THE NATURE EXPERIENCE

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TITLE SHEET

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ABSTRACT

This master thesis is a design solution for a vacation complex in Iceland. The complex is located right next to the lake Mývatn which is well known for the amazing nature around it. Inspired by the nature phenomena of Iceland and using architecture to minimize the threat from tourists against the nature, the project focuses on the building in relation to the site, considering both the processing of the landscape as well as using the country's history and natural resources in the design - hence the name "The nature experience". The project includes a main complex consisting of a visitor center with the purpose of educating about the Icelandic nature and how to act in the area, a restaurant, a thermal bath, a residential area for the hosts running the complex, a horse barn and additionally service functions. Next to the main complex separate cabins provide shelter for tourist staying overnight to watch the northern light. As a part of the environmentally sustainable approach, the project focuses on the cradle-to-cradle philosophy and biodegradable materials. The main complex is built from a heavy earth structure and uses the natural terrain to create level differences in the interior spaces. In contrast transportable and lightweight structures are the main part of the concept for the cabins which leave no permanent relation between the building and the landscape.

PREFACE

The nature experience is a master thesis project developed by Maiken Rævdal as the completion of the Architecture Master education at Aalborg University. The project is based upon an interest for working with the relation between a building and its location in several aspects and uses a sustainable approach as the academic direction for the design. The project is developed on the basis of an architectural competition hosted by Beebreders in the spring of 2018 regarding the design of guest houses near lake Mývatn in Iceland. This master thesis was started as a group project and later finished as an individual. Consequently, the initial extent of the project was wide compared to a single person's working capacity. In order to still deliver a project which achieves a high level corresponding to the learning goals for the semester, some choices have been made to focus on developing parts of the project further than others and in some cases projecting a design solution to other similar situations. These constrictions influences the latter phases of the design process as well as the presentation materials for the project.

CONTENT

MOTIVATION

The motivation for this project is a wish to design a building in a context different from an urban setting; a rural site. This wish combined with an interest in sustainable design sets the foundation for the project, which will concern a Visitor Center with accommodation in Iceland. Architecture should consider many aspects such as functionality, aesthetics and atmosphere, but a big part of making architecture is also about designing for the context, why different approaches are used when designing in an urban setting compared to a rural site. A close relation to Nordic design and an interest in the challenges of integrating a harmless but changing nature phenomena; the Northern light, into a design, makes Iceland a suited location for the project. The tourism in Iceland helps the country's economy but also takes its toll on, especially, the original nature. These problems are interesting to face in the project along with a high consideration on contextuality and a focus on sustainable architectural solutions with the goal of responding to these problems.

METHODOLOGY

This project concerns the design of a Visitor Center with accommodation facilities in Iceland. Being an architectural project, a holistic approach will be used to combine the different aspects from the architectural and the engineering field. This chapter will describe the approach to the project in terms of the overall process as well as an explanation of different methods used to achieve results throughout the project.

The project work will be based on the Integrated Design Process (IDP) by Mary-Ann Knudstrup (Knudstrup, M., 2005). The IDP consists of five phases, aiming to combine knowledge and methods related to the architectural and engineering approaches from an early stage. The IDP is an iterative process presented in a rough timeline, meaning that one may go back and forth between the phases to improve the project when gaining new knowledge, and thereby creating an integrated and holistic design

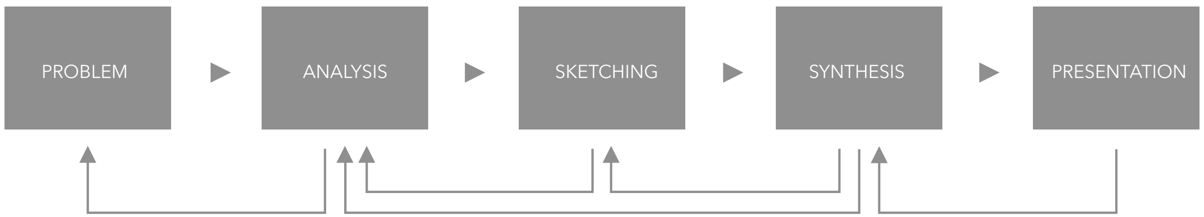
The first phase is the problem definition, which is where the constraints of the project are explained. This phase contains a limitation of the project to clearly specify the initial approach. The problem is the foundation for what to achieve with the project and it clarifies the problematic areas that the projects should cover.

The second phase is the analysis phase. Based on the initial problem definition several subjects are analyzed to fully understand the extent of the project. Different approaches are used to interpret gathered information and material. The analysis phase is concluded with a number of design criteria and a vision to create a more defined direction for the process of designing and a basis for qualified decisions.

The third phase is the sketching phase. In this phase a concept is developed, and design proposals are made based on the knowledge gained in the analysis. In this phase a lot of different ideas are tried out to meet the design criteria and answer the problem.

The fourth phase is the synthesis. In this phase the ideas are made into one main idea synthesizing the best solutions from the sketching phase. The project gets more detailed and further developed regarding the different aspects of its technical performance.

The final phase is the presentation phase. Here different approaches are used to present and explain the final concept and design both in terms of aesthetic and functional aspects, but also in terms of technical performance. The project will be presented in this report as well as in the materials brought at the exam. Different types of presentation material will be used to make the project comprehendible for the reader.



ill. 1 - The integrated design process

	Description	How to use	Purpose
Analysis phase:			
Academic themes/frame-work	Investigation of different themes relevant for the project.	A critical research is made to find sources with relevant information. Based on the sources, several topics will be described in an independent analysis providing a summary of the reading.	The purpose of the method is to understand and describe the extend of the project. The method is used to narrow the field for the project and determinate directions for the project.
Mapping	A method used to identify and understand the site in its context.	In the area the infrastructure as well as the functions are described using a map.	To understand the physical structure of the area, how to arrive to the site as well as which functions the area lacks.
Quantitave studies of site	Investigation of the micro-climate including wind, sun, clouds, precipitation and temperature.	Based on quantitative data, diagrams are used to describe the weather conditions at the site.	To understand how the seasonal changes will affect the site and the vegetation, as well as the weather conditions for watching the northern light.
Qualitative studies of site	Investigation of material to acheive a qualitative understanding and perception of the site.	Hence we are not visiting the site, studies of photos and vidoes given in the competition material will set the foundation for the method.	To achieve a visual perception of the site, its nearby surroundings and the greenery.
3D modelling	Three dimensional representation of the site and the nearby context.	A 3D software tool is used to model the site based on found contour lines for the ares.	The method is used to investigate the complexity of the site.
Sketching phase:			
Hand sketching	Fast drawings to communicate and brainstorm different ideas.	Drawings based of thoughts and references.	A way of quickly communicate and express different ideas for design solutions.
3D modelling	Three-dimensional representation of skteches.	A 3D model made i Revit or sketchup based on initial thoughts and drawings.	To give an better overall understanding of the complexity of a design and how to fit the building to the context. Can help solve problems arising when going from 2D drawings to 3D.
Physical models	Hand-made models in paper, foam etc.	Models made in different scales based on initial thoughts and drawings.	To quickly investigate and compare different shapes, and get an understanding of the building proportions.

ill. 2a - The applied methods

	Description	How to use	Purpose
Synthesis phase:			
Simulation software	Working with different building simulation software such as Bsim.	Using simulation software to understand how a given environmental aspect can influence the dimensioning of constructions and placement of openings etc.	To give a realistic result and understanding of how an environmental aspect can influence a design and the uilding's techincal performance.
Presentation phase:			
3D modelling	A spatial representation of the final design.	A final 3D model is used as foundation for presenting the project with renders.	To give an understanding of spatiality and volumes, and to visualize the final ideas for the reader.
Diagrams and illustrations	Visual material to present the final design.	A visual desctiption of the project explained through different kinds of diagrams and illustrations.	To give the reader a visually understanding of the project as well as describing different principles in the building.
Textual communication	Short texts describing different parts of the project.	A description to substitute the graphic material in the presentation.	To give a more thorough understanding of information communicated in illustrations.

ill. 2b - The applied methods

PROBLEM

In recent years an increasing number of tourists have been visiting Iceland to experience the nature phenomenon: The northern lights. As a country close to the northern magnetic pole, Iceland provides some of the best locations and conditions to see the phenomenon, which combined with its otherwise impressive and unique landscape, have become one of the biggest tourist attractions in Iceland (Óladóttir, O., 2018). The tourism helps the Icelandic economy, but also takes its toll on, especially, the original nature (Iceland monitor, 2018). Therefore, the theme of this project will be to design a sustainable tourist accommodation along with a visitor center to inform and educate about the Icelandic nature.

One challenge is to design with the utmost respect for the nature, while still providing the visitors the unique experience, that they are searching for. With a focus on sustainability, the project should investigate how different environmentally sustainable approaches can be used to reestablish a, in tourism often lost, connection to the original nature to promote sustainable tourism.

The tectonic principles in the project should support the environmental sustainability. The scale of the building will allow close detailing of connections and joints in the building, leading to the question; how can the construction be designed to enhance the experience and atmosphere of the building in correlation to the environmental sustainability approach?

COMPETITION BRIEF

The project takes it starting point in the competition for the Iceland Northern Lights Rooms hosted by Bee Breeders in spring 2018 (BeeBreeders, 2018). The competition conditions contain an initial building program as well as a range of requirements which will be a part of the framework for the project. The competition site is a 3 hectares-large site located in the northeast region of Island. The site is nearby the lake Mývatn and close to the volcano, Hverfjall, and thermal pools.

The competition brief states that the overall purpose of the project is to create a concept for a guest house from which to view the nature phenomenon Northern Light. The building complex is to functions as a guest house, with facilities for accommodation for up to 20 staying guests as well as facilities needed for the hosts running the place.

Separated bedrooms ranging from one to four people should be provided for the guests as well as kitchens and bathrooms. From all the bedrooms there should be a view to the sky with the opportunity to capture the Northern Light. A dining area is needed for the visitors, and it should be able to host and serve all the visitors at once. Along with the dining there should be space for the hosts and up to five invited staff members, to provide room for the needed related facilities.

Housing both guests and hosts, a clear division should be made between the guest house facilities and the private accommodation for the hosts. The host facilities should provide a permanent home for the hosts and their family and include a bedroom, living room, bathroom and a small kitchen. Additionally the brief states, that a covered terrace should be included in the design as well as a barn used as shelter for 10 Icelandic horses owned by the host. The project must also include a strategy for parking and considerations should be put on the internal and external circulation spaces.

Project proposal requirements from the competition brief:

1. Adaptable and moveable types of bedrooms

2. Able to provide comfortable shelter for several days to all occupants in all weather conditions

3. Cost effective construction for remote areas

4. Resistant to heat, cold, rain, snow and wind

5. Environmentally responsible and energy efficient for providing bath amenities

6. Able to generate its own power and provide safe drinking water

7. Low maintenance in terms of effort and costs.

ill. 3 - Iceland and the location of Lake Myvatn

ANALYSIS

ACADEMIC THEMES

This chapter will elaborate on different focus areas in the project. With sustainability being the main specialization for the project, the chapter will start by introducing the essential sustainable focuses of the project. The sustainable focus will be followed by an elaboration of the themes atmosphere, the tectonic detailing and the building's relation to the landscape. The aim of the chapter is to clarify and determine superior directions for the project.

SUSTAINABILITY

The most common and universal definition of sustainability comes from the Brundtland Report, 1987 also called 'Our Common Future'. In the report sustainable development was specified as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (United Nations, 1987). In 1992 sustainability was concretized in the Rio-declaration on environment and development, from which we know the three pillars: environmental, social and economic sustainability (United Nations, 1992).

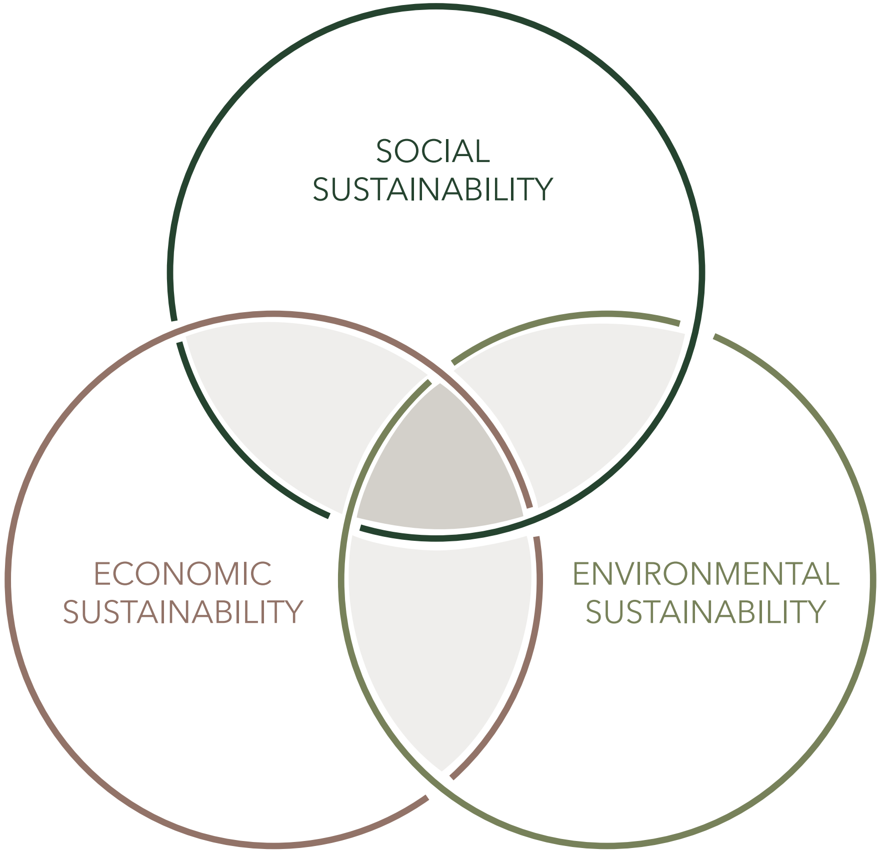
When looking at sustainability in relation to architecture, it is essential to consider the building in a short-term as well as a long-term perspective. The environmental pillar of sustainability is related to energy and emission. Social sustainability is highly related to the user of the building and the indoor comfort. Culture is often considered as an aspect of the social sustainability pillar, as culture will influence a person's social life and thereby the social understanding of sustainability (Soini, K. et al., 2013). The economic sustainable building focuses on short-term as well as long-term financial savings thanks to great considerations in the economic aspects when making design solutions (ibid.)

The three pillars of sustainability are to be seen as a combined unit describing a buildings sustainable performance. Decisions made to enhance one aspect of sustainability will influence the others, therefore considerations towards all three aspects should be concluded when designing. Due to the content in this specific project and the location of the project site, a higher focus will be on the environmental sustainability. When considering environmental sustainability in relation to this specific project, a variety of different parameters should be meet. The site itself is an essential premise for creating environmentally sustainable architecture. Working with a rural site in a remote location invites to great considerations regarding how to work with a natural context and how to preserve and respect the qualities of the site.

A building will use different resources as well as it will generate waste. Buildings do thereby have impact on the environment through all its lifecycle and are roughly responsible for 40% of the energy consumption in Europe (European Commision, 2018). This makes reduction of the environmental impact in all phases an important theme to address when making architecture. Iceland offers great conditions for the use of renewable energy strategies, which makes the country leading in the field (Askja Energy). With its unique conditions, using renewable energy to supply almost 100% of the country's electricity consumption and nearly 85% of the energy consumption (Askja Energy, a), the energy consumption of the building will not be the most critical aspect of the environmental sustainability, as it basically will be running on green energy. This causes for an alternative way of thinking of the environmental sustainability of a design, compared to designing buildings for locations in Denmark.

As well as energy, materials is likewise a central aspect of the environmentally sustainable dimension. The definition of a sustainable material will depend on both the technical properties of the material itself as well as the climatic conditions in a location (Bejder, A. et al, 2014, p. 38). In general, the location will have great influence on the materials, as accessibility and transportation will be parts of defining the sustainability of a material at a specific location. These aspects will pay a central role when making a project on a more secluded site. In the same way the harsh Icelandic micro-climate should pay an important role in the design in terms of material and maintenance considerations as well as the use of different passive strategies to develop the energy consumption as well as the indoor climate conditions.

To pay attention to the materials, a focus will be on the production philosophy Cradle-to-cradle created by the American architect William McDonough and a German chemical professor Michael Braungart. Cradle-to-cradle describes how a material should be a part of a repeating cycle, where the materials will be either biodegradable or a part of en technical cycle where it will be utilized in a way, so that it can be recycled after use. Additionally, all production in the different life phases of a material should cause a minimum of pollution and waste production. (Vugge til vugge, n.d.)



ill. 4 - The three pillars of sustainability

ATMOSPHERE

"Quality of architecture … is when a building manages to move me." (Zumthor, P. 2005, p. 10).

Architecture is not all about creating the physical frames and shelter for the users, architecture can appeal to our minds and set us in certain moods or provoke feelings. In a time, when a lot of modern architecture comes down to numbers – energy, cost, time – it is important to remember to work with the more subtle and poetic faces of architecture. A term that can be used in this context, is atmosphere – the characteristic mood or feeling of a space. In the project, the term atmosphere will be used by working with creating different atmospheres to suit the various users and their use of the spaces.

The Swiss architect Peter Zumthor uses nine key features to generate atmosphere in his architectural works. These features are described in the book Atmospheres from 2005, that is a transcript of a lecture, Peter Zumthor held in 2003 (Zumthor, 2005). In the following these nine features will be described and discussed.

The Body of Architecture:
To Peter Zumthor the way the building is put together compares to the human body. The physical frame of the architecture whether it be walls, columns, vaults or anything in between, correlates to the human anatomy with its skin, bones, muscles etc. He believes we can relate and interact with the building through these similarities.

Material Compatibility:
This feature concerns the use of materials and how materials are compatible with each other. Zumthor emphasizes that materials react with each other to a higher or lesser degree depending on their characteristics, and that they have endless possibilities. He also states that there is a critical proximity between materials, meaning that if they are too close or too far away from each other, they cannot react to each other.

The Sound of Space:
The third feature, Zumthor describes, concerns how the building or spaces treat sound. He links it to the shape of the room, the materials and the surfaces of the room among other. To him, there is unfortunately many people who are not aware of how a room enhances sound.

The Temperature of a Space:
This fourth feature concerns how a space is thermally experienced. He links the characteristics of the used materials to the way we experience the space due to its ability to store cold or heat. However, he states that it is not only a physical feeling: it can also be psychological and be experienced through not only touch but also vision.

Surrounding Objects:
Zumthor values how people as the users of a space gives it character and a personal touch through the things, they decide to surround themselves with and values the presence of.

Between Composure and Seduction:
This sixth feature concerns the way architecture urges us to move around, not necessarily by suggesting a certain path, but also by leaving room and choice to the human to move and stroll around as they please.

Tension between Interior and Exterior:
The seventh feature addresses the meeting between the outside and the inside and discusses how the user changes from the feeling of being enveloped to being outside in the open. How the architecture treats the transition between inside and outside through elements such as facades, thresholds and crossings, determines how the user feels the change from inside to outside.

Levels of intimacy:
The eighth feature concerns the dimension, scale and the building mass as a contrast to the human body. He describes how there is a tension between different sized objects and that working with dimensions and scale, can create an experience when it is related to the human body.

The Light on Things:
The last of the nine features concerns how the light enhances architecture. Zumthor describes the two approaches to light, that he likes the most: the first being imagining the architecture completely dark, and then carefully placing lights where they are needed to showcase certain things. The other being aware of how materials reflect light around them.

Incorporating these nine features in the architectural design, will aid to design a building that urges the user to have a sensual, atmospheric experience. All the key features involve an interaction between the architecture and the human for the atmosphere to be felt by us – as in the words of Gernot Böhme: atmosphere is something felt between the object and the subject (Böhme, G., 1998). The elements, that Zumthor describes are all dependent on the relation between these two and how the human senses the elements. To further understand how the senses address architecture, the studies of Juhani Pallasmaa can be helpful. In his work The Eyes of the Skin from 1996 (Pallasmaa, J., 1996), he criticizes how many architects mainly seek to stimulate the vision as the primary sense, leaving most other senses – ear, nose, skin, tongue, skeleton and muscle - unstimulated. Instead architecture should become a multi-sensory experience by addressing all senses and the architect should design with the human body as the center of the process. Pallasmaa sees the touch as the basis of all other senses – also the vision – since the body through the other senses gets reminded of how the object feels to touch. In architecture the spatiality and our perception of distance and materiality is crucial and according to Pallasmaa, this would not be possible without the collaboration between the senses and the tactile memory. As another contrast to the sense of sight, Pallasmaa mentions the sense of hearing. The sight is directional, while sound comes from all directions and will articulate and support the spatial experience in a room.

The project will aim to incorporate aspects from all Zumthor's nine key features, however some of them will be in greater focus due to the nature of the project. The Material Compatibility will be considered important in the work with materiality related to Pallasmaa's theory on how touch is one of the basis senses and how our memory is triggered when sensing different materials. In the project this principle will be followed by using natural materials, such as earth and stone, which are materials, that the human memory easily can relate to and imagine how will feel. The materials will contrast each other while corresponding to their placement in or outside the building volume so that raw and hard materials are used on the outside, while softer appearing materials will be used on the inside.

To facilitate a good experience in the Icelandic nature, the feature Tension between Interior and Exterior will also be crucial and used to enhance both the physical and mental feeling of being inside, but in connection to the outside nature. Regarding this, the complex will urge the user to venture into the natural surroundings both close to the building and further away through logistical placements of functions and path systems, that invite to adventure into the nature on site. The physical meeting between inside and outside, will be expressed in the façade by enhancing the entrance to the building around the doors through materiality and facade depth.

Thinking of Pallasmaa's approach to designing with the body in the center, the feature Levels of Intimacy will be applied to relate the human body to the building. To do so, the scale of the building volumes will change, depending on the use of the rooms and the user's experience of being inside the room. However, this will not only be expressed through scale, but will also be dependent on placement of windows related to where the user is situated and how this placement will orient the user towards either the inside or outside of the building.

TECTONICS

As stated previously, architecture is more than just numbers – it contains a subtlety and sensibility, that through atmosphere can be felt and thereby affect the users of the architecture. To work with atmosphere, a wish to incorporate the work of Peter Zumthor and Juhani Pallasmaa was stated in the previous chapter. Their findings and theories will be crucial in the work with the tectonics of the building – more specifically, in the work with detailing the building, since the detailing of joints concerns especially the materiality and the relation to the human scale, which is some of their main focuses. To investigate how details can add quality to architecture, the theories of Marco Frascari will be discussed in the following.

"The art of detailing is really the joining of materials, elements, components, and building parts in a functional and aesthetic manner. The complexity of this art of joining is such that a detail performing satisfactorily in one building may fail in another to very subtle reasons." (Frascari, M., 1984, p. 2)

In his work Tell-the-Tale-Detail from 1984, Marco Frascari states the above. In this he addresses the challenge of making elements meet and describes details as being 'much more than subordinate elements; they can be regarded as the minimal units of signification in the architectural production of meanings' (Frascari, M., 2984, p. 1). To him, detailing can make or break architecture and must be considered and carefully designed to avoid building failure – both on the ethical and the aesthetic level.

To Frascari, the detail is always a joint, and he separates joints into two types: material joints – such as the meeting between a column and a beam – and formal joints – such as a porch, that is the connection between interior and exterior. When thinking of details in this way, it is clear that all details are always the functional considerations in a building. How the building is supposed to be used must be told in the details – hence the tell-the-tale detail. Architecture is not only a profession; it is also an art, that seeks to put spaces and materials together in a meaningful way. To do this, the process of making a detail – whether it is a material or formal joint – involves first the mental construing of the joint and then the actual physical construction of the joint. As he says: "The joint, that is the fertile detail, is the place where both the construction and the construing of architecture take place" (Frascari, M., 1984, p. 11).

The mental construing comes before the actual construction and requires the architect to be able to visualize the detail before making it. The architect has a certain idealistic wish of how the detail must look to express the architectural idea that is the reasoning behind the detail. However, the mental construing requires a skilled mind and often challenges are not thought of before the actual construction of the detail, meaning that the clarity of the architectural idea can be weakened.

Working with tectonics by focusing on the detailing, will fit very well to the wish of incorporating atmosphere in the shape of materiality and the human relation to the surroundings. Since Frascari describes joints as both formal and material, the two key features of Peter Zumthor, The Material Compatibility and Tension between Interior and Exterior will be addressed through detailing of joints and connections. Pallasmaa's fundamental theory, that the sense of touch is the basis of all senses, further supports the importance of working with materiality and scale in the detailing. Especially the detailing around the entrances to the building will be important in the design and will help the visitor relate to the threshold between inside and outside. This detailing will be done through a variation in materials and depths of the façade. The handling of details will also be used according to the buildings constructional system, where a clear and honest design will be used to show the natural forces in the detailing of the windows and a high attention is brought to placing the windows in the wall considering both the structural system, passive strategies and the effect in the interior space. Furthermore, the design of the surfaces will focus on exposing natural materials in an pure form to enhance the tactility of the space.


ill. 5


ill. 6


ill. 7

LANDSCAPE

To build in a remote location without an urban context, sets a great focus on the architecture in relation to the landscape. The project site along with its context is very untouched, which is a less familiar basis for us to design from. This in many ways different starting point for designing raises questions regarding how the landscape and the site can affect the design of the building.

This text has its source in the section 'Fitting the house to the land' from the book 'The Place of Houses' written by the three American architects Charles Moore, Gerald Allen and Donlyn Lyndon (Moore, C. et al., 1974). The text is interesting for us, as it proposes different ways in which a building can be designed to the landscape. How to fit a building to the landscape depends on the individual situation, and it is important that one considers both the opportunities that a site may offer as well as the problems brought by a given site. According to the three architects, the ways of fitting a building in a landscape can be summarized into four core approaches: by merging, claiming, enfronting and surrounding.

Merging:
Merge can be defined as more elements combined into one. Merging a building to the land is a human made fusion between the nature and the building, to create the building as one with its surroundings. The approach is often used in a context with strong textures, such as hills or trees, which gives the opportunity for a building to naturally blend in with the site. In some cases, a merge can almost happen by itself and can be difficult to avoid without making alteration to the vegetation and terrain. Even though the merge can seem most suited for a vegetated land, it can also happen on a wide-open piece of land, where the building is merged with the background by keeping it low and horizontal in its expression.

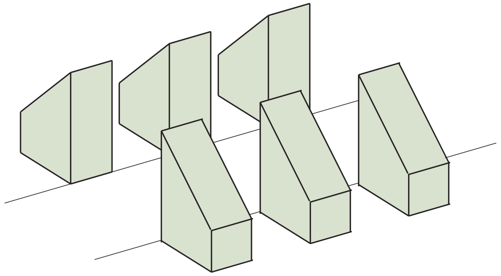
Claiming:
Being the opposite of merging, claiming can easiest be described as when a building is in a clear contrast to its surroundings. In this situation it should be clear, that the building is intended to be different and detach itself from its natural setting. Claiming is most prominent in large homogeneous rural sites undisturbed by vegetation, high terrain differences and other buildings. Colors and shape are key factors, in which one can make a clear distinction to the land around the building. A strong and prominently shape gives the building a dominating character and thereby a power to claim its own part of the context. The strength of claiming the land will depend on the individual situation. If a building is placed high, it possesses a bigger power to claim the landscape around it, as seen in the ancient Greek temples.

Enfronting:
Enfronting is like defining an edge, by giving parts of a building, often one of the facades, a unique design to highlight an element on a site. Enfronting can be used to enhance a certain feature on the site and is often used to emphasize a street, a square, or a plaza. As it may seem that enfronting is mostly used in an urban context, the approach can also be used on an open rural site to enfront features such as a specific view, a nearby river or other landmarks.

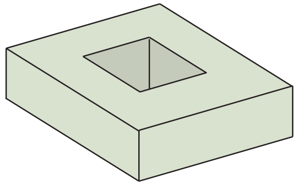
Surrounding:
In a surrounding building the intentions of claiming are turned inwards. Different elements of the building are used to close around and outdoor area and create a private space. The surrounding can be completely closed or partly open, creating different levels of privacy. This approach gives the opportunity to create a courtyard with a completely transformed character compared to the rest of the site. Surrounding turns away from the landscape by creating a smaller and separated outdoor area, which is why the approach is less used on the more remote open sites. Surrounding is a sought for approach in locations where it is desirable to create shielded outdoor areas due to climatic conditions.

Common for all the four possibilities is, that the chosen approach should fit to the specific site, the vegetation and the climate. As stated earlier in this text, working with a remote location is challenging by being less familiar for us. In the rural sites the building should relate to the natural texture of the terrain and trees whereas buildings in the dense urban sites should be related to a human made urban production. The more rural site offers more opportunities for different ways of fitting the building to the landscape compared to an urban context in cities and suburbs. A site can in some cases accommodate all the four ways and will sometimes do several things at once.

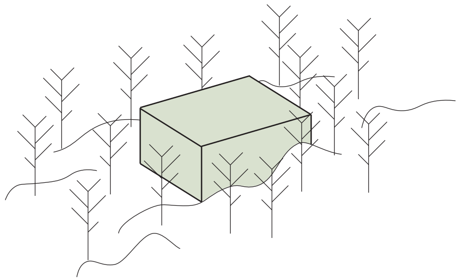
To investigate which way of fitting the building will be most suitable for the project site, different analysis regarding the site conditions should be considered early to narrow down and set guidelines for the possibilities for fitting the building to the specific land. However, it will also be essential to experiment with different designs based on several of the four approaches of placing the building, to fully understand the potentials of the site and how different solutions will collaborate with the other themes and criteria addressed in the project.



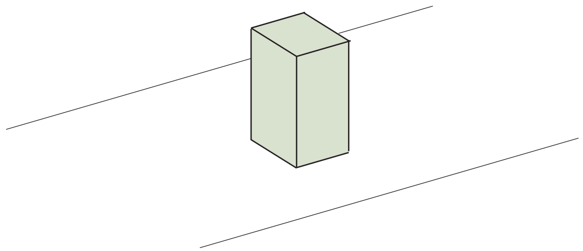
ill. 8 - Enfronting



ill. 9 - Sorrounding



ill. 10 - Merging



ill. 11 - Claiming

FRAMEWORK

This chapter presents different studies and research based upon the qualities of the Icelandic context. The aim of the chapter is to understand and further describe the possible extend of the project, by investigating the unique potentials Iceland can provide to the project. The studies will investigate the tourism in Iceland, Icelandic vernacular architecture, the northern lights and a study of the accessible renewable energy sources and their potentials.

TOURISM IN ICELAND

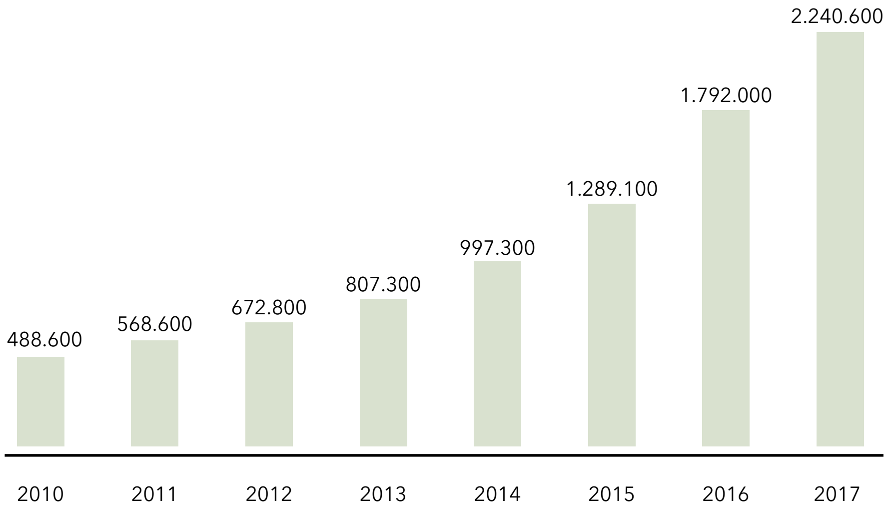
Tourism has during the latest years had an immense impact on Iceland – both positive and negative. Iceland with a population of 340.000 was in 2018 visited by no less than 2.2 million tourists – a number that has been rapidly growing since 2010 with an average increase of 24,3% each year (Óladóttir, O., 2018). As a country that was highly impacted by the economic collapse in 2008, the tourism has become one the most important economic sectors in Iceland (Guðmundsdóttir, K. H., 2016). However, the economic prosperity comes with a cost: 75% of Icelanders think that the tourism has a negative effect on the Icelandic nature (Óladóttir, O., 2018). This is a highly important topic for not only the average Icelander, but also the government that will use their presidency for the Nordic Council in 2019 to focus among other on sustainable tourism (Nordic Co-operation, 2019). Sustainable tourism focuses on the authentic respectful interaction with the local culture and nature as opposed to so-called mass-tourism that is typically driven by the urge to earn money. Though, sustainable tourism is considered the best solution, it is often economically hard for a country to go without the income from mass-tourism. (Lacanilao, P., 2017)

The increase of the number of tourists is due to many factors (Jónsson, A.). The nature phenomena and attractions that draw the tourists to the country, has existed for thousands of years, however due to raised media attention in the latest years, Iceland has gained attention from international tourists. With the eruption of the volcano Eyjafjallajökull in 2010 causing cancelled flights and a huge media attention, the country received a never seen interest from the outside world. The nature phenomenon drew an immense attention to the harsh and impressive nature of Iceland and fueled the growth in tourism. Other elements that keep drawing attention to Iceland in a tourist's eye is Hollywood movies being shot in Icelandic locations, the economic collapse, new Icelandic music etc. combined with easier and cheaper airline access has made the number of tourists rapidly grow ever since.

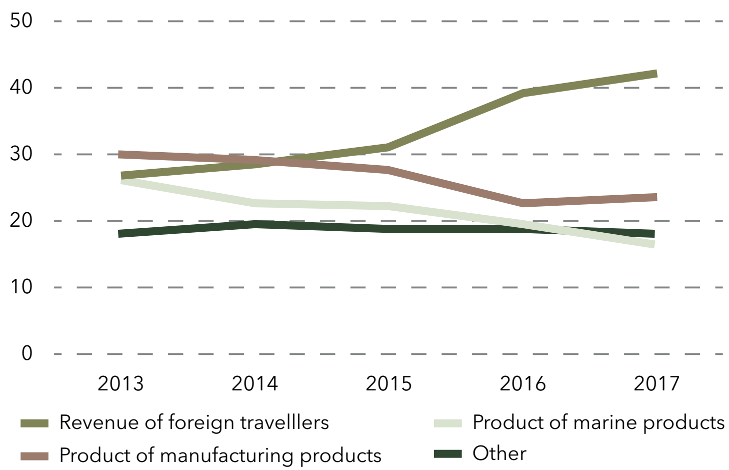
Asking the tourists themselves, topics such as the various nature features incl. the northern lights, interest in the Nordic region, and nature related recreation, are among their top reasons for visiting the country (Óladóttir, O., 2018). However, paradoxically the original Icelandic nature is under massive pressure from this tourist attention, and in many cases, experts are describing the situation as 'overtourism' with tourists being the biggest threat to the aspects that in the beginning attracted them to the island. But how to balance the financial need for tourists and the wish to preserve the unique nature? The Icelandic government is trying to implement solutions to settle the immediate problems such as a ban of bus traffic in Reykjavik and a 90-day limit for Airbnb hosts. However, these solutions are met with much criticism from government opposition and the public, who see the solutions as very short term and ineffective. (Chapman, M., 2017).

It is safe to say, that the main challenge that Iceland faces regarding the tourists, is how to protect the original and treasured nature. The solution would according to some critics be to limit the number of tourists, that are allowed to visit certain sites or Iceland in general. However, others fear that this might harm the attractiveness of Iceland to international tourists, and thereby causing fewer tourists to want to visit the country (Chapman, M., 2017). What might ideally be needed is a change of mind of both tourists and locals towards sustainable tourism: to ensure quality over quantity. For tourists to be understanding and accepting towards the measurements that need to be taken and for the locals to realize that the current income from tourists will only be possible as long as the nature is kept in respect and preserved.

The project will therefore propose a design, that promotes sustainable tourism in a way, that is respectful to the original nature. The complex should use sustainable, biodegradable or reusable materials and promote the use of these materials and their advantages to both local building owners, tourists and the local inhabitants. The visitor center function will promote the area and its attractions while educating tourists on how to act in the area. Locals will see an example of how tourism can be done in a sustainable non-harmful way, while still providing a completely unique experience, that will attract tourists to Iceland.



ill. 12 - International visitors to Iceland in 2010-2017



ill. 13 - Export of goods and services (%) 2013-2017

TURF HOUSES

Being a country influenced and ruled by other nations several times, the architecture of Iceland has through time been affected by many architectural styles. Icelandic architecture offers among other examples of stone buildings designed and erected by Danish architects and houses in Swiss chalet style from the rule of Norway. These styles are still visible and preserved in many parts of Iceland, for example in the streets of Reykjavik where colorful corrugated iron facades show the Icelandic take on the Swiss chalet style. However, traditional vernacular Icelandic architecture has a unique approach to the harsh Icelandic climate and its challenges in the shape of turf houses. According to the UNESCO World Heritage nomination from 2011"the turf house is an exceptional example of a vernacular architectural tradition, which has survived in Iceland," and "The form and design of the turf house is an expression of the cultural values of the society and has adapted to the social and technological changes that took place through the centuries." (UNESCO, 2011). The traditional Icelandic vernacular housing will be described in the following due to its unique approach to the Icelandic climate conditions, its morphology that merges with the landscape and its building technique shaped by scarcity of materials.

Until the 9th century, Iceland was uninhabited. Between 870-930 AD Vikings from Norway accidently found Iceland, when exploring and decided to settle on the harsh island – this first settlement is today known as landnám (Smith, K., 1995). With the settlement there was a need of building materials and due to the scarcity of wood on the island, the answer was turf: the upper layer of the soil intervened by the roots of grass so tightly that it can be cut into mats. This vernacular technique proved to be especially suiting the Icelandic climate and provided a thermally insulating envelope for the cold environment. The concept is not unique to Iceland since the use of turf as a building material is also seen in other areas, however the users of the Icelandic dwellings are unique by being from every class of society, while they traditionally were for the lower classes in other areas (Valgardsson, E.M., 2016).

The idea for the oldest turf houses were brought from Scandinavia and was very similar to the traditional Viking longhouse. Later through time, the houses evolved to gain their own Icelandic touch shaped by the climate and the evolving culture. Turf houses typically consist of a light wooden frame (often driftwood found at shores) covered with stacked turf mats. The foundation and often the walls are constructed from Icelandic stone – either basalt or lava stone depending on the location – to prevent ground moisture. To construct the roof, there were also used turf mats, which over time would grow into each other making the roof watertight. If constructed properly, a roof made of turf can last 20-30 years before needing change (van Hoof, J. et al., 2007). An example of a turf house, that still stands today, is the Glaumbær farm in North Iceland (see illustration 14)

The construction of a turf wall consist of several layers. The wall construction is built one a stone layer to protect against moisture. The outsides of the wall is constructed from rows of inclined turf blocks stacked in layers. In some cases a horizontal layer of sods is used to connect the inner and outer turf, going all the way through the wall. The cavity between the turf layers is typically filled with soil.

The main goal when using turf was to shield the inhabitant from the cold Icelandic weather. By constructing walls with in some cases up to 3,5 m thick layers of turf, the indoor temperature was stabilized and the thermal comfort highly improved. However, the indoor temperature relied heavily on the number of people present in the houses, since the heat from humans in most cases were the only heat source. This also meant, that the air change was kept low to keep the heat inside. So even though the thermal comfort might have been considered satisfactory (by that time), the quality of the indoor air must have been poor, possibly resulting in poor health among the inhabitants (ibid.).

Turf houses were until approximately 1910 one of the most widespread housing types in Iceland housing up to 50% of the inhabitants. With the implementation of modern farming, came modern building techniques and today the existing turf houses are an important and valued cultural aspect, but are no longer used for housing. The turf houses illustrate a unique architectural approach to sustainable architecture and simultaneously express a significant architectural aesthetic by merging with the landscape. Though, their original appearance might not be directly applicable in a modern setting, they do exemplify a very sustainable approach to locally sought materials and the climatic challenges of Iceland.

ill. 14 - The Glaumbær farm

MATERIAL STUDIES

In an environmentally sustainable design, the choice of materials has a great role in a building's impact on the environment. A material's impact on the environment can be compared in several aspects such as the embodied energy and their global warming potential. When choosing materials, one should therefore consider the material in all the phases from production to demolition or reuse. That includes considering aspects as transport, production, maintenance, and lifespan.

Today Iceland has a very limited availability of locally produced building materials as they mainly produce aluminum, concrete, stone wool and basaltic rocks (Marteinsson, B. 2002). With Iceland being almost exclusively supplied by renewable energy sources, the energy used for extraction and production of these materials can be considered vey sustainablein contrast to the pollution cost of importing materials from other countries. The resources used to produce the building materials in Iceland today is not unlimited, the country does however have a great potential for utilizing other natural materials in the building industry. Therefore, the focus when choosing materials in this project, has been on using locally produced materials in combination with challenging the potentials of using other available resources in Iceland. Another focus point has been to work the cradle-to-cradle philosophy focusing on biodegradable materials, whit a minimum of pollution and waste during production. This text focuses on exploring the potentials and disadvantages of some alternative and commonly used building materials relevant for this project, considered in a sustainable matter for the specific location.

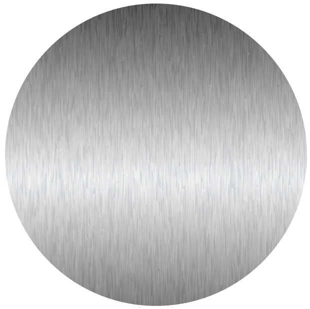
BASALTIC ROCK

Basalt is a rock formed from magma erupted from a volcano. Being placed on the edge of the Mid-Atlantic ridge, Iceland has a high formation of volcanoes with around 30 active volcanic systems, and more than 100 inactive volcanoes. Basalt is a dark grey stone and the most common stone species in Iceland, covering roughly 90% of the rock formations in the country (Steinporsson, S. 2005). When the basalt cools slowly it forms clusters of hexagonal shapes in a columnar structure, which can be cut in blocks and used as a building material like cladding (Perkins, S. 2015). As the rocks are grown in nature, the surface is already very resistant to the weather making it an attractive material to use on exterior surfaces. The natural rough surface of the rocks can bring tactility and depth when used as a building material.

ill. 15 - Basaltic rock

ALUMINIUM

Aluminum is one of the main produced materials in Iceland and is a great export product for the country due to their use of renewable energy during the production. The aluminum industry consumes no less than 73% of Iceland's electricity use. Aluminum is produced from a stone specie called bauxite, where a heating process is used to extract the aluminum from the stone. To do this process a lot of energy is used, and a lot of waste is produced (Aude Raas, J., n.d.). When looking at aluminum, the metal is in far most cases not consumed during the lifetime of a building, making it a strong and reliable material. Aluminum has the potential of being able to be recycled without losing any existing properties, and when first produced, it requires up to 95% less energy to recycle aluminum than to produce it from the primary metals (ALU, 2018). Aluminum can have many uses in the building industry, and is used to everything from structures to cladding, screws and other assembling items.



ill. 16 - Aluminium

DRIFTWOOD

An alternative to using standard wood in Iceland is the driftwood. Driftwood moves through rivers, lakes or oceans, and Iceland has a great volume of driftwood drifting ashore every year. Driftwood is naturally treated by the sun, air, and the salt content of the ocean, making it stronger, better resistant to the tough climate and a long-lasting material. The longer the wood stays in the sea, the more saturated it gets. Surface treatment is therefore not necessary, but the lifespan can be extended with the use of oil or similar. Today the driftwood is mainly used for rough constructions as well as decorative elements in buildings and art projects (NAT, n.d.). Driftwood is often a grayish brown color with a raw natural surface. Compared to other types of wood, driftwood is limited by the assorted sizes and qualities, as well as the amount of driftwood drifting ashore. Considering buildings this can limit the possibilities for using driftwood as a construction material but has great potential for facade cladding. As driftwood is naturally treated on its journey to the coasts of Iceland, the production of the material mainly concerns selection, cleaning and cutting of the wood. Driftwood is a biodegradable material, but as other types of wood it needs treatment to avoid bugs.

ill. 17 - Driftwood

WOOD

Wood is usually considered as a sustainable material among other things because of its low emission during construction and for being a biodegradable material. Compared to driftwood, it is a more reliable material to use for constructions. Likewise the sheep wool, the wood also has the ability of admitting CO2. Wood is a very limited resources in Iceland, as the country still suffers from the first settlers who chopped down big tree-covered areas in order to use the wood for fuel and lumber. Iceland is trying to recreate the green areas with new forests, but have up to the present not been able to restore the forest and vegetation. Therefore, the wood used for buildings in Iceland today is imported from other countries but will hopefully be produced locally in the future (Rodriquez, J. 2017). Wood is an optimum biodegradable choice when building lightweight constructions.

ill. 18 - Wood

CONCRETE

Concrete is a very flexible building material, and one of the few materials which is locally produced in Iceland. Production of concrete normally releases a significant amount of CO2, however, as Iceland produces the material locally the production will be fuelled on renewable energy. Even though concrete is locally produced it is still a heavy material and requires a lot of effort in order to move it from the manufacturer to the building site. One quality when considering concrete in a sustainable matter is the thermal mass properties, helping to stabilize and control indoor temperatures. Concrete is a very strong material with a very long lifespan and can be expected to outlive the need for the building it is used for before it fails due to age (GreenSpec, n.d.). In its raw sense concrete can be described as a green material, made from rocks and other earth materials. As a powder concrete can be degradable, however when the concrete is mixed with water, it quickly starts to harden, which deprive its degradable properties. There is often a lot of water waste during production of concrete, as well as the mixture itself, which will harden, if it is not used immediately. When disposing concrete, it must be broken into pieces in order to be removed in chunks (Murray-White, J. 2018).

ill. 19 - Concrete

SHEEP WOOL

With approximately 800.000 sheep in Iceland and only 323.000 inhabitants, the amount of sheep wool is great (Jóhannsdóttir, E. 2017). Sheep wool can be used as an organic and biodegradable alternative to the traditional rock wool insulation.The process of producing sheep wool as insulation is initially very sustainable as the wool naturally grows on the sheep feeding from grass. Wool captures CO2 as the fleece grows, reducing the global warming potential of the insulation, furthermore wool has a low embodied energy of manufacture. When the wool has been shorn from the sheep, it undergoes a scouring bath until only the raw fibers are remaining. The wool is immersed in a solution to protect it from pests and improve fire resistance. Sheep wool can achieve insulation values on level with traditional insulation materials by its very nature (SheepWool Insulation, n.d.). Consisting of only natural fibers, sheep wool can safely be reused or recycled at the end of its lifespan. Sheep wool will start decomposing when exposed to moisture in a prolonged period. Under ideal conditions, untreated wool can be almost completely degraded in soil within six months (IWTO, 2017).

STONE WOOL

Is one of the locally produced materials in Iceland. Stone wool can be produced with the basaltic rock as the primary material. As volcano activity and plate tectonics every year produces new resources of the stone, it is a natural resource in plenty of capacity. When used for insulation, the basaltic rocks are melted into fibers at a very high temperature and added few amounts of binding material. With a very high R-value, stone wool is one of the most efficient insulation materials on the market. Compared to sheep wool, stone wool isn't biodegradable, but today a big part of the product can be reused in new insulation after end of use, however it requires that the material is clean and contain a minimum of foreign substances which can be transferred from other nearby construction materials (Rockwool, 2017). When considered in the context of Iceland, stone wool can be seen as an optimum choice as it is locally produced and thereby easy to come across. However, Iceland has a great potential for exploiting the production of sheep wool insulation. Sheep wool can achieve the same thermal properties, is biodegradable and doesn't leave any toxic waste.

GLASS

As glass is not locally produced in Iceland, all glass is imported. Glass is an importing part of a building, as it allows natural light to enter the building and is a visual connection between interior and exterior spaces. Glass is a fully recyclable material made from abundant natural raw materials. The combination of raw materials impacts the properties of the glass. The raw materials are heated to a melting point converting the fibers into glass. Glass can be recycled again and again to use in another glass product, this means that the waste during production is very low, as almost all the glass can be reused. The recycling process of glass saves energy in the melting process, as the cullets melt at a lower temperature than the original raw materials (GlassAlliance Europe, n.d.). As the material is not locally produced today, it will often be produced from fossil fuels and release CO2 during production as well as when transported. However, due to the unique qualities of the product, it is difficult to replace with a more sustainable alternative.

ill. 20 - Sheep wool

ill. 21 - Stone wool

RAMMED EARTH

In light of the wish to use the cradle-to-cradle principle, the historic turf houses propose an on-site solution for the load bearing construction of the complex: rammed earth constructions. The historical problem of scarce construction materials still exists in Iceland, however, the modern ways of acquiring materials through often expensive and non-sustainable import, has made it possible to use other materials. When searching for a new solution to the problem, it is obvious to look back to the traditional vernacular way of using earth. Some of the biggest advantages of using earth is its ability to completely return to nature after its end of life stage and its good indoor environment qualities such as its thermal mass and acoustic properties.

To take the harsh wet Icelandic climate into consideration, the construction would probably have to be pre-fabricated, so that assembly on-site will take as short a time as possible. Pre-fabrication is a relatively new way of working with rammed earth, and the process expands the types of projects, that can be done using earth as a construction material (Sauer, M. 2015), meaning the construction method can replace other less sustainable solutions.

To construct using rammed earth, the first thing to pay attention to, is the quality of the soil available regarding its mixture of different soil types. The most common agreement among constructors, are that the best load-bearing properties are gained when using a 30/70 mixture of clay and sand (Rammed Earth Works, 2010). However, this does not have to be followed exact, since there are numerous examples of rammed earth constructions with a different composure, that time has proven strong. More importantly, the soil mixture should be tested before building and optimized according to the results by e.g. adding more clay. In Iceland there are several types of soil, that can be used, however, there might be a need for mixing the types to optimize the composure. The most clayey soil type available in Iceland is called histic andosol and has a clay content of around 36% (Arnalds, O. 2015), meaning that this is suitable for rammed earth construction. Though this type of soil is available in Iceland, it is not present on site (Rangarvellir), meaning that if used on the specific site for the project, the soil might possibly have to be mixed with this histic andosol to improve the properties. Histic andosol is present in the area around the town of Akureyri located approximately 50 km from site. Due to the histic andosols appearance in Akureyri, the town could very well house the place of prefabrication. Being the second largest city in Iceland, Akureyri will very likely also have labour for the process. However, this leads to some transportation of both soil and finished structural components, but it is expected to outweigh the alternative cost of construction on site since this will require extra time and protection against weather.

Designing with earth as a material sets some guidelines just as all other materials. Using the material on its own conditions leads to a clear design strategy focusing on the properties of the earth. Based on *A Review for Rammed Earth Construction* (Maniatidis, V. 2003) and *Rammed Earth Construction – Cutting Edge on Traditional and Modern Rammed Earth* (Ciancio, D. 2015), the following design guidelines will be used in the design:

Min. distance between windows in load bearing construction:
600-1000 mm

Height above window crown:
450 mm

Max.length of windows on façade:
1/3 of total façade length

Min. distance from wall corner to first window:
750 mm

Min. thickness of wall: 250 mm (New Zealand standard)
Place a lintel above windows, when making a larger span.

ill. 22 - Rammed earth

AURORA

The aurora is a phenomenon displaying colorful lights dancing in the sky. Many mythologies have been written by our ancient ancestors describing the aurora phenomenon, who have believed the phenomenon to be spirits of gods bringing all from good to bad. Depending on the location, the frequency of the aurora light varies greatly, and different legends have been told. In the Norse mythology one legend suggest that the lights were to be a glowing bridge which led those fallen in battle to their final resting place in Valhalla, while another says that the lights were reflections from the shields of female warriors deciding who may live and die in battle. The Icelandic ancestors associated the aurora lights with childbirth and believed that the lights would relieve the pain if the expectant mother didn't look at the sky whilst giving birth (Aurora Zone, n.d.).

Considering the aurora scientifically it is a nature phenomenon displaying lights in the sky visible around the magnetic poles of the northern and the southern hemispheres. 'Northern light' and 'Aurora Borealis' are two terms for auroras in the northern hemisphere while auroras occurring in the southern hemisphere are called 'Aurora Australis' or 'Southern lights'. Green is the most common color for auroras, but it can also change between nuances in yellow, red, blue and violet. The color depends on the type of gas particles colliding and their height location above the earth's surface (Service Aurora, 2019a).

The closer one gets to the magnetic poles, the bigger the chances are for the phenomenon to occur, as the strength of the light needed for it to be visible is smaller. The magnetic south pole lies in Antarctica, making locations near the magnetic north pole such as North America, Northern Scandinavia and Iceland more attractive locations for watching the phenomenon. Other light sources pollute the opportunity for observing the phenomenon, therefore a more remote location in a distance from the city is ideal. The closer to the north pole one is located, the higher the aurora will be displayed on the horizon. (Service Aurora, 2019a). The Aurora is displayed in an irregular oval shape centered above each magnetic pole. The size of the oval depends on the geomagnetic activity at the poles. At a low activity the oval will be smaller while at a higher activity the size of the oval will expand. The size of the Aurora-oval changes the optimum location from where to watch the northern light as well as the direction to look. The size of the geomagnetism depends on the activity of the sun (Service Aurora, 2019b).

To determinate the best location for the phenomenon of aurora can be difficult, hence it relies on reaching a balance between several factors. The winter months are the darkest, creating an optimum foundation for watching the lights, however even though the winter months have a high frequency of clear nights they are also the cloudiest. At the same time the activity of the sun as well as the strength of the northern lights should be considered. These aspects make the northern light a rare attraction, causing people from around the world to travel north to experience the phenomenon (Service Aurora, 2019b).

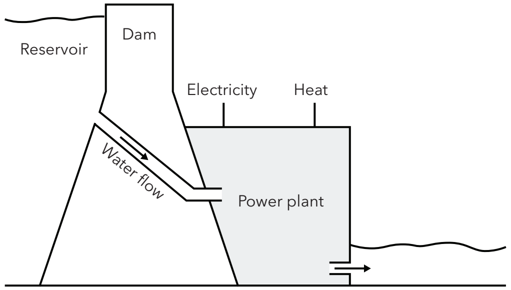
Given the location for the project a very little strength is needed for the northern light to be visible from the site. As the Aurora Oval changes size with the amount of geomagnetic activity, Iceland's position in proportion to the magnetic pole allows the northern light to be visible in changing orientations. The most common orientation to watch the northern light will be north or northwest, which is in the direction of the northern magnetic pole, where the northern light origins. However, as the oval sometimes will expand the northern light will be showcased in the sky above the country or occasionally towards the south. The northern lights are an interesting aspect to include in the design, as it is a unique aspects of Iceland and an illustration of the wonderful things the nature has to offer. To make the best use of the northern light and at the same time create the best conditions for watching the phenomena, the design of the building should be flexible, so that it can be fitted to the conditions at a specific time.

ill. 23 - Northern light in Iceland

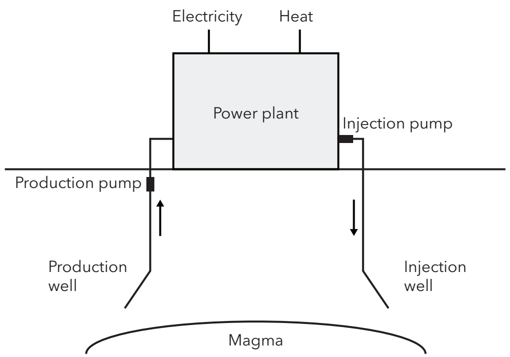
RENEWABLE ENERGY

With its unique geographical placement right on top of the Midatlantic Ridge, Iceland offers exceptional possibilities for producing renewable energy in the form of mainly geothermal power and hydropower. As of today, almost 100% of Iceland's electricity consumption and nearly 85% of the total consumption of primary energy is covered by renewable energy (Askja Energy, a). The electricity is supplied by the so-called Landsnet, which is Iceland's electricity grid. This grid is extremely reliable and up to date, since continuous maintenance is of high priority. The Landsnet consists of both underground and overhead cables and lines, that connect approximately 70 substations which supplies the users. (Askja Energy, b). These geothermal substations consist of three kinds: power plants, heat plants and CHP plants. In power plants the geothermal energy is used to produce electricity, while heat plants use the energy to produce heat for the district heating system. A combination of these, are the CHP plants, which stands for combined heat and power plant. All power plants and CHP plants are connected to the Landsnet, while the heat plants are connected by the district heating system together with the CHP plants (Björnsson, S., 2010).

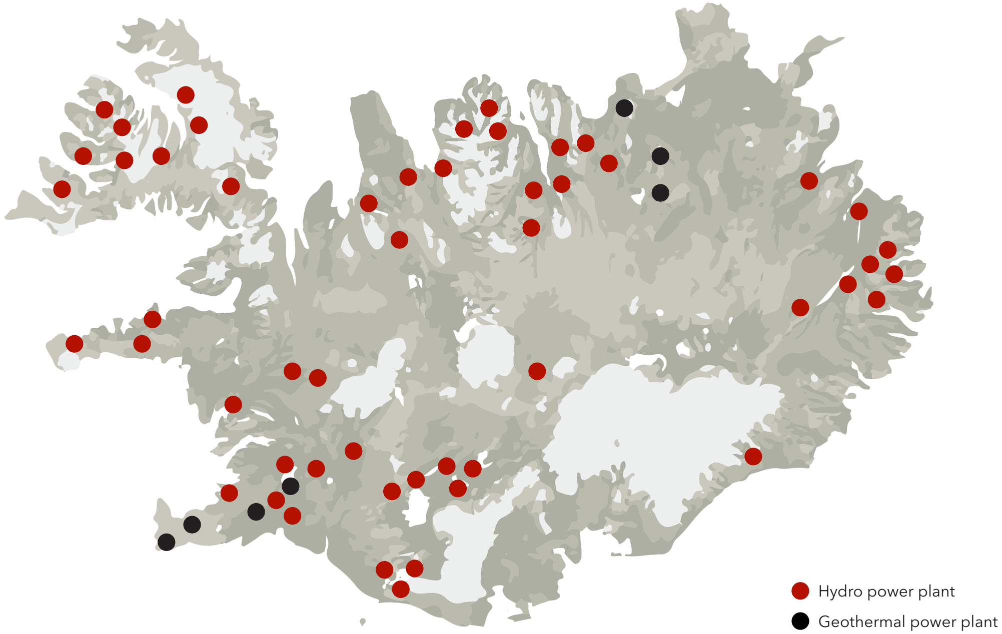
Due to this very well-developed energy grid, the benefits of connecting a building to this grid must be considered when designing the energy system for the project. Though the competition asks for a self-sufficient building, the advantages of connecting to the energy grid, weighs higher. Being connected to the grid utilizes an already existing power plant and therefore removes the need for establishing an on-site energy production. A such establishment would probably be in the shape of a geothermal system, that can have a relatively high impact on the site due to drilling far into the ground, which does not resonate well with the wish to leave as little impact as possible when the building reaches its end-of-life stage. Therefore, the building can very well be connected to the nearby Bjarnarflag plant, which is a CHP plant – a combined heat and power plant – meaning that the building complex can be connected to both the electricity grid and the district heating system from here (Orkustofnun, 2019). To connect the building complex to the grid, it will be needed to establish pipes and cables to the site, however the surrounding towns of Vogar and Reykjahlíð are presumed to be supplied by the Bjarnarflag plant and there are therefore existing lines and pipes very close to the site. The establishment of these, are expected to be done simultaneously with the connection to the sewer system in the initial building process.



ill. 24 - The principle behind using hydropower



ill. 25 - The principle behind using geothermal power



ill. 26 - Map of hydropower and geothermal power stations

SITE STUDIES

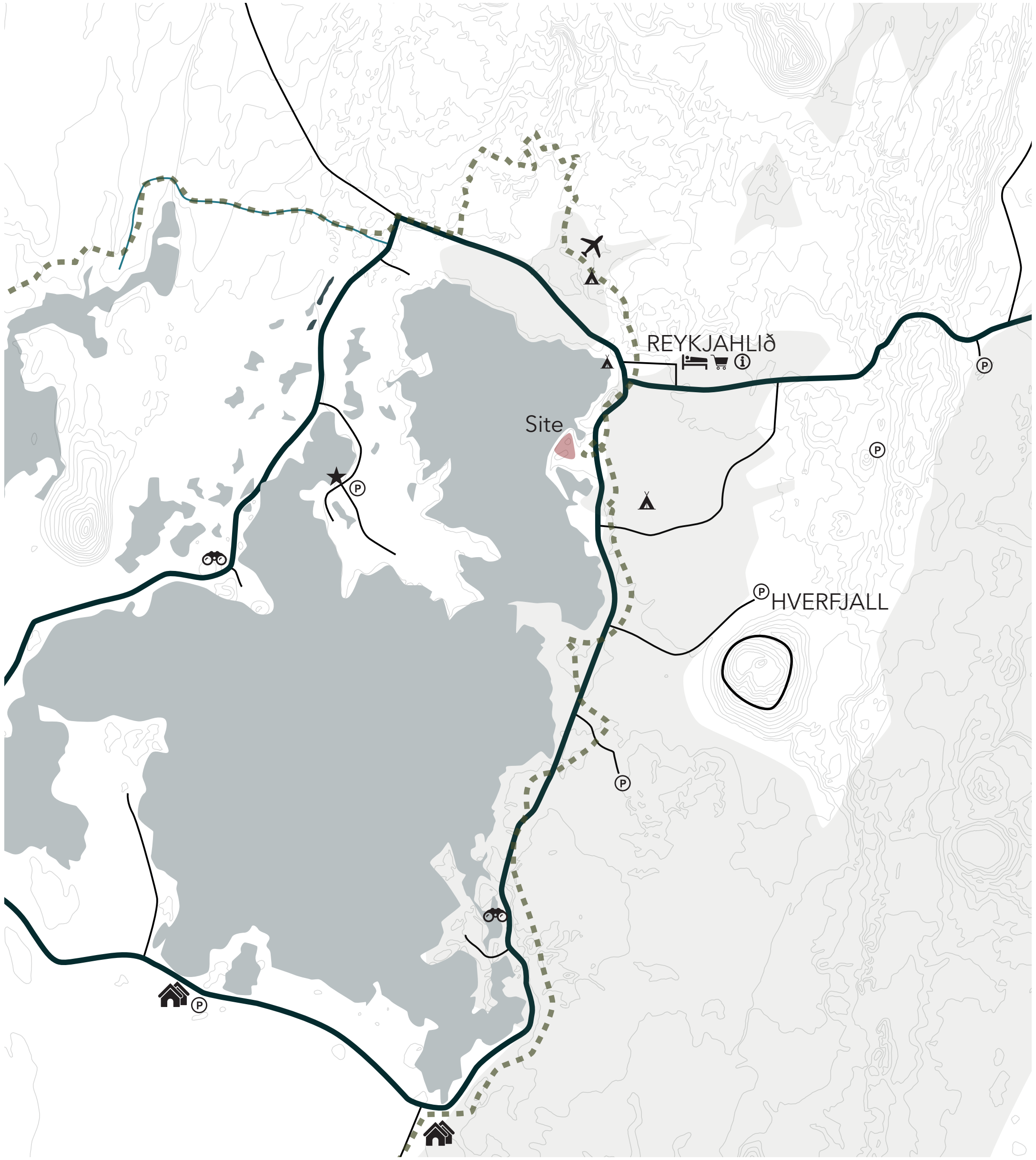
This chapter will present the project site and its nearby context. The chapter will start by introducing the site in its context by the use of a mapping analysis. The site is afterwards further investigated in terms of its climatic conditions and considerations towards the geology, topography and vegetation. Pictures of the site will be presented, to support a phenomenological understanding of the site. By the use of both quantitative and qualitative data, the site analysis will seek to give an understanding of both measurable characteristics of the site along with creating a more visual perception.

MAPPING

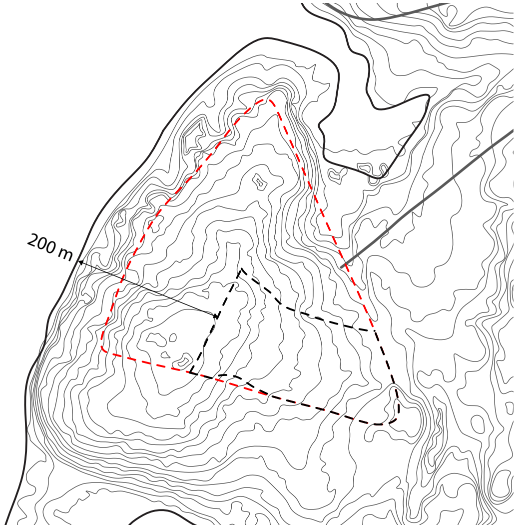
The project site is located north east of the lake Myvatn between two bays. It is approximately 3 hectares and is positioned in a protected nature area which has been monitored by Myvatn Research Station since 1976, due to it being a popular nesting area for ducks. Because of this nature area, the competition material states, that no permanent construction is prohibited within 200m of the lake.

The site is close to the small city Reykjahlíð located north of the site. The city offers hotels, shopping opportunities, a tourist information center and a visitor center which is open during the summer months. Other accommodation opportunities in the area include camping sites close to the lake. The area is connected to the remaining Iceland by the Ring Road which connects all the main cities of Iceland, and there are several opportunities for parking in the area. The area also offers different tourist attractions such as hot springs and the Hverfjall volcano, which is close to the project site. North of the lake Myvatn is a small airport, which besides having international traffic, also offers sight-seeing flights above the lake.

Being connected to the ring road and offering several nature tourist attractions to explore in the nearby area, the site offers a great potential for a project which is easy to access, compared to many other destinations in Iceland. In contrast to the existing functions in the area, the project will provide a combination of accommodation facilities along with a tourist attraction represented in the visitor center, reaching out for a wide target group. The complex should be open all year, and thereby bring activity and life to the area through all seasons.



ill. 27 - Lake Myvatn and its surroundings , 1:90.000



ill. 28 - Project site, 1:10.000

- Airport
- Tourist information
- Hotel
- Shopping
- Museum
- View point
- Village
- Parking
- Lava stone area
- Lake
- Protected nature area

SITE DESCRIPTION

The following description is based on provided photos and videos from the competition material. The videos include 360 degrees views of the site along with an oral description of elements visible from the site. Furthermore, the description is based on studies of maps and Google Streetview. (BeeBreeders, 2018).

Following the road running along the lake Myvatn, you will arrive to the site from the North East. The site is hidden from the road by small birch trees and lava rock formations, and you will have to leave the main road and continue by a narrow dirt path to access the site. At first, you experience that the vegetation embraces you with birch trees, but changes to mainly low plants, such as grass and small shrubs when you move closer to the site and suddenly you find yourself in an open field. The basalt rocks become fewer and fewer until arriving at the site, where the ground is mainly covered in long grass. Right before entering the actual site, a small part of Myvatn is visible to the right with the small town of Reykjahlid appearing in remote distance behind the lake. To the left, one can see the remote mountains and the volcano Hverfjall behind the small village of Vogar. The birch trees and rock formations that before embraced you, now shelter the site from the road and cancel out the noise from the traffic, leaving the site calm and silent. From the highest point of the site, one can overlook the lake Myvatn and the entire site.

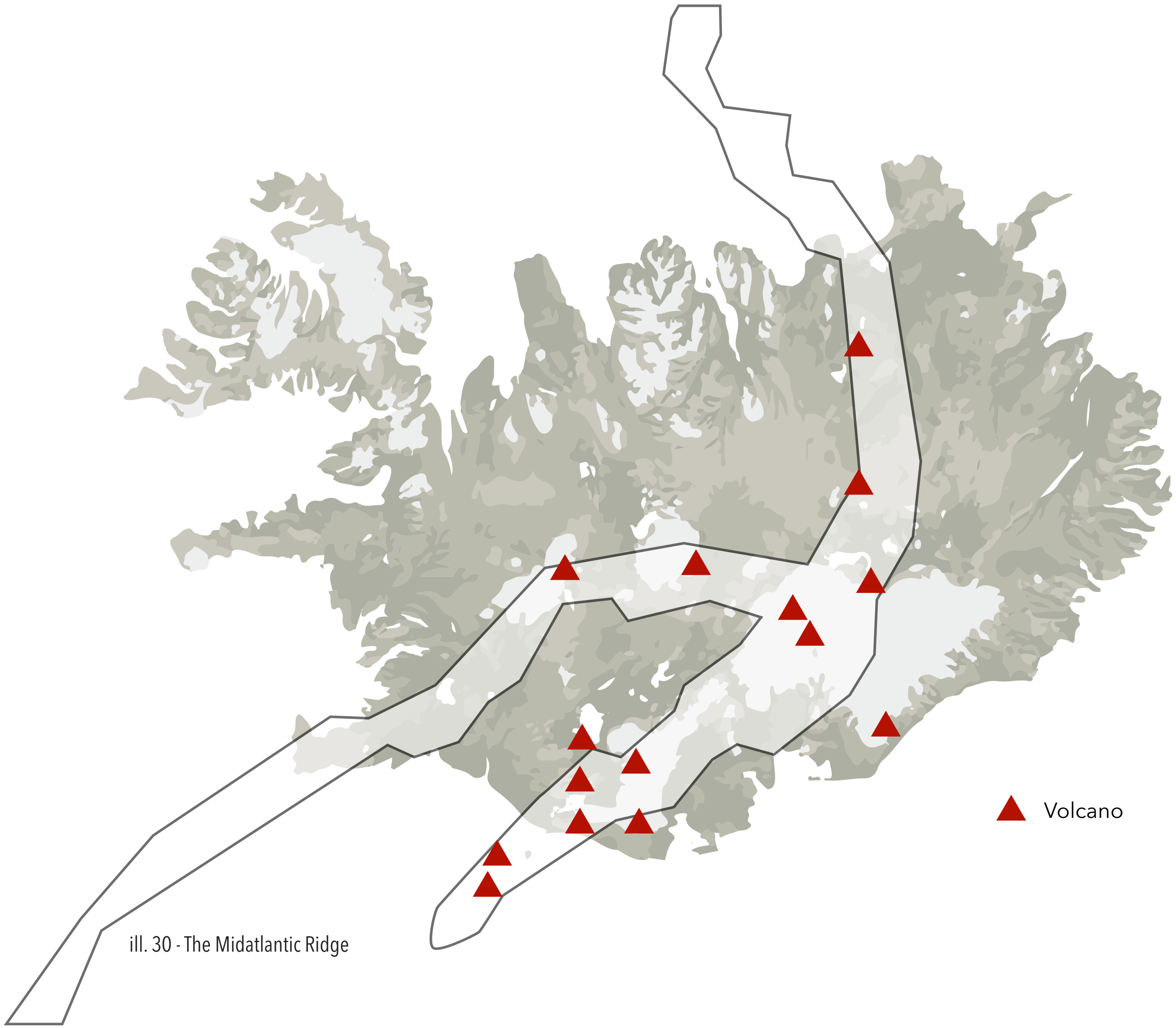
ill. 29 - Site pictures

ICELANDIC NATURE

Iceland has a very unique climate being placed on the edge of the polar circle but right on top of the so called Mid-Atlantic Ridge, that is the meeting between two tectonic plates called the Eurasian plate and the North American plate (Mustain, A., 2012). Though the air temperatures might be low, the underground contains much volcanic activity that often emerges through the surface in the shape of volcanoes and hot springs. As seen on the map (ill. 30), the Lake Myvatn lies in the volcanic zone, meaning that there is a potential for volcanic activity in the area. This is seen in the presence of the Hverfjall volcano and the relatively close Krafla volcano. There is also many hot springs in the area, whereof several are used baths. The volcanic activity can also be seen when visiting the so-called pseudo craters in the area, that are caused by lava flows over wet ground.

Iceland contains glaciers with an approximate 11% of the ground being covered by glaciers. These are mostly located in the midlands and the southern parts of Iceland due to the lower average annual temperatures in these higher grounds than closer to the coasts. Caves are also a very common nature phenomena in Iceland, and in some places it is possible to experience ice caves, which is caves formed in the glaciers during the coldest periods. The biggest glacier of Iceland is called Vatnajökull and is around 8000 km^2 (Notendur).

There is no place with a similar clash between fire and ice and the Icelandic culture has through many aspects been affected by these climatic elements such as volcanoes erupting. These nature and climate phenomena are extremely unique to Iceland and have resulted in several natural elements near the site, that can inspire the design of the architecture – for example the volcano, volcanic rocks, pseudo craters and hot springs – to create localized architecture with a high relation between the building and the natural context. Furthermore, the rare nature phenomena of Iceland offer great opportunities and potentials for the use of renewable resources, which should be integrated into the design solutions.



ill. 30 - The Midatlantic Ridge

ill. 40 - Hot spring

ill. 42 - Godafoss waterfall

ill. 41 - Pseudo crater

ill. 43 - Rock formations


ill. 44 - Fumarole


ill. 45 - Glacier

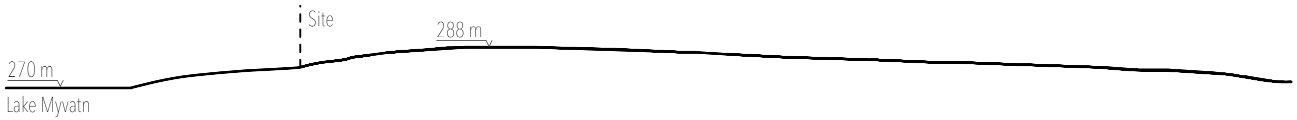

ill. 46 - Floating iceberg


ill. 47 - Waterfall seen frome cave

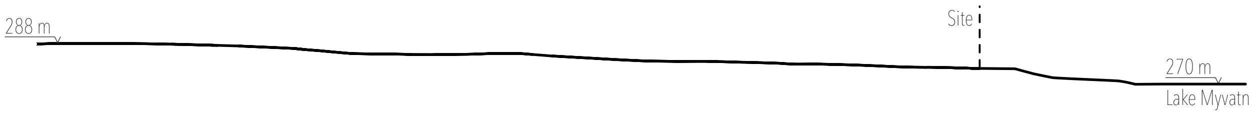
TOPOGRAPHY

The site and the surroundings near Lake Myvatn is characterized by being relatively flat compared to other nearby areas such as the volcano Hverfjall. The height above water of the site varies from 272 to 288 meters above water. As seen from the sections, the sight has an almost steady increase in height toward the highest point on the site located in the south western part. There is a significant height variation between the site and the surface of Lake Myvatn.

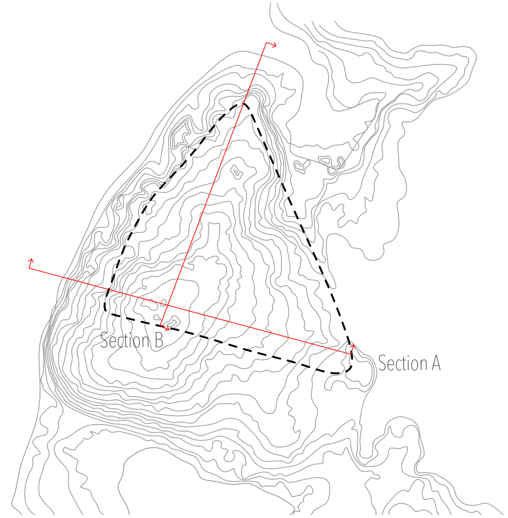
The varying topography of the site offers different approaches to the architecture, and the topography should be considered when investigating solutions for fitting the building to the land. The placing of the building on the site is important, as it offers different possibilities of using the topography in the design. The hill on the site, gives an opportunity for using the topography as an element in the design, for example by digging into the hill and creating a cantilevered building. In contrast, the flatter areas of the site will ask for less interference when building. When working with a terrain with different heights, it will also be important to consider the views to and from the building, when choosing where to place and how to orientate the building on the site.



ill. 48 - Section A, 1:3000



ill. 49 - Section B, 1:3000



ill. 50 - Map with sections

ill. 51 - Relation between building and landsacpe

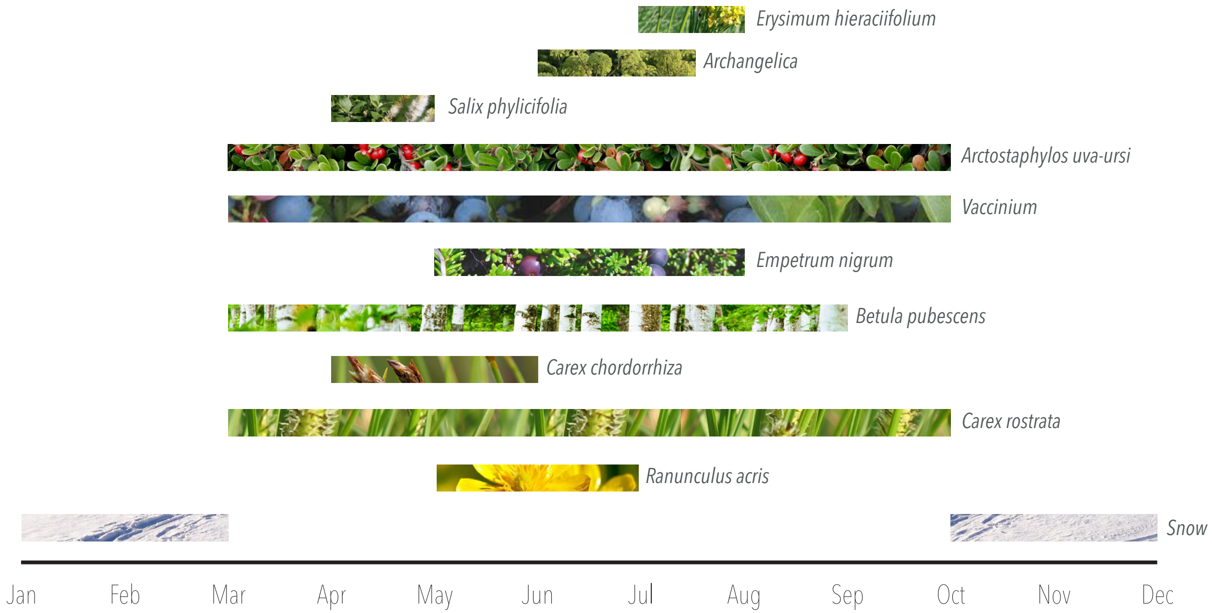
VEGETATION

The area around Lake Myvatn is one of the most fertile in Iceland due to the many minerals in the water from the lake. This provides good ground conditions for many types of plants and animals to live at. Regarding the vegetation, there is primarily low to medium high plants such as blueberry bushes (Vaccinum) and willow (Salix phylicyfolia).

As in the rest of Iceland, there is not many trees except for birch trees (Betula pubescens), which are most common in the northern parts of the area around the lake including the project site. In July and August, it is possible to find the plant Eysimum hieracifolium, popularly called Queen of Myvatn, which is very uncommon in the rest of Iceland (Notendur).

The growing season normally starts around March; however, this depends on the temperatures and when the snow melts. When exactly the landscape starts to color with plants, often varies from year to year.

The area around lake Myvatn is in general very rich on nature, where bushes and other vegetation serve as a delight for the sights as well as a survival source for animals in the area. The specific area chosen for the project is mostly composed of different grasses and other ground cover plant, making it less planted than much of the nearby area. This makes the site a suited candidate for building, compared to the rest of the area, as it will not demand the same interference with the planting.

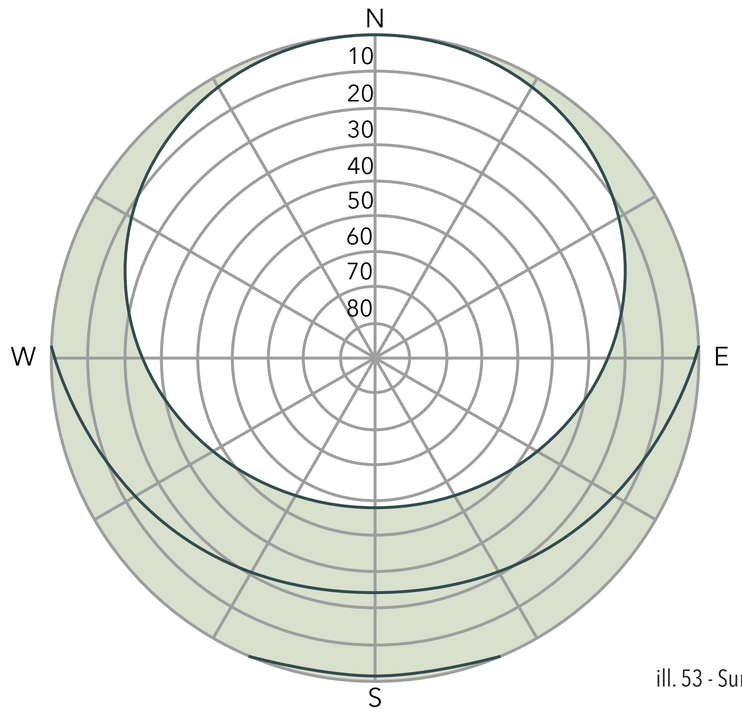


ill. 52 - When some of the most common plants in the area are the most visible

SUNPATH

The sun path is based on data from the city Akureyri located to the north west of lake Myvatn (Gaisma). It shows how the sun moves during the year, and illustrates the equinox, the summer solstice and winter solstice. It is noticeable that the day is very short during the winter, because the sun rises late and sets early. This means, that the winter month have very good conditions for watching the northern light. Opposite, the day is very long during the summer, and the phenomenon midnight sun can be experienced since the sun only sets for very few hours.

When designing in a climate, where the sun is only visible for three hours a day during winter, it will be essential to work with ways of achieving as much potential from these hours as possible. That means, that the building complex should be designed with high considerations on this aspect, which can have influence on the general orientation of the building and its outdoor areas as well as how to place different rooms inside the building.

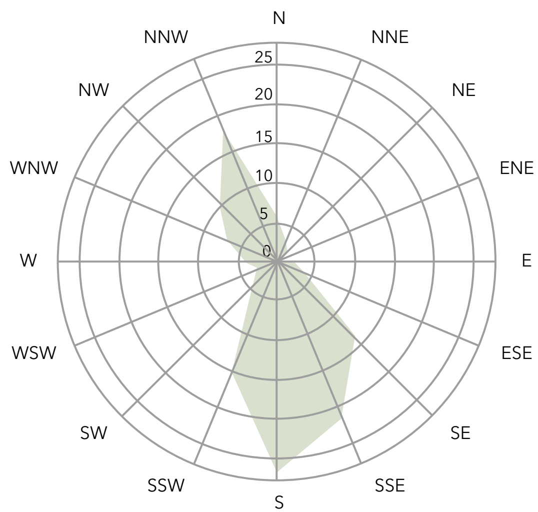


ill. 53 - Sunpath, Reykjahlid

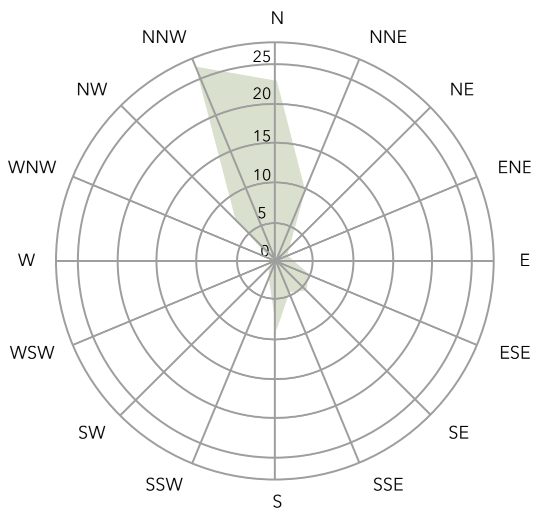
WIND

The wind roses are based on data from the Akureyri Airport located to the north west of lake Myvatn (Windfinder, 2019), meaning that they are not from the exact site which should be considered in the analysis. As seen from the two wind roses, one for summer and one for winter, the wind direction changes a lot during the year. From studies of the remaining year, it was shown that the general conditions during the winter are very similar to the one for December, where most wind comes from south, while the general conditions during summer are very similar to the one for June, where most wind comes from north.

Since the building will have visitors both during summer and winter, it is important to integrate ways to shelter from wind both during winter and summer, when shaping the building and the outdoor areas. One challenge will be how to make a shield from the wind from south during winter, without compromising with the qualities of the rare winter sun, also coming from the southern direction.



ill. 54 - Wind rose, December

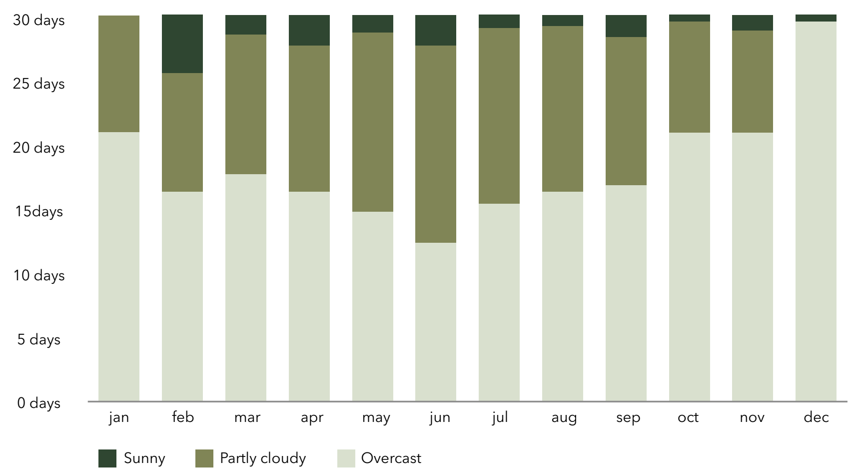


ill. 55 - Wind rose, June

CLOUDS

This graph is based on data from Reykjahlid, and indicates how many sunny, overcast and partly cloudy days occurring during each month of the year (meteoblue, 2019). As seen, there is almost no sunny days during winter (December and January have none). This is also due to the very few hours with daylight each day during the winter. Most of the days during the rest of the year are overcast or partly overcast, which effects the chances to see the aurora. Since the clouds determine if the aurora is visible or not, this can have influence on the activity at the resort in periods.

In case of bad weather conditions, exhibitions and other ways of learning about the phenomena can be another way of getting close to the northern light. In situations where the sky is only partly clouded, it could be considered if the design of the building could be adaptable, to always give the best opportunities for watching the aurora.

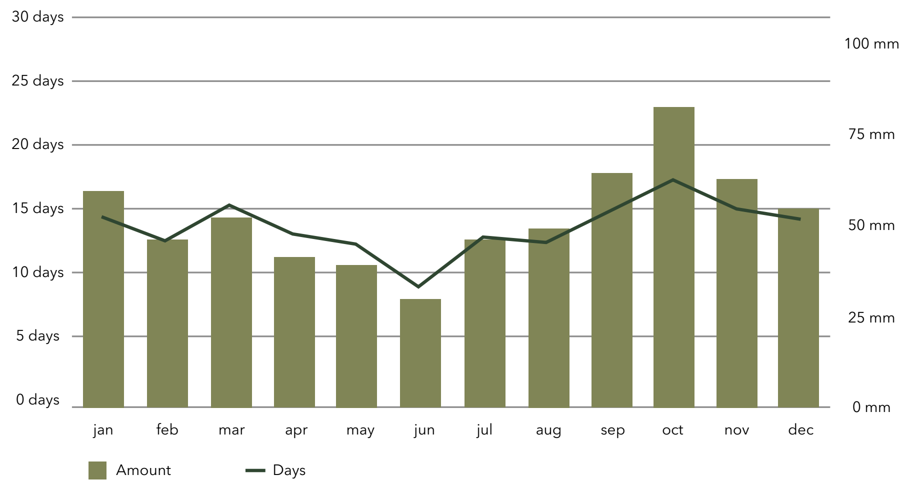


ill. 56 - Amount of days pr month that are sunny, partly cloudy or overcast

PRECIPITATION

The precipitation graph is likewise based on data from Reykjahlid and shows the annual amount of precipitation along with the annual numbers of days with precipitation per month (meteoblue, 2019). The data shows that the area in general have a steady amount of precipitation all year, but most of it will fall during autumn and winter.

The data shows, that precipitation will fall all year on the site. This offer an opportunity for working with collection of rainwater to use for running the buildings as self-sufficient. This should be considered in the design, to achieve an integrated solution for gathering rainwater. The distribution of the precipitation is irregular during the year, why it should also be considered to work with storage facilities. During winter a lot of the precipitation will fall as snow due to low temperatures - this should be considered when designing, as it affects the needed load capacity of the building constructions and can cause possible complications with transport in the area. Furthermore, long periods only with snow, can also cause challenges regarding collection of rainwater, where it should be considered if a combined system with other solutions, such as exploiting the water from the lake, is needed.



ill. 57 - Number of days pr month with precipitation and the amount pr month
From November to March, the precipitation falls as snow

CASE STUDIES

With offset from four key focus points, it is chosen to analyze three entries from the BeeBreeders competition from 2018. All entries were available on the competition website, including the winning project, the two runners-ups and some honorable mentions. From all entries, three were chosen based on their general qualities and especially with the following key points in mind: Self-sufficiency, creation of atmosphere, relation to context and movability/adaptability.

To investigate the qualities of the projects, they were assessed based on their strengths and weaknesses related to the before mentioned features. Self-sufficiency is valued depending on their ability to produce own energy, independence from the grid, choice of energy source and implementation in the actual design. Creation of atmosphere is valued based on the theory of Peter Zumthor and Juhani Pallasmaa and focuses on how the materials are used, the scale of the buildings compared to the human body, and how the tension between interior and exterior is handled. Relation to context is valued depending on how the project is fitted to the surrounding landscape, the Icelandic tradition and history, and if it draws inspiration from the nature around it. The movability/adaptability of the project is discussed based on its flexibility, the users' ability to change the placement, and the overall convenience.

The studies of the competition entries help by identifying elements and aspects of the designs, that are interesting in the light of other analysis, such as relation to landscape, creation of atmosphere, detailing and moveability. From the study, the importance of a strong relation to tradition, history and context is seen especially in the project The Circle, where the turf houses play a large role as inspiration. This is similar to the wish of using inspiration from traditional turf houses in a modern way, however the introversion of the project is less desired due to the wish of having a view to the surroundings. Therefore, a surrounding introvert shape is desired to be avoided. This is handled differently in the winning project IN-visible, in which the main building is constructed with traditional turf walls but orients itself towards the outside nature as desired in this project.

From the solution for the cabins in the Thule project, the high level of user flexibility regarding placement on site is inspirational. The users control where the bedrooms are placed through an app, however the cabins become rather large and static, where only the bedrooms are movable. This solutions could be integrated in this project by having the users decide where the cabin is placed with the help of the staff. Possibly the users can request the cabin moved after their wish and this movement around site, will facilitate a variation of experiences in nature.

IN-VISIBLE

This project by Kamila Szatanowska and Paulina Rogalska was chosen as the winning project (Szatanowska, K. et al, 2018). The project consists of a number of moveable cabins with a central building made from turf among other materials. The cabins are constructed with wheels and are clad with reflective glass, that is transparent when looking out with no light turned on, but reflective when looking in. The central building has a strong relation to the Icelandic culture by using turf – however it is used in a combination with modern insulation to improve the performance of the wall's insulation. The use of the turf is also visible when being in the internal courtyard, which becomes a link between the interior and the exterior.

	Strengths	**Weaknesses**
Relation to context	- Strong relation through traditional turf - Merge with landscape through reflective glass	- Main building becomes introvert by not utilizing the surrounding site and creating its own interior courtyard
Self-sufficiency	- Cabins are equipped with bath, toilet and kitchen - Main building uses geothermal heating - Thermal bath using hot springs from the lake	- Cabins use gas that needs to be refilled from unnamed source
Creation of atmosphere	- Transition between interior and exterior is enhanced through rough materials and use of exterior structures - 360 degree view to the Northern Lights in cabin	
Movability/adaptability	- Equipped with wheels	- Wheels are dependent on flat ground and can only be moved by vehicle

ill. 58 - In-Visible exterior of Cabin

THULE

THULE is a project by Matteo Pegorin, Massimo Fontana and Franscesco Quattrone (Pegorin, M. et al, 2018). The project takes inspiration from the Icelandic climate and the seven largest volcanos and consists of seven guesthouses, a restaurant, a sauna and the host family house. The layout of the whole complex is inspired by the shape of the ridge between the tectonic plates, that are under Iceland. The guesthouses propose a unique approach to movability by having one or two bedrooms that are able to detach from the remaining house (toilet, kitchen and small living area) through an app. The bedrooms can be controlled and moved with the app and are equipped with both wheels and floatable pontons that make the bedroom able to be on ground and water.

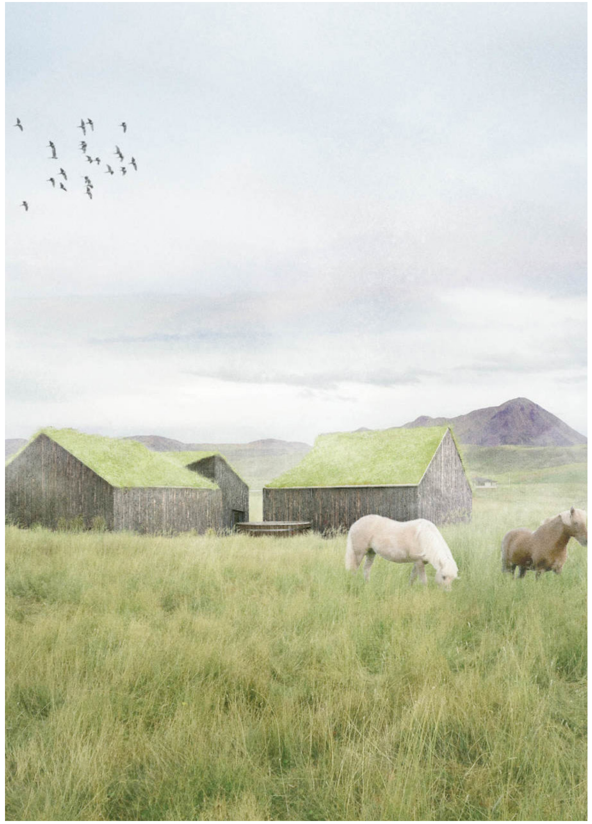
	Strengths	**Weaknesses**
Relation to context	- Inspiration from the Icelandic climate and the seven largest volcanos gives a strong relation to the context	- Due to the strong concept of the volcanos, the buildings are not very fitted to the actual site
Self-sufficiency	- Uses a combination of geothermal heat and photovoltaic cells as supply - Rain water is used for toilet flushes - Uses solar gain as passive strategies	- Drinking water is supplied from the grid and not produced on site - Solar panels are unreliable in winter dur to very limited hours of sun
Creation of atmosphere		
Movability/ad-aptability	- Bedrooms can detach from the cabins and be controlled by the user through an app	- Only bedrooms are movable and not the remaining cabin

ill. 59 - Thule, terrace at Cabin

THE CIRCLE

The project The Circle was made by Kinga Grzybowska, Michal Hondo, Vera Swahn and Erpinio Labrozzi (Grzybowska, K. et al, 2018). It is inspired by the traditional vernacular housing in Iceland: the turf houses, that are typically placed right next to each other. The project has a strong relation to the Icelandic culture by using this traditional principle and placing the houses in relation to each other by centering them around a hearth – another important element in the Icelandic culture. To house the people, who are going to be present in the main building, the project also focuses on the human relation to the building through varying scale in spaces and rooms and an embracing shape. The project has a clear sustainable strategy making the building completely self-sufficient by using wind power and geothermal heat. The cabins are supplied using batteries, that can be charged by the wind turbine.

	Strengths	**Weaknesses**
Relation to context	- Inspiration from turf houses are used in a layout that embraces and protects against the weather conditions - Some of the permanent buildings are embedded in the ground to use soil as insulation, like turf houses	- Main building becomes introvert by not utilizing the surrounding site and creating its own interior courtyard
Self-sufficiency	- The cabins use rechargable batteries that are charged by a wind turbin on site - The permanent buildings are heated using geothermal heat - Water is collected from all roofs and stored in a central tank	
Creation of atmosphere	- A high attention to detailing and joining of construction elements, create a sensual and atmospheric building - The human scale and relation to the building is adressed through various sized rooms and building elements	
Movability/adaptability	- Cabins are equipped with wheels - Cabins are made from functional elements, so a high flexibility in the design is reached	- Wheels are dependent on flat ground and can only be moved by vehicle



ill. 60 - The Circle, exterioir of main complex

PROGRAMME

The programme is an outline of studies related to different functions in the building. The chapter will begin with an elaboration on different ways of addressing a visitor center. This will be followed by a description of different user groups and their mutual interactions. Finally, a room program will further describe the intentions of the individual functions, while a design matrix explains the functions relation to one another. The aim of this chapter is to understand the importance of the individual functions and establish a point of departure for the programming of the building.

VISITOR CENTERS

The Icelandic nature and its phenomena are the main reasons tourists travel to Iceland as previously stated. Nevertheless, this regional tourism is also the biggest threat towards the very same nature due to their massive number and their treatment of it. Educating tourists about the environment they are visiting, helps to raise their respect for the nature and their consideration when they are travelling and experiencing it. To actually do this, our project will comprise a visitor center functioning as a learning tool/education hub about the Icelandic nature as the setting for the Northern Lights.

The planning and design of the mentioned visitor center takes offset from the studies of Philip L. Pearce, Professor of Tourism at the James Cook University, Australia (Pearce. L., 2004). He proposes the so-called Four Plus model for the planning and functioning of a visitor center focusing on improving the experience in and effect of visiting a visitor center. This method will be used to specify the type of visitor center that is needed, and which functions should be considered in the design to promote sustainable tourism in the area.

With the Four Plus model Pearce identifies four main functions of a visitor center. They are often overlapping and differ in importance depending on the present visitor center and its purpose. The functions are:

Promotion of the area: this function involves the active promotion of an area with the goal of stimulating tourist demand and often increase the number of visitors.

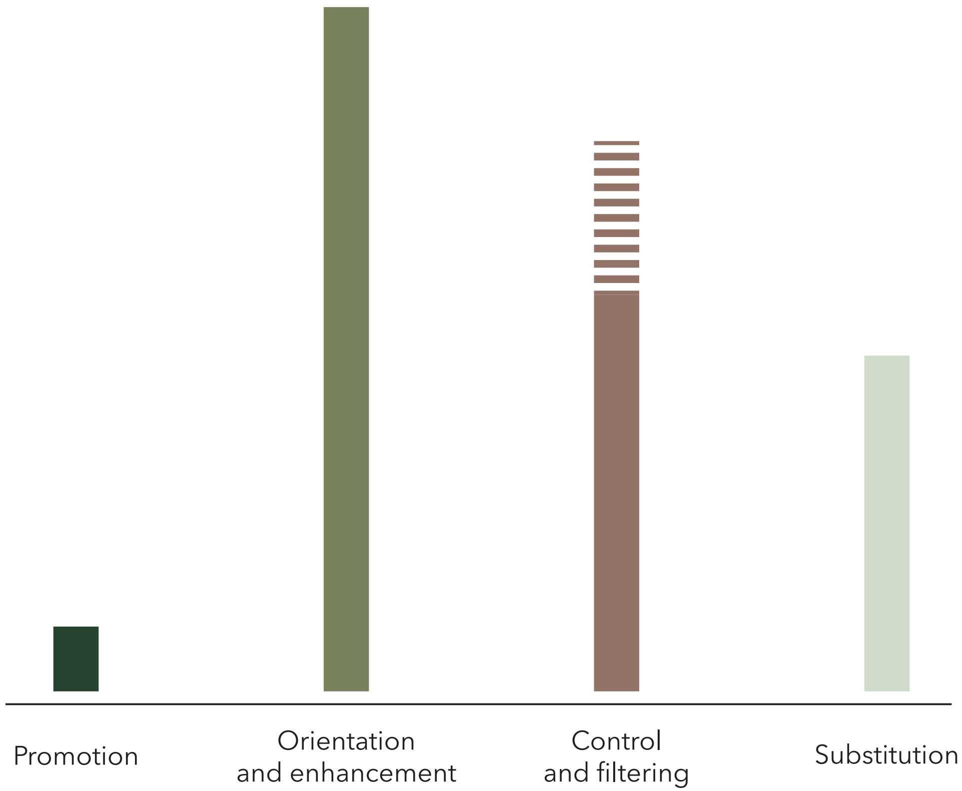
Orientation to and enhancement of the area's attractions: this function focuses on improving the experience for the visitor by informing about what to do in the area and where to go. By giving tourists suggestions of what to do, it aims to shape the tourists' behavior and thereby promote sustainable tourism by educating about the attractions.

Control and filtering of visitor flows: This function aims to control the number and flow of tourists visiting a certain area/site to lessen the pressure on the attraction. This could be in the case of a cultural heritage site or a protected nature area. This might require the visitor center to function as a gate-way that monitors and limits the number of people visiting by administrating the only access-way to the site. The control can also be done through suggestion of specific visiting hours, alternative suggestions for less visited sites and guided tours to decrease the pressure on the attraction.

Substitution for on-site visits: this function is to be a substitute for the actual attraction by using exhibitions. It might be in an area inaccessible for the visitors (e.g. a marine area) or at least inaccessible to a high number of the visitors due to physical limitations. This can also be relevant in case the visitors lack the knowledge to understand the attraction making education and information essential.

Based on how a visitor center emphasizes the various functions, its overall character and goal can be described. Due to the nature of our site, the wish to educate, and the number of tourists, the weight of the functions will most likely be as shown in illustration 61.

Since the area around Myvatn, the northern lights and Iceland in general already is popular among tourists the wish is not to promote the area, hence the little emphasis on this function. Instead the education and information about the area to promote sustainable tourism is the main goal, which is why the orientation and enhancement together with the substitution are the most important functions. Especially the northern lights might require substitution, since you as a tourist cannot be sure to experience it and it might also require quite a bit education and explanation. Regarding the filtering function, ideally the center could help take some pressure of the nature around the lake, however since the center most likely will not be able to be a gate-way to the area, this function cannot be as emphasized as wished. Using this knowledge about the needed visitor center, can help when organizing room programs to make sure all functions are present and emphasized as needed. The actual interior design will also need to support the function of the space to give the visitor the best experience being in the center.



ill. 61 - The enhancement of the various functions in the visitor center

USER GROUP

This visitor center with accommodation will host different types of user groups. First it will be necessary to consider the people running the building, which will be both the hosts and additionally staff. Secondly the guests will be divided into visiting and staying guests.

Host: The host family for the project is assumed to be locals and are defined as a family of four consisting of two parents and two children. The parents' primary tasks will be to manage the resort and be the public face of the center. They will be in charge of administrative assignments, managing the front desk for arrivals as well as various service tasks related to the day-to-day running of the resort. The resort is going to function as a permanent home for the hosts as well as a fulltime job. Therefore, the host family will have different facilities for living which are clearly separated from the rest of the facilities, but still allow them easy access around the resort.

Staff: A number of staff members will be employed to assist the hosts with tasks related to the daily running of the resort. The staff members will in contrast to the host family be living elsewhere. The staff members will thereby mainly use functional spaces needed to perform different services such as cleaning, laundry and cooking.

The tourists staying at the resort will come to watch the nature phenomenon the Northern Lights during night and stay at the resort for a couple of days. This kind of tourists will have a big interest in experiencing the nature. During the day, the guests can benefit from the resort's offered facilities or they can go investigate by themselves. Statistics show, that foreigners are more likely to stay overnight in a guesthouse in Iceland compared to the inlanders (Óladóttir, O., 2018, p. 15). The target group staying at the resort can be both singles, couples and families. The staying guests will be staying in an accommodation which will meet their basic needs and provide viewpoints to enjoy the aurora borealis. Due to the purposes of a trip to this remote location, a dining area at the resort will offer all the meals of the day, so that the guests can focus on exploring the beautiful nature. The staying guest will primarily be divided into three groups.

Young adults: Last year 35,4% of international visitors in Iceland were in the age 25-34 years while 18,2% where 15-24 years (Óladóttir, O., 2018, p. 16). This group is people going on adventures to get new experiences and investigate the world, maybe before settling down and establishing a family. The young adults could be travelling alone, however, it is assumed that it will mainly be couples or a smaller group.

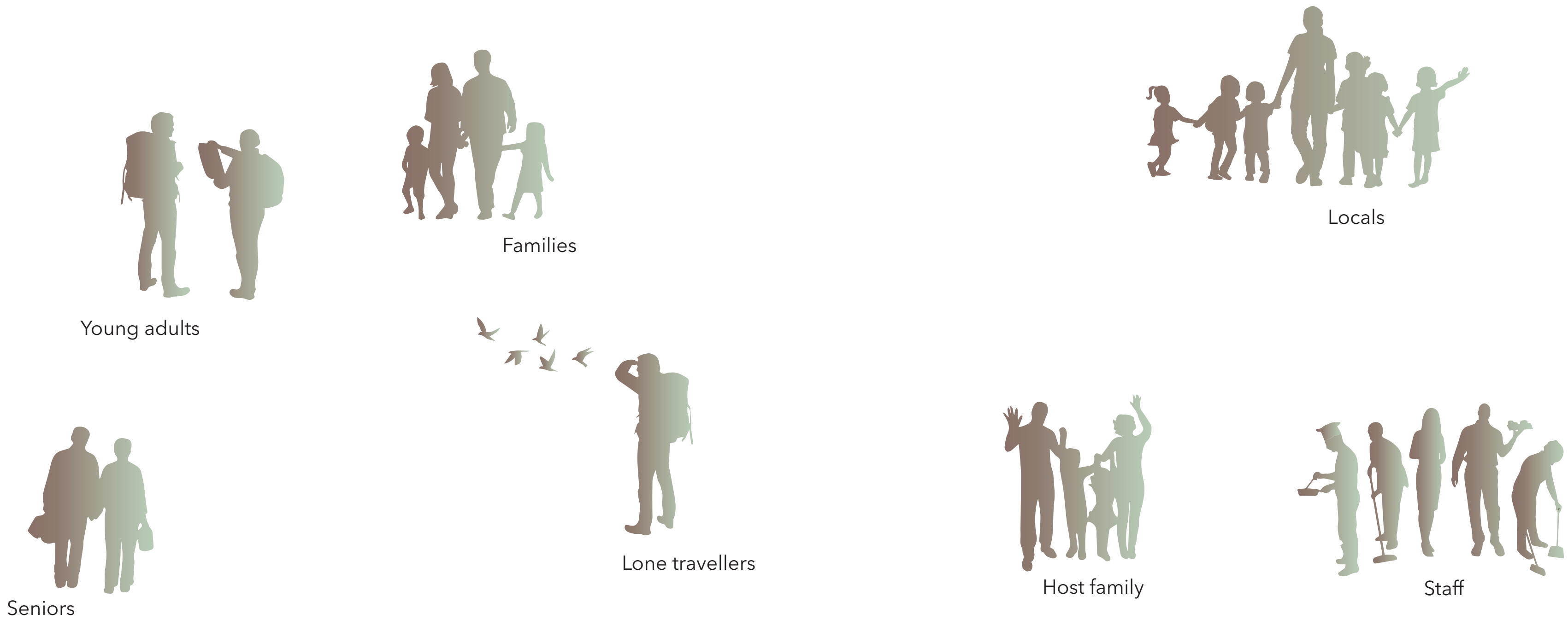
Families: Another subcategory is families, which will be parents with one or two children. It is assumed that the children will be of a certain age, so that they are old enough to understand and appreciate the qualities of travelling to explore the nature.

Seniors: The last subcategory is seniors who have retired and now have more free time to travel and enjoy life. Compared to the young adults and the families, the seniors are assumed to stay more at the resort during the day.

With a visitor center to educate about the Icelandic nature, it is assumed that some guest will only be visiting the resort. The visitor center will be open for the public and will house a restaurant where to enjoy a meal during the day. The visiting guest will primarily be locals and people travelling in the area.

Locals: A number of foreigners visit Iceland yearly however, the project site is also a popular destination among locals (Óladóttir, O., 2018 p. 26). Therefore, the resort will also function as an attraction for the locals. The locals could be people visiting the center in their spare time, but it could also be groups such as a school class coming to learn from the exhibition.

Travellers: It is assumed, that different kind of people will be travelling around in the area without staying at the resort. This could be one or two people travelling on their own and maybe staying in the nature or in another accommodation, but it could also be larger tourist groups travelling together with an agency.

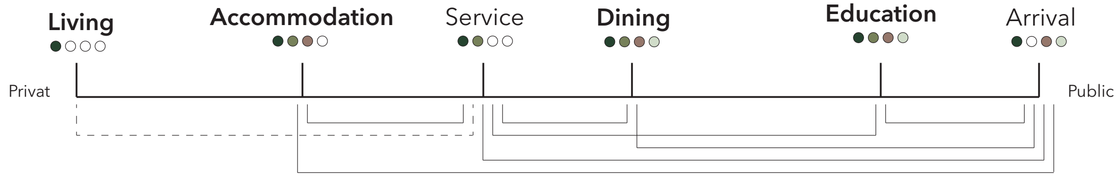

Young adults
Families
Locals
Seniors
Lone travellers
Host family
Staff

ill. 62

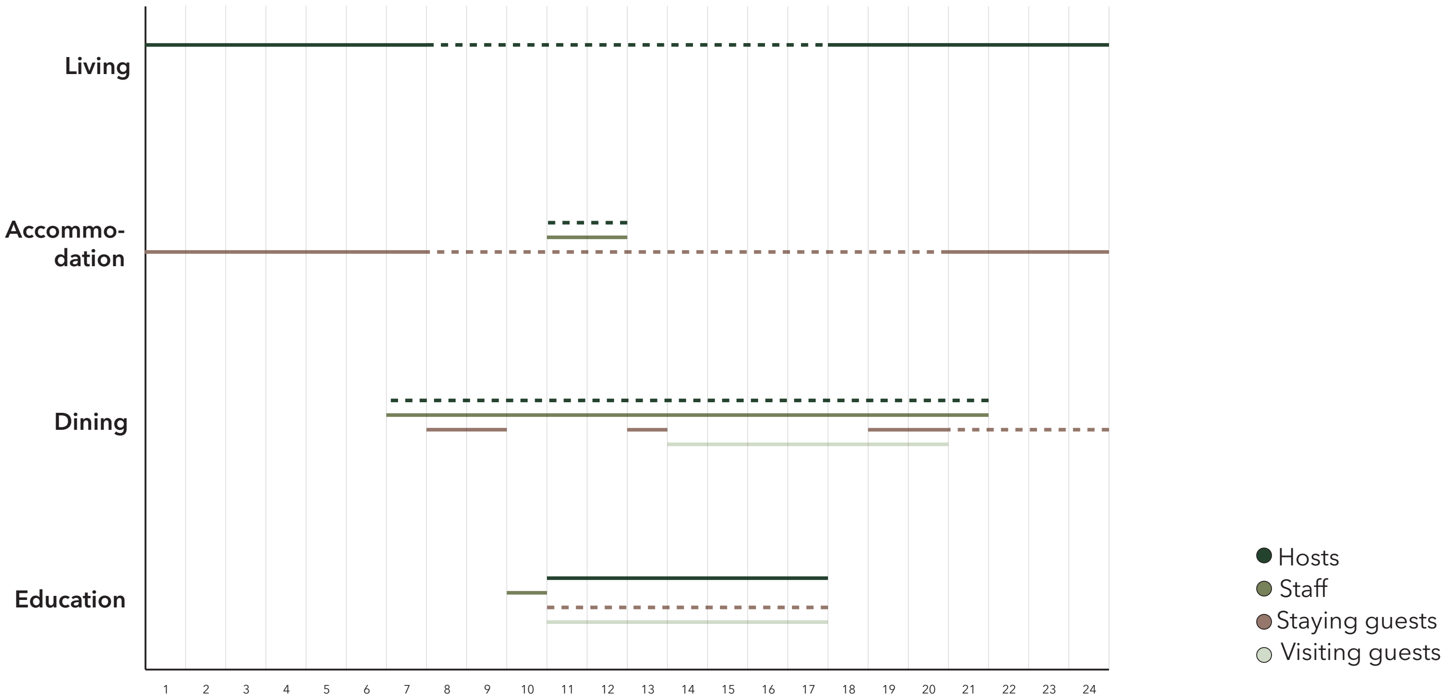
USER & FUNCTIONS

Daily use: As different user groups will be using the same facilities, it is interesting to investigate how these interact with each other, as the design must consider all the present user groups in a given room. To understand how the different functions should be designed, so that the right atmosphere is experienced by the user groups, the functions are listed to see the diversity between the private and public character (ill. 63). Connections are drawn between the functions, which illustrates that the servant functions 'Arrival' and 'Service' will work as nodes between the additional served functions. Living does not have a direct connection to the other functions, as the function of living is a place for the host, while the rest of the functions highly depend on each other. This illustration should help set the frames regarding the design and the orientation in the building.

The served functions are the primary areas and are the functions mostly used by the users. An estimate of the daily use of the served functions shows the occupancy of the rooms, which influences the needed capacity and space needed for the functions as well as indoor climate considerations (ill. 64). The servant functions will only be visited briefly or by internal staff. In many cases the servant functions will be a part of the served functions, for instance the kitchen is a service function serving the restaurant, for which reasons these are not directly included in the daily usage diagram as an individual function. The illustration is an example of a typical day illustrating when the user groups will use the different functions. As the daily use of the resort varies from day to day, the illustration also shows the more flexible periods where the users might be present, while they most likely will not or only for a short time. The remaining time it will be most unlikely that a certain user group will be using the function.



ill. 63 - The different functions' relation to one another



ill. 64 - Hours of use by different user groups

SPATIAL PROGRAMME

The functions in the project is as a starting point based upon the competition brief. After doing the analysis some functions had been added and adjusted for this project. As previous stated, a Visitor center is added, as an essential part of the project. Furthermore, the dining area will be extended to a restaurant with room for 30 persons, this is due to the added visitor center as well as the mapping analysis showing, that the nearby area do not offer any similar facilities. A big part of the Icelandic culture and tourist industry is the unique nature phenomenon, therefore a thermal bath will be added as a secondary function in the project. The room program list all the functions in the building placed in superior categories.

Room	Area (m^2)	Public/private	Views	Thermal comfort	Functions	Needs
Visitor center	168	Public	Large views towards landscape in the exibition.	Winter: 16,0-22,0 Summer: 21,0-25,0	Exhibition space, cloakroom, reception, storage, toilets.	
Restaurant	125	Public	View towards landscape from seating areas.	Winter: 20,0-25,0 Summer: 23,0-26,0	Seating area, bar, reception desk, cloakroom, toilets.	Seating for 30 persons.
Kitchen	52	Private	Preferably view towards nature.	All year: 16,0-25,0	Kitchen facilities, dishwashing area, storage, dry storage, freezer, cold storage.	Delivery and employee entrance, easy access to staff functions, easy acces from kitchen to restaurant.
Lounge	40	Public	View towards landscape from seating areas.	Winter: 20,0-25,0 Summer: 23,0-26,0	Seating area, bar.	Easy access to terrace.
Terrace	50	Public	Being an exterior facility, views towards the landscape is the leading concept.		Seating area.	Covered for weather.
Shower and toilet facilities	66	Public	No view needed.	Winter: 20,0-25,0 Summer: 23,0-26,0	Gender-specific bathing facilities, changing area, toilets.	3 showers for each gender, 5 toilets, a family room.

ill. 65a - Spatial programme

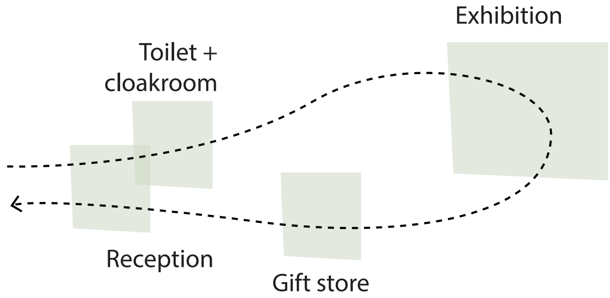
Room	Area (m^2)	Public/private	Views	Thermal comfort	Functions	Needs
Cabin	Per module: 5,6 (+3,6 in loft)	Public	View towards the sky is crucial to give best conditions for watching the northern light.	All year: 18,0 - 26,0	Sleeping area, living area, toilet, outdoor seating space, an additional space to park when getting recharged etc.	Accommodate up to 20 person i total, ranging from 1-4 persons, self-sufficient, moveable, space for luggage, skylight to watch northern light from bed.
Host dwelling	86	Private	Preferably views towards nature.	Winter: 20,0-25,0 Summer: 23,0-26,0	Master bedroom, two children bedrooms, bathroom, kitchen, dinning area, living room, entrance, utility room.	Easy access to horse barn.
Staff functions	52	Private	Preferably views towards nature.	All year: 16,0-25,0	Canteen, wardrobe, toilet, shower, rest room, office.	
Practical rooms	11	Private	No view needed.	All year: 16,0-25,0	Cleaning, laundry.	
Horse barn	85	(Public)	No view needed.		Horse pen, storage.	Individual box stables for 10 horses (3x2 m2 each), adjacent to outdoor horse enclosure, storage for hay and riding equipment.
Thermal bath	50	Public	View towards sky.		Geothermal bath.	Easy access to shower and toilet facilities, rack for towels etc.
Technical rooms	-	Private	No view needed.	All year: 16,0-25,0	Space for mechanical ventilation units, water heaters etc.	Should be placed strategically to cover all functions.

ill. 65b - Spatial programme

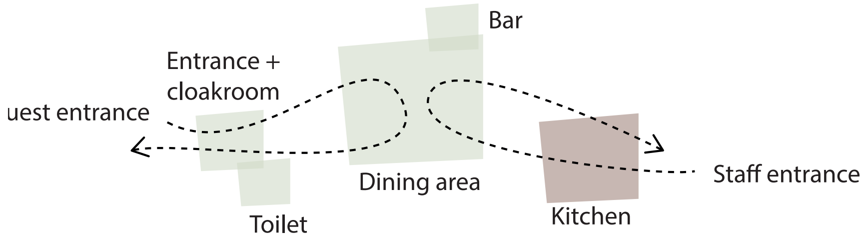
FUNCTION DIAGRAMS

To further explain the individual functions in each category mentioned in the spatial program, these illustrations display the relations and connections in the complex. As it is explained in the spatial program, the functions can be placed in superior categories as some of the functions are directly related to one another, while the connection across these groups are less important for the functionality of the complex. Besides showing the connections between the rooms, the illustrations also indicates the main flow and movement between functions.

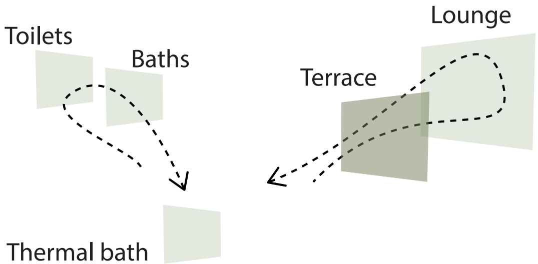
Visitor center



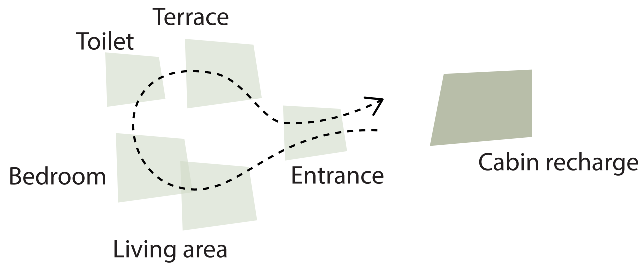
Restaurant



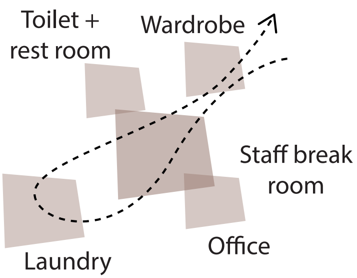
Lounge & bath facilities



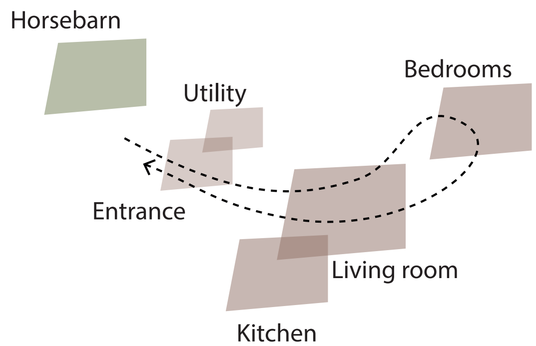
Cabin



Staff functions



Host dwelling



Public
Private
Outdoor

ill. 66

SUMMARY

The summary is a conclusion of the studies and investigations made through the earlier chapters of analysis. Through a description of the indented atmospheres along with design parameters, a mission and a vision for the project, the summary will totalize the challenges for the upcoming design process, and thereby serve as a starting point for a concept development.

DESIGN PARAMETERS

Aesthetic

01. The architectural language should be argued by a relation to the Icelandic nature and culture.

02. The building should complement the landscape in the way it is fitted to the site.

03. Enhance the experience of the northern light by facilitating the best possibilities for views.

04. Materiality, tactility, relation to surroundings, the human scale and detailing should be used to enhance and define the experience and atmosphere of the individual rooms.

Technical

05. Passive strategies should be used to improve the building's energy consumption and meet the current standards.

06. The cabins should be designed and dimensioned to function off-grid for shorter period, both regarding energy and water supply.

07. Indoor comfort must be achieved through reaching of atmospheric, thermal and visual requirements.

08. Material choices should be based on an envinromental aspect, considering the lifecycle and the related costs, with a focus on local and natural materials.

Functional

09. Create a functional division between the public and private functions, to separate the hosts and the visitor facilities.

10. The guest bedrooms should be adaptable and moveable to enhance the experience of the northern light and use the potential of the no-construction zone.

11. The building should be inviting and create the frames for promoting sustainable tourism through education.

VISION

The aim of this project is to design a Visitor Center with accommodation at a site near the Icelandic lake Myvatn for tourists to experience the northern light. The project will be founded in and draw inspiration from the unique and harsh nature of Iceland and the area around the lake to create an identity through a strong relation to the context and traditions. The way that the building is fitted to the land should treasure the natural potentials of the present site. Environmental sustainability must be a central part of the concept and support the aim of creating an education hub with respect and considerations towards the surrounding nature. This should be supported by a high consideration towards materials and how these are considered in the cradle-to-cradle philosophy. The architecture should support the different experiences in the building by emphasizing a variety of atmospheres. These atmospheres are to reflect the various perceptions ranging from the intimate and embracing experience of being in the private zones to the educating and inviting experience when in the public zone.

ATMOSPHERE

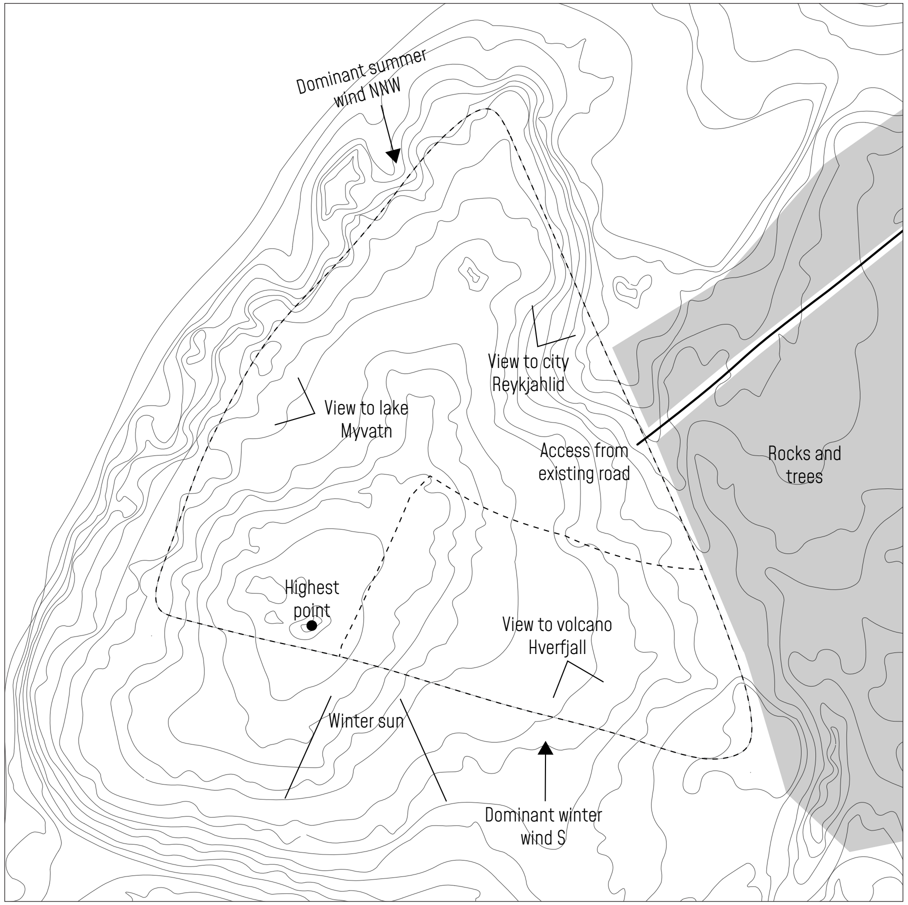
Based upon the atmospheric studies of Peter Zumthor, a part of this project will emphasize the work with atmosphere in the architecture. As the project involve a range of functions, it is desired to embrace a variety of different atmospheres. These figures are made to illustrate the part of the vision regarding atmosphere. As the vision for the project also embrace the relation to the nature, the meeting with the nature in different scenarios will be an essential part of the atmospheric considerations.

ill. 67 - Different atmospheres through visual connections to the nature

PROCESS

POTENTIALS OF THE SITE

Based on the analysis phase a map was made to illustrate the potentials the site has to offer as well as some conditions to be aware of when beginning the design phase. The idea of the map is to make some directions which could be used early in the design and for placing the building on the site. The map illustrates different views which can be achieved from the site and the directions to orientate the building to achieve the views. The highest point of the site is illustrated as well as the access point to the site from the existing road. The illustrations also clarify the main wind directions during summer and winter as well as where the few hours of sun during winter will reach the site.



ill. 68 - Map 1:5000

PLACEMENT ON THE SITE

Taking the no-construction zone into consideration, the site still offers a great area for placement of the main complex. To further decide where to place the main complex inside the construction zone, a comparison is made between a placement on top of the site towards northeast and in the bottom of the site towards southwest. Each proposal was compared and evaluated based on a line of categories.

The decision of where to place the main building was made based upon the vision and aim of the project. From that it was decided to place the building on top of the site, as this position offers the best conditions for integrating different views and creating a more extrovert building which interacts with the rest of the site. Furthermore, the placement offers the possibilities of utilizing the variation of the terrain, which can be used to emphasize different expressions and atmospheres and at the same time create a stronger relation between the building and the landscape.

Top of construction field ill. 69

Bottom of construction field ill. 70

Access	Relative direct arrival from the existing road. Building can be seen from the road.	Sharp angle to the existing road, building will be difficult to see from the existing road.
Views	The building will be placed around the highest point of the terrain, making it possible to achieve several views and create a connection with views between the main building and the cabins.	The building will be placed on the lower part of the terrain. Possible to get views towards south, but difficult in the remaining directions.
Openness	Extrovert by overlooking the site and context.	Introvert by havingfewer views and less relation to the rest of the site.
Relation to landscape	The steepestslope on the site appearshere – the most suited for digging the buildinginto the site.	The flattest area of the construction zone - easy to move around and access different functions.
Microclimate	Completely detached, making it difficult to use any natural surroundings in the building design.	Partly sheltered by the rock formations and trees for wind.

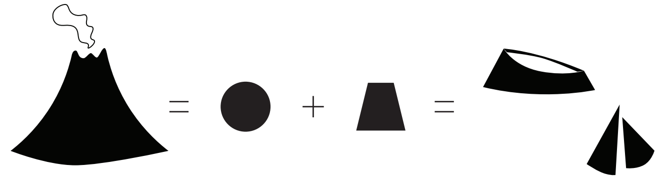
ill. 71 - Comparison table

IDEA GENERATION

The initial part of the design process, was based on a general brainstorm of ideas, exploring different proposals and directions. Using the vision of achieving a high relation to the nature through the architecture as a starting point, the brainstorm was based on different nature phenomena specific for Iceland. The brainstorm was used to investigate how the nature phenomena can be a source of inspiration in different elements of the design. At this point a focus was on shapes and the relation to the landscape, materiality and the association between the main complex and the moveable cabins. The illustrations in this spread presents ideas for the different categories using the nature phenomena: volcano, glacier and the Marimo balls living in the bottom of lake Mývatn.

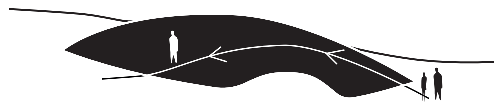
SHAPE & RELATION TO LANDSCAPE

VOLCANO



The combination of the circle and trapezoid in the volcanic shape

GLACIER



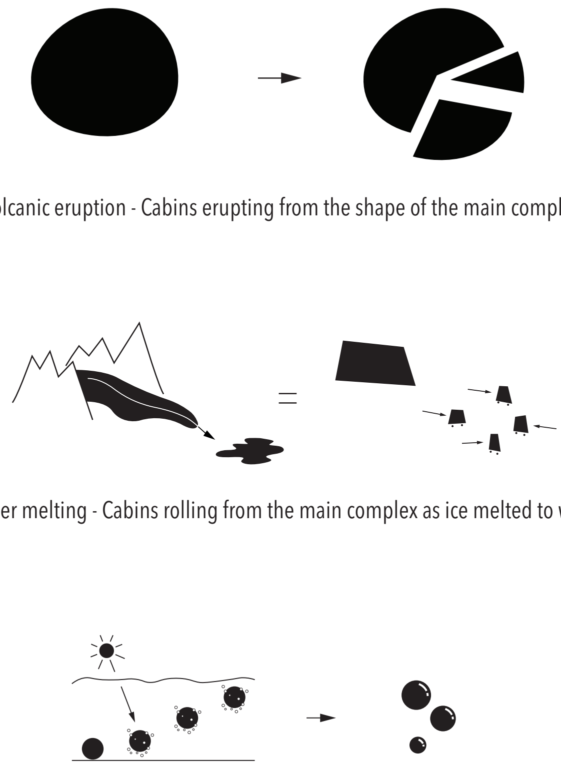
Glacier becomes part of the landscape - People can walk on the building

MARIMO

Natural states of the marimo - Parts of the building embedded in ground

ill. 72

MOVEABILITY



VOLCANO

Volcanic eruption - Cabins erupting from the shape of the main complex

GLACIER

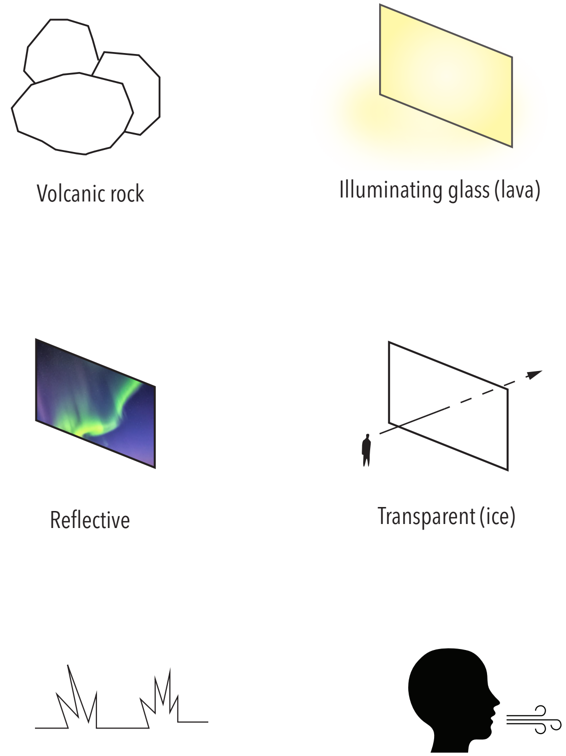
Glacier melting - Cabins rolling from the main complex as ice melted to water

MARIMO

Photosyntheses makes marimo float from air bobles - Cabins moved by air

ill. 73

MATERIALITY



VOLCANO

Volcanic rock

Illuminating glass (lava)

GLACIER

Reflective

Transparent (ice)

MARIMO

Grass & earth materials

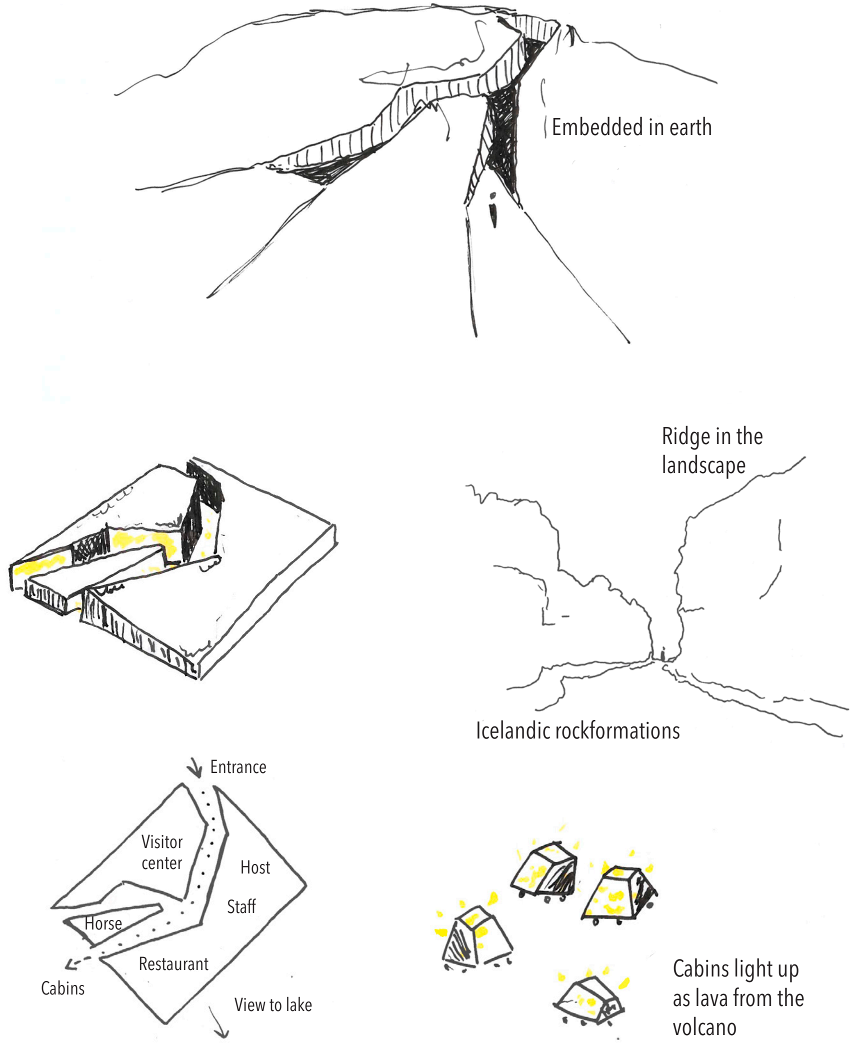
Inflatable materials

ill. 74

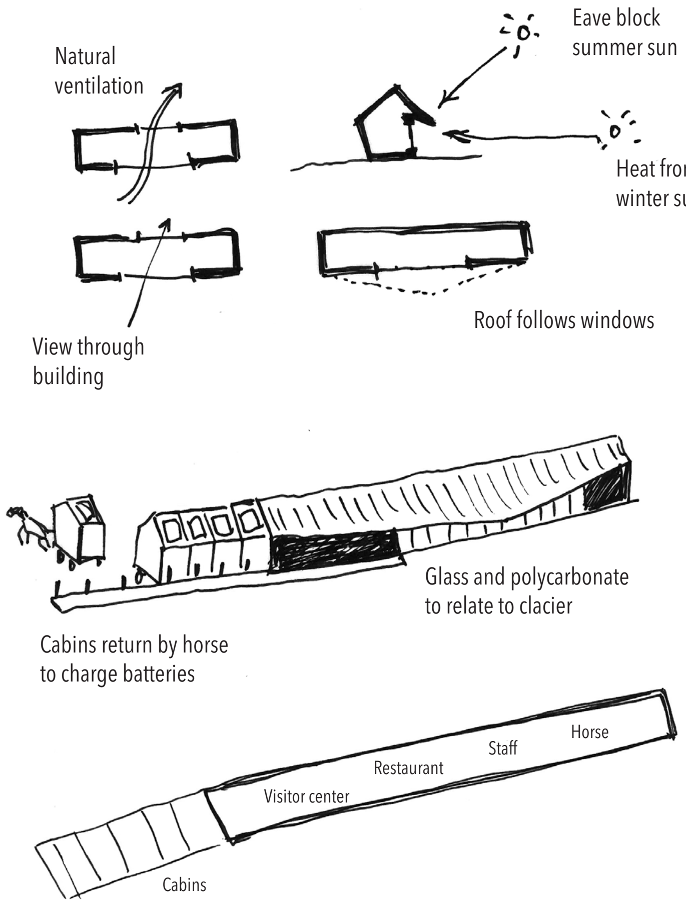
IDEA PROGRESSION

Based on the brainstorm, a more detailed approach was used to further develop the ideas. With the nature phenomena still being the source of inspiration, the purpose was now to combine several elements inspired by the nature into one combined concept. In this phase, three initial concepts were developed.

Concept 1:
Inspired by the volcanoes placed in the crack of the Mid-Atlantic ridge, a concept was developed as a building being divided into different pieces by a crack in the roof. The building is built into the landscape, placing one below ground when walking through the crack, which will function as a hallway between different functions. The cabins are connected to the main building by symbolizing the magma from a volcano eruption and light up in the landscape.

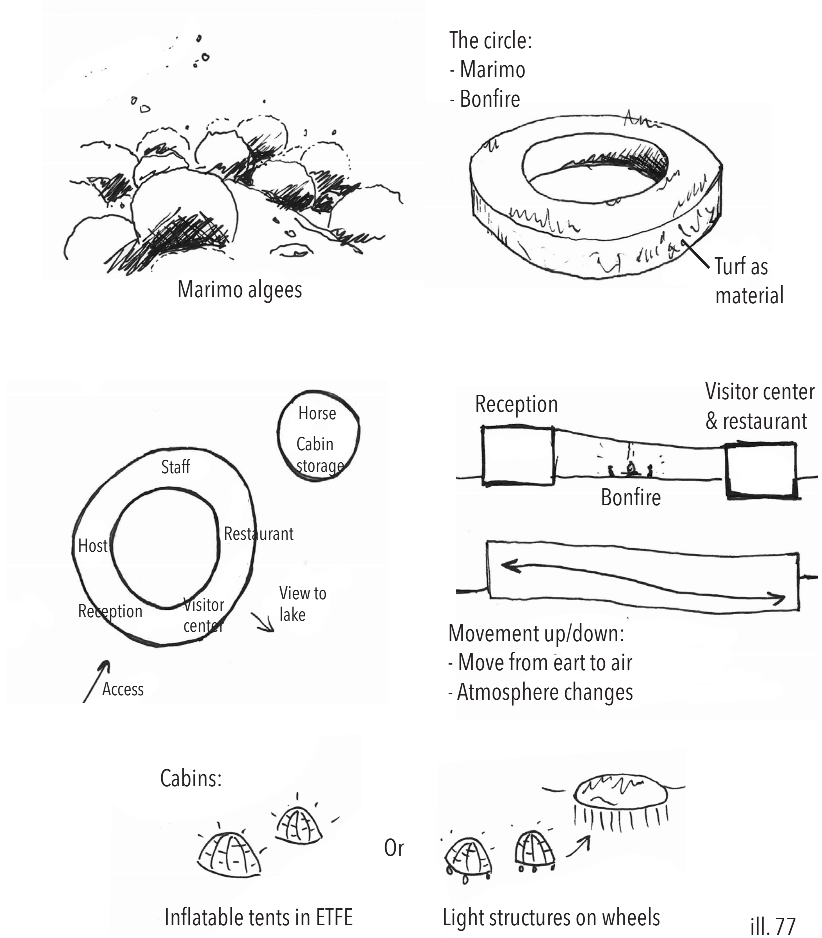


ill. 75



ill. 76

Concept 2:
Inspired by the glacier a concept was made with a building placed on top of the landscape. The building shape is long and narrow, and the line gathering the roof and the facade will vary, to adjust to the need of different functions, considerations regarding the micro-climate, and to give the building a less regular shape. The building is shaped as a long building were the cabins can be added in the end, so that they will return to be a part of the original shape.



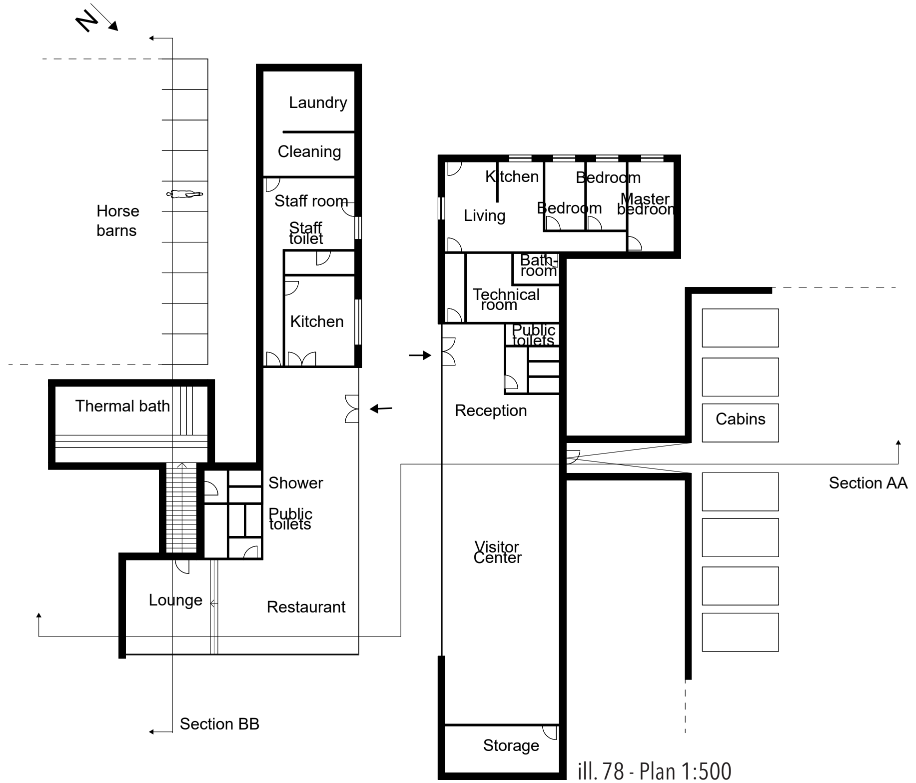
ill. 77

Concept 3:
Inspired by the Marimo balls this concept is highly inspired by the circular shape. The building is shaped as a closed circle in plan with an exterior space in the middle used for a bonfire place. The building is partly embedded in the ground giving a movement up and down when walking in the building, which is inspired by the natural photosynthesis of the Marimo. Additionally to the main complex, the cabins are small domes, either working as an inflatable construction or as a lightweight construction on wheels having their own shelter to recharge somewhere else on the site.

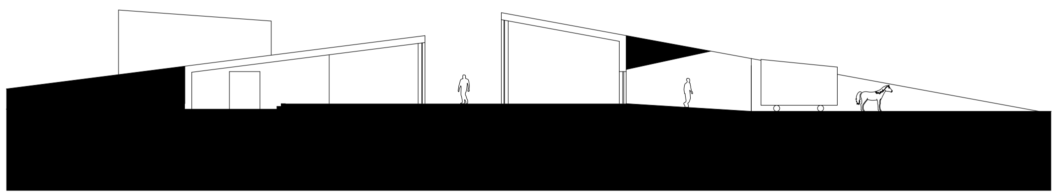
IDEA NARROWING

Based on the qualities and shortcomings of the concepts made in the progression phase, a further detailing was made, to develop the shapes as well as getting a more realistic understanding of what is durable when considering the concepts with a more functional approach concerning plan layouts and orientations.

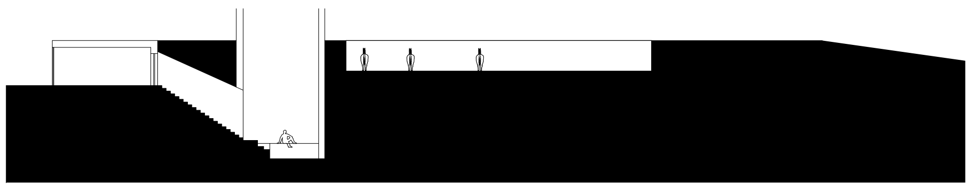
Concept 1:
The volcano inspired concept was developed in plan, where different proposals for where to place the functions were made. Openings from the building through the landscape was added, in order to create different accesses with different experiences, and challenge the way of moving around in the building. This concept is merging very well with the landscape and has a very strong visual connection between the different functions, however, when working with the plan, it became clear, that the building appeared very introvert and that it was difficult to get light into the building.



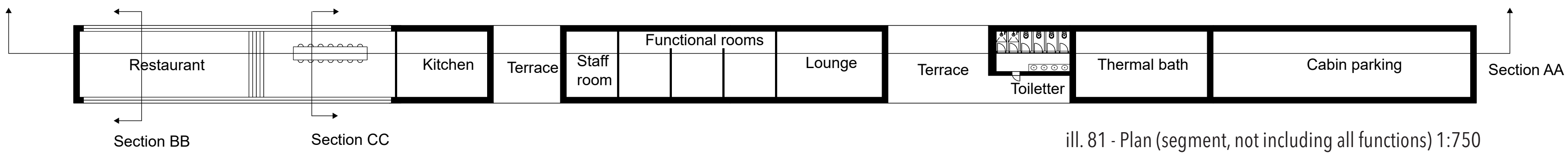
ill. 78 - Plan 1:500



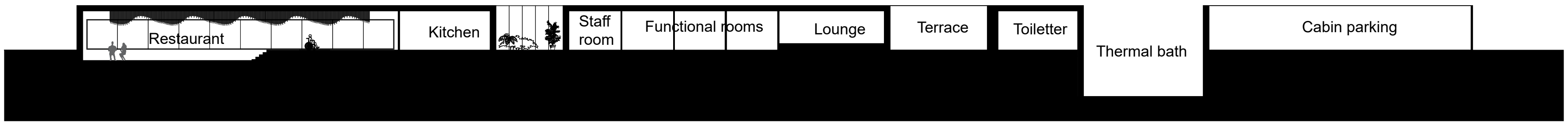
ill. 79 - Section AA 1:500



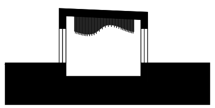
ill. 80 - Section BB 1:500



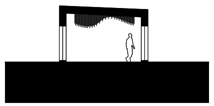
ill. 81 - Plan (segment, not including all functions) 1:750



ill. 82 - Section AA 1:750

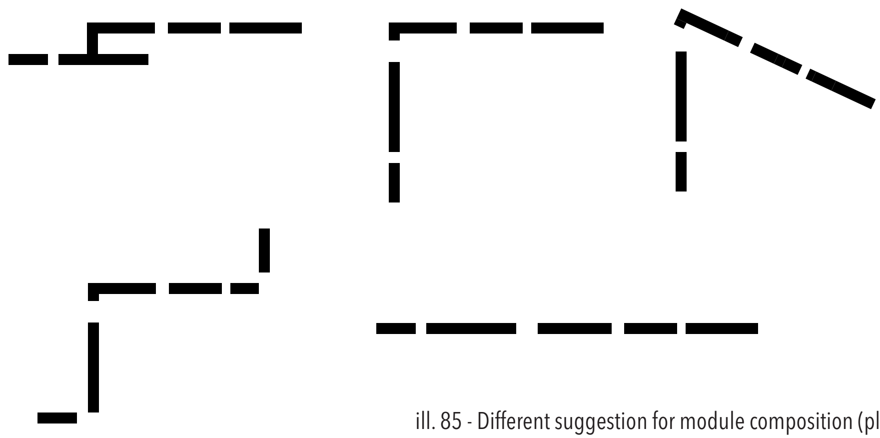


ill. 83 - Section BB 1:750



ill. 84 - Section CC 1:750

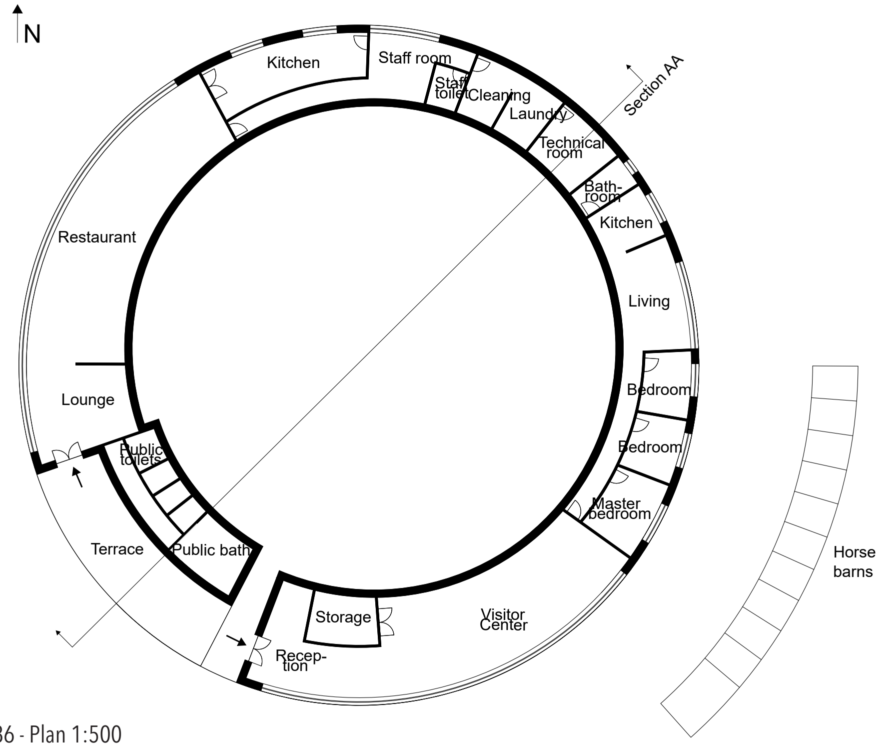
Concept 2:
In the narrowing phase, the glacial inspired idea developed to be several modules each with its own function, combined into one long building. Each module could then be treated differently according to a desired expression and relation to the landscape. The modules are connected in the long axis, making it possible to move from the inside between the functions, while they can also be entered from the outside. The very long narrow shape does however create a long distance between many of the functions, and therefore several proposes was made suggesting to bend the building as well as splitting the building into parallel rows to minimize the distance between functions and to allow the functions to get different orientations.



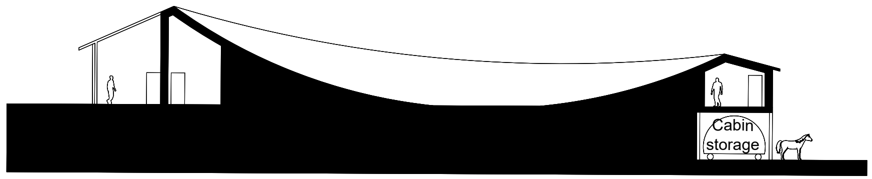
ill. 85 - Different suggestion for module composition (plan)

Concept 3:

As the marimo concept became more developed, a connection to the traditions of sitting around a bonfire telling myths as well as an inspiration from the traditional turf house became integrated in the design. The interior courtyard developed to be a processing of the landscape, creating a fire pit in the middle with greenery placed in a soft slope from the ground all the way to the roof. Some of the difficulties in this concept, was again working with windows only at one side of the building. The building became an introvert building with an isolated and intimate exterior space in the middle. The round building allowed for the use of several orientations towards the sun as well as views in all direction. Considering the logistics, the functions did however seem very isolated, as they had no visual connection to one another.



ill. 86 - Plan 1:500



ill. 87 - Section AA 1:500

IDEA SUMMARY

All the three concepts offered very different suggestionsto the design. So far, the concepts had been a very figurative reproduction of the specific nature phenomena, which was used as a source of inspiration. The qualities and shortcomings of each proposal was evaluated and compared to the vision of the project, to combine the qualities of each concept in the ongoing process to reach a functional shape.

The concepts made so far gave a greater understanding of the wishes regarding atmospheres and different ways of achieving it by working with the relation between the landscape and the building. It had become clear, that a building embedded into the ground could enhance a very different atmosphere compared to being above ground. However, when having a building completely embedded in the ground, complications regarding achieving daylight and the desired views occurred, which is why a solution working with a combined solution seemed optimum for the continuing process.

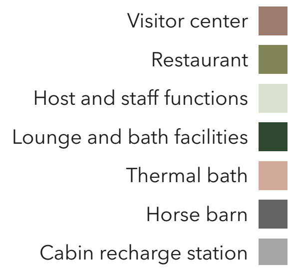
The concepts also had a very different expression regarding their openness. This is an important factor as it affects both the relation between the main complex and the cabins as well as how one meets the building when arriving to the site. From the evaluations of the concepts it was decided to continue with and open and extrovert building that allows for the cabins to be more engaged with the main complex, and will have a welcoming character for the guest arriving to the site.

All the three concepts developed during these phases had very different plan layouts. This gave a good process of working with placing the functions into different shapes and see how they could interact with one another. A comparison of the plans shows a pattern in the relation between the functions and the logistic of the building, from which it became clear, that many of the functions are connected to each other. These desired connectionswere difficult to create with all functions placed into one compact building volume and it resulted in a lot of transitioning space, which was the case in concept 1 and 3. Therefore it was decided to split the functions into groups and place them in several buildings. Concept 2 began to show the potentials of splitting up the functions by placing each function in its own module. The concept also allows the visitor to engage more with the nature, by moving between inside and outside when going from one function to another. Dividing the functions into several buildings also gives an opportunity for processing the functions differently, considering orientation as well as relation to the landscape and atmosphere.

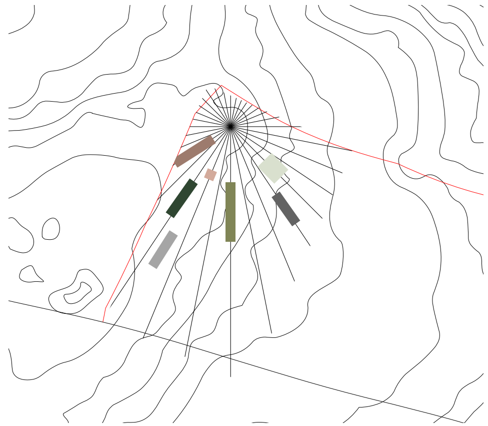
GRID-STUDIES

As it was decided to divide the functions into several buildings, a study was made of different ways of placing the buildings on the site. Different types of grids were tested, to determinate a system to place the buildings from. The knowledge gained during the analysis phase and the initial design studies, has already given a clear idea about the desired relations between the buildings to create the best logistic between the different functions. Furthermore, it was desired to achieve views from the visitor center towards the lake Mývatn and from the restaurant towards the volcano Hverfjall. Different types of grids were tested to see how they match these requirements.

When deciding between the different grids one main factor was the origin of the grids, as it was desired to choose a grid created from natural elements with a higher relation to the context. Compared to the grids with the intersecting lines, the two radial grids offer more flexibility according to orientation of the buildings, however the orientation cannot be combined with the logistic between the functions, as each orientation is locked to a specific line. The grid based on the views to the mountains was chosen, as it has the desired relation to the context, allowing the buildings to be placed according to their internal relations and giving the opportunity to include the views towards different elements in the context.



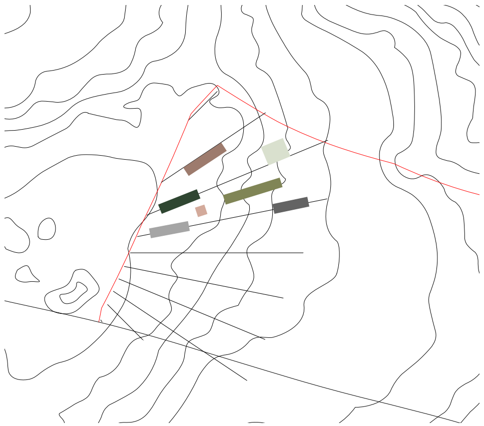

ill. 88


ill. 89

Regular grid:
A regular grid with lines placed perpendicular on each other was tested. The regular grid offers a very structured organization of the buildings, making it easy to place them in relation to one another. However, the very structured grid seemed very distant to the softer and natural site and context.

Radial:
A radial grid was tested by making lines extracting from a point inside the construction field of the site. By using this method all the buildings have a shared focus point, which creates a connection between the buildings. At the same time, every grid line has its own orientation, creating good conditions for placing the building in a desired orientation.

Visitor center
Restaurant
Host and staff functions
Lounge and bath facilities
Thermal bath
Horse barn
Cabin recharge station



ill. 90

ill. 91

ill. 92

Radial center highest point:
Another version of the radial grid was tested, placing the center point on the highest point of the site, changing the focus from inside to outside of the construction zone. By changing the focus point of the building to the highest point, this grid has a better connection to the site. However, moving the focus point outside of the construction field, results in the buildings creating a back and front on the site.

Water:
In this grid the lines from the border to the lake Mývatn are projected on the site to create a grid of crossing lines. When placing the buildings in this grid, a clearer path of movement between the buildings appears as the buildings seems less spread. However, the orientation of the lines makes it difficult to achieve the desired views from the buildings.

Mountains:
Another version of the grid was made using the view directions from the highest point on the site towards two big mountains in the context. The directions of the grid lines in this proposal allows the buildings to be placed close to another and, while they can still be positioned in two very different orientations respectively to each line.

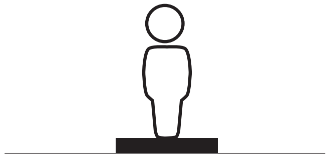
LANDSCAPE

The starting point of the landscape design was to find a solution which provides a connection between the buildings through a logistical placement of functions and path systems. As the site is placed on a very rural location, the intention from the beginning was to preserve the original nature and expression of the site, by not introducing any extra or foreign vegetation. Therefore, the main part of the landscape design was regarding the hard landscape by placing paths, fences and benches.

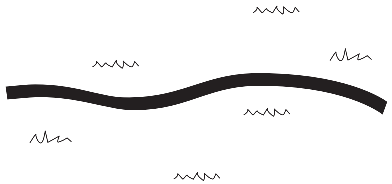
Primary and secondary paths:
The paths should be used to lead the people in a desired direction. As the main complex contains several functions, different approaches will be used to make a diversity, creating primary and secondary pathways. During the design process, different solutions were investigated. A raised path in a firm material can be used when wanting to make a clear path in the landscape. By being lifted from the ground level with sharp edges, the path will be in contrast to the remaining landscape. Opposite, a path in a softer material, in the level of the terrain and with blurred lines to the remaining part of the landscape can be used to create the secondary paths. By not having a completely clear border between the path itself and the landscape, this kind of pathway will be considered less dominant.

Organic and edged layout:
Another investigation made in the design of the paths was the language of form. Here different solutions with soft organic shapes as well as more edged shapes was considered. The soft organic shapes wereinitially considered due to the site and the surroundings. Designing for a very rural site with only grass and nature, the organic shape has the ability to more naturally blend in with the context. In contrast, the more edged paths create more distance between the nature and what is man-made by not trying to make itself look as was it occurred naturally. Considering these aspects, it was chosen to work with the edged design. The purpose of the paths is to lead the people between the buildings, why the edged shape seems most suited by having a stronger connection to the buildings' shapes than the nature. Working with the edged shapes also allow the paths to follow the grid made for placing the buildings, creating an even stronger relation between them and the buildings.

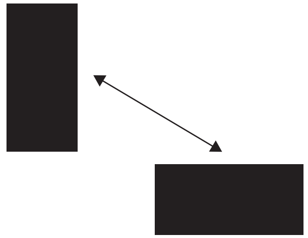
Placement:
When considering the placement of the paths two different approaches was considered. A proposal was made focusing on creating a direct access between the different entrances, as this will be the most efficient way to move around. It was however chosen to go in another direction, and work with paths along the buildings as this approach can be used to attract people towards other functions. As the complex contain several functions,some visitors will only come to visit a specific function. Having to pass directly by the visitor center, even though one may come with the purpose of visiting the restaurant, this way of moving around can help create an interest for the guests, which support the purpose of the visitor center designed to educate about the Icelandic nature. Secondly, this approach also relates to the intentions of leaving the landscape very untouched, as it allows big areas withnatural vegetation between the buildings, and it relates to the composition of the buildings by following the grid lines. On the remaining part of the site, where no permanent buildings are placed, small areas with pavement will be scattered out and placed according to the grid-lines to create small spots with benches, which can be used as a resting place for guest walking in the nature. The grid-lines will also be used in the design of a fence for the horse enclosure.



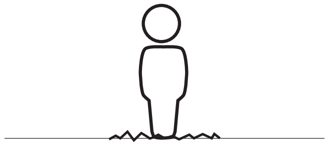
ill. 93a - Primary path



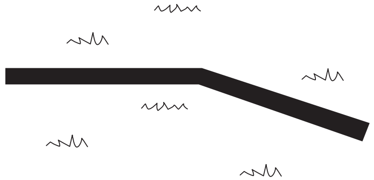
ill. 94a - Organic layout



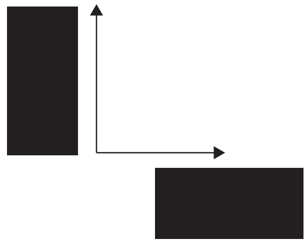
ill. 95a - Connecting entrances



ill. 93b - Secondary path



ill. 94b - Edged layout

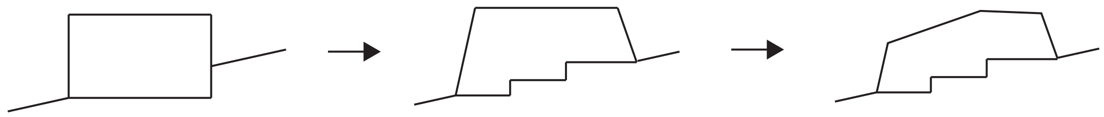


ill. 95b - Following buildings

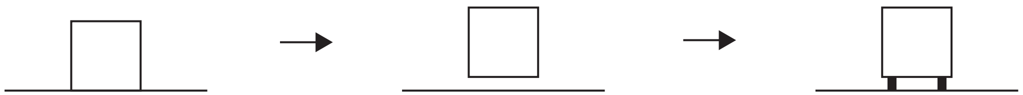
RELATION TO LANDSCAPE

As previous described, the buildings in the main complex were initially placed in a grid. The buildings are dimensioned to be long and slim, based on the functional use of the buildings as well as the grid lines. The proportions of the buildings relate to the vision regarding a connection to the nature, as it allows for a strong visual connection through views from the building towards the landscape. The long slim shape also allows the building to be lit from both sides and the light to enter far into the building. Different design iterations were made of the shape, to investigate the buildings' relation to the landscape. As a very regular shape can seem distant to the site, it was decided to shape the building in the main complex in a way that allows it to adapt more to the landscape. To do so, the regular shape was reshaped with inclined facades and an angled roof. As the buildings contain several functions the highest point of the roof can be placed to emphasis a change of functions inside the building. Furthermore, the inclination is used inside to create level differences following the landscape.

The cabins and the main-complex can be seen as in contrast to one another - the light and the heavy. In contrast to the main complex, which will appear heavy and permanent, the cabins' relation to the landscape will therefore be very different. The cabins are going to be moveable and will therefore be designed with a much lighter expression concerning the relation to the landscape as well as material choices. Considering the relation to the landscape, the cabins will be lifted from the ground only touching by the wheels used to move them around.



ill. 96 - Main complex relation to landscape

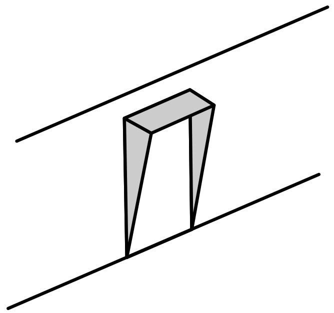


ill. 97 - Cabins relation to landscape

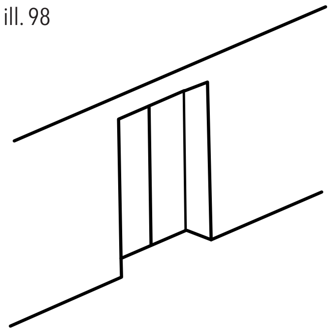
ENTRANCE

One of the nine key features by Peter Zumthor is the tension between interior and exterior. An approach to facilitate this feature in the project is in the work with shaping the entrance, and how different options can affect the meeting between interior and exterior. The entrance was considered as an important aspect, as it should be obvious for the user where to enter the building - especially in the buildings used by guests. A brainstorm was made to evaluate different solutions. As a result, the brainstorm suggest different proposals concerning the use of another material around the door as well as different facade depths and eaves.

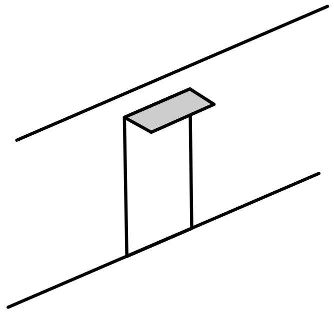
During the process with the landscape design, it was decided to make paths running along the buildings. Considering this decision, working with elements pointing out from the facade can be conflicting, depending on the width of the path, as it will take up transition space. Therefore, it was for the final entrance design chosen to work with a level difference in the facade by making an offset inward. The level difference marks a clear change in the facade and will in combination with the use of a different material around the door emphasize the entrance of the building. The use of a softer material in comparison to the rest of the facade cladding, will create a more inviting atmosphere around the entrance.



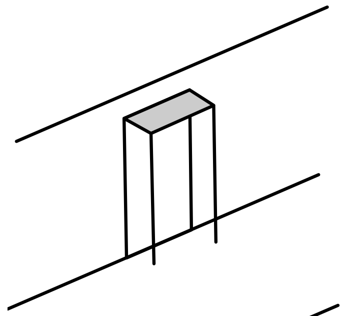
ill. 98



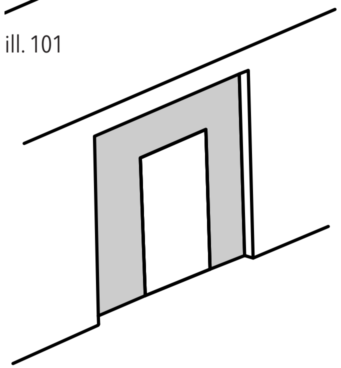
ill. 99



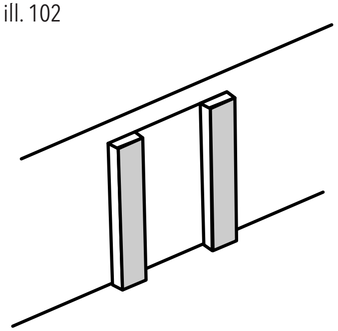
ill. 100



ill. 101



ill. 102



ill. 103

WINDOW DIMENSIONING

When designing the facades in the main complex the indoor simulation tool BSim was used to investigate how different amounts of windows affect the indoor comfort. The actual placement of the windows had a very little effect, and therefore different simulations were made to compare the total area and number of windows with the indoor temperature.

This approach was used, as it is preferable to keep the facades simple with windows that function without any additional overhang or screening between the inside and the landscape. As the exterior walls are very thick and the insulation is placed on the outside of the structural system, the wall itself will already function as an overhang. However, it is a wish to use the depth of the wall in the design of the interior spaces, why the placement in the wall should not be too deep (see detail drawing at page 134). Prior to this investigation the simulation model was tested with different scenarios regarding the composition of the building envelope to find a solution that seemed suited to perform the investigation. The final U-values for the building is presented in appendix 1.

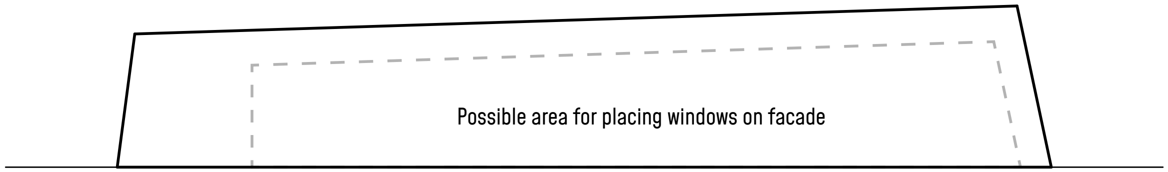
The visitor center is considered the worst case when considering overheating due to the orientation and a wish for an open facade with many windows. According to the air change calculations (see appendix 2), the visitor center needs an airflow rate at 0,28 m3/s to avoid any sensory pollution and fulfill the basic requirements from the Danish building regulation. From the building simulation it was found, that the air flow at 0,28 m3/s was likewise sufficient according to CO2 pollution. However, it quickly became clear, that if the building should have the desired expression with many windows, the air flow rate wasn't sufficient when considering the temperature.

The ventilation ratio was therefore raised based on a rough calculation considering the size of the ventilation pipes, before doing the investigation. A rough calculation showed, that with a maximum allowed air velocity in the pipes a 5 m/s, which is considered low enough to ensure an acceptable sound level below 30 dB when using round pipes placed above a suspended ceiling (Stampe, O. 2000 - p. 321), an air flow rate of 0,28 m3/s requires a pipe with a diameter of 315mm. The air flow rate can however be raised to 0,38 m3/s and still keep the same pipe size at 315mm, and therefore the value is increased to 0,38 m/s as the basis of this investigation to minimize the hours with overheating (see appendix 3).

Because of the historical relation to the context and the good properties of the earth construction, the complex is going to be made using rammed earth walls supplied with insulation to achieve the required thermal transmittance. The use of earth walls creates some guidelines for how to place the windows in the wall, which were considered to determine the area of the facade where the windows can be placed.

Based on the above considerations a range of simulations were made to narrow down the area and number of windows. All the windows were dimensioned with a permanent height and changing widths according to each scenario. To compare the results from the simulation, the building was tested according to the goals of max. 100 hours above 26 degrees and max. 25 hours above 27 degrees yearly (Bygningsreglementet, 2018).

The first table presents a range of results from different simulations. The table is only partly filled-in, as the model was continuous adapted to the results during the investigation. The results show that several windows cause fewer hours with overheating, which can probably be explained by a higher line loss when dividing the area. In the model used for this investigation the windows where placed identical on the two facades. However, as the orientation is respectively southeast and northwest, more sun radiation will enter the building from the southeast oriented facade. This means that the northwest facade will allow more window area without overheating compared to the southeast, which is confirmed in the second table, and should be a focus when designing the exhibition and the visual relation to the nature.



ill. 104 - The area for placing windows on the facade

Number of windows	26 m²		28 m²		30 m²		32 m²	
	H > 26 °C	H > 27 °C	H > 26 °C	H > 27 °C	H > 26 °C	H > 27 °C	H > 26 °C	H > 27 °C
10	26	0	144	1				
12			49	0	185	5		
14					84	0	221	11

ill. 105 - Investigation of overheating with different amount of windows and window area

Number of windows	SE: 30 m² + NW: 30 m²		SE: 25 m² + NW: 35 m²	
	H > 26 °C	H > 27 °C	H > 26 °C	H > 27 °C
12	185	5	82	0
14	84	0	21	0

ill. 106 - Different window area on each side of the building

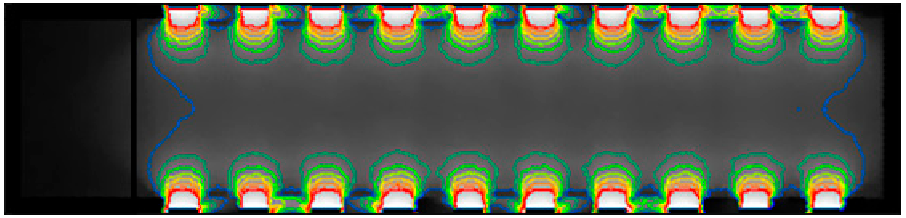
DAYLIGHT STUDIES

Overheating was not the only concern when placing the windows in the building. The window composition should result in a solution balancing both aesthetics, visual connections, temperatures and daylight. When considering the daylight in a building, the windows should allow for enough light to enter the building, this can be measured by controlling if a desired daylight factor is achieved.

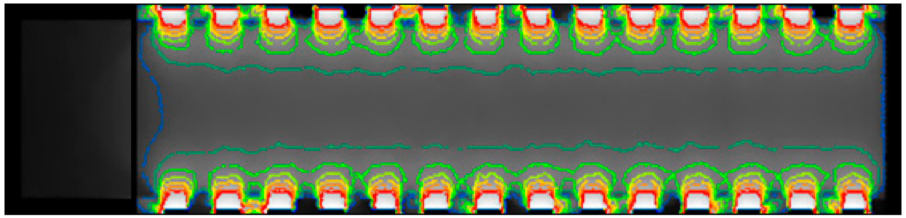
Before beginning the final placement of the windows, daylight simulations were therefore made using Velux simulation tool, to see if the number of windows allowed without causing overheating also allowed a daylight factor above 2,1% in average in half of the room (Dansk standard, 2018). If not, more windows will have to be added, and other strategies such as overhang, screening or the windows' placement in the wall should be re-considered.

Following compositions are tested:
30 m2 with 14 windows = average of 2,7%
26 m2 with 10 windows = average of 2,1%

The daylight factor will depend on the dimensions as well as how the windows are placed on the facade. In this test, the windows are placed with an equal distance between them, to best spread the light inside the room. As the results show, both compositions achieve the desired daylight factor, however, the composition with 30 m2 of windows do as assumed perform best. This study will be used as a guideline in the further development of the facade design.



ill. 107 - Plan 1:250 - Dayligt factor 26 m2 with 10 windows



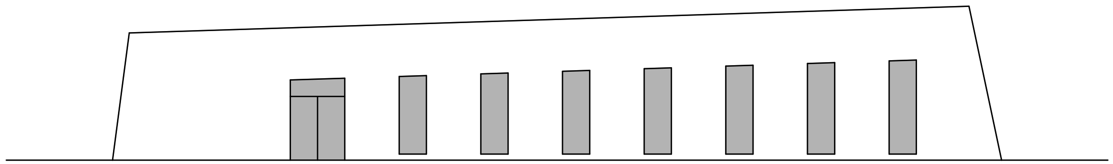
ill. 108 - Plan 1:250 - Dayligt factor 30 m2 with 14 windows

WINDOW COMPOSITION

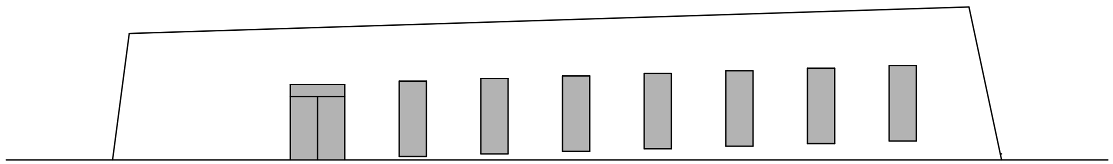
As the buildings' roofs are angled, a study was made to compare different compositions of the shapes and placement of the windows on the facade in relation to the shape of the roof. The intention was to create a uniform expression fitted to the shape of the building and still related to the studies of overheating. The presented illustrations are made to provide a conceptually picture of the different proposals for window compositions.

The different compositions present different ways of working with the windows in relation to the roof. The first proposal used the inclination of the roof to increase the height of the windows accordingly. In the second proposal all the windows have the same height but are raised from the ground to keep a constant distance to the roof. In the third proposal the windows are changed from orthogonal rectangles by inclining the top frame of the window according to the roof. The last proposals showcase a simple design were the windows have the same size and are placed in a completely regular composition using the same height above ground level.

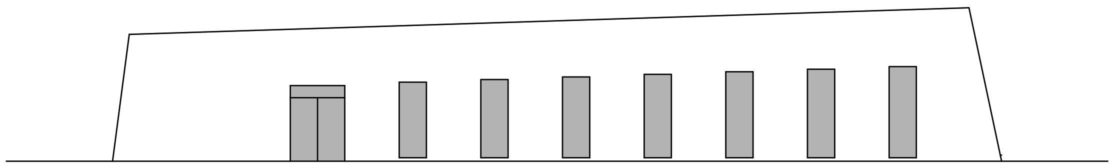
The final window composition will consist of a mixture of a regular composition with small deviations. It was chosen to go with a simple composition as the design appears calmer, and it allows to use several windows in the same dimensions, which is easier and more economic during production. The final window composition will therefore include the use of a few different window sizes. The more irregular building shape and the small deviations will contribute to a less strict, though still controlled, facade expression.



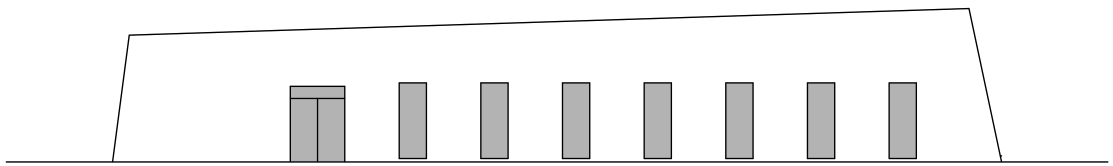
ill. 109 - Facade 1:250 - Windows angled in top after the roof and gradually incresed in size



ill. 110 - Facade 1:250 - Windows samme size, gradullay raised according to roof angle



ill. 111 - Facade 1:250 - Windows same height placement, gradullay raised according to roof angle



ill. 112 - Facade 1:250 - Windows in regular composition using same height and placement in wall

CABIN PRINCIPLES

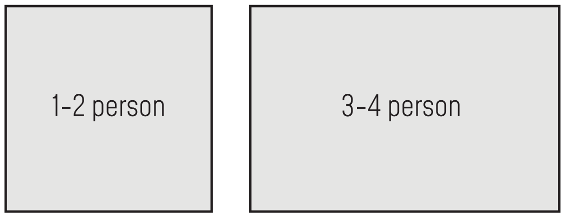
During the design phase, the awareness of the cabins and the main complex being two different things became clearer, and the design of the two became parallel but different design sequences. From the competition brief it was stated that the project should include cabins with sleeping facilities ranging from 1-4 persons. A brainstorm of ideas for the cabins was made, proposing different solutions for the plan layout as well as studying which functions to finally include in the cabins. The conclusion of the brainstorm was three different main principles for the cabins.

The first principle gained from the brainstorm, was to design two different cabins respectively for either 1-2 persons or 3-4 persons. The two types of cabins should be coherent by using the same shape but will be in two different sizes to include the needed functions according to the amount of guest staying there.

The second principle consist of one cabin with sleeping facilities for 2 persons along with the additional needed functions. This part would be considered as the main part of the cabin and can be used alone or together with a smaller building only containing an extra bed, creating space for up to 4 guests.

The third proposal is to make one cabin for 1-2 persons which can be connected to one another, so that the same cabin can function for 1-2 persons when used alone and for up to 4 persons when two are connected.

To best utilize the resources it was in the interest to make a solution for the cabins which was flexible and can adapt to a current need, and therefore the first principle with two types of cabins for either 1-2 persons or 3-4 did not seem to be the optimum solution. The two other principles offered a more flexible design, however, in principle two, the extra bed can only be used in connection with the other part and not alone, while principle three besides from offering an extra bed will double the amount of the additional functions, which will not all be necessary. The conclusion was to continue working with a building which can connect several modules, offering both the desired flexibility as well as making them easier to transport by dividing the weight. To avoid the double functions, which are not needed when connecting several cabins, the toilet functions should be removed and have its own module.



ill. 113 - Two different cabins for 1-2 or 3-4 person

ill. 114 - A main part and an extra bed

ill. 115 - Two identical cabins

CABIN ENERGY STUDIES

As a main part of the concept for the cabins they are going to be transportable to take advantage of the no construction zone and make a design which is adaptable to the changing northern lights. This also means, that the cabins will be supplied from off-grid systems. Each cabin will be equipped with a battery to generate the needed power, which will be recharged at the main complex. To determinate the needed power during the year, and thereby find and dimension the needed battery, simulations were made of the indoor climate in the cabins. The following calculations are based on the cabin module designed for sleeping and residence. Due to the function and the concept for the cabins, it was decided to allow a bigger spread in the indoor temperature, allowing a span from 18-26 degrees. As the cabins are movable the weight is an important factor in the design, and is therefore a main aspect during the following investigations.

To understand the influence of the amount of used insulation, an initial comparison of the heating demand in different scenarios was tested. Due to the concept, it is essential to keep the cabins small, therefore a thin construction was desired. Three different amounts of insulation were tested and compared with the needed energy for heating (see final U-values in appendix 1). The result showed as expected, that an increased amount of insulated equals decreased heating demands. When comparing the total amount of kWh needed for heating on a yearly basis, the energy use fell with 41,4% when the insulation is increased from 150mm to 250 mm (see more detailed data in appendix 4).

	150 mm	200 mm	250 mm
Energy use kWh pr. year	1245	921	730

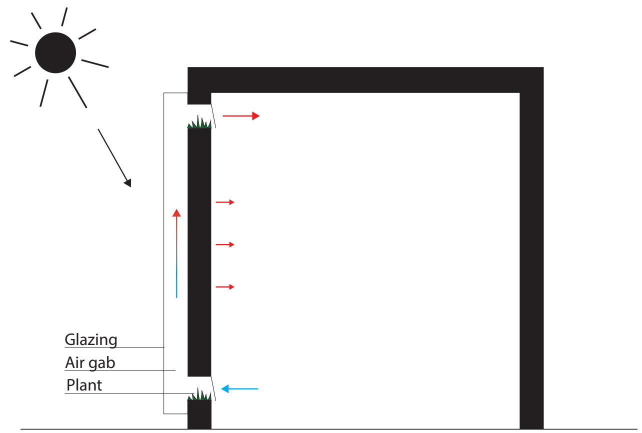
ill. 116

TROMBE WALL

As a passive strategy to contribute to the heating demands, a trombe wall is integrated in the facade of the cabin. The trombe wall contributes as a thermal mass by heating up the shared wall between itself and the cabin and can have an even greater effect through openings which can be opened and closed between the two parts. As the simulation didn't allow for a precise investigation of the mixing between the two, a comparison of the contribution from the shared wall was made, which confirms the positive contribution in the overall heating demands for the cabin, as the heating is decreased by 20% in all the tested scenarios (see more detailed data in appendix 4).

	150 mm	200 mm	250 mm
Energy use kWh pr. year	984	734	585
Decrease kWh pr. year	-262	-178	-145

ill. 117



ill. 118 - The principle of a Trombe wall

ENERGY CONSUMPTION

The cabins are going to be in use all year, but they will have very different needs during winter and summer. To maintain a good indoor climate, when considering the CO2 pollution as well as the temperature, the cabins will during winter need mechanical ventilation as well as heating. Contrary to that, the building simulations shows, that natural ventilation during the skylight can be enough to ensure the indoor climate during the summer months. However, an unexpected rain shower can cause a need for the use of mechanical ventilation during the summer months as well. The calculations presented, illustrates how the most critical day in December will need energy to support heating, the fan power and the heating surface in the ventilations system as well as lighting. The values for all months can be seen in appendix 5, and showcases the energy use, when using mechanical ventilation all year.

	150 mm	200 mm	250 mm
	kWh pr. day	kWh pr. day	kWh pr. day
Heating	3,432	5,040	4,200
HtCoil	6,360	2,064	2,064
Fan power	0,216	0,216	0,216
Light + equipment	0,240	0,240	0,240
Total	10,248	7,650	6,720

ill. 119

BATTERIES

As the most critical day for the energy use appears to be in December, the battery should be dimensioned to fulfill the needs of this day. To decide on the amount of insulation, and thereby the thickness of the structure, a comparison was made of the weight and dimensions for suited batteries. The data presented is a lithium battery made by Sonnen in Germany. The Eco 9.43 battery from Sonnen is interesting as it is a flexible system allowing for several battery modules to be connected (Sonnen, 2018). That means, that some parts of the battery can be removed from the cabin when the energy need is lower to make the total weight lower.

When comparing the batteries with the energy use, as construction with 150mm insulation will request a battery with a nominal capacity of 12,5 kWh for one day use, while the battery one size smaller will provide enough energy when using both 200mm and 250mm insulation. It is therefore chosen to use the 200 mm insulation, as this gives a thinner construction but do not need any additional battery capacity. It is decided to go with a battery only covering one day of energy in the winter, as people are assumed to stay for shorter periods doing winter, and will most likely not be using the cabin doing the day, giving the staff an opportunity to recharge it.

Nominal capacity	90% usage	Weight (excl. cabinet)	Dimensions
kWh	kWh	kg	(H / W / D) in cm
5	4,5	46	49 / 67 / 23
7,5	6,75	69	73,5 / 67 / 23
10	**9**	**92**	**98 / 67 / 23**
12,5	11,25	115	122,5 / 67 / 23
15	13,5	138	147 / 67 / 23

ill. 120

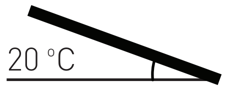
SOLAR PANELS

As the cabins are functioning off-grid, it was investigated how solar power could be used as another renewable energy source to recharge the cabins and extending the time between the cabin having to get the battery changed or return to the main complex to get it recharged. A test was made placing 2 m2 of solar panels on the roof. As the cabins are moveable, they will not have a permanent orientation, however, the northern light will mostly be visible towards north or northeast, which could be used as a guideline to place the solar panels. Simulations were made to see how the angle of the roof will affect the possible gain of solar power and to compare orientations towards east, west and south.

As the energy use is highest during winter, and there are very few hours of sun, the solar panels will not have any visible impact during this period. The tables show the results in a regular day from May to August and was made with monocrystalline panels (see results from all year in annex 6).

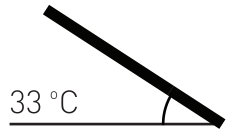
May	June	July	August
1,056 kWh pr. day	0,648 kWh pr. day	0,528 kWh pr. day	0,552 kWh pr. day

ill. 121 - Daily energy use i summer months



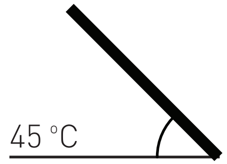
	South	West	East
	kWh	kWh	kWh
May	1,17	1,03	1,02
Jun	1,15	1,04	1,06
Jul	1,10	0,99	0,99
Aug	0,89	0,77	0,75

ill. 122 - Energy production at 20 degrees



	South	West	East
	kWh	kWh	kWh
May	1,16	0,91	0,90
Jun	1,11	0,90	0,92
Jul	1,07	0,86	0,86
Aug	0,91	0,68	0,66

ill. 123 - Energy production at 33 degrees



	South	West	East
	kWh	kWh	kWh
May	1,12	0,81	0,79
Jun	1,05	0,79	0,81
Jul	1,02	0,76	0,76
Aug	0,89	0,61	0,58

ill. 124 - Energy production at 45 degrees

Due to the high summer sun, the solar panels will perform best doing summer at a low angle when measuring from a horizontal plan. At this point of the process, the cabins were designed with a roof with a higher inclination, so it was tested how much the performance of the solar panels will decrease at other angles. The simulations showed, that several positions would be able to cover the needed energy on a daily basis during summer. However, due to the previous investigations it was decided not to implement the solar panels. The used battery is very flexible, as parts of it can be removed to reduce the weight doing summer. With the very little energy use doing summer, the cabin will be able function independent for a week in June, July and August, with only one module from the battery installed and delivering 4,5 kWh. With that in mind, the solar panels seemed like a big grasp compared to their contribution, considering both the resources with installing and maintaining the panels and the unsteadiness of the cabins' orientation, but also regarding the aesthetics of the cabin and the weight. A solar panel in this size will weigh about 28 kg., which will affect the cabin all year and adds more weight than one battery module (VivaEnergi, n.d.).

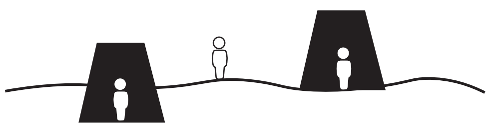
PRESENTATION

MAIN COMPLEX

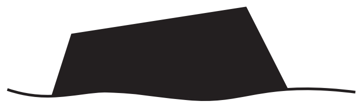
The concept behind the main complex derives from the desire of creating a variation of experiences. To enhance a differentiation between the functions and create a stronger relation from the buildings to the exterior spaces the main functions are scattered into several buildings. A relation between the natural sloped terrain and the interior spaces are used as a way of enhancing different atmospheres in the different functions.

It is wanted to have a strong relation between the buildings in the main complex and the landscape. in order to accomplish this the buildings are given a heavy character as if they originate from the earth. This is expressed in the choice of materials as well as the buildings' shape and proportions.

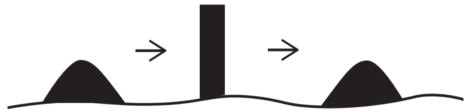
The overall approach to materials is based on the cradle-to-cradle philosophy. Biodegradable materials are used as a relation between the cradle-to-cradle philosophy and the vernacular building traditions of Iceland. With the limitations of locally produced building materials, the concept focuses on the potentials of using alternative materials in Iceland.



ill. 125 - Experience of variation



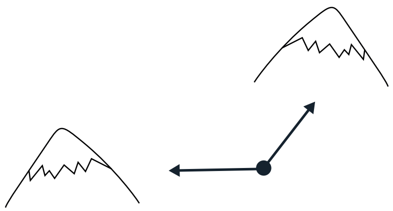
ill. 126 - Merging with landscape



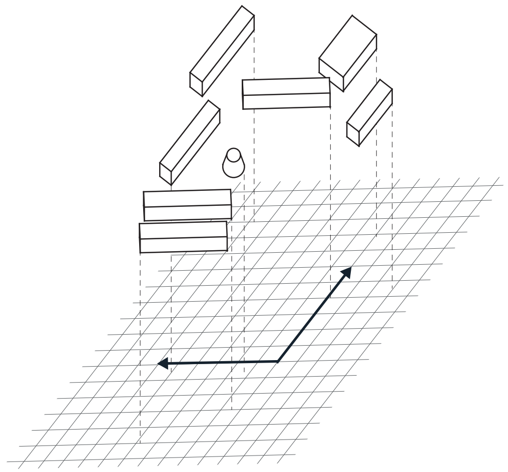
ill. 127 - From earth to earth

GRID

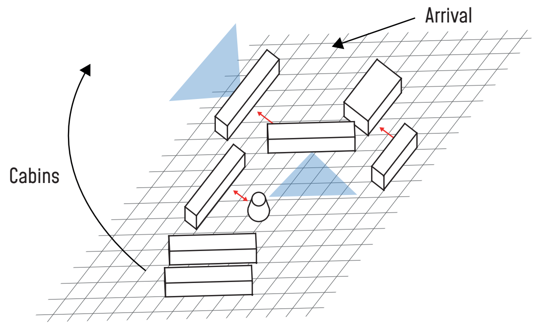
A grid is used to place the buildings and pathways on the otherwise unaffected site. The grid is based upon two view linesfrom the highest point of the site towards nearby mountains. The lines are afterwards extended and mirrored all over the site. The buildings are placed in the grid according to the wanted internal connection, desired orientations and views.



ill. 128 - Origin of grid



ill. 129 - Extended grid lines



ill. 130 - Placing of buildings

MASTERPLAN

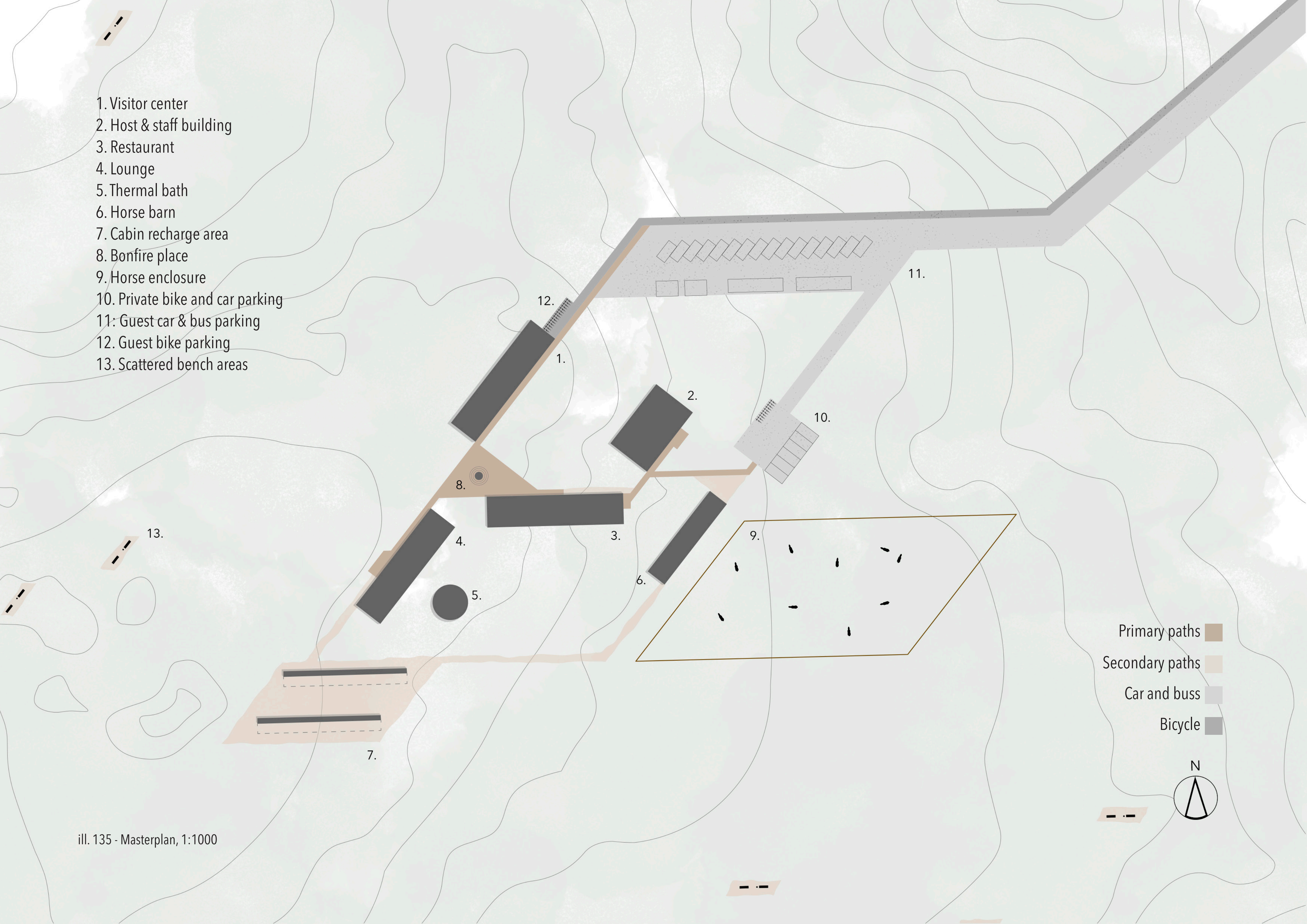
ill. 131 - Masterplan,1:5000

When one arrives to the site, the complex will be connected to an existing road leading one to a parking lot with car parking, handicap parking and bus parking. A bicycle path allows bikes to drive closer to the complex and park on a separate parking lot. A smaller and more discrete road from the main parking leads to the host and staff parking facilities. Different path systems are made for the transitioning between buildings to create secondary and primary paths. The paths are placed along the buildings, leaving the landscape very untouched. The placing of the paths also creates attention towards other functions in the complex when walking around. The visitor center, restaurant and lounge area are the main functions for the guests. The paths to the three functions meet in a plateau with a bonfire. The plateau connects the functions and creates a space for the guests to socialize in a way that is related to the ancient traditions regarding meeting around a bonfire and telling myths.

ill. 132 - Asphalt is used on the roads, parking lot and bicycle lane to create a solid ground sheet.

ill. 133 - Raised wooden paths will be used for the primary pathways, creating a clear contrast to the landscape.

ill. 134 - Gravel paths in the same level as the terrain will be used as secondary pathways.



ill. 135 - Masterplan, 1:1000

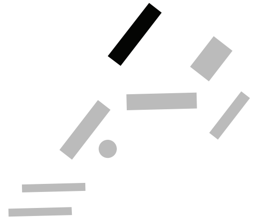
EXTERIOR MATERIALS

The exterior materials of the main complex are chosen based on the cradle-to-cradle philosophy. Glass is an essential part of the exterior materials as it emphasizes a visual relation between the interior and exterior spaces and provides the buildings with daylight. Basaltic rock is locally produced and used in vertical tiles as the main facade cladding on the building. The stones are attached using small hooks, making it easy to reuse them after end of life for the building. Driftwood gathered on the shores of Iceland is used to emphasize the entrance and together with an offset in the facade soften the meeting between interior and exterior. A green roof is continued down the angled facades of the building creating a smooth transitioning between the building and landscape. In this and the next spread the facades of the Visitor center are displayed. The additional buildings will have the same use of materials and are shown in appendix 7 to 9.

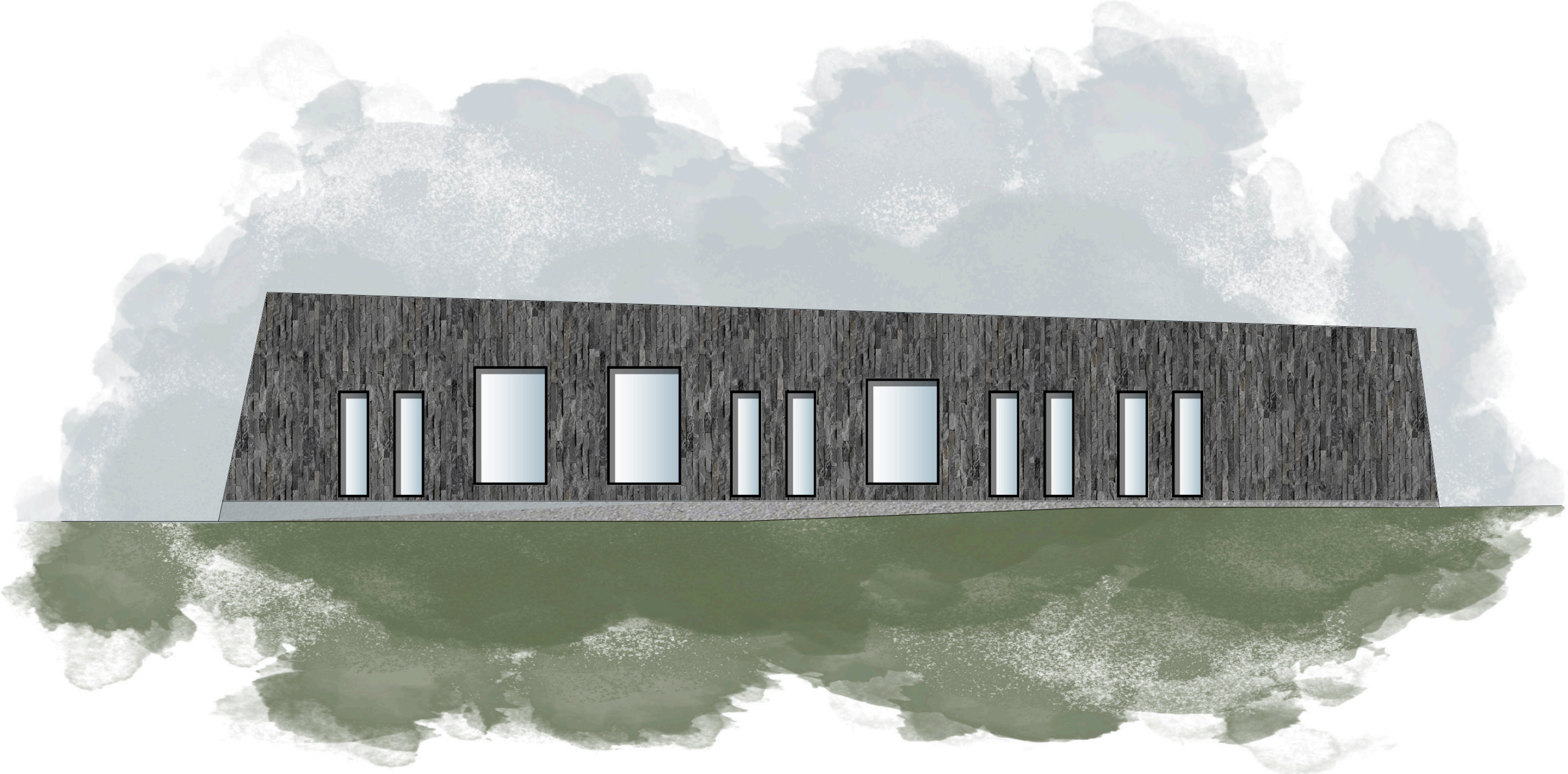
ill. 136 - Basaltic rock

ill. 137 - Driftwood

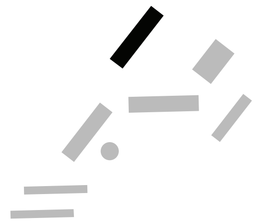
ill. 138 - Green roof

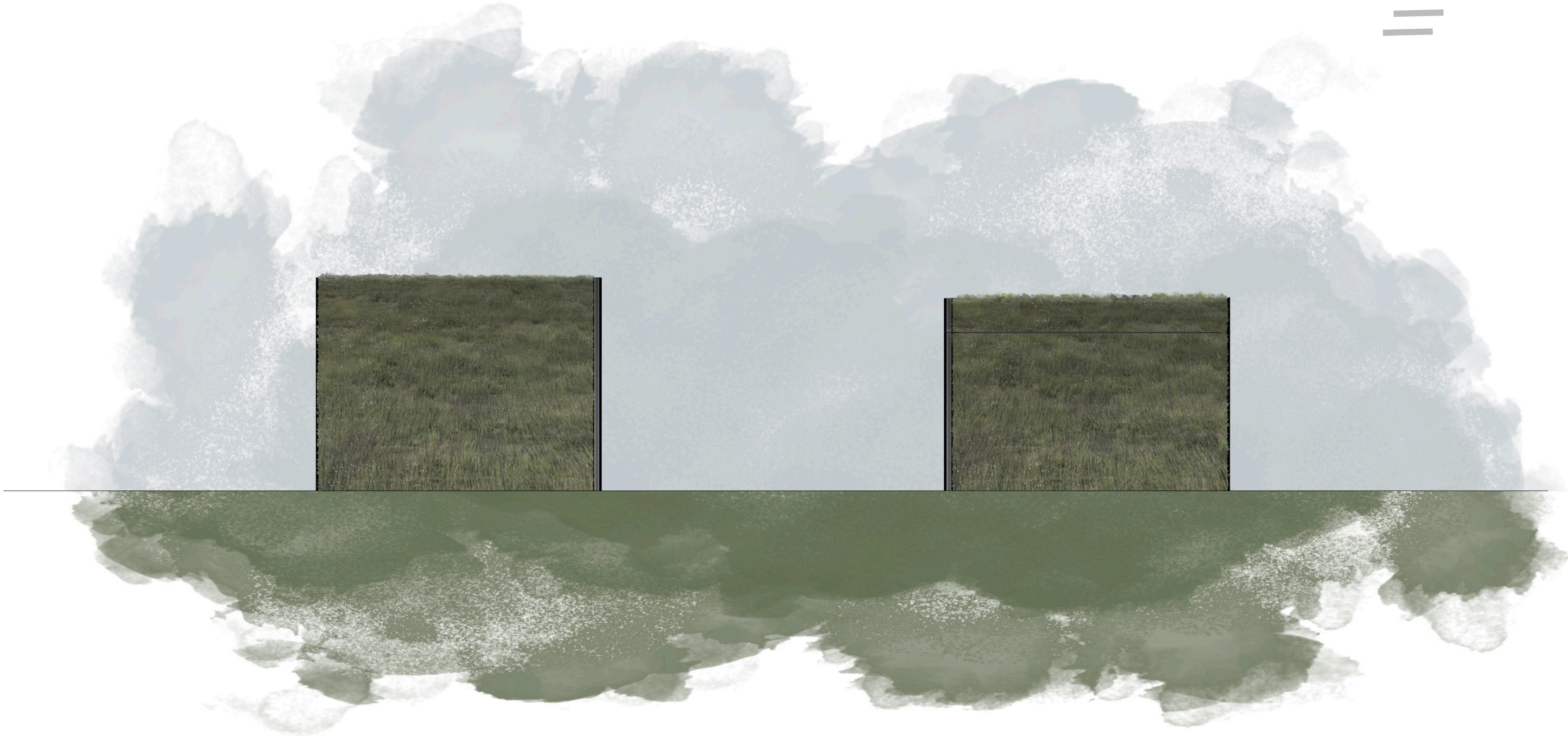


ill. 139 - Visitor center facade SE, 1:150



ill. 140 - Visitor center facade NW, 1:150

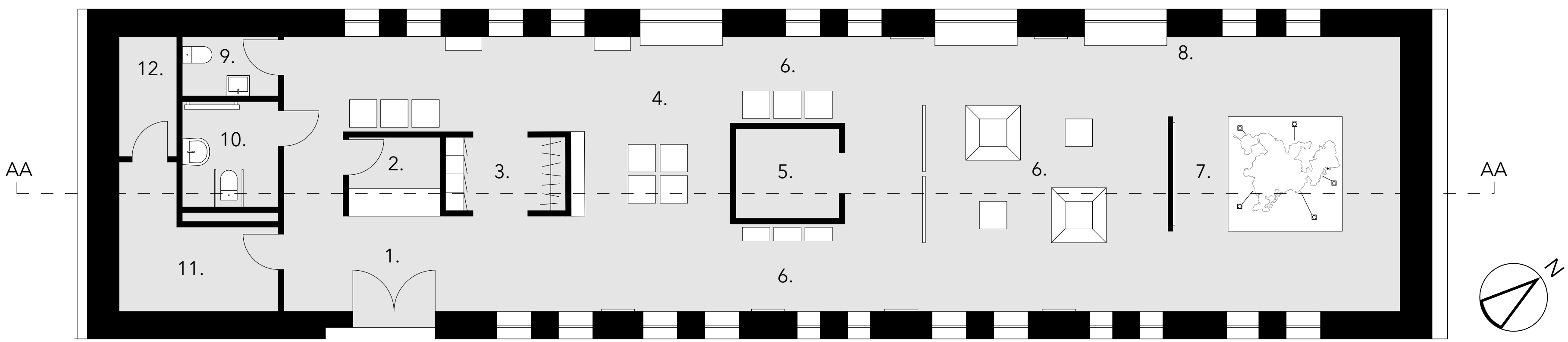




ill. 141 - Visitor center facade NE, 1:150

ill. 142 - Visitor center facade SW, 1:150

VISITOR CENTER



ill. 143 - Plan, 1:150

1. Entrance
2. Reception
3. Cloakroom
4. Gift shop
5. Light experience
6. Exhibition area
7. Active map and screen over local area
8. Bench build into window opening
9. Toilet
10. Handicap toilet
11. Storage
12. Technical room

ill. 144 - Section AA, 1:150

The visitor center is the first building the guests will reach, when following the walking path from the parking lot to the complex. The purpose of the visitor center is to educate and inform about the Icelandic nature and how tourists can help preserving the nature when visiting the country. The visitor center will include an exhibition divided into areas with different functions. The country's fascinating nature and its history will be described using specimen of rocks, earth etc. together with textual communication and pictures. An installed box will be used to simulate different nature phenomena, such as northern light, by using artificial light effects. A map of the lake Myvatn will function as an interactive media, where guests can select different locations around the lake whereupon different information on the location will be displayed on a screen. With its many windows the building focuses on creating a connection between the exhibition and the outside nature. Placed on the highest spot in the construction zone, it allows for views towards the lake, which can be enjoyed from build-in benches placed in the windows.

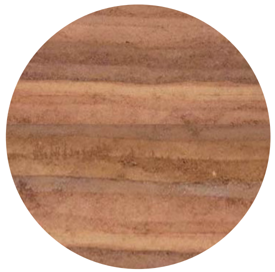
ill. 145 - Interior render from Restaurant

INTERIOR MATERIALS

With the concept of earth-to-earth and the relation to the vernacular turf-house architecture, the interior walls are made from different types of earth pressed together in a rammed earth construction and insulated with sheep wool. The earth walls are not only biodegradable but also enhances the relation to the nature when inside the building and brings a warm feeling to the room by its color and tactility. The earthen wall has the ability to absorb and release moisture, which helps balancing the indoor climate. By using different types of soil, the wall gets layers of different colors.

A suspended ceiling made from biodegradable sphagnum hides the ventilation pipes, which improves the acoustics by absorbing sound and make the room appear more spatial with its light color. Due to the constructional properties of the earth walls, wooden lintels are placed above the majority of the windows to improve the load bearing properties of the construction. The floor is covered in rammed earth made from only one type of earth to give it a homogeneous expression.

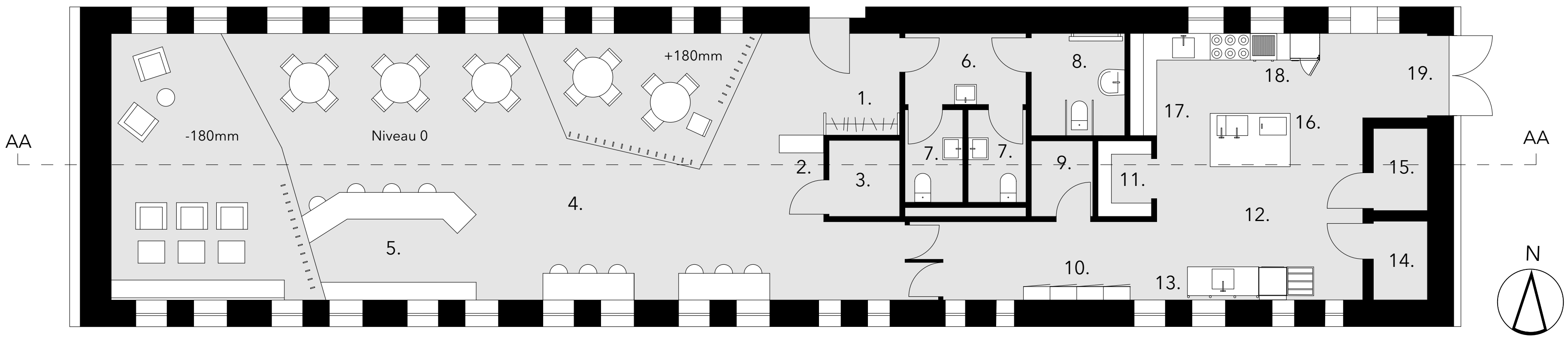
ill. 146 - Sheep wool



ill. 147 - Rammed earth

ill. 148 - Sphagnum board

RESTAURANT



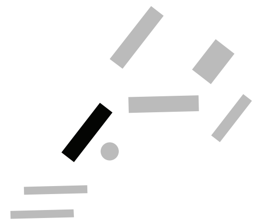
ill. 149 - Plan, 1:150

1. Cloakroom
2. Host stand
3. Storage
4. Seating area
5. Bar
6. Toilet entrance hall
7. Toilet
8. Handicap toilet
9. Technical room
10. Tableware storage
11. Dry storage
12. Kitchen
13. Dishwashing zone
14. Freezer
15. Cold storage
16. Vegetable zone
17. Serving zone
18. Meat zone
19. Delivery of goods

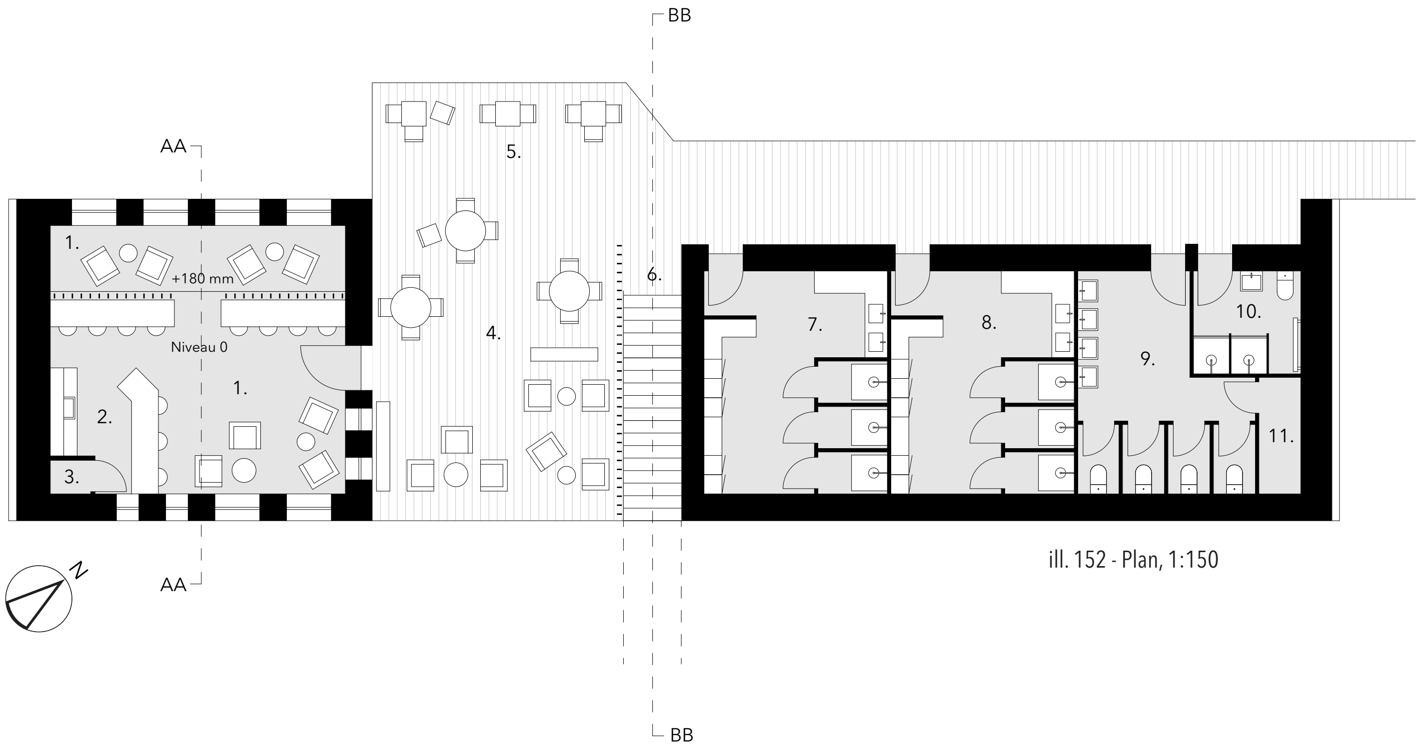
ill. 150 - Section AA, 1:150

For the guests the restaurant will be entered from the northern facade facing towards the visitor center. Due to its orientation and placement on the site one will quickly after entering the building find oneself being deeper into the ground. The windows placed just above the level of the terrain in front of the building enhances the perception of this relation and creates seating area in eye level with the terrain. Small level differences are used as a way to divide the room. The building is tallest at the entrance area, creating an open and welcoming atmosphere. When moving deeper into the building, the character of the restaurant will change to be more relaxed and intimate. From the south facade of the building, the guests will be able to enjoy a view towards the volcano Hverfjall. For the staff members and delivery of goods a separate entrance is placed on the east facade of the building giving a direct access to the kitchen facilities.

LOUNGE



This building is mainly meant to used as additional functions for the guest staying in the cabins. As the cabins are going to be minimal on functions due to the wish for a compact and easily moveable structure, the main complex will contain functions related to the cabins, which can be used during daytime. The building offers a relaxing zone with a lounge area and a small bar. From the lounge big windows provide views towards the nature. The lounge is placed in extension of a mainly covered terrace which can likewise be used to enjoy the nature. The covered part allows for the terrace to be functional during more time of the year. The building also includes toilet and shower facilities.



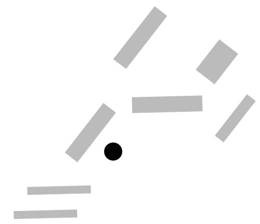
ill. 152 - Plan, 1:150

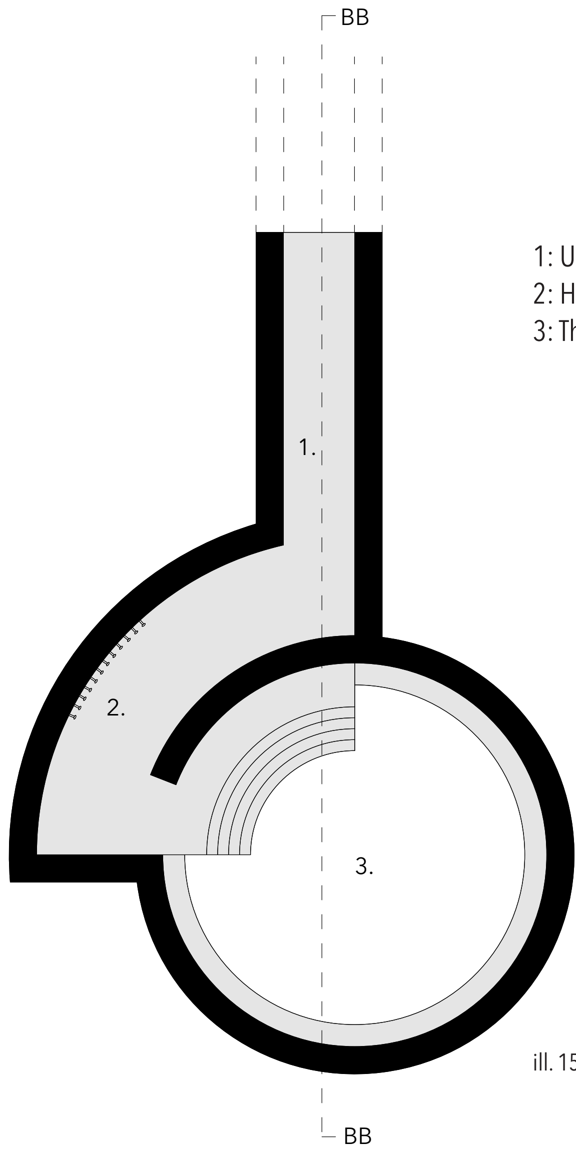
1. Seating area
2. Bar
3. Technical room
4. Covered terrace
5. Exposed terrace
6. Stair to thermal bath
7. Women bath facilities
8. Men bath facilities
9. Toilets
10. Family room
11. Techincal room

ill. 153 - Section AA, 1:150

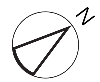
THERMAL BATH

The thermal bath is entered through an underground corridor from the terrace, making it convenient to enter the shower and toilet facilities in connection with the use of the thermal bath. The way of entering the bath gives it a unique atmosphere and the perception of the spatiality is essential. The open terrace and the placement of it in relation to the thermal bath allows for a visual connection to the bath when going down the stairs. One will go from an outdoor open space, into the dark corridor and lastly enter into the bath which is a high circular room only lit from an opening in the top. The experience of the bath will be far different and surprisingly more spatial than when seen from above ground.

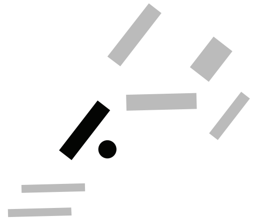


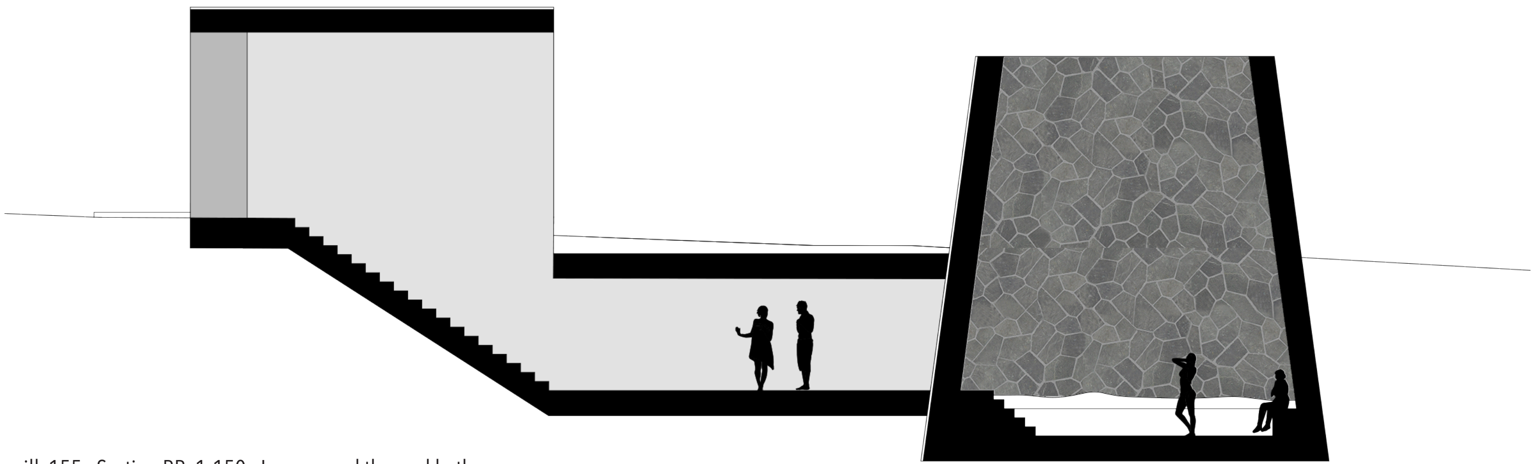


1: Underground passage
2: Hooks for bathrobe etc.
3: Thermal bath



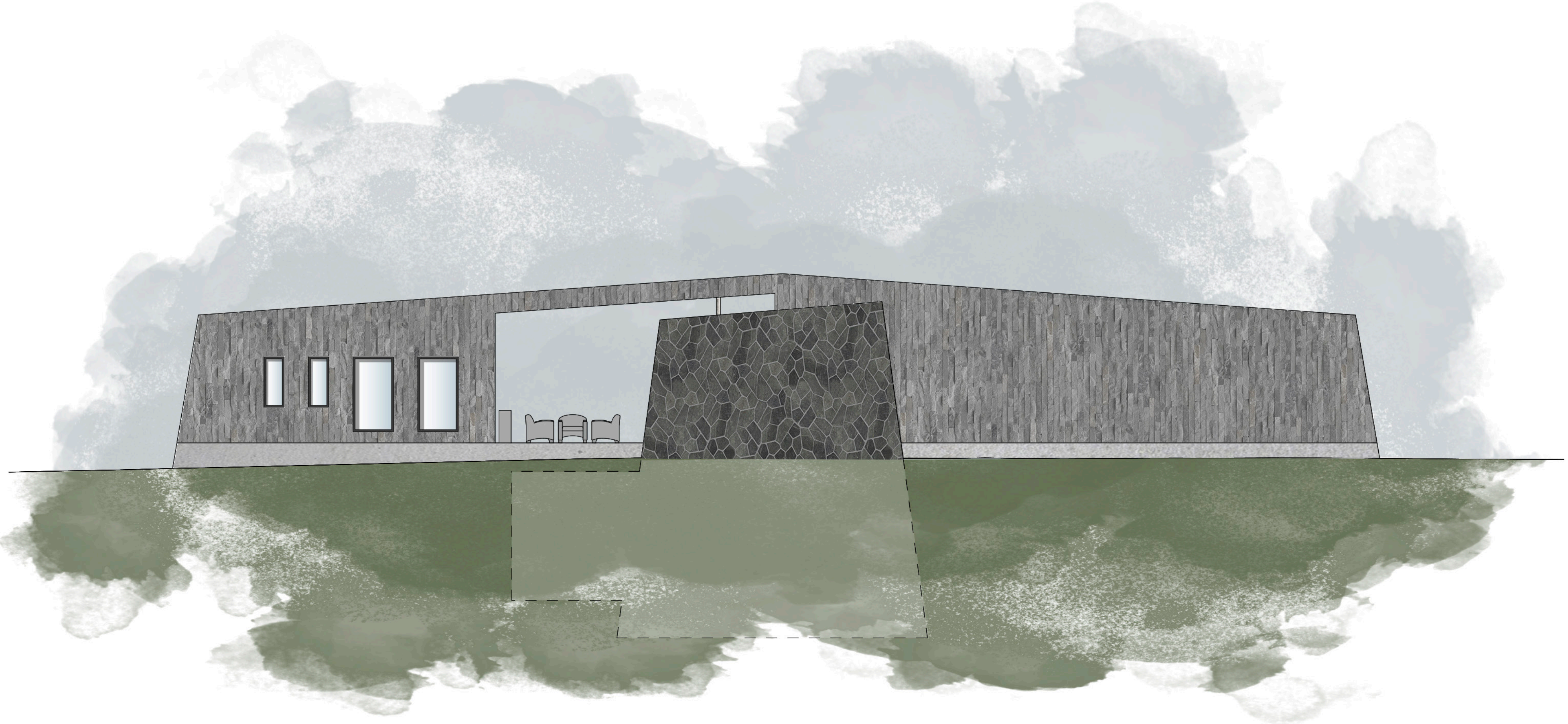
ill. 154 - Plan, 1:150



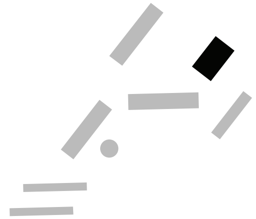


ill. 155 - Section BB, 1:150 - Lounge and thermal bath

ill. 156 - Basaltic rock cladding in its natural shape



ill. 157: Facade SE, 1:150 - Lounge and thermal bath

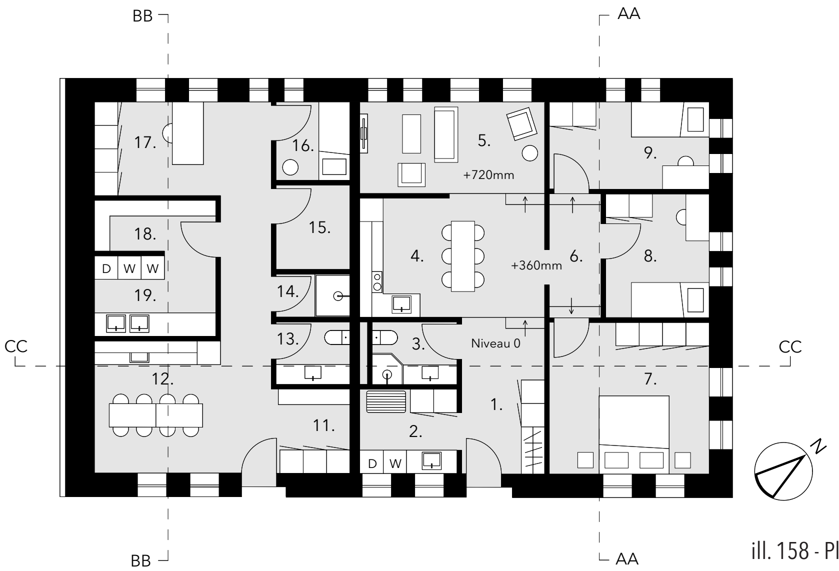


HOST & STAFF BUILDING

The host residence and the staff related functions are placed in one building, not open for the public. The building has two entrances separating the two function groups. Placed next to the secondary parking lot, it is easy to arrive to the building for staff as well as the host family.

The host residence is designed for housing a family of two adults and two children. The terrain is used to create different levels inside. The building is highest when entered and is gradually getting lower when moving towards the living area, creating a more intimate atmosphere. In the building's opposite axis the roof is shaped to give more height and spatiality in the accommodation spaces and is used as a storage on top of the bathroom. As the only building in the main complex, the building has three open facades to allow for the needed daylight in the several small functions.

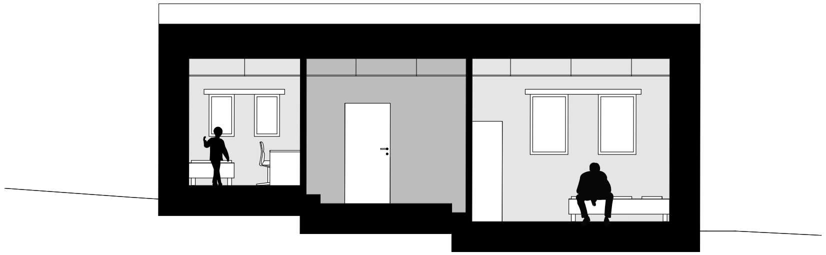
The staff functions are all placed in one level, making it more practical to move around. This part of the building will be used when staff arrives and leaves as well as during the working hours. The entrance to the staff functions are placed close to the kitchen in the restaurant, making it convenient for the staff to move between the two.



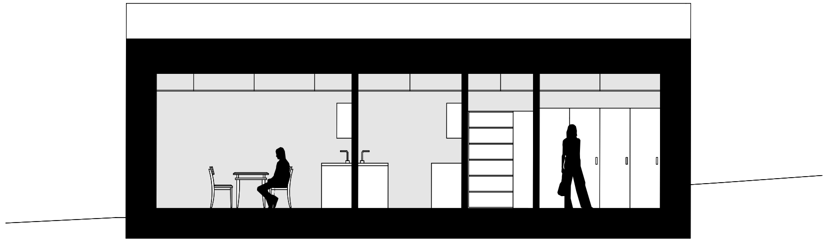
ill. 158 - Plan, 1:150

Host residence:
1. Entrance
2. Utility room
3. Bathroom
4. Kitchen & dinning area
5. Living room
6. Hallway area
7. Master bedroom
8. Bedroom
9. Bedroom
10. Storage

Staff functions:
11. Wardrobe
12. Canteen
13. Toilet
14. Shower
15. Technical room
16. Rest room
17. Office
18. Storage
19. Cleaning/laundry



ill. 159 - Host residence section AA, 1:150

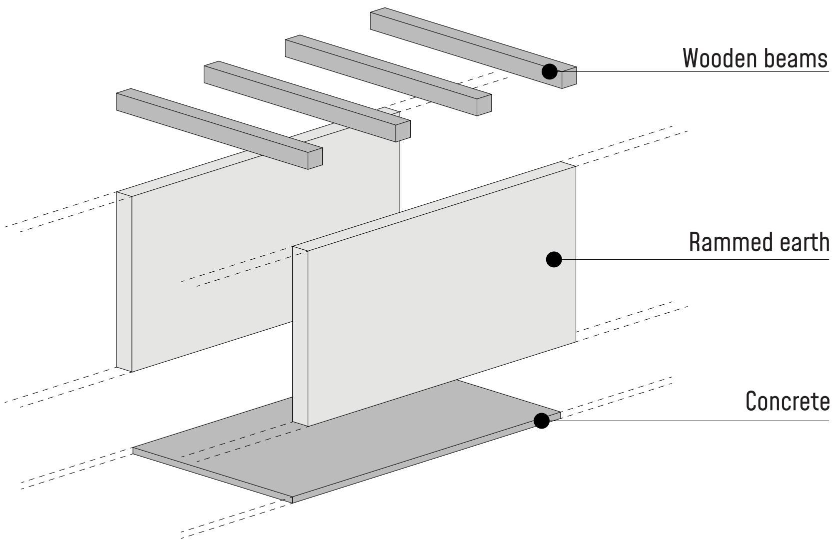


ill. 160 - Staff functions section BB, 1:150

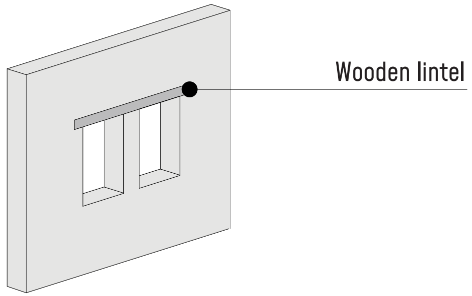
ill. 161 - Host residence + staff functions section CC, 1:150

CONSTRUCTIONAL PRINCIPLE

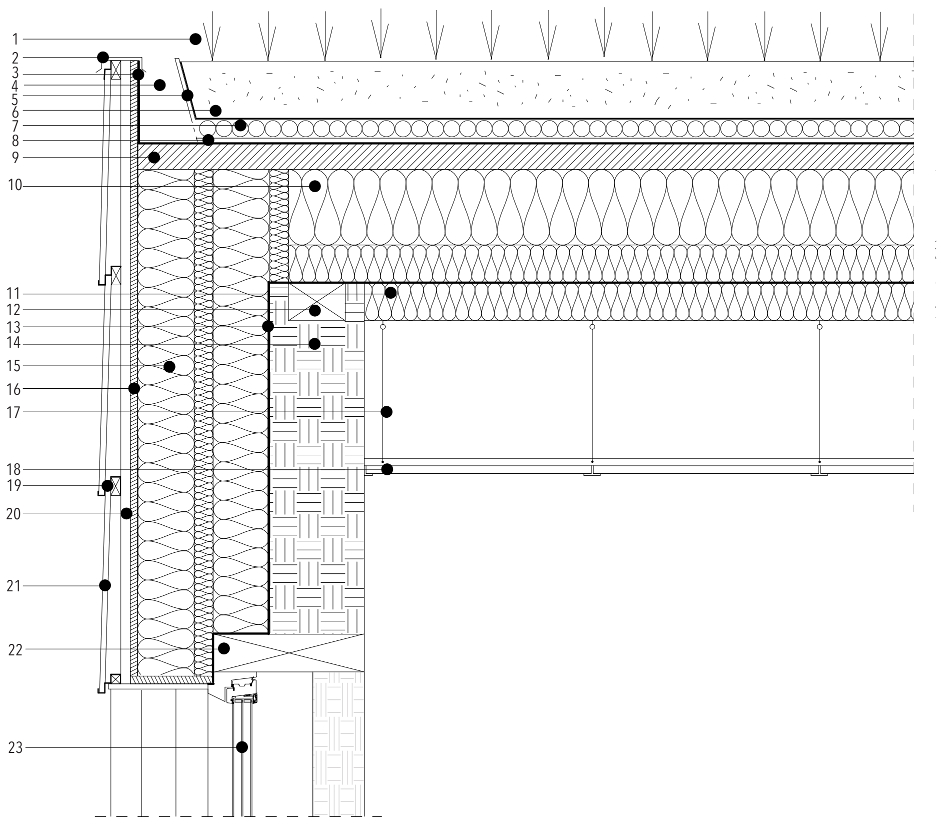
Starting from the top of the buildings, the green roof is built upon a layer of load-bearing wooden beams made from construction wood and spanning across the short axis of the building. The wooden beams in the roof lie on another wooden beam placed in the top of the wall construction. As the building with combined host and staff functions has a larger span than the additional buildings, the beams are here used in the opposite direction resting on one facade and a load-bearing wall dividing the host residence from the staff functions. The walls are made from rammed earth and operate as a plate structure leading the forces from the roof to the ground. Using rammed earth for the walls sets some limitations for placing windows as it has a decreasing effect on the strength of the wall. As a part of the facade design, many of the windows are placed in pairs having the same height. This approach is used due to aesthetical reasons to create a system in the facades, but it also allows for one wooden lintel to be placed on top of two windows at the same time to strengthen the load bearing function of the structure. Some of the facades have a few pair of windows which are offset in height. These windows are very slim, and in these cases the lintel is left out. The floor is constructed from a layer of concrete with installations to a floor heating system, and is afterwards covered with a layer of earth. The concrete layer is used to stabilize the earth floor covering, to avoid cracks and the like when the ground below the buildings operates.



ill. 162 - Constructional principle

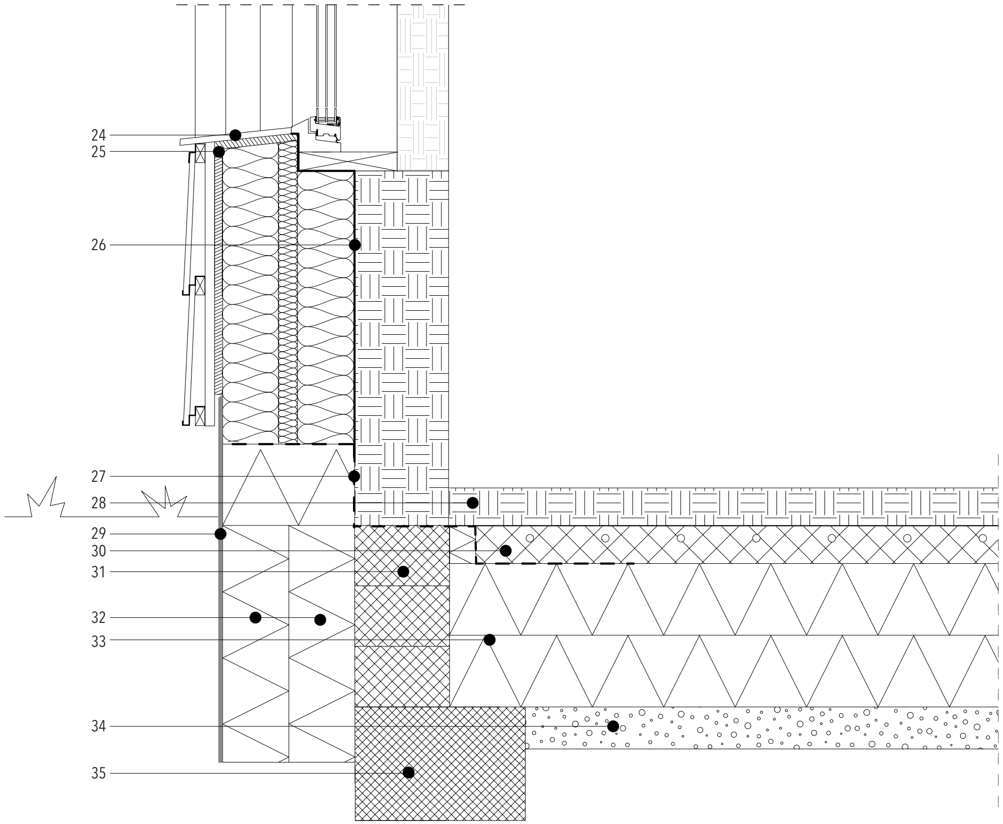


ill. 163 - Enhancement w. windows



ill. 164 - Meeting between roof, exterior wall and window, 1:20

1: Grass
2: Zink capping
3: PVC waterproof membrane
4: Gutter w. gravel
5: Filter cloth
6: Growing medium
7: Drainage layer
8: Root barrier
9: Waterproof roof plywood 60 mm
10: Sheep wool w. 300 mm rafter c/c 500 mm
11: Sheep wool w. transverse battens, 100 mm
12: Wooden beam
13: Vapour barrier
14: Rammed earth wall 250 mm
15: Sheep wool 350 mm w. dislocated I-profiles
16: OSB slab
17: Suspended ceiling w. ventilation pipes
18: Biological spaghnum boards 600x600mm
19: Horisontal battens with mountings
20: Vertical battens
21: Basalt cladding
22: Woddel lintel
23: Window

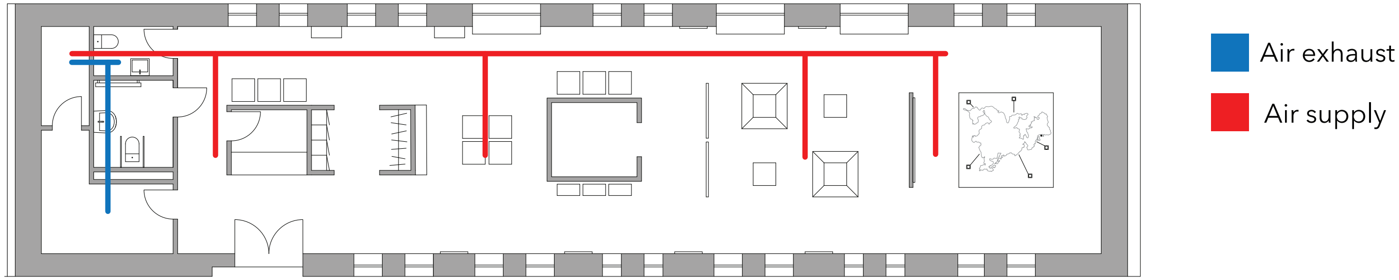


ill. 165 - Meeting between foundation, exterior wall and window, 1:20

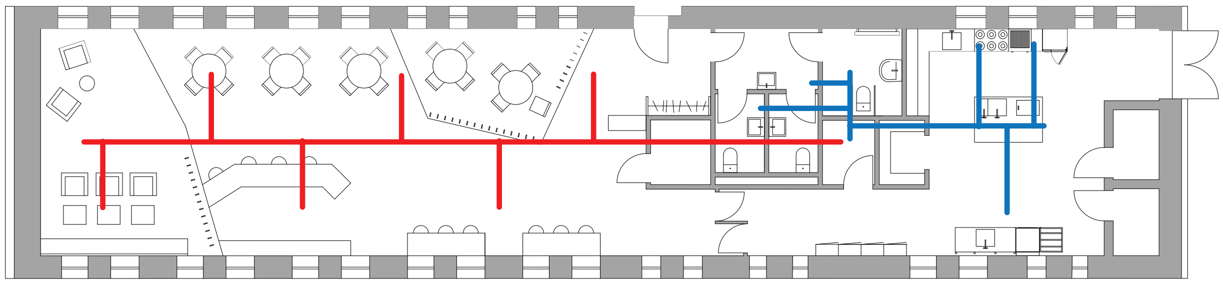
24: Still of one piece polished basalt
25: OSB slab
26: Vapour barrier
27: Radon and moisture barrier
28: Rammed earth flooring
29: Concrete plate
30: 100mm reinforced concrete w. floorheating
31: Lightweight foundation blocks w. insulation
32: 2x175mm polystyrene
33: 2x200 mm polystyrene
34: Sand cushion
35: Concrete foundation block

VENTILATION STRATEGY

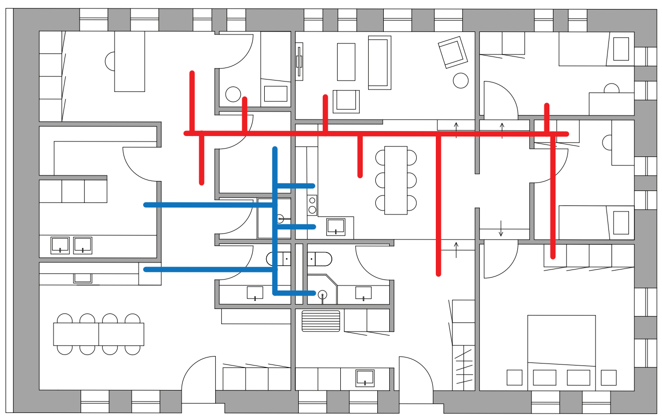
The main complex will be ventilated by a mechanical ventilation system using mixture ventilation from fittings placed in the roof. In the more functional rooms such as the restaurant's kitchen and storage rooms, the ventilation pipes will be visible, while suspended ceilings are used in rooms for visitors and living spaces. Each building will have its own ventilation unit supplying both inlet and outlet air to ensure a balanced ventilation. The shown plan drawings are a conceptual proposal for the placement of the ventilation pipes and which rooms will need an air supply and air exhaust.



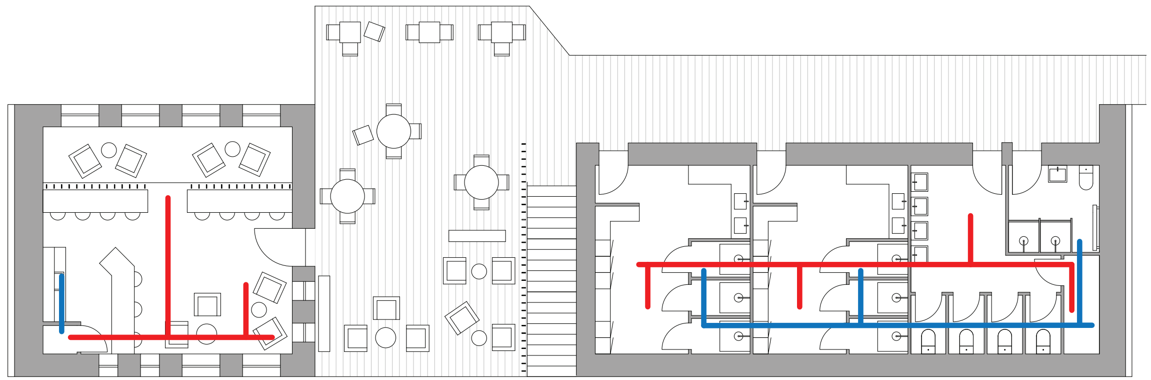
ill. 166 - Plan Visitor Center, 1:200



ill. 167 - Plan Restaurant, 1:200



ill. 168 - Host & staff building, 1:200



ill. 169 - Plan Lounge and bath facilities, 1:200

INDOOR CLIMATE

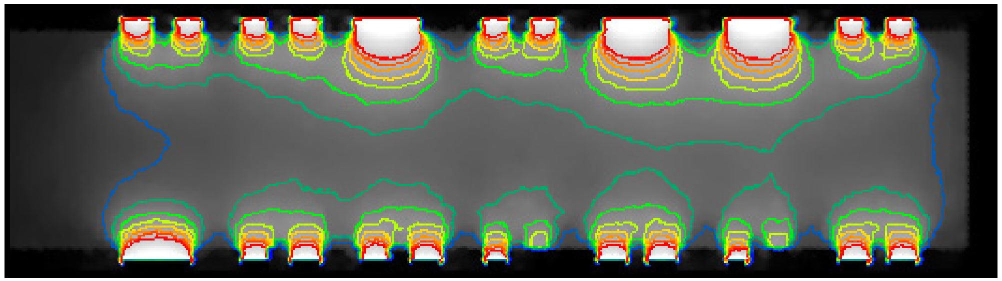
For the main complex the indoor climate of the visitor center is tested with its final window composition. As the complex is going to be supplied by the nearby plant Bjarnaflag, the energy used in the building is green energy supplied from a geothermal source. Therefore, in contrast to the cabins running on power from a battery, the focus in the main complex has not been on saving energy. Considering this and the weather conditions of Iceland, it is decided to use mechanical ventilation all year in the Visitor center. In this type of building, it is preferable to keep a more constant indoor climate, where natural ventilation can be hard to control, and it can be difficult to place openings near any exhibition parts due to draft, rain and snow.

The building is compared to following demands:
Max PPM level = 850 (Dansk standard, 2007 - p. 36)
Temp. mean summer = 23-26 degrees
(Dansk standard, 2007 - p. 31)
Temp. mean winter = 20-24 degrees
(Dansk standard, 2007 - p. 31)
Max. 100 hours > 26 degrees (Bygningsreglementet, 2018)
Max. 25 hours > 27 degrees (Bygningsreglementet, 2018)

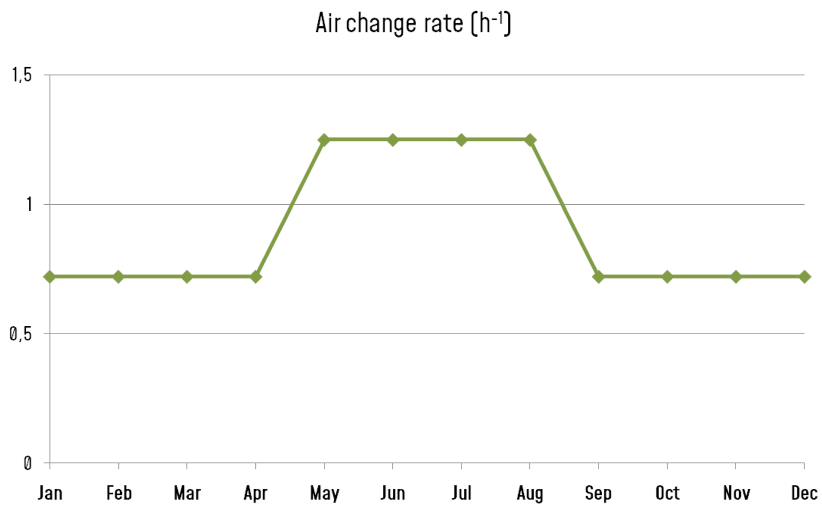
The presented results show that the indoor temperature follows the outdoor temperature. Described in the initial studiesin the process investigating the window area on the facade, the air flow used in the mechanical ventilation was dimensioned to use a ventilation pipe with a diameter at 315mm and an air speed on 5 m/s, allowing a possible air change up to 0,38 m3/s. To achieve an optimum indoor climate, the mechanical ventilation will only be active during the hours of use in winter, however in the warmest months; May, June, July and Augusts, it will be necessary to extend the mechanical ventilation a couple of hours before and after the opening hours, to avoid overheating. This can be seen in the results of the mean air change, which is raised in these months.

During the simulations of the final indoor climate, a simulation was made to investigate the effect of using natural ventilation during summer. Due to the low outdoor temperatures it will be necessary to use heating during the summer months if natural ventilation is applied to the visitor center. That means, that even though the energy used for mechanical ventilation will be lower, besides from creating a less controlled indoor climate, the decreased energy needed for ventilation will cause an increased energy demand for heating.

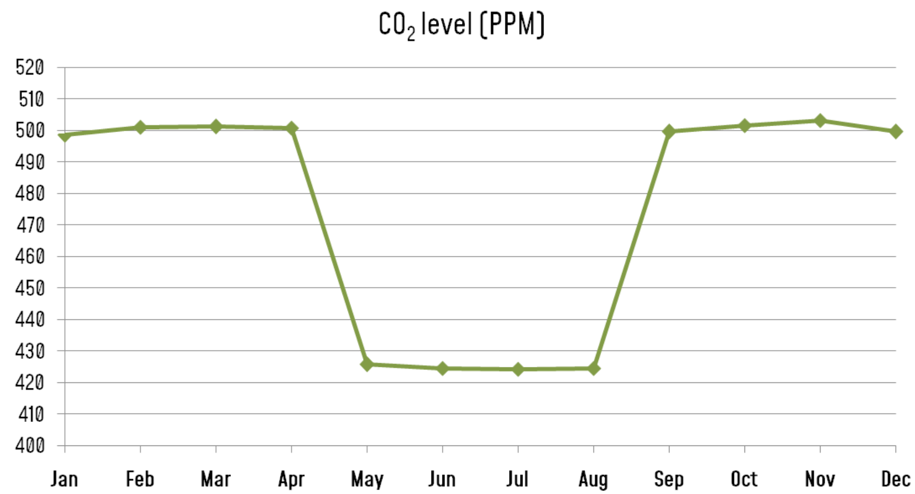
As the visitor center is to be used during the day and will partly function as a workplace, the final daylight factor is tested. New European standards suggest that the average daylight factor should be above 2,1% inhalf of the room in a workplace (Dansk Standard, 2018). The building is provided with many windows creating a more transparent and open building with a strong visual relation to the landscape. The design creates good conditions for getting enough daylight, and does when tested on an overcast sky has an average daylight factor on 2,6%.



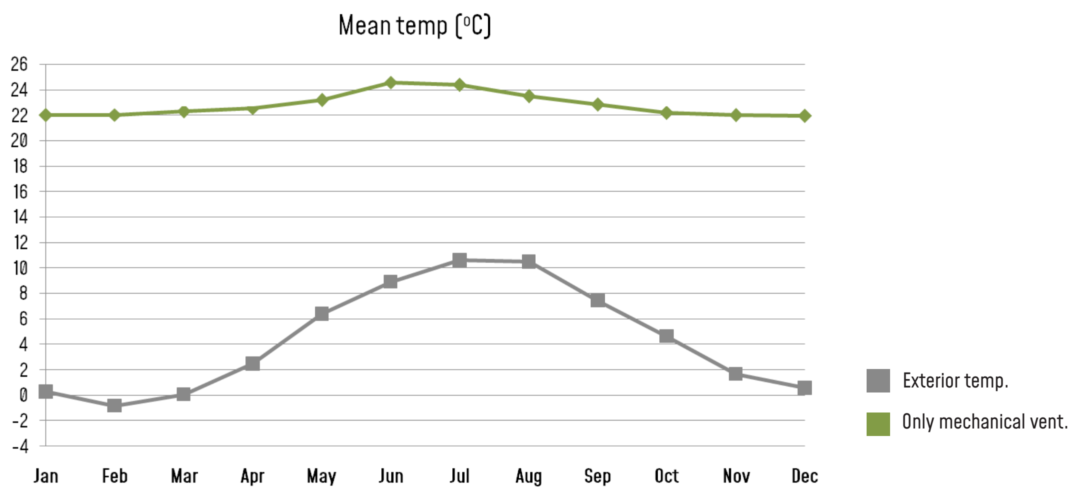
ill. 170 - Plan Exhibition in visitor Center, 1:200



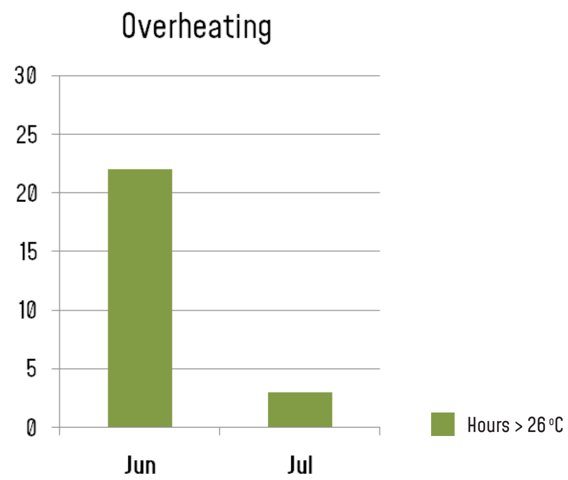
ill. 171 - Air change rate



ill. 172 - CO2 level

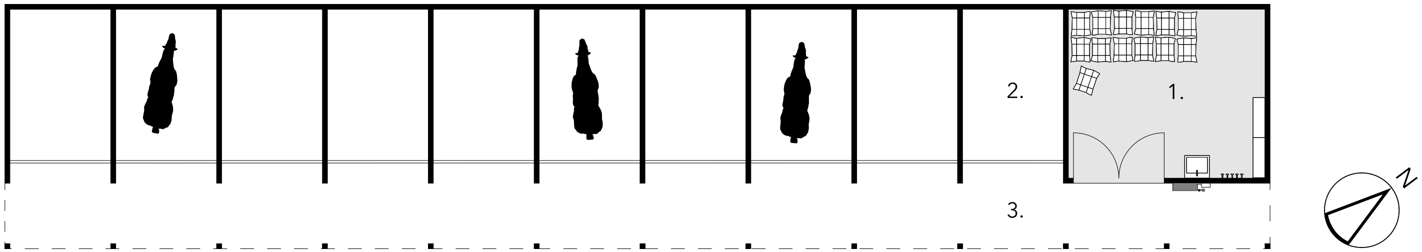


ill. 173 - Mean temp.



ill. 174 - Hours above 26 degrees

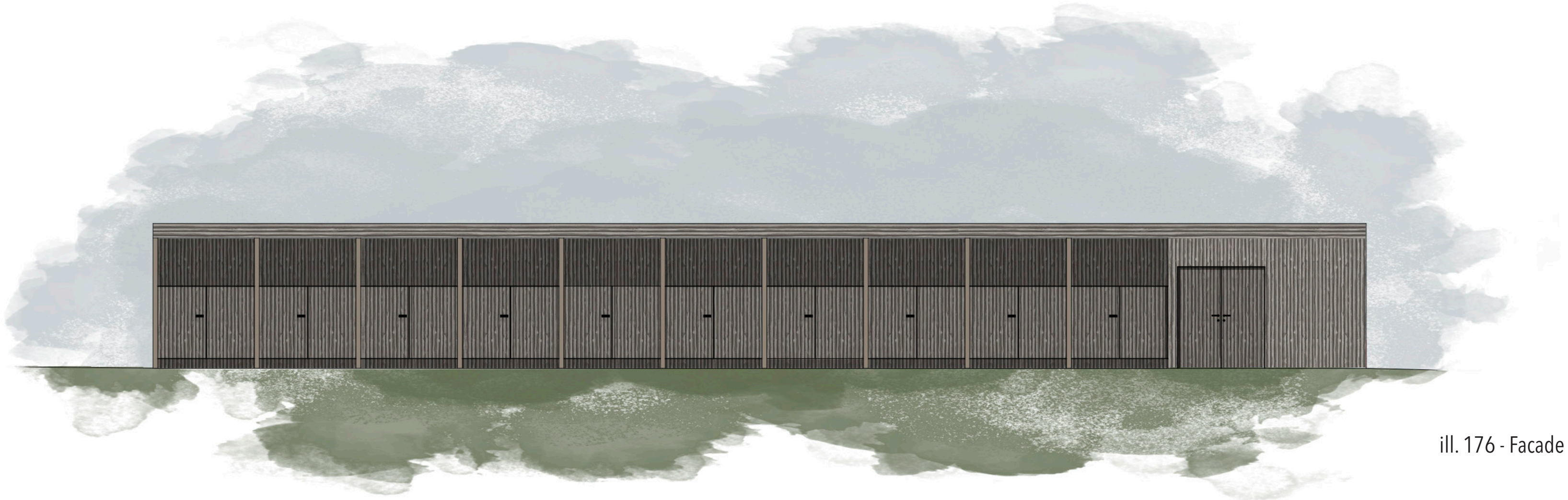
HORSE BARN



1. Storage
2. Horse box stable (6m^2 for each horse)
3. Covered path

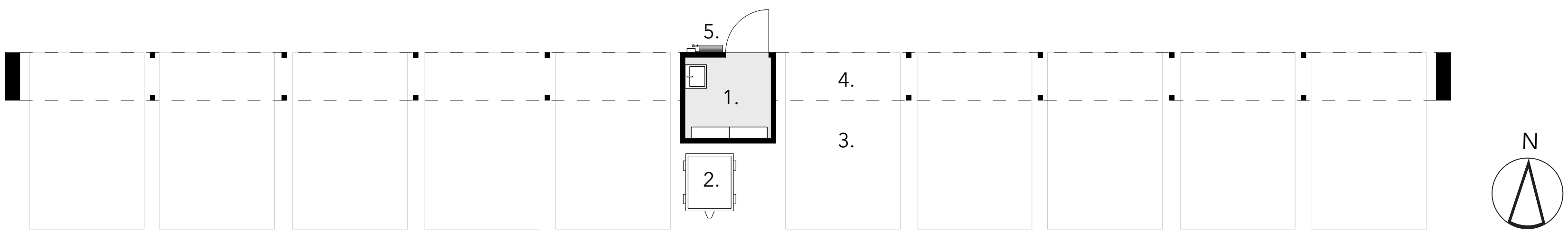
ill. 175 - Plan, 1:150

The horse barn is designed to house 10 Icelandic horses owned by the hosts. The horse barn is placed next to a horse enclosure, making it convenient to move the horses between the two. To create a calm environment for the horses, the horse barn is placed at the edge of the complex. This will at the same time reduce the discomfort from smells spreading to the rest of the complex, but still allow for the guests to visit the barn if they should desire to. The horse barn is placed nearest to the private parking lot and the host residence, as they are going to be taken care of by the hosts and need supplies delivered. From the horse barn a path goes to the cabin recharge station, making it convenient to bring the horses when the cabins need transport. The horse barn is going to be built from construction wood with a driftwood cladding (see additional facades in appendix 10).



ill. 176 - Facade NE, 1:150

CABIN RECHARGE

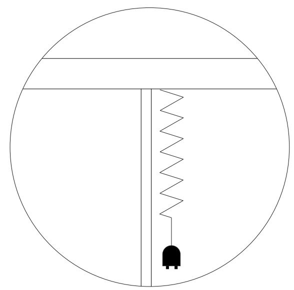


ill. 177 - Plan, 1:150

1. Storage
2. Horse trailer
3. Cabin parking space
4. Roof with electricty wires
5. Water hose

A recharge station will offer space for 20 cabin modules separated into two lines divided by their functions. At the recharge station a part of each parking spot will be covered, making it possible to drag power cables to each module from a common shelter in the middle of the rows. The modules needing water will have refillable tanks which likewise can be filled here. To make it easier to move the cabins around the complex without disturbing the resisting functions, the recharge station is located on an outer edge of the complex. From the reception in the visitor center, the guests can go directly to the recharge station to follow their cabin and pick a location on the site. The recharge station will likewise the horse barn mainly be built from construction wood and driftwood cladding (see additional facades in appendix 11).

ill. 178 - Facade N, 1:150



ill. 179 - Cable for recharging battery

CABINS

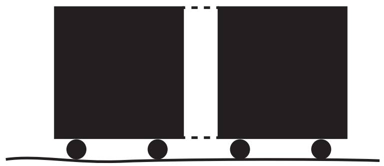
The concept behind the cabins is based upon creating the best circumstances for watching the northern light. It is therefore wanted to avoid light pollution between the cabins, which is an essential part in the design. In contrast to the functions in the main complex which are mainly to be used during the day and evening hours, the cabins are for the guest staying overnight - the time where the possibilities for watching the northern light on the sky is best.

To create the best circumstances for observing the nature phenomenon the cabins are going to be moveable so that they can be oriented according to the prognoses and the guests' wishes. The cabins will be moved by the Icelandic horses owned by the hosts, and are designed in light materials. As an important part of the concept the cabins therefore has to be able to function off-grid.

To minimize the weight of the cabins and secure a sustainable use of the cabins considering the specific needs in a given situation, the cabins will have to be flexible in their design. Therefore a part of the concept is to build the cabins from modules which can be connected as desired.

ill. 180 - Moveable

ill. 181 - View to northern light

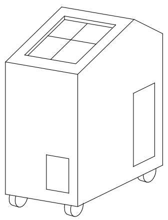


ill. 182 - Flexible

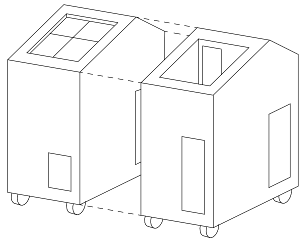
MODULE PRINCIPLE

The cabin is the center for relaxing and watching the northern light phenomena. A part of the concept for the cabins is to keep them lightweight, so that they can easier be moved around. To achieve the goal of making the cabins lightweight and transportable, they are split into several modules with different functions. One module will include sleeping facilities, while another will include toilet functions along with an outdoor view facility.

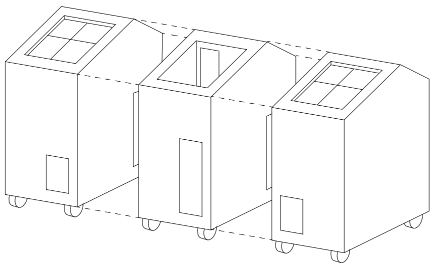
The cabin module with the sleeping facilities will be made in two versions. Both versions with identical design, but mirrored to one another. In this way one sleeping module can either be used alone or along with a module with toilet functions, while two mirrored sleeping modules can be connected on each side of the toilet module, creating a cabin for four persons.



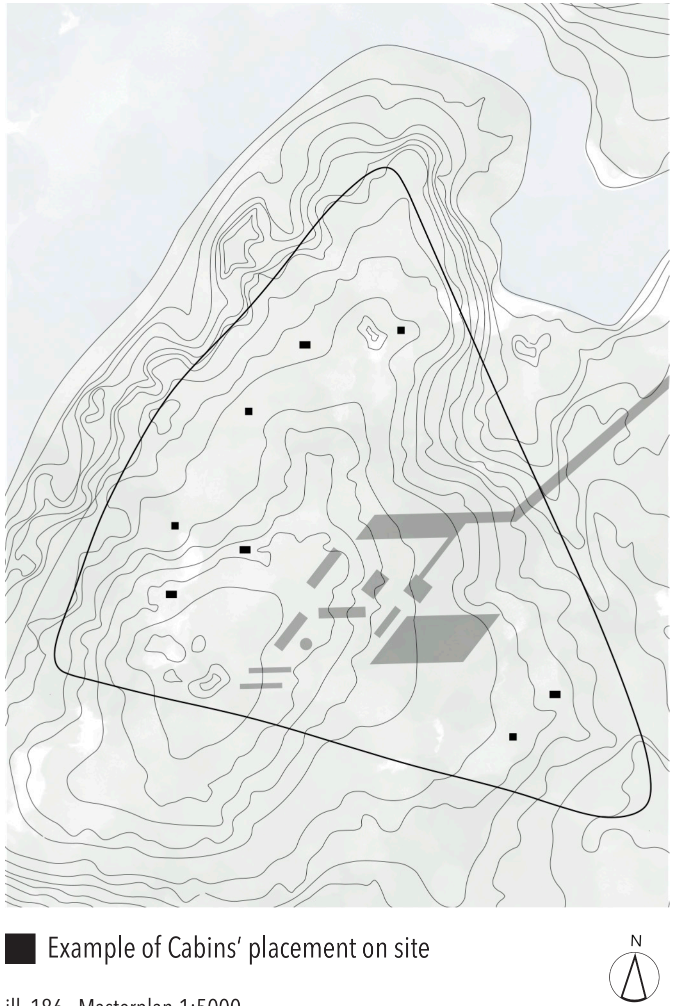
ill. 183 - Sleeping module (2 pers.)



ill. 184 - Sleeping- & toilet module (2 pers.)



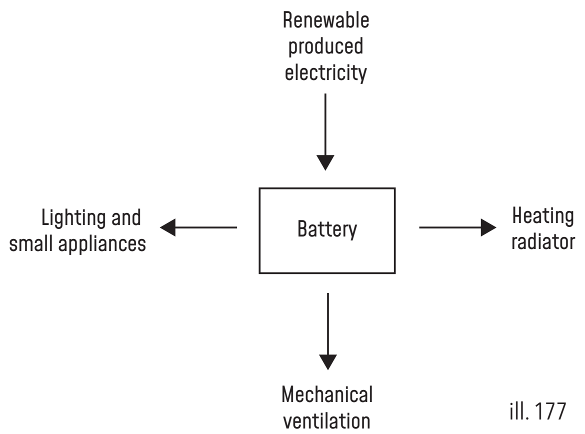
ill. 185 - Sleeping- & toilet module (4 pers.)



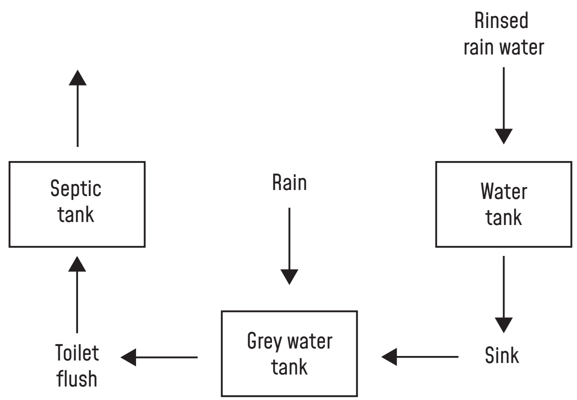
Example of Cabins' placement on site

ill. 186 - Masterplan,1:5000

OFF-GRID SYSTEMS



ill. 177



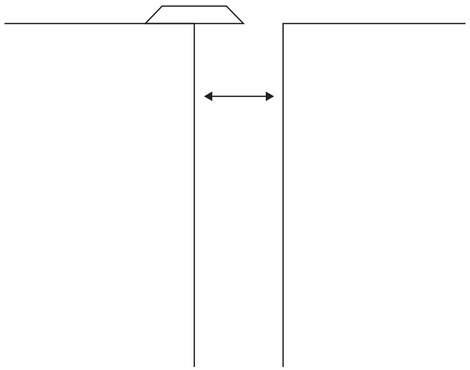
ill. 178

ENERGY SUPPLY

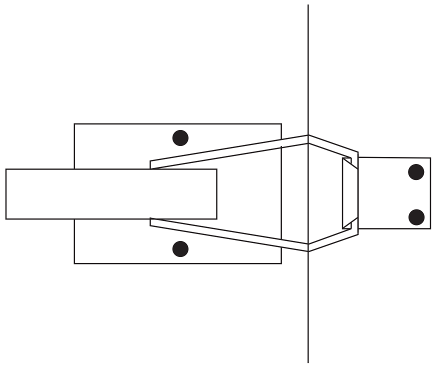
As the cabins are moveable they are going to work off-grid. The cabins will be supplied with electricity from the main complex. As the main-complex is supplied with geothermal power from the Bjarnaflag power plant, the energy for running the cabins will be renewable. Each cabin will be equipped with its own SonnenBatterie eco 9.43 (Sonnen, 2018). The battery will be used all year for lightning and charging of smaller appliances, an furthermore a mechanical ventilation system and an electrical radiator mainly used during winter.

WATER SUPPLY

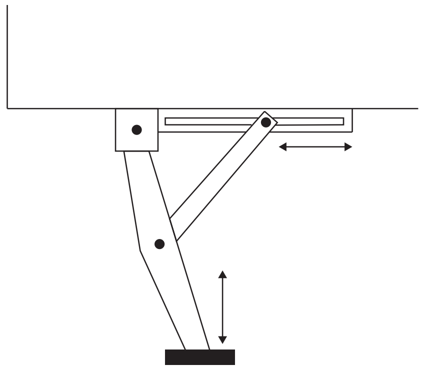
The cabins with toilet facilities will besides from electricity also need a system for water supply. The system will include three different tanks. One will be filled manually at the main complex and provide clean water for the zinc. The used water from the zinc will be gathered into a tank together with rain water collected from the open terrace in the roof of the module. The grey water tank will be used for toilet flushing. Finally a septic tank will be connected to the compost-toilet, which will be emptied manually, when the cabins return to the main complex.



ill. 179



ill. 180



ill. 181

OVERLAP

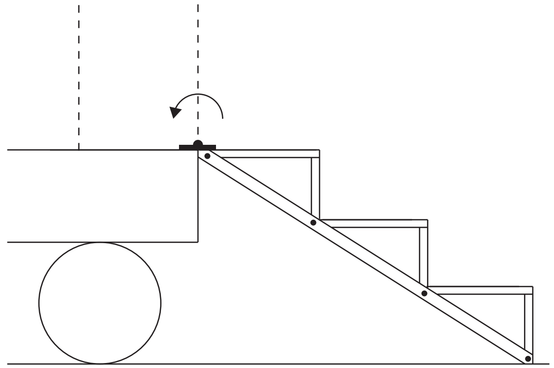
To prevent water between two cabin modules, a small panel will be mounted on the edge of the roof to cover the joining between two modules. The roof is angled in the opposite axis, leading the water away from the joining.

LOCKING

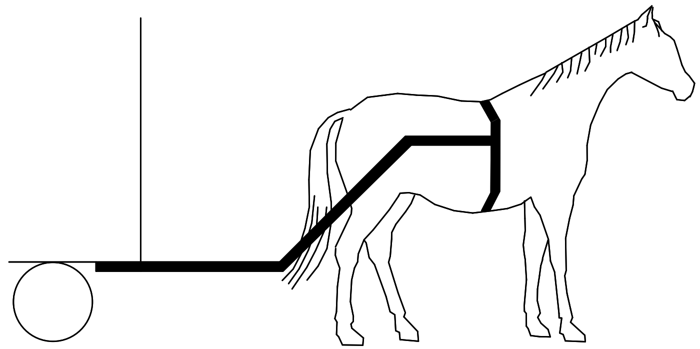
Locking fastenings will be used to connect collect two cabin modules.

LEGS

Adjustable legs will be mounted under the cabin to ensure that the floor in the cabins is at an equal level when placed on an uneven terrain.



ill. 182



ill. 183

STAIR

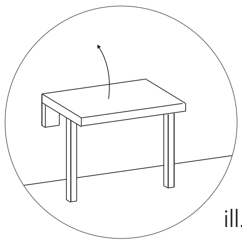
To equalize the height different between the cabin and the terrain a stair will be mounted with a hinge in the door opening. The stair can be tipped into the cabin, when moving it from the main complex to the desired location and folded out when the cabin is in use.

MOVEABLE

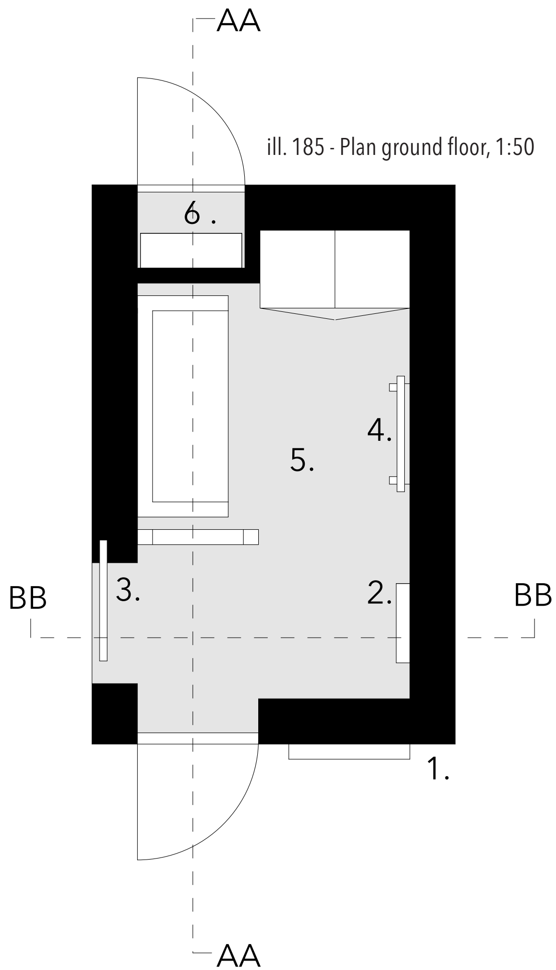
The cabins will be moved by the Icelandic horses owned by the hosts. The horses are going to be harnessed to the bottom of the cabin with a separate system in the same manner as a horse carriage.

SLEEPING MODULE

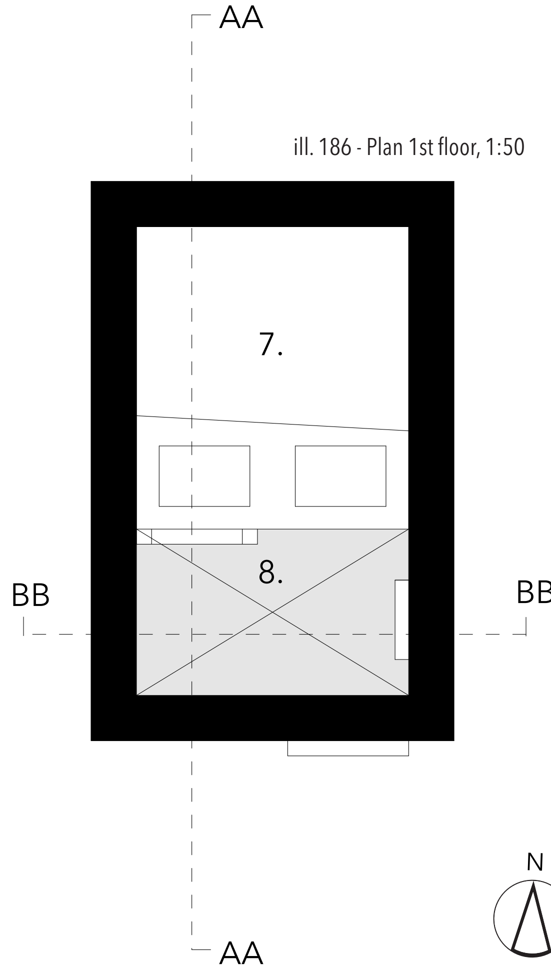
The sleeping module focuses on setting the scene for an indoor view to the northern light. The module is composed of a ground floor with an access area, a small living area with storage space and a technical room assigned to the electrical off-grid system. The technical room is placed with a direct access from the outside, making it easy to recharge. To save space in the living area a foldable table is mounted to the wall and can be unfolded if needed. A bed is placed on the loft, from which a big skylight gives a direct view to the northern light. The only other window in the cabin is placed in the door and is used as a discrete way to underline the access from exterior to interior. The window in the door can allow for a small amount of light to enter into the living are and can be sealed off with shutters to avoid light pollution, setting the best conditions in order to observe the northern light.



ill. 184



ill. 185 - Plan ground floor, 1:50

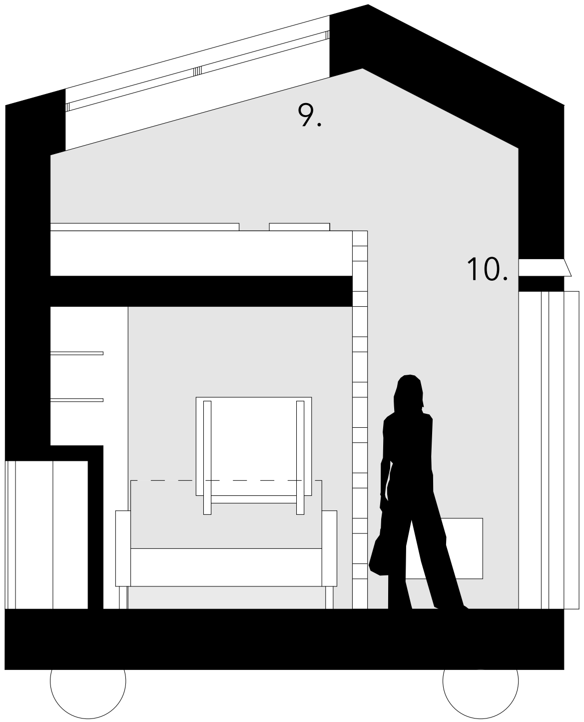


ill. 186 - Plan 1st floor, 1:50

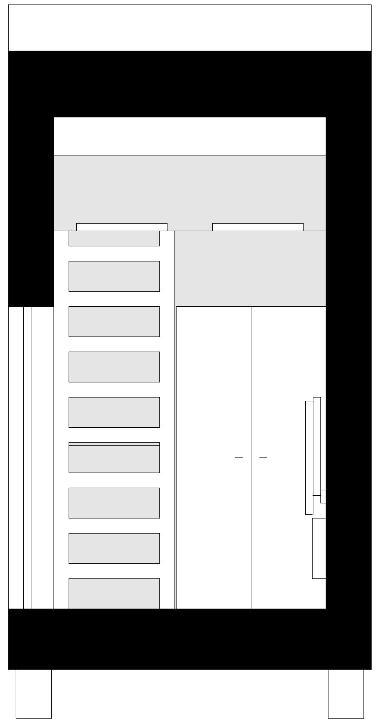
N

Potential orientation

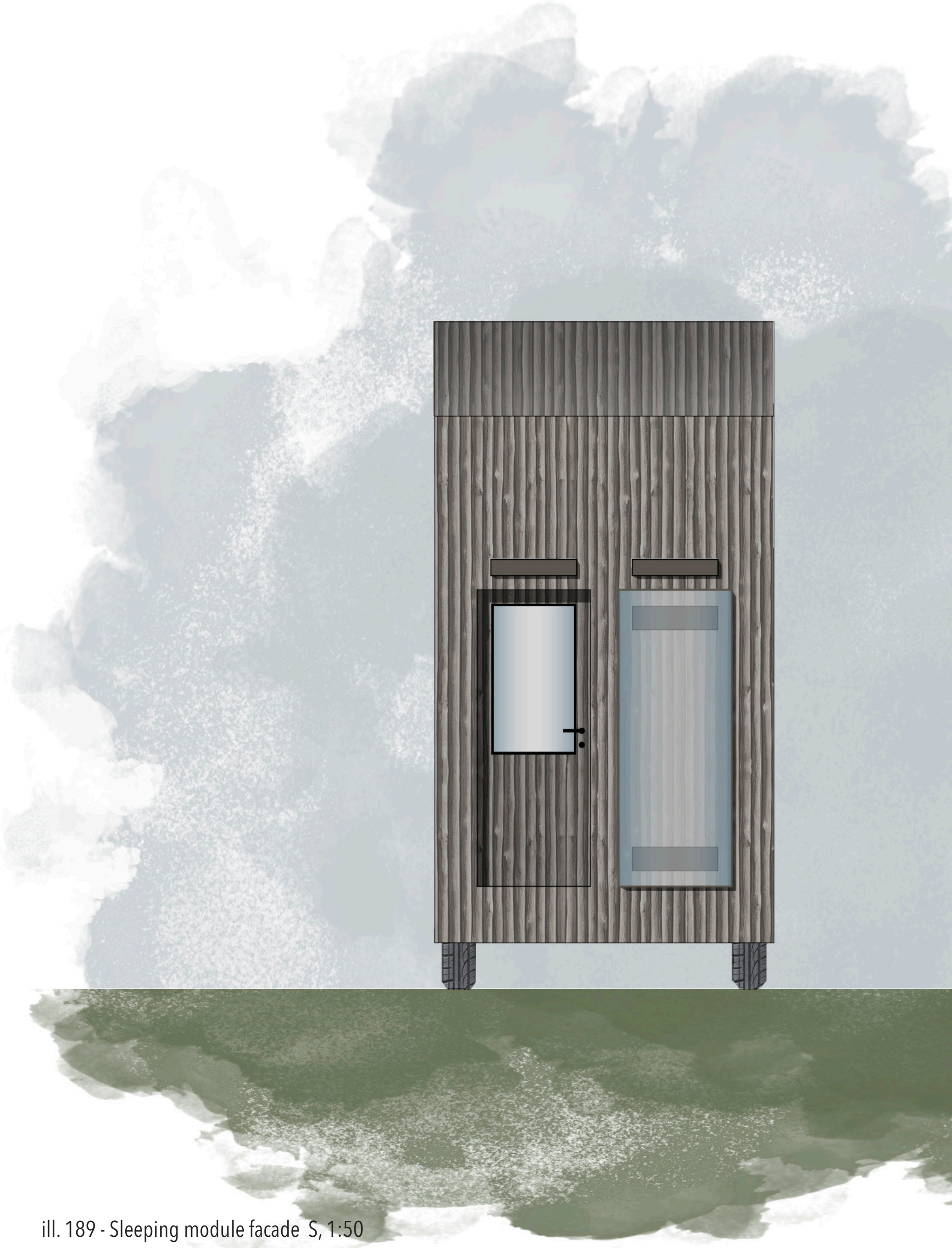
1. Trombe wall
2. Radiator
3. Sliding door
4. Foldable table
5: Living area
6. Battery
7. Sleeping area
8. Double height room
9. Skyligth
10. Mech. ventilation



ill. 187 - Section AA, 1:50

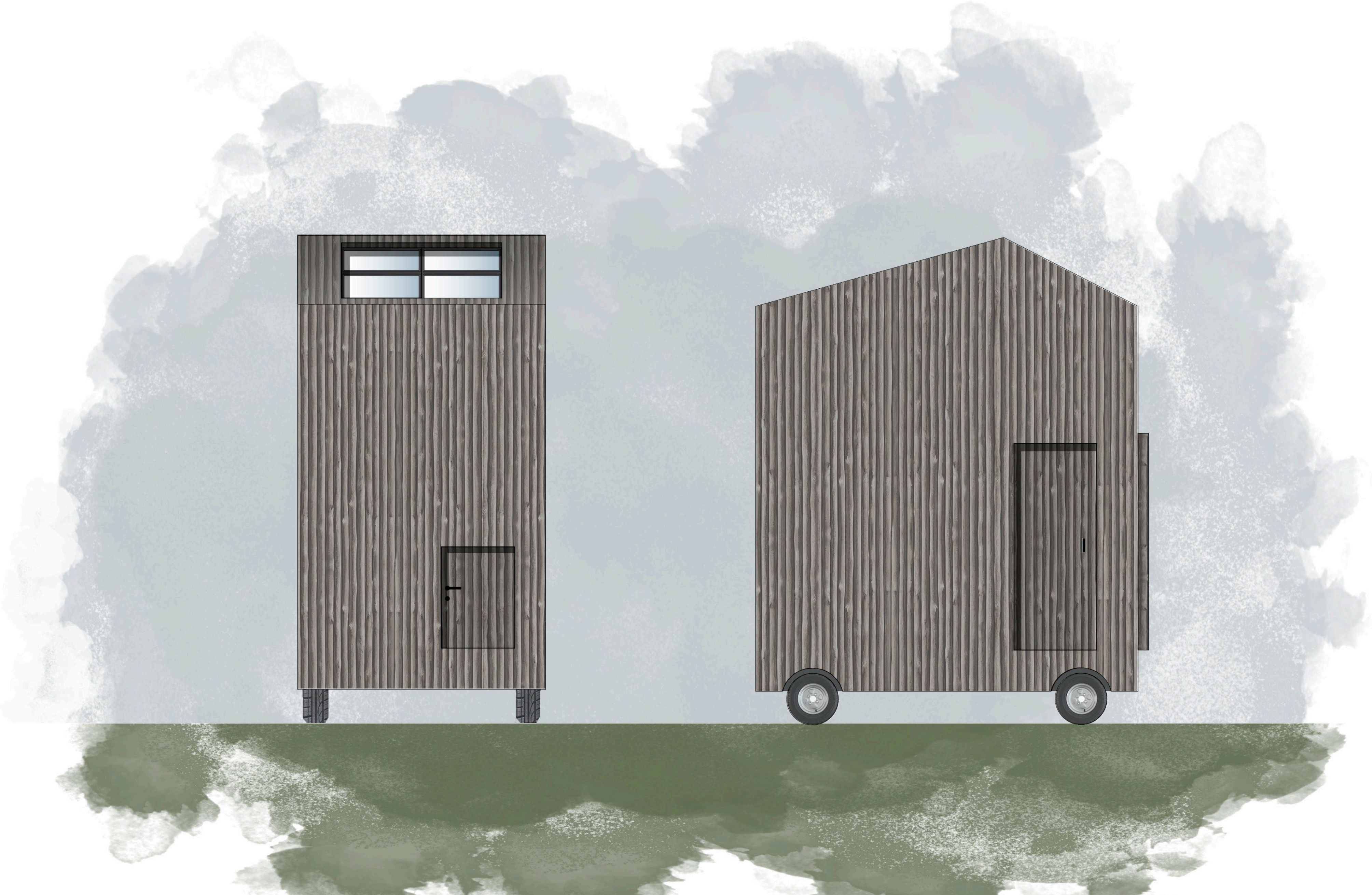


ill. 188 - Section BB, 1:50



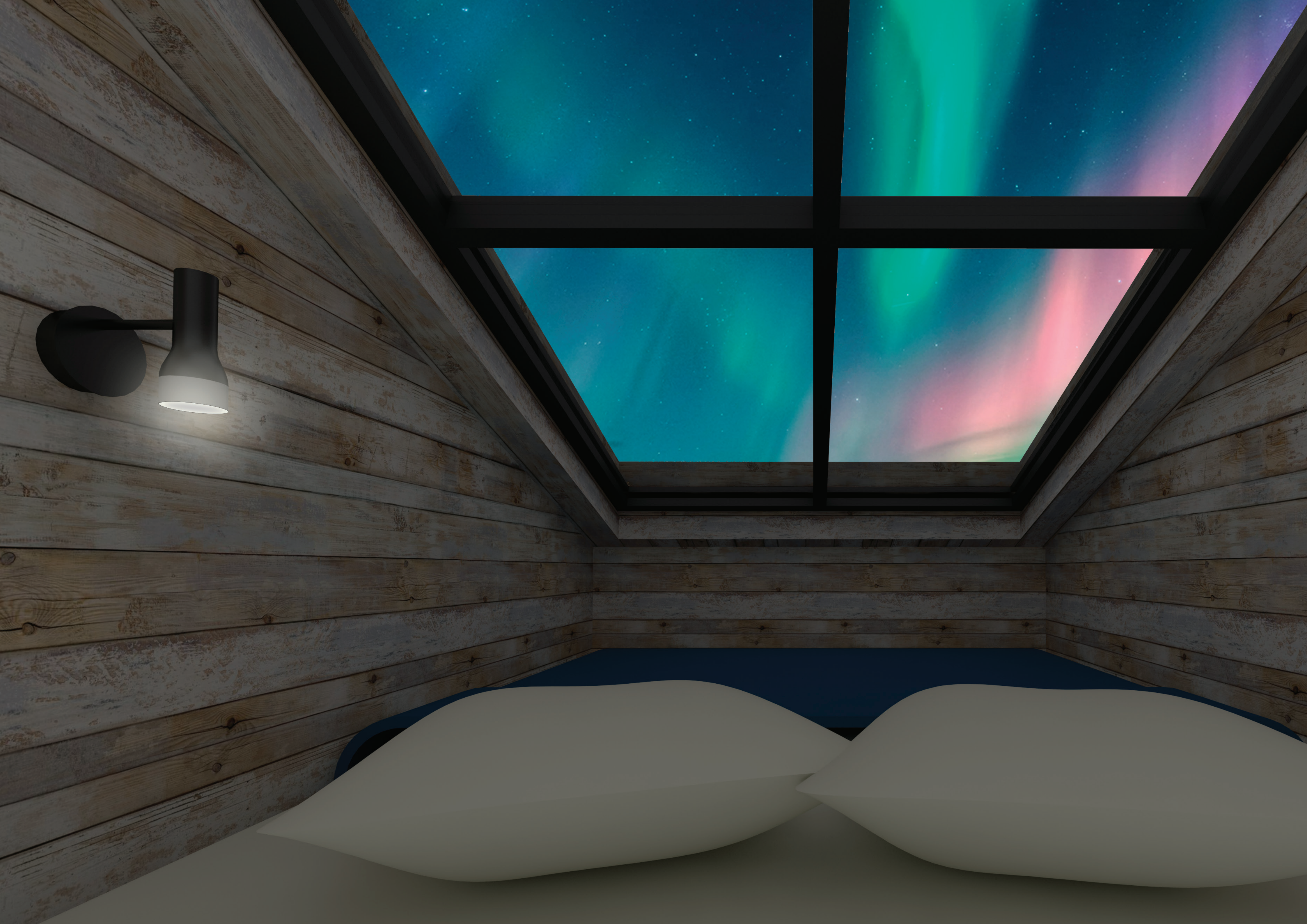
ill. 189 - Sleeping module facade S, 1:50

ill. 190 - Sleeping module facade E, 1:50



ill. 191 - Sleeping module facade N, 1:50

ill. 192 - Sleeping module facade W, 1:50



ill. 193 - Interior render from loft in Cabin

MATERIALS

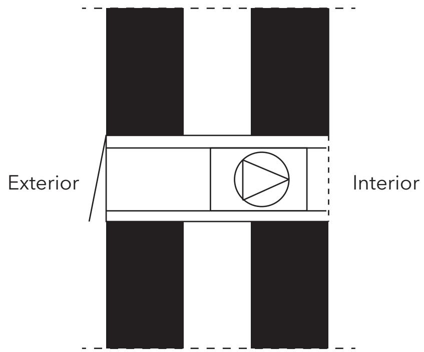
The materials for the cabins have likewise those used in the main complex been chosen based on the cradle-to-cradle philosophy with a focus on biodegradable materials and the possible resources Iceland has to offer. As the cabins transportability is a part of the concept, a focus has been on minimizing the needed functions and make a compact plan layout, which also minimizes the material use. For the final design it is chosen to make a column beam structure of construction wood and a minimized amount of sheep wool for insulation. To minimize the proportions and weight of the construction, battens with a high strength class will be used. Driftwood will be used for the cladding and expressed in a more rough and natural way on the exterior facade, while the interior panels will be dressed and have a softer expression. The facades of the sleeping module was presented in previous spread, the additional module with toilet facilities will have the same use of materials and are shown in appendix 12.

ill. 194 - Driftwood

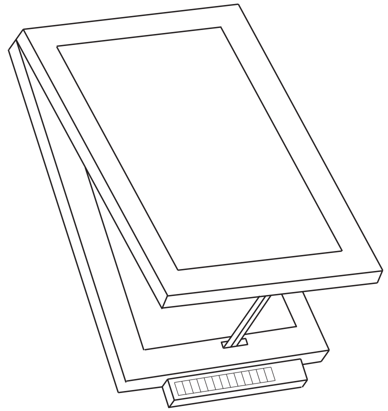
ill. 195 - Construction wood

ill. 196 - Sheep wool

VENTILATION STRATEGY



ill. 197



ill. 198

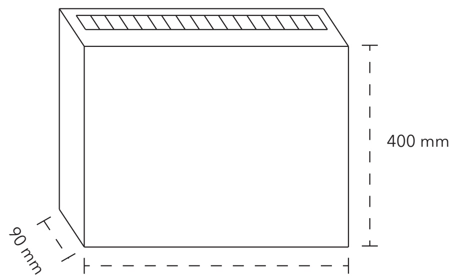
MECHANICAL VENTILATION

As an alternative to the traditional central mechanical ventilation system, a ventilations system called MicroVent will be used to regulate the indoor climate in the cabins. MicroVent is a local detached unit which is placed directly in the exterior walls. The system works in paired units, which coordinates and shift between in- and outlet air. MicroVent use very little energy, operates at a very low SEL-value, and has ahigh heat recovery, furthermore it is far less space consuming due to the removal of pipes. From calculations of the needed air change rate (see appendix 2), the needed ventilation calculated for the cabin is 20,3 l/s to avoid pollution. This is afterwards confirmed to be sufficient in the indoor simulation studies of temperature and CO2 level. This amount can be covered by one set of MV4, with a SEL-value on only 284 J/m3 and a heat recovery up to 92%. The systems have a size of 607mm x 115mm in the facade (InVentilate, n.d.)

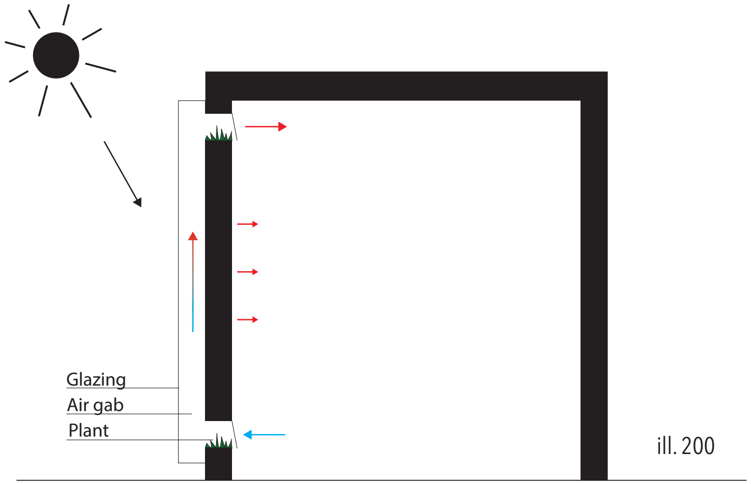
NATURAL VENTILATION

The skylight is a central part of the cabin, as it is the place from where the guests mainly are to observe the nature phenomena aurora borealis. During summer, the window will also function as a natural ventilation system in the cabin. The skylight used is a Velux Solar Powered "Fresh Air" skylight. This particular skylight has a very smooth surface, where rain disperses, and snow evaporate quickly. The skylight can be both controlled by sensors and manually. The censored control will make sure, that the window close automatically if inclement weather approaches and is powered by a small solar panel attached in the bottom of the window (Velux, n.d.). Due to the outdoor temperatures, the passive strategy with using the skylight for natural ventilation will only be in use during summer, where the opportunities for benefitting from the sun powered control is best.

HEATING STRATEGY



ill. 199



ill. 200

ACTIVE HEATING

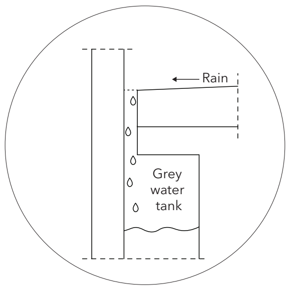
An electric radiator will be the main heating source in the cabin.The electrical radiator was chosen as it is a simple and lightweight solution compared to water-borne radiators and floor heating systems. A fireplace was also considered due to its ability to contribute to a certain atmosphere, which seems very well suited to the cabins. However, to avoid pollution and being able to better control the indoor climate, the radiator was chosen as heating source. The indoor simulations showed, that December was the month, with the highest need for heating. A more detailed result from December showed, that the maximum energy use for heating is 308 W, which therefore should be the minimum yielding capacity of the radiator (see data from appendix 5). An electric radiator from Nobø is chosen. The radiator has an elegant simple design and can deliver up to 500W in the dimensions h/b/d = 400/525/90 mm (Greenline, n.d.).

PASSIVE HEATING

As a passive contribution to the heating demands in the cabin a trombe wall is installed. The trombe wall is an extra wall made of glass built onto one of the exterior walls. The trombe wall will contribute to the heating demands by operating as a thermal mass. The glass will allow for the sun radiation to pass by almost unimpeded, heating the air inside the trombe wall as well as the shared wall between itself and the cabin. The shared wall will then release heat into the cabin. Additionally, small openings will be made, to allow a mixing of air between the trombe wall and the cabin. The direct mixing of air will be more efficient and can be opened and closed depending on need.

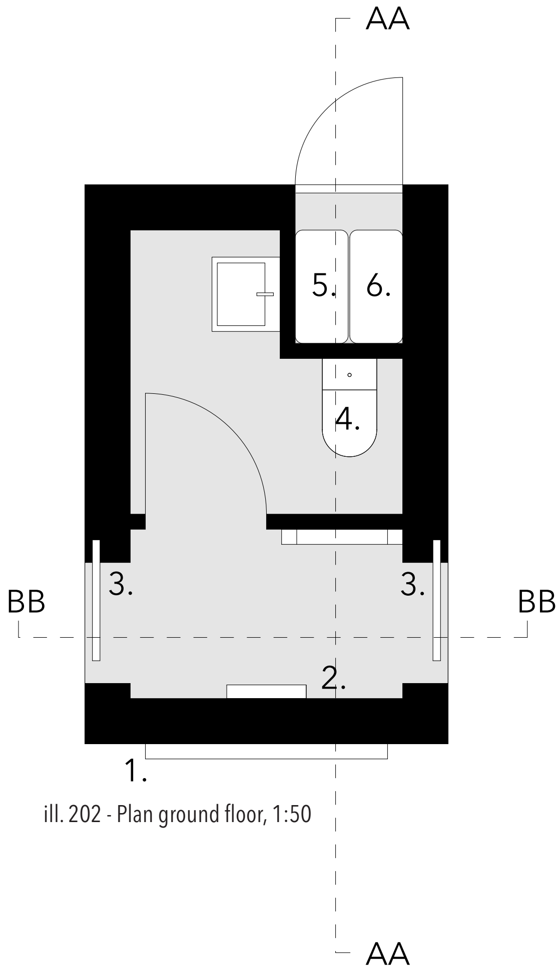
TOILET MODULE

The toilet module focuses on providing toilet facilities as well as an outdoor space for watching the northern light. In the ground floor one can access the module from the two sides, where the module can be connected to a sleeping module through opening the sliding doors. Instead of a loft, this module is provided with an open roof terrace. Compared to the sleeping module, the module is provided with a bigger technical room, as it also needs to house a system with different tanks needed for water. From the roof terrace a pipe is used to gather rain water which will go directly into the grey water tank in the cabin and can be used for toilet flushes.

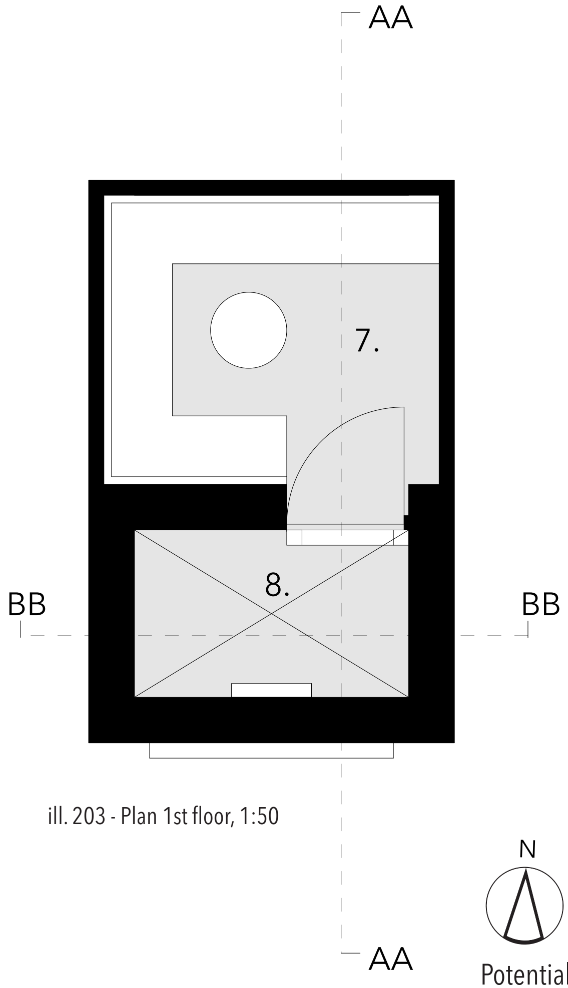


ill. 201

1. Trombe wall
2. Radiator
3. Sliding door
4. Compost toilet
5: Rinsed water tank
6. Grey water tank
7. Outdoor roof terrace
8. Double height room
9. Battery
10. Septic tank
11. Mech. ventilation

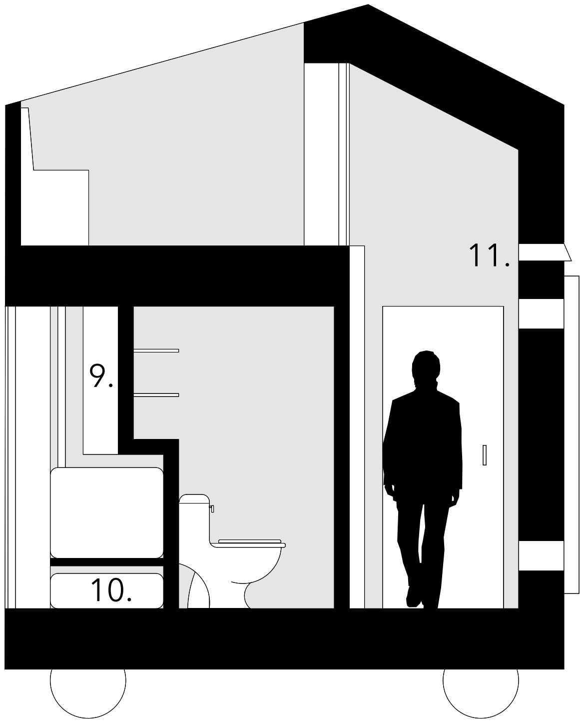


ill. 202 - Plan ground floor, 1:50

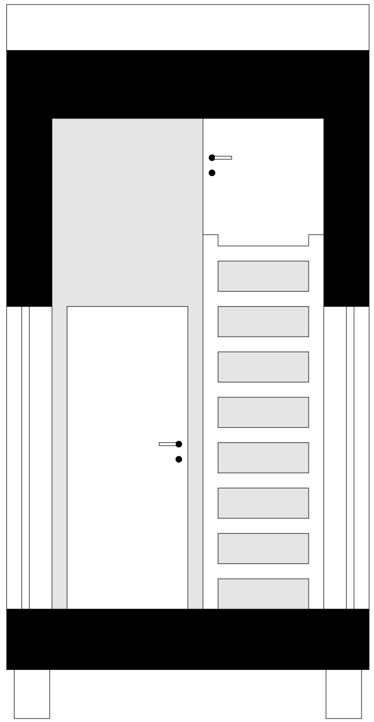


ill. 203 - Plan 1st floor, 1:50

Potential orientation



ill. 204 - Section AA, 1:50



ill. 205 - Section BB, 1:50

INDOOR CLIMATE

For the final indoor climate of the cabins, the sleeping module is tested, as this is considered most critical due to being in use in longer periods and the big skylight which will both contribute with heating during summer but also has a high transmission loss. The final definition of the building envelope has been the results of several iterations to keep the buildings small and lightweight and at the same time meet the demands regarding the indoor climate. The solution has been achieved with a 200mm sheep wool insulation with 100mm wooden columns (se final U-value calculation in appendix 1).

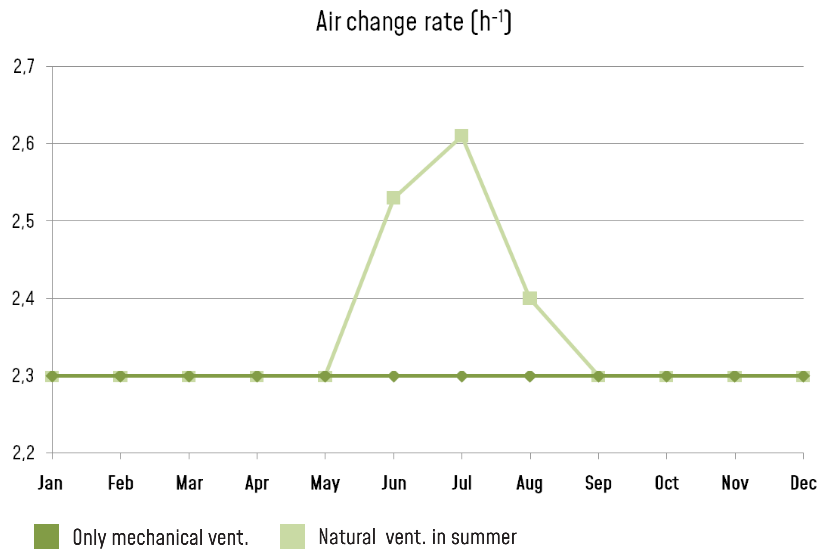
As stated earlier, it can be necessary to use mechanical ventilation if it rains during summer. However, The indoor climate will vary in the two scenarios of using respectively natural ventilation and mechanical ventilation. A comparison is made between using mechanical ventilation all year and using natural ventilation during the summer months June, July and August (the months with highest outdoor temperature).

The building is compared to following demands:
Max PPM level = 850 (Dansk standard, 2007 - p. 36)
Temp.mean = 18-26 degrees (Dansk standard, 2007 - p. 31)
Max. 100 hours > 26 degrees (Bygningsreglementet, 2018)
Max. 25 hours >27 degrees (Bygningsreglementet, 2018)

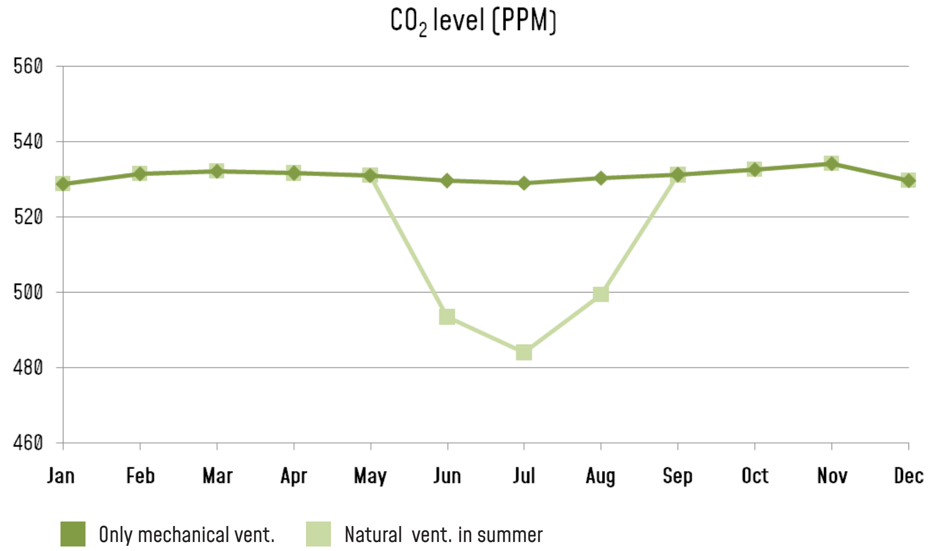
Considering the PPM level in the cabin during the year, the PPM is less controlled in the scenario with the natural ventilation. The mechanical ventilation rate is calculated based on the sensory pollution and demands from the buildings regulations (see appendix 2). The results from the simulation show, that the air change rate is far sufficient to achieve a decent level of PPM. When using natural ventilation, the air change rate is somewhat increased during summer, as the window allows for a higher air change, and therefore can ventilate more efficient to minimize the temperature and avoid overheating (see initial natural ventilation calculations in appendix 13).

This also means, that when looking at the temperature, the results shows a far higher number of hours above 26 and 27 degrees during summer, when only the mechanical ventilation is used. These values are however considered acceptable, as the optimum situation will never be to only use the mechanical ventilation, and the hours occurs during the day, which is not considered as the period of use of the cabin and thereby not in the period where the demands for overheating are in force. If wanting to lower the temperature during summer, the mechanical ventilation system will have to be larger to provide a higher flow rate, this will however affect the energy use during all year, as a ventilation system with a higher flow rate also has a higher SEL-value which will increase the needed capacity of the battery.

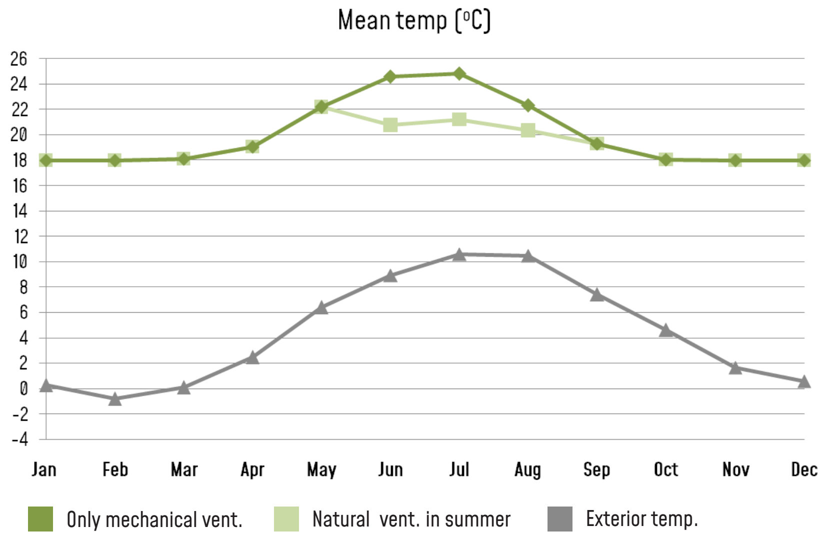
Working with a light wooden structure at this location does of course influence the indoor climate, as it has a very low capacity for storage heating. Compared to the main complex, this becomes visible in a high variation in the temperature during day, where the earth walls are used to stabilize the indoor climate in the main complex.



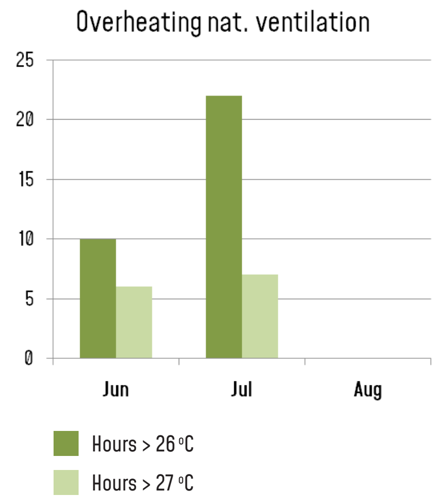
ill. 206 - Air change rate



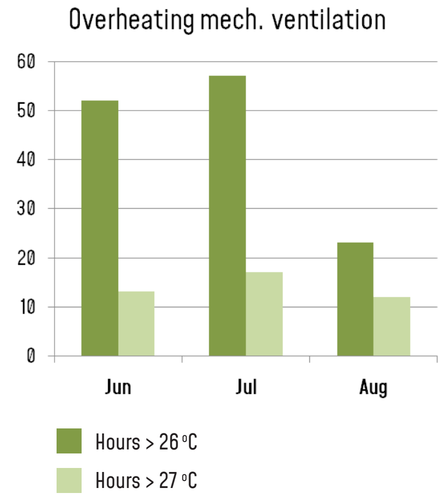
ill. 207 - CO2 level



ill. 208 - Mean temp.



ill. 209 - Hours above 26 & 27 degrees



ill. 210 - Hours above 26 & 27 degrees

EPILOGUE

CONCLUSION

This master thesis presents a design proposal for a vacation complex in Iceland. The main approach of the project has been the relation between the building and the context through considerations regarding processing of the landscape and designing with a strong relation to the country's nature and history. As a part of the vision for the project, the architecture should support different experiences and a variety of atmospheres.

Comparing the main complex and the cabins, the work with very different materials gives the main complex a heavy character in contrast to the light structures in the cabins. This is followed by two very different approaches to process the relation between the building and the landscape. As a main part of the concept for the cabins they are designed to be lightweight and moveable, to always create the best conditions for positioning to orientate the cabins according to the northern light. The cabins are lifted from the ground and only interacting with the landscape from the small surfaces of the wheels used for transporting them - leaving almost no permanent relation between the building and the landscape. The main complex on the other hand has a strong relation to the landscape through the way it is grounded and shaped. The roof is angled and covered with grass continuing all the way down to the landscape on several facades. Furthermore, the buildings relate to the landscape through the use of the natural terrain in the design of the main complex to create level differences which are used to divide spaces and support a desired atmosphere. As an example the visitor center is placed completely on top of the ground to create a strong visual connection to the nature, while the restaurant is partly underground supporting a more intimate atmosphere and a stronger relation to the ground itself by having windows placed just above the exterior ground level. The main complex is divided into several buildings, which is favorable for achieving the desired views and daylight. It also favors the connection between the interior and exterior spaces, by making the users engage with the nature when moving from one function to another.

The environmental sustainability has been a main focus of the process. Iceland is already a front player in the use of renewable energy, which is why a focus has been on materials and how to use passive strategies to achieve an optimal indoor climate.The cabins are shaped according to achieve a compact shape with only the needed facilities. Compared to the main complex, which is supplied by the local grids supporting renewable energy, a greater concern has been paid to the energy use in the cabins as they have to function off-grid for a period. Due to the cold climate in Iceland, the use of passive strategies to lower the heating demands such as the trombe wall and the amount of insulation, as well as the use of the energy efficient ventilation systems InVentilate has therefore been important for a balanced final design solution.

The project attempts to follow the cradle-to-cradle philosophy and challenges the very limited market for locally produced buildings materials in Iceland today. From investigating the opportunities of resources in the country, rammed earth, sheep wool and driftwood are chosen as main materials in the project. The materials are all biodegradable and interesting in the context as Iceland has a great amount of local resources for all of them which could be utilized in the future.

REFLECTION

To be able to learn as much as possible from the process, it is important to reflect upon the decisions made during the project. The goal of this section is therefore to take a step back and evaluate the work and the challenges during the process. As some parts of the project has been studied more in depth, this chapter also present suggestions for a further development of the presented design.

The topic of this project has accumulated knowledge of the many challenges of working with a rural unspoiled site. Compared to an urban setting, it has been challenging to make a design which only concerns itself and the landscape around it, which is why a lot of time was spend in the initial phases of the process trying to gain a direction for the design.

In this project the analysis phase was very important to understand the different approaches used when designing a building in Denmark and Iceland. Iceland has a different micro-climate and the country's renewable energy production influences what is important to consider when designing, therefore an environmentally sustainable focus quickly became the materials. During the investigation of possible materials for the project it became clear how difficult it was to find information regarding the properties of more alternative building materials. Initially the intention was to use a Life Cycle analysis to compare the materials and based on this make qualified and documented decisions, but with the lack of data the decisions had to be made using the available information. The final material choices are mainly based upon what is today locally produced and what could potentially be locally produced in the future. Wood is chosen for the structural systems of the cabins and the roof in the main complex. Today the amount of wood is very limited in Iceland, and to fully complete the used approach, a further development of the project could be to investigate the opportunities for creating more forest in Iceland or plant trees on the project site.

As the buildings are supplied by renewable energy sources, the project does not focus on the buildings' energy use, why no final energy calculations were made for the main complex. However, the concept of a sustainable building is not only about being able to cover the energy use with green energy, but also about optimizing the building. For a further development of the project, the implementation and design of passive strategies could be challenged to lower the total energy use of the building while still keeping the indoor climate in mind. When looking at the indoor climate simulations made in the project one could reflect upon the use of the Danish demands to make design decisions. This is not the optimum solution, but it was considered suited as no information from Iceland was available.

Considering the structural elements of the projects, the decisions made regarding the dimensions of the elements are based upon examples and previous projects. As no previous acquaintance has been made with the earth walls other studies has been used to dimension the construction. Calculations of the thickness of the earth wall as well as the cross section in the wooden structures would be useful to fully understand how the structural systems influences the architectural expression, the weight of the cabins and to some degree the indoor climate.

In the initial phases of the process, a lot of time was spend considering what to include in the cabins. It was desired to keep the cabins at a minimum with no heating or mechanical ventilation, however, this was not realistic with the defined indoor climate demands. As the design of the cabins developed from one gathered function to several modules, most focus was put in the module with sleeping facilities, which was also used for the indoor climate simulations. The two modules will of course perform differently, among other things the toilet module does not have any windows and will be used in shorter periods. The concept of a light and moveable cabin influenced the choice of materials and was considered in the investigations of the size of the climate screen along with the weight of the battery. For a further development and to fully achieve the potentials of the movable cabin a next step could be to calculate the total weight of the cabin. This approach could also have been used during the process to compare different solutions regarding plan layout, division of functions, materials etc.

The atmosphere and the detailing of the buildings has been some of the initial approaches to the project. This focus has among other things been accomplished through the detailing of the entrances, the relation to the landscape and working with the tactility and contrast in the used materials. Considering the focus on the relation between the building and the landscape a step to advance the project could be to work with the detailing in the exact meeting between the two.

As it was decided to divide the main complex into several buildings a grid was introduced in order to decide the placement of the buildings. As different solutions were investigated, a grid was found, which allowed to place the buildings according to initial thoughts regarding views, connections and orientations. This seemed as a ideal approach to make a controlled placement of the buildings and was also used for the landscape design. Considering the landscape design one aspect that is not included in the project is the implementation of exterior lightning. This is an essential aspect to include in a further development of the design, and could for instance be integrated into the design of the paths.

One aspect that was briefly introduced during the project was the gathering of rainwater, as the toilet module in the cabins has an integrated solution to do so. The rain water collection is an interesting topic that goes along with the overall concept of the project. Initially calculations were made to see how much rainwater could be collected from the roofs (see appendix 14), however, due to prioritizing it was never further developed how a system for using the water could be implemented in the design.

In general, one could reflect upon how the change from a group project to an individual project has affected the end result. To still deliver a project which achieves a high level corresponding to the learning goals for the semester, some choices has been made to focus on developing parts of the project further than others and in some cases projecting a design solution to other similar situations. This approach has affected the final result and the amount of presentation material, which also become clear in this reflection, where several steps for further development has been necessary to leave out so far. The situation has however given a lesson regarding time-use and prioritizing, and when considered in a non-academic aspect, it can be seen as a preparation for dealing with similar situations when beginning a professional career.

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ill. 26: Map of hydropower and geothermal power stations - Own production based upon (Orkustofnun, O. 2019).

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ill. 40: Hot spring - Planas Labad, D. (2011). Photograph. Available at: http://daniplanaslabad.com/travel/niceland/ [Accessed 6. June 2019].

ill. 41: Pseudo Crater - Planas Labad, D. (2011). Photograph. Available at: http://daniplanaslabad.com/travel/niceland/ [Accessed 6. June 2019].

ill. 42: Godafoss Waterfall - Planas Labad, D. (2011). Photograph. Available at: http://daniplanaslabad.com/travel/niceland/ [Accessed 6. June 2019].

ill. 43: Rock formations - Planas Labad, D. (2011). Photograph. Available at: http://daniplanaslabad.com/travel/niceland/ [Accessed 6. June 2019].

ill. 44: Fumarole - Planas Labad, D. (2011). Photograph. Available at: http://daniplanaslabad.com/travel/niceland/ [Accessed 6. June 2019].

ill. 45: Glacier - Planas Labad, D. (2011). Photograph. Available at: http://daniplanaslabad.com/travel/niceland/ [Accessed 6. June 2019].

ill. 46: Floating Iceberg - Planas Labad, D. (2011). Photograph. Available at: http://daniplanaslabad.com/travel/niceland/ [Accessed 6. June 2019].

ill 47: Waterfall seen from cave - Planas Labad, D. (2011). Photograph. Available at: http://daniplanaslabad.com/travel/niceland/ [Accessed 6. June 2019].

ill. 53: Sunpath Reykjahlid - Own production based upon (Gaisma)

ill. 54 + 55: Wind roses - Own production based upon (Windfinder, 2019)

ill. 56: Amount of days pr month that are sunny, partly clouded or overcast - Own production based upon (meteoblue, 2019).

ill. 57: Numbers of days pr month with precipitation - Own production based upon (meteoblue, 2019)

ill. 58: In-Visible, exterior of Cabin - Szatanowska, K. et al. (2018). Render. Available at: https://northernlightsrooms.beebreeders.com/shortlisted-projects [Accessed 6. June 2019].

ill. 59: Thule, terrace at cabin - Pegorin, M. et al. (2018). Render. Available at: https://northernlightsrooms.beebreeders.com/shortlisted-projects [Accessed 6. June 2019].

ill. 60: The Circle, exterior of main complex - Grzybowska, K. et al. (2018). Render. Available at: https://northernlightsrooms.beebreeders.com/shortlisted-projects [Accessed 6. June 2019].

ill. 132: Asfalt - Pexels (n.d.). Photographs. Available at: https://www.pexels.com/photo/close-up-concrete-creativity-dark-908286/ [Accessed 6. June 2019].

ill. 133: Wooden paths - Kratochvil, P. (n.d.). Close-up of a wood texture. Photograph. Available at: http://www.freestockphotos.biz/stockphoto/9002 [Accessed 6. June 2019].

ill. 134: Gravel - Shupilo, A. (n.d.). Photograph. Available at: https://www.colourbox.dk/billede/abstrakt-sten-naturlig-billede-1496112 [Accessed 6. June 2019].

ill. 136: Basaltic Rock - Colourbox (n.d.). Photograph. Available at: https://www.colourbox.dk/billede/stenmur-tekstur-baggrund-billede-7193004 [Accessed 6. June 2019].

ill. 137: Driftwood - Pexels (n.d.). Photographs. Available at: https://www.pexels.com/photo/background-board-construction-dirty-269035/ [Accessed 6. June 2019].

ill. 138: Green roof - Staudt, A. (n.d.). Stock foto of grass. Photograph. Available at: https://www.colourbox.dk/billede/grass-buzzer-clean-billede-27522054 [Accessed 6. June 2019].

ill. 146: Sheep wool - Pexels (n.d.). Photographs. Available at: https://www.pexels.com/photo/background-beige-brown-close-up-317333/ [Accessed 6. June 2019].

ill. 147: Rammed earth - Pexels (n.d.). Photographs. Available at: https://www.colourbox.dk/billede/sand-nedenunder-under-billede-11699200 [Accessed 6. June 2019].

ill. 148: Sphagnum board - 2RETHINK (n.d.). Photograph. Available at: https://www.2rethink.dk/products/billige-akustikpaneler?variant=862229233679&cmp_id=225572406&adg_id=14510317566&k-wd=&device=c&gclid=CjwKCAjw8-LnBRAyEiwA6eUMGv40RMWrue0_pSAK_sgvqzVxb4WIrXjGsE7BnoKthwx4mGw3Kbx1YRoCksQQAvD_BwE [Accessed 6. June 2019].

ill. 156: Basaltic Rock - Colourbox (n.d.). Photograph. Available at: https://www.colourbox.dk/billede/stenmur-tekstur-baggrund-billede-7193004 [Accessed 6. June 2019].

ill. 194: Driftwood - Pexels (n.d.). Photographs. Available at: https://www.pexels.com/photo/background-board-construction-dirty-269035/ [Accessed 6. June 2019].

ill. 195: Construction wood - Kratochvil, P. (n.d.). Close-up of a wood texture. Photograph. Available at: http://www.freestockphotos.biz/stockphoto/9002 [Accessed 6. June 2019].

ill. 196: Sheep wool - Pexels (n.d.). Photographs. Available at: https://www.pexels.com/photo/background-beige-brown-close-up-317333/ [Accessed 6. June 2019].

All additional photographs and illustrations are own production.

APPENDIX

APPENDIX OUTLINE

APPENDIX 1 - U-VALUES

Example of calculation of walls in cabin

The U-values are calculated using: $U' = \frac{1}{R_{si} + R_{se} + \sum R_h + \sum \frac{d}{\lambda'}}$

The thermal conductivity for the inhomogeneous layers is calculated using: $\lambda' = \frac{A_a \lambda_a + A_b \lambda_b + ...}{A_a + A_b + ...}$

Inhomogeneous layer 1: $\lambda' = \frac{55\ cm * 0{,}024 \frac{W}{m} °C + 5\ cm * 0{,}18\ W/m°C}{55\ cm + 5\ cm} = 0{,}037\ W/m°C$

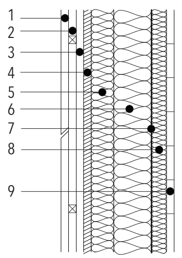
Inhomogeneous layer 2: $\lambda' = \frac{90\ cm \cdot 0{,}04 \frac{W}{m} °C + 10\ cm \cdot 0{,}12 \frac{W}{m} °C}{90\ cm + 10\ cm} = 0{,}048\ W/m°C$

Inhomogeneous layer 3: $\lambda' = \frac{90\ cm * 0{,}04 \frac{W}{m} °C + 5\ cm * 0{,}18\ W/m°C}{90\ cm + 5\ cm} = 0{,}047\ W/m°C$

Total U-value of homogeneous layers: $\sum R_h = 0{,}10 \frac{W}{m^2} °C + 0{,}13 \frac{W}{m^2} °C + 1{,}5 \frac{W}{m^2} °C + 0{,}01 \frac{W}{m^2} °C + 0{,}10 \frac{W}{m^2} °C = 1{,}85 \frac{W}{m^2} °C$

Total U-value of wall: $U' = \frac{1}{0{,}04 \frac{m^2 °C}{W} + 0{,}13 \frac{m^2 °C}{W} + 1{,}85 \frac{m^2 °C}{W} + \frac{0{,}04 m}{0{,}037\ W/m°C} + \frac{0{,}01 m}{0{,}048\ W/m°C} + \frac{0{,}04 m}{0{,}047\ W/m°C}} = 0{,}16 \frac{W}{m^2} °C$

	d	λ	R = d/λ
	(m)	W/m °C	$\frac{W}{m^2}$ °C
Driftwood cladding	0,02	0,2	0,10
Inhomogeneous layer 1:			
- Air gab	0,04	0,024	1,67
- Battens	0,04	0,18	0,22
OSB-board	0,02	0,15	0,13
Sheep wool	0,06	0,04	1,50
Inhomogeneous layer 2:			
- Sheep wool	0,1	0,04	2,50
- Construction wood	0,1	0,12	0,83
Moisture barrier	0,002	0,17	0,01
Inhomogeneous layer 3:			
- Sheep wool	0,04	0,04	1,00
- Battens	0,04	0,18	0,22
Driftwood cladding	0,02	0,2	0,10



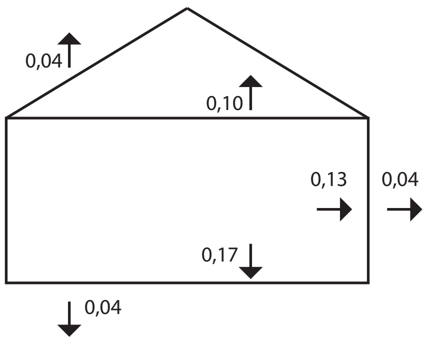
1: Vertical driftwood cladding
2: Horisontal battens
3: Vertical battens
4: OSB slab
5: Sheep wool w. I-profiles
6: Sheep wool w. 100mm wooden coloumns
7: Vapour barrier
8: Sheep wool w. battens
9: Horisontal driftwood cladding

Cabin wall 1:20

Additionally U-values used in the project:

	U-value
Main complex:	
Roof	0,058
Foundation	0,068
Exterior wall	0,084
Interior wall	2,29
Cabin:	
Walls	0,16
Roof and floor	0,13

Thermal resistance:



APPENDIX 2 – AIR CHANGE CALCULATIONS

The air change rate was calculated considering respectively the needed air change to avoid sensory pollution and the minimum air change rate according to the building regulations. The tables below shows the results for the visitor center and the cabin, from which indoor simulations are presented in the report. The calculated air change rate was used in the BSim models, where the results show if the calculated values are sufficient when considering CO2 pollution and temperature.

Visitor center

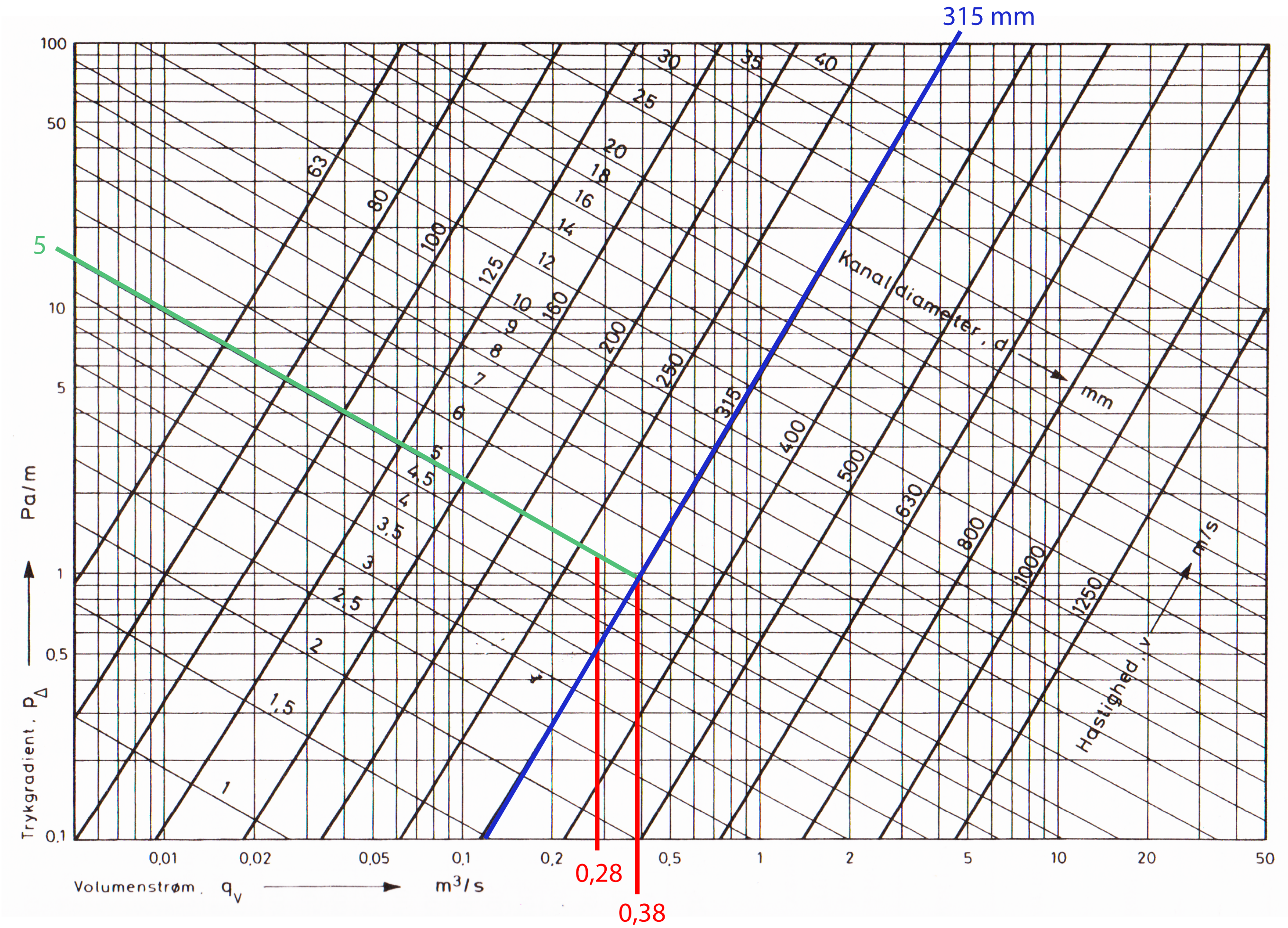
	Sensory									**BR18**		
	Pollution load					**Airflow supply**						
	n	q_p	A	q_B	$q_{tot} = n * q_p + A * q_B$	c	c_i	$V_l = (10*(q/c)+c_i)/0,9$	V_l	Demand	Demand	Basis supply
		(olf)	*(m^2)*	*(olf)*	*(olf)*	*(dp)*	*(dp)*	*(l/s)*	*(m^3/s)*	*(l/s)*	*(m^3/s)*	*(m^3/s)*
Exhibition	15	1	147	0,1	29,7	1,4	0	235,71	**0,28**	44,1		0,044
Toilet	1	1	7,8	0,1	1,8	1,4	0	14,13	**0,01**	15	0,015	0,002
Storage	0	1	12	0,1	1,3	1,4	0	10,08	**0,01**	3,51		0,004

Cabin

	Sensory									**BR18**		
	Pollution load					**Airflow supply**						
	n	q_p	A	q_B	$q_{tot} = n * q_p + A * q_B$	c	c_i	$V_l = (10*(q/c)+c_i)/0,9$	V_l	Demand	Demand	Basis supply
		(olf)	*(m^2)*	*(olf)*	*(olf)*	*(dp)*	*(dp)*	*(l/s)*	*(m^3/s)*	*(l/s)*	*(m^3/s)*	*(m^3/s)*
Cabin	2	1	5,6	0,1	2,6	1,4	0	20,30	**0,02**	1,674		0,002

APPENDIX 3 - PIPE DIMENSIONS

Rough calculation of the dimensioning of ventilation pipes in the visitor center. The table considers the air velocity in the pipes, the sound as well as the airflow rate. The colored lines on the table indicates the calculated air flow at 0,20 m3/s as and how that values in combination with an air velocity at 5 m/s will demand a pipe with a diameter of 315mm. It also illustrates that this size of pipe can go up to 0,38 m3/s with the same air velocity (Stampe, O. 2000 - p. 322).



APPENDIX 4 - HEATING DEMANDS CABIN

The tables below present the energy use for heating every month when using different amounts of insulation. It also compares the postive effect on the heating demand when adding the trombe wall.

	Without trombe			With trombe		
Insulation thickness	**150mm**	**200mm**	**250mm**	**150mm**	**200mm**	**250mm**
	kWh	kWh	kWh	kWh	kWh	kWh
Jan	192	148	123	183	143	119
Feb	185	144	118	158	122	99
Mar	160	119	94	112	81	62
Apr	91	60	41	52	29	16
May	25	9	2	4	1	0
Jun	7	1	0	1	0	0
Jul	5	1	0	1	0	0
Aug	10	3	0	2	0	0
Sep	56	36	24	25	14	7
Oct	128	97	77	87	62	47
Nov	180	141	116	161	126	104
Dec	207	163	135	197	156	130
Total	1245	921	730	984	734	585

APPENDIX 5 – MONTHLY ENERGY USE CABIN

The tables below display the worst daily energy need in each month of the year when using three different amounts of insulation, all of the results is made with the attached trombe wall.

150mm insulation:

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
	kWh pr. day	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*
Heating	5,904	5,664	3,624	1,728	0,144	0,024	0,024	0,072	0,84	2,808	5,376	3,432
HtCoil	2,088	2,208	2,232	1,632	0,624	0,264	0,096	0,144	0,744	1,392	1,92	6,36
Fanpower	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216
Lighting	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24
Total	**8,448**	**8,328**	**6,312**	**3,816**	**1,224**	**0,744**	**0,576**	**0,672**	**2,04**	**4,656**	**7,752**	**10,248**

200mm insulation:

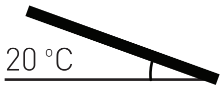
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
	kWh pr. day	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*
Heating	4,608	4,368	2,616	0,96	0,024	0	0	0	0,456	2,016	4,2	5,04
HtCoil	2,136	2,376	2,256	1,632	0,576	0,192	0,072	0,096	0,72	1,416	1,944	2,064
Fanpower	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216
Lighting	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24
Total	7,2	7,2	5,328	3,048	1,056	0,648	0,528	0,552	1,632	3,888	6,6	7,56

250mm insulation:

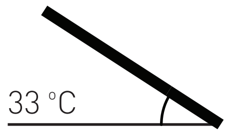
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	kWh pr. day	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*	*kWh pr. day*
Heating	3,84	3,552	1,992	0,8	0	0	0	0	0,24	1,512	3,456	4,2
HtCoil	2,136	2,4	2,256	1,608	0,504	0,048	0,048	0,072	0,696	1,44	1,968	2,064
Fanpower	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216	0,216
Lighting	0,24	0,24	0,240	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24
Total	6,432	6,408	**4,704**	2,864	0,96	0,504	0,504	0,528	1,392	3,408	5,88	6,72

APPENDIX 6 – SOLAR EFFECT

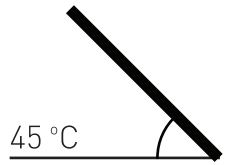
The tables below displays the daily possible effect of the tested solar panels in thre different angles all months of the year.



	South	West	East
	kWh	kWh	kWh
January	0,01	0,00	0,00
February	0,15	0,09	0,10
March	0,53	0,39	0,38
April	0,76	0,64	0,63
May	1,17	1,03	1,02
June	1,15	1,04	1,06
July	1,10	0,99	0,99
August	0,89	0,77	0,75
September	0,63	0,47	0,49
October	0,33	0,21	0,21
November	0,05	0,03	0,03
December	0,00	0,00	0,00

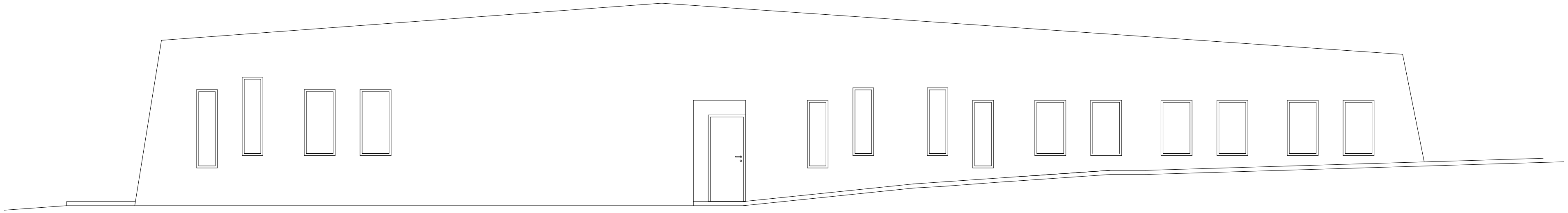


	South	West	East
	kWh	kWh	kWh
January	0,01	0,00	0,00
February	0,17	0,08	0,08
March	0,59	0,36	0,34
April	0,79	0,56	0,54
May	1,16	0,91	0,90
June	1,11	0,90	0,92
July	1,07	0,86	0,86
August	0,91	0,68	0,66
September	0,68	0,41	0,44
October	0,38	0,19	0,19
November	0,06	0,02	0,02
December	0,00	0,00	0,00

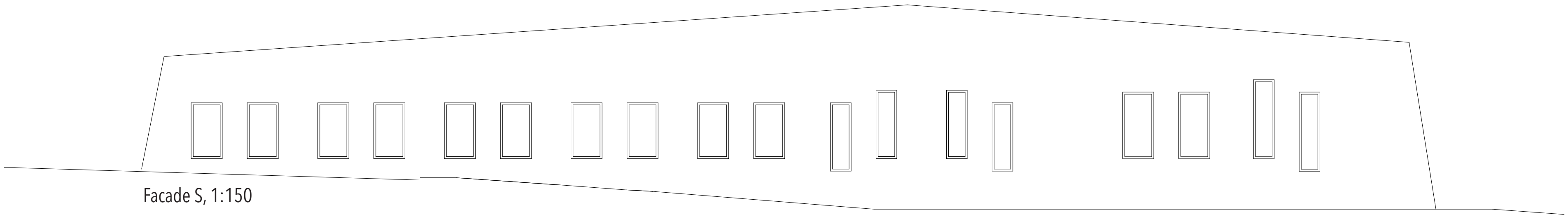


	South	West	East
	kWh	kWh	kWh
January	0,01	0,00	0,00
February	0,19	0,07	0,08
March	0,62	0,33	0,31
April	0,79	0,50	0,48
May	1,12	0,81	0,79
June	1,05	0,79	0,81
July	1,02	0,76	0,76
August	0,89	0,61	0,58
September	0,70	0,37	0,40
October	0,42	0,18	0,17
November	0,07	0,02	0,02
December	0,00	0,00	0,00

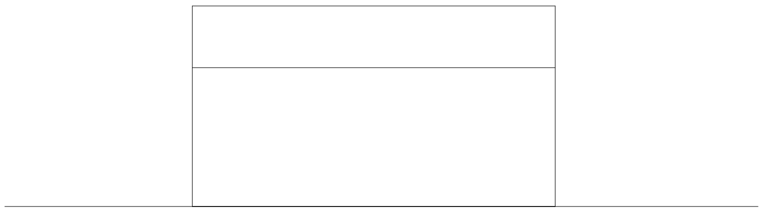
APPENDIX 7 - FACADES RESTAURANT



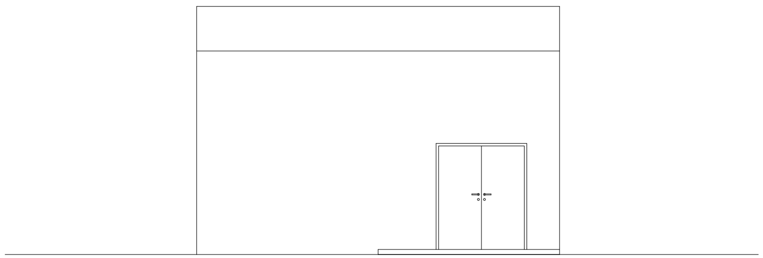
Facade N, 1:150



Facade S, 1:150

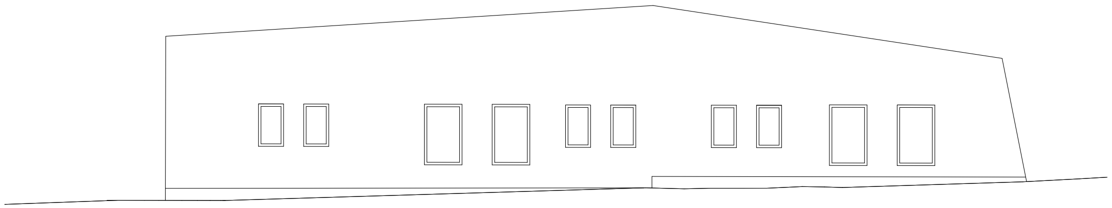


Facade W, 1:150

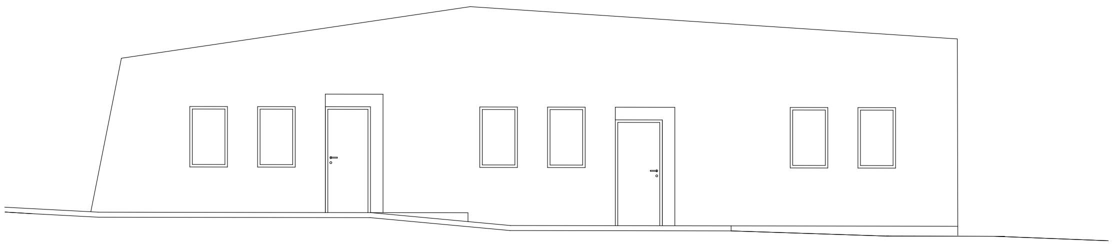


Facade E, 1:150

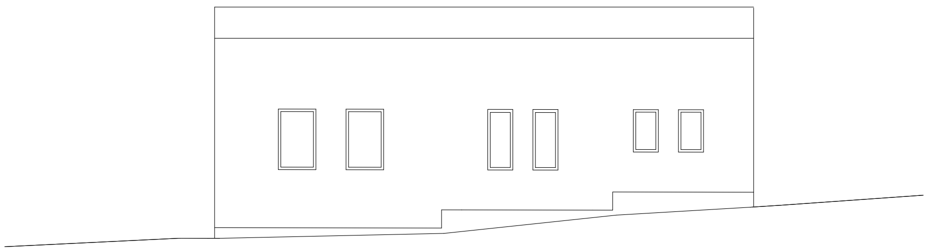
APPENDIX 8 - FACADES HOST AND STAFF BUILDING



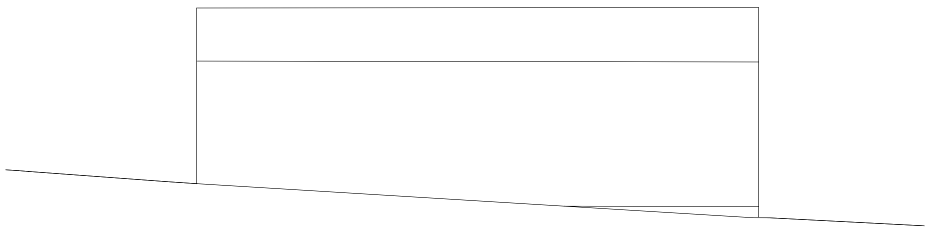
Facade NW, 1:150



Facade SE, 1:150

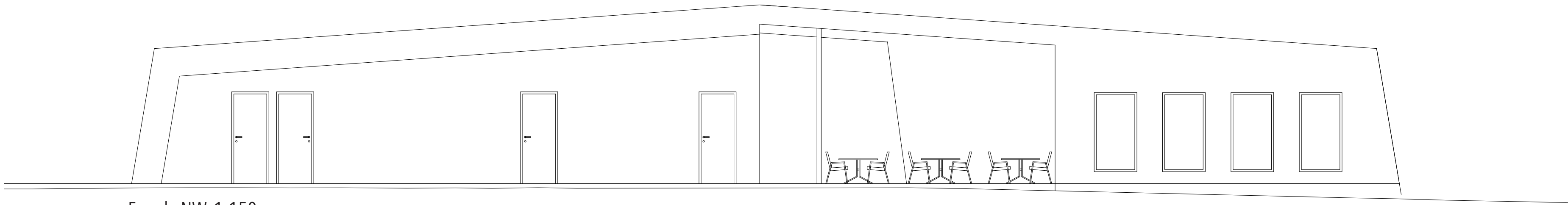


Facade NE, 1:150

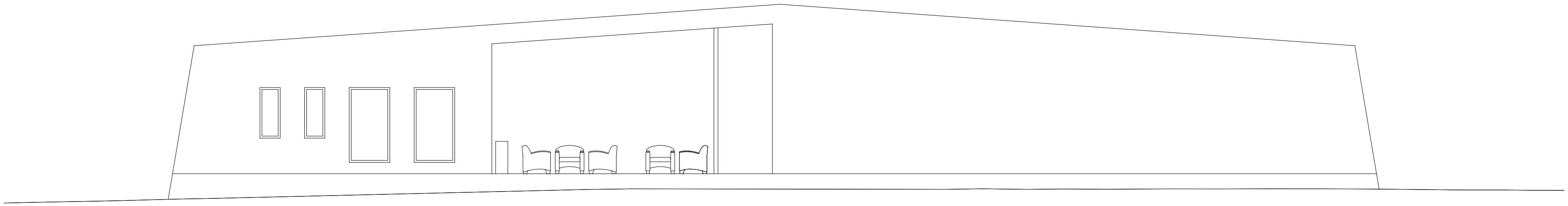


Facade SW, 1:150

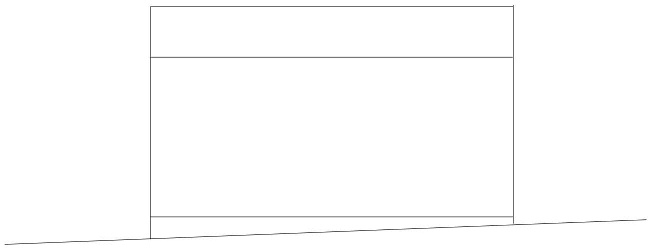
APPENDIX 9 - FACADES LOUNGE



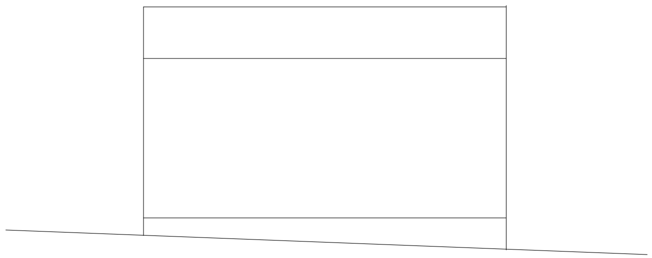
Facade NW, 1:150



Facade SE, 1:150

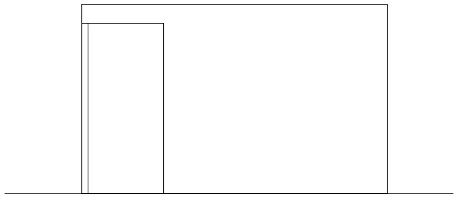


Facade NE, 1:150

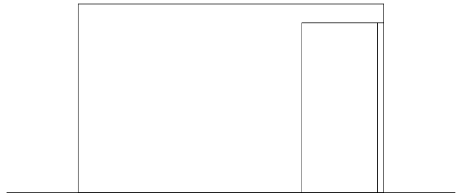


Facade SW, 1:150

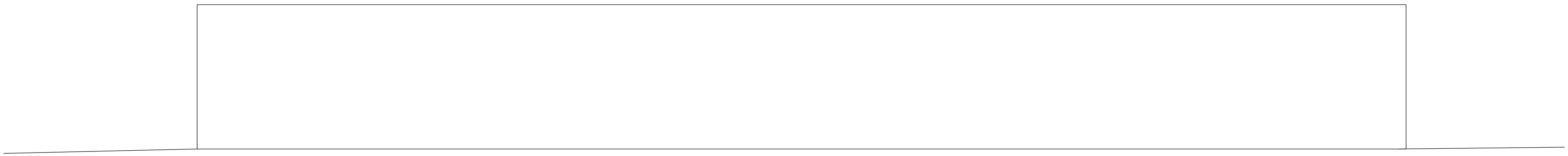
APPENDIX 10 - FACADES HORSE BARN



Facade NE, 1:150

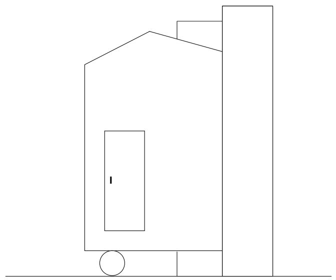


Facade SW, 1:150

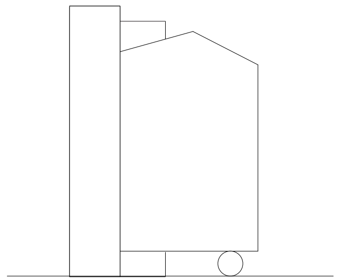


Facade NW, 1:150

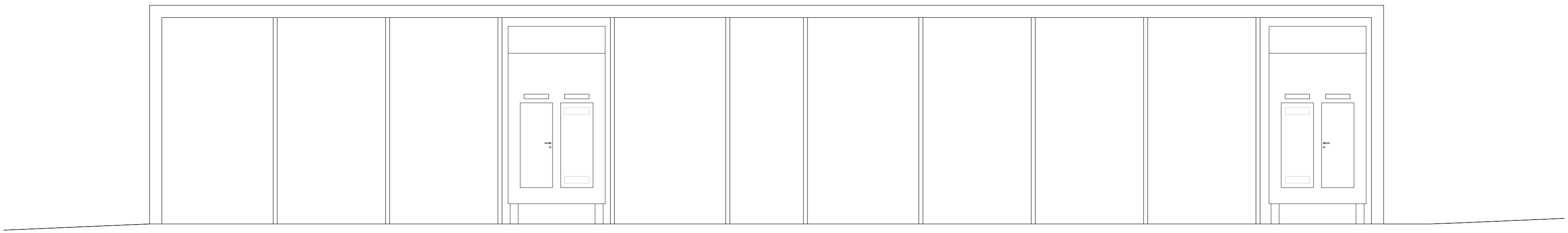
APPENDIX 11 - FACADES CABIN RECHARGE



Facade W, 1:150

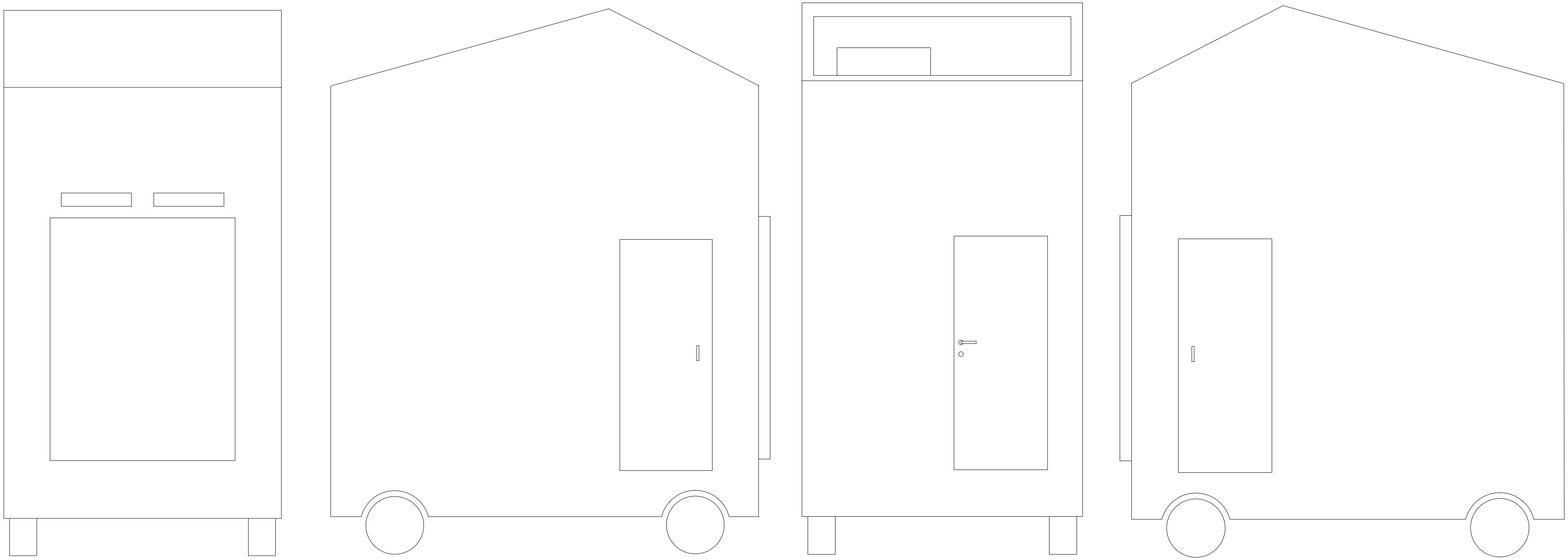


Facade E, 1:150



Facade S, 1:150

APPENDIX 12 - FACADES CABIN W. TOILET



Facade S, 1:50

Facade E, 1:50

Facade N, 1:50

Facade W, 1:50

APPENDIX 13 - NATURAL VENTILATION

To understand the effect of using the skylight in the cabin for natural ventilation, some initial calculations were made to compare different size of openings. As the window is placed in the inclined roof, the natural ventilation will both be due to thermal buoyancy and wind. The calculations was used to give an initial understanding and showed that it is possible to get the needed air change rate even with a small opening. The indoor simulation tool BSim was used later in the process to model and calculate the needed effect in the final building design.

The air flow rate is given by: $q = \frac{A}{2} \cdot \sqrt{C_1 \cdot v_{ref}^2 + C_2 \cdot (H_t - H_b) \cdot (T_i - T_u) + C_3}$

$A = The\ effective\ window\ opening\ area\ (m^2) = Areal \cdot\ C_d$
$C_1 = a\ dimensionsless\ coefficient\ depending\ on\ the\ wind\ \Rightarrow 0{,}001$
$C_2 = a\ constant\ depending\ on\ thermal\ buoyancy \Rightarrow 0{,}0035$
$C_3\ = a\ constant\ depending\ on\ wind\ turbulence\ \Rightarrow 0{,}01$
$H_t = height\ from\ floor\ to\ window\ top$
$H_b = height\ from\ floor\ to\ window\ buttom$
$T_i = indoor\ temperature$
$T_u = outdoor\ temperature$

$$v_{ref} = v_{meteo\ ,10} \cdot k \cdot\ h^a\ \left(\frac{m}{s}\right) = 1\frac{m}{s} \cdot 0{,}68 \cdot\ 3{,}8^{0{,}17} = 0{,}85\ \frac{m}{S}$$

$k\ and\ a\ are\ defined\ by\ terrain\ type. For\ open\ flat\ lan\ uses\ k = 0{,}68\ and\ a = 0{,}17$
$v_{meteo\ ,10}\ is\ a\ meteorological\ wind\ sped\ measured\ in\ the\ height\ of\ 10\ m\ above\ ground.$

Opening area *(m^2)*	*Discharge coefficient C_d*	*Eff. Areal A* *(m^2)*	*H_t* *(m)*	*H_b* *(m)*	*Ti* *°C*	*Tu* *°C*	*AFR = q* *(m3/s)*	*Floor area* *(m^2)*	*Room height* *(m)*	*Air exchange rate* *(h^{-1})*
0,2	0,7	0,14	3,3	3	18	12	0,0091	5,6	3,3	1,8
0,4	0,7	0,28	3,3	3	18	12	0,018	5,6	3,3	3,5
0,6	0,7	0,42	3,3	3	18	12	0,027	5,6	3,3	5,2
0,8	0,7	0,56	3,3	3	18	12	0,036	5,6	3,3	7,0
1	0,7	0,7	3,3	3	18	12	0,045	5,6	3,3	8,7

APPENDIX 14 – RAIN WATER COLLECTION

Calculations of the possible amount of rain water to collect from the roofs of the buildings when using different roof materials. The calulations are based on data from (PermaDesign, n.d.) and (Livingroofs, n.d.)

Rainwater Myvatn	637	$l/m^2/year$
Run-off coefficients		
Asphalt or concrete	0,9	
Extensive green roof	0,6	
Intensive green roof	0,4	
Metal	0,95	

	Roof area	Possible rainwater collection			
		Asphalt or concrete	Extensive green roof	Intensive green roof	Metal
	m^2	*l/year*	*l/year*	*l/year*	*l/year*
Host + staff	178,5	102334	68223	45482	108019
Restaurant	217	124406	82937	55292	131318
Visitor Center	205	117527	78351	52234	124056
Lounge	205	117527	78351	52234	124056
Horsebarn	112	64210	42806	28538	67777
Cabin shelter	195,8	112252	74835	49890	118488
Cabins total	178	102047	68032	45354	107717
Individual cabin	8,9	5102	3402	2268	5386
		740302	496936	331291	786816

Toilet flush

Water use pr flush 3 *l*

	Flushes pr hour	Active hours	Total water for flushes *l/year*
Host	3	10	32850
Restaurant	6	15	98550
VC	2	8	17520
Lounge	10	17	186150
Individual cabin	0,25	12	3285
			338355

Laundry

Water use pr person for laundry 19 *l/day/person*

Water use pr hotel room for laundry 100 *l/room/day*

	Number of rooms/person	Total water for laundry *l/year*
Host	4	27740
Cabins	10	365000
		392740

Drinking water

Water use pr horse for drinking 19,8 *l/day/horse*

	Water pr horse *l/year*	Number of horses	Total water consumption *l/year*
Water for horses:	7227	10	72270