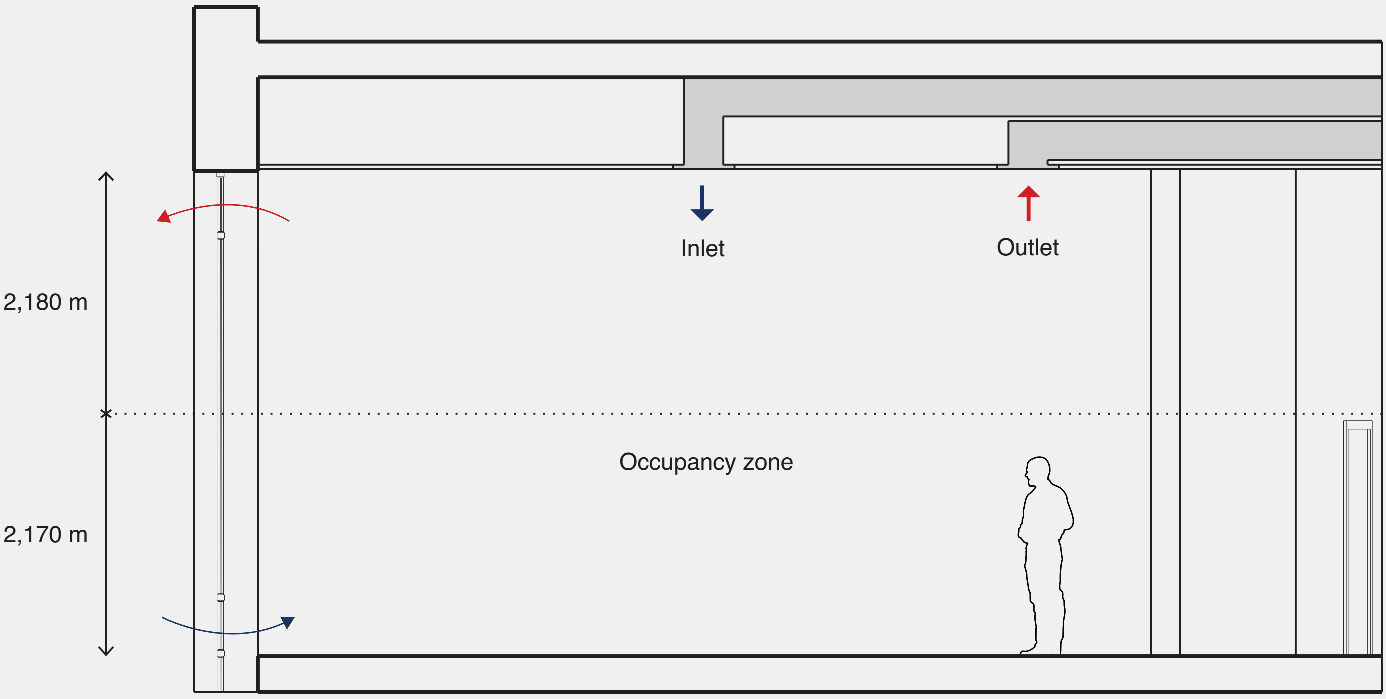


Fig. 81. Ventilation Strategy

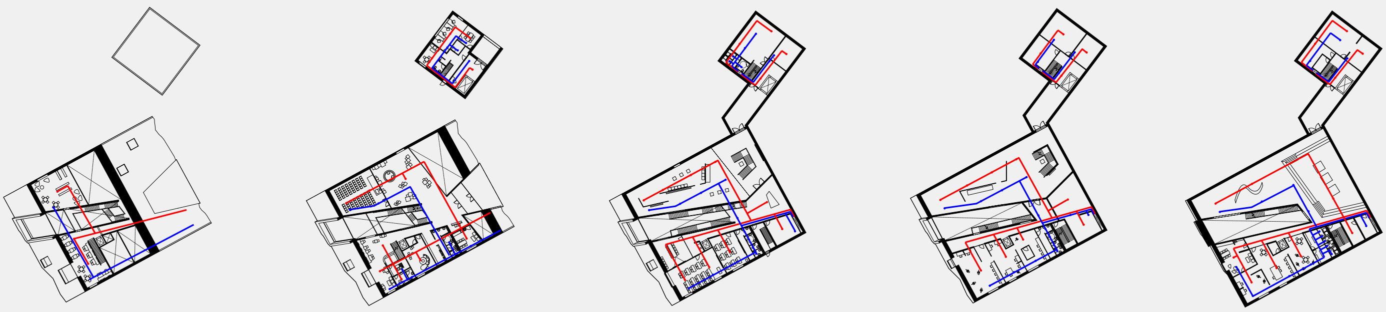


Fig. 82. Inlet and Outlet

the above placed images diagrams illustrate the ventilation strategy used in the building. the plans placed underneath showcase where the inlets and outlets are placed within the rooms

Materials

The atmosphere in the Art Hub is given not only by the geometry of the building, but also by the use of materials. Due to the lack of local resources in terms of sustainable building, we can not talk about truly sustainable materials as such. Therefore, the choice of materials was influenced by durability and aesthetic appearance.

The envelope of the building is reinforced concrete. The hue of the material contrast the colors of the surrounding landscape, therefore highlighting the presence of the building. However, the texture of the material, as well as the turfed top reintegrates the structure into the landscape. Hence, the building can be seen as an alien form to the surrounding context, that has been embraced and nurtured by its adoptive contextual surrounding.

A defined direction when designing spaces for exhibitions, is the minimalistic approach that stresses the importance of keeping the materiality of spaces simplistic so that the art is the main attraction. The proposed solution dwells on this approach in terms of materiality, however it doesn't reduce architecture as a secondary element, but uses it to frame the art. The spacial experiences created differ from where the viewer is standing within the art hub, as the same material can offer different experiences. Such an example is the use of white plaster walls. Within the exhibition spaces, the walls are being humble to the art. However, within the workshop and classroom facilities, the white walls are used for reflective purposes, therefore increasing the DF of the spaces.

Moreover, the core of the building is visually expressed through the dramatic change in materiality from cold, plain surfaces, to warm textured materials. The staircase which wraps around the atrium has is of American Black Walnut Timber, contrasting the simplicity of it's architectural context and adding warmth to the interior.

An interesting feature is the glazing used in the facade openings. The traditional window has here been replaced with 60mm thick acrylic sheets. The materials can withstand high velocity winds and the weight of the snow, feature typical for the local weather conditions. . Additionally, the material provides an extremely high degree of transparency, reducing the boundary between the inside and the outside

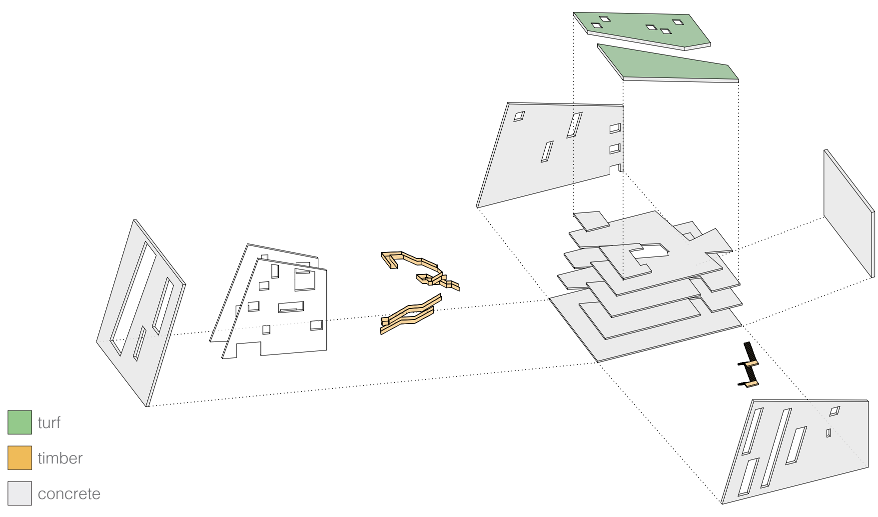


Fig. 83. Materials Diagram

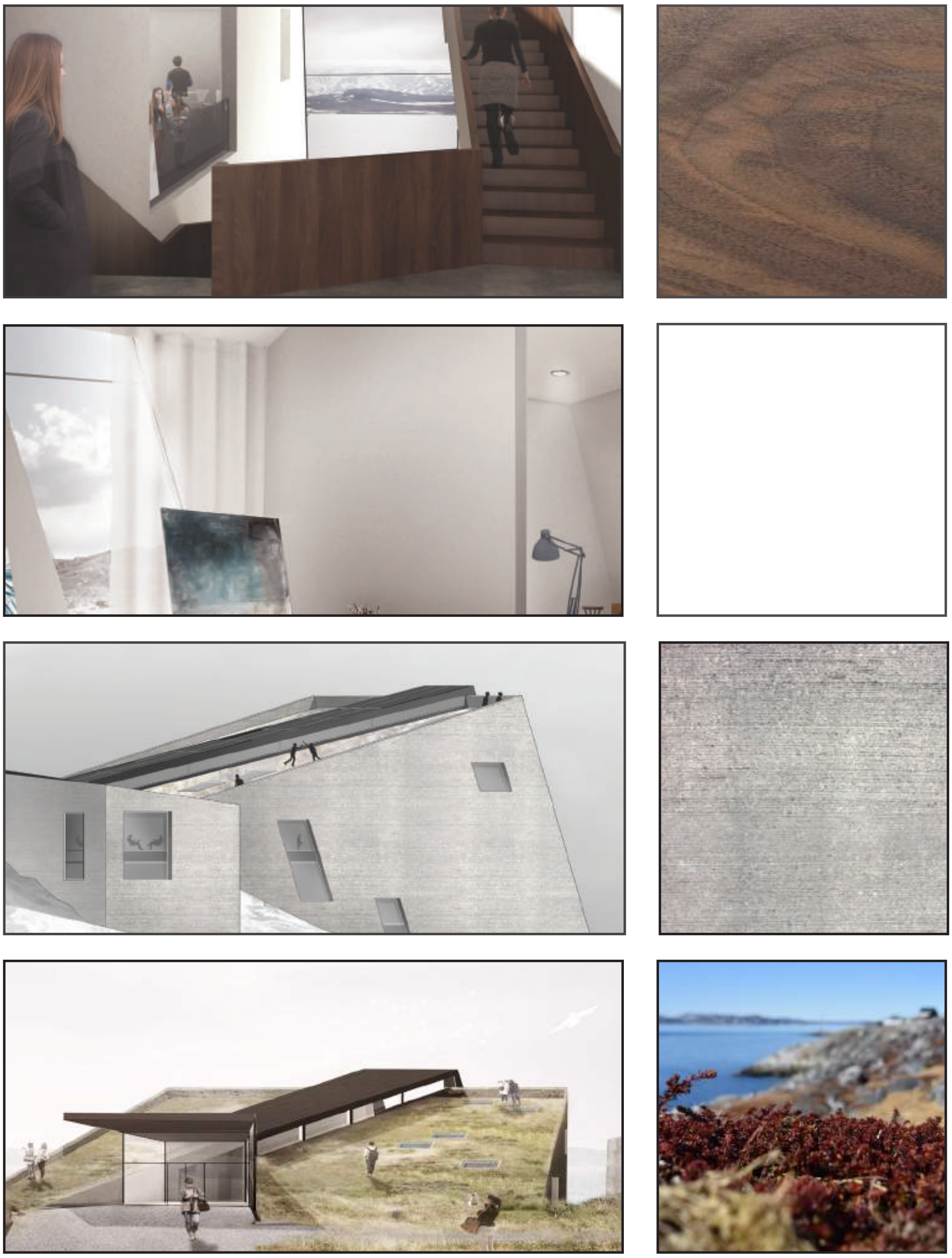


Fig. 84. Materiality

the above placed images showcase the raw material palette used in the building, as well as places the materials in context in order to reveal the sensorial perception they create

The Atrium

The atrium acts as a catalyst between the two functions housed under the roof of the main building.

Point of Departure

The Art Hub is designed for a large variety of users, having the aim of sustaining an active and informative program. The social intention is to create a synergy between these two programs through the means of artistic expression. The intention is therefore manifested through the architecture of the center. This is achieved by way of the gesture of the focal point, the nucleus, which takes the shape of the atrium.

To accommodate this, a single entrance that is shaped to direct the user onto this focal point is accessed from the ground level of Tuapannguit street.

From here, the user is presented with the choice of descending towards the National Gallery and the Arts and Crafts facilities, or remain on ground level, where public functions such as a shop, a cafe and a library have been placed.

The circulation route is perceived as a visual statement, as the Dark Walnut Stairs stand out in the plain scene of the atrium.

An important vision stated in the initial design phases, that of the narrative and the open view, is repeated in the interior of the venue. This intention is realized through the generous atrium window which offers a splendid view out onto the fjord. Therefore the apogee of the formulated narrative can be experienced both from the outside, as well as from within the Hub.

Fig. 85. The Entrance to the National Gallery

Fig. 86. The Atrium

The National Gallery

The spacial qualities of the exhibition rooms in the National Gallery replicate those of the existing Kunst Museum in Nuuk, as these feature have been rendered suitable for the art.

Spatial Considerations

A point of departure in outlining the qualities necessary for the interior environment of the National Gallery exhibition spaces has been the visit to the existing Kunst Museum in Nuuk.

Similarly to the existing framework, the spaces defined in the proposal are protected from direct daylight. However, within the proposed design the use of natural light has been placed at the top of the design parameters. Therefore, atmospheric qualities have been added to the space by making use of indirect daylight for lighting up the spaces. This is achieved by defining strategic openings in the wall facing the naturally lit atrium. Yet, a number of different peaces such as the *Greelandic Mummies* demand complete isolation from uncontrolled light. Hence, absolute dark corners, only lit by special artificial lighting, have been provided within the two levels of the National Gallery.

The exhibition spaces for the National Gallery are placed on levels -1 and -2 having controlled access. Level -3 opens up the Special Exhibition and Performance Space alcove to the entire public. Within these spaces, works of the artist laboring in the facilities provided in the Art Hub will be exhibited.

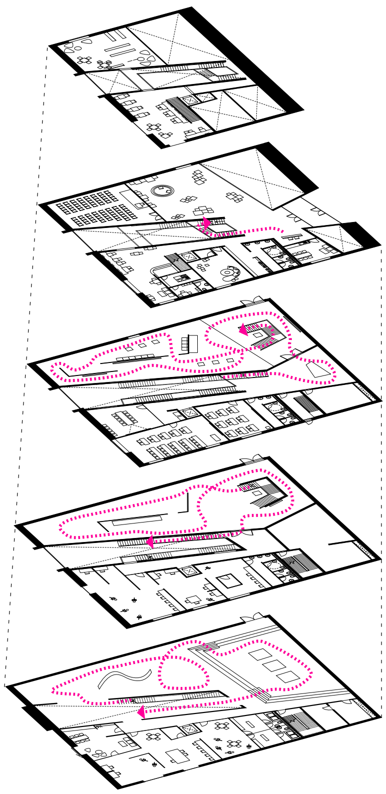


Fig. 87. Flow in National Gallery

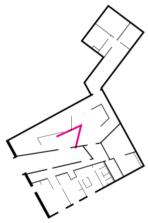


Fig. 88. The Museum

Light Concept

The experience of the exhibition spaces plays an important role in defining the design. The objective has been to utilize light in order to create different spatial experiences. Where possible natural light has been used.

As previously mentioned light in exhibition spaces is important in a museum, however the exposure to direct sunlight may cause damage to the pieces. Therefore, direct sunlight has been avoided, the only natural light entering the exhibition being through the atrium. However, level -1 of the exhibition is equipped with a strategically placed opening on the NW facade, that frames the view of the fjord and therefore promotes the landscape itself as a part of the exhibition.

Even though natural light has been used when defining the spacial divisions of the exhibitions spaces, primary attention has been given to artificial light. The artificial light is used to place the attention onto the art pieces, while the trajectory of the visitor has been dimmed down in terms of light intensity.

This approach therefore uses, where possible, natural light to set the atmosphere within the rooms while artificial light is used to emphasize attention on the exhibited pieces.

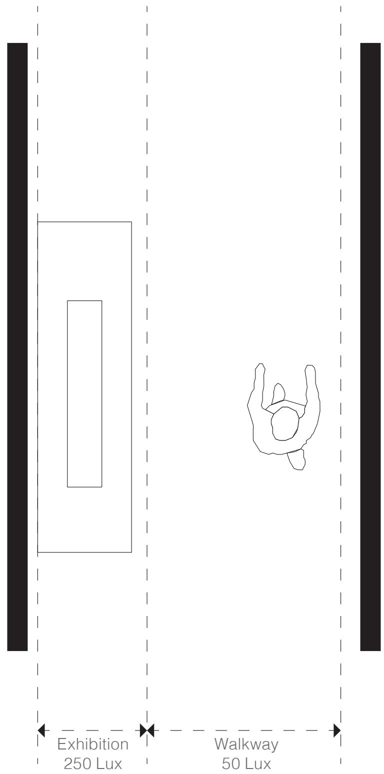


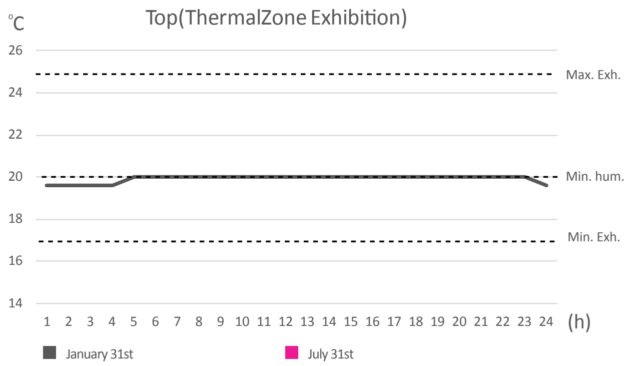
Fig. 89. Light Strategy in Museum

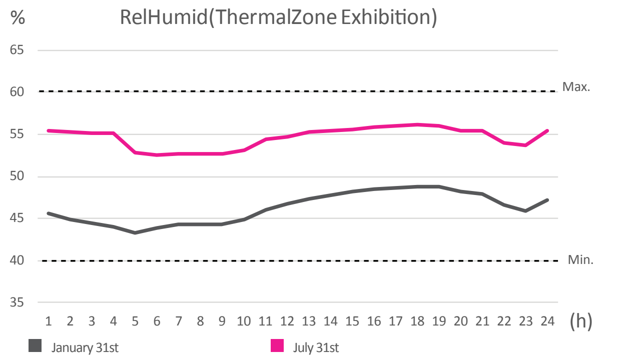
Indoor Climate

When looking at exhibition design, it is essential to sustain a good and stable indoor environment in order to protect the artifacts from deterioration.

Therefore, the ventilation in the exhibition rooms is only provided by mechanical ventilation that is supplied with heat recovery, so that a highly controlled environment can be maintained. Moreover, and a humidifier has been added. Floor heating is used throughout the entire year. This is provided with a day and night schedule in order to lower the heating demands during the night, and therefore reduce the overall energy demand. The temperature is only lowered by 0,5°C as it is directly affecting the relative humidity of the room [RH], which shouldn't be subjected to big variations in exhibition spaces. When the temperature falls RH rises as the dew point is lowered with the temperature. Hence, the humidifier is activated from October to July as the cold air does not contain enough water, after preheating the inlet air. Hence, the RH would drop below the minimum requirement of 40% RH. The RH is very close to be within the maximum allowed fluctuation of +/-5% within a 24h period, but is considered within an acceptable level.

The CO_2 level is made for a people load of 10 people during opening hours and has a maximum of 739 ppm. The calculation has been done for one level of the gallery.





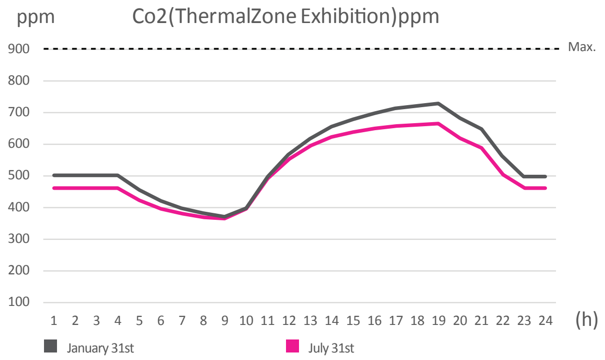


Fig. 90. Numbers for Indoor Climate in Exhibition Room, Resulted from BSim calculations

The Art and Crafts Facilities

The defined classroom and workshop spaces facilitate the development of the local artistic movement, bu providing spaces for the Greenlandic artists.

Spatial Considerations

As mentioned in the previous chapters, a strong local movement in terms of expression through art can be recognized.

Therefore, the proposed art center will provide local artists with the spaces required to produce their peaces. Moreover, the Arts and Crafts section of the building has spaces dedicated for educative purposes, so that children, and adults alike can be schooled about local traditions and beliefs.

The Arts and Crafts facilities are spread on floors -1, -2 and -3 of the Art Hub. The functionality of the spaces has been grouped into educative and lucrative sections. Hence, the educative quarters, with classrooms and meeting rooms are placed on floor -1, the first level of the processional route through the building. As the spaces are meant to service a great variety of people, they have been places closer to the entrance. The workshop spaces however, designated for the local artists, require a deeper understanding of the artistic scene, and are therefore metaphorically placed deeper within the building.

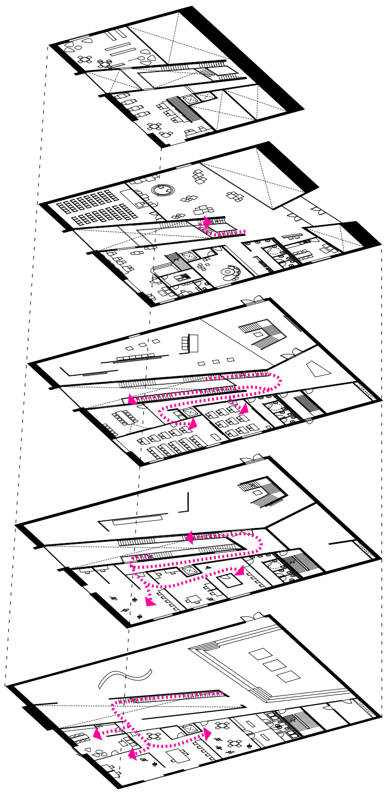


Fig. 91. Flow in Arts and Crafts Section

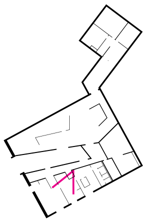


Fig. 92. The Art Hub

Light Strategy

The use of natural daylight within the spaces of the Arts and Crafts facilities has been the main factor in defining the layout and orientation of the spaces.

The openings towards the SouthEast offer exposure to natural light during the hours that the facilities will be in use. Moreover, setting a good working environment is not only achieved at a sensorial level, but as well at a mental one. It is a known fact that daylight and the sun have positive influences of productivity levels. Therefore, by framing a view to the natural landscape, the users of the space can be unconsciously encouraged to be more creative.

As an interior finish, white coating has been applied to the walls in order to reflect the light and therefore increase the light conditions of the room [Bejder, 2015].

However, depending of the nature of the work and on the time of day, shading needs to be provided. The geometry of the windows offer the possibility of shading the spaces beyond in a unique way, as illustrated in Fig. 93.

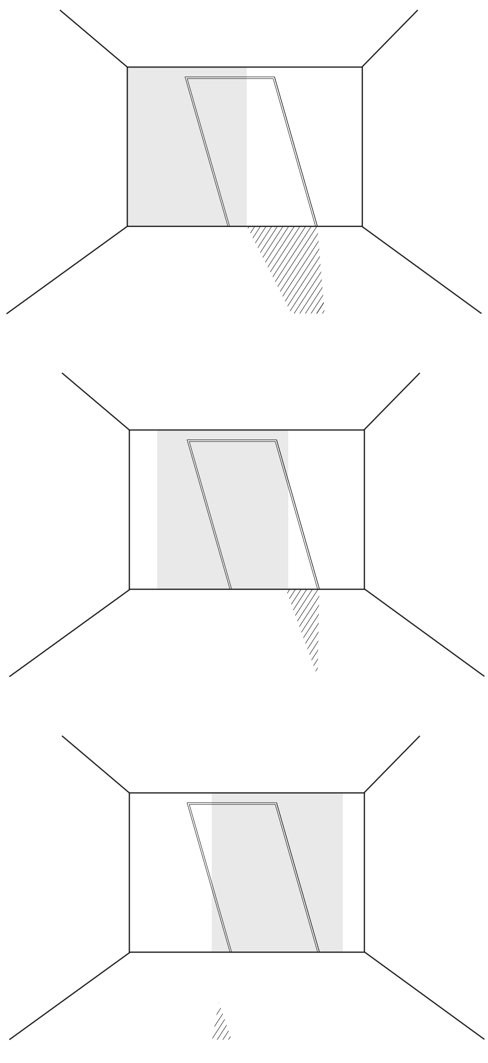


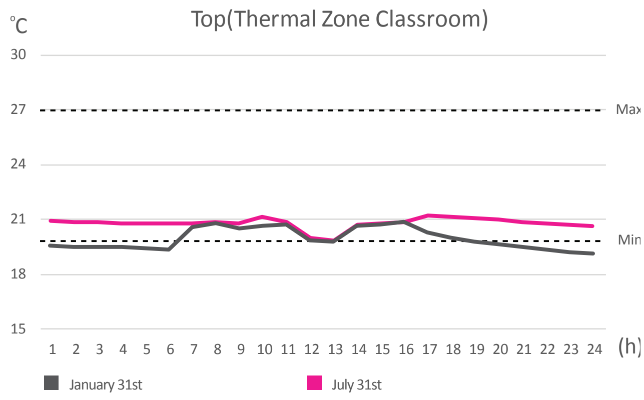
Fig. 93. Shading Options for Workshop Space

Indoor Climate

In order to achieve a good working environment, great consideration has to be given to the air quality of the space. Therefore, in the classrooms, the mechanical ventilation starts during the day when the facilities are in use. The calculation evaluated in the diagrams consider the 'worst case', which is considered to be 25 people occupying the space between 8-12 am and 13-16 pm. When the classroom is used each day, the heating will only be needed during the night from November until January, as the internal heat gains from people and passive solar radiation through the South oriented windows will suffice.

However, a notable event is that the temperature drops in the middle of the day, when people are not in the room. This is due to the ventilation strategy, that only regulates for the temperature, unless the CO_2 is above the allowed amount of 900 ppm, which would be then the defining factor for the regulation system.

Although there is no overheating according to BSim, the Be10 results and our study trip to Nuuk have shown that overheating in the summer can occur. Therefore, at a theoretical level, the mechanical ventilation will stop, being replaced with natural ventilation when the temperatures in the classroom reach 25°C.



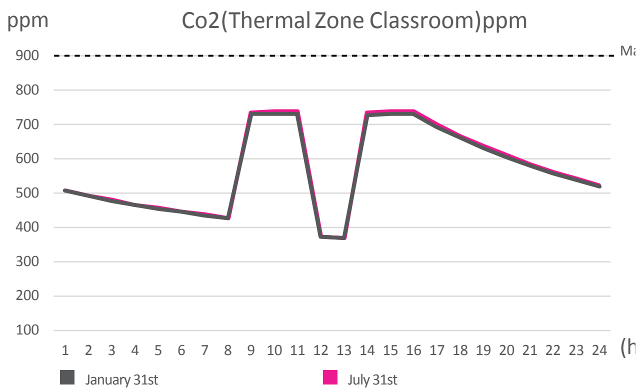


Fig. 94. Numbers for Indoor Environment in Classrooms, resulted from BSim Calculations

Fig. 95. The Traditional and the Modern

PROCESS

Fig. 96. View of the site

Design Development

In the Process Chapter, the iterations that lead to defining the final design are presented. Therefore, the chapter is divided into three sections following the overall design process. The sections are:

Contextual Approach

Ideation

Materialization

Contextual Approach

Although having the intention of creating a local landmark, it has been essential to integrate the proposal into the existing social, architectural and natural context.

The Architecture

In the previous chapters, the idea of unsympathetic modern architecture has been underlined. Not only have some of the modern architecture of the city been rendered as 'monumentally ugly' [Cornwallis, G., Swaney, D., 2001], but also lacking any consideration to the social and environmental context in which they were placed [Sejersen, 2015; Barfoed, 2016].

However, more succesfull examples can be seen. Such examples are the Katuaq Culture Centre designed by Schidt Hammer Lassen, as well as the local Swimming Pool by KHR Arkitekter and Tegnestuen Nuuk.

In order to propose a design that is, at the same time, emblematic for the city and integrated into the existing context, a mood-board showcasing different architectural principles has been set up.

While looking at the existing commercial architecture of the city, it is easy to observe the collective desire of fitting into the modern world. Regardless of the harsh climatic conditions of the Arctic region, modern glazed architecture can be seen erecting from the stony grounds.

Moreover, the simplistic lines defined in the Sweedish log house which is replicated thoroughly within Nuuk, have been replaced by organic shapes.

However, when moving away from the center of the city, one finds himself facing simplistic block-like colorful dwellings. The typology is not only typical of single family housing, but also of residential blocks, as seen in the moodboard placed aside.

1. Residential Blocks
2.Residential Housing
3. University of Nuuk
4. Residential Blocks
5. Residential Housing
6. Katuak Culture Centre
7. Swimming Pool
8. Single Family Housing

Fig. 97. Moodboard of Local Architecture

the above placed photograph showcase some of the existing architecture of Nuuk

Ideation

This section presents a number of primary studies made at the beginning of the process in order to inform the design.

Experiences Within the Building

As formulated in *Design Parameters*, at an experiential level the Art Hub shall house three different functions: the informative [National Gallery] the lucrative [the Workshops], and the educative [Classrooms].

While Classroom and Workshops spaces follow a similar organizational typology, exhibition spaces need to be assessed separately.

The experience of an exhibition space is not only given by the division of a space [as seen in Fig.98], but also by the circulation within [Fig. 97]. Analyzing the typology of these flows, a conclusion has been formulated. In this sense, the layout of the exhibition will introduce a single flow trajectory, the user of the space being able to walk in one way, and out another.

When analyzing the typology of work stations and teaching spaces, a notable direction is the attention given to providing different instances for each of these activities. Therefore, favorable teaching and working spaces give the user the opportunity to choose between spaces characterized by different densities and different levels of privacy.

The observations made within this topic will be dwelled upon when defining the design of the proposal. As an integrated design approach is sustained throughout the entire process, the defined principles have been subjected to an iterative process that rendered the maximal potential of their integration into the design.

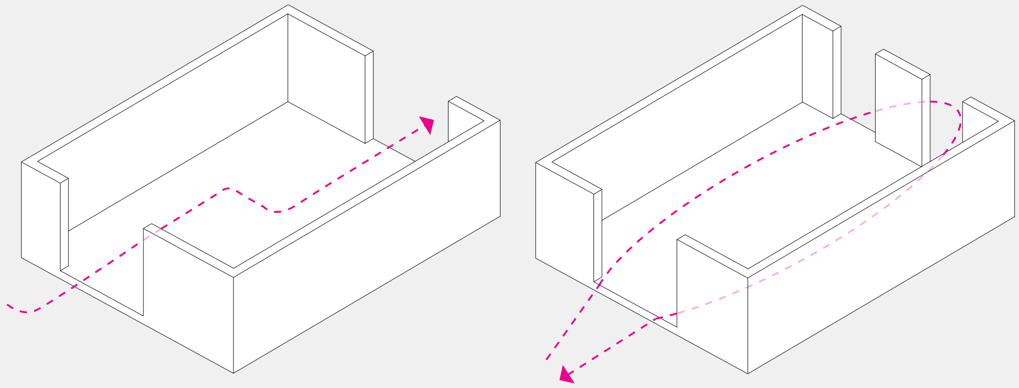


Fig. 98. Single and Double Flow in Exhibition

exhibition spaces can be characterized by two different circulation types. single flow in which the viewer passes through each space once, or double flow, in which the viewer uses the same route to return

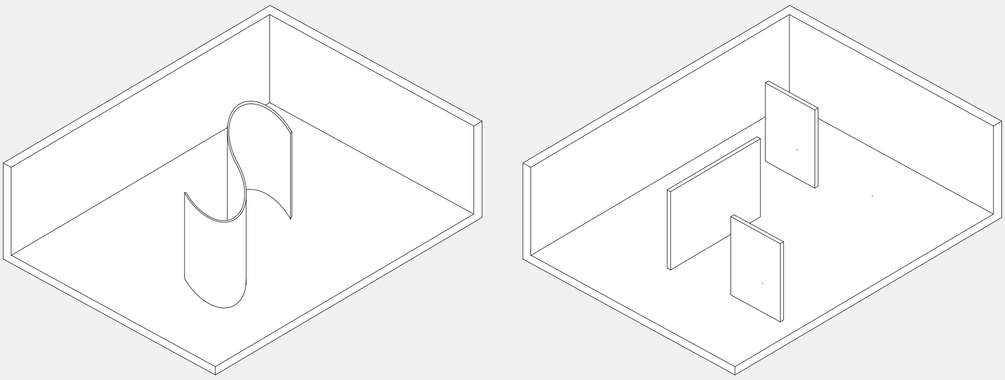


Fig. 99. Adaptable spaces

the exhibition spaces as well as the workshops should be adaptable in order to accommodate a multitude of activity typologies

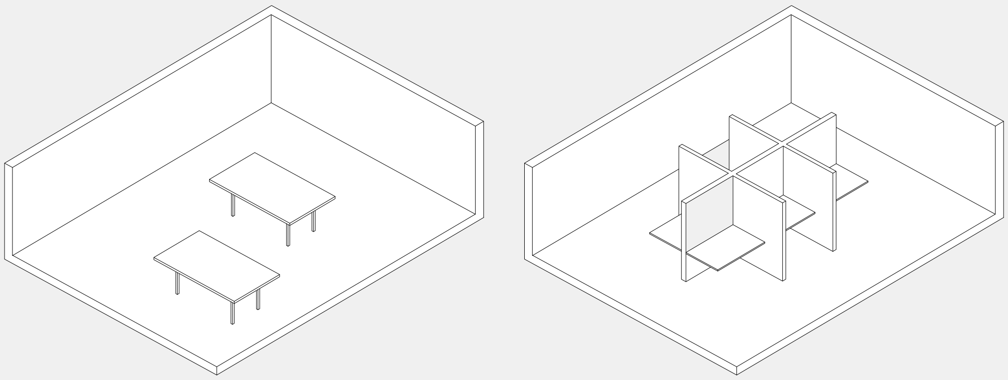


Fig. 100. Individual and Group Work Stations

classrooms and workshops should provide both individual study and work places, as well as facilitate group interaction

Orientation

The initial studies in BSim were made to get a better understanding of the climate conditions in Nuuk. For this purpose there has been made calculations in BSim on a simple room of 100 m^2 with walls facing the same thermal zone and one facade with a big window, providing a daylight factor of 5%.

The orientation North, South, West and East has been tested to see how the different orientations influence the thermal conditions of the room. With a people load of 60 people and artificial light, the conducted calculations have shown that there will not be a problem concerning overheating regardless the orientation of the building. However, the data may not probably be entirely accurate, as it has been shown that excessive heating can indeed occur, according to Be10 calculations.

The information has still been one of the defining factors in determining the orientation of the building on site. Due to assumed minor overheating concerns big windows can be considered towards the South East and West.

Therefore, spaces demanding natural daylight will be placed according to the parameter mentioned above. However, this technical parameter intertwines harmoniously with the architectural intention of framing the view. From the perspective of the site, the view of the fjord is facing the Southern border. Hence, the criterion of placing generous openings of the Southwards oriented facade informs not only the architectural intention, but also the effectiveness of conscious planning.

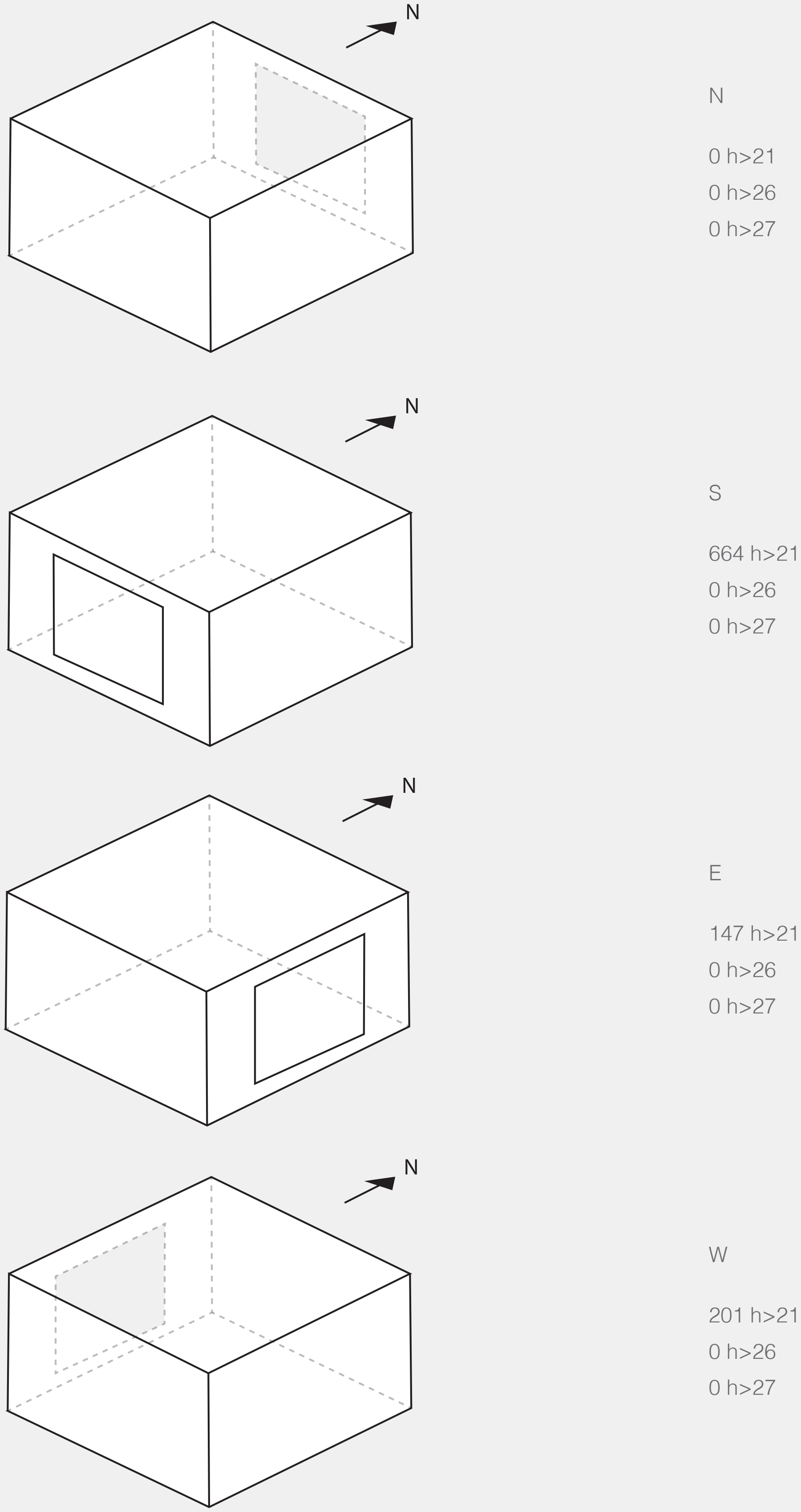


Fig. 101. Overheating Study in BSim

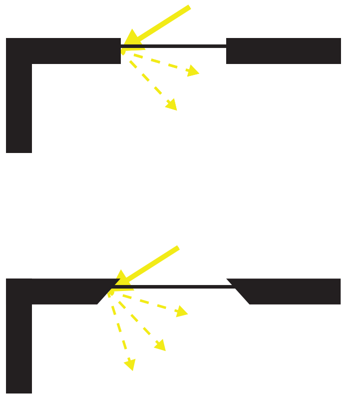


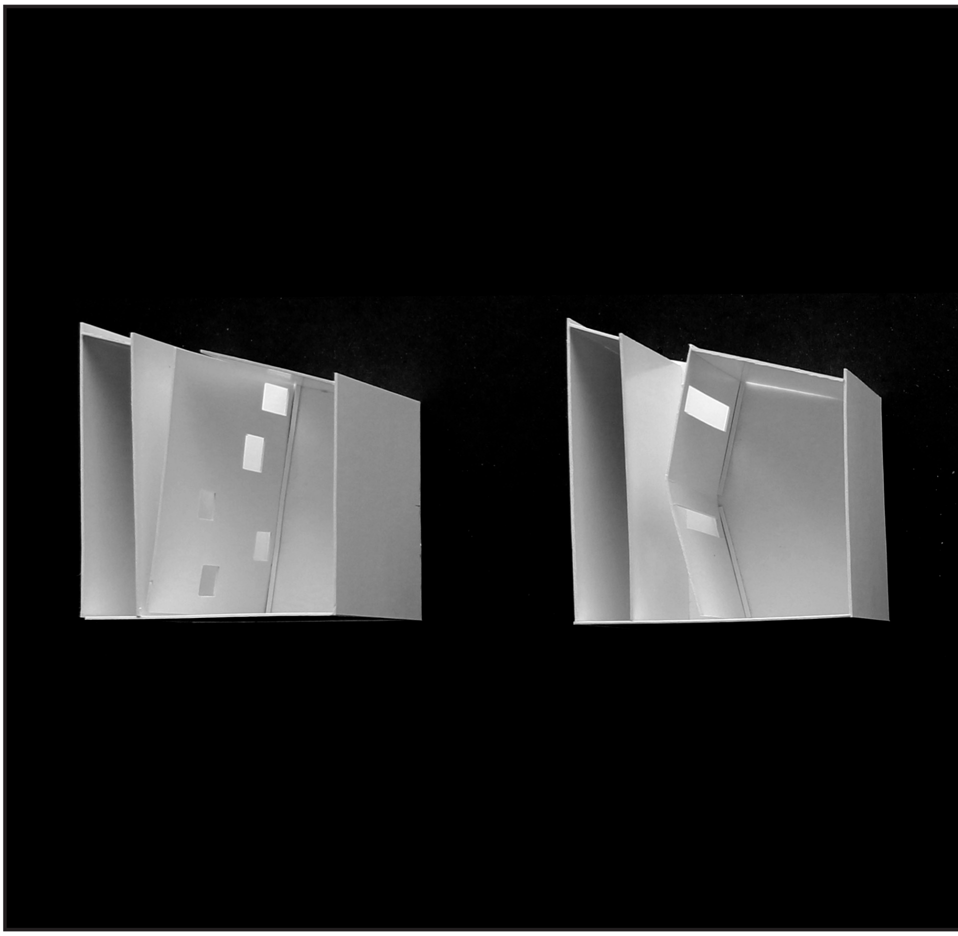
Fig. 102. Detailing the Windows [Bejder, 2015]

The Atrium

After formulating the concept of the central core for circulation and capture of light, model studies have been made in order to assess the potential of different geometrical compositions as seen in Fig.102.

The resolution of this study has been that in order to utilize the use of indirect natural light through reflectance on the atrium walls, the walls need to be directed outwards towards the facade. This is a result of the low sun angle typical for the Arctic climate.

Nonetheless, efficient lighting design is also given by small details such as the window frame as seen in the diagram placed aside [Bejder, 2015].



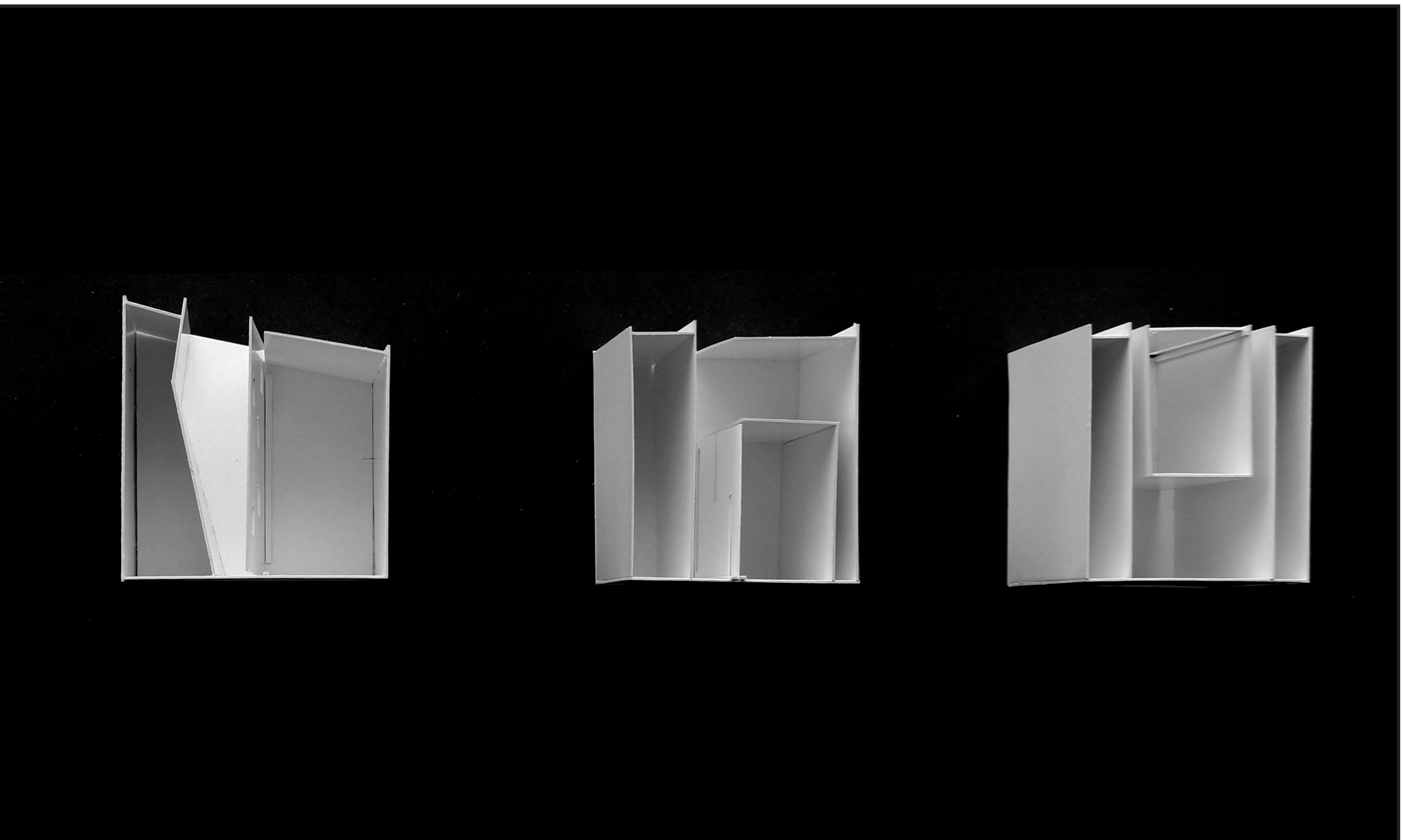
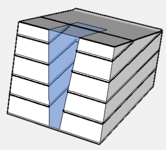
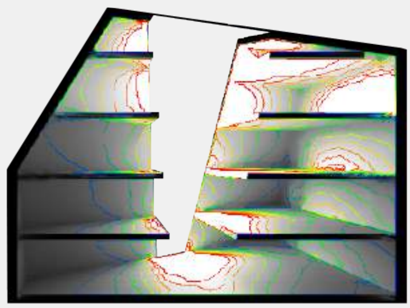


Fig. 103. Atrium Geometry Study

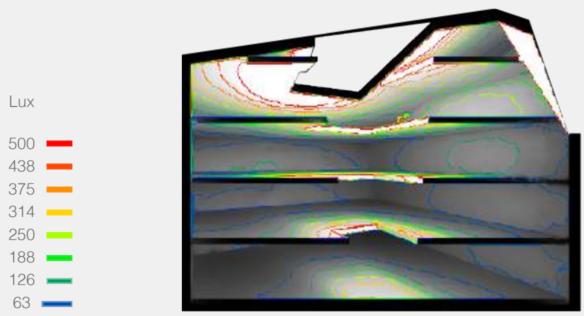
Daylight Study in Atrium



Dwelling upon an integrated approach that considers both the aesthetic qualities of the atrium opening, as well as the energy and indoor climate implications of the geometry, a series of iterations have been tested at a more detailed level. Previously, the atmonpheric qualities of different geometries have been analyzed. This Daylight Study within the atrium shows the difference in Dayligh Factor according to variations in the geometry of the openings on the facade, in an intermediately overcast environment. The type of environment has been chosen due to the climatic conditions of Nuuk, which are described by fast changing weather, but predominantly clear skies.



Moreover, the study has been conducted in Velux Daylight Vizualiser, with the location beeing set to Reykjavik, Iceland, as Nuuk has been unavailable. The daylight conditions in Rejkiavik are similar to those in the Greenlandic capital, however, Nuuk has slighlty clearer skies. Therefore, we can assume that the obtained results can be increased in order to assess the realistic numbers for Nuuk.



The objective of the study was to assess which geometry offers the interior of the atrium the biggest daylight factor. The informations will be afterwards overlapped atop the atmospheric study.

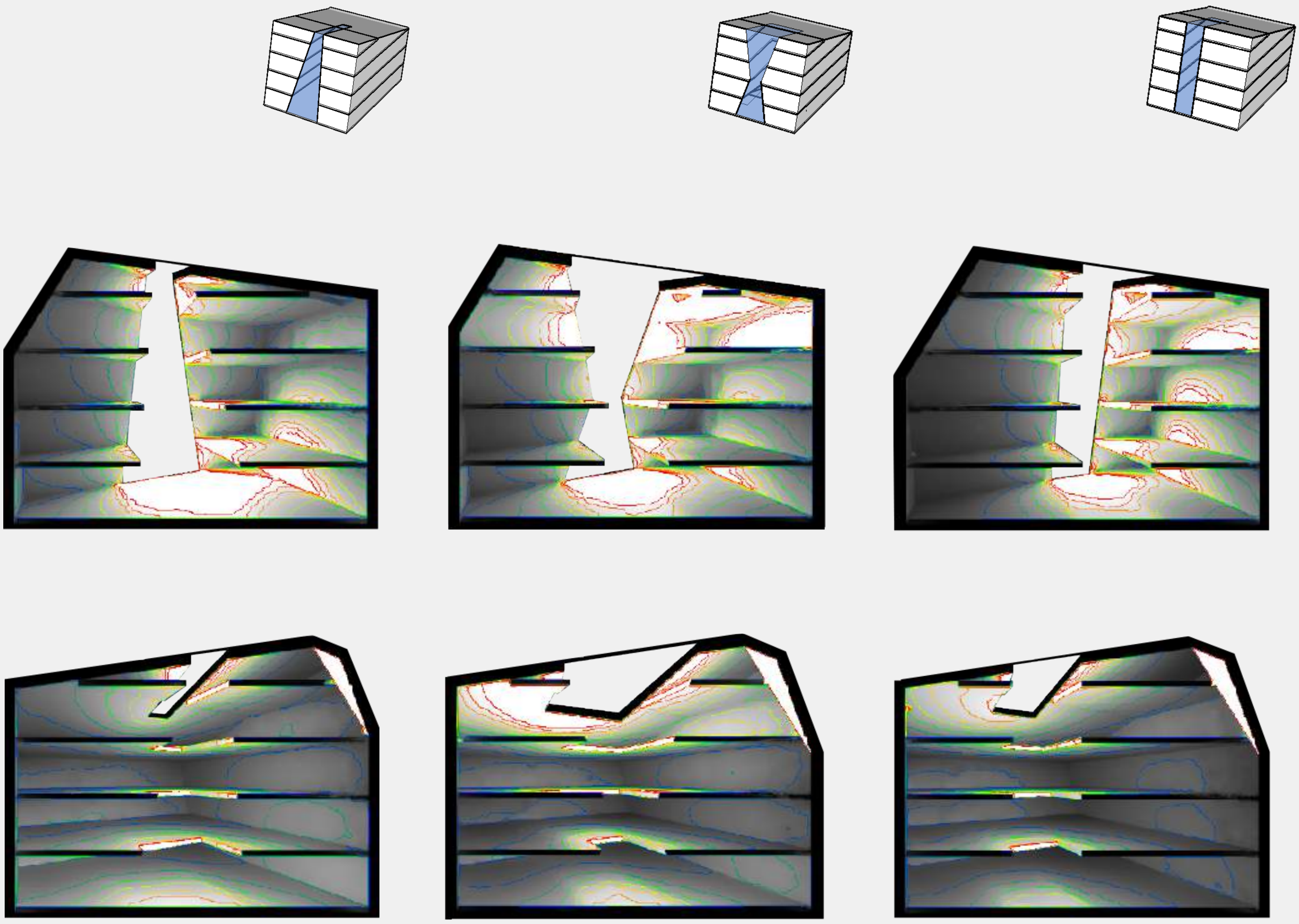


Fig. 104. Atrium Daylight Factor Study [Velux Daylight Visualizer]

Window Openings

When looking at the window openings, initial studies have been made on how the size of the window openings will affect the energy requirements for heating.

The calculation has been done on a room with a big and a small window providing a daylight factor of 2% and 5%. This room has first been oriented South and North. When looking at the results, it is seen that by having big windows towards the south, passive solar radiation can be utilized in order to lower the energy consumption for heating.

The results when having a window opening towards North have shown, as expected, that due to the lack of solar radiation on the façade, the openings have to be reduced in order to minimize energy loss through the windows. By placing the exhibition spaces, which only require little to none daylight, towards the North, and inversely the workshop spaces, that additionally can allow for bigger fluctuations in temperatures, towards the South, the overall energy requirement for heating the building will be reduced.

The topography of the site facilitates the immersing of the Eastern façade into the ground, consequently having the biggest façade towards the West. By knowing how the climate has an influence on the building, it is best to rotate the biggest façade more towards the South in order to utilize passive solar gain.

Therefore a new series of calculation have been conducted, with a orientation closer to the final proposal. The new orientation is tested in Bsim with window openings on the South Eastern façade and the South western façade (see graph).

When utilizing the passive solar radiation in the rooms, shading is not beneficial in the given climate. This can cause problems due to the low angle of the sun and can cause problematic glare. Hence, internal shading in form of light thin curtains has been introduced. These will let the solar radiation into the room and reduce the need for energy consumption through heating, but shade from the direct sun.

Fig. 105. BSim Study of Window Openings

Thermal Capacity

The same model used for the study of the orientation of the building, has been tested according to thermal mass.

This results show that the temperature in one of the hottest days [the 31st of July], will vary from 19ºC to 24ºC, when considering a light construction inside. When replacing the light construction with a heavier one, the fluctuations in the operative temperature are lowered from 20ºC to 22ºC over the same day.

When looking at the energy consumption for the light construction, the room will consume 7800 kwh more per year compared with the construction with a greater thermal mass. Although this is not much of a saving, it still means that greater thermal mass will be the best solution in order to have a steady indoor climate for the exhibition spaces, and at the same time provide better thermal comfort.

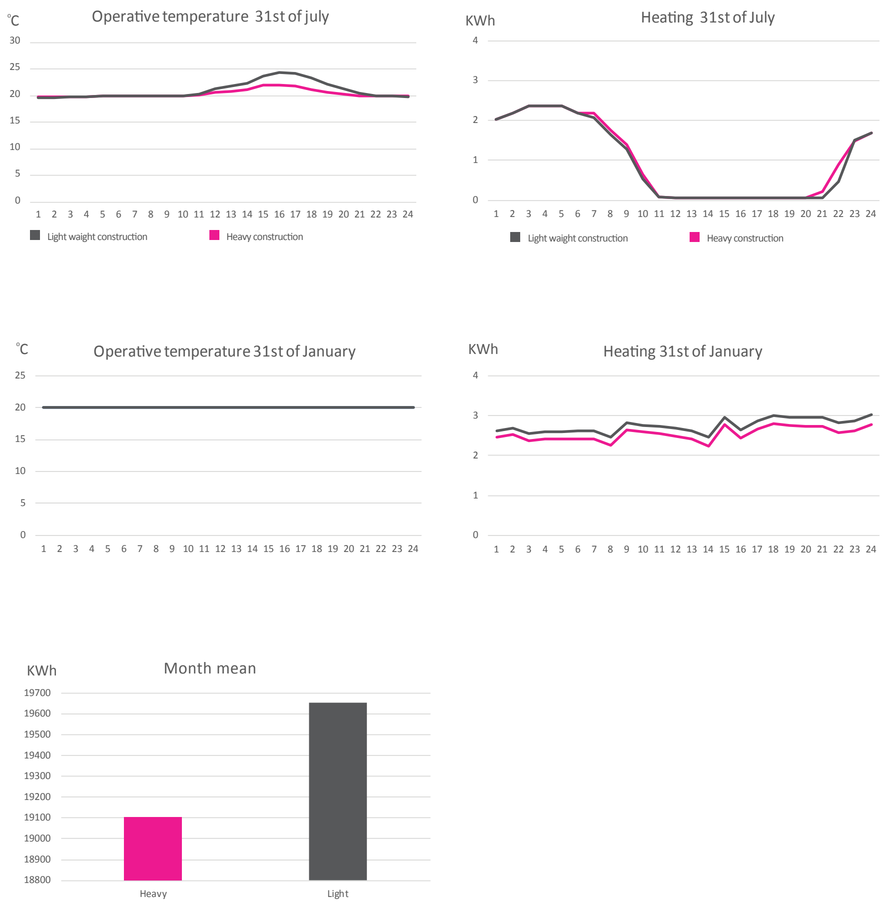


Fig. 106. BSim Study of Window Openings

Active Stratergies

Active Energy Solutions
Greenland is the world biggest island with the smallest density of the population. Historically, Greenland has generated their energy by diesel-driven power plants driven by imported fossil fuel, the biggest contribution to Greenland's greenhouse gas emission [ABB, 2012].

In order to lower the carbon footprint, Greenland has over the past few year replaced many of the fossil fuel generators with renewable energy, which now provides more then 50% of the energy demands [North Of 56, 2013].

A short analysis on renewable energy solutions is made in order to find the most suitable solutions for energy production for the given location.

Hydropower
The biggest renewable energy source in Greenland is Hydropower, generated by five hydropower plants. These are powered by water from precipitation, as well as melting water from glaciers. It is important to study the feasibility for such a power plant, so it still will have enough water resources available in the future. Hydropower is a high reliable source as the energy can be generated on demand to comply with the amount of energy needed. A hydropower plant is highly efficient, but a large number of users need to be utilizing the plant in order to make the investigation profitable considering transportation distances [Nordic Folkecenter, 2016; Climate Greenland, 2016]. Furthermore this solution is not an option on site, as water resources for such use are not available on site.

Wave energy
Wave energy is not currently utilized, despite a good potential in SouthWest Greenland due to the estimated 20-30 kwh/m wave power [Linearinductionwavepower, 2016]. Wave energy is only possible in ice-free areas, but according to The Danish meteorological institute DMI, the ocean in Nuuk will not freeze.

There are a multitude of solutions for wave energy plants, but most will be visible on the water or coast. The main types of offshore plants are Attenuator, Point absorber and Terminator. The Attenuator device is floating perpendicular to the waves on the surface of the ocean. The Point absorber can be both floating on top or submerged in the water, and is generating energy from either up down motion on the surface, or pressure difference in the water. The Terminator is has mechanical principle, and is placed perpendicular to the wave direction to physically intercept the waves. This is considered as one of the most efficient Wave Energy Converters.

Furthermore there are shoreline devices which are easily maintained, close to the utility network, and subjected to less damage in extreme weather conditions. These devices are visible on the coast, which is why it has to be considered in the design phase [Drew, Plummer,, Sahinkaya, 2009; DMI, 2016; Estefen, S.F., 2012]

Tidal Energy
In Nuuk the tidal range can be up to 4,6m, therefore having good potential for utilizing tidal energy. The ice can be a disadvantage in some regions, but Nuuk is in an ice-free zone [DMI, 2016]. No studies of the feasibility of tidal energy in Greenland have been made, but the big differences in tidal heights and big fjords, can determine significant speeds of water movement [Sørensen, Adelsteinsson, Knudsen, Hofstad, 2006].Tidal energy turbines are in a basic understanding much like wind mills that are installed on the seabed.

The tidal cycles are producing kinetic energy caused by the fast-moving current, which the turbine then converts in to energy. Unlike other renewable energy systems, tidal is a predictable and reliable source [Marine Current Turbines, 2016]. “Despite its promise, however, today there are less than a dozen tidal turbine projects operating worldwide, and few look alike” [Climate Central, 2010].

Wind Power
Greenland is not located in a favorable

location for wind power, being a feasible source only in the South. The information about the potential of generating energy from wind power in Greenland is limited. Wind energy is a minor energy source at the current state, because of low availability. One of the reasons for why there has been so little research about the feasibility of wind energy is, that the wind speed is highly variable from each location as the wind is being influenced by mountains and fjords [Naalakkersuisut Government of Greenland, 2016; Sørensen, Adelsteinsson, Knudsen, Hofstad, 2006].

Despite this fact, Niras [Miljøministeriet,2016] has made a research of feasible locations for wind power in Greenland. The project leader, Henrik Mai, states however that the introducing of wind power in Greenland is not recommended, as similar projects located outside of the middle latitudes of the globe, have not been a success. Moreover, when looking at different wind power systems such as smaller turbines that do not requirehigh velocity wind speeds, it becomes clear that the surroundings on site most likely would cause too much wind turbulence from buildings and 'fjeldet' for the turbine to sustain its rotation [Galsworthy J., 2015].

Geothermal Energy

Geothermal energy is generated by heat pumps that push an antifreeze liquid trough pipes, which are immersed into the ground, the heat from the ground being therefore utilized. Other types utilize the heat from hot springs, but not such geothermal activity existits in Nuuk. [Hjartarson, Armannson, 2010].

Two types of pumps exist. One example uses horizontal pipes, while the other has vertical pipes sunken deeper into the ground. The vertical pipe system would be the most likely to use in Nuuk, as it should remain free from the permafrost, the ground being mainly rock. The energy company Nukissiorfiit has conducted test drillings that reveal a good potential for geothermal energy in Nuuk, despite cooler ground temperatures. A drilling in Nuuk of approximately 200m has a mean temperature of 2,49°C and a specific effect of 38,5W/m. Nukissiorfiit already assigned one of their buildings to run only on heat from the drillings, with positive feedback [Hellström, Göran, n.d.]. Geothermal energy is furthermore a solution that has the advantage of not being visible on the building, raising some constraints on the design.

Solar Energy

During the past few years a growing interest in solar energy in Greenland can be seen. As other active solutions, solar energy can be produced by use of a wide range of different systems. The two basic types are Photovoltaic [PV] that produce electricity, and Solar Thermal Collectors that produce heat [Planet Energies, 2015]. Most people will often tend to believe that solar power is a bad idea in Greenland because of the very dark winters. However, in Southern regions, where Nuuk is located, there are nearly the same hours of sunshine than in Denmark, although distributed differently throughout the year. Product specialist, Jess Rowedder from Verdo explains, that a solar power plant in Nuuk placed with an optimal inclination can produce approximately 1.025 KWh/KWp whereas the same system would produce around 900 KWh/KWp in Denmark which is 14 percent less than in Greenland [Sejlund, 2013; Randers I Dag, 2013].

A calculation done by PhD Janne Dragsted from the Department of Civil Engineering in Denmark, shows that the potential production of a solar collector in Nuuk, placed with an angle of 45°, facing south should have a result of 1176 KWh/m^2 whereas the same angle and orientation in Copenhagen would produce 1148 KWh/m^2. These calculations have been followed by examining the performance in the Low Energy House in Sisimiut. This has shown that the practical result of the heat production is 7,5 % lower than expected but with some improvements it does not seem unrealistic that the solar fraction could reach 50% and even higher [Dragsted, 2011].

Due to the reflections of the snow from the surrounding environment and the low temperatures all year round, Pv's and solar collectors have a good potential for making Greenland greener in terms of renewable energy. These stated facts are quite good results, but one is made by the solar energy company Verdo, and is not an independent source which should be considered. On the other hand the calculation and studies by Janne Dragsted are reliable research and proven in practice. Also the occasionally tough weather should be accounted for before constructing, to ensure the sturdiness of the system.

Conclusion

When looking at an overview of the six solutions at once, there are some more suitable for energy production on the given site, than others.

The Hydropower plant is already a reality in Nuuk, but requires water resources on site that can not be sufficed. The existing hydropower plant generates enough energy to supply Nuuk, and it is therefore a good idea to connect to the grid. The wave and tidal energy are the two solutions that normally are not feasible for energy production on site, but given the location of the site, this was seen as an interesting examination. Through research of local data it has been found that energy generated by either wave or tidal range is not a possibility for the location. Wind power on site is not a feasible option either, as the turbulence caused by the context will impact the laminar wind flow required for any wind turbine to sustain its rotation and energy outcome.

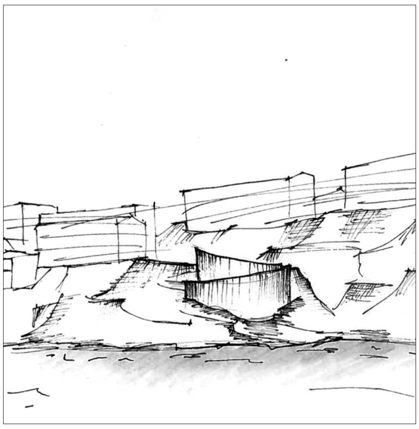
Geothermal energy would be a good solution as it has already been tested in Nuuk, and existing data from the test drillings exist. Sun energy has, despite of the long dark and cold winter days, a surprisingly great potential for a good energy outcome. With actual studies and data supporting the good results it could be a suitable integrated design solution.

The grid electricity is green energy produced by hydropower plants, therefore the decision to connect to the grid has been made. However, in order to lower the energy consumption and reach an even bigger green footprint, the building is supplied with geothermal energy and solar power. Nuuk has various different grids that supply the city with energy from the Buksefjorden hydroelectric power plant, and the incineration plant. In Nuuk it is not possible to supply all the city with a firm heating supply all year round, therefore areas where backup on fuel exists can be seen [Sermersooq. gl, 2015]. The site for the Art Hub is not close enough to district heating but close to a firm electric heating network, hence enabling to the supply for electric water heating for the building [Nukissiorfiit, 2016].

Taking Shape

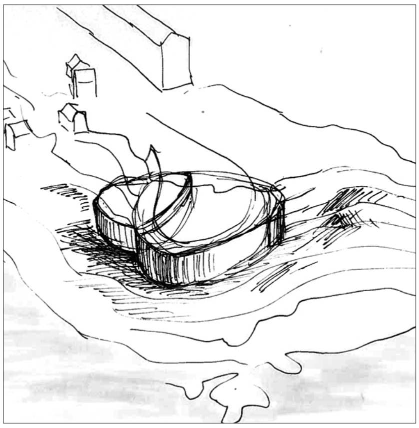
The Section presents and overview on the variety of iterations the design has undergone until reaching its final form.

Form Development



At an initial stage, a number of sketches have been produced in order to understand the vision that each member of the team had aimed for.

Here, the design was free to express the architectural intention and conceptual gesture, as more site and climate specific studies have not yet been completes, therefore the framework for ideation was loose.



Although great variety of principles have been defined, a common feature repeated in a big number of the sketched proposals is that of having the architecture follow the landscape or be immersed into the landscape.

At a subliminal level, a tendency towards creating a synergy between the building and the landscape has been appointed.

The sketches placed aside showcase some of the more successful proposals.

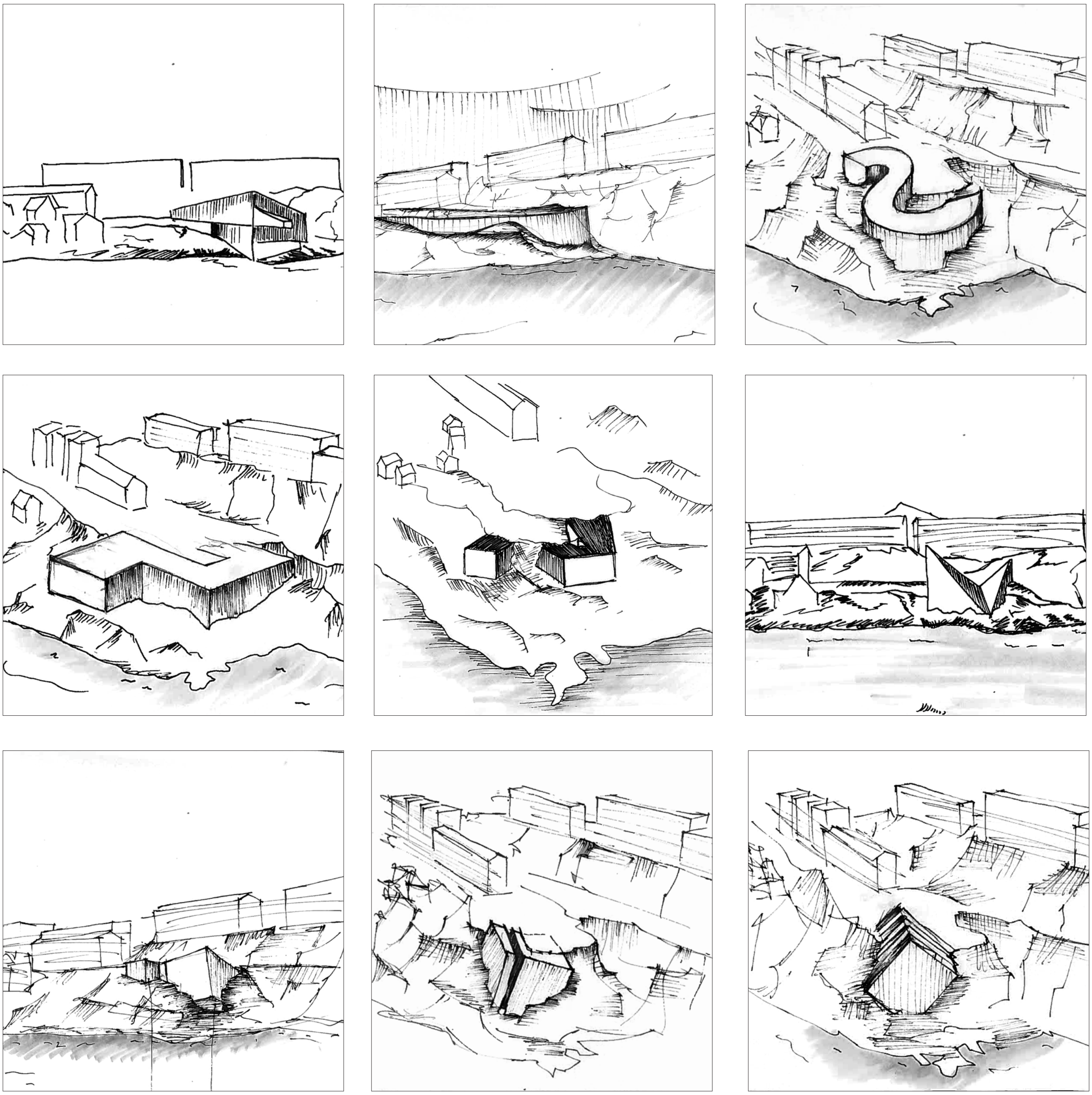


Fig. 107. Sketches

The Roof

This topic looks at principles that can be used in sustaining the concept of the open view, expressed through the gesture of the peak point.

Therefore, the study has looked at Danish Architecture Firm Henning Larsen's design for Moesgaard Museum.

The building has become emblematic due to the powerful gesture of a colossal sloped roof structure that erupts from the ground. This roof acts both as a container for all museum functions housed underneath, while also providing an accessible public space above. The space placed on the top of the roof adapts it's function according to the time of the year. Hence, during the summer months it can be used for picnics, barbecues, lectures and other events such as the traditional Midsummer's Day celebrations. However, in the winter, the snow-covered slope will provide an ideal site for sledging [ArcSpace, 2015; DeZeen, 2014].

Therefore, the rooftop appear to be appreciated by some as not the secondary function of the building, but actually engage more with the view provided by the high structure. Guests to the site believe that climbing the zigzagging path up the roof before entering the museum almost feels like a rite of passage [ArcSpace, 2015]. Opportunities such as these may seem like a lucky consequence of the building design, but with so many Danish architecture firms currently questioning how buildings can give back to the public realm, it is obvious that this was a conscious design motivation by HLA.

By introducing such an element in our design, we will not only create an outdoor space for the citisenz of Nuuk, but also affiliate with the local tradition of turf houses. This intention will therefore tackle the collective memory of the user, easing the potential of embracing the building as one of their own.

When considering the inclination degree of the sloped roof, the slope of some artificial public spaces, as well as local building requirements, have set the frame for the design. Therefore, the angle of the roof has to exceed a minimum of 7% in order to respond to building regulations, and must not surpass a maximum of 23% in order to maintain a walkable surface.

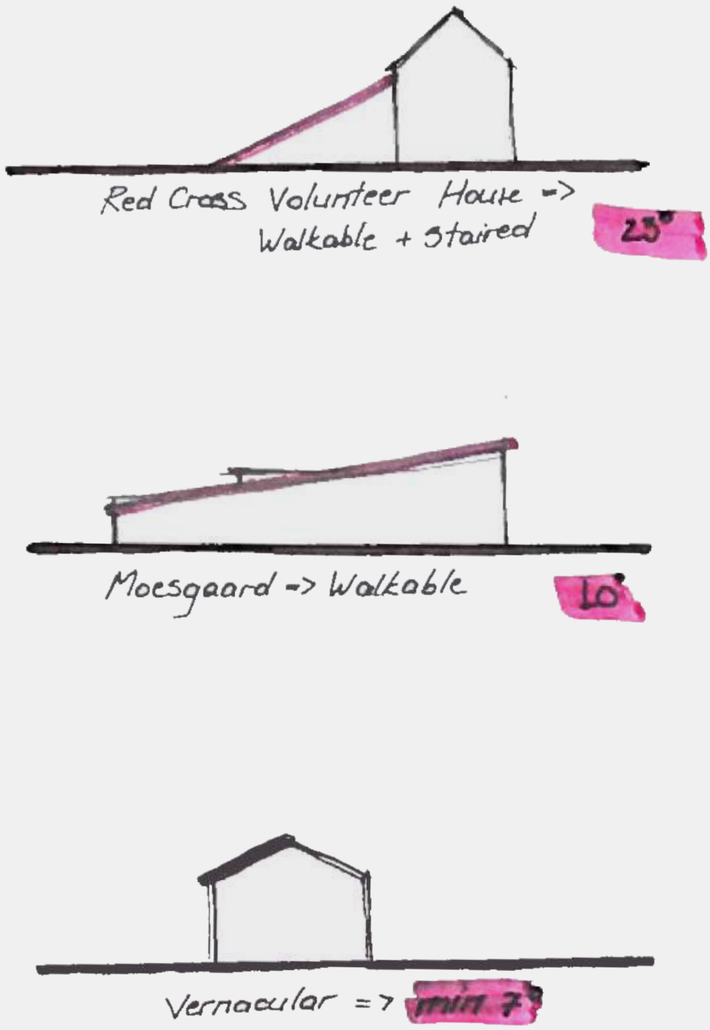


Fig. 108. Roof Inclination Study

the study has aided the development of the roof top terrace, as influenced both by successful modern Nordic architecture, but also the local vernacular style.

The Arrival

Once the placement on site of the main entrance has been established, a series of alterations that express the conceptual parameters showcased in Fig. 108 have been done.

When delivering the outline proposal for the arrival within the building, great importance has been given to the clarity through which the entrance is showed on the facade.

Therefore, by raising a part of the roof, instead of cutting into it in order to define the entrance a more inviting perception has been attained. Nonetheless, by cutting into the geometry, part of the level 0 area wouls have been reduced, rendering it troublesome to work with a generous atrium.

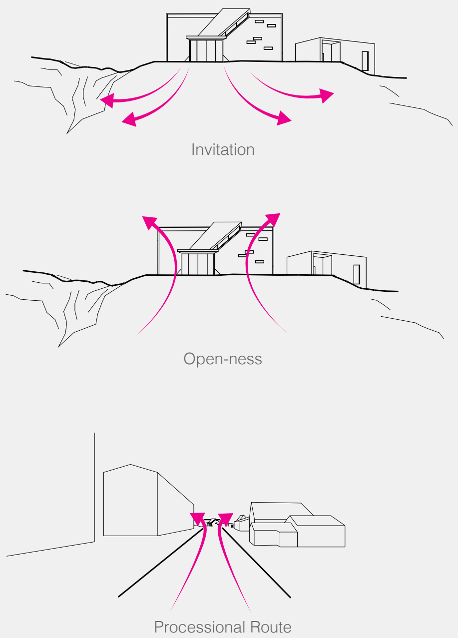


Fig. 109. Arrival Intentions

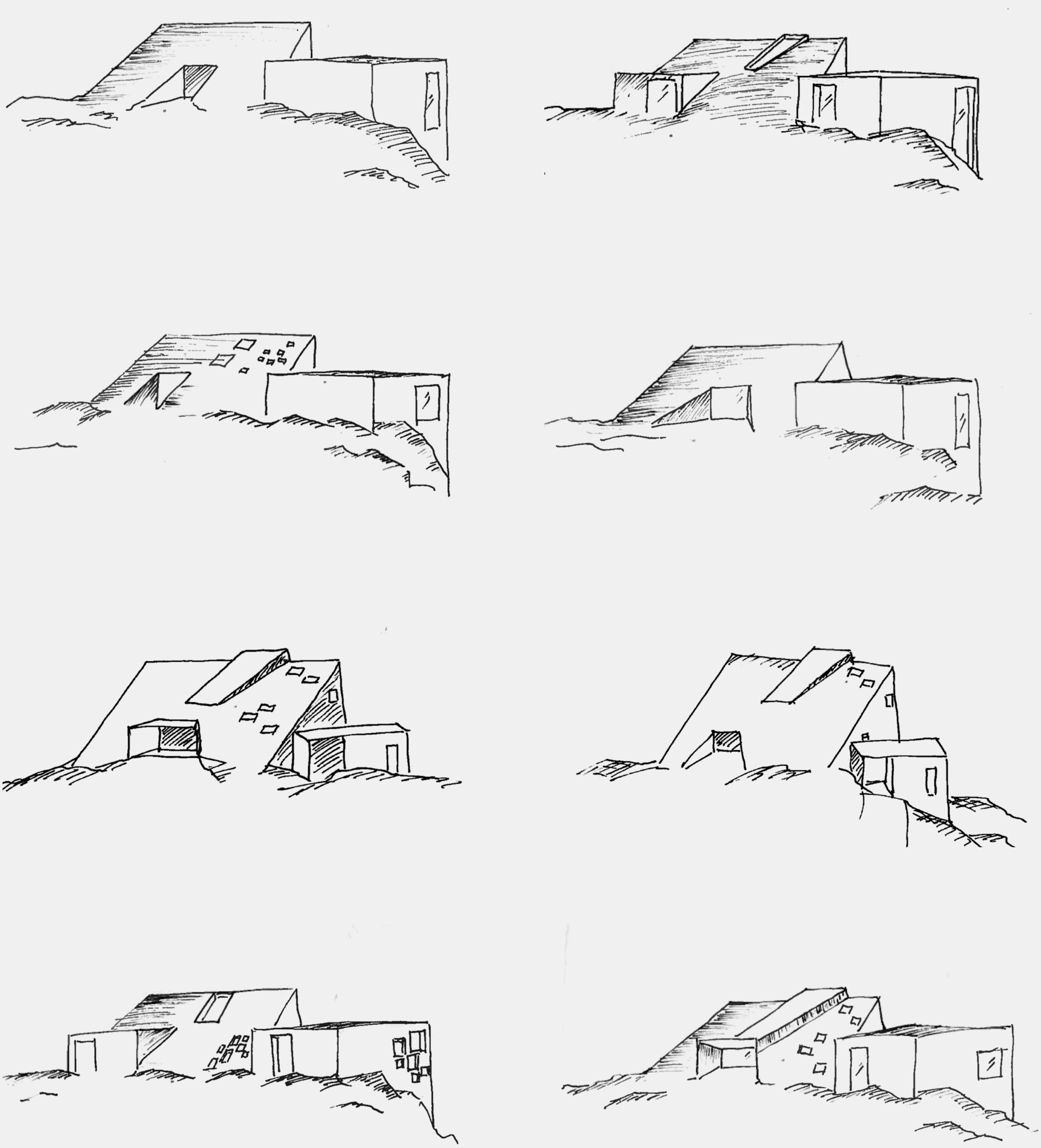


Fig. 110. Arrival Sketches

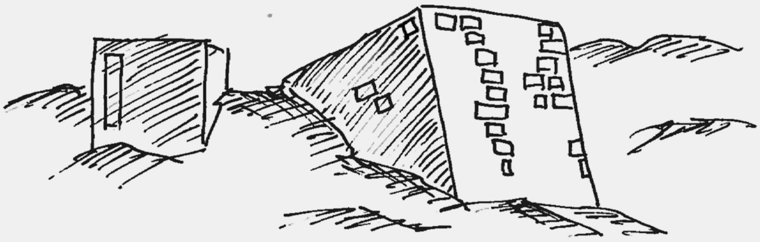
Facade Development

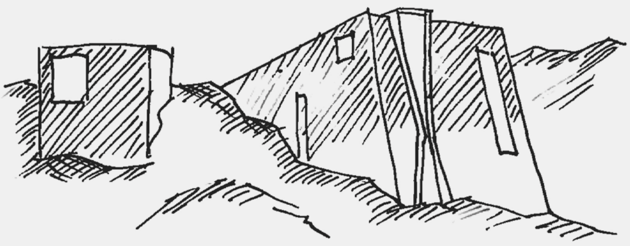
After defining a series of working principles for the facade design in the *Ideation* section, a number of different solutions have been tested.

When working from outside-in, a design parameters in shaping the alterations has been to clearly show where the atrium is placed.

When working from inside out, the focus has been placed on framing the view of the surrounding landscape, while at the same time achieve good daylight qualities in the corresponding place.

Therefore, through a series of iterations, the final shape of the facade, seen in the Synthesis Chapter, has been found suitable in answering all the intended aesthetic and technical parameters.





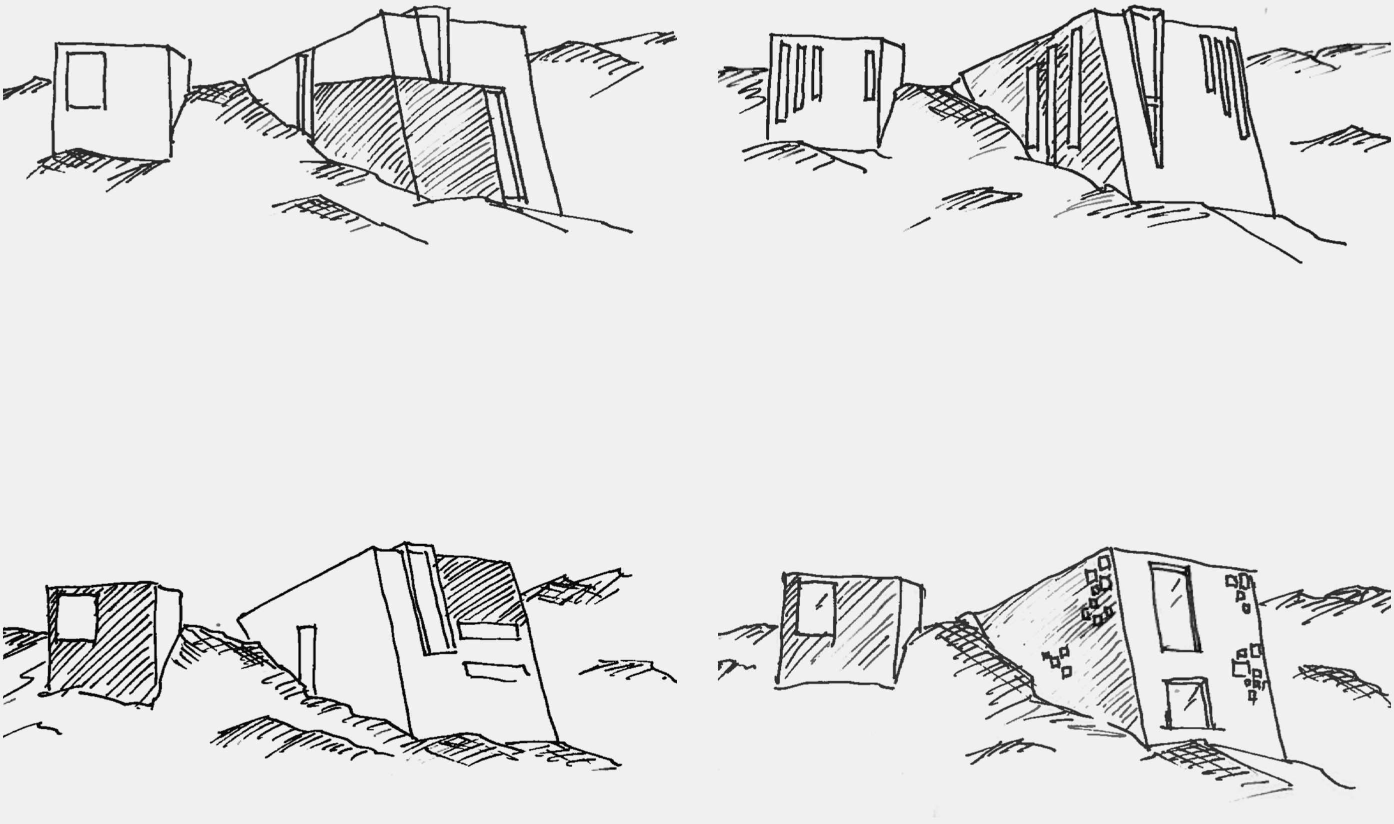


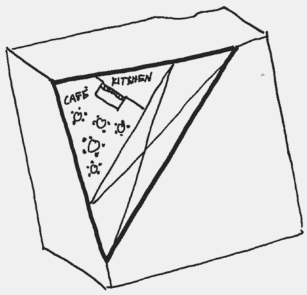
Fig. 111. Iterations of Facades

Development of the Plan

When defining the layout of the Art Hub, a series of variations have been tested.

After defining the role of the atrium as the common ground, the catalyst, that fuels the National Gallery quarters and the Arts and Crafts facilities, the placement of this element has been studies. At the same time, the atrium acts as the main provider for natural daylight in the space. Therefore, the orientation of this component needs to face Southwards in order to supply the space with as much natural light as possible.

Moreover, at a morphological level, a relationship between the entrance and the atrium has to be maintained in order to answer the concept of the continued narrative that finds its apogee in the view.



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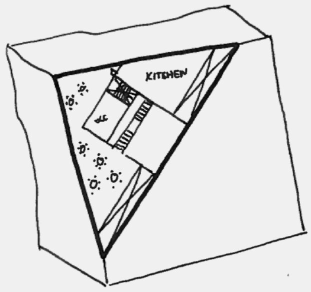

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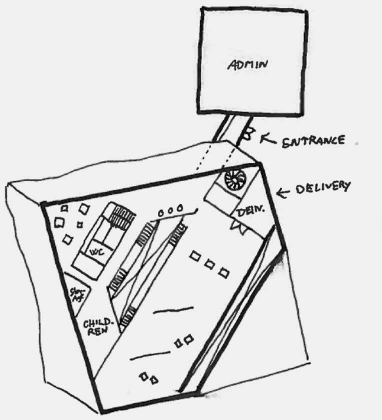

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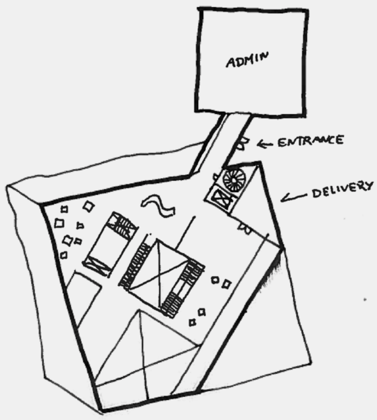

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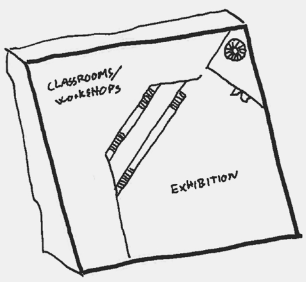
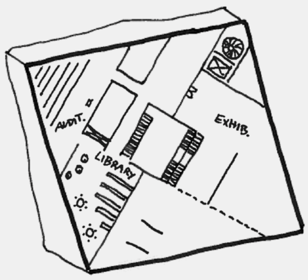


LEVEL -1



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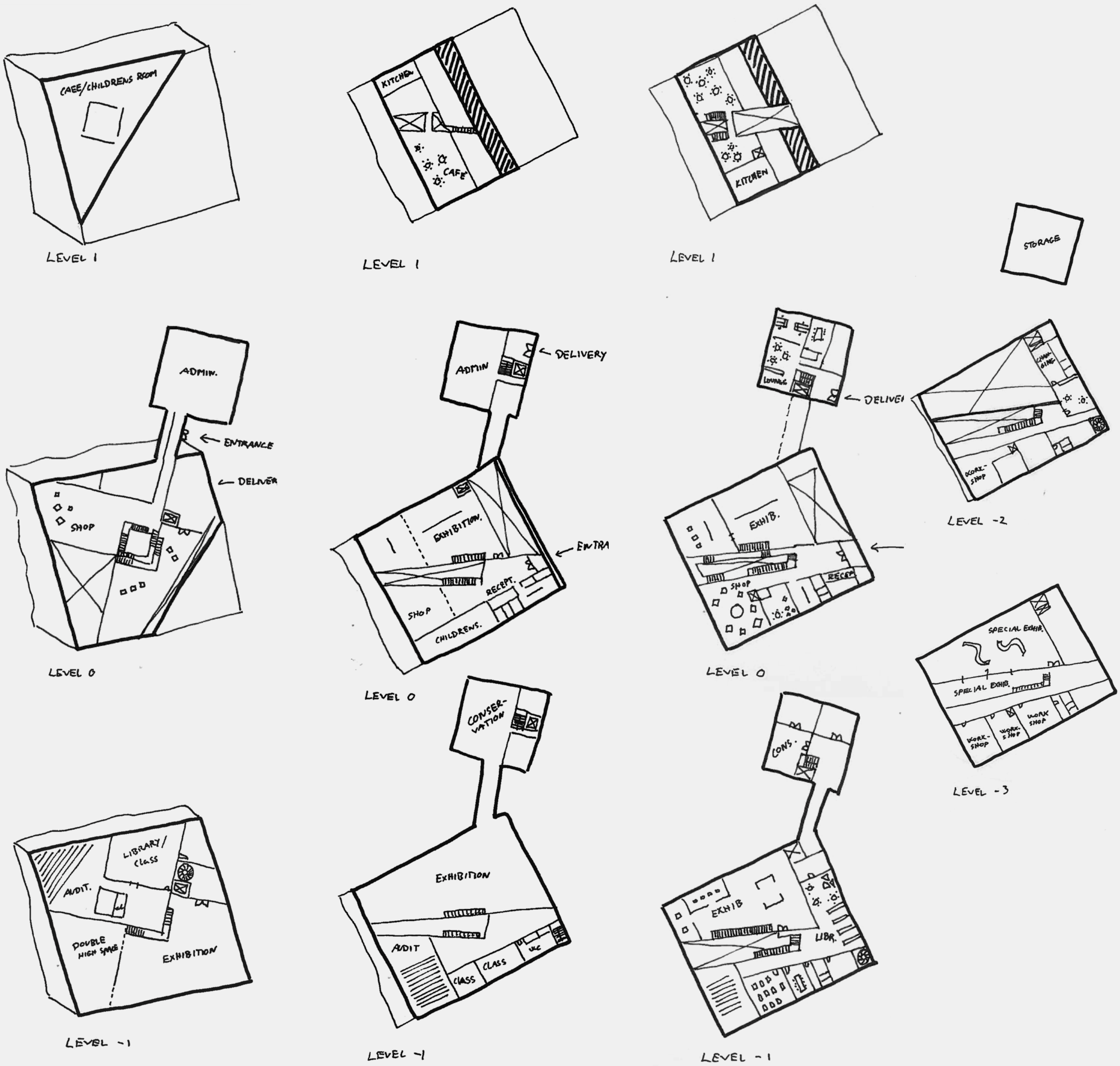

Fig. 112. Iterations of Layout Solutions

Fig. 113. View in Nuuk

EPILOGUE

Fig. 114. Local Art

Epilogue

Within this Chapter we recall upon the design and the process that lead to the realization of the project. Moreover, additional information about our results and attested sources will be provided.

Conclusion

The conclusion summarizes the architectural intention that justifies the success of the proposal not only at as physical presence in the cityscape, but also a metaphysical level, in the process of shaping a future for the community.

The Intention

Nuuk Art Hub responds to societies' ambition of taking charge of their own future. This is achieved by accommodating the means through which they express this desire: *Art*. The local artistic movement, as well as the intention of the Municipality to develop a new National Gallery for the city, are therefore brought together under the same room, establishing the function of the new proposal as a cultural event.

Situated on the waterfront of the fjord, on raised ground, the natural topography of the place proposes the site as emblematic for the city. The building is placed on the edge of the cliff, as to make full use of the site's potential, thus being perceived as a landmark not only at a socio-cultural level, but also visually, when seen from both the waterfront, and Tuapannguit street.

Aside its strategic placement on site and the institution it houses, the proposal triggers the start of a relevant discussion about how the future of the Greenlandic Culture will be shaped, and to what extent will local traditions be embraced in a modern development.

Perception of the Place
By continuing the pre-existing narrative of the site, and placing the proposal at the apogee of this experience, we strive to achieve a landmark for the city while, at the same time, maintain the identity of the location.

Therefore the apogee of the site's story is materialized under the unique perspective placed at the top of the roof terrace. From here, the viewer can experience the fjord, as well as look back onto the site, rendering it possible to experience the place from a new perspective.

The view is also expressed in the interior of the building, where the atrium frames the surrounding landscape and brings it into the center.

Although having a unique and very distinctive identity, the building becomes an integrated part of the natural scene by immersing into the ground. Therefore, at a metaphorical level, the building is embraced by its surroundings, becoming part of the scene.

Moreover, the building gives something back to the city not only through its function, but also through its active use which opens up the site for everyone. The roof can be used as a place for gathering regardless the time of the year.

A Platform for Knowledge
The unique function of the Art Hub promotes knowledge through its three main programmes: the informative [National Gallery], the lucrative [the workshop spaces], as well as the educative [the classrooms]. Hence, the proposal will sustain a good platform for the development of an informed communitty.

Reflection

In the reflection, the success of our proposal is analyzed.

Fulfilling the Intention

Every building carries its role in a society. Sejersen [2015, p.158] argues that by creating ‘a destination’ and ‘an event’, an opportunity of global relations and reinvention of a place for cultural consumption is made.

Therefore, through the already placed initiative of the National Gallery of Art, we are seizing the opportunity for creating a place to shelter the local arts and crafts movement. This ambition has the potential to support the movement towards the establishment of global integration by raising awareness. Through our proposal we are recognizing the Inuit peoples as competent future-makers in possession of the necessary collective political, economic and intellectual resources, and we offer them the means with which to develop their own path.

Hence, a dual relationship in which cultural exchange between the modern world and the local traditions of the Inuits of Greenlands by way of an art hub is stressed. The function, which supports the trilogy of education, production and exhibition, can respond to the needs outlined in the previous paragraph. From here a modernization of this Nordic society by raising awareness of their own traditions can be achieved.

Through the means of a specialized cultural center, which favors the direct interaction between the public and the artists, the proposal seeks to contribute to ‘the development of a living culture’ [Bione, 2009, p.7].

Moreover, at an initial phase the building sets out to meet local building requirements . However, through informed design and constant iterations, the design reaches 2015 Low Energy Building Requirements. With the implementation of and area of 110 m^2 of PV panels, the building will succeed in attaining 2020 goals for energy.

In a discussion with local base engineering and architecture practices, the practice of mall building strategies has been pointed out. This is due to the unavailability of local resources, making it expensive to acquire the necessarily material. However, our strategy has shown that sustainable building in the given context is indeed plausible, therefore we stand to raise the question:

> ‘should society not be educated more on sustainable building traditions and the effectiveness of the return of investment in long term perspective?’

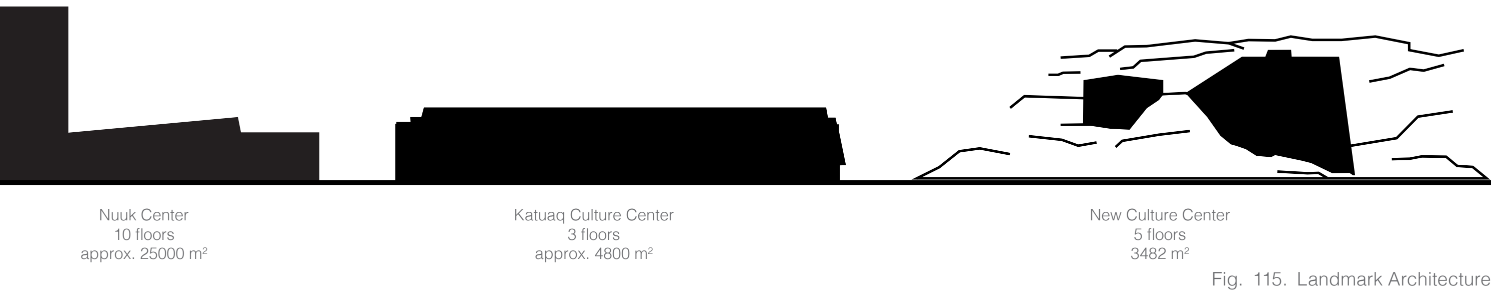

Fig. 115. Landmark Architecture

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Image List

Fig.1-3 - Own Image
Fig.4 - Image available at: < https://www.wexas.com/itinerary-offers/grand-tour-of-south-greenland-103475 >
Fig.5 - Own Image
Fig.6-7 - Own Image [information from Madsen, 2000]
Fig.8-14 - Own Image
Fig.15 - Own Image [information from http://www.gaisma.com/en/location/nuuk.html; http://www.natgal.gl/wp-content/uploads/Nationalgalleri.pdf]
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Fig.20 - Image available at: < http://www.greenland.com/en/about-greenland/ >
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Fig.26 - Image available at: < https://mypolarworld.files.wordpress.com/2011/11/20111113_traditional_viking_home.jpg >
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Fig.29 - Edited from: < http://www.architecturenewsplus.com/projects/1612 >
Fig.30 - Edited from: < http://www.rmi.org/innovationcenter >
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Fig.34 - Own Image [information from Kierkeby, 2006]
Fig.35 - Own Image [information from Brunsgaard, 2015]
Fig.36 - Own Image [information from Bygningsregelemter.dk, 2016; Direktoratet for Boliger og Infrastruktur, 2006; DS/EN15251:2007]
Fig.37 - Own Image
Fig.38 - Own Image [information from http://www.noao.edu/education/QLTkit/ACTIVITY_Documents/Safety/LightLevels_outdoor+indoor.pdf]
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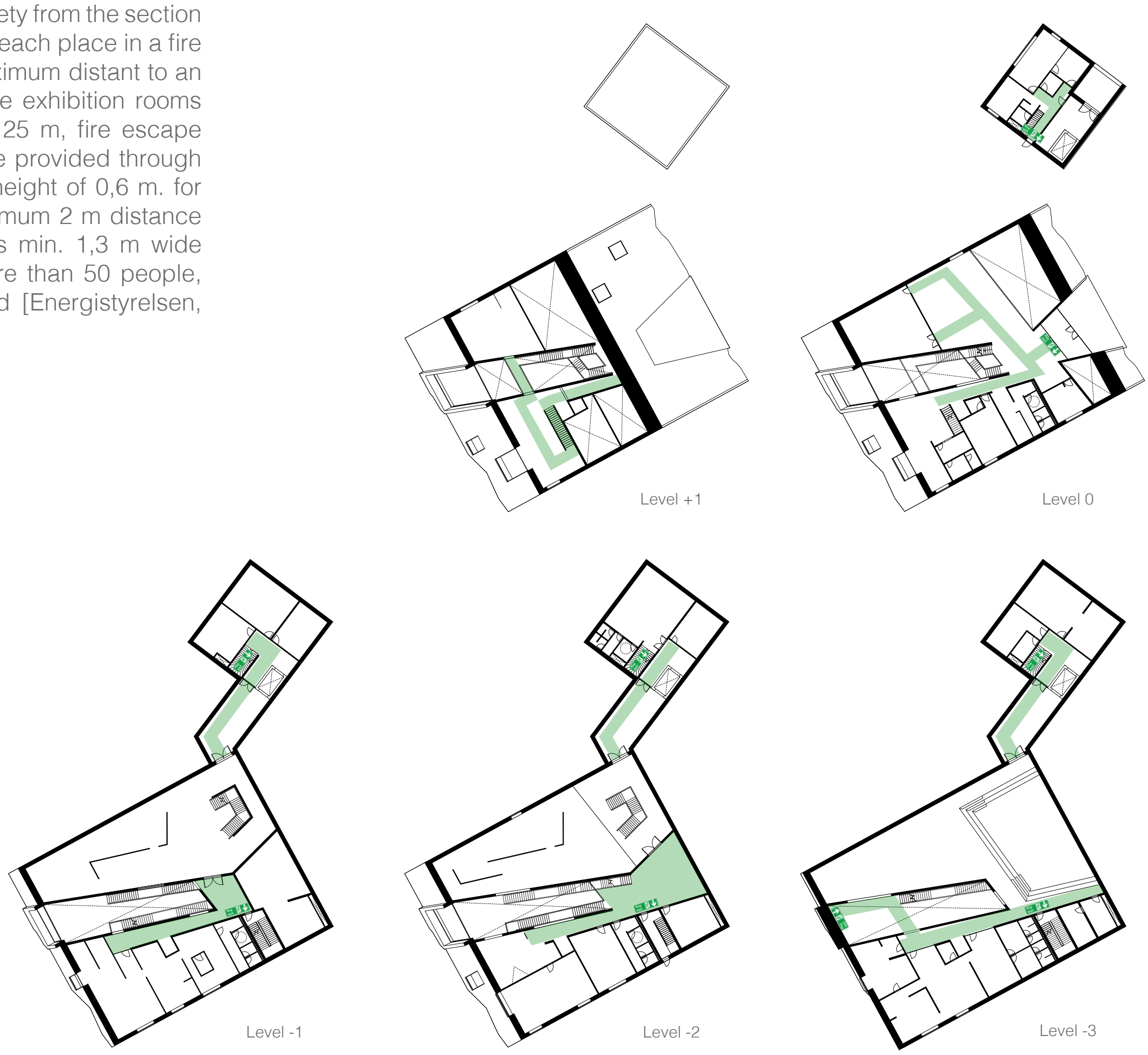
Fig.63-79 - Own Image
Fig. 80 - Own Image [information from http://www.rmi.org/innovationcenter]
Fig.81-97 - Own Image
Fig.98-100 - Own Image [information from Kierkeby, 2006; Kurokawa, 2002]
Fig.101 - Own Image
Fig.102 - Edited from Bejder, 2015
Fig.103-121 - Own Image

Annex

Fire Escape

The building is divided in to five fire sections, that allow safety from the section of the fire origin. From each place in a fire section or cell the maximum distant to an exit is 25 m and in the exhibition rooms where there are over 25 m, fire escape openings to terrain are provided through the windows with an height of 0,6 m. for the opening and maximum 2 m distance to terrain. Each exit is min. 1,3 m wide and in rooms for more than 50 people, two exits are provided [Energistyrelsen, 2012].



Local Art Scene

This study has shown that the equipment required can be housed within ordinary workshop spaces. No special considerations are required.

Fig. 116. Glass Workshop

Fig. 117. Coper's Workshop

Hand Calculations for Air Change Rate in Classroom

Design values for indoor climate is set to II to meet the requirements of the In order To calculate how much the restaurant needs to be ventilated, the experienced air quality and CO2 level is calculated. The highest value is used for the ventilation. Since it is only up to 10 oC in the summer in Nuuk, it is heating season all year round and the Art Hub will therefore only be mechanical ventilated. Wen visiting Nuuk it has been found that there can be very big variations in the temperatures, and the calculations in Be10 have proven that there can be a little access heat during the summer months, although the BSim study does not show overheating. This can be due to the different weather conditions of Reykjavik which has been used for the BSim calculations. To prevent overheating it has been chosen to calculate the natural ventilation as this will bring down the operative temperatures in the classroom and workshops and bring down the energy for mechanical ventilation.

All values and formulas for the following calculations for ventilation is according to [Hyldgård, Funch and Steen-Thøde, 1997].

Design values for indoor climate is set to II to meet the requirements of the Danish Standards. Category II applyes to a normal level of expectations that should be used for new buildings. [DS/EN15251:2007].

It has been chosen to calculate for one of the classrooms as these are facing south and have the biggest people load.

AIR CHANGE RATE BASED ON THE EXPERIENCED AIR QUALITY (OLF)

Classroom:
Nuber of people in room = 25
Area of room = 73 m^2
Hight of room = 4,7 m
V = 11m x 6,7m x 4,7m = 346 m^3

Pollution load
For 1 person = 1 olf
For building materials = 0,2 olf pr. m^2

Air flow:
VL = q * 10 / (c – ci)
VL is the required air flow rate (l/s)
q is the pollution load (olf)
c is the experienced air quality (decipol)
ci is the experienced air quality of the outdoor air (decipol)

The Classroom:
q = 25 olf + (0,2 olf *73 m^2) = 39,6 olf
c = 1,4 dp (eaquals 20% dissatisfaction)
Ci = 0,03 dp = Cities with a low pollution

Air flow in the classroom:
VL = (q *10) / (c – ci)
VL = (39,6 olf * 10)/(1,4 dp – 0,03 dp) = 289,0 l/s
In m^3/s = Airflow/1000 = 0.28 m^3/s

According to the Danish Building regulation the air flow must not be lower than 5 l/s/person plus 0,3 l/s/m² which this air flow rate will meet. [Søren Aggerholm, 2013]

Air change rate in the classroom:
(VL*3600)/(1000*(volume)) = 3,0 h^{-1}

AIR CHANGE RATE BASED ON CO² POLLUTION

The CO² level should according to the Danish Building Regulation, not exceed 900 ppm in longer periods. [bygningsreglementet.dk,2016]

The outdoor air is set to 350 ppm which is a normal outdoor level. [The Engineering Toolbox, 2016.]

Air change based on CO²
C = q / (nV) + ci
n = Airchange
q = Production rate of pollution in the room (m³)
c = Allowable pollution rate (ppm)
ci = Pollution rate in the inlet air (ppm)
v = Volume of the room (m³)

CO2 Produktion
1 person exhales 10 l/min
Exhale concentration 4% CO²

Production rate of CO²
The amount of CO² a person pollute while sitting down
q = (4/100) *(1 pers ((10 l/m * 60 min/h) / 1000 l/m³))= 0,024 m³/h

The classroom:
q = (4/100) *(25 pers ((10 l/m * 60 min/h) / 1000 l/m3))= 0,6 m³/h
c = 900 ppm
ci= 350 ppm

Air change rate
n = (106 * 0,6 m³/h) / ((900 ppm – 350 ppm)*(346 m³))= 3,18 h^{-1}

Since both the air change rate for the CO_2 level is a little bit higher that the air change rate based on olf, there will be ventilated according to the CO_2 level.

THERMAL BUOYANCY
The possible air change through the windows by thermal buoyancy in the classroom is based on mean outdoor temperature in Nuuk in the summer months.

Location of the neutral plane of the openings:

$H_0 = (A_1{}^2*H1+A_2{}^2*H_2) / (A_1{}^2+A_2{}^2)$

H_0 - hight of the neutral plane (m)
H_1- hight of the first opening (m) 1,2
H_2 - hight of the second opening (m) 4,4
A_1 - area of the first opening (m²) 0,9
A_2 - area of the second opening (m²) 0,9
H_0=(0,92*1,2+0,92*4,4)/(0,92+0,92)=2,8

The pressure difference of the inlet and outlet air is calculated using the average temperature for Nuuk in July 2014. The average temperature is 9 °C and the desired indoor temperature is 20°.

Inlet: $\Delta p_i = p_u*g\ (H_0-H_1)((T_i-T_u/T_i)$
Outlet: $\Delta p_i = p_u*g\ (H_0-H_2)((T_i-T_u/T_u)$

ρ_u - density (kg/m³)
g - gravity (m/s²)
H_0 - hight of the neutral plane (m)
H_1 - hight of the first opening (m) 1,2
H_2 - hight of the second opening (m) 4,4
T_i - temperature indoors (K) = 293,1
T_u - temperature outdoors (K) =282,1

Inlet pressure difference, when the outdoor temperature is 9°C.
Δpi= 1,25 kg/m³ * 9,82 m/s² *(2,8m-1,2m)*((293,15K–282,15K)/ 293,1) = 0,7 Pa

Outlet pressure difference, when the outdoor temperature is 9°C.
Δpi= 1,25 kg/m³ * 9,82 m/s² *(2,8m-4,4m)*((293,15K–282,15K)/ 282,1) = - 0,7 Pa

Air flow rate:
Q=Cd * A * √(2 * |Δp| / Pu)

Q - air flow rate (m3/s)
C_d - discharge coefficient
A - area of requierd window opening (m2)
Δ_p is wind induced pressure (Pa)
ρ_u is air density (kg/m3)

When outside temperature is 9°C
Q= 0,68 * 0,9m² * √(2 * I0,7I / 1,25kg/m³) = 0,57 m³/s
The air change:
n= Q * 3600 / V
Q is the air flow rate (m³/s)
V is the volume of the classroom (m³)
n = 0,57 m³/s * (3600 / 346 m³) = 5,9 h^{-1}

Dimensions for Ventilation Channels

Ventilation channel dimensions:
(π*r2)* U m²/s = q m³/s
r = √((Q m³/s/U m2/s)/ π)
r = Radius of pipe (m)
U = Air velocity (m2/s)
q = Airflow (m³/s)½

Total airflow for inlet, floor level -1 = 1,54 m³/s
Air velocity should not exceed 2-3 m³/s close to diffusers and 5-7 m³/s close to the fan in order to prevent a too high noise level. (assumption)

Close to the fan:
r = √((1,54 m³/s/7 m2/s)/ π) = 0,26
Ø = 0,52 m
The first channel until the first division must be squared (0,3mx0,75m as the suspended ceiling is lowered 0,48 m.

After division:
r = √((0,59 m³/s/2 m2/s)/ π) = 0,3
Ø = 0,6 m

Close to diffusers in class rooms:
r = √((0,3 m³/s/2 m2/s)/ π) = 0,21
Ø = 0,42 m

Air Change Calculations

Airchange C02

	Pers.	Polut prod m³/h	c_Polut Alow ppm	ci Polut ppm	Room m²	Room Volume m³	Airchange rate h-1	Airflow l/s	Airflow m³/s	Airflow m³/h
1st Floor										
Restaurant	24	0,576	900	350	97	348	3,01	290,91	0,29	1047,27
Library	3	0,072	900	350	81	417	0,31	36,36	0,04	130,91
Level 0										
Auditorium	85	2,04	900	350	89	418,3	8,87	1030,30	1,03	3709,09
Restaurant	21	0,504	900	350	69	324,3	2,83	254,55	0,25	916,36
Kitchen	2	0,048	900	350	24	112,8	0,77	24,24	0,02	87,27
Children	10	0,24	900	350	40	188	2,32	121,21	0,12	436,36
Wadrobe	3	0,072	900	350	17	79,9	1,64	36,36	0,04	130,91
Toilets	2	0,048	900	350	24	112,8	0,77	24,24	0,02	87,27
Staff	2	0,048	900	350	30	141	0,62	24,24	0,02	87,27
Foyer	10	0,24	900	350	307	1442,9	0,30	121,21	0,12	436,36
Level -1										
Exhibition	10	0,24	900	350	327	1536,9	0,28	121,21	0,12	436,36
Common area	2	0,048	900	350	228	1071,6	0,08	24,24	0,02	87,27
Class room 1	25	0,6	900	350	73	343,1	3,18	303,03	0,30	1090,91
Class room2	10	0,24	900	350	45	211,5	2,06	121,21	0,12	436,36
Meeting	8	0,192	900	350	26	122,2	2,86	96,97	0,10	349,09
Toilets	2	0,048	900	350	24	112,8	0,77	24,24	0,02	87,27
Photo	1	0,024	900	350	30	141	0,31	12,12	0,01	43,64
Level -2										
Exhibition	5	0,12	900	350	339	1593,3	0,14	60,61	0,06	218,18
Common area	2	0,048	900	350	195	916,5	0,10	24,24	0,02	87,27
Plant room	1	0,024	900	350	78	366,6	0,12	12,12	0,01	43,64
Workshops	10	0,24	900	350	177	831,9	0,52	121,21	0,12	436,36
Toilets	2	0,048	900	350	24	112,8	0,77	24,24	0,02	87,27
Level-3										
Workshops	10	0,24	900	350	201	944,7	0,46	121,21	0,12	436,36
Toilets	2	0,048	900	350	24	112,8	0,77	24,24	0,02	87,27
Cleaning	1	0,024	900	350	30	141	0,31	12,12	0,01	43,64
Exhibition	10	0,24	900	350	577	2711,9	0,16	121,21	0,12	436,36

Airchange Olf	Additional olfactory (olf pr. m²)	Building material (olf)	q Pollution load (olf)	c Experienced air quality (dp)c	Ci Cities with moderate pollution	Airflow l/s	Airflow m³/s
1st Floor							
Restaurant	0,1	0,2	53,1	1,4	0,03	387,59	0,39
Library	0	0,2	19,2	1,4	0,03	140,15	0,14
Level 0							
Auditorium	0	0,2	102,8	1,4	0,03	750,36	0,75
Restaurant	0,1	0,2	41,7	1,4	0,03	304,38	0,30
Kitchen	0,1	0,2	9,2	1,4	0,03	67,15	0,07
Children	0	0,2	18	1,4	0,03	131,39	0,13
Wadrobe	0	0,2	6,4	1,4	0,03	46,72	0,05
Toilets	0,1	0,2	9,2	1,4	0,03	67,15	0,07
Staff	0	0,2	8	1,4	0,03	58,39	0,06
Foyer	0	0,2	71,4	1,4	0,03	521,17	0,52
Level -1							
Exhibition	0	0,2	75,4	1,4	0,03	550,36	0,55
Common area	0	0,2	47,6	1,4	0,03	347,45	0,35
Class room 1	0	0,2	39,6	1,4	0,03	289,05	0,29
Class room2	0	0,2	19	1,4	0,03	138,69	0,14
Meeting	0	0,2	13,2	1,4	0,03	96,35	0,10
Toilets	0,1	0,2	9,2	1,4	0,03	67,15	0,07
Photo	0	0,2	7	1,4	0,03	51,09	0,05
Level -2							
Exhibition	0	0,2	72,8	1,4	0,03	531,39	0,53
Common area	0	0,2	41	1,4	0,03	299,27	0,30
Plant room	0	0,2	16,6	1,4	0,03	121,17	0,12
Workshops	0,1	0,2	63,1	1,4	0,03	460,58	0,46
Toilets	0,1	0,2	9,2	1,4	0,03	67,15	0,07
Level-3							
Workshops	0,1	0,2	70,3	1,4	0,03	513,14	0,51
Toilets	0,1	0,2	9,2	1,4	0,03	67,15	0,07
Cleaning	0	0,2	7	1,4	0,03	51,09	0,05
Exhibition	0	0,2	125,4	1,4	0,03	915,33	0,92

U-Values

Constructions

Type	U-value
Exterior walls	0,09
Basement walls	0,09
Basement floor	0,09
Roof	0,09

Type	U-value
Skylights	0,5
Window in atrium top	0,5
Windows SW	0,62
Windows SE	0,62
Windows NW	0,5

Energy Calculations in Be10

MWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heat requirement	16,43	14,5	12,41	4,11	0,68	0	0	0	3,18	7,57	12	12,29
Incident solar radiation	0,76	2,63	7,63	10,42	12,89	13,12	15,76	9,4	5,43	3,79	1,12	0,28
Internal supply	6,34	5,72	6,34	6,13	6,34	6,13	6,34	6,34	6,13	6,34	6,13	6,34
Utilization factor	1	0,99	0,97	0,86	0,72	0,65	0,46	0,61	0,87	0,96	0,99	0,99

In this project, Be10 has been used to verify the changes in the design process. The calculation has only been made on the main building, as this is the one that will contribute to the biggest energy consumption. Several changes has been made in order to fulfill the goal for a Zero-Energy building during the summer months.

The placement of functions according to the building orientation and window opening has been a major factor together with construction of the walls and roof. The building will fulfill the energy requirements by the Greenlandic standard 2006 Zone 1. With only passive strategies the building will consume 89,4 kWh/m² per year. With implementing geothermal energy with one heat pump, and 345m² Pv's on the atrium and the administration building, the building fulfills the energy requirements for the low energy class 2015 in Be10 with 40,2kWh/m² per year. For meeting the energy requirements for building class 2015 there are furthermore requirements for the U-values of the outer walls, that according to the Danish building regulation are not allowed to be higher than 0,3 W/m² K, 0,2 W/m²K for basement floors and roofs. This requirement is met by a U-value of 0,09 W/m²K for the constructions facing the outdoors.

The energy consumption for the building operations, is primarily used on electricity and for heating the building. The contributed heat to the building such as people, mechanical equipment and lighting is from November to March 100 % utilized, seen as the utilization factor is 1. In the summer months the utilization goes down to 0,4 which is due to less heating requirement and to a higher incident solar radiation that is 15,76 MWh compared to 0,28 MWh in December. For the future, the building would be able to meet the regulations of building class 2020 by adding another 128 m² of Pv's to the building.

Key numbers, kWh/m² year

	Building without natural ventilation	Building with natural ventilation	Building with 345 m² pv's and Geothermal energy	Building with additional 110 m² pv's and Geothermal energy
Energy frame in BR 2010				
Without supplement	72,0	72,0	72,0	72,0
Supplement for special conditions	0,0	0,0	0,0	0,0
Total energy frame	72,0	72,0	72,0	72,0
Total energy requirement	95,3	89,4	45,5	39,1
Energy frame low energy buildings 2015				
Without supplement	41,4	41,4	41,4	41,4
Supplement for special conditions	0,0	0,0	0,0	0,0
Total energy frame	41,4	41,4	41,4	41,4
Total energy requirement	88,4	82,6	40,2	33,8
Energy frame Buildings 2020				
Without supplement	25,0	25,0	25,0	25,0
Supplement for special conditions	0,0	0,0	0,0	0,0
Total energy frame	25,0	25,0	25,0	25,0
Total energy requirement	66,1	60,3	29,6	25,0
Contribution to energy requirement				
Heat	34,3	34,3	26,3	26,3
El. for operation of bulding	22,1	22,1	7,6	5,1
Excessive in rooms	5,9	0,0	0,0	0,0
Net requirement				
Room heating	33,6	33,6	33,6	33,6
Domestic hot water	13,5	13,5	13,5	13,5
Cooling	0,0	0,0	0,0	0,0
Selected electricity requirements				
Lighting	7,5	7,5	7,5	7,5
Heating of rooms	0,0	0,0	0,0	0,0
Heating of DHW	13,5	13,5	0,0	0,0
Heat pump	0,0	0,0	7,1	7,1
Ventilators	1,1	1,1	1,1	1,1
Pumps	0,0	0,0	0,0	0,0
Cooling	0,0	0,0	0,0	0,0
Total el. consumption	39,8	39,8	33,4	33,4
Heat loss from installations				
Room heating	0,7	0,7	0,7	0,7
Domestic hot water	0,4	0,4	0,4	0,4
Output from special sources				
Solar heat	0,0	0,0	0,0	0,0
Heat pump	0,0	0,0	21,4	21,4
Solar cells	0,0	0,0	8,0	10,6
Wind mills	0,0	0,0	0,0	0,0

Fig. 118. Be10 Results

Bsim Results

ThermalZon	Sum/Mean	1 (31 days)	2 (28 days)	3 (31 days)	4 (30 days)	5 (31 days)	6 (30 days)	7 (31 days)	8 (31 days)	9 (30 days)	10 (31 days)	11 (30 days)	12 (31 days)
qHeating	24305,37	2953,45	2716,48	2804,41	2203,19	1859,02	1190,82	906,71	964,10	1268,24	2095,63	2523,83	2819,49
qCooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
qInfiltration	-1041,86	0,00	0,00	0,00	0,00	-332,61	-258,21	-224,35	-226,68	0,00	0,00	0,00	0,00
qVenting	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
qSunRad	1030,01	6,70	23,11	69,24	114,66	170,33	193,12	179,65	134,12	82,73	40,95	12,35	3,06
qPeople	3431,00	291,40	263,20	291,40	282,00	291,40	282,00	291,40	291,40	282,00	291,40	282,00	291,40
qEquipment	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
qLighting	1533,00	130,20	117,60	130,20	126,00	130,20	126,00	130,20	130,20	126,00	130,20	126,00	130,20
qTransmissi	-23731,45	-2787,97	-2548,57	-2690,83	-2215,84	-1710,38	-1216,89	-1007,19	-1014,89	-1395,69	-2090,07	-2395,69	-2657,43
qMixing	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
qVentilation	-5526,08	-593,78	-571,81	-604,42	-510,01	-407,96	-316,85	-276,42	-278,24	-363,27	-468,11	-548,49	-586,72
Sum	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-0,00	-0,00	-0,00	-0,00	0,00
tOutdoor me	4,4	0,3	-0,8	0,1	2,5	6,4	8,9	10,6	10,5	7,4	4,6	1,7	0,6
tOp mean(°C	19,9	19,9	19,9	19,9	19,9	19,9	19,9	19,9	19,9	19,9	19,9	19,9	19,9
AirChange(/	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3
Rel. Moistur	49,2	44,1	45,0	46,1	48,6	51,1	56,2	50,8	50,6	44,3	53,1	52,0	48,8
Co2(ppm)	548,5	561,6	565,1	565,9	565,7	515,8	514,8	514,6	514,8	565,5	566,4	568,3	562,9
PAQ(-)	0,4	0,4	0,4	0,4	0,4	0,4	0,3	0,4	0,4	0,4	0,3	0,3	0,3
Hours > 21	0	0	0	0	0	0	0	0	0	0	0	0	0
Hours > 26	0	0	0	0	0	0	0	0	0	0	0	0	0
Hours > 27	0	0	0	0	0	0	0	0	0	0	0	0	0
Hours < 20	8702	744	672	744	720	744	720	690	740	720	744	720	744
FanPow	475,54	40,39	36,48	40,39	39,09	40,39	39,09	40,39	40,39	39,09	40,39	39,09	40,39
HtRec	10434,64	1125,46	1085,41	1146,02	963,70	768,65	594,94	513,94	520,18	682,37	883,78	1038,75	1111,45
ClRec	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
HtCoil	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
ClCoil	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Humidif	3746,17	425,39	384,22	425,39	411,67	425,39	411,67	0,00	0,00	0,00	425,39	411,67	425,39
FloorHeat	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
FloorCool	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CentHeatPu	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CentCooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CentHeatPu	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CentCooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

exhibition results

Fig. 119. BSim Results for Exhibition

Thermal Zor	Sum/Mean	1 (31 days)	2 (28 days)	3 (31 days)	4 (30 days)	5 (31 days)	6 (30 days)	7 (31 days)	8 (31 days)	9 (30 days)	10 (31 days)	11 (30 days)	12 (31 days)
qHeating	2009,79	241,85	223,22	240,44	220,49	206,09	0,00	0,00	0,00	194,55	216,80	226,21	240,15
qCooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
qInfiltration	-1209,64	-127,73	-118,92	-130,78	-115,55	-98,91	-72,65	-61,25	-61,78	-89,65	-105,28	-111,95	-115,19
qVenting	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
qSunRad	1806,08	12,19	75,80	183,11	196,21	254,83	237,21	230,65	215,56	206,14	147,07	43,75	3,55
qPeople	2783,13	236,38	213,50	236,38	228,75	236,38	228,75	236,38	236,38	228,75	236,38	228,75	236,38
qEquipment	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
qLighting	252,60	54,72	33,96	16,80	5,64	2,40	1,68	3,36	3,48	8,52	20,40	42,36	59,28
qTransmissi	-1365,02	-46,32	-122,66	-154,48	-125,25	-140,30	-78,32	-114,57	-92,35	-91,44	-103,49	-130,70	-165,14
qMixing	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
qVentilation	-4276,96	-371,09	-304,90	-391,46	-410,29	-460,48	-316,68	-294,57	-301,30	-456,87	-411,87	-298,43	-259,03
Sum	-0,02	-0,00	-0,00	-0,00	-0,00	0,00	-0,00	-0,00	-0,00	0,00	-0,00	-0,00	-0,01
tOutdoor me	4,4	0,3	-0,8	0,1	2,5	6,4	8,9	10,6	10,5	7,4	4,6	1,7	0,6
tOp mean(°C	20,9	21,0	20,2	20,9	21,6	22,3	21,0	20,5	20,5	22,4	21,5	19,8	19,0
AirChange(/	1,7	1,7	1,7	1,7	1,7	1,7	1,7	1,7	1,7	1,7	1,7	1,7	1,7
Rel. Moistur	31,6	29,2	25,9	24,3	23,1	31,0	36,4	44,3	45,8	33,8	29,5	29,2	26,9
Co2(ppm)	461,2	459,0	461,0	461,2	461,0	461,9	461,9	461,7	461,8	460,7	461,3	462,7	460,1
PAQ(-)	0,6	0,6	0,7	0,7	0,7	0,5	0,5	0,4	0,4	0,5	0,6	0,7	0,7
Hours > 21	4008	399	107	340	547	724	360	110	148	705	534	34	0
Hours > 26	0	0	0	0	0	0	0	0	0	0	0	0	0
Hours > 27	0	0	0	0	0	0	0	0	0	0	0	0	0
Hours < 20	2018	136	317	143	0	0	59	139	186	1	2	431	604
FanPow	542,29	46,06	41,60	46,06	44,57	46,06	44,57	46,06	46,06	44,57	46,06	44,57	46,06
HtRec	12549,24	1422,03	1342,37	1422,16	1212,74	958,22	649,65	516,92	514,95	839,74	1100,67	1249,06	1320,72
ClRec	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
HtCoil	2432,75	359,75	391,13	339,79	206,60	53,15	58,80	34,52	22,16	22,43	158,31	351,59	434,54
ClCoil	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Humidif	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
FloorHeat	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
FloorCool	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CentHeatPu	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CentCooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CentHeatPu	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CentCooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

classroom results

Fig. 120. BSim Results for Classroom

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