SÁMI FOREST KINDERGARTEN

2017

Colophon

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Abstract

This project is a proposal for the design of a Sami forest kindergarten in Tromsø, Norway. The project is developed with integrated design process and holistic approach to the design. The aim of the project was to investigate how the forest kindergarten approach would contribute to the kindergarten for indigenous Sami people in Norway. The project description was developed from the own idea which was expanded through the research about Sami people, their culture, needs, climate and the forest kindergarten principles. After comprehensive analyses, the design criteria were formulated as a baseline for the start of the design phase. The design phase consisted of various interpretations and proposals which were trying to respond to the demanding design criteria. During the process different tools and sketches were used to test architectural and technical qualities. A lot of attention was devoted to the simulations in relation to the sun exposure and the indoor qualities such as daylight and thermal comfort. The final concept is based on the idea of a shelter, formed in the few small building units. The sustainable performance was presented with graphs and data about Zero Energy performance and indoor quality, but the significant impact on the design was as also the consideration about material sustainability and the final environmental impact of the building.

Preface

This paper is a Master Thesis of the 4th semester (MSc4) in Master's programme in Architecture, under the Board of Studies for Architecture and Design and School of Architecture, Design and Planning at Aalborg University.

The document is a result of collaborative work of two architecture students from Aalborg University for the period between February 6th and May 18th 2017.

The paper contains the project description that is based on the own initiative and research, and a design proposal for Sámi forest kindergarten in Tromsø. The knowledge is generated through the literature studies, site visit, interviews with the individuals that are related to the topic, and visits to relevant institutions (kindergartens) in Norway and Denmark.

The paper is accessible to all users of the Project library from Aalborg University, and it can be directed to both architects and non-architects. Besides its architectural and technical content, in the Analysis part there is a lot of information related to social topics concerning the integration of Sámi people in the modern society and pedagogical aspects of outdoor learning for children.

Readers guide

The document is divided into six chapters in the order to introduce the reader with the project through the different stages of the process. Each chapter is introduced with a brief description of the general content of the chapter and a background photo which is related to the landscape and natural surroundings of the site location. Each chapter contains several subtitles that are structured in 3 levels of hierarchy. The graphics and photos in every chapter are named in small captions next to the photos.

The illustration numbers are following the page numbers, so it is easier to find them when they are mentioned in the text. In cases where there are several illustrations under one name, they are referred in the text as A, B, C or D (for ex. Illustration 127.1/A) following the order from left to right.

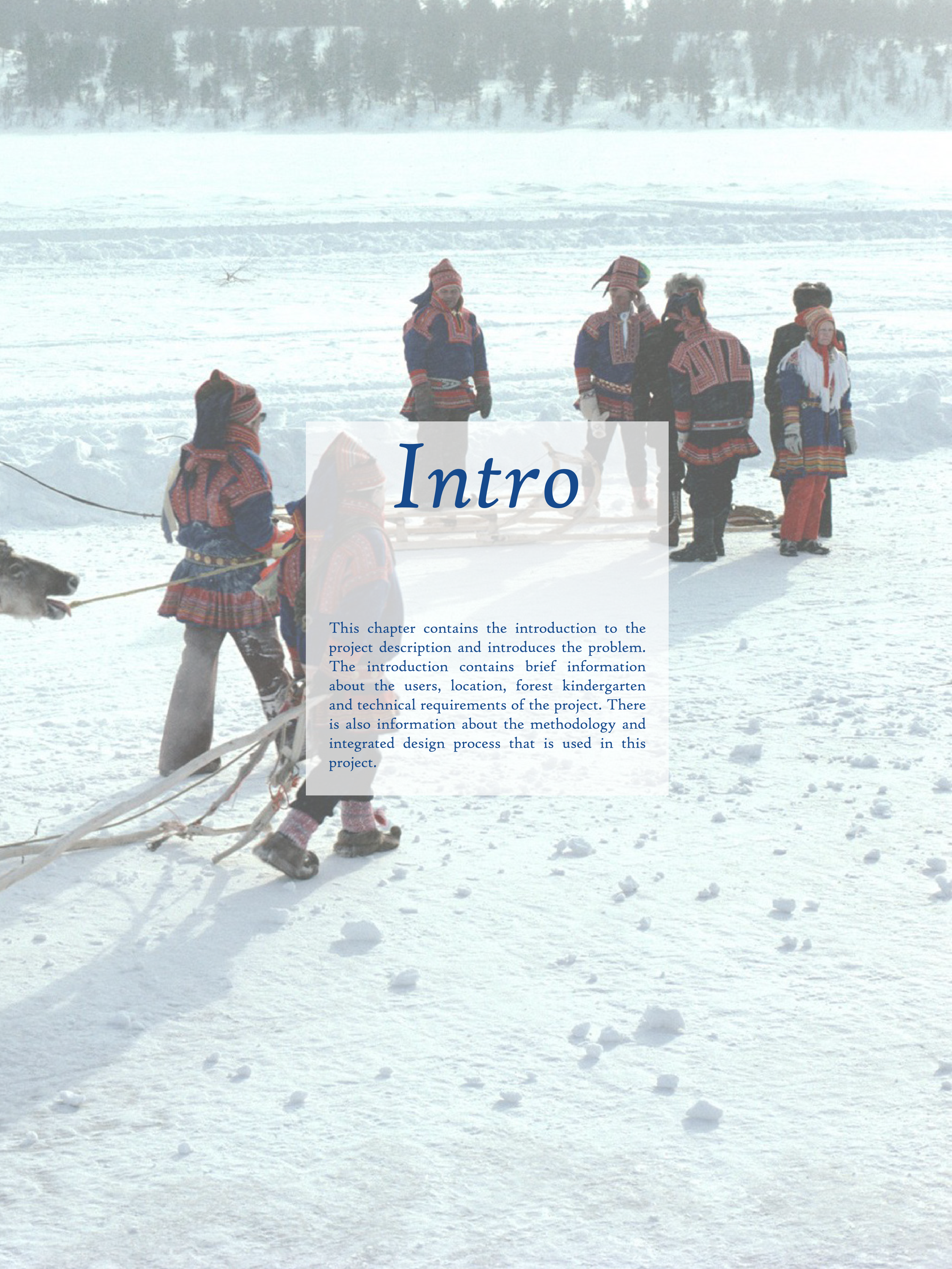
In the Presentation chapter, the buildings are named from A to D, with all the rooms listed on the ground floor plan (p. 78). The position of the spatial visualisation views are marked on the master plan (p. 74, v1-v3) and floor plan (p. 78, v4-v6) of the building. The position of the details (p. 112) are marked in the sections between the page 90 and 94 (Detail A-D). The technical calculations and the key numbers from the final results are documented in the Appendix which is referred in the text when needed.

Content

DESIGN PROCESS

EPILOGUE

APPENDIX



Intro

This chapter contains the introduction to the project description and introduces the problem. The introduction contains brief information about the users, location, forest kindergarten and technical requirements of the project. There is also information about the methodology and integrated design process that is used in this project.

Introduction

The Sámi people have been living in the Arctic area for more than 5 000 years, and their culture is significant part of Scandinavian history and European legacy. They are considered as an ethnic group with a fundamental connection with the nature. Through centuries they had suffered from aggressive assimilation policies, which resulted with only 100 000 Sámi people left. Most of them are living in urban areas and are constrained to use another language and culture instead of their own. (Keskitalo, Määttä, Uusiautti, 2011)

Today, the Norwegian government has given a higher priority to the Sámi education. Due to the Sámi political movements and the new policy of Norway in the last few decades, there is a will to fix the damage of the past and help the Sámi people to maintain their language and culture, while becoming an integrated part of the modern society. (Norwegian Ministry of Education and Research, 2006) The possibility of having a Sámi kindergarten is important for the Sámi parents since they want their children to be taught in Sámi language and culture in the most crucial part of their child's development. (Aleksandersen Nutti, L. 2017) There is an escalated need for bigger capacity of Sámi kindergartens, but also a lack of specific projects which can emphasize the characteristics of Sámi culture.

The approach of Forest Kindergartens has many years experiences in Scandinavia. Using mostly outdoor spaces for learning, it can offer a unique possibility to educate children in nature, while developing their social, physical and mental skills. The method had already big success in other countries with scientifically proven health benefits and improved skills. (Williams-Siegfredsen, 2012) Taking into account the historical background of Sami people and their connection with nature, the idea of the forest kindergarten could be beneficial for the Sámi children.

In order to correspond to the needs of the Sami people, the kindergarten design should also consider the Sami cultural signature in terms of aesthetics, spatial forms and shapes.

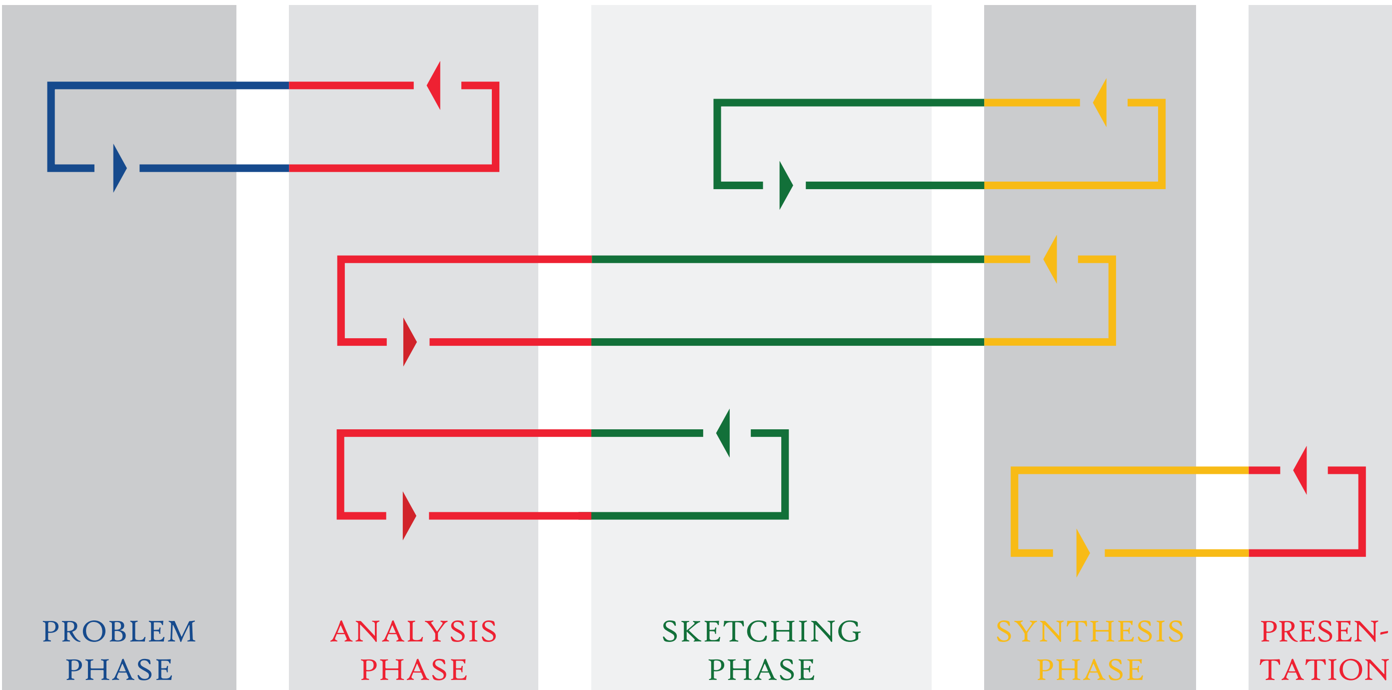
There is a significant cultural heritage in the traditional Sámi building techniques and their ways of using materials, so it will be a challenge to implement them in the design of a functional kindergarten.

The chosen location is Tromsø, the biggest town of Northern Norway, a rapidly growing cultural and economic center with numerous Sámi connections. The local Sámi society is fighting for years to get more possibilities for their children's early education. The continuous increase of population is also giving a challenge to the city planners, who have to create a sustainable and liveable settlement beyond the Arctic Circle. The building design should follow the Danish building regulations (BR15), and Building class 2020 with a Zero Energy Building standard. The design proposal should represent a sustainable environment with the spatial quality that respects traditional materials, highest energy standards and minimal environmental footprint on the world.

Finally, the building design should correspond to all mentioned aspects with integrated approach of a Forest kindergarten to provide a better alternative for Sámi kindergartens.

▼ *Illustration 10.1.*
Sámi flag

Methodology



▲ *Illustration 11.1.*
The phases of Integrated design process

The methodology of this project is based on the Integrated Design Process, which was defined by Mary Ann Knudstrup in 2005. The Process consists of five phases: problem, analysis, sketching, synthesis and presentation. The phases are based on a non-linear progress and phases are revised many times before their finalisation. The aim of this method is to combine the architectural and engineering design process and make all the important decisions in the early stage of the building project. (Knudstrup, 2005)

The project starts with the problem definition which later becomes the base for the project description.

The second phase are the analyses where all the relevant information about the site, context and the users is gathered, processed and documented. This phase also include site visits, interviews with relevant authorities for the topic, investigations, and literature studies. The summarized knowledge is the basis for the further design process after creating the problem formulation and setting the design criteria.

In the sketching phase the architectural and engineering knowledge is used to meet the requirements and wishes, by using different tools for sketching, modeling, and technical performance simulations. Different methods and softwares are used to simulate various solutions in relation to sun exposure (*Grasshopper plug ins: Ladybug, Galapagos*), structure and spatial expression (*Rhinoceros*) in order to optimize the project until it fulfills the design criteria.

The building complex reaches its final form in the synthesis phase where all the different solutions from the sketching phase are integrated in a coherent form. The performance is documented and later presented in the final phase.

The presentation shows all the qualities of the project, using technical drawings, visualizations, diagrams, graphs and physical models. The phase also points out how the aims of the project and design criteria are fulfilled.

Analysis

This chapter includes all relevant information about the history of the Sámi people, their education and architecture, forest kindergartens, site location, context and the climate. There is also information about the technical requirements in terms of sustainability, energy use and materials. The gathered information is basis for the formulation of the design criteria which are listed on the end of the chapter.

Sámi people

HISTORY

The Sámi people, or with older appellation, the Lapps, are indigenous Finno-Ugric people, inhabiting the area of Sápmi (Illustration 15.1). This is the cultural region spreading through Norway, Sweden, Finland and Russia, primarily in the Arctic area above the Arctic Circle. The traditionally called "Lapland" is only a minor part of it, located in Northern Finland and Sweden.

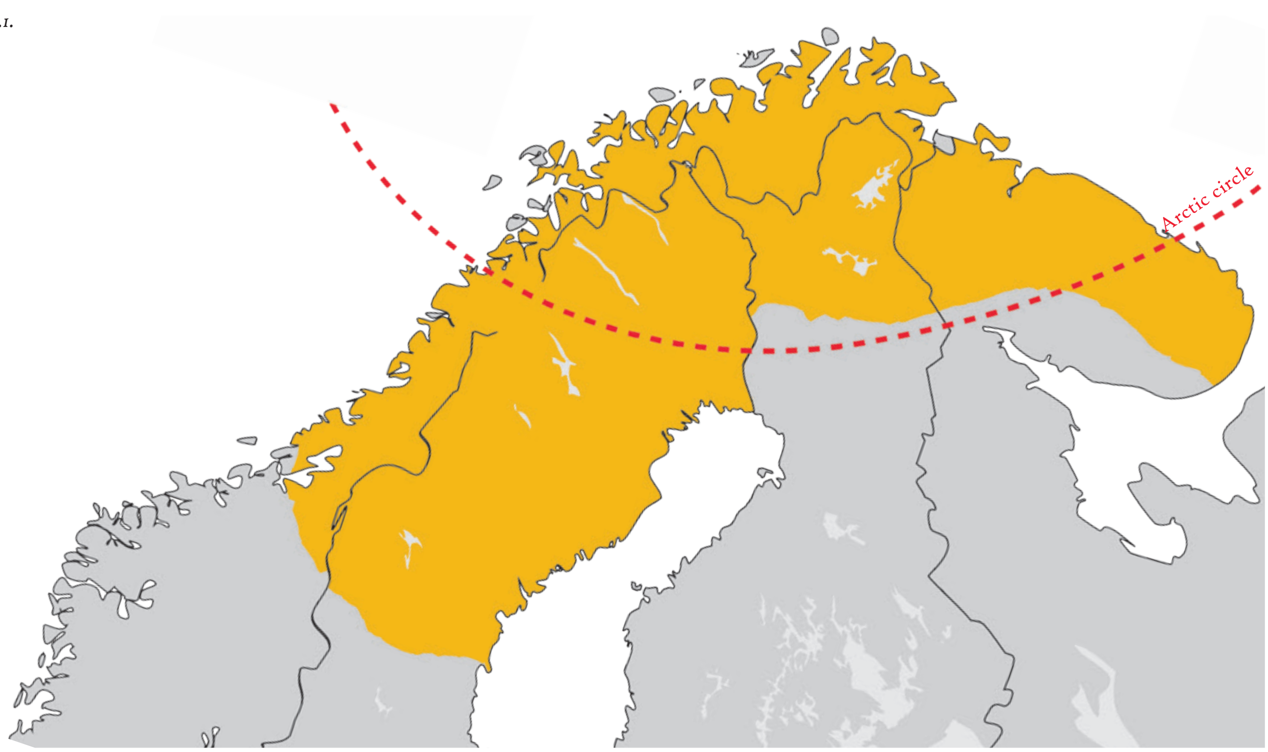
The Sámi are the only indigenous people in Europe. According to most of the sources, their current population is approximately 100 000 people. and half of them live in Norway. About 40 000 of them speak one of the Sámi languages, while the rest are using the main language of their country. (Keskitalo, Määttä, Uusiautti, 2011) They are best known of their traditional semi-nomadic livelihood, depending on the reindeer herding. However, only 10% of current Sámis are concerned in this lifestyle, and the biggest part of the population lives in urbanized areas by now. During the history, they had to face many problems and challenges concerning their culture and education.

The missionary activities made a huge impact on the shamanist beliefs and the traditional way of life in Sápmi.
At the same time, Norway started to establish itself as a nation, putting the Sámi people under severe pressure. Sápmi area became gradually populated by more and more Norwegians. Industry started to take an interest in the water, ore and fishing resources. (Özerk, 2009) School was the most powerful tool of assimilation and Sámi languages could be used only in exceptional situations.(Keskitalo, Määttä, Uusiautti, 2011)

After the World War II, the Norwegian government continued infrastructure development in the remote nordic areas. Moreover, the intensifying Sámi identity and self-expression, formed as a political gesture, known as Sámi Movement. They gradually reevaluated their self-image, invented a new context for a unifying, cultural commonality, and became a political force on the Nordic scene. (Eidheim, 1997)

◀*Illustration 14.1.*
Sámi people

▼ *Illustration 15.1.*
Sápmi area



The restrictive policies started to cease in 1969, when a new "Law of Basic Education" was passed. This gave the possibility to parents who used the Sámi language in their daily lives to let their children be taught in the Sámi language (Özerk, 2009).

From the 1970s, the Sámi people's own opinion was introduced in their education planning, but this far their original cultural identity was replaced with the culture of the surrounding society. The school system for Sámi people was adopted by Norwegian curriculum without considerations for the Sámi needs, cultural identity and teaching arrangements.Today, they still need a system that make pupils, parents and teachers understand themselves, their culture, and others' culture, too. (Keskitalo, Määttä, Uusiautti, 2011)

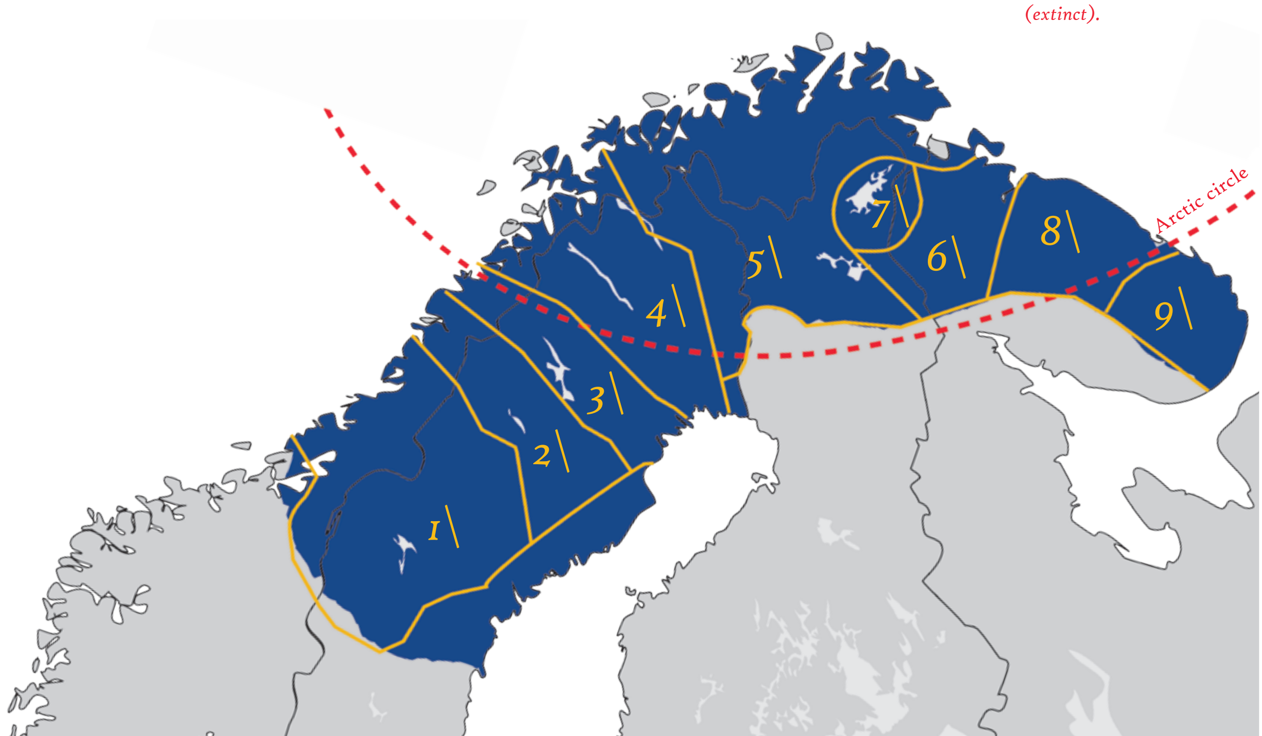
Sámi people are historically distinguished as "Sea Sámi" and "Mountain Sámi". Today the very major of their population (around 90%), based on the former "Sea Sámi", live in urban areas. The other 10% still settles "on the Mountain", continuing the nomadic life of reindeer herders. (Slaastad, 2016)

Language

Sámi language is a member of the Uralic linguistic group along with languages such as Finnish, Estonian and Hungarian. (Nordnorge.com, 2017)

The language is one of the biggest holder of their culture, but it is branched into 9-10 bigger languages (Illustration 16.1), which are geographically distributed along the Sápmi area. Northern Sámi is the most widespread Sámi language, while the other significant ones are the Southern Sámi and the Lule Sámi. The Northern Sami also represent the strongest cultural base and dominates among the others languages (Nutti, 2017). The biggest settlement in this language area is the city Tromsø in Norway, with currently 70 000 inhabitants.

▼ Illustration 16.1.
Sámi language areas:
1. Southern Sámi (Åarjil),
2. Ume Sámi (Upme),
3. Pite Sámi (Bitthun),
4. Lule Sámi (Julev),
5. Northern Sámi (Davvi),
6. Skolt Sámi,
7. Inari Sámi (Ánár),
8. Kildin Sámi,
9. Ter Sámi, 10. Kemi Sámi (extinct).



▲ *Illustration 17.1.*
Traditional Sámi clothing

CULTURE

The Sámi culture is very unique in it's way of expression. Their traditional way of handicraft (*duoddji* on Sámi language) was used to make clothes, boots, drums, wooden tools, and knifes. The traditional Sámi clothing, the *gákti*, was usually made from reindeer leather and sinews, but today they wear it for special occasions and ceremonies. (Nordnorge.com, 2017)

The clothes are mostly made in Sámi colours: blue, red, green and yellow (Illustration 17.1), which are also used in the Sámi flag, where red in the circle represents the Sun, and blue represents the Moon.

The Sámi way of singing, called *joik*, is one of the oldest song traditions in Europe. It is a form of a chant that is usually sung *a cappella* in slow and deep motions. Yoiks can be dedicated to animals in nature, special people, or a place, and they can express joy, sorrow or melancholy.
(En.wikipedia.org, 2017)

Today, there are many ways where they can stay in contact with their traditional life, using the newspapers, literature, markets, events and festivals. (Eidheim 1997)

In Tromsø for example, they celebrate Sámi national day on 6th of February and hold the famous reindeer race around the town, with additional programe in the museums and cinemas. (Msm.no, 2017).

ARCHITECTURE

Vernacular buildings

The traditional Sámi building structures are representative examples of indigenous architecture. Their unique way of crafting and use of natural materials makes them the essential element in the Sámi culture, also on the ground of respecting the natural laws, forces and climate. (En.wikipedia.org, 2017)

The Sámi experience in a harsh environment forced them to create an intricate social and cultural community. The evolution of the different building types goes back from the archaic nomad facilities towards the more permanent dwellings. All these archetypes are similar in function, organization and thermal system.

The first and most important function is to provide protection against the forces of nature. The way of starting a settlement is highly dependable on the microclimate of the actual building site in relation to building placement, entrance position and wind protection.

The interior formation, such as the usual central floor plan and low inner height, ensures the optimal spread of heat from the central fire place called *Arran* (Illustration 19.3). The Arran is central point for the functional organization as well. Everyone and everything has its own place inside of the shelter which is highly respected by each member of the family. (Emmons, 2004)

The differences are based on the different lifestyle of tribes, and can be noticed at the structural and tectonic solutions. Both animal herding among the Mountain Sámi and the coastal fishing lifestyle among the Sea Sámi has influenced the way of creating shelter for themselves. The animal husbandry and the frequent change of dwelling site required a simple, easily transportable shelter system consisting of poles and animal hides. This type is known as *lávvu* tent (*koavas* or *kota*) (Illustration 19.1). It can be easily taken down and erected even by one person, making each pole equally supported by the others.

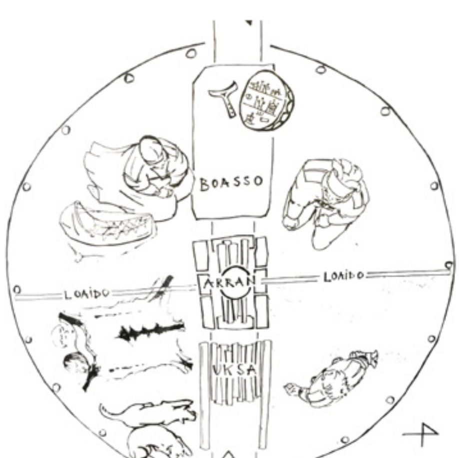
▼ *Illustration 18.1.*
Construction of goahti

▲ *Illustration 19.1.*
Example of lávvu

In the case of Sea Sámi, the *goahti* (*gåhte*, *gamme* or *kota*) structure (Illustration 19.2) is based on an inner load-bearing frame, often making a more square-like shape in the plan. Although it can be also used temporarily as a tent, the inner frame can offer enough stability to hold massive insulation materials such as earth or turf upon. (Illustration 18.1) This way they can last up to 10 years, creating "small hills" and slowly and smoothly dissolving into the landscape. (Emmons, 2004)

During the centuries of assimilation, the Sámi people have adopted Western technologies and building types as well. Despite this, both *lávvu* and *goahti* are essential and respected symbols of their culture and good examples of vernacular architecture in the harsh Arctic environment.

▲ *Illustration 19.2.*
Structural system of goahti



▶ *Illustration 19.3.*
Floor plan of lávvu and goahti

Conteporary buildings

Since the political and cultural revival, the Sámi people are trying to emphasize their self-identity with the appearance of their buildings as well. The form of the lávvu tent became an international symbol and has a wide range of visual usage, including architecture and other visual arts. Both building types have inspired some remarkable contemporary buildings, like Várjjat Sámi Museum in Varangerbotn (1994), the Sámi Parliament (Illustration 21.1) in Karasjok (1995/2005) or the Sámi Cultural Center Sajos in Inari, Finland (2012).

There are two fields of conflict when interpreting the traditional architecture in modern buildings today. First, the majority of Sámi population have already terminated the nomadic lifestyle and settled down in smaller or bigger urban areas, participating in the Western way of living now. The second conflict is caused in the cases when the traditional Sámi architecture appears on contemporary buildings only as a gesture or rather a decoration, using the exact form of archetypes without interpreting the deeper architectural (tectonic, material or environmental) values. (NTNU, 2007)

Many architects with or without Sámi roots are determined to give a valuable architecture in Sámi connected buildings. The majority of the built examples has cultural or governmental function, like the well-known building of the Sámi Parliament in Karasjok, Norway (Illustration 21.1). This was the first institute to represent the union and the political power of the modern Sámi people. The room for plenary assembly hall is the centrum of the complex, with an experience of the traditional structures in a big-scale building. The external envelope is made of Siberian larch, while the interior is covered by birch, pine and oak. (Archdaily.com, 2009)

The Norwegian architect Stein Halvorsen have made several Sámi related projects since winning the competition for the Parliament. Two examples are the building of District Court in Tana (2004), Norway (Illustration 21.2) and the extension of Sámi Parliament in 2015 (Illustration 20.1). Both are introducing a new architectural language while still related to the Sámi culture. The extension building offers a new entrance connected by a closed corridor with the building of the parliament. (Sh-arkitekter.no, 2017)

▼ *Illustration 20.1.*
Extension of Sámi Parlaiment, Karasjok, 2015

▲ *Illustration 21.1.*
Sámi Parlaiment, Karasjok, 1995

▼ *Illustration 21.2.*
District Court, Tana, 2004

There are examples from Finland where, instead of the geometry, the usage of materials and the composition of spaces are for emphasizing the Sámi connections, like the Siida museum by Juhani Pallasmaa (1998) and the Sajos cultural center by HALO Architects (2012), both in Inari, Finland.

Even though there are no examples of any educational buildings related to Sámi culture, these examples are good basis for understanding how to present the Sámi characteristics in public buildings.

SÁMI KINDERGARTENS

As a result of the activity of Sámi Movement, the step by step changes in the policy of the Norwegian government in the last 40 years have been complemented by changes in Sámi attitudes towards their own language and culture. (Özerk, 2009) According to special act of Indigenous peoples, Norway has an obligation to protect the interests of Sámi children and parents and help them to develop their language and culture regardless where they live in Norway. (Norwegian Ministry of Education and Research, 2006)

Kindergartens play an important role in the cultural identity of the children. Since early childhood is the most significant period for development of a language, kindergartens need to have a good knowledge about children's language progress. (Tromsø kommune, 2016)

Children are able to go either to Sámi kindergartens, that by statute are built on the Sámi language and culture, or to Norwegian kindergartens, creating Sámi groups in them. (Norwegian Ministry of Labour and Social inclusion, 2006)

"Kindergartens shall take account of children's age, level of functioning, gender, and social, ethnic and cultural background, including the language and culture of Sámi children."

Kindergarten Act, Section 2 (Norwegian Ministry of Education and Research, 2005)

▼ *Illustration 22.1.*
Outdoor kindergarten, Trondheim

▲ *Illustration 23.1.*
Sámi school in northern Lapland

It is hard to determine the exact number of children who participate in the Sámi kindergarten system. According to the Norwegian Ministry of Labour and Social inclusion, 2009, their number was a bit lower than 1000; while another source reports that the number "became doubled, to 1145 children since 1999" (Özerk, 2009).
In 2014 there are around 900 children in Sámi kindergartens and another 700 in mixed kindergartens on the area of whole Sápmi, according to Sámi statistik 2016.

In Sámi districts, the kindergartens must be an integrated part of Sámi society and must demonstrate the diversity, vigour and variety of Sámi society. The kindergartens are place for strengthening children's identity as Sámi people through use of Sámi language, and by teaching children about Sámi culture, ways of life and society. In kindergartens outside Sámi districts the staff is expected to be familiar with Sámi culture and language, and to emphasise it as part of the kindergarten's programme. (Norwegian Ministry of Education and Research, 2006)

Despite the positive changes of regulations and the increasing number of pupils educated in Sámi language, the special features of Sámi education are not considered sufficiently in teaching arrangements, the school culture doesn't meet the people's need. The lack of autonomy in educational issues restricts the indigenous people. Both the spatial system of the class rooms and the curriculum are basically copying of the national ones, rather serving the majority people than the Sámis (Keskitalo et al. 2011).

Beside of teaching Sámi language and culture, the kindergartens are also providing outdoor activities that include reindeer racing and other events that are practiced by Sámi people (Tromsø kommune, 2016). The Sámi kindergartens are usually provided by the commune in form of occupying an older building for their groups. There is not a known kindergarten in Sápmi area which was directly designed for representing and using the Sámi culture in education. Taking this into account, the conclusion is that there is a significant need for new Sámi kindergartens in the Sápmi area (Nutti 2017), and that that these facts should be considered in the design process for a new Sámi kindergarten

USER GROUPS

The User groups are consisting of Sámi children, Sámi teachers or pedagogues who are fluent in Sámi language and familiar with their culture. They are helped by also staff members, chefs in the kitchen, head of maintenance or other consultants in case of need.

Sámi children

The children in the kindergarten are divided to groups according to their age from 1 to 3 years and 3 to 6 years. Children have to be able to develop their creative potential, basic knowledge, skills, sense of wonder and need to investigate. In the kindergarten they learn to take care of themselves, each other and nature.The activities should be organized according to their age and abilities (Norwegian Ministry of Education and Research 2006). The environment for the children have to be inviting and enable them to feel safe and free to develop their skills and interests through play and socialising.

In the case of Sámi children, it is important to use their language, and to learn about their culture and habits. In the early childhood they can already understand the nature around them and the importance of their historical connection with nature when using traditional buildings like lávvu or goahti. In kindergartens in Sámi populated areas, it could happen that the children are using different Sámi languages and cultures, so they need to be carefully organised in a way that they can still feel in a home-like environment. (Nutti, 2017)

The age group from 1 to 3 years follows the nursery standards. It has a restricted and protected outdoor area with separated sleeping area, both indoor and outdoor. They require more attention and guidance, and there are more teachers per child in this group. The youngest children have barely developed motoric functions and just have learned to walk. They use outdoor area under supervision, without trips to the forest. (Williams-Siegfredsen, 2012)

The age group from 3 to 6 years spend 2-3 hours daily in the forest and outdoor area. Their social and motoric skills are more developed so they require less supervision. They can also participate in small chores around the kindergarten, like helping with the cooking or serving meal.

▼ *Illustration 24.1.*
Sámi Children at the Jokkmokk Winter Market in Sweden

▲ *Illustration 25.1.*
Sámi kindergarten in Snåsa, Norway

Sámi teachers

According to regulations there must be one pedagogical leader per 7 to 9 children under the age of 3 and per 14 to 18 children over the age of 3. (Norwegian Ministry of Education and Research 2014) The municipal guidelines then specify staff-children ratio which is one adult per 3 children under 3 years of age, and one adult per 6 children over the age of 3.
(Tromsø kommune, 2016)

The teachers in the Sámi kindergarten are required to fluently speak Sámi language and have to be well introduced with the Sámi culture, behaviour and manners.

The teachers and pedagogues are trained and educated professionals for children education. When they are not with the children they use their own spaces such as office or meeting rooms.

The Staff

The staff include all employees that are not involved in children's education but are responsible for technical functioning of a building. They can be either a chef who is preparing daily meals, a cleaning person, or a maintenance person responsible for system functionality and repairs in the building.

In case of smaller kindergartens there is no need for staff and the teachers are organised to prepare food for their groups.

SUMMARY

The Sámi culture and language is experiencing a revival in the last decades, however there are numerous barriers and challenges which can be originated from their restricted autonomy. Despite the most of them lives in urban area today, mixed with the majority people of Norway, there is still demand to build more connections to their original nature-based lifestyle and traditions. Their colorful and viral habits have always been influenced and depended by the surrounding Arctic environment, and they still live on in the very most branches of culture, including music, handicraft and visual arts.

Kindergartens play an important role in maintaining Sámi language and cultural identity and the people of Sápmi are in constant need to develop more of them. There is still a lack of having any kindergarten which is considered specifically to Sámi people.

The qualities from their culture and vernacular architecture are inspiring for the design of a kindergarten in terms of aesthetic expression and functional organisation.

► *Illustration 27.1.*
Sámi kindergarten in Snåsa, Norway

Forest kindergarten

HISTORY

The Forest kindergartens are the kindergartens were the children use outdoors every day, the whole year round as a part of pre-school education. Scandinavian countries are often acknowledged as a "countries of reference" for this outdoor school approaches.
(Bentsen et al., 2010).

The Scandinavian concept of *udeskole* (outdoor school) and outdoor education have also inspired other countries to use the same approach such as Forest Schools in United Kingdom from the 1990s. There are many iterations and similar concepts developed in Denmark and the other Scandinavian countries like nature kindergartens, forest schools, forest groups, depending on their organisation and location. (Williams-Siegfredsen, 2012)

The Scandinavian approach of using outdoors as a part of children's education was influenced by Friedrich Froebel's kindergarten concept in Germany from 1840. Since then, the Danish pedagogical practice was also influenced by many world renowned theorists such as J.J. Rousseau, Maria Montessori, Jean Piaget, Mihály Csíkszentmihályi, Howard Gardner etc. In 1970's energy crisis and oil consumption started to remind people of our dependence on nature and the environment. There were more and more research about benefits of using outdoor activities in human health and psyche.

In 1990's the group of lecturers from Bridegewater Colleague started visiting Denmark forest schools, and within a decade, it became widely used in the United Kingdom. Over the years, the lecturers from Australia, US, Canada and Portugal were also introduced to this system and started implementing good practices in their own environments.
(Williams-Siegfredsen, 2012)

Health benefits

The benefits for children that are spending time outdoors on a daily basis, all year round, has been documented in Scandinavia for over 20 years, and more recent studies in the United Kingdom confirmed the findings.
(Williams-Siegfredsen, 2012)

The research showed that spending time outdoors develop children's physical, cognitive, linguistics, social and emotional competences, and it is also beneficial for health. The children are more attentive and have fewer infections, better brain function, better language development and are learning more skills.

There is also evidence that children use more complex language and construct longer sentences outdoors, so that is how learning outdoors stimulates language development. (Herholdt, 2003)

◀*Illustration 28.1.*
Forest kindergarten in Bronderslev

PEDAGOGY

The main pedagogical principles with outdoor teaching are based on holistic approach to children's development. It is stated that every child is unique and competent, interactive learner, and that children thrive on child-centered environments. (Williams-Siegfredsen, 2012)

The holistic approach take into account child's intellectual, emotional, physical, creative and spiritual potential in their learning and development process. According to Mihály Csíkszentmihályi the child is in a flow when they are asked to perform a challenge that is slightly higher than their capabilities and this theory is also in the roots of the Danish pedagogical practices. (Csíkszentmihályi, 2002)

The active learning for children starts with experiences in a way that they learn more about the nature, seasons, animals and the world around them by actually experiencing this processes and spending time in nature. All children are by nature observers and explorers, so exposing them to real-life situations and allowing them to use real tools and materials, they build self confidence and skills. Another important aspect of children's learning process is social interaction between peers during play or rest.

The pedagogues have to create safe environment where children can thrive and discover their potential. They also serve as a role model from which children can learn about social manners and respect for each other.
(Williams-Siegfredsen, 2012)

The curriculum of preschool education includes six areas of learning: the child's personal development, social development, language, body and movement, nature and natural phenomenon and cultural values. Parents also prefer smaller groups of children which are more child oriented, and that is why local authorities also support this idea and consider building more forest kindergartens as investment in children's future. (Williams-Siegfredsen, 2012)

▼ *Illustration 30.1.*
Children sleeping outdoors

▲ *Illustration 31.1.*
Outdoor preschool
"I Ur och Skur", Stockholm

ORGANISATION

The outdoor kindergartens are equally using indoor and outdoor spaces as educational environments. According to Danish Centre for Educational Environments the learning environment should be considered holistically, taking into account physical, psychological and aesthetic elements. (Dansk Center for Undervisningmiljø 2011) These elements affects children's daily life, their perception of the community and space and the environment around them.

The indoor environment has to be welcoming for children, enabling them to move safely, freely and independently. The indoor space has to be child-centered, equipped with child sized furniture, tools and rooms to play, sleep, eat and socialize. The aesthetics of the space should respond to children's perception in terms of colours, figures or drawings. The indoor environment should also provide appropriate lighting, both natural and artificial.

When compared to standard kindergarten, the room program for the forest kindergarten has more area for cloakroom where children deposit all their clothes for outdoors, and also use space to exhibit their collections from nature in "wonder cabinets". The standard practice is also to have outdoor sleeping areas which are used all year round, or big kitchen which could be used both by children and the staff.

The outdoor environment can be either a forest or a gardening farm or can be organised around the kindergarten. The area include large digging surfaces covered with sand or soil and a circular fire pit which is usually covered with a roof. The children use fire to dry themselves during cold and rainy weather or to cook food with the pedagogues once a week. The outdoor area is mostly designed from wooden and natural materials or resources, cointainting grassed earth for climbing and sliding and willow structures to build with. There is also a shed with craft tools that children can use and learn how to build their own structures from the materials that they found in nature. (Williams-Siegfredsen, 2012)

SUMMARY

The concept of forest/outdoor education is proven to be beneficial to the children's development and health. In order to use this potential, the possibility of spending time in the outdoor area and its quality has to be considered in the design process of a kindergarten. Although it is developed in Scandinavia, the results can be applied to other countries, nations or cultures as well.

These are especially interesting findings for Sámi children who want to preserve and develop their language, culture and integrate better in the society around them. A lot of the forest kindergarten principles are already compatible with nomadic lifestyle and values of the Sámi people in relation to their dependance and appreciation of nature.

The qualities of outdoor kindergartens could contribute to the design of Sámi kindergarten in terms of functional needs, organisation and flow in the building, while prioritizing the outdoor area as a main activity zone for the children.

► *Illustration 32.1.*
Forest kindergarten in Bronderslev

Location

TROMSØ

Tromsø is the biggest settlement in the Northern Sámi area in Norway, with a continuously growing population. The city has measured increasing birth rates in the last years and both outland and inland migration.
(Tromsø kommune, 2017)

Tromsø is the administrative center of Troms county. The town has grown from the medieval Tromsøya island towards the Eastern mainlands and the Western Kvaløya island. It has a subarctic climate, with a mild winter weather because of the ice-free Norwegian sea.

It is one of the main economic center of the Northern area, with a viral population and culture. The local architecture that contains a mixture of traditional Nordic wooden house heritage and also modern examples, such as the Tromsø Bridge and the Arctic Cathedral.
The local Sámi population was heavily assimilated into the Norwegian culture during the 18-20th century, however due to the actions of the Sámi Movement there is an intensifying presence of them in the last few decades. In 2011 the town almost became part of the Sámi Language Administrative Area, which has caused heavy political debates until today.
(NRK.no, 2011)

Demographics

The municipality had 69 000 inhabitants in 2012 with more than half of the inhabitants living on the central Tromsøya island. It is among the fastest growing settlements in Scandinavia and predictions show that the number of the population will increase to 81 500 until 2027 (+18% in fifteen years). (Tromsø kommune, 2012)

Answering the challenges of the increased population, the municipality has several proposes for handling the increasing city density. The new developed area is spreading primarily to the East on the mainland (ca. 4700 new households in these districts), and West towards Kvaløya island.

The municipality has set their wish to carry of the developments "on an environmental-friendly way", which is in order to create smaller hubs in the city where all the everyday target points (schools, shops, services and greeneries) are max. 5-10 minutes walk from the residential areas. The general aim is to make a compact sustainable city with reduced transportation, sufficient housing development, soil protection, prioritized biodiversity and infrastructure.
(Tromsø kommune, 2014)

◀ *Illustration 34.1.*
Tromsø aerial view from the hill Nordfjellet

▼ *Illustration 35.1.*
The aerial view of Tromsdalen area

EDUCATION STRATEGY

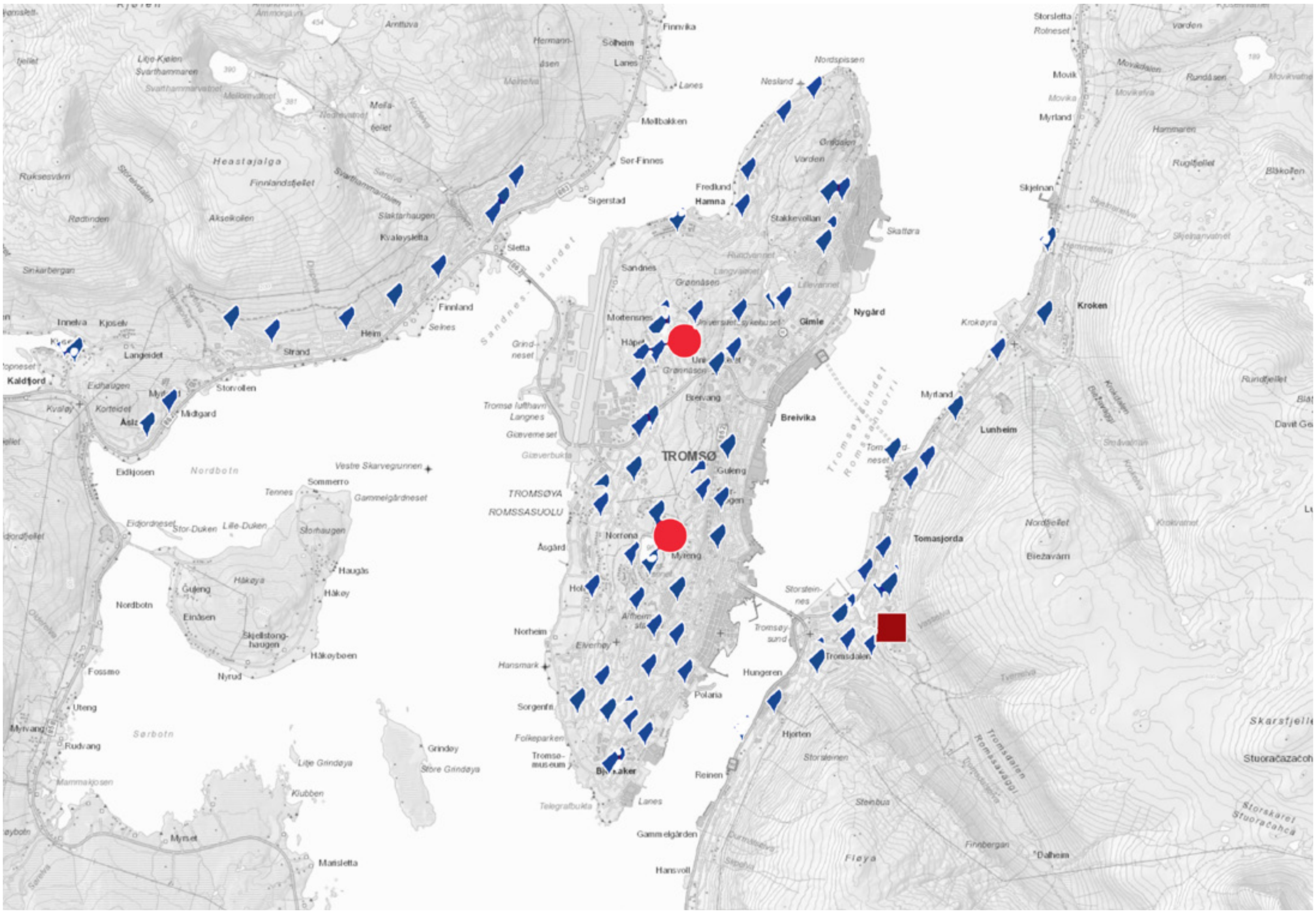
The municipality holds the issue of kindergartens and primary schools in the higher possible priority, taking them as prime factors in case of starting a new residential development. The Planprogram 2015-2026 suggests a more decentralized urban structure, making several hubs, smaller centrums with education, services, shops and green areas. These hubs shall be reached by foot in 5-10 minutes from the residential areas. Also, every new neighborhood has to have an open green area in less than 500 m distance, according to the sustainability strategy of Tromsø. Also, on every 1000 households there should be one kindergarten built. (Tromsø kommune, 2014)

There is an "increased pressure and need" for green areas, both in terms of improved public health and to develop an attractive outdoor community. This has special importance regarded to residential and educational areas. Every new educational project has to have an outdoor green area and also a "green corridor" towards the nearest natural site, water coast or forest. (Tromsø kommune, 2011)

The municipality has published a well-described Requirements Plan (Barnehagebehovsplan) for kindergartens with all the demanded criteria for such an institution, however, without a specific definitions of the Sámi demands.

The municipality plan program includes some newly built kindergartens or existing ones to extend or refurbished, without mentioning or specifying the needs for Sámi children. Therefore, the new Sámi kindergarten has to fulfill the criteria and the needs of the Sámi children. In Tromsø, there is only one Sámi kindergarten and one mixed kindergarten that have separated group for Sami children. According to the pedagogical leader from West kindergarten unit in Tromsø there is currently a high demand for more Sami kindergartens in the area (Djupnes, 2017).

▼ *Illustration 36.1.*
Recently built kindergarten in Tromsø



▲ *Illustration 31.1.*
Kindergarten locations in Tromsø

■ Chosen site for Sámi Kindergarten

● Norwegian kindergartens

● Sámi or mixed kindergartens

SITE LOCATION

The site is situated in the area where it has an access to the natural environment (park, forest, river), and accessibility from residential area and city center. The crucial factor for the location was also a distance from the traffic noise areas.

After analysis of the city maps provided by the municipality, the possible location of the site was placed in the Tromsdalen district on the mainland (Illustration 39.1).

The valley of Tromsdalen itself is the natural visual extension of Tromsø Bridge and the shortest connection towards the city centre. The area is the surrounded between urban and natural green area, enriched by the stream of Tromsdalselva. The slopes of the nearby hill are also used for camping and sport facilities, but there are also hiking trails towards Tromsdalstinden mountain.

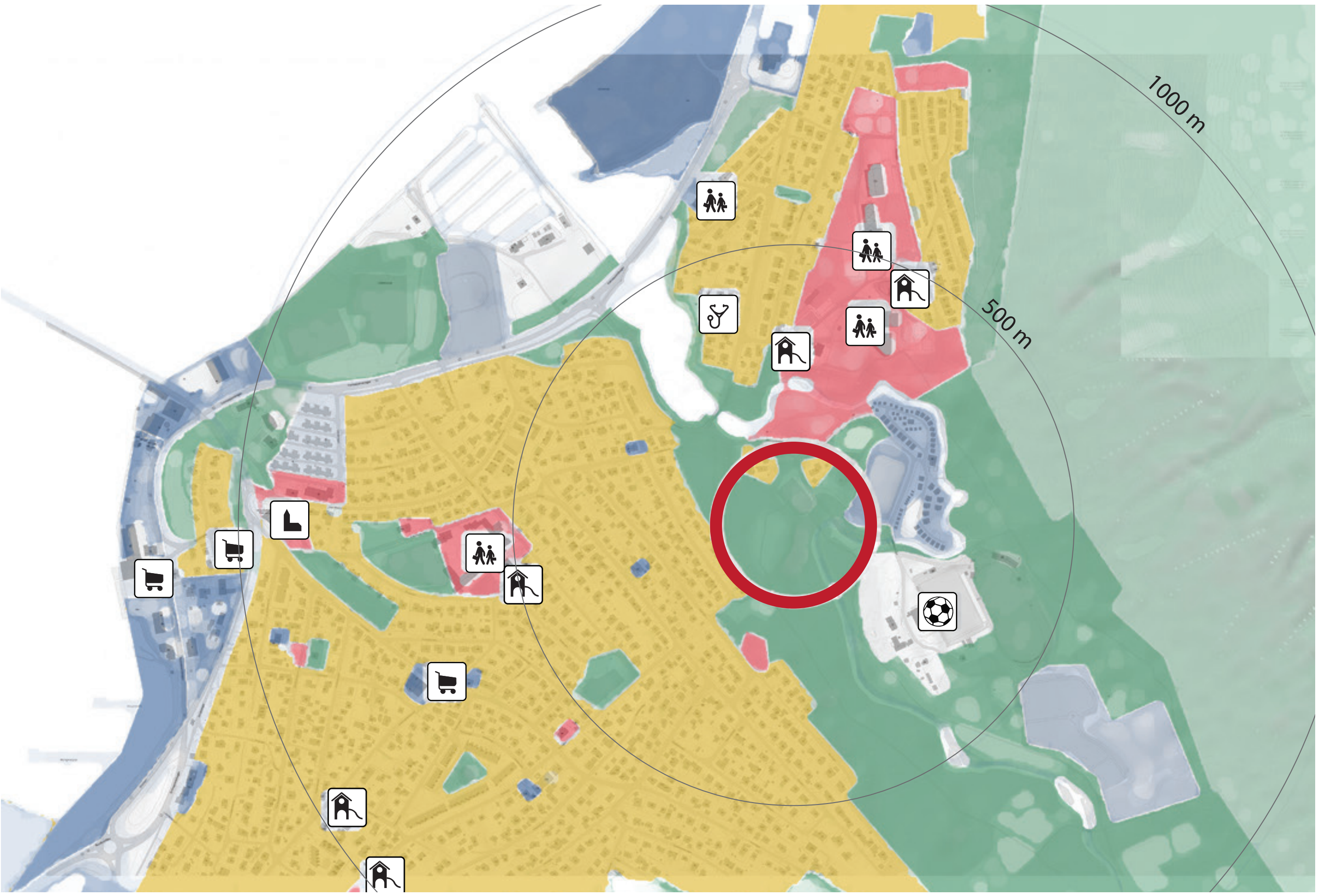
Tromsdalstinden (Northern Sámi: Sálašoaivi or Sálašcohkka) is situated on the southern end of the Tromsdalen valley and is also of great importance to to the Sámi people. The Sámi claimed that the mountain is sacred for their people since ancient times, although they don't practice classic Sámi religion any more.
(En.wikipedia.org, 2017)

The site location is accessible from the city center from the Elvestrandvegen streent, while it is also reachable from the residential by the pedestrian hiking trails. The site is approximately 8.500m2 in size, placed on the clear plot surrounded by medium size vegetation around.

▼ *Illustration 38.1.*
Site location

▲ *Illustration 39.1.*
Site photo

SITE MAPPINGS



▲ *Illustration 40.1.*
Function map
(adjusted, Tromsø kommune)

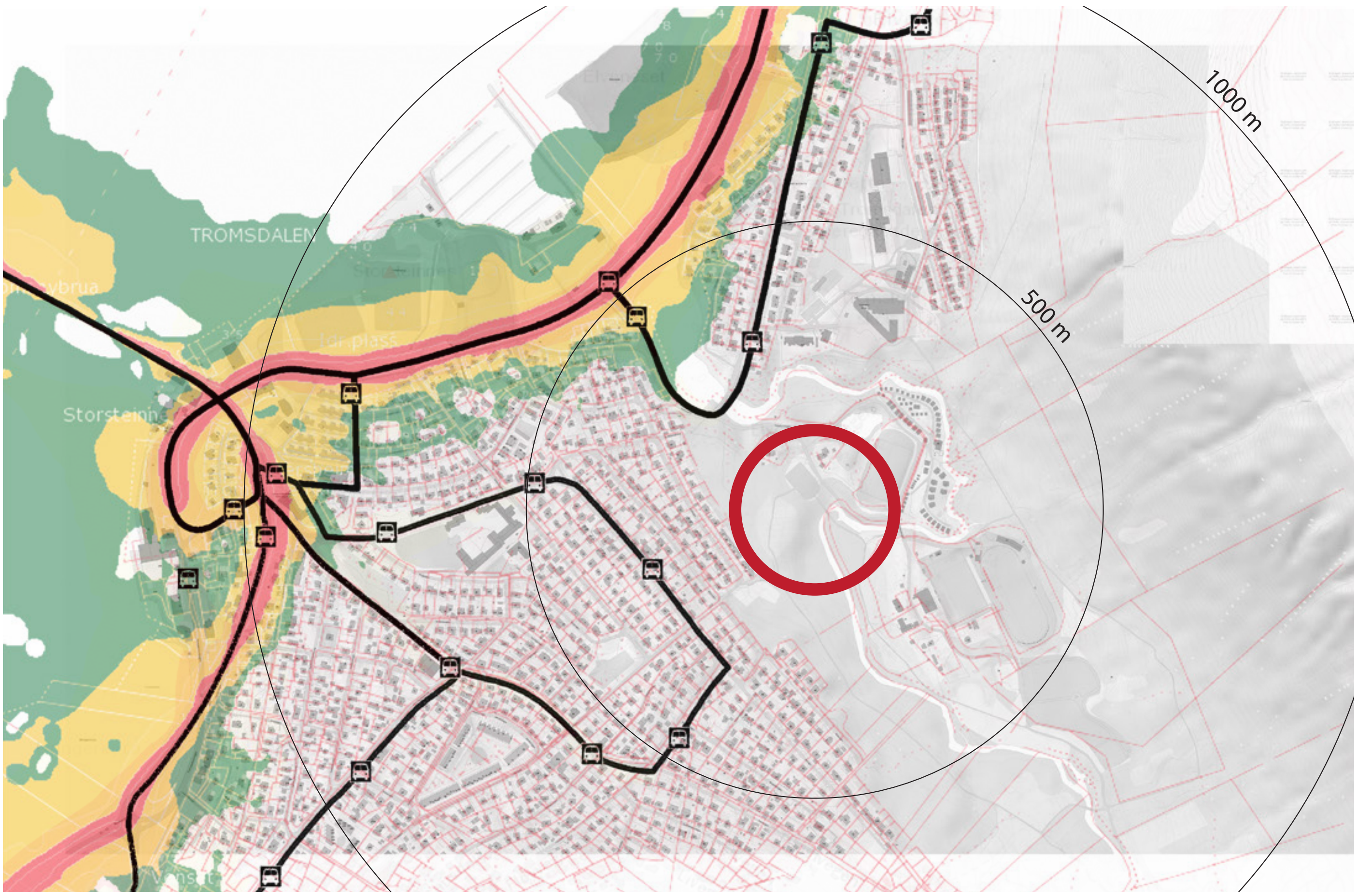
Functions

The area is on the borderline between urban and natural districts, with numerous activites and possibilities towards both directions. There are residential areas, schools, services towards West and North. The Tromsø Bridge is just 10 minutes of walk away, so the city center is easily reachable. There is camping site and sport facilities in Eastern and Spouthern directions, and evidently the green corridor towards the woods of valley of Tromsdalselva and the hill of Nordfjellet.

- Chosen site for Sámi Kindergarten

- Residential area
- Public and private services
- Business and shopping
- Nature and free time

- Kindergarten
- School
- Shopping
- Church
- Doctor
- Sport



▲ *Illustration 39.1.*
Traffic and noise map
(adjusted, Tromsø kommune)

Chosen site for Sámi Kindergarten

50-55 dB area

55-65 dB area

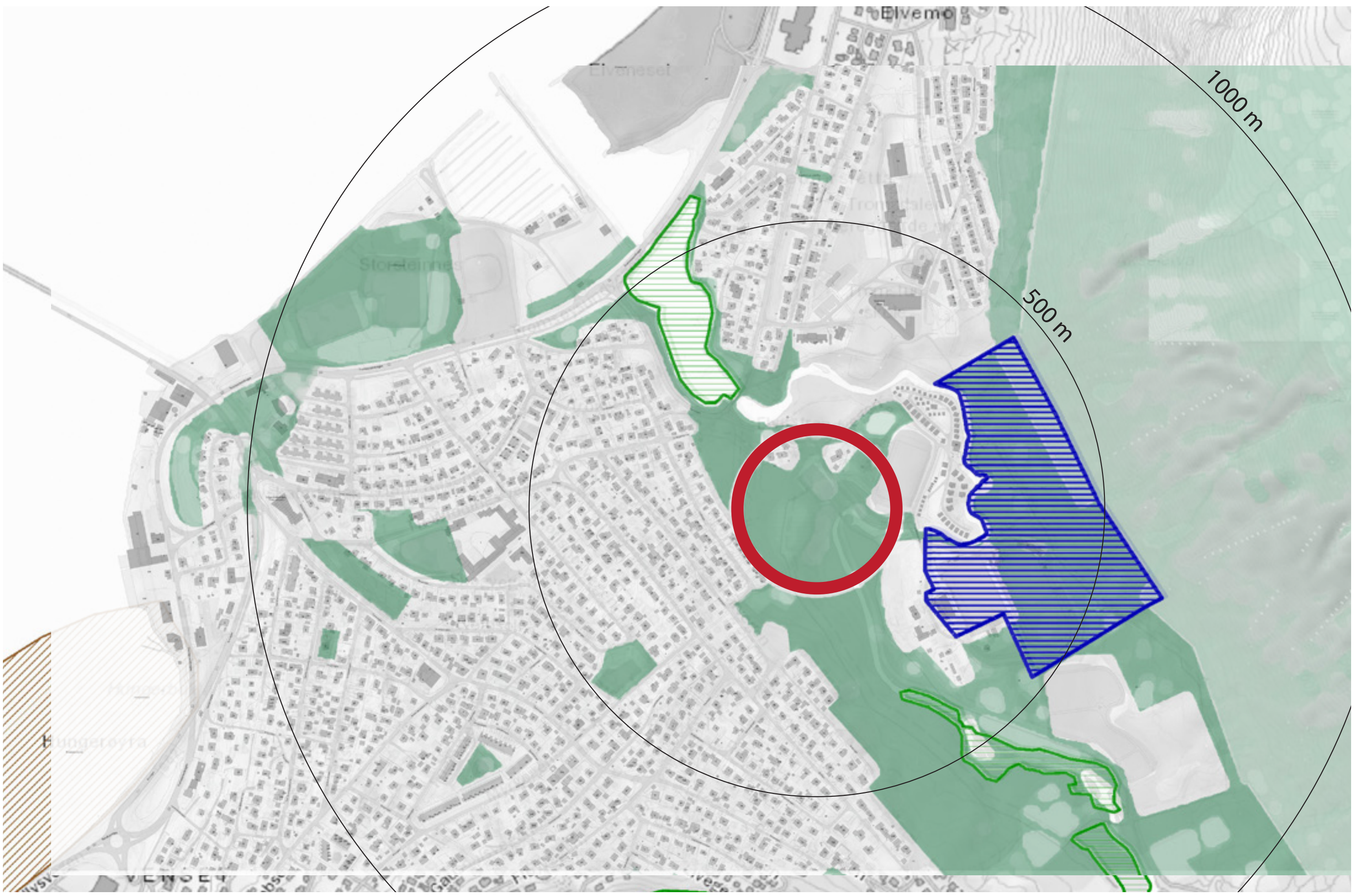
65-75 dB area

Local bus lines with stations

Traffic and noise

The site is well connected with the city center by the public transport. The closest bus station is 300 meters far from the site.

The biggest noise factor in the area is the airport. The kidnergarten site is in significant distance from the airport and the intense trrafic roads, sitting in the noise-free zone that is >50dB. (Illustration 41.1).



Vegetation and green zones

Chosen site for Sámi Kindergarten

General green area

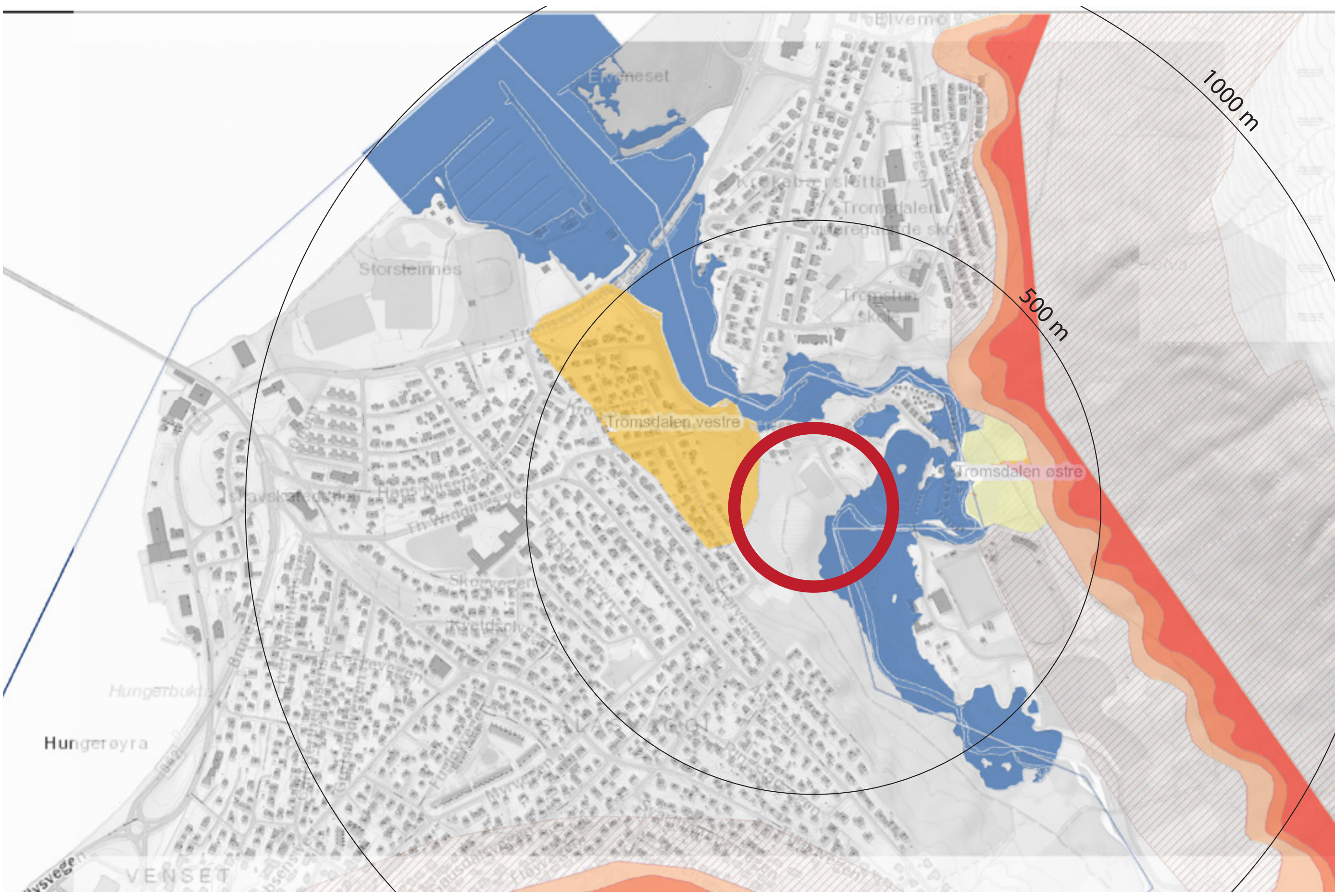
Protected green area

Leisure area

▲ *Illustration 42.1.*
Vegetation map
(adjusted,Tromsø kommune)

The vast green area is starting from the site location and spreading towards the Tromsdalstinden mountain several kilometers on the South-east. The green zones are divided into protected green areas, vegetation areas and leisure areas that include camping or other activities. From the site location there are numerous paths up to the hill of Nordfjellet, and hiking trails to the Tromsdalstinden mountain.

The vegetation areas around the site are consisting mostly of birch (Betula pubescens), which is also the most common tree species in Norway. The other significant species are also the Norway spruce (Picea abies) and Scots pine (Pinus sylvestris). Norway spruce is also economically the most valuable tree species. Due to its good properties, it is commonly used as a construction material for buildings. (Sciencenordic.com, 2013)



▲ *Illustration 43.1.*
Hazard map
(adjusted, Tromsø kommune)

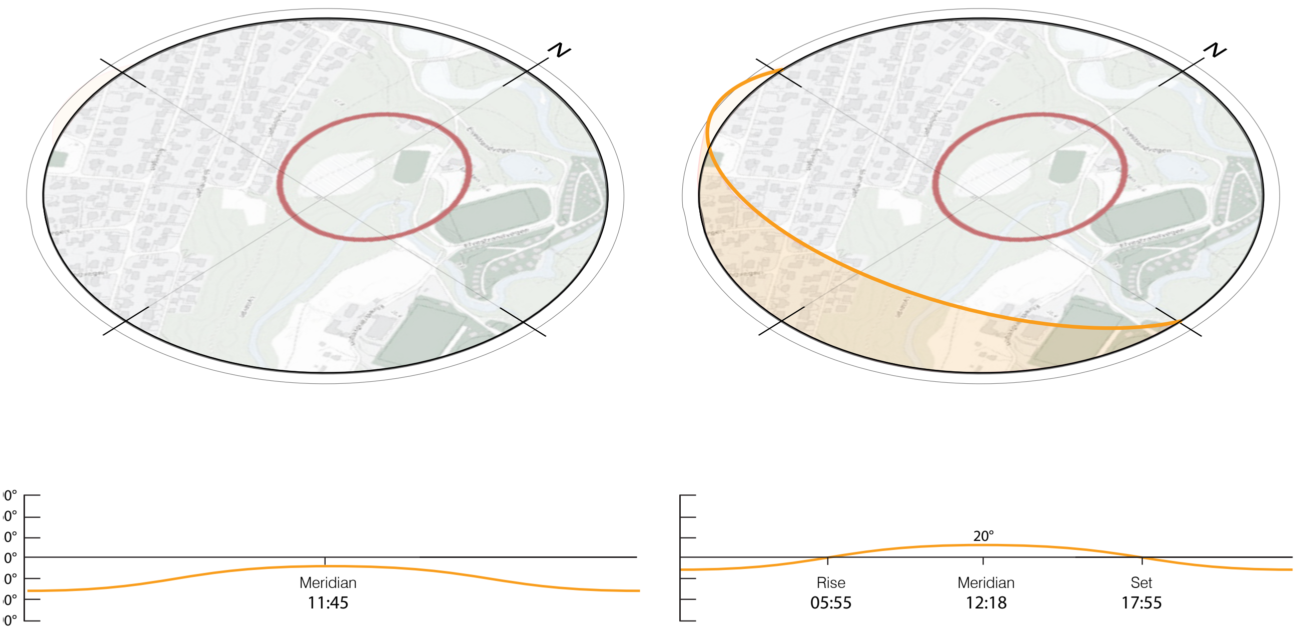
Chosen site for Sámi Kindergarten

Avalanche risk
Attention area
Flood risk
Quick clay

Hazard

The site is on an uplifted plateau, surrounded by a turn of the river Tromsdalelva. Its position gives protection against avalanaches and floods as well.

CLIMATE



▲ *Illustration 44.1.*
Sun path on the 21 June and 19th March

Sun and temerature

There are four relevant aspects of climate analysis: temperature, properties of Sun, wind and precipitation.

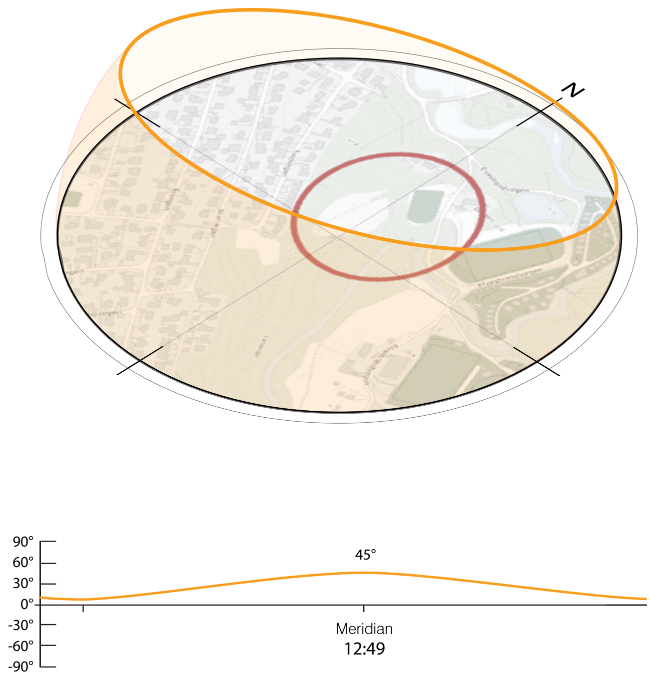
Tromsø lays 400 km to the North from the Arctic Circle which has a significant effect on sensing path of the Sun from the site.

There are several weeks in December, when it does not reach the horizon line (Illustration 45.1), causing a dusk-like "daylight" in the hours around noon. The darkness this time is usually overcame by artificial lighting, the highly reflective snow cover and the occasional moments of northern lights (Aurora borealis).

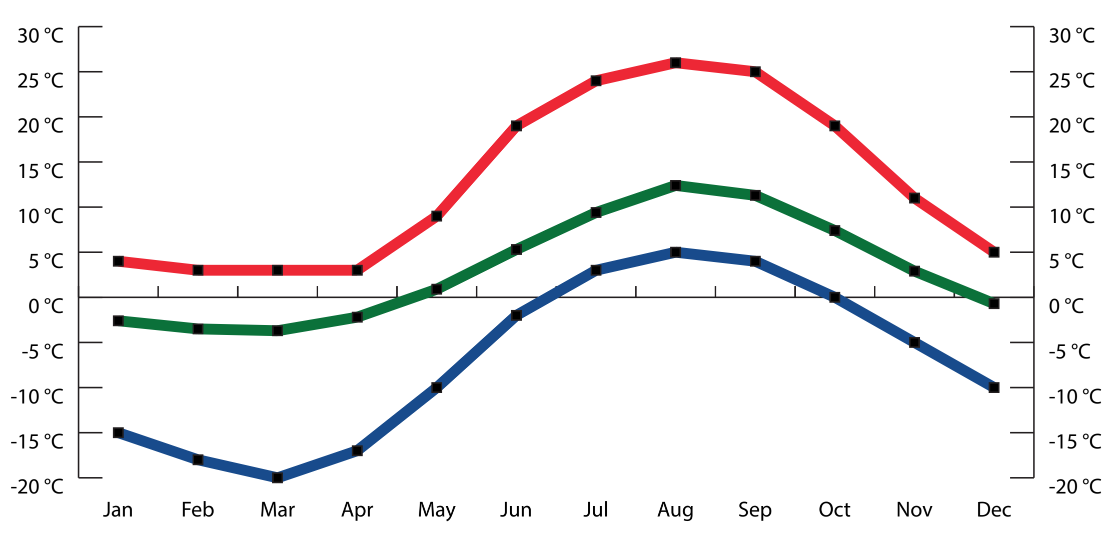
Conversely, during summer there is time when the Sun does not set at all, causing "midnight sun" for several weeks (Illustration 44.1). (Suncalc.org, 2017)

The temperature is milder than it would seem for this high latitude. It is because of the Gulf stream that is active around Norwegian see, making the coastal climate relatively mild, but there can be rapid changes during all year.

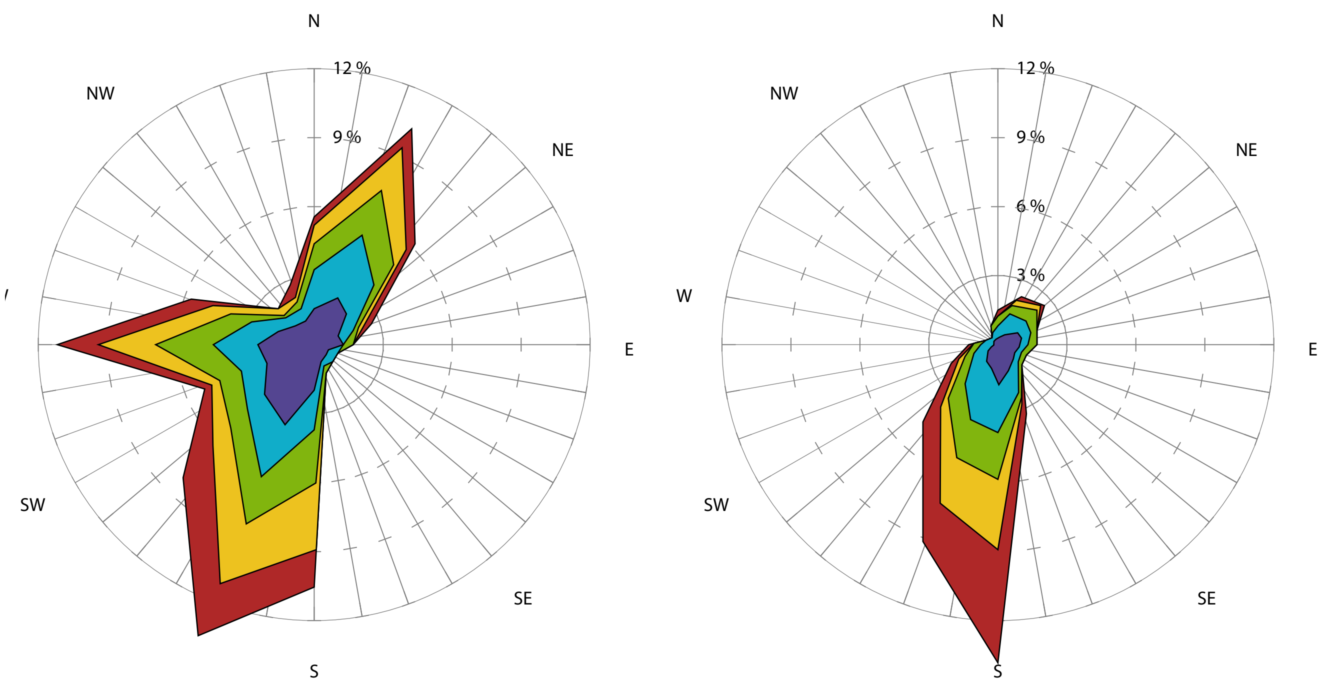
According to the mean daily temperatures, the coldest month is February (avr. -5 °C) and the warmest is July (avr. 14 °C). (Illustration 45.2)



▲ *Illustration 45.1.*
Sun path on 21st December



▲ *Illustration 45.2.*
Monthly temperatures for Tromsø

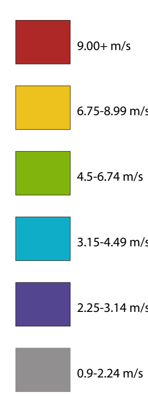


Wind

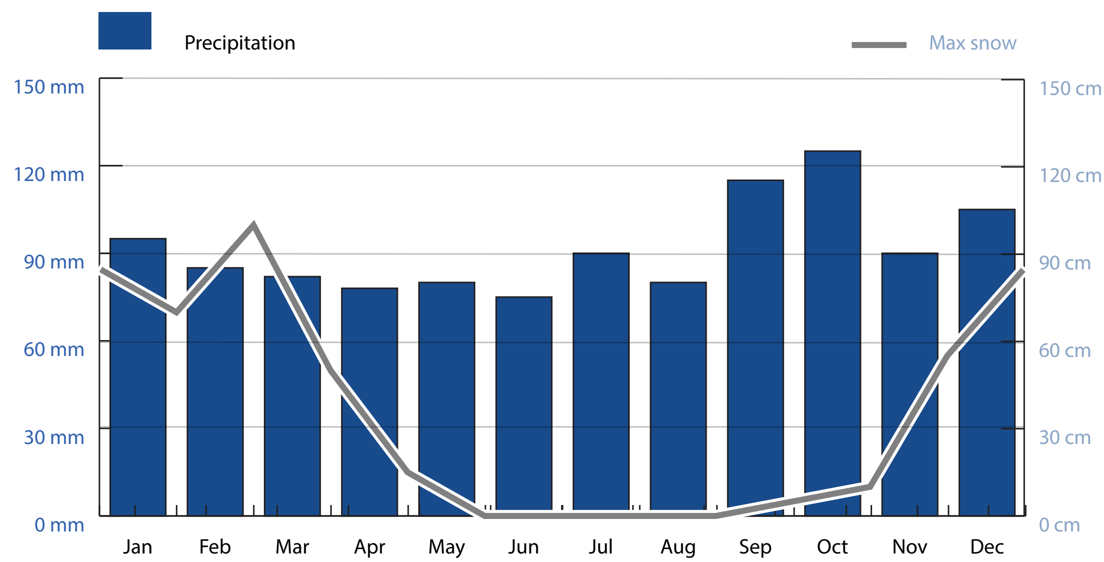
The dominant wind direction is from the South, usually reaching the category of breeze (9+ m/s) (Illustration 46.1).

In Summer the winds are more frequent and blowing from more directions, so except from the south, the West and the North are also common directions. This data provide more options and orientations for a design of natural ventilation system and the outdoor organization.

In Winter, the only dominant direction remains the the South which has to be taken into account, when designing outdoor activities for colder months in the year. (Byggforsk.no, 2017)



▲ *Illustration 46.1.*
Wind diagram for Summer and Winter season



▲ *Illustration 47.1.*
Precipitation and snow chart

Precipitation and snow

The precipitation level is generally high in each month, oscillating between 90-120 mm. (Illustration 47.1) This requires proper envelope to protect the buildings. The snow cover can reach 1 meter thickness during winter which can make an effect on the yearly schedule of building usage and on the construction as well.

SUMMARY

Tromsø is the biggest town of Northern Sápmi, a continuously growing urban area which is popular living place for many Sámi families as well. The municipality has created a well-detailed strategy plan to handle the changes of the next decades, however the needs for kindergarten age Sámi children are not emphasized in them.

After analyzing all the relevant maps of the city, related to the current and future density, noise and green areas, the district Tromsdalen was chosen as an optimal location for the project site. The new Sámi kindergarten is on an ideal and safe plot on the borderland between urban and natural areas with good connections both towards the city and the nature.

The climatic analyses on the site have shown the amount of Sun hours in different seasons, precipitation rates and wind intensity and dominant directions, which will be considered in several ways (lighting, structure and envelope, natural ventilation, site organization) during the design process.

► *Illustration 48.1.*
View on Tromsdalen

Sustainability

DIRECTIONS

Sustainable design of a building contain many aspects such as energy consumption, renewable resources, embodied energy of a materials, water and waste management and healthy indoor environment. Sustainability assessments should also include maintenance, longevity and adaptability, facilities management, social and economic issues related to whole life cycle of a building.

In order to “measure” and address sustainability, there are commonly used certifications that take into account the most relevant aspects of the sustainable design.
In Norway, there are two commonly used certification systems of sustainability - BREEAM NOR and FutureBuilt. But for this project, DGNB is chosen as a sustainability measurement, due to its adequate balance of social, economical and environmental aspects in consideration. (DGNB system Denmark, 2015) It is is an adopted system from Germany which is adopted for Danish standards.

This DGNB criteria should serve as a guidelines in the design process that are directly focused on energy demand, material consideration, indoor quality and healthy environment.

ENVIRONMENTAL QUALITY
1.1. Life cycle impact assessment
1.2. Local Environmental impact
2.1. Life cycle assessment Primary energy

ECONOMIC QUALITY
2.1. Flexibility and adaptability

SOCIAL QUALITY
1.1. Thermal comfort
1.2. Indoor air quality
1.4. Visual comfort
1.6. Quality of outdoor spaces

TECHNICAL QUALITY
1.3. Building envelope quality

PROCESS QUALITY
1.2. Integrated design

SITE QUALITY
1.1. Local environment
1.4. Access to amenities

◀*Illustration 51.1.*
Illustration about sustainability

ENERGY FRAMEWORK

The EU Energy Performance of Buildings Directive 2012 sets that every new building from 2020 and every new public building from 2018 shall be fulfill the nZEB (nearly Zero Energy Building) requirements. Norway was an active supporter in the creation of this directive, setting also its National Target aiming the same goal from 2020, however, Norway still hasn't defined nZEB causing several barriers in this field. (Energy performance of buildings, 2015)

Therefore, the current project will follow Danish Building regulations for the Building class 2020. For this class, the total building related energy demand should be below 20 kWh per year. In order to reach the Zero Energy standard, the building must reach energy neutrality on annually basis with passive solutions and renewable energy sources.

The Energy performance in buildings directive (European Parliament, 2010) described Zero Energy building as "A building that has a very high energy performance", but there are several definitions of Zero Energy Buildings, such as nearly ZEB, net ZEB and plus ZEB. The nearly ZEB buildings cover most of the energy demand from renewable sources and energy generation on site, but also from fossil based energy that is not totally counterbalanced by renewable sources.

The chosen definition for this project is the net ZEB, which can reach energy neutrality on annual basis with interaction between the electric grid and renewable energy sources. The goal is to cover all building related energy, but also the user related energy whish refers to appliances and equipment in the building.

▼ *Illustration 52.1.*
Illustration about sustainabile solutions

ENERGY IN NORWAY

▲ *Illustration 53.1.*
Contemporary hydropower plant in Norway.

In Norway, 98% of electricity production comes from renewable sources which are primarily hydropower, but there is also some amount from thermal energy and wind power.
(Goverment.no, 2016)

Because of its ratio of renewable energy, the Primary energy factor for Norway is much lower than in Denmark. The Primary energy factor (PEF) indicate the amount of energy that is required to provide one unit of energy to the user (Good, 2016). The data from 2010 show that PEF equals 1,19 for Norway, compared to 2,5 in Denmark where most of its electricity production comes from the fossil fuels.
(ADAPT Consulting, 2013)

According to prEN 15603 primary energy factors for renewable energy is 1 for grid electricity from hydropower plant, and 2 for PV electricity temporary exported and reimported later.
(prEN 15603, 2013)

Although there is still no decision in Norway about which factors to use (Good, 2016), from the available literature it was assumed for this project that the Primary energy factor for electricity would be 1 for the building class 2020, instead of 1,8 for Danish case.

Heating

Because of its high production of electricity from hydropower plants, it is common in Norway to use electrical heating. The district heating is not that common, and it is not accessible everywhere. The district heating in Tromsø is currently being built and it will continue for the next 15 years (Itromso.no (2016) Having that in mind, it seems logical to use electricity as a main source of heat for this project.

INDOOR ENVIRONMENT

The Danish regulations BR15 and the Norwegian TEK10 has numerous equivalent regulations about indoor environment. To achieve a healthy and comfortable indoor environment several aspect have to be considered such as: the daylight factor in living spaces, keeping the pollution ratio under recommended values, achieving recommended temperatures in order to have thermal comfort and application of healthy materials.

In winter days there is no sunlight in the Tromsø area, so important considerations should be given to a design of the artificial lightning.

The lack of direct sunlight influences human behaviour and serotonin levels, but there is a method of using light therapy for everyday use. In the case of a kindergarten, the artificial lights which imitate the white lightwaves of Sun and can substitute natural lighting.
(TheLocal.se 2014)

The requirements for thermal comfort and air quality are defined in the regulations DS/EN 15251:2007 (Class II), and CR 1752:1998.

The calculations for indoor environment quality will be executed in BSim software for indoor quality.

THERMAL COMFORT	Summer: 21,5 - 25,5 °C
INDOOR AIR	Winter: 17,5 - 22,5 °C
QUALITY	CO_2: 500 above outside concentration
DAYLIGHT	DF preferebly about 5 %
ACOUSTIC	Reverberation 0.5. Noise from services: < 32 dB

▼ *Illustration 54.1.*
Built example about good indoor environment

MATERIAL CONSIDERATIONS

The building sector is responsible for 30% of the world's greenhouse emissions and 40% of total energy use (United Nations Environment Programme, 2009). However, the strict building regulations in Denmark have resulted in more energy-efficient buildings (Kleis, B. 2014), so the energy use for the operation of the buildings have been significantly decreased compared to energy use for materials which remained the same (Ill. x.x). For this reason, the choice of the materials, their embodied energy and a life cycle have significant share of the total environmental impact of the building.

When addressing the theme of sustainability in materials there are more aspects for consideration such as: local availability, embodied energy of raw materials, energy required to recycle/ upcycle materials, expected lifetime of a material, technical performance, thermal mass or how much waste is a result of material production. (Sustainia, 2015)

The estimation of a total environmental impact of a building through its lifetime can be provided by Life cycle
impact assessment of a DGNB scheme. (DGNB system Denmark, 2015)

Life cycle assessment of buildings takes into account embodied energy of material production, construction, maintenance, demolition, removal and disposal of a building and these are all aspects to be considered during the design process. (Steen Larsen, T. 2016)

▲ *Illustration 55.1.*
Illustration for recycling

SUMMARY

The sustainable approaches should be considered at the beginning of the design process in order to reach the Zero Energy standard. In order to reach energy neutrality, passive and active solutions has to be taken into consideration.

There are several indoor criteria to reach, regarding thermal comfort, air quality, and the use of artificial and natural lighting. The materials will be considered fro Life cycle analysis, prioritizing the most sustainable solutions and combinations.

The design parameters should include all required data for optimal building performance and minimal environmental impact. The DGBB criteria will serve as a guidelines in the design process that will include energy standard for net Zero Energy Building, optimal indoor environment, and sustainable material use.

▼ *Illustration 56.1.*
Towards the bright future

SUMMARY OF ANALYSES

The analysis and studies are crucial part for the program theme of the project. The basic research of the users and location are base for a problem formulation and start of a design process. Collected data, maps and graphs are used to define the main design criteria for the Sámi forest kindergarten in terms of functional, technical and aesthetic aspects. The program starts with introducing the users, their history and culture and why is it important to design a kindergarten for Sámi children. The essence of their culture is in their language, which they can learn and strengthen in a Sámi kindergarten as a children. The demand for the Sámi kindergarten is quite high in the Northern Norway, since it is the only opportunity for Sámi children to learn and preserve their ways.

The point of departure in the problem is forest kindergarten concept that uses outdoor space as a learning environment. The outdoor learning methods have been shown to improve children's health, skills and learning abilities, especially the language development in small children.

The location for the project is city of Tromsø, which is the largest urban area in the northern Norway. There are a lot of Sámi people living and studying in the area, so the need for educational institutions is constantly growing with the interest in Sámi culture and language.

The site location was chosen based on several criterias such as access to forest, proximity to growing residential area and connections to the city infrastructures. Since the noise pollution is high on the main island of Tromsø due to the airport placement, the location of the kindergarten is placed outside that area. The proximity of flooding area and existing vegetation will determine the final placement of the building on the site.

There are also climate studies that have to be taken into account when considering orientation, views, amount of daylight, and energy performance. In order to reach net Zero Energy Standard, the energy demand of the building must be below 20kWh per year, which can be reached by applying passive solutions, such as passive heating and natural ventilation. The remained energy demand should be covered with renewable energy sources so it is important to include them in the design process.

This accumulated knowledge and information are crucial for proper understanding of the site context which ensures that the design proposal will correspond to the user's needs. The architectural proposal should respect the surrounding context and create healthy sustainable living environment.

► *Illustration x.x.*
Fagerborg kindergarten, 2010
Reiulf Ramstad Arkitekter

Design criteria

FUNCTIONAL

- Use the Forest Kindergarten approach both indoors and outdoors

INDOOR ENVIRONMENT

- Kindergarten capacity for up to 60 children
- Organization by two age groups: 1-3 years old and 3-6 years old, with ratio ~1:2
- All children have to have access both to "dirty" cloakroom and an inner cloakroom
- Spacious common hall as meeting point and alternative playing area prolonging the season. It shall be preferably unheated.
- Provide indoor areas for play, creative work (workshops for different kinds of duodji) and integrated quiet reading corners, too
- Logical connection of indoor spaces, following the seasonal flow.
- Smooth transition between indoor and outdoor areas
- Provide outdoor sleeping area, preferably for the small age group

OUTDOOR AREA

- Natural and spacious outdoor play area for all age groups, ~2500 m2
- Protected outdoor areas for playing, eating, storing, etc., incl. fire pit with a roof for warming up and cooking
- Area for digging with sand or soil
- Shed for the tools and vehicles (bikes, skis, sledges...)
- Examples of traditional Sámi architecture (lávvu, goahti) for education and play
- Turf and grassed earth surfaces for climbing integrated in the buildings

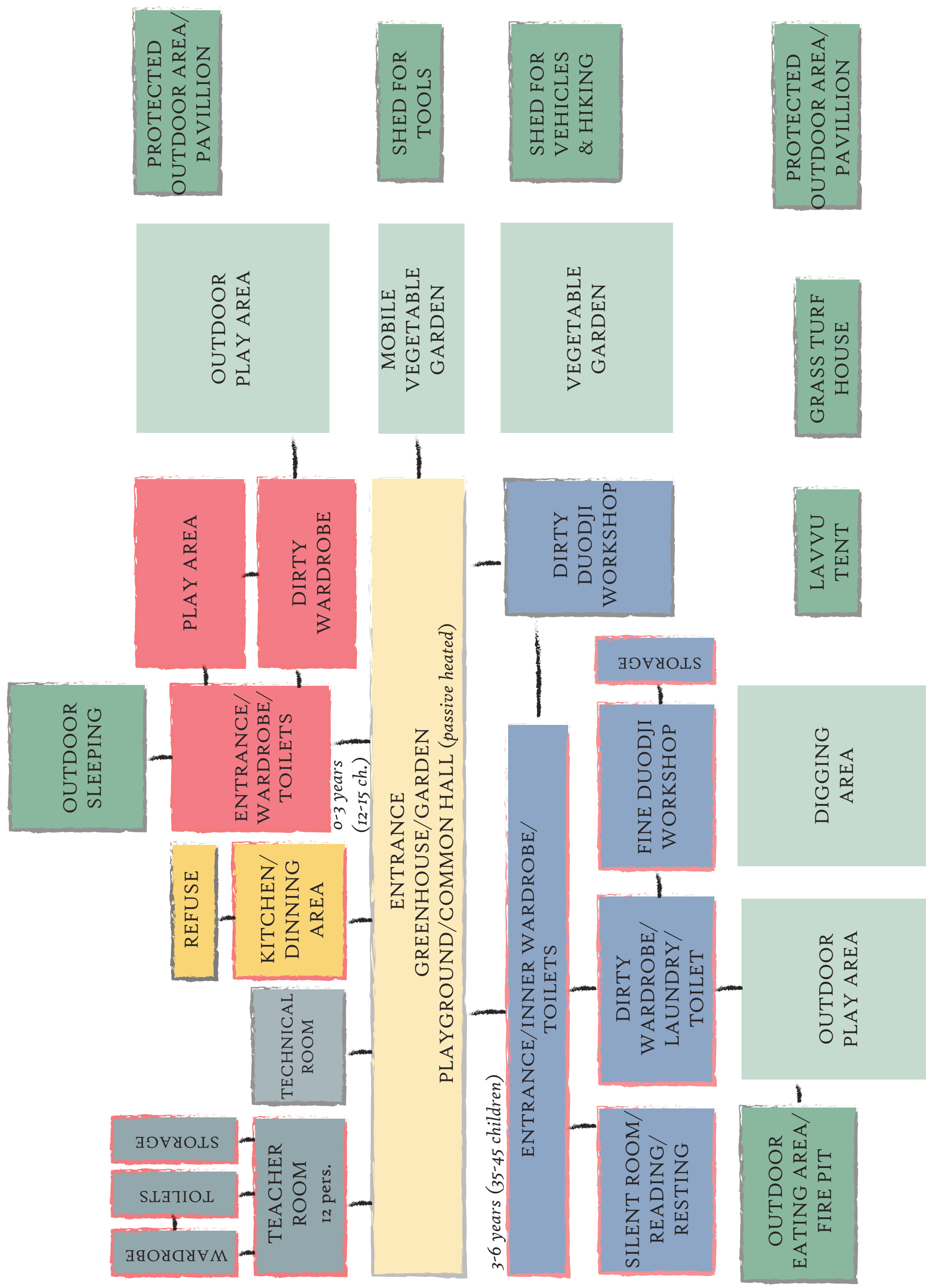
TECHNICAL

- Consider precipitation (rain + snow) effect in relation to envelops and loadbearing
- Pursuing for reaching the optimal solar radiation
- Meet the requirements for Zero Energy Building on an annual basis, with connection to the grid (netZEB)
- Meet the demands for healthy indoor environment for the children:
indoor air temperature 22 C in frequented spaces, 15 C in secondary heated spaces
air quality 800 ppm above outdoor CO_2 level
ventilation: considering natural ventilation during summer
daylight factor min 3% in frequented spaces, min 2% in secondary spaces
acoustics: max Rb = 0.5 sec, max L = 26 dB
- Use of local and sustainable materials
- Consider light therapy lightning during winter

AESTHETIC

- External appearance in relation to natural environment and context
- Considering the examples of traditional Sámi architecture and materials
- Child-centered design of indoor and outdoor spaces, considering material and colors

Function diagram



Room program

	function	*area*	*therm*	*DF*
1	common hall // greenhouse	200 m2	non-heated	min 3%
2	teachers office (12 pers, temporary)	16 m2	20°C	min 2%
3	teachers' wardrobe	7 m2	20°C	
4	teachers' storage	7 m2	20°C	
5	teachers' toilet	4 m2	20°C	
6	technical room	30 m2	non-heated	
7	kitchen / dining hall	50 m2	20°C	min 3%
8	refuse	7 m2	non-heated	
9	entrance / inner wardrobe / storage	20 m2	20°C	min 2%
10	dirty wardrobe / laundy / toilet	25 m2	20°C	min 2%
11	play area for smalls (15 children)	40 m2	20°C	min 3%
12	entrance / inner wardrobe / storage	30 m2	20°C	min 2%
13	dirty wardrobe / laundy / toilet	50 m2	20°C	min 2%
14	silent area for bigs (45 children)	60 m2	20°C	min 3%
15	fine duodji workshop	30 m2	20°C	min 3%
16	dirty duodji workshop	50 m2	18°C	min 3%
17	storage	10 m2	18°C	
18	outdoor pavilions	20 m2	non-heated	
19	shed for tools, ski eq., vehicle	20 m2	non-heated	
20	sami buildings	20 m2	non-heated	
21	playgrounds	2000 m2	-	
22	sandboxes	300 m2	-	
23	vegetables	200 m2	-	

Vision

The vision of this project is to enhance the possibility for a safe place where Sámi children can learn, play and get educated on their mother's tongue and traditional culture, without the interference by other languages. Using the forest kindergarten approach, they can learn how to be curious and what are their connections to the nature. In a Zero Energy complex on the edge of modern Tromsø which is following the traditional Arctic dwellings but in the same time shows example in sustainability and zero energy. A place where they can 'understand themselves, their culture, and others' culture, too.'

Problem formulation

How can a kindergarten design be enhanced with forest kindergarten approach?

How can outdoor learning concept enable Sami children to learn their language and preserve their culture in the modern society?

Can the use of local and sustainable materials and traditional architecture help Sami people to feel more connected with their identity in the building?

Which strategies can be possible solutions to reach Zero Energy level?

How can Integrated Design Process help solving all the architectural, engineering and social issues?

Presentation

The following chapter is containing the final design of the Sámi forest kindergarten in Tromsø. The Presentation include the Context, Concept, and then outdoor and indoor areas with floor plants and spatial views. The drawings of the sections help to understand the context connections and spatial experience in the area. The chapter also contains technical part about sustainable performance of the building and results for the Zero energy building standard.

Context

The site of the kindergarten is located between the residential area and the mountain with vast green area towards North and East. The area around the kindergarten is observed as a Base Zone, with a shelter and safe area for the children. The border of the Base Zone is not a physical barrier, but it is defined between the teachers and the children. This is the area where they can be without a strict supervision; where they can run, play and explore everything with the freedom inside the borderlines.

Away from the Base Zone there are forest trails towards the Tromsdalstinden, the sacred mountain for Sámi people. The forest area around is also meant to be the activity area for the children, so it is defined in several distance zones which can be visited only with adult supervision:

Zone 1 and 2 are around 300 - 600 meters meters away from the Base Zone. These are stations on the forest trail along the Tromsdalselva river where children can learn and explore about the flora and fauna of the forest.

Zone 3 is within 300 meters away, at the coast of a nearby lake where the children can drive on the boat and swimming during summer and ice skating during winter.

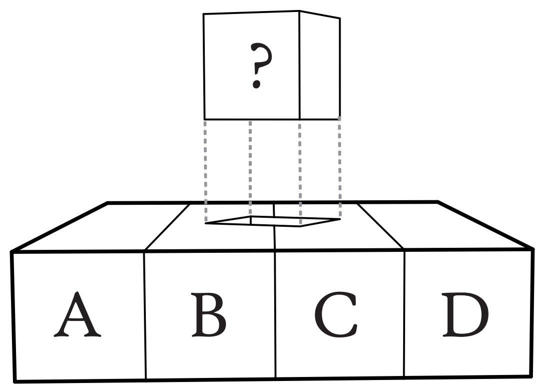
Zone 4 and 5 are 600 - 800 meters away from the Base Zone. The pathways up to the hill Nordfjellet are starting from these points, so these trails are more demanding but ideal for the bigger children to start hiking and use nature for physical activity.

► *Illustration 67.1.*
Context map

ZONE 3
300m
ZONE 4
600m
BASE
ZONE
ZONE 1
300m
ZONE 5
800m
ZONE 2
600m
0 0.05 0.1 0.2 km

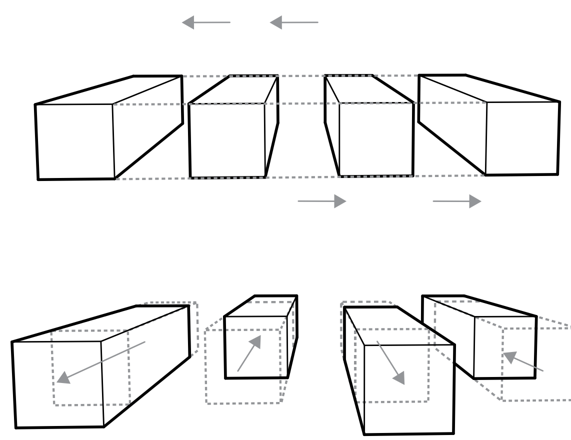
Concept

The shelter



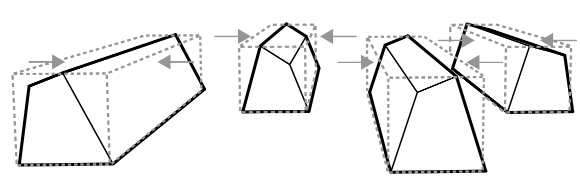
The concept has developed from the idea of a shelter, that is required for the children playing outdoors all day. The shelter should be donwnscaled to minimum needs that are required for rest, recovery, creative work or reading. The building volume developed from one compact geometry to four smaller units that are adjusted for the user groups.

Scattering



The compact building is divided into four smaller units in relation to its user groups. The distance between the building should provide sufficient amount of light to each wing of the building and open the composition towards the landscape. The in-between spaces are getting shorter by shifting the units and creating the outdoor hubs for external activities such as playgrounds, digging areas, vegetable garden and common areas.

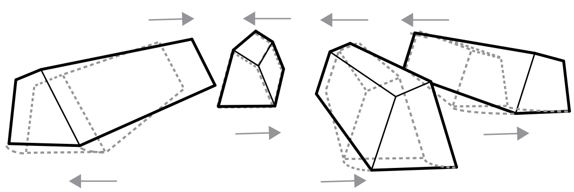
Adjusting to the climate



The cross section of units is formed after experiencing different solutions in relation to climate and function. The final forms are providing solutions to the challenges of winter snow, rain and solar conditions, while offering sufficient indoor space as well. The 60 and 75° inclined walls are optimal in relation to solar radiation and dealing with the snow, while it still lets enough usable space in the interior. Beside functionality, it was important to give character to each unit which would be recognizable to its users.

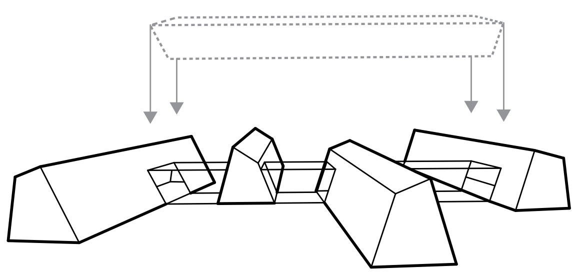
▲ *Illustration 68.1./A-E*
Concept diagrams

Adjusting to the lanscape



Horizontal rotation of the different units formed the fine organization of outdoor activities, creating outdoor hubs with different functions such as main entrance, garden, digging and crafting areas. The angle of rotation also helps the building wings to reach the optimal form to receive the maximum solar radiation, regarding to the surrounding landscape.

Connecting the buildings



The way of connecting the units is a significant point in the design process. Beside the spatial communication between the units, it also has to deal with the hierarchy between its own form and the main buildings. In case of bad weather it would served as a sheltered outdoor area as well, while it is also an important transition zone between indoor and outdoor, and a way to connect all the units of the kindergarten to the overall context of the landscape.

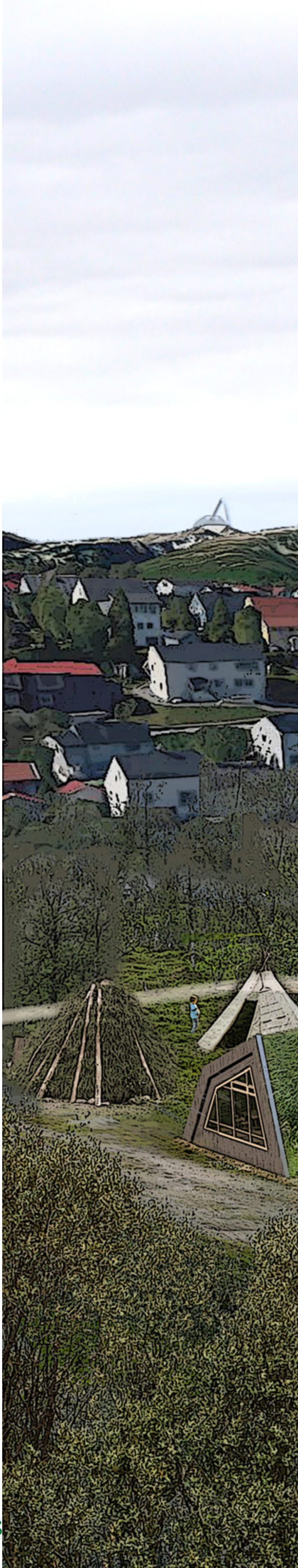
Outdoor spaces

The kindergarten creates a special connection between the urban and natural environment. The Base Zone is consisting of the kindergarten building complex and the site which is mostly natural and wild. The area also provides some facilities for different outdoor activities. Children can freely play, run and explore the whole area of the zone, towards the forest area in the surroundings.

The built facilities are organized around the main building complex and they give possibility to play and move but also to eat and rest outside.

There is a garden plot for summer plants and different examples of traditional Sámi buildings such as lávvu and goahti. These are helping the children to learn the about their roots and culture. The main buildings offer shelter to the users who might need interior spaces for resting, recovery, creative and silent activities in cases of bad weather.

► *Illustration 73.1.*
Aerial view from the east




border of Base Zone
PLAY AREA
play
zone
ACCESS from
the road to Kroken
N
V3
V1
towards the riverside
DIGGING
AREA
skovebutik
V2
DIGGING
AREA
vegetable
garden
tree
house
tools
lavvu
goahti
eating
shelter
towards the forest
at Tromsdalstinden
ACCESS from
Tromsdalen neigbourhood
border of Base Zone

Activities

In the outdoor area there are different small scale facilities to give space for different outdoor activities. It is important that these are simple structures made of local natural materials, but they need to have also a character that children can feel remarkable.

A small playground "welcomes" the arrivers from the northern side, with teeters, sliders, and columns. The small children's group have a separated area for play without bothering each other with the other groups. It is big digging area with some smaller sliders etc.

The nearby forest contains wooden playground constructions to play with, climb on, slide down etc. There are tiny shelters (Ill. 75.1/A) like "skovbutikken" and tree house, which are important locations of role play and presenting what they learn of the forest life.

The garden has raised beds for summer plants. Children can learn how plants "work" as they grow from seed to an entire organism. There are several mobile raised beds as well, and since the area is connected to a greenhouse, some plants can be saved during wintertime, too.

South from the complex, there is the big playing area with several playing tools for climbing, swinging, slide and sledge etc. Examples of traditional Sámi architecture, lávvu and goahti can be used as shelters for more people, too, just like the bigger pavilion to contain the whole group to eat together (Illustration 75.1).

▲ *Illustration 75.1.* /A-D
Outdoor facilities

◀ *Illustration 74.1.*
Master plan

Indoor spaces

Approaching the shelter

The complex can be reached primarily from North, where a big parking lot welcomes the cars from Elvestrandvegen. After leaving the car, there is a ca. 50 meters path to reach the main entrance. It is possible to arrive from the residential area of district Tromsdalen, a small passengers path leads from Southern direction. Visitors can directly reach the bigger children's wardrobe from here, as well.

The entrance

The main entrance is an open-air shelter at the central part of the complex. By arriving, visitors passing by a small fire place which can accept 20 people to sit and warm up at. This room is a direct interpretation of the Arran in the traditional Sámi buildings; entering the dwelling, you are facing with the spirit of fire at first.

► *Illustration 78.1.*
The entrance

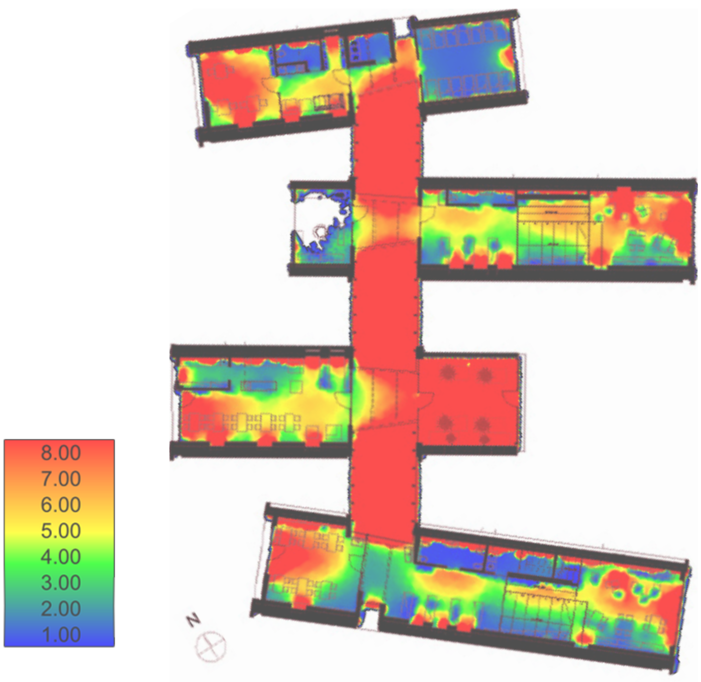
Building D: staff office (D1), rest and kitchen (D2), toilet (D3), technical room (D4), sleeping shelter (D5)
Building C: main entrance (C1), dirty wardrobe (C2), toilets (C3), fine wardrobe and stairs (C4), group room (C5)
Building B: kitchen and storage (B1), dining/common space (B2), greenhouse (B3)
Building A: dirty workshop (A1), dirty wardrobe (A2), toilets (A3), fine wardrobe and stairs (A4), laundry (A5), duodji workshop (A6)

THE BUILDING COMPLEX

The four wings of the building complex contain the different user groups. Each unit has its own wardrobe and toilets, following the simple indoor organization of mountain cabins. The southernmost unit, Building A is for homing the bigger children. Building B has a big and flexible common space for indoor playing and dining, and it is directly connected to the greenhouse and hence the outdoor garden. Building C, where the main entrance founds, is for the smaller children's group room. Building D is containing staff and technical rooms.

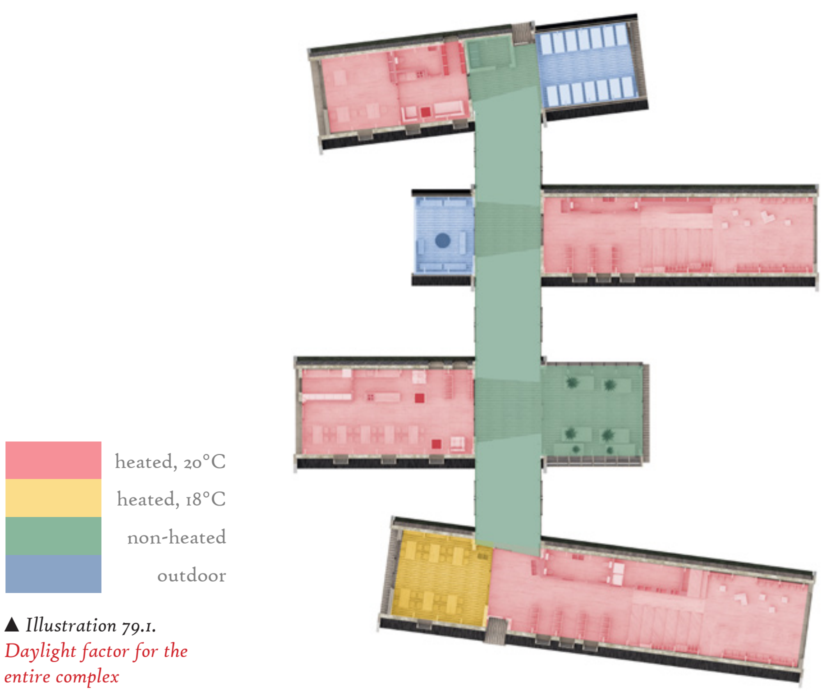
Daylight

By scattering the building units and using skylights, there is an enormous amount of daylight that can enter the building. Since half of the year has very restricted light conditions, it is important for each room to reach the minimum amount of daylight factor. The quality of daylight is determined by the skylights and the end wall's glazings, meanwhile smaller windows with sitting surfaces offer visual connection with the outdoor hubs. The quantitative properties of daylight are explained in the Sustainable chapter (site 111).



Indoor comfort

Kindergartens, compared to other public institutes, generally have less heating demand on the ground of higher amount of physical activities during daytime. Forest kindergartens have the speciality of free flowing between indoor and outdoor activities, which requires more flexibility by changing climate zones, which gives challenges regarded to air tightness and air change. The local Arctic climate also demands transition zones between indoor and outdoor spaces in case of colder weather. The quantitative properties of thermal and air quality properties are explained in the Sustainable chapter (site 104).



▲ *Illustration 79.1.*
Daylight factor for the entire complex

▲ *Illustration 79.2.*
Thermal zones

◀ *Illustration 78.1.*
Floor plan, 1:200

FUNCTIONAL ORGANISATION

The dirty wardrobe

The wardrobe system is basically the heart for a forest kindergarten. Dealing with rougher weather conditions, it is important to offer possibilities to switch between different layers of clothes. There are two wardrobes for each group. The one, called dirty wardrobe is for the outdoor layers of clothes, which are considered to be wore in harsher conditions. A laundry is connected to the wardrobe in order to clean the clothes. There is also a smaller, inner wardrobe between the dirty wardrobe and group rooms, for storing smaller pieces used for indoor usage

Dirty workshop

Both forest kindergarten users and Sámi children are encouraged to craft works with bigger responsibility, like carving and woodworking. The children are educated here to learn how to use saw, hammer and other crafting tools. This kind of art is extremely related to the forest world and what the children can learn from them, hence the dirty workshop is directly connected to the exterior pathway towards the southern forests. There is a digging area to give the creative freedom to the final products and combine the experiences in role plays.

► *Illustration 81.1.*
View from the dirty wardrobe to the duodji workshop


Sálmo

Duodji workshop

Duodji workshop is primarily for usual indoor creative works, drawing, painting, textile works etc. It also works as meeting point for the bigger children. The area is not separated by walls from the wardrobes, but raised vertically by 90 centimeters. The stairs to reach its level offers new perspectives for play, meanwhile focuses the end wall's view towards the Tromsdalstinden mountain. There is a 3rd level of activities as well, on the top of the toilets small nest to play and hide.
The group room for smaller children has the same principles of space like the big ones' fine workshop, with reduced dimension.

Reading/eating area

Building B offers a series of rooms related to activities with food. From the outdoor garden of summer plants, the flow leads through the greenhouse of winter plants and ends up in the eating room which is a bigger space with kitchen facilities and flexible usage common room, to eat, read, do art or play board games.

Greenhouse

Located in the direct continuity from the eating room, the greenhouse also works as a gate towards the outdoor gardens. Its position so trying to present the connection of spaces regarded to wood: Garden - Greenhouse - Kitchen.
Te greenhouse is also a place for prolonging the warmer season for gardening, using smaller raised beds on wheel to move the plants inside for the 2nd half of the year.

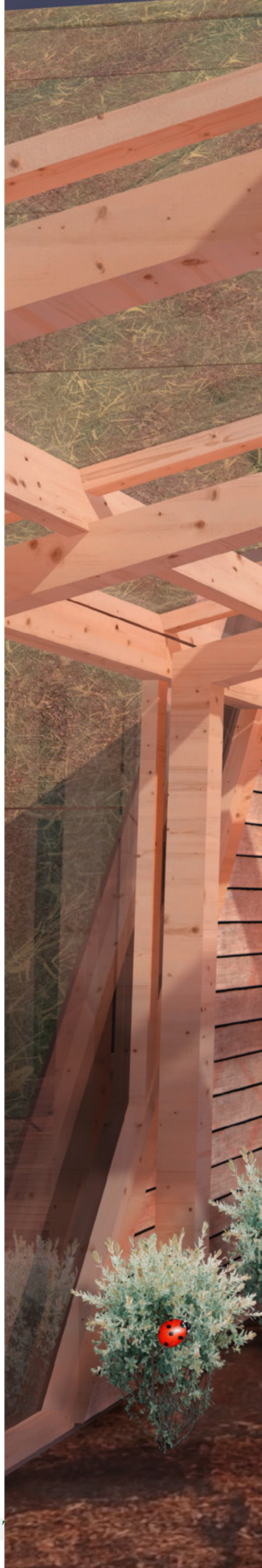
◀*Illustration 82.1*
View from the kitchen to the green house

THE PASSAGE

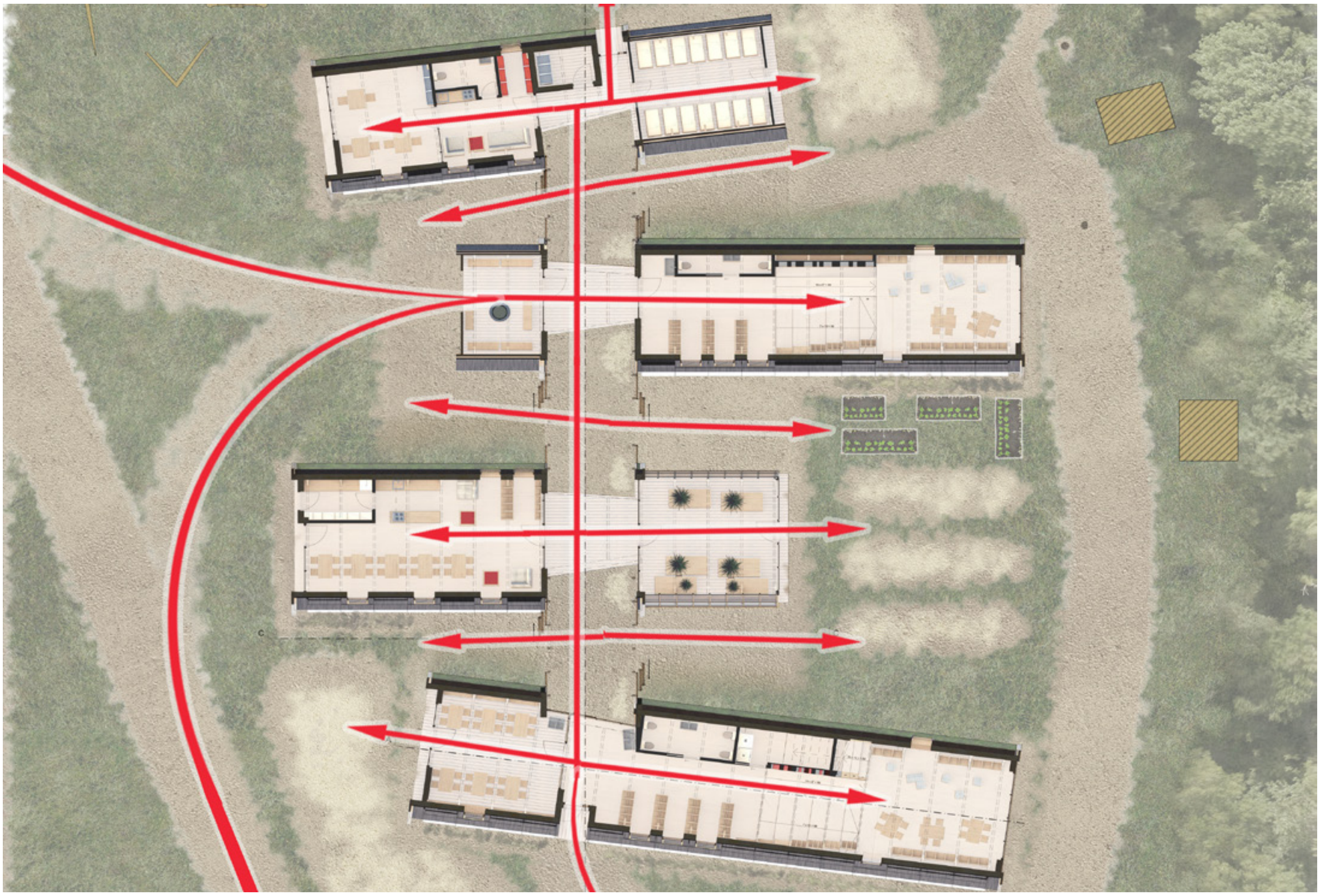
It was crucial to find such a solution to connect the four building units that doesn't interrupt the balance of indoor-outdoor transmissions, meanwhile offers enough value to integrate it functionally to the building program. The final solution of this glazed passage is a covered unheated area that interlinks the different departments without destroying their architectural appearance. The glazed surface provides transparency between indoor and outdoor. The flexible opening panels at each side give the opportunity to open it up completely during summertime. Meanwhile, during wintertime they offer a shelter against precipitation and wind, also, it functions as a windbreak before entering the main buildings. The planted greenery support the outdoor approach of the space, while the installable motion mesh helps the children have fun even in case of bad weather.

"The transition between indoor and outdoor area."

► *Illustration 85.1.*
View along the Passage, from south to north



SEASONAL FLOW



Summer season

During summer, the main activities are happening outdoors. The smaller children might spend more time inside or sleeping, but the bigger ones are considered to be out in the Base Zone or hiking to another Zone. The Passage is open up in this period, by sliding the doors to the side, encouraging the free flow between the buildings and letting use the outdoor hubs integrated: the different digging and motion areas, the garden and the shelters.

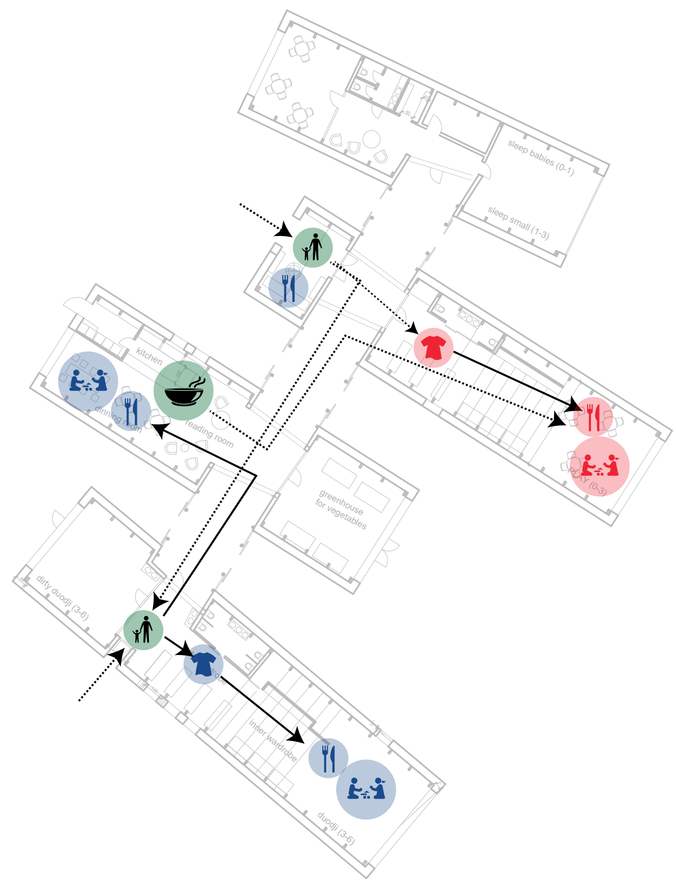
▲ *Illustration 86.1.*
Summer flow

Winter season

During winter the activities still considered to be taken mostly outside, but it is more expected that the daily program suddenly need to be taken indoors. The Passage is closed and offering a non-heated wind free and waterproof area. As prolonging the warmer season, children can play different games in the passage using the motion mesh. The gardening activities can be continued in the greenhouse, while the workshops are working as an extension of the group rooms.

▲ *Illustration 87.1.*
Winter flow

DAILY PROGRAME

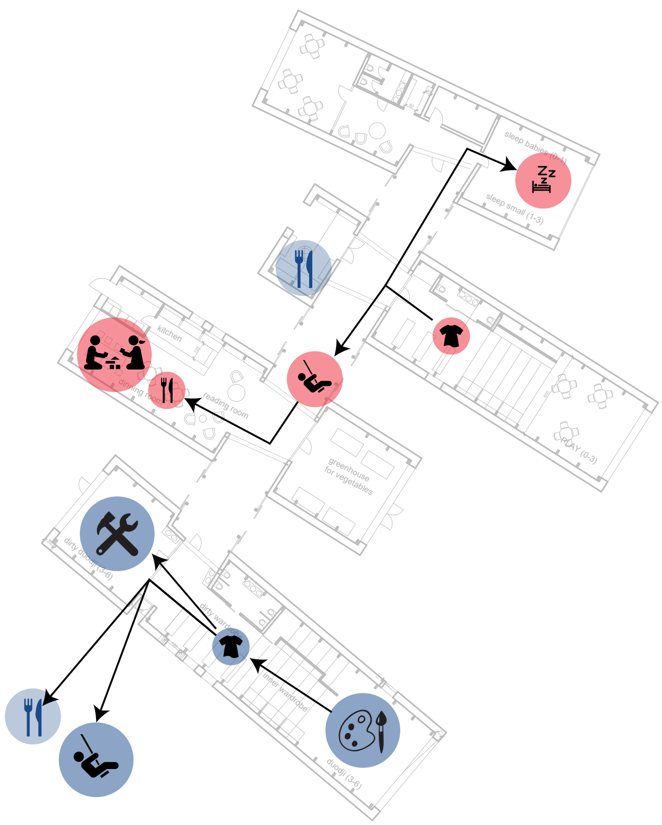


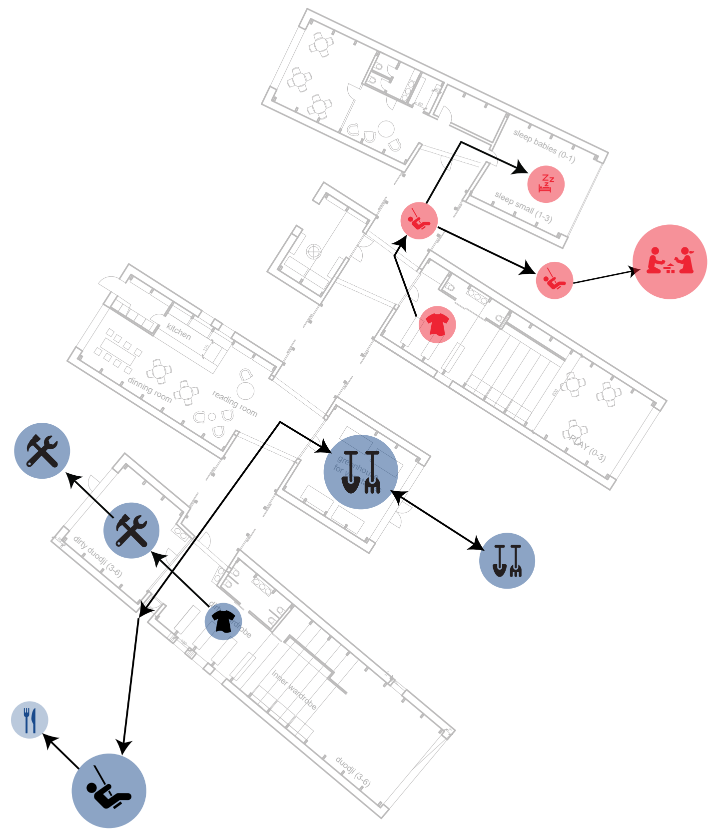
The challenge in a forest kindergarten project is to set the outdoor activities as main part of the daily schedule and to use the indoors only in the intermediate time. It follows, that setting the daily program is crucial for launching a kindergarten, where the several groups can have different demands of the commons rooms. The situation can be more difficult, the original plan shall be overwritten because of bad weather.

Morning acctivities

The complex follows the usual opening hours of the kindergartens: the gates are opened from 7:00, and the children arrive all by 9:00. The smaller ones can be directly taken to their group room in Building C, while the bigger ones can be left at the main entrance or their dirty wardrobe. The breakfast is eaten outside, or in case of bad weather in their group room. The smaller ones get the food from the kitchen carried on a trolley, the bigger ones can choose both workshops and the dining room for eating. Some groups can even use the fireplace around the main entrance.

▲► *Illustration 88.1*
Daily flow diagrams
Morning, midday, afternoon





Midday activities

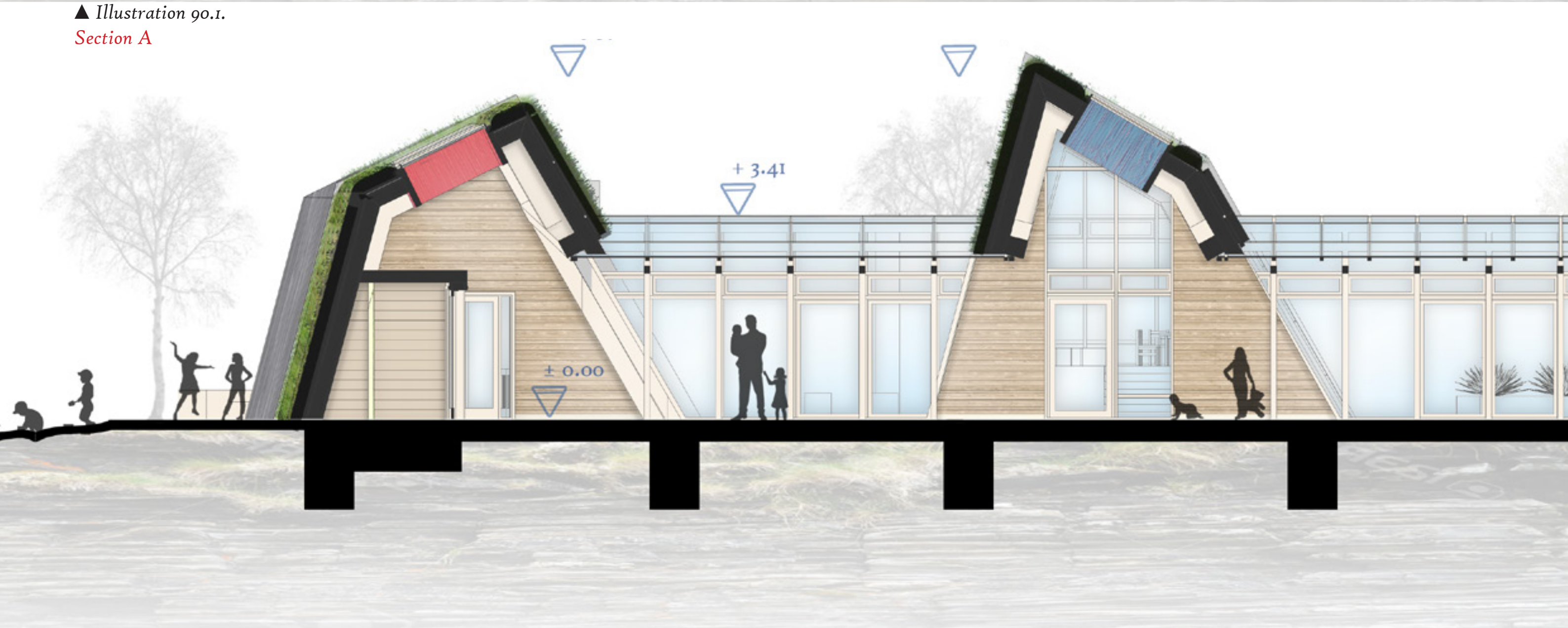
After breakfast the main activities are outside. The teachers' curriculum contains the general schedule for each month, but the exact weekly program is only done in the beginning of the actual week. During the day, they might leave the Base Zone to discover the external Zones in the nearby, or the groups might use both workshops for their projects. Meanwhile, the small ones might use the dining room to play games.

Afternoon acctivities

In the early afternoon, the smaller children usually have a nap. They can do this in their group room or in the non-heated shelter in Building D. Other ways they spend the afternoon outside at their playing area. The bigger children can do the activities regarded with the dirty workshop or outside ones like gardening.
The day closes at 17:00 when the parents take them back from the teachers.

SECTIONS 1:125

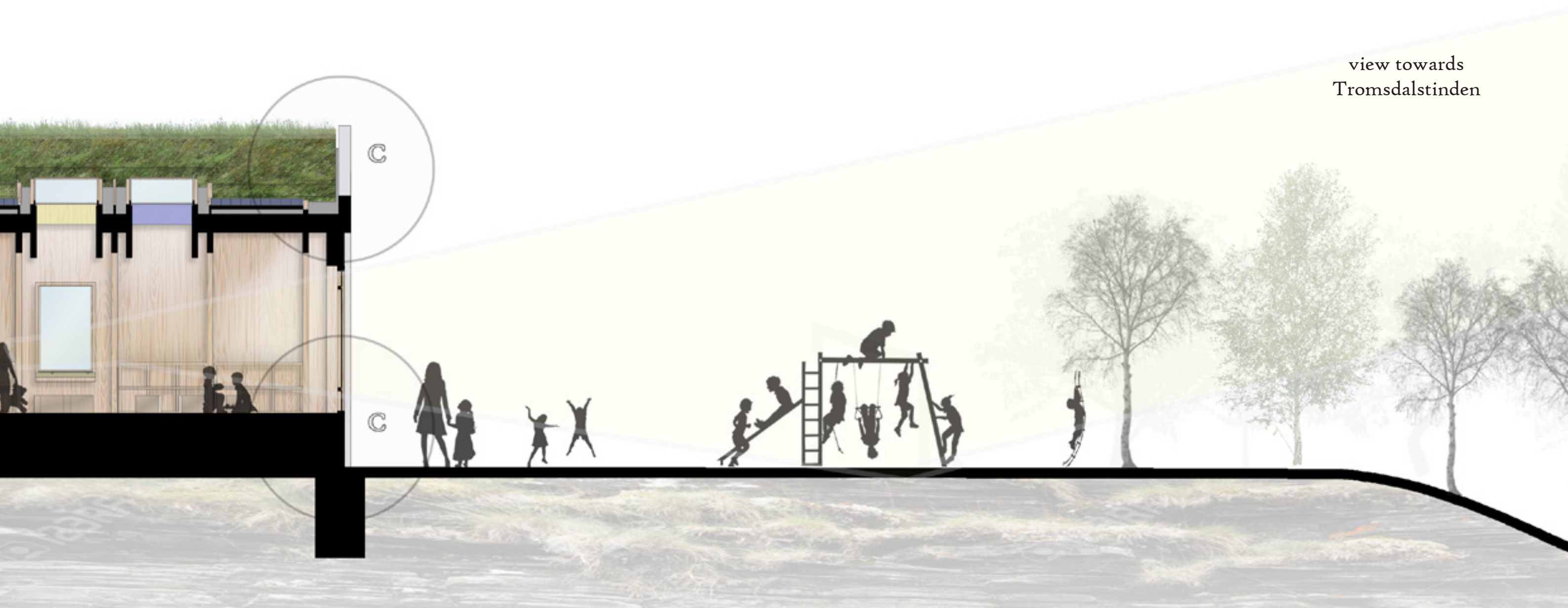
▲ *Illustration 90.1.*
Section A



▲ *Illustration 90.2.*
Section B

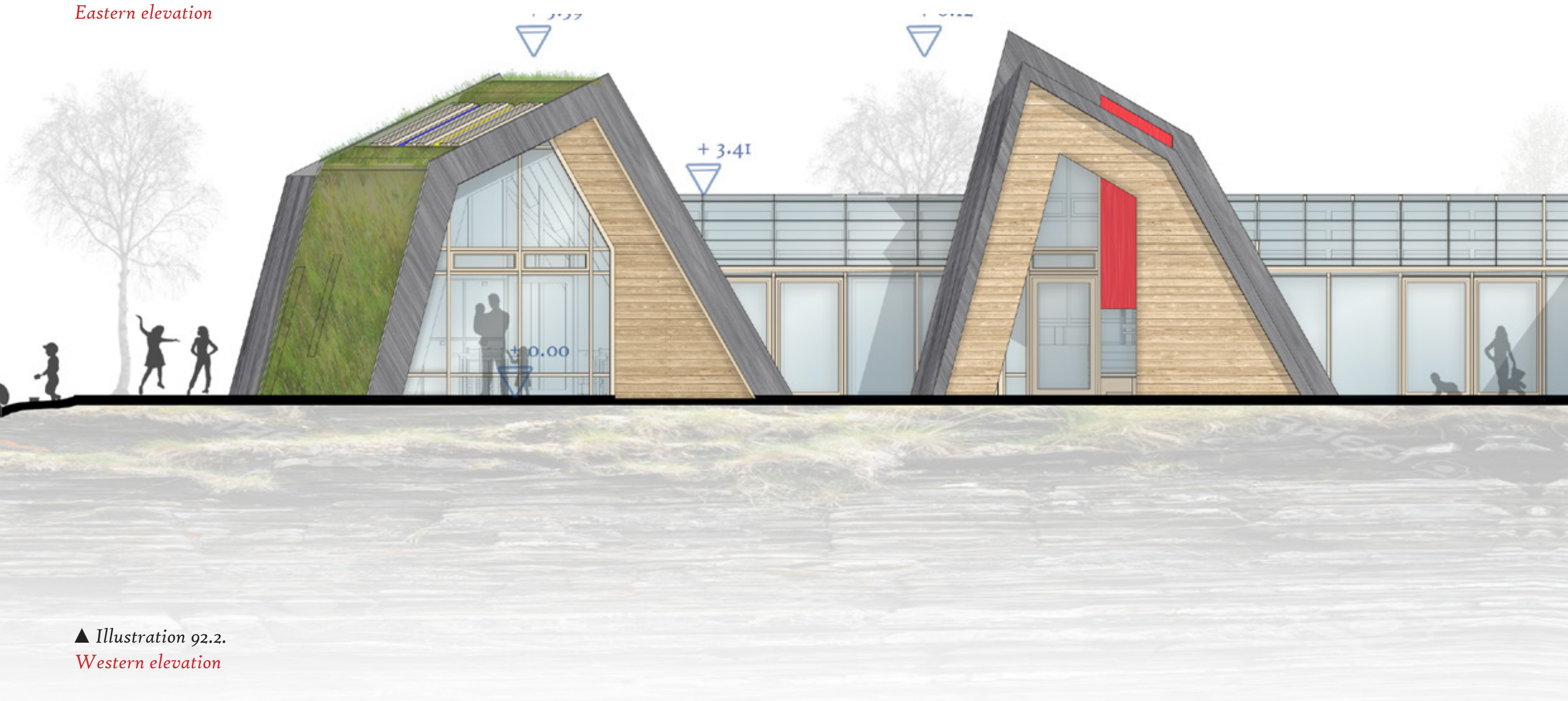
Catching sunlight and view

By rotating the building units several aims were taken into consideration, such as maximizing solar gain on the longitudinal side of the buildings and orient the shorter sides towards the environment. The raised group rooms of Building A and C gave the opportunity to orient the building axes towards the most important mountain of the area, called Tromsdalstinden. The 90-cm rising makes it possible to emphasize the view above the nearby forest of small trees, while still keeping the visual connection between the inner group room and the outer playground.



ELEVATIONS 1:125

▲ *Illustration 92.1.*
Eastern elevation

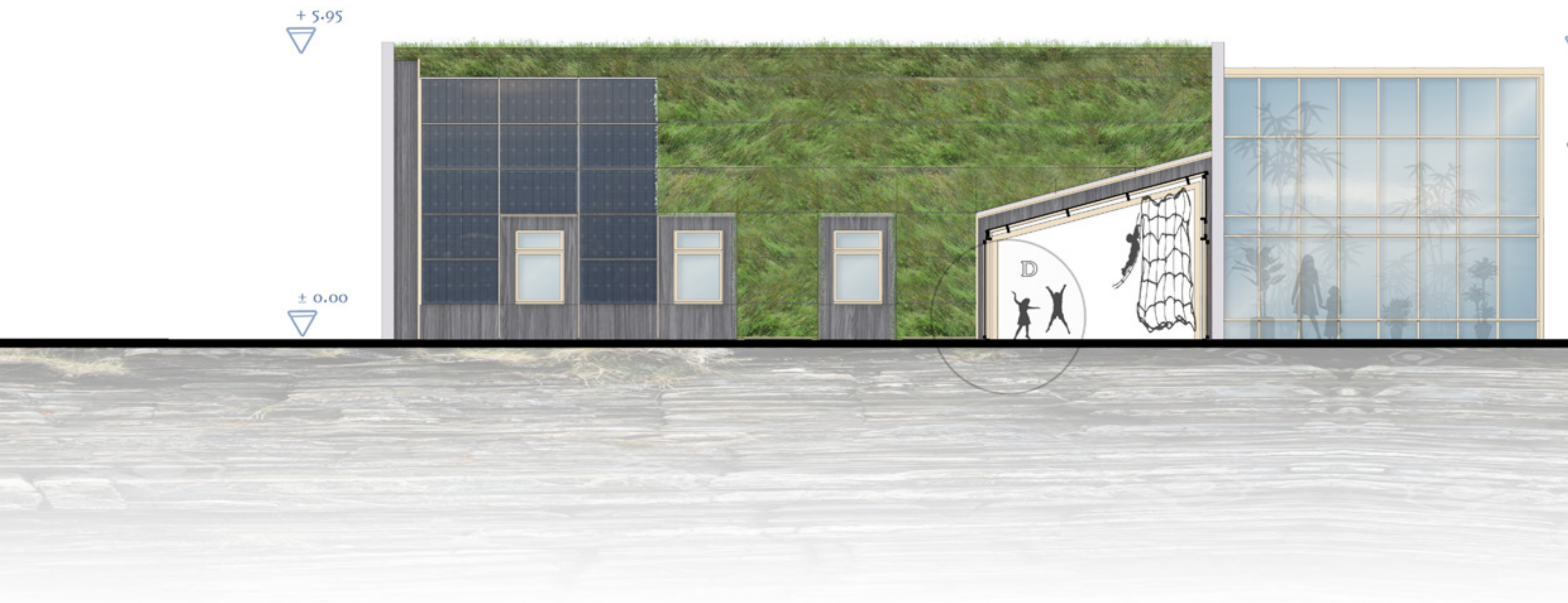


▲ *Illustration 92.2.*
Western elevation

Expressing transparency

The corridor which connects the buildings gives huge possibility to do outdoor activities even in case of bad weather, while during its flexibility and transparency it is completely immaterial compared to the massive volume of the four main buildings.
The glazing system of the end walls cooperates with the corridor's elevation, creating a unified architectural expression between indoors and outdoors.

ELEVATIONS 1:125

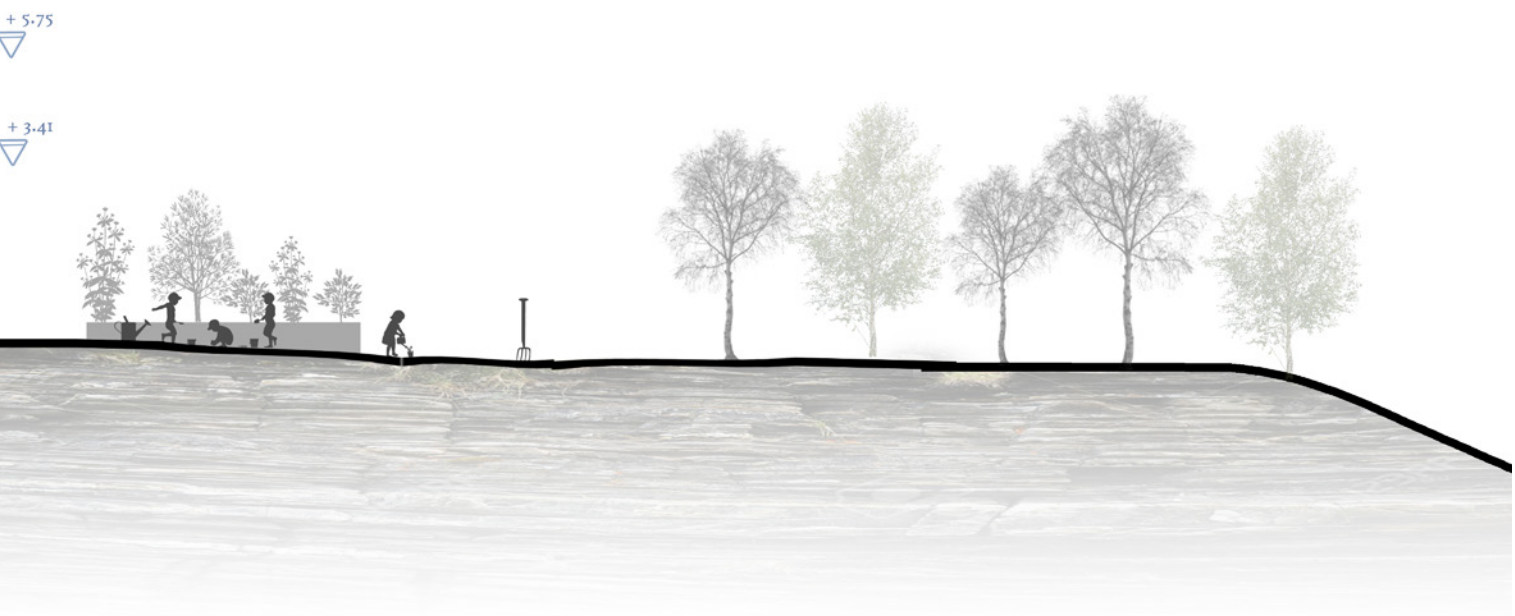


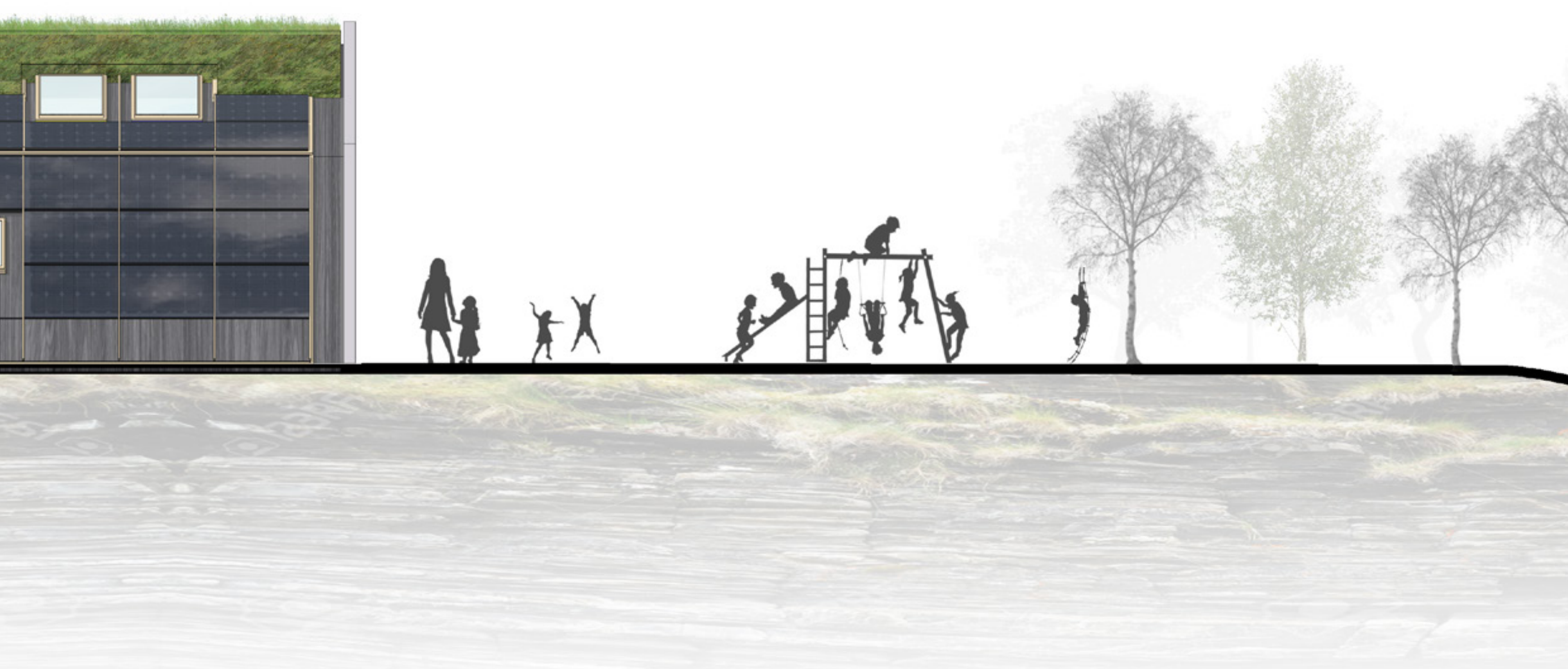
▲ *Illustration 94.1.*
Section C, Southern facade of Building B

▲ *Illustration 94.2.*
Southern facade of Building A

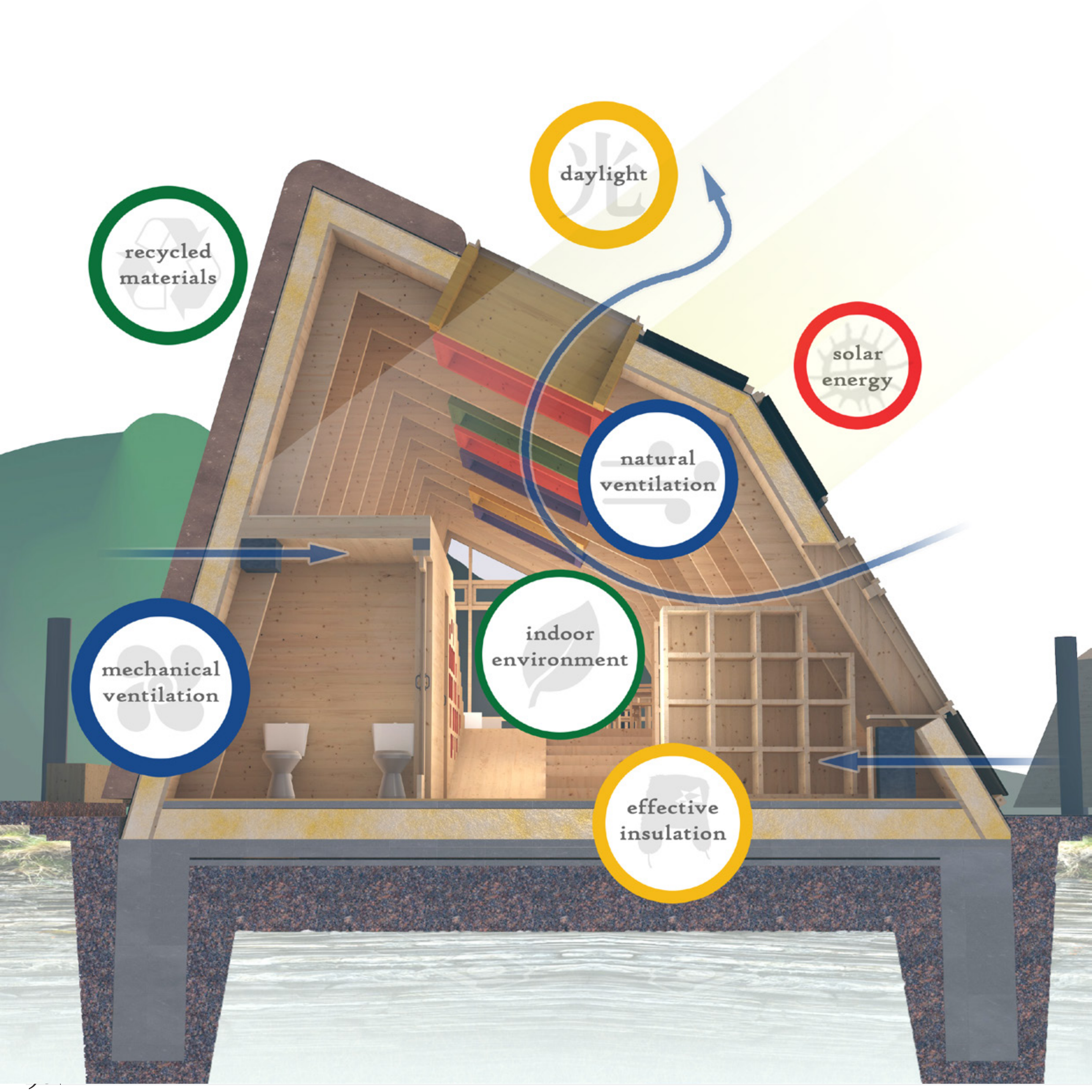
Integrated photovoltaics

All the facades were tested in many different simulation software, which areas of their surface are the most optimal to receive the maximum solar radiation.
This was the basis of the idea, where exactly to install the photovoltaic panels on, such as the complete southern elevation of Building A and partial coverings on Buildings B, C, D.
The surface of the chosen solar panel type SunPower X21-345 BLACK gives an opaque dark surface which cooperates well with the other facade materials: window glazing, larch and turf.





Sustainable performance



The sustainable performance of this project has been documented for energy demand, passive and active solutions, indoor environment and material considerations.

The design is following Danish building regulations (BR15), the 2020 building class and net ZEB definition which were applied and adjusted for Norwegian context. In order to comply with Zero Energy level, the total energy demand of the building had to be minimal, or in this case, lower than 25 kWh /m².

Within the integrated design process, different tools and software have been used to simulate and determine performance of various working models of the design.

The energy demand of the building is calculated in software Be15 which follows Danish building regulations 2015. Indoor environment is simulated and calculated in software BSim, and daylight factor is documented with Velux daylight visualizer. For exploring different possibilities, the other tools have been used such as Grasshopper plug-ins Ladybug and Galapagos to determine sun radiation and sun hour exposure.

The calculations are conducted here for the Building A, which results can apply for the whole building complex.

▲ *Illustration 97.1.*
Regulations and tools

◀ *Illustration 96.1.*
Sustainable principles

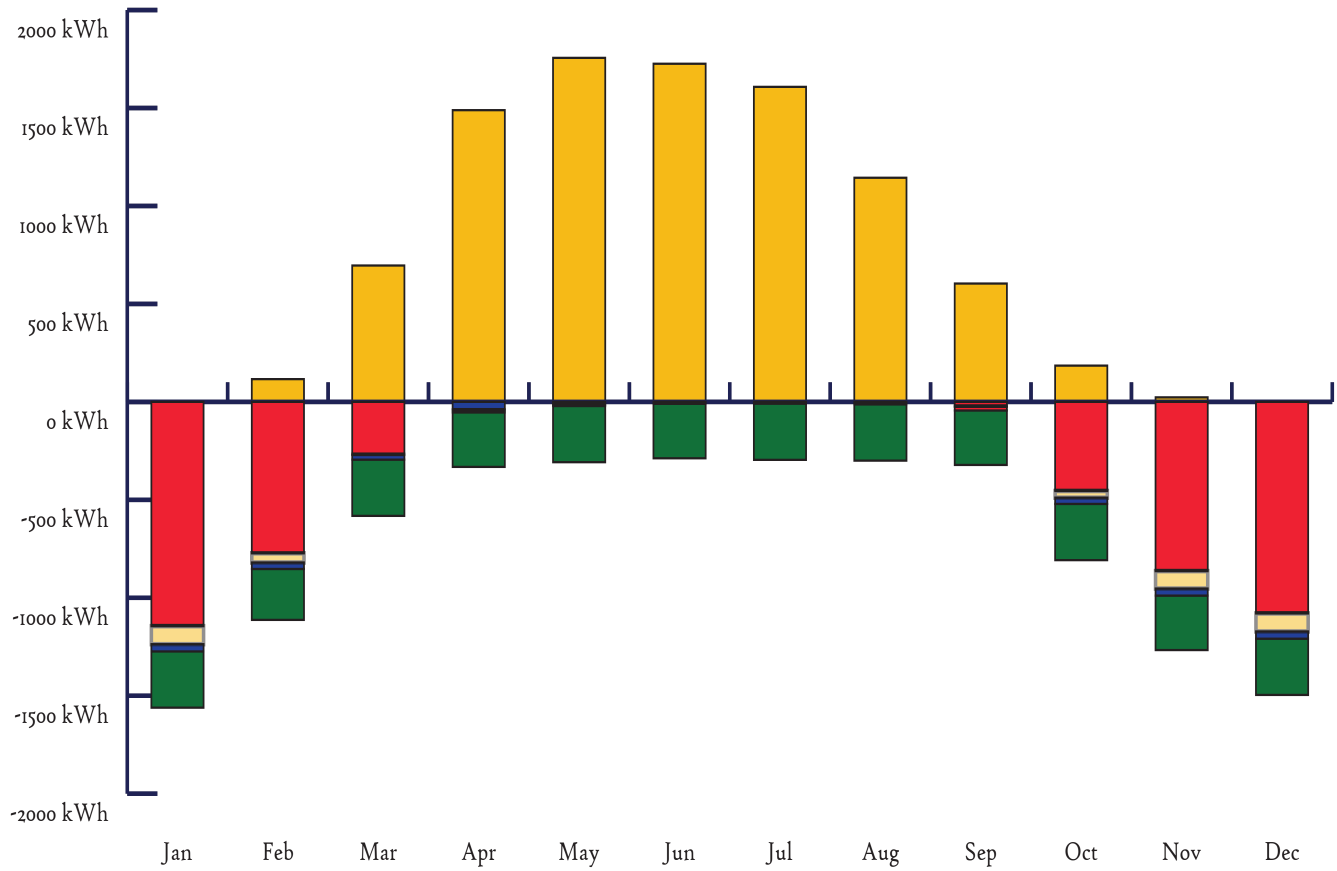
ENERGY DEMAND

The total energy demand for building is calculated in software Be15. The results in Be15 are based on the input data that include the area of the building envelope, area of openings, linear losses, ventilation systems, heat loads and lighting. The software is adjusted for Danish building standards, so the climate file had to be inserted for Tromsø.

Because of the lack of district heating in Tromsø, the project is designed for electric heating, so it was more challenging to meet energy demand for heating. Due to the long winter and demanding climate, the heat loses from the large glazed surfaces were quite significant, so some of the skylight windows were removed and reduced in size. From the total energy demand of the building (24,5kW/m2), almost all of the energy accounts for electric heating (Illustration 98.1), while the only 13% of the overall demand is contributed from domestic hot water, ventilation and lighting.

The key numbers and complete results from Be15 are shown in the Appendix A. The total energy demand for electric use is 24.5kW/m2 which is also considered as a total energy demand of the building, so it should not be multiplied with factor 1.8 factor as it is suggested in Be15. The energy demand for building class 2020 is reached without applying active solutions.

▲ *Illustration 98.1.*
Key numbers



▲ *Illustration 99.1.*
Annual energy balance

pv production

heating

ventilation

lighting

dhw

equipment

User related energy use

The energy required for the equipment of the building (user related energy) is assumed and automatically generated in Be15 (Appendix A). The assumption from Be15 is exaggerated since there was no possibility to input specific function of the building, so the numbers are generated based on average assumptions for non-residential buildings. Having that in mind, the calculation for the active solutions and Zero energy balance still used the numbers that are assumed in Be15 so it can cover the total energy demand for the building related energy use and the user related energy use (equipment).

Annual energy balance

The energy need for the building drastically varies through the different seasons of the year. In the winter there is high demand for heating, while almost zero energy production from the active solutions (Illustration 99.1). In summer there is no requirement for heating, and the solar energy production is significantly high due to the 24 hours of sun exposure. This is why it was important to set the right ZEB definition and to have the possibility to interact with the electric grid, in order to reach the yero balance over the period of one year.

PASSIVE STRATEGIES

Building envelope

A Zero-energy building, with a high energy performance, has to contain thermally efficient envelope to prevent heat losses in unfavorable climate conditions.

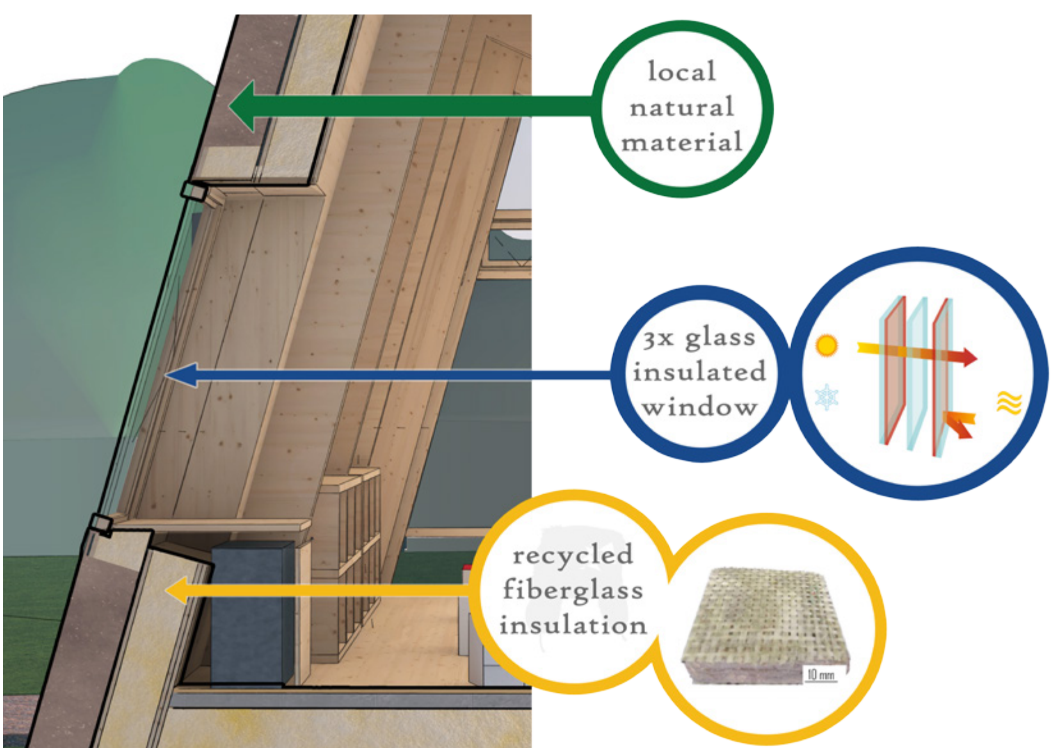
The building envelope is the most important building element which protects heat from escaping into the environment. In this project the walls and roof are acting as a one continuous surface which forms the envelope around the longitudinal floor plan of the building. The layers of the envelope are considered with efficient thermal insulation in order to reach minimum U value, preferably < 0,1W/m2K.

A good thermal insulation has a low thermal conductivity, λ, so the thermal resistance could be higher. Since the sustainable aspect has an important role in this project, the aim was also to find materials that would have less embodied energy and global warming potential (GWP) than conventional materials.

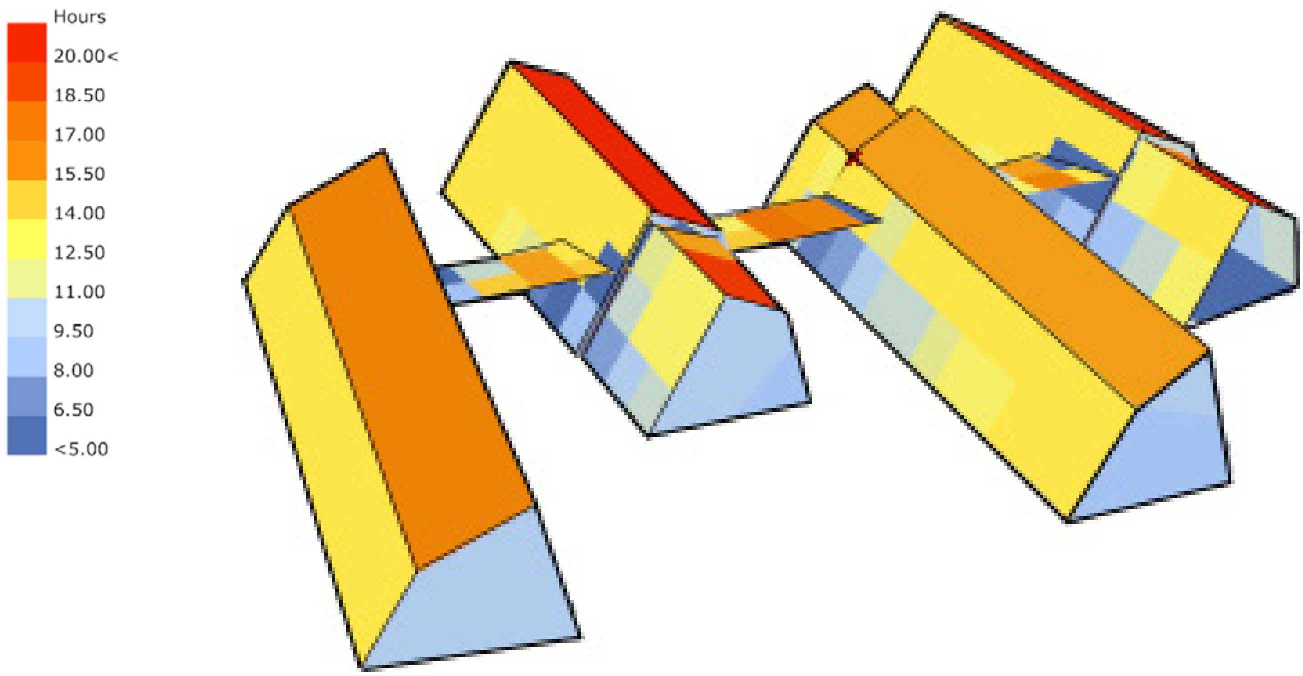
After some research, the unconventional material has been introduced which is a thermal sheet of foam glass granules made from glass waste. According to Ayadi et al. the material has excellent thermal (λ = 0,031 W/mK) and acoustic (R=15dB) properties. This results are better than conventional materials such as mineral wool or EPS. After applying all layers and their properties, the final U-value equals, U=0,094 W/m2K (Appendix B).

Besides the walls and roofs, the biggest critical surfaces for heat loss are glazed areas which are needed to provide quality indoor environment. The glazing for the windows are chosen from the product database of manufacturer Guardian Glass. The triple glazing (4+14+4+14+4) is filled with krypton and still shows high light transmittance of 73%, and g value 0,62 (Guardianglass.com 2017).

The glazed area allow passive heating of the building, which are very beneficial during colder months of the year. With more passive heat gain, the less energy for the heating is required. For summer months it is crucial to consider natural ventilation strategies which are enabling passive cooling and prevent overheating of the building.

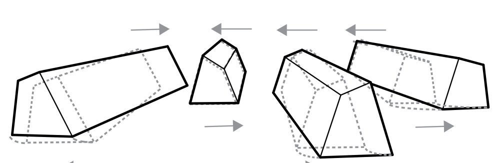


◀ *Illustration 100.1.*
Different solutions for effecient insulations



Orientation and position

The building is set on a plot in between two hills from North and south East-south side. For this reason, the building wings are rotated towards South-west side where the long facades would be most exposed to the Sun. The four buildings are slightly different oriented from each other in order to get less shaded surfaces, but also open to the landscape and provide views.



The choice of facade materials are following the principles of energy efficiency related to Sun exposure, so the Northern and shaded facades are covered with turf and the Southern facades with pv cells. The building composition is also perpendicular to the strongest wind directions from the south, but it is still open for small intensity winds from east and west directions in Summer (Illustration 101.2) in order to provide natural ventilation through the passage.

The inclinations and the surfaces related to orientation are tested in the Ladybug (Illustration 101.1) with Sun hours illustration on the building surfaces. The both ends of the longitudinal buildings are glazed, but the biggest glass surfaces are facing south-east in order to get a passive heat gain into the workshops during colder temperatures.

The choice of the window glazing was also considered in regards to the solar heat gain with the g value = 0,62.

▲ *Illustration 101.1.*
Sun hours in June, from SE and NW

▶ *Illustration 101.2.*
Rotation concept

ACTIVE STRATEGIES

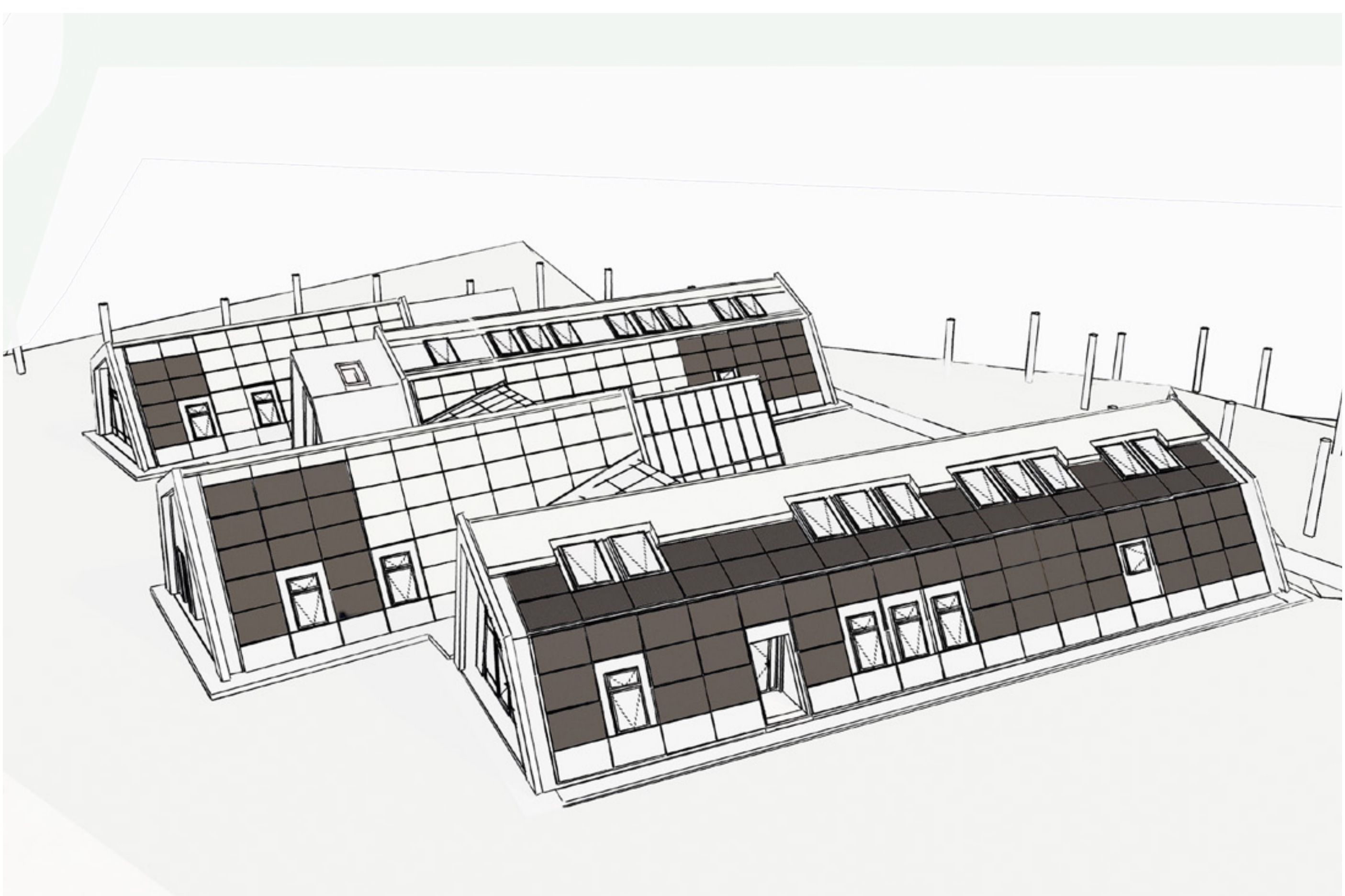
Photovoltaic cells

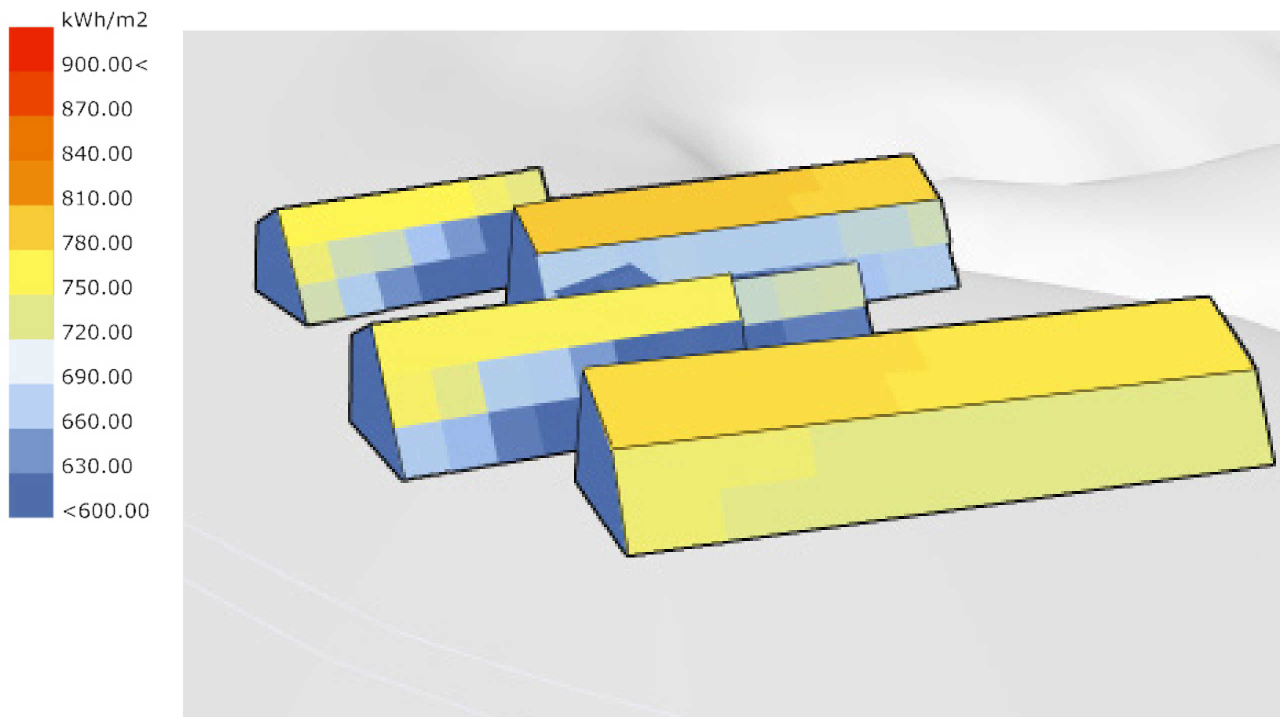
The zero energy balance of the building is reached from the energy exchange between the building and the electricity grid on annual basis. The building is using active solution in form of renewable energy source that would be produced on the site.

Due to the extreme disbalance in Sun exposure through the year, the building is exchanging energy with the grid, by using the Primary energy factor 2 (prEN 15603, 2013). During Summer it is exporting the excess energy to the grid, and importing the energy back in winter days when there is a high demand for heating. (Illustration 102.1)

In this project, the active solutions that are applied are photovoltaic (pv) panels that are covering the energy demand (24.5kWh/m2) for the building.

The PV cells are also designed to cover the assumption of user related energy (16,5 kWh/m2) which refers to the appliances use, but in building A, there are almost no appliances that would justify that consumption.





The placement, orientation and inclination of the surfaces are tested in Ladybug in order to get the best performance and still keep the desired design proposal. Considering the extreme climate of the site and with plenty diffused light with few direct sun exposure, it was important to choose high efficient PVs that could be most effective for the given conditions. The chosen type for the PV installation is X-Series solar panels from manufacturer Sun Power with average panel efficiency of 21% and nominal power 335 W.

The chosen module has a system that is proven to hold efficiency much better in low-light conditions with high-quality anti-reflective glass that traps incoming light from all angles. (Sunpower.com, 2017) The PVs are mounted on the inclined (60°) wall surfaces on the Sun facing facades.

The total designed area of PV cells on the building A is around 100 m2 which is twice as much the need for covering both building related and user related energy use. Since the other buildings have smaller PV capacity, the excess energy from the building A would be distributed according to needs. The production is sufficient for 44 kWh/m2 (Appendix A), and the calculation for the required area of the PVs is listed in Appendix D. Total electricity production from the PVs of the building A is 9.347kW per year.

▲ *Illustration 103.1.*
Solar radiation in June

◀ *Illustration 86.1.*
Position of PVs

INDOOR ENVIRONMENT

The indoor environment quality is presented in relation to thermal comfort, air quality, daylight and acoustics. The thermal comfort and air quality are simulated in BSim, with adjusted systems for heating, mechanical and natural ventilation, lighting, infiltration, people load and equipment (Illustration 105.1.)

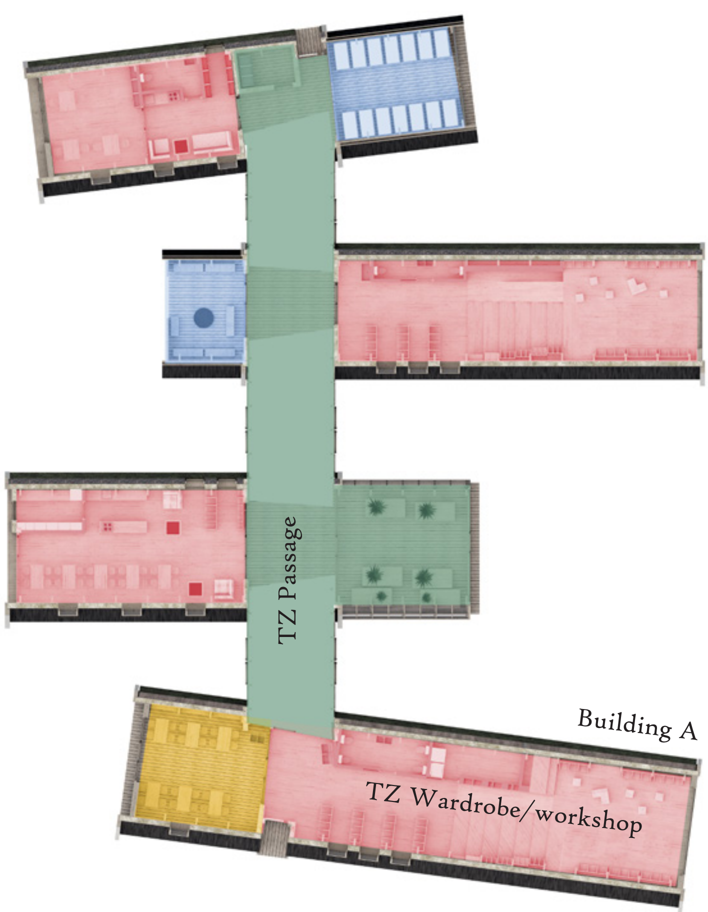
Thermal zones

The building complex is designed with four different thermal zones (TZ) which include heated indoor space with average temperature 20°C (CR 1752), semi-heated area (15°C), non-heated spaces with almost outdoor temperatures, and areas that are part of the building but have no closed envelope. The heated areas include all indoor group areas for reading, playing or painting, dirty and clean wardrobes, kitchen and teachers area.

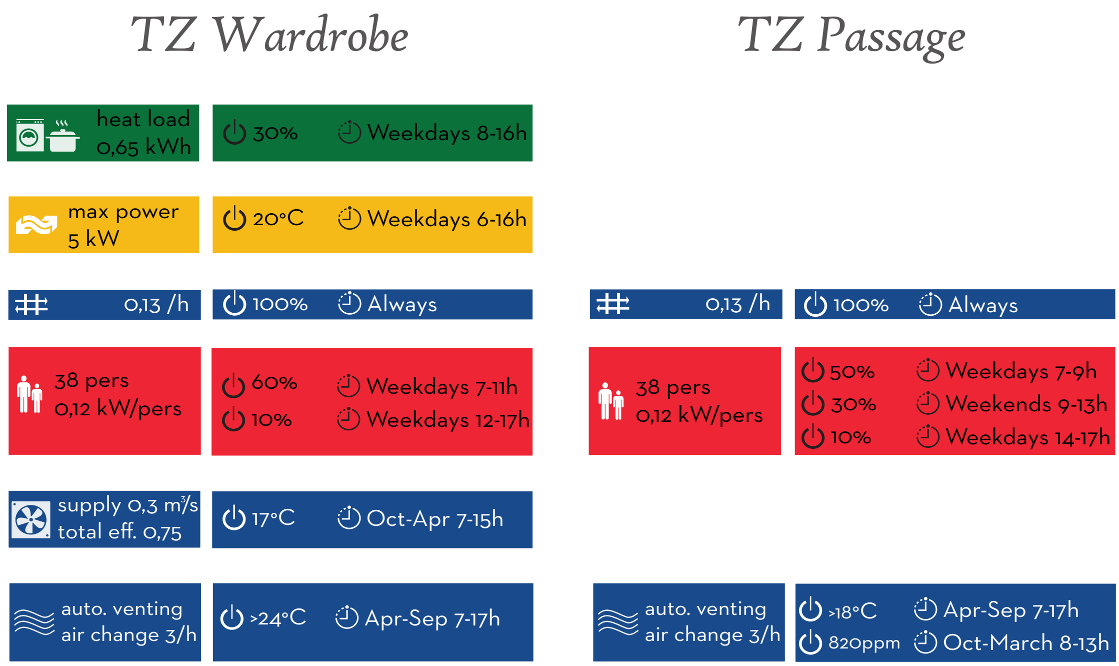
The semi-heated area is only dirty workshop which can be used as an area connected to outdoor activities, so there will be no need to heat it in this case.

If however, the area would be used without connection to outdoors as an indoor room, it will be heated to either 15°C or 20°C. Non-heated area include the passage and the greenhouse which is covered only in the glass envelope that protects the space from heavy rainfalls and wind, and it is used as a protected outdoor area.

The fourth zone are outdoor areas which are sleeping room and entrance, so the room are partly having the envelope but are open on one side which means they have the same thermal conditions as outdoor area (Illustration 104.1).
Building A was simulated in BSim with two observed Thermal zones: the heated zone with dirty wardrobe, clean wardrobe and duodji workshop, and the non-heated passage.



◄ *Illustration 104.1.*
Thermal zones



▲ *Illustration 105.1.*
BSim system input data

BSim systems

The systems that are set for this zone are shown in the Illustration 105.1 comparing the difference between the systems, operations and schedules. Since the passage is in a non-heated zone, there is no heat or mechanical ventilation system.

The heat gain from equipment is assumed to be 6 W/m2 as stated in the SBi guidelines (Statens Byggeforskningsinstitut, 2008) for non- residential buildings. That amount has been lowered for 20%, because there is almost no equipment in the area.

Heating is set only for heated zones, with operation control to maintain average temperature of 20°C during hours of use.

Infiltration is active 24 hours every day at the constant basic air change of 0,13/h (Statens Byggeforskningsinstitut, 2008) for both thermal zones.

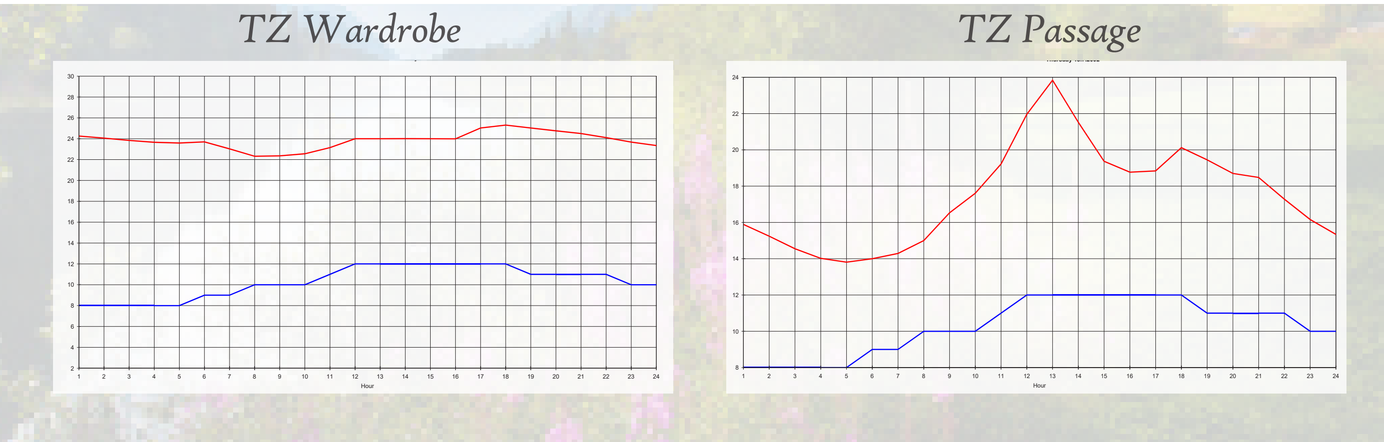
Lighting is set to for the Wardrobe/workshop zone to 300 lux, which satisfies the needs of the workshop areas, (DS/EN 12464-1, 2011), although it could be lower for the wardrobe since it is not a working area.

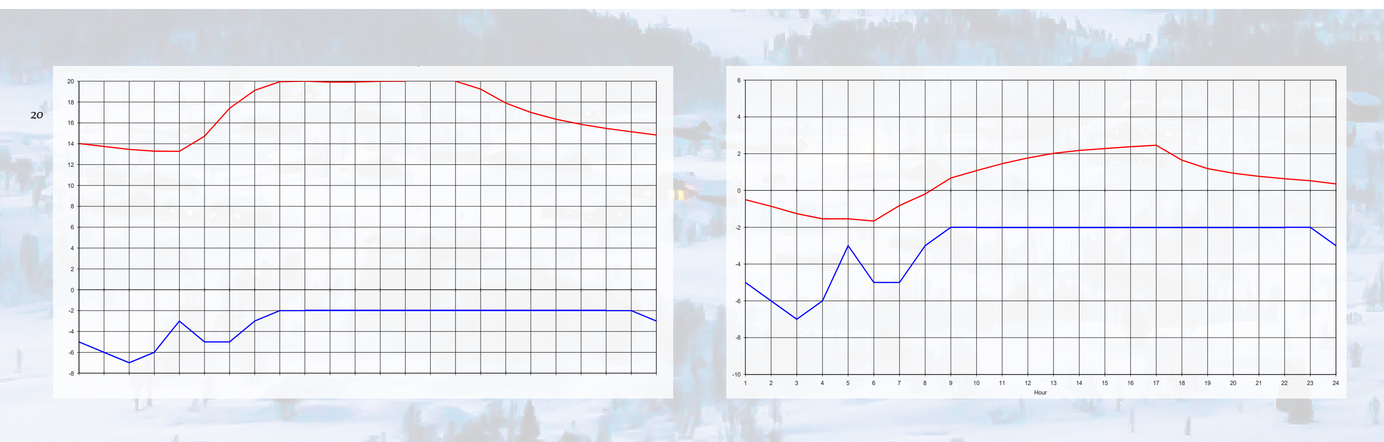
The chosen lighting system is LED light Philips School Vision energy-efficient Lighting solution that has proven to increase the learning performance of children and students. (Lighting. Phillips.com 2017)

People
People are scheduled to be mostly in the building during morning when they have breakfast (Flow chart, Illustration 88.1), and short activities before lunch in case of unfavorable weather. Most of the time they spend outdoors.

Ventilation
Mechanical ventilation is set for colder months of the year. The system is the most active in the mornings during winter months when children spend some time indoors. The system is set only for the heated Wardrobe/workshop zone, while the passage is naturally vented according to needs during whole year.

Venting
The venting system is used to provide fresh air during warmer months of the year. The openings in the building are all openable in order to provide more than needed airflow. The venting systems are also used to prevent overheating in the rooms in the period between June and August.





▲ *Illustration 106.1.*
Temperature for 24 hours for July(top) and January(bottom)

indoor temperature °C
outdoor temperature °C

Thermal comfort

Thermal comfort is achieved with adjusting the systems in different seasons, resulting with temperature graph for the period of 24 hours (Illustration 106.1).

The minimum temperature requirements for heating areas are in the range from 17,5°C to 22,5°C, resulting with an average of 20 °C. These temperatures are recommended due to the higher activity levels measured for kindergartens (1,4 met) which include sitting and walking activities. In summer, the maximum allowed temperature is 25,5 °C. (DS/EN 15251, 2007)

Overheating in summer is prevented by activating the natural ventilation system in the period between June and August.
(Illustration 107.1)

In the TZ Passage the temperatures are offset from outdoor temperatures by around 5°C and it is considered as an outdoor area. In the summer season, the flexible doors are open so the transition between areas are more freely.

Air quality

The air quality is evaluated in BSim on the basis of CO_2 level that are recommended to be 500 ppm above the outdoor area, which is 350 ppm (DS/EN 15251, 2007).

During winter months is was challenging to reach optimal levels when there is more frequent occupation in the buildings. Since the mornings are most occupied, the rates of the ventilation systems had to be increased in order to provide required air quality. In Summer season the natural ventilation is used to provide fresh air supply in the buildings.

Natural ventilation

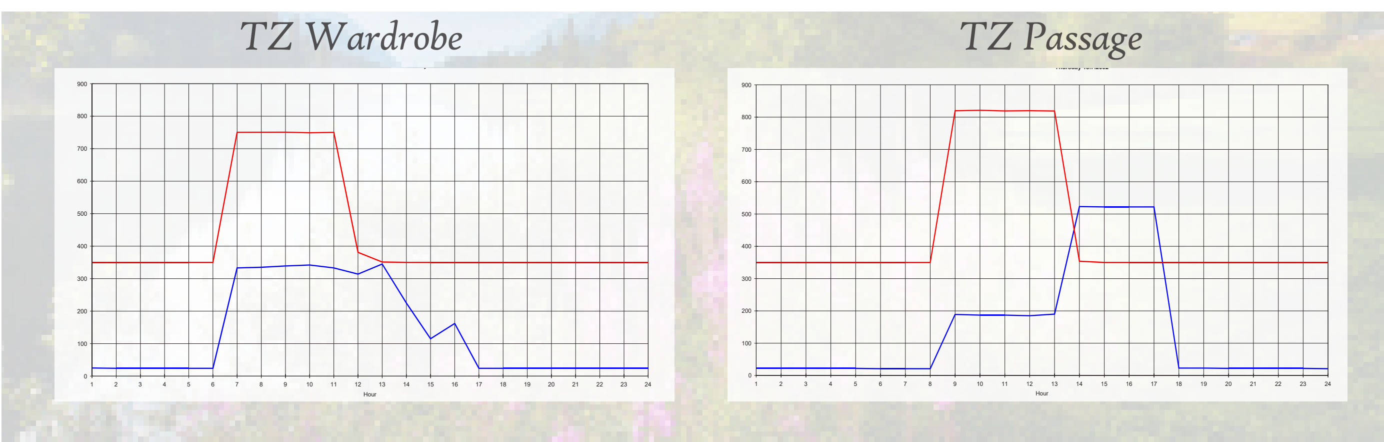
The driving force of the natural ventilation is inducted by the stack effect and causing the thermal buoyancy flow. The natural ventilation is enabling the passive cooling to the critical rooms.

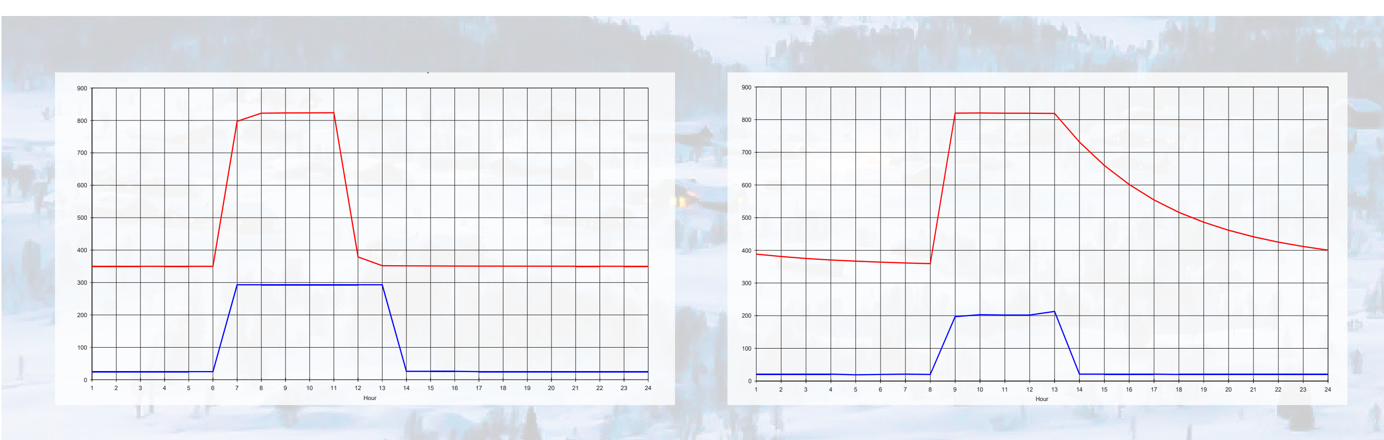
Thermal buoyancy is a design principle that works on the basis of temperature differences which is enabled by the design of higher opening in the building (Illustration 108.1).

The fresh air is colder and heavier than the polluted warmer air so the system works in a way that the fresh air is provides from the wall windows, while the exhaust air exits the building through the series of skylights on the roof.

— CO^2 ppm
— Air Change (*100) /h

▼ *Illustration 107.1.*
Temperature for 24 hours for July(top) and January(bottom)



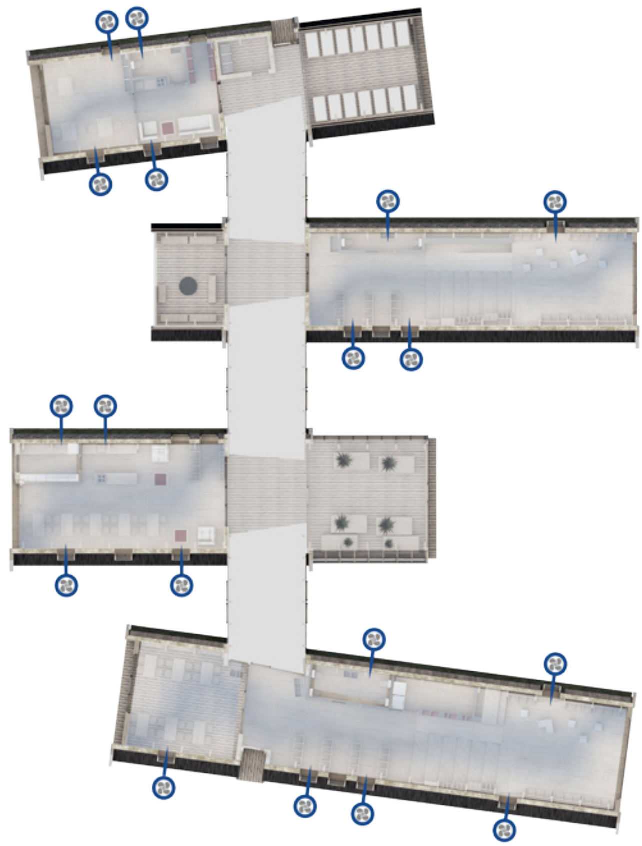


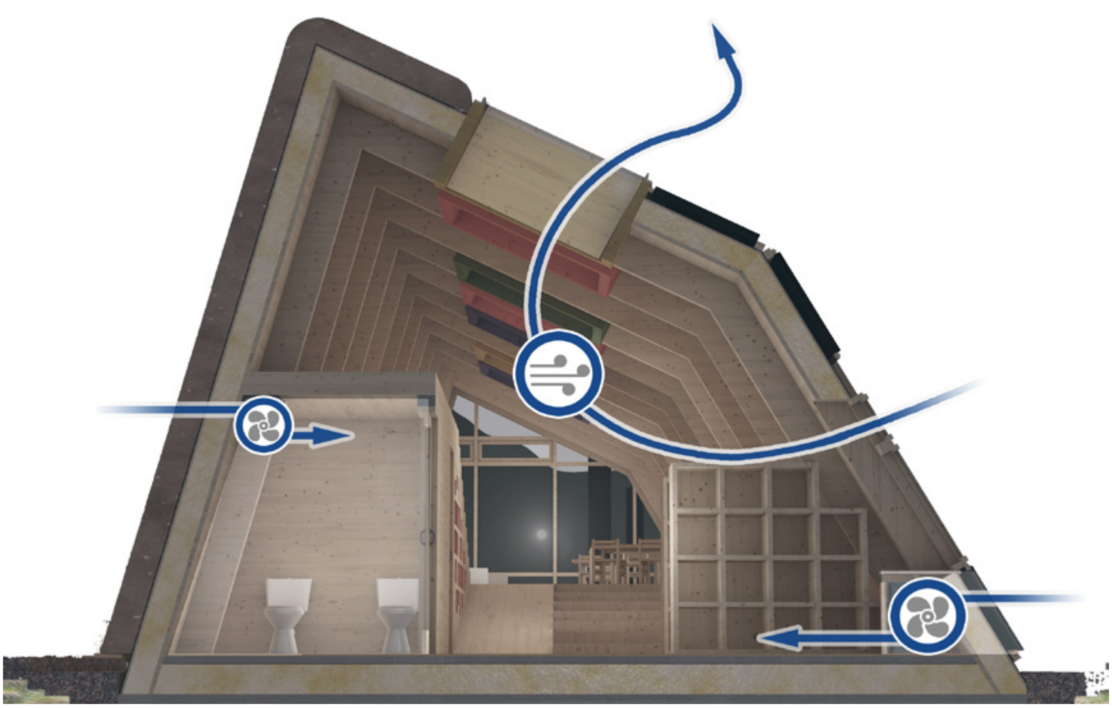
Mechanical ventilation

The mechanical ventilation is active only in colder periods of the year when there is active heating system in the building. The mechanical ventilation is decentralized in each building, and using the displacement design principle.

The number of required heat recovery units are placed under the window seal (Illustration 108.1). The detail is provided in the Illustration XX which shows the inlet and exhaust air supply. The dimensioning of the overall air supply is shown in the Appendix C.

The ventilation units are having heat recovery system in order to prevent heat losses during the heating period.





▲ *Illustration 108.1.*
Location of ventilation units

◀ *Illustration 108.2.*
Diagram for venting and ventilation

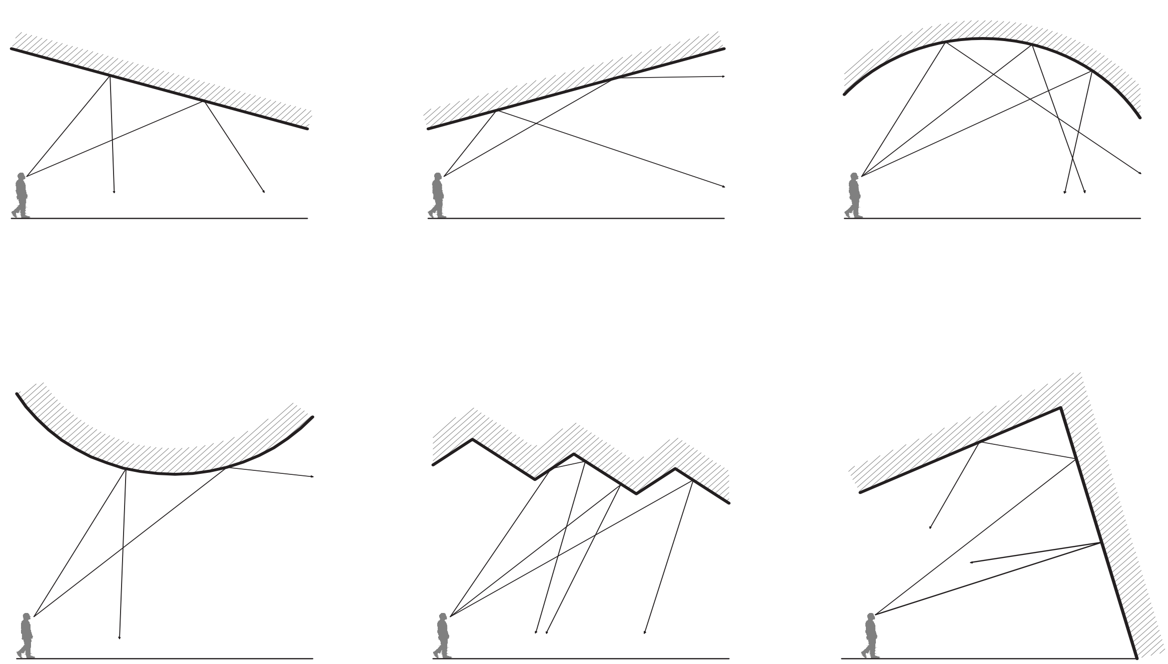
Acoustics

Indoor environment quality is also experienced from the acoustics in the space, and in this project it is considered from the aspect of material choice and the form of the building. In the Illustration 109.1, different forms are tested in order to understand the behaviour of the sound movements and its effect in the space. When it is emitted from the source, the sound wave can be reflected, absorbed, diffused or diffracted from the surface or obstacle (Long, 2006).

The recommendation for achieving good acoustic include avoidance of parallel surfaces and large rooms in relation to the design, and avoidance of hard smooth materials. (Bejder et al., 2014).

In case of parallel smooth surfaces with no absorptive material, the sound waves would bounce between these walls causing negative effect of flutter echo. (Long, 2006) After illustration of several different options for ceiling surfaces, the process showed good advantage of using the tilted walls (Illustration 109.1) in terms of acoustics. The sound is better distributed and scattered through the space which is important for the educational areas, in this case workshops or the area with children.

In terms of material, the choice of wood was primarily used due to its sustainable advantages, and local availability, but it is also shown as a quality material in terms of acoustics. The use of soft materials such as carpets, textiles and pillows can increase sound absorption, so they are freely distributed in the spaces for better acoustic comfort.



► *Illustration 109.1.*
Relations between acoustics and form


113.8
234.2
95.5
82.5
135.5
131.5
95.4
210.2
lux
500
438
375
313
250
188
126
63

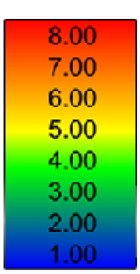
Daylight

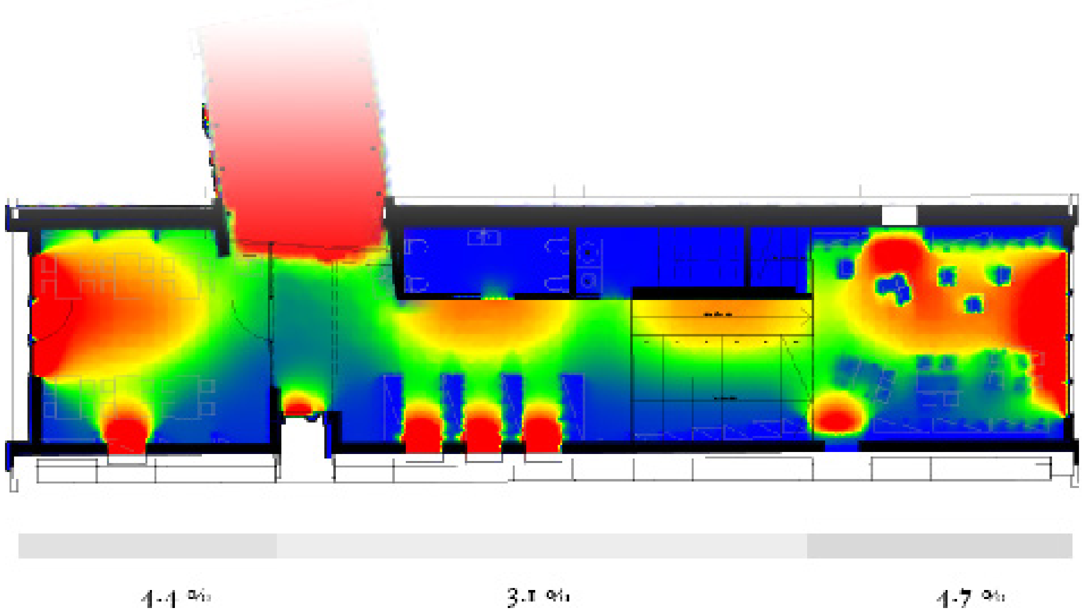
Daylight is essential for achieving quality atmosphere and comfort in the space. In the case of the kindergarten or other educational spaces, it is crucial for creating healthy and efficient learning environment. In the design process it is important to consider both quantitative and qualitative aspects of daylight. (Bejder et al., 2014).

The quantitative qualities include passive solar heat gain and amount of light which is documented by using the daylight factor and illuminance simulation in Velux visualizer (Illustration 110.1 and 111.1). Although the requirements from the Danish Building Regulations 2015 state the minimum daylight factor of 2%, the design criteria were more ambitious, especially because of the unfavorable climate of the site where the daylight is much appreciated.

The skylights in the building are crucial part of the overall design which are providing diffused light through the whole building with the average DF between 3-4%. The surfaces and colours are also integrated part of daylight experience where coloured wooden textures are transmitting and filtering the sun rays in the colored tone.

The workshop rooms as the main creative nests at the end of the buildings which are given the more priority for the quality perception of the daylight. The large glazing units are providing also some direct sunlight and view to the outdoors from in the rooms. The experience of the space is also enhanced with shadowed area along the longitudinal walls, while the central active is illuminated with constant diffused light even in cloudy or misty weather conditions.

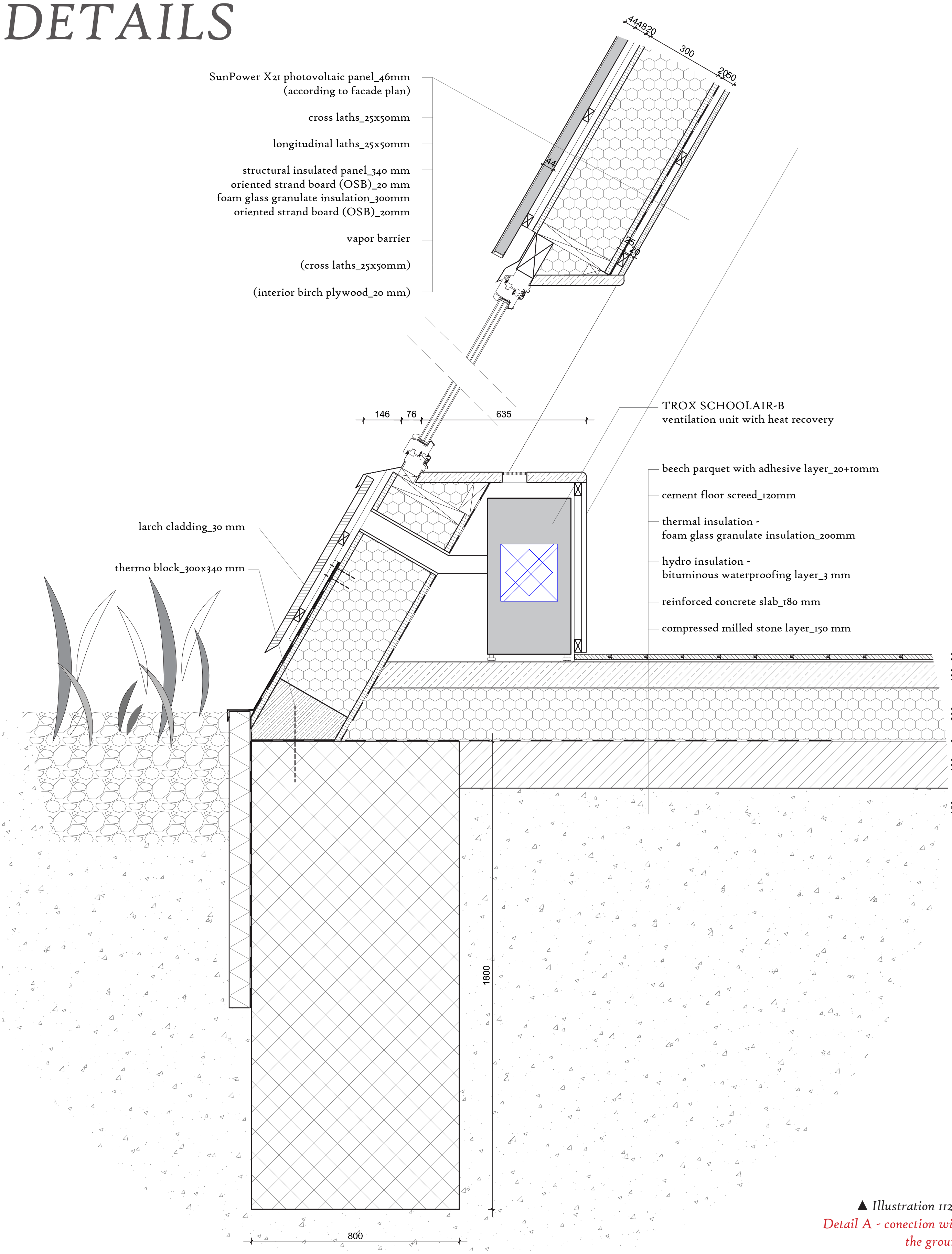




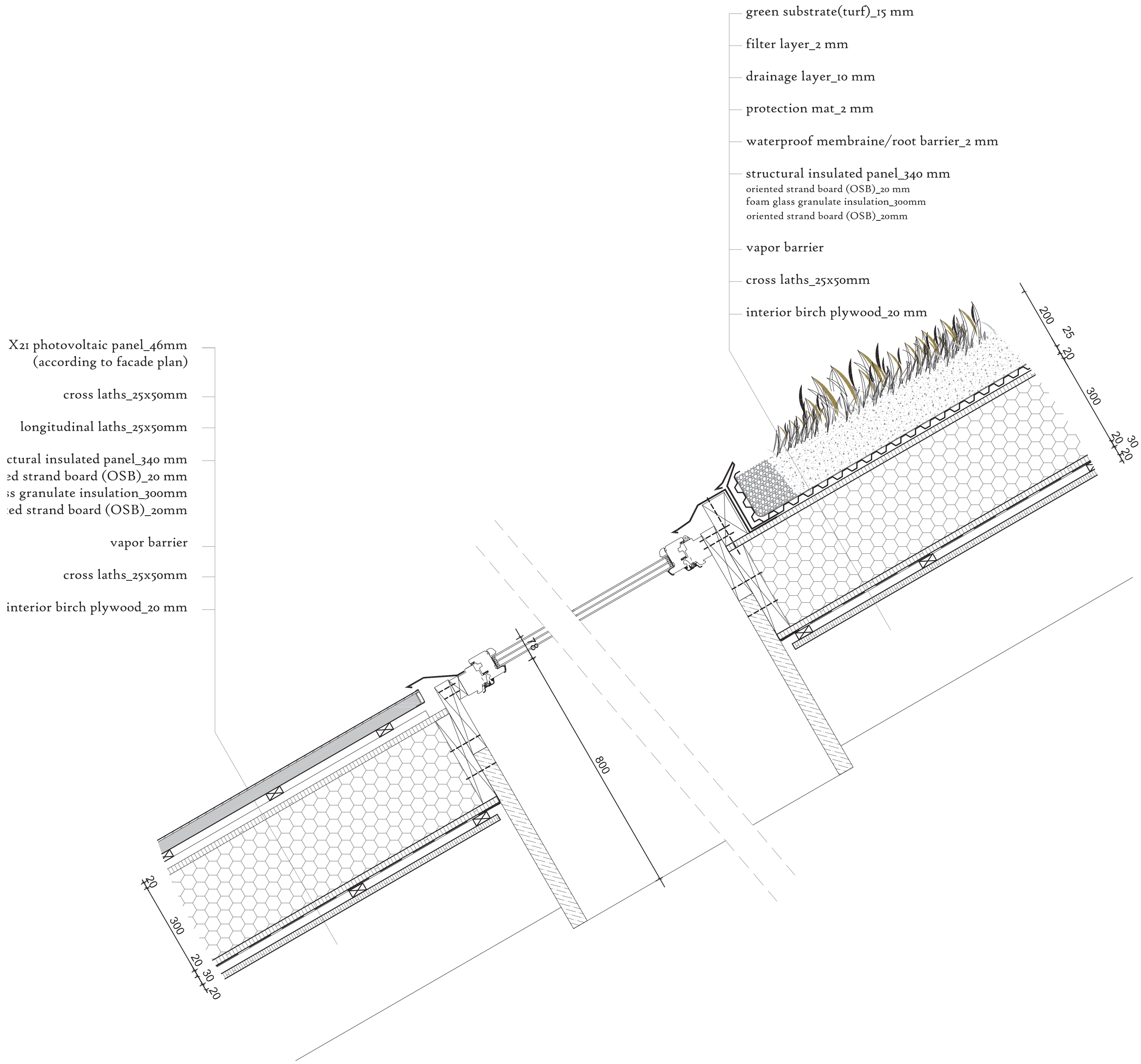
▶ *Illustration 110.1.*
Daylight factor graph for building A

◀ *Illustration 110.1.*
Illumination preview from the dirty workshop

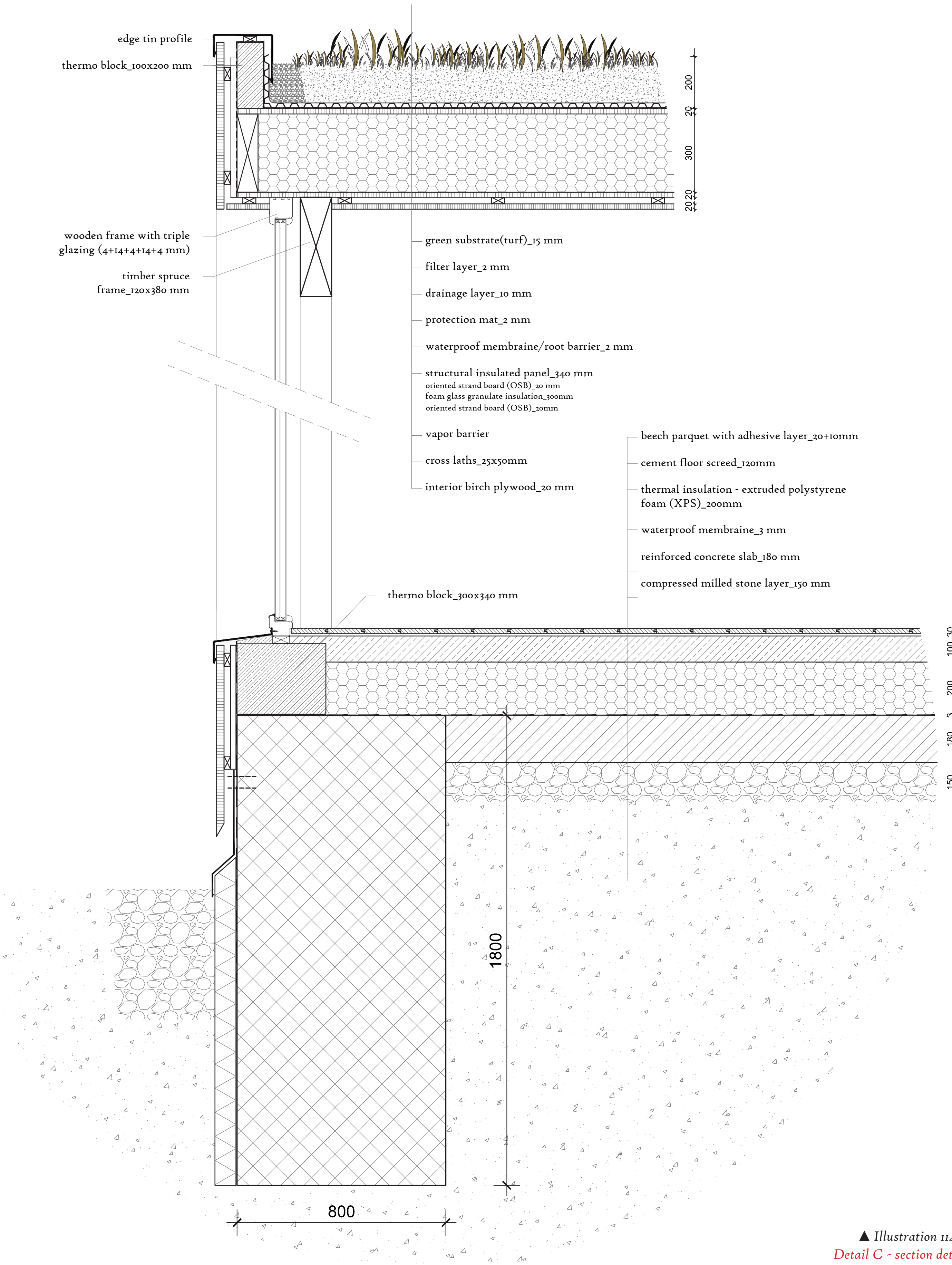
DETAILS



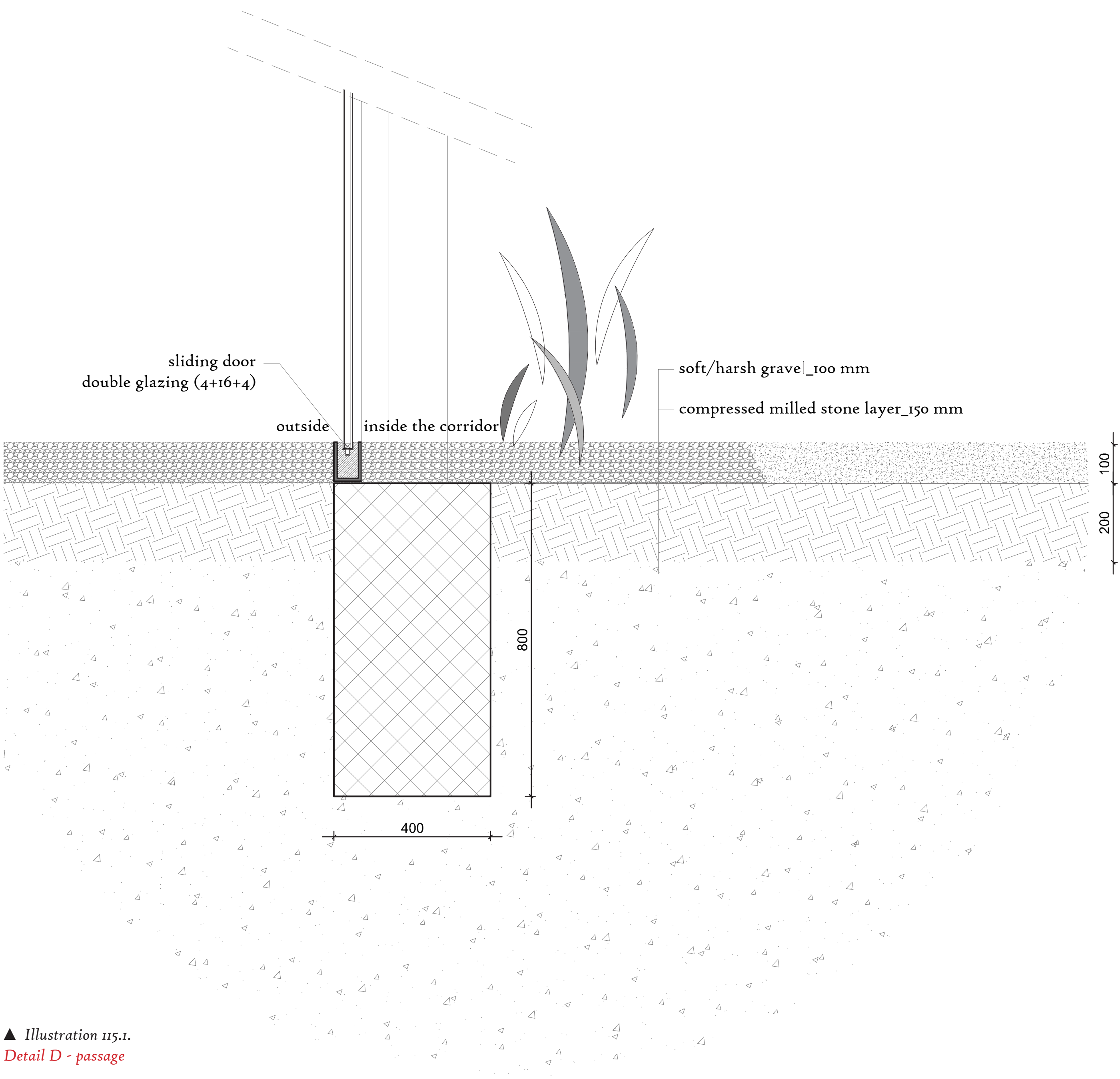
▲ *Illustration 112.1.*
Detail A - conection with the ground



▲ *Illustration 113.1.*
Detail B - skylight



▲ *Illustration 114.1.*
Detail C - section detial



▲ *Illustration 115.1.*
Detail D - passage

MATERIAL CONSIDERATIONS

The materials for this project have been considered for structure, envelope, outdoor, indoor and the passage area. In the design criteria it was stated that the materials have to be considered in terms of sustainability, local availability and connection with the Sámi traditional architecture.

Structure

The material used for the structure is Norway spruce (Picea abies) which is economically the most valuable tree species in Norway. (Sciencenordic.com, 2013) The load bearing frames are made from the spruce timber, which was chosen due to its high technical performance, low weight, local availability and sustainable aspects (Illustration 116.1/A).

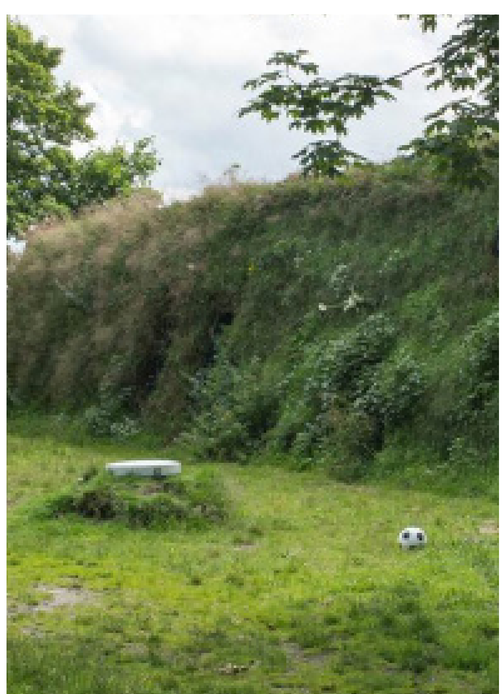
Envelope

The most of the envelope is covered by turf or sod, which is a traditional material for Scandinavian type of green roof. The turf is the upper stratum of soil that includes grass and roots which are horizontally cut from the ground and placed in layers to cover the roof. There is a possibility to take the turf directly from the site location like in the example of Kirstinelyst visitor centre (Illustration 116.1/B, by courtesy of Lars Juel Thiis, Cubo Architects).

Outdoor cladding

The south facades of the envelope are covered with photovoltaic panels with some cladding around the windows and non-usable area for the PV-s. The facade cladding is made from Siberian larch (Larix sibirica) which is durable wood resistant to weather conditions and rotting. The wood can also be charred which means there is no more moisture in the wood so it can extend its lifespan to 30 or 50 years. The larch cladding is also placed on the end facades of the building around window area.

▼ *Illustration 116.1.*
Materials for the envelope:
Norwegian spruce
Turf
Siberian larch





▲ *Illustration 117.1.*
Materials:
Gravel
Birch plywood
Glass

The passage

The passage is a transition zone between indoor and outdoor areas, so it was important to define a floor material that would unite these two spaces. The floors are covered with a combination of gravel and sand which can be treated as a hard and soft surfaces around the active zones in the passage.

Transparent areas

As a transition zone, the passage also needed to be expressed as a transparent protected area where the users could still have a connection to the outdoor environment. The glass surfaces were introduced to cover the whole envelope of the passage that is in between the main buildings. The glazing is also dominating at the end facades of the longitudinal buildings.

Indoor surfaces

Indoor rooms are all covered in birch plywood in between the spruce timber frames. The material was chosen because of its local availability since the birch is the most common species in Norway, but also because it was used for interior structures in the traditional Sámi goahti buildings. The birch is also quality wood for interior surfaces because of its light texture and good interaction with the light.

LCA CONSIDERATIONS

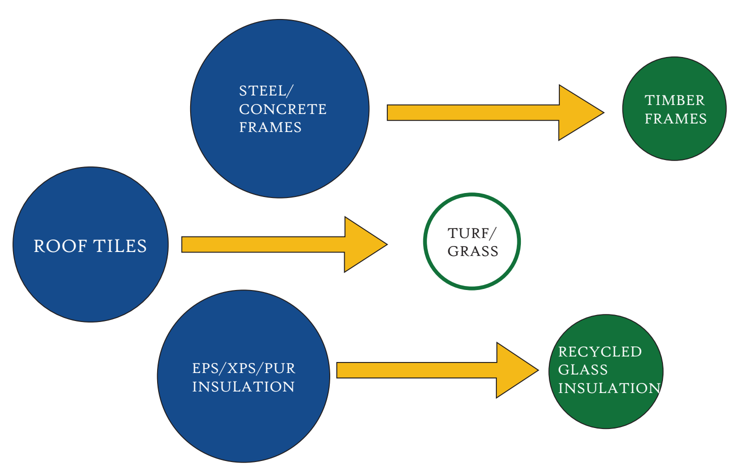
The LCA includes total environmental impact of the building through its life cycle. This includes material production, construction, maintenance, operation, demolition and removal of the building. In this project the material choice had an important role in the entire concept of the building, both in relation to sustainability but also to the connection with the Sámi traditional buildings and their use of natural materials. The materials were considered in relation to their environmental impact (global warming potential, GWP, in CO_2 equiv.), local availability and technical properties. The main building elements that were crucial in forming the the building are structure and the envelope.

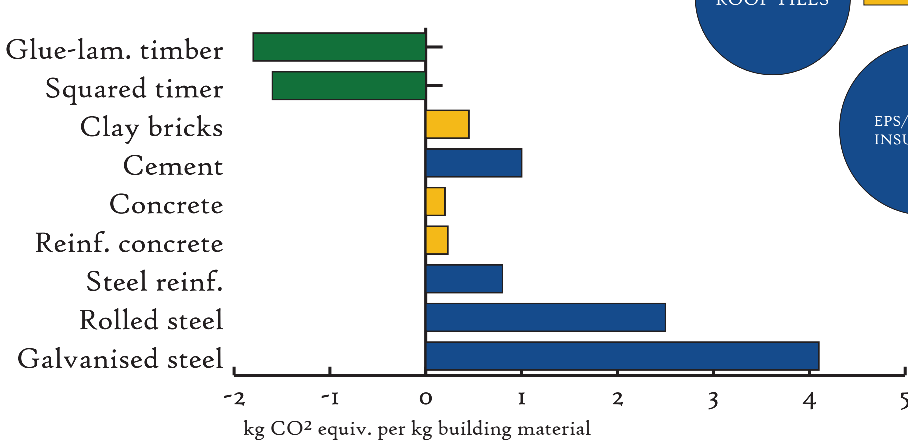
The structure was designed in timber because it is a local traditional material with positive impact on the environment. From all most common materials in building industry wood is considered the most sustainable since it is carbon neutral due to adsorbed CO_2 over its lifetime photosynthesis (Illustration 118.2) (Kolb, 2008). There are also tectonic qualities and indoor atmosphere that is common for the timber buildings.

The main focus in the envelope was outter layer of the building. Without even any connection to the Sámi buildings, the green roofs were considered because of their properties and positive impact on the environment.

Compared to the other options for roof cladding, the turf layer has no global warming potential or embodied energy, except for the work that is required to take the turf from the ground and put it on the roof. The turf is also traditional Scandinavian roof, but at the same time it was used as a cover for Sámi goathi structures.

Because of the high energy standard that had to be achieved it was required to design a significant amount of thermal insulation to reach the energy demand. This means at least 30cm of thermal insulation arun the whole envelope surface which requires a lot of material. For this reason it was important to find alternative for the commonly used insulations such as expanded polystyrene (EPS) or mineral wool. The interesting findings revealed while reading through the scientific literature on environmental friendly insulations and their performance. The research from Ayadi et al. presented the results from the insulation material made of porous granules based on waste glass. Their thermal performance is even better than the one from standard materials, and it is made of waste glass which directly contribute to the reduction of waste. Moreover, the manufacture of 100% recycled glass requires 25% of energy in less than the production of raw materials. (Ayadi et al., 2011)

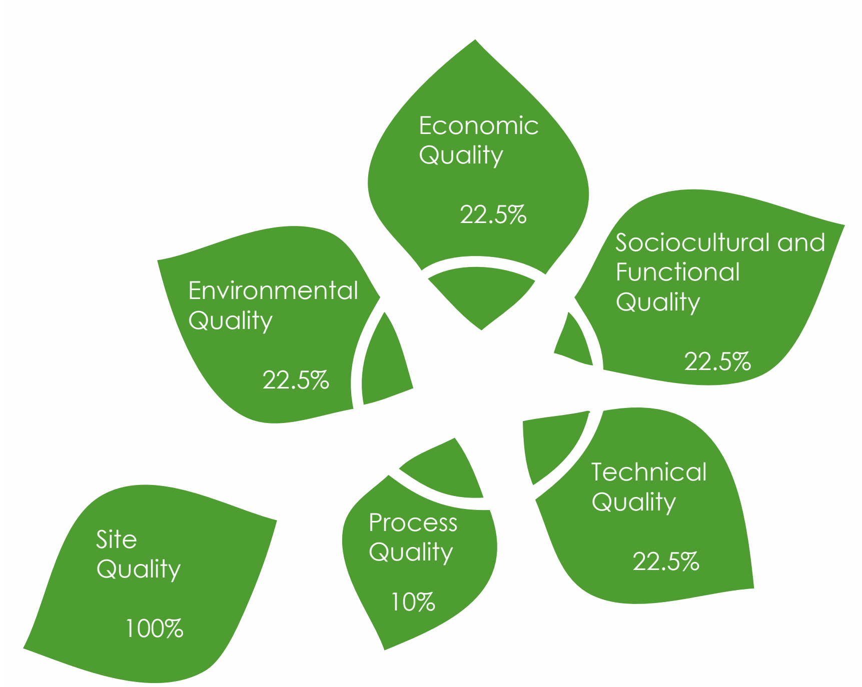




▲ *Illustration 118.2.*
Material preferences

◀ *Illustration 118.1.*
CO^2 emissions from the material production (Kolb, 2008)

REFLECTION ON DGNB CRITERIA



▲ *Illustration 119.1.*
DGNB flower chart

The 12 criteria from the DGNB scheme were chosen as a guidelines in the program of this project, and many were already integrated in the design criteria and were elaborated in the project (Life cycle assessment Primary energy, Social criteria - indoor environment, Building envelope etc.). Through the design process, these guidelines were considered in various phases of the project development. The guidelines were helpful and informative in terms of defining materials, technical requirements or social qualities. The groups of the criteria that are considered in this project are: environment, economy, social, technical, process and site qualities. The critera that has not been mentioned so far in the reporet, are considered in the following text.

Environment

Besides the Life cycle impact assessment and Life cycle assessment Primary energy, there is one more considered criteria:
1.2. Local Environmental Impact is considering the toxicity and health impact of the materials, so the use of natural materials are very much encouraged. It is also important to carefully choose coatings and decorative paints with environmental properties.
(DGNB system Denmark, 2015)

Economy

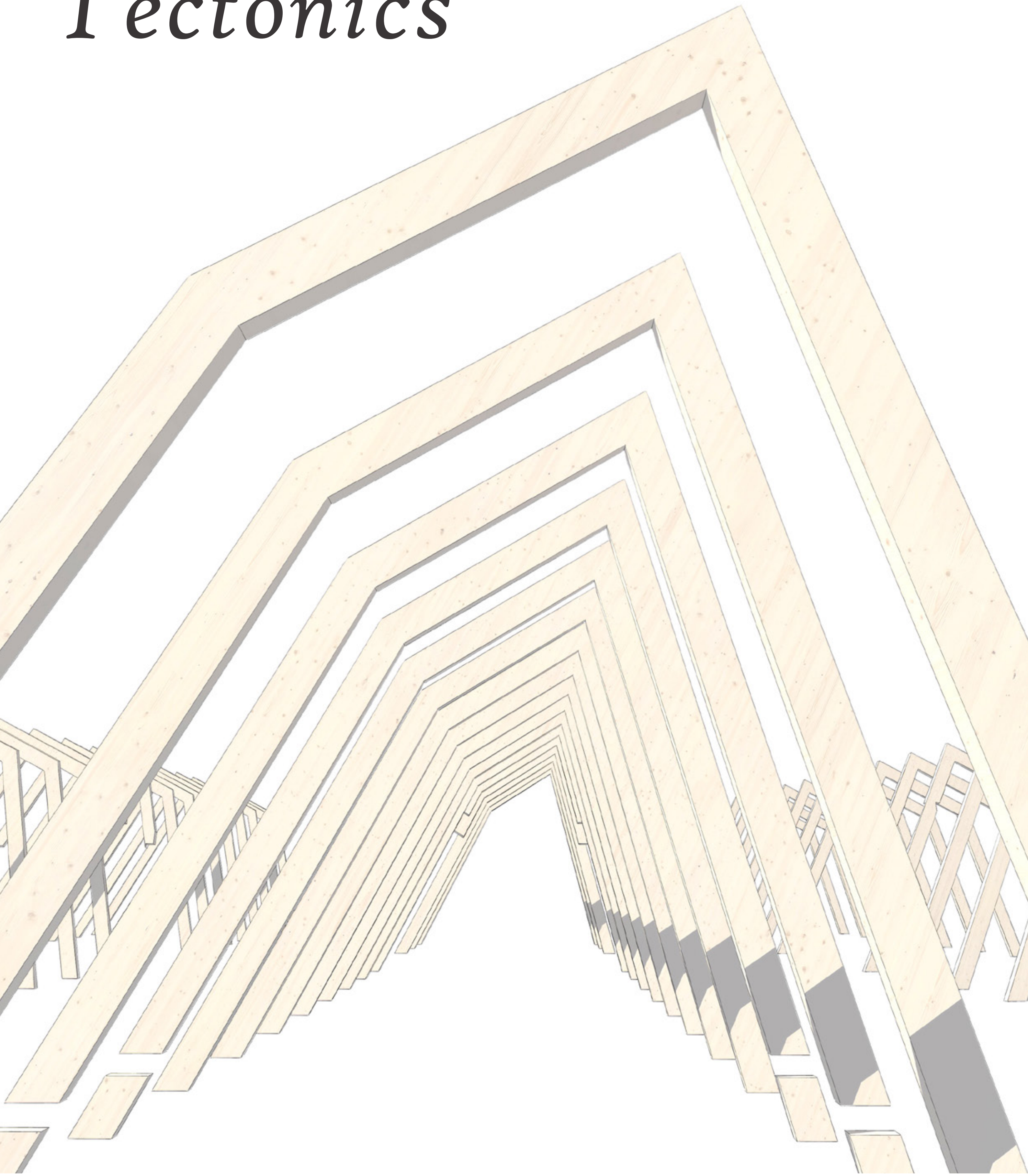
1.1. Life cycle cost are construction costs, operation costs, maintenance, replacement costs and cleaning expenses. When considering local availability and natural materials, it is assumed that the materials would be also more cost-effective and less contribution to the transport consumption. (DGNB system Denmark, 2015)

2.1. Flexibility and adaptability refer to changing requirements for building use in order to prolong the service life of the building and reduce costs through the lifecycle. In case it this wouldn not be a kindergarten, the rooms can alwazs be adapted for other public use such as home for creative workshops, reading rooms or facilities for the young people. (DGNB Denmark, 2015)

Process

1.2. Integrated design considers interdisciplinary work between collaborators using holistic approach in the design process and it has been part of this project development.
(DGNB system Denmark, 2015)

Tectonics



Structure

The Sámi people are the indigenous people Scandinavia, although they are usually "forgotten" while mentioning the Nordic people. Despite their small amount of population and social differences from the majority nations, they can show up such cultural and artistic inventions like their unique architecture.

This project is trying to avoid the formal copying of traditional architecture, the aim is rather to understand the basic principles of tectonics above the Arctic Circle and to interpret the experiences into the architectural design. Reflecting to the climate can offer numerous challenges in the design process, just like thermal compactness, orientation and rotation related to the sun and wind, or to deal with the thick snow cover.

The local "rule of thumb" is to make the inclination bigger than 30° , which is usually not enough to make the snow completely slip down, on the other hand, some snow cover can be considered as an extra insulation layer during winter.

The structure of the main buildings is a timber framework, consisting of 100x300 mm size Norway spruce beams, in a grid of 1.60 m. (Illustration 120.1) The local material can largely decrease the carbon footprint of the project, while the simplified geometry (many repeating element and similar angles at each building) helps to optimize the construction expenses as well.

▲ *Illustration 120.1*
Illustration 121.1
Timbe framework

Design process

The design process shows the development of the project through varius phases and stages. The proces was divided into 6 phases which are chronologicaly explained with sketches, drawings and simulations.

Integrated design

This project was developed through the phases of integrated design process and holistic approach. The architectural forms were continuously tested and stimulated with engineering tools in order to test their technical performance. Following the problem formulation and analyses, the sketching phase included many steps in order to fulfill the design criteria and vision. During the evolution of the design, different approaches and tools were used to confirm or emphasize the basic idea, including hand sketches, physical modeling, digital drawings and engineering simulating tools. The process was be divided into six phases which are explaining the chronological evolution and different stages of the design:

Phase 1 shows the relation to the context and the initial steps to find the design boundaries of the site, scale, dimensions and typologies.

Phase 2 includes the finding the form, the first alternatives for the building form, finding the correct organization of functions in relation of the appearance of the building.

Phase 3 shows opening to the landscape and how the light was brought to the indoor areas. That was the phase when the first experiences regarded to the integrated was used of cross-section geometries.

Phase 4 presents sun exposure simulation and a technical phase by using different simulating methods which correspond to the exposure of the sun.

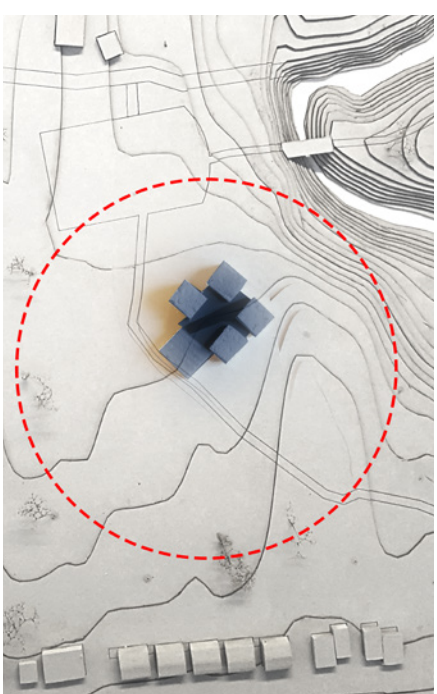
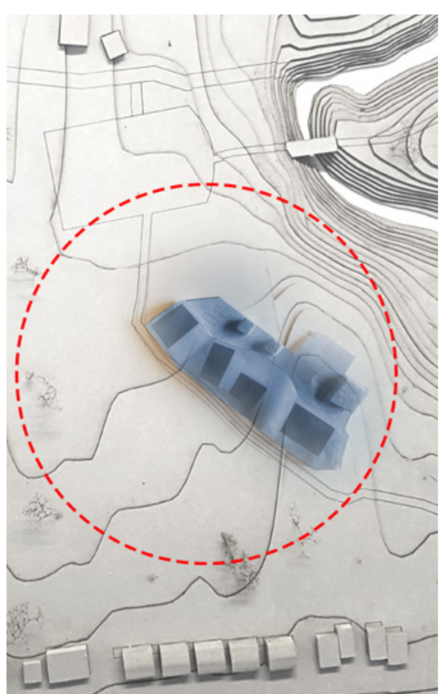
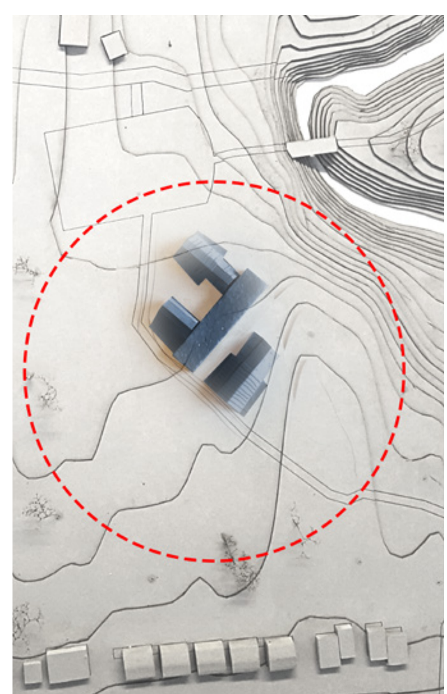
Phase 5 explains the outdoor connections and how the final indoor organization was connected with the outdoor conditions.
Phase 6 shows the connection process of the buildings and how the corridor structure was defined.

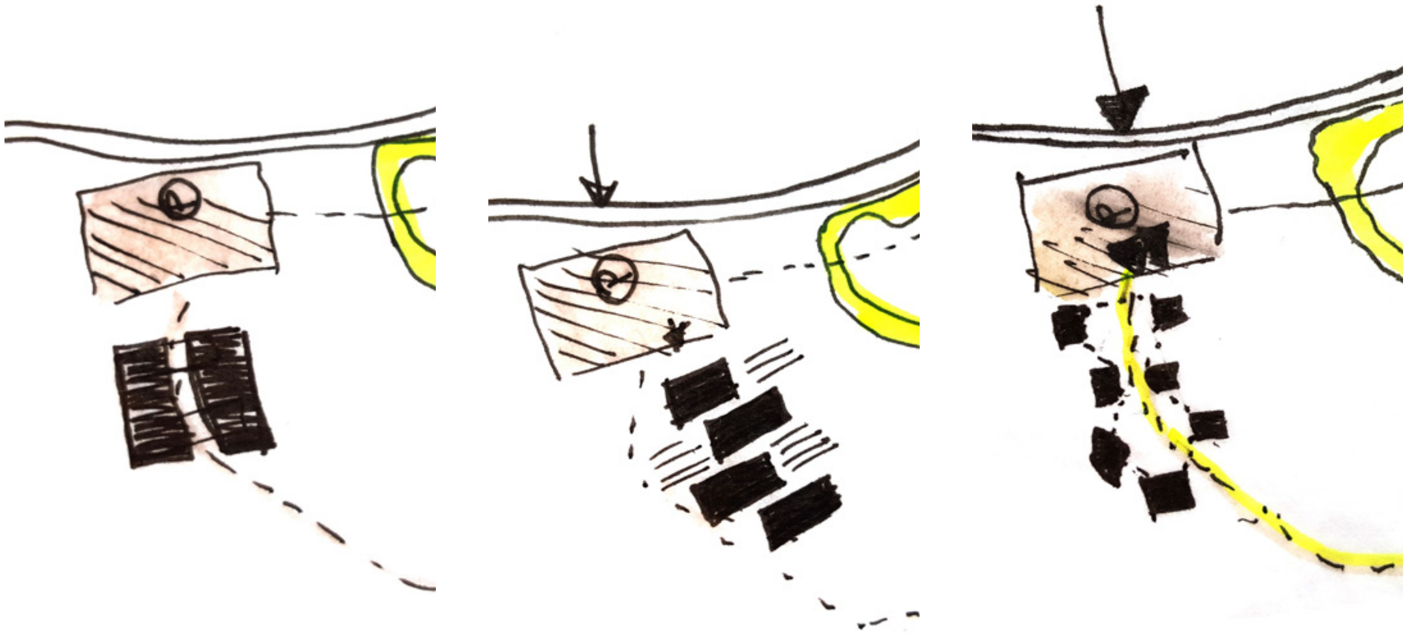
► *Illustration 124.1.*
The context model

1\ RELATION TO THE CONTEXT

The design phase has started after problem formulation and analyses. The first initial sketches were formed in their relation to the context. The outstanding nature and the area around suggested to use more open typologies, instead of closing up to the inside of the one building. The forms were examined on the very basic levels, presenting the major functional rooms in the building. The first compositions (Illustration 126.1) were all based on the premises that the design shouldn't impose to the environment, but rather blend into the existing context. The scale of the forms were following the existing nearby buildings which were mostly family houses and cabins. Since the program defined the number of children in the kindergarten (up to sixty), the composition was already scattered in several forms which would be different group rooms. On the first sketch on the left in the Illustration 126.1 the composition was formed around central atrium with several group rooms facing the atrium. The other compositions follow the similar system but forming longitudinal atrium or displaced shared area. The overall point of departure defined in the design criteria was about forming the common area for play during unfavorable weather conditions.

▼ *Illustration 126.1.*
Different compositions in the context



▲ *Illustration 127.1.*
Possible typologies: compact, lamelas or the village

Typology

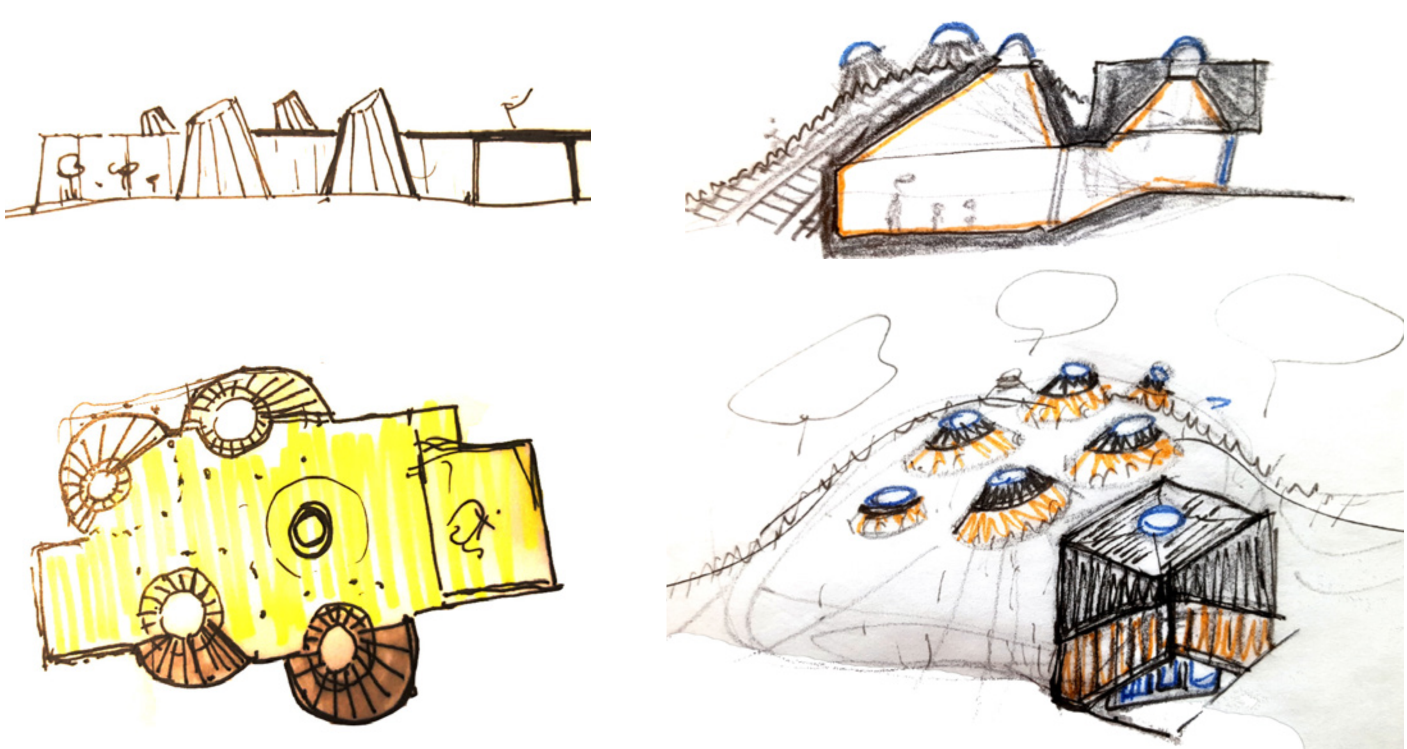
The basic sketches about possible typologies (Illustration 127.1) were used to test different options on how to respond to the context but also a functional disposition of the building. Already at this stage, it was evident that the compact building would be more massive and dominant related to the context, while the *village* option would provide less dominance but more challenges for energy demand. At this level it was insufficient to draw conclusions but it was a basis for further steps and the consideration about using the smaller scale were taken into the next phase for development.

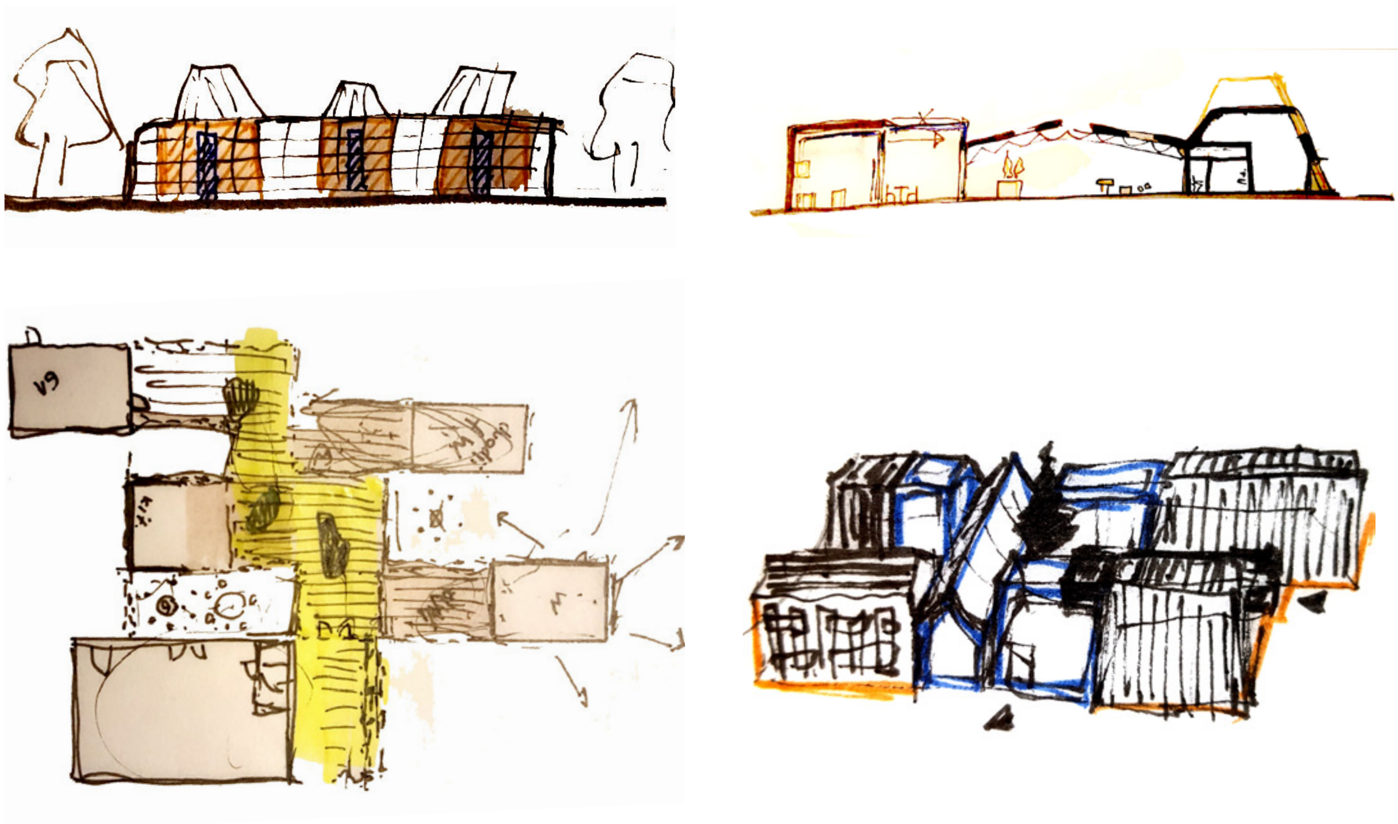
2\ FINDING A FORM

The initial sketches of the form went in all directions trying to respond to the design criteria. The major challenges in finding the forms were how to fulfill the design criteria considering snow, a common greenhouse, daylight and the interpretation of Sámi architecture. It seemed that all the criteria can't fit together: so many of the proposals were responding to only a few of the settled criteria.

The most consistent idea was a common greenhouse that is connecting the other functions together, so the compositions were mostly based around the central atrium type organization. Some proposals were trying to interpret Sámi architecture (Illustration 128.1), using the form of lavvu tent to create the group grooms. These examples were facing too many challenges and couldn't fully respond to the other criteria.

▼ *Illustration 128.1.*
Interpretations of Sámi architecture





▲ *Illustration 129.1.*
The proposal with the central greenhouse

Forming a greenhouse

The next stage was following the functional organisation of a cluster type with different group rooms and functions facing the common greenhouse (Illustration 129.1). The intention of this proposal was to create a sheltered space between outdoor and indoor area, that would also serve as a play area, growing plants and as an entrance zone. The challenge with this form was to face problems with thermal balance and structure: the large span of the greenhouse ceiling which could not cope with the snow problem. The connection between the different functions were unclear, and the total spatial form of the buildings became too complex (Illustration 129.1/D). The smaller clusters and their form didn't respond to the large ceiling area of the greenhouse.
There were also some ideas about inserting the skylights into the large greenhouse roof (Illustration 129.1/A), but it was still not a solution to the snow challenge and the complexity of the forms.

3\OPENING TO THE LANDSCAPE

The building volume

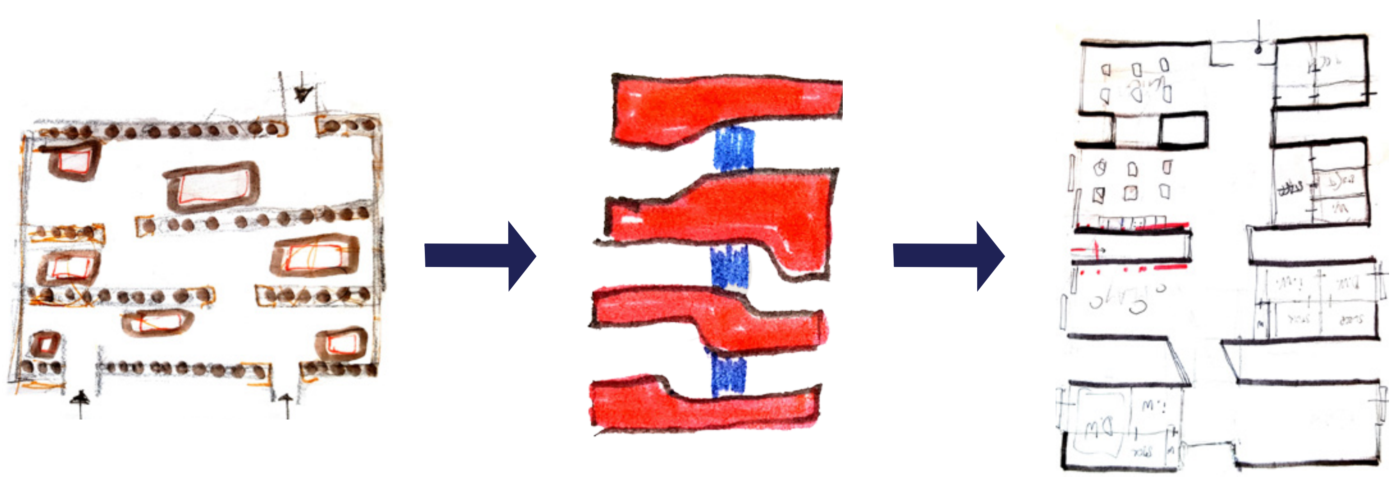
After the last phase, the design process was shifted one step back, trying to examine the building typology again with some basic functional organisation. The functional clusters (group rooms) were placed next to each other on their longitudinal side forming a single rectangle shaped volume (Illustration 130.1/A).

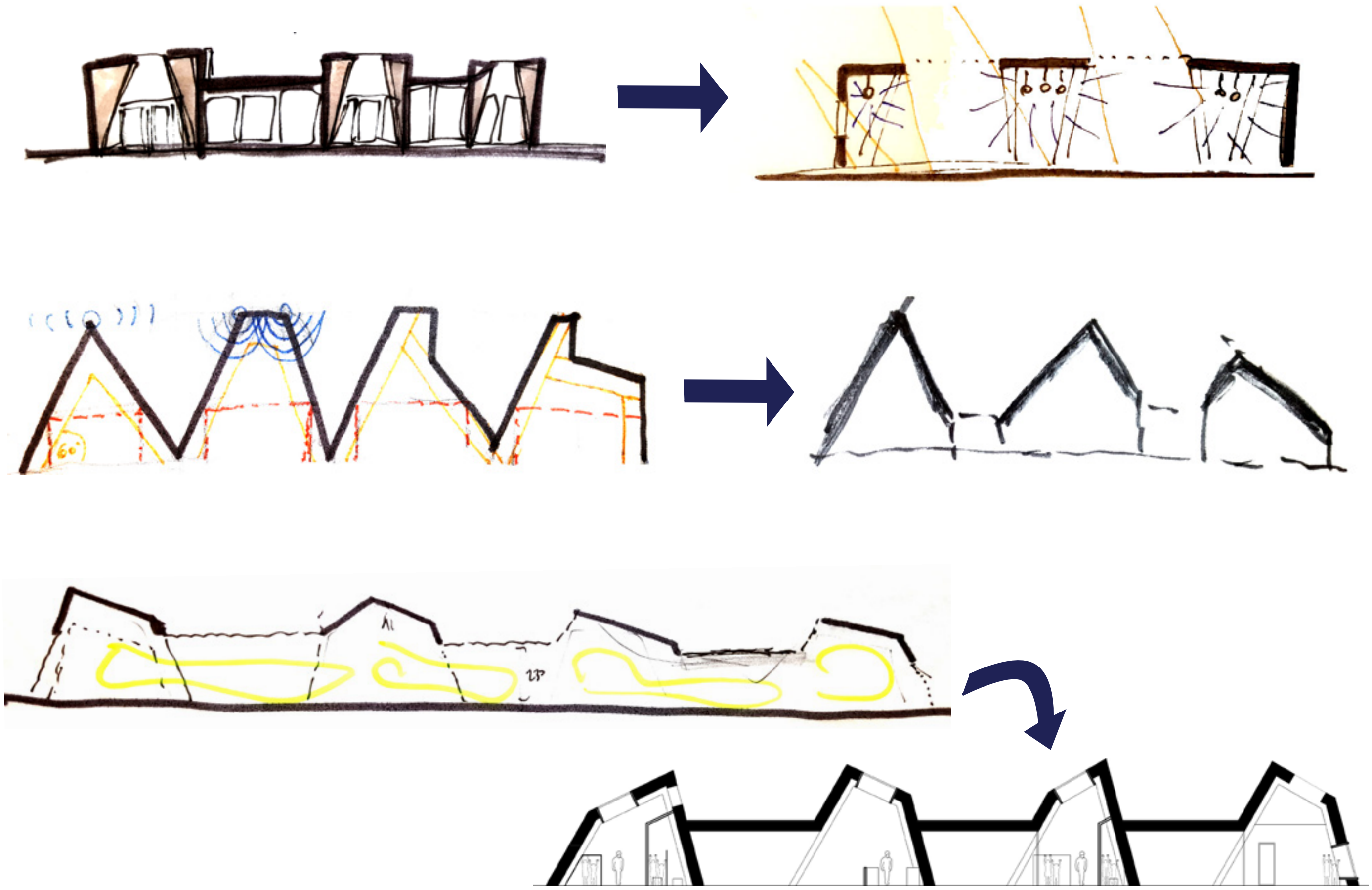
The purpose of this step was to examine the new connections and the so formed common areas in the building volume. It was concluded that the problem with light could be solved with introducing small atriums around the clusters, bringing light around the common areas. The volume had to get more massive which was not satisfactory in relation to the context but also the response to the snow.

The clusters were then separated to form more openings to the landscape and allowing more light into the building. By dividing the lamelas there became new spaces formed in between. These spaces started to form a transition zone and communication towards the outdoors.

At this point, the center of the attention was not anymore in the atriums inside of the buildings, but on the frequency zones that lead to the outdoors. The challenge with these zones were the fact that they could be too narrow and uncomfortable if they are not developed carefully.

▼ *Illustration 130.1.*
Evolution of the volumes





▲ *Illustration 131.1.*
Evolution of the sections

Section forms

After separating the buildings, the next step was to define the form and the character of these clusters which would also respond to the given criteria. The evolution of the sections started with the rectangular section (Illustration 131.1/A-B), which transformed to more tilted roofs that would allow snow to slide off the surfaces. In this case it was also important to realise that this roofs could form the negative area that could accumulate even more snow if they are not separated enough (Illustration 131/C).

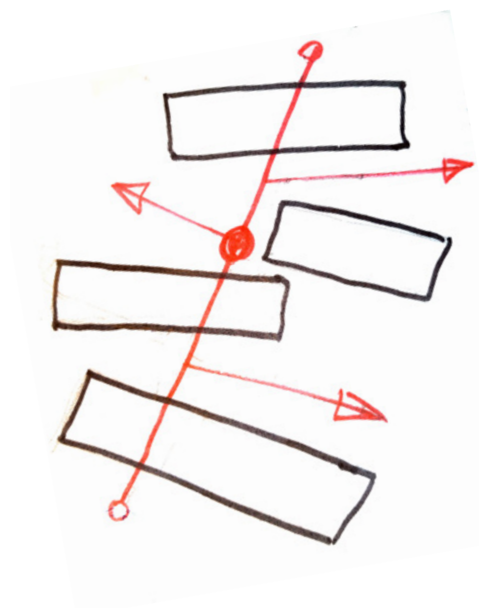
The section was also enhanced by introducing the skylights along the roof surfaces, but also enabling the thermal buoyancy for efficient natural ventilation in the space (Illustration 131/F). The remaining challenge was still to achieve the proper angles for the snow distribution but at the same time to get the adequate angle for the sun radiation which is below 45°. The aspect that was also taken into account was that the lower angle of the roof envelope might decrease the usable area in the indoor spaces, so the proper balance had to be achieved in this matter.

4\SUN EXPOSURE SIMULATIONS

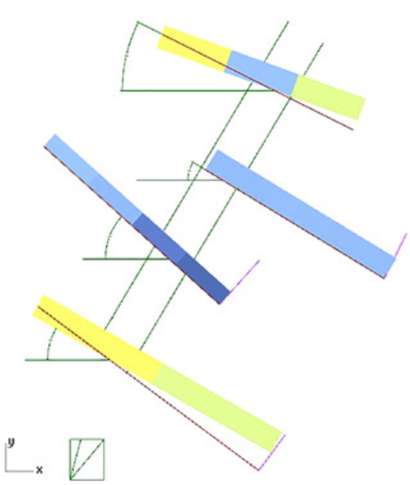
Rotations

In order to reduce the negative impact of the two nearby hills (north and south), the building wings were rotated away from the straight southward. Moreover, each building wing has a different need for rotation and even for inclination of their surfaces, in order to diminish the self-shading factor of the complex.

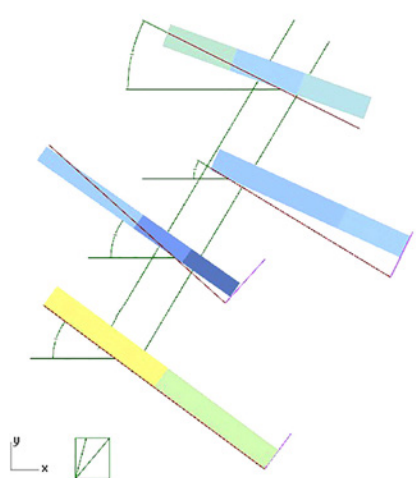
Software Ladybug combined with Galapagos is able to make evolutionary simulation of complex geometries, studying different combinations of the given geometry parameters. In this project, three groups of parameters were tested with the method above. The first group of parameters allowed the surfaces to have inclination separately between 50° and 75°. The second group allowed different maximum heights between 4 and 5 meters. The third group was controlling the horizontal rotation of each wing, between 0° (perpendicular to southward) and 50°. The Galapagos simulation was making numerous combinations of these factors and simulated it with Ladybug to find which combinations can reach the maximum total solar radiation. Similar final results can also be reached from very different cases, such as the ones illustrated below.



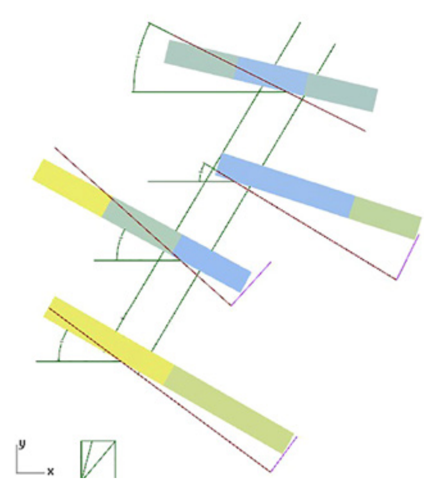
▼ *Illustration 132.1.*
Different outcomes from Galapagos



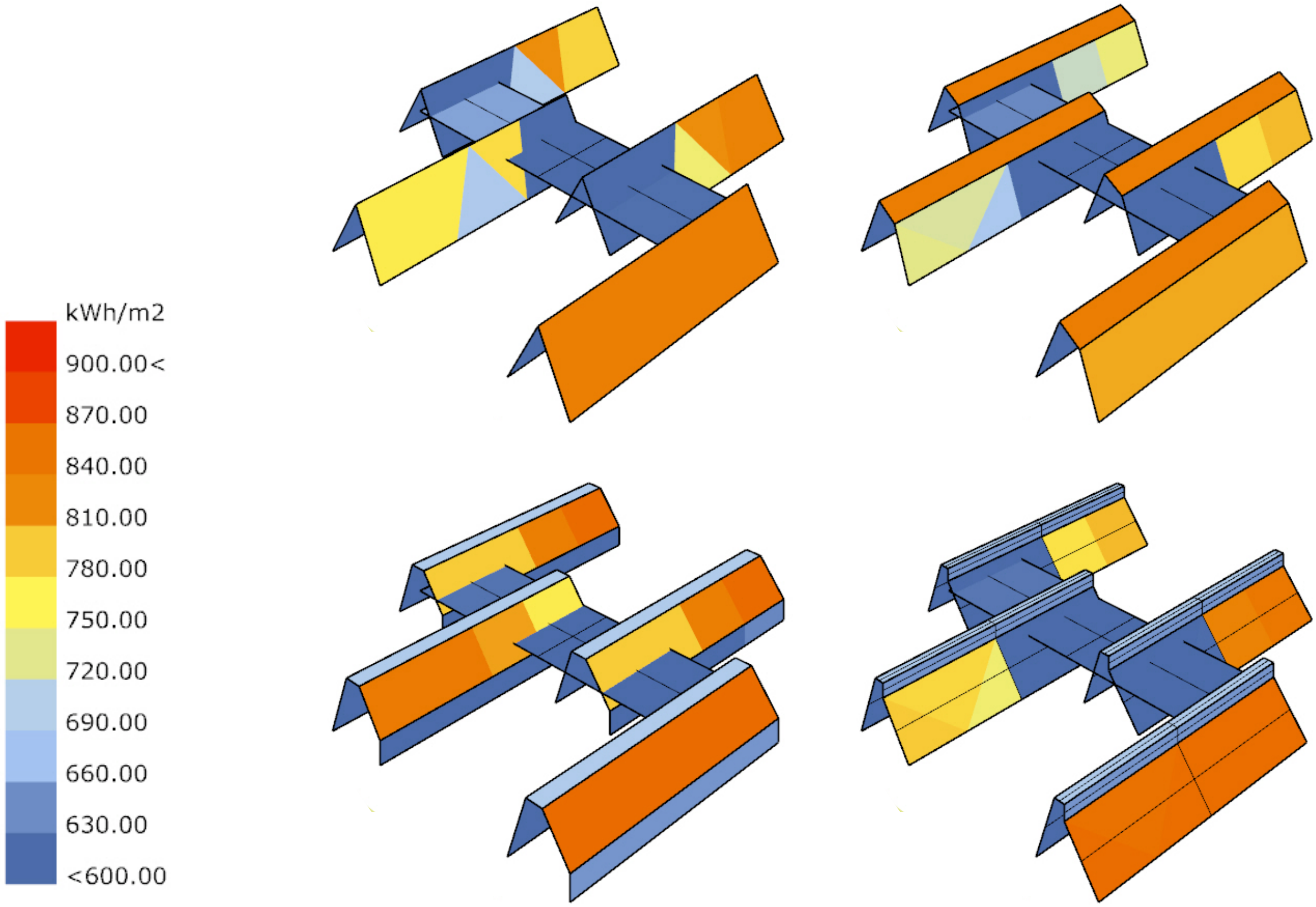
A: angle 50°, heght 5m, rotation 30°
B: angle 60°, heght 5m, rotation 45°
C: angle 50°, heght 5m, rotation 40°
D: angle 50°, heght 4m, rotation 25°
Total radiation: 330 MW



A: angle 50°, heght 5m, rotation 35°
B: angle 60°, heght 5m, rotation 35°
C: angle 50°, heght 5m, rotation 50°
D: angle 50°, heght 5m, rotation 25°
Total radiation: 344 MW



A: angle 50°, heght 5m, rotation 30°
B: angle 60°, heght 5m, rotation 30°
C: angle 50°, heght 5m, rotation 20°
D: angle 50°, heght 5m, rotation 20°
Total radiation: 356 MW



▲ *Illustration 133.1.*
Sun radiation exposure in Ladybug

Ladybug analyses

From the early stages of the design process, the roof surfaces were intended for photovoltaic cells that were installed on the southern elevation of the buildings. The simulations of the sun exposure were important part of the section development because it was important to examine options for the optimal sun radiation. The best results were achieved when the sun rays are perpendicular to the pv cells, but this was hard to achieve because of the low angle of of sun (max 45° in summer).

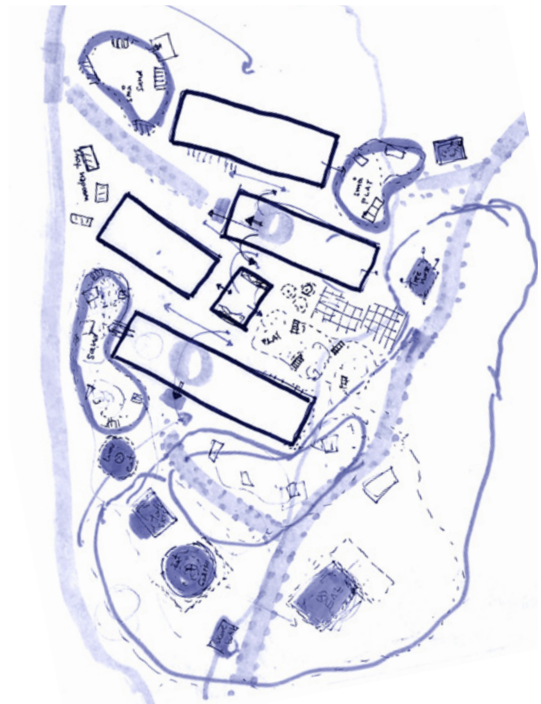
Different cross sections of the building wings were tested in software Ladybug in order to get the amount of the solar radiation per m2 on the surfaces (Illustration 133.1). The input angles were set between the 50° and 75° which were defined in relation to snow, functional usability and the sun radiation angles. The calculation also took into account the context of the two hills from the north and south side which slightly decreased the performance photovoltaic cells.

The simulation shows better result as the angle become closer to the 45° while it gets worse as the buildings get more shadows from each other. The positioning of the photovoltaic cells were determined by these results, providing average sun radiation from 700 kWh/m2.

5\ OUTDOOR CONNECTIONS

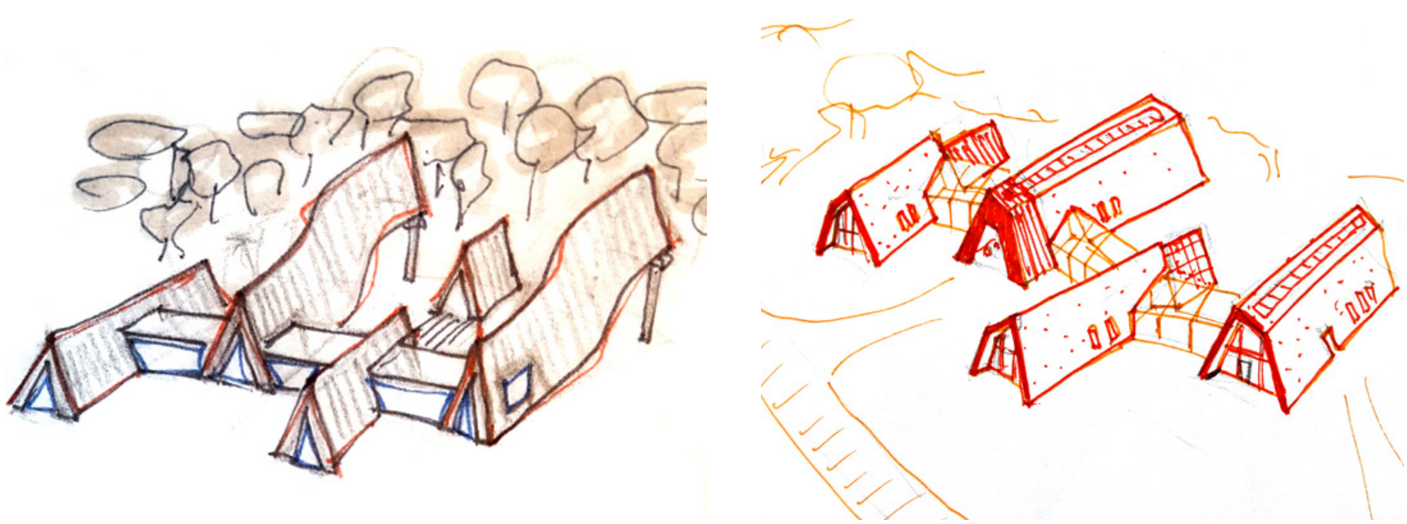
The outdoor areas are considered at the early stage of the project when the composition of the building started to split and open to the landscape. The areas in between the buildings are rotated in a way to form the direction of movement which are making more connections to the outdoors (Illustration 134.1).

The first steps were to connect the access to the site with the functional rooms (dirty wardrobes). The more entrances were introduces in the proposal so the different users can use different areas at the same time. The pathway from the south is connected to the dirty wardrobe of the older group, while the main entrance is kept from the west. The next important direction was to create exit points from dirty workshop and greenhouse where the activities connected to the inner spaces (digging area, vegetable garden). The main activity area is still the forest around the complex that is accompanied by the functional toys and play areas.

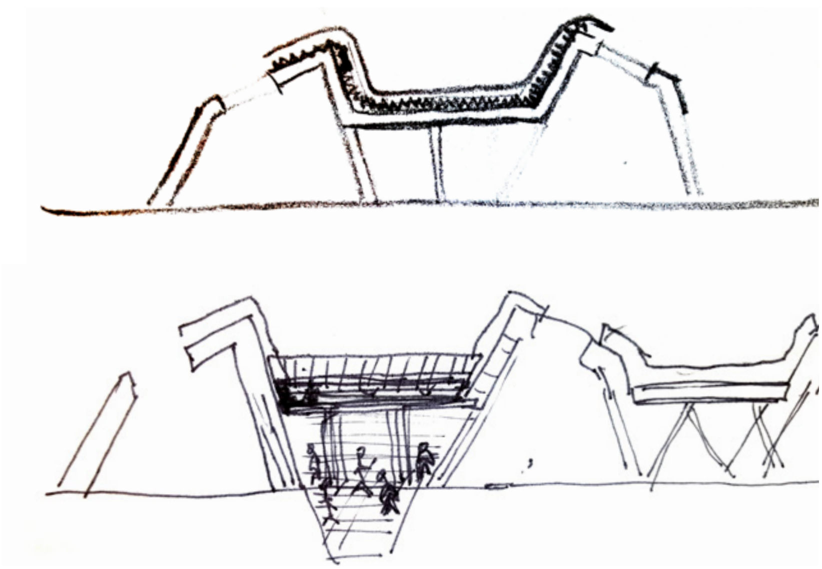


◀*Illustration 134.1.*
First draft of outdoor activities

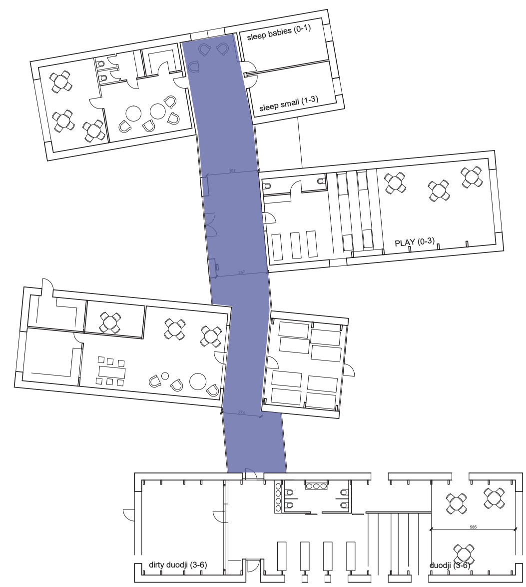
▼ *Illustration 134.1.*
Spatial forms in the landscape



6\CONNECTING THE BULDINGS



▲ *Illustration 135.1.*
The corridor construction

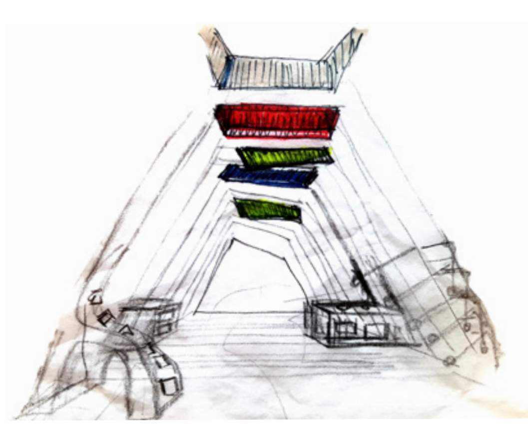


▶ *Illustration 135.2.*
The first draf of the corridor plan

The biggest challenge of the existing building composition was the area connecting all the wings together, that was formed as a corridor. Since the building volumes are plain longitudinal trapezoids it was unclear how to introduce a completely new form without imposing a threat to the building expresion. The first draft of the corridor construction had a heavy ceiling continuously flowing from the turf envelope of the other buildings (Illustration 135.1). In this case the appearance seemed too heavy and disturbing for the total composition of the main buildings. For this reason ,the new lighter materials were implemented in order to form a transparent passage as a transition zone between indoors and outdoors as it was stated at the beginning of the design phases.

Indoors

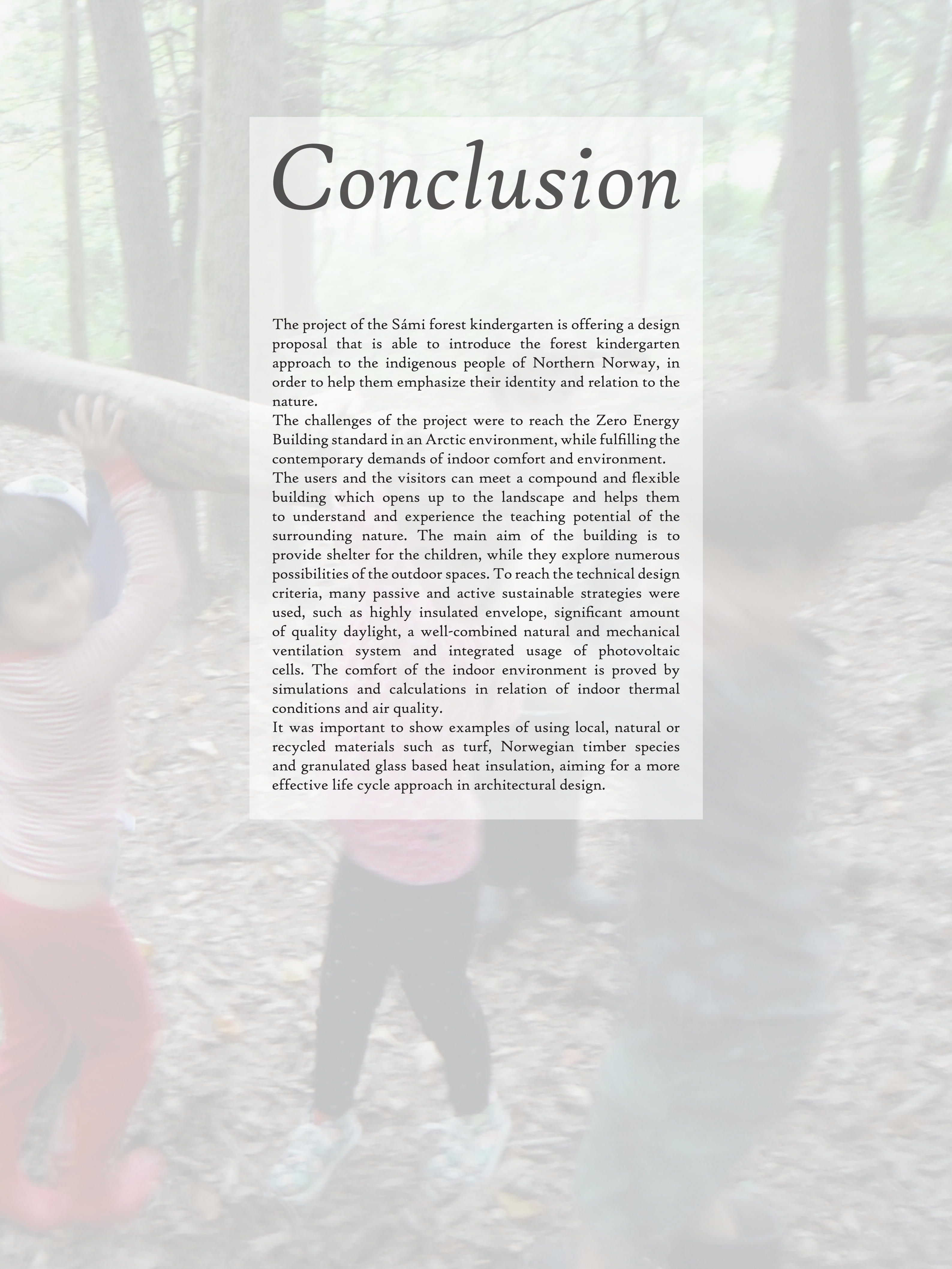
The indoor perception was expressed with the timber structure but also the appearance of skylights that are providing daylight. The light boxes are coloured to reflect the diffused light in Sámi colours: blue, red, green and yellow.



▶ *Illustration 135.3.*
Indoor experience of the skylights

Epilogue

The Epilogue contains conclusion of the project and reflection upon the whole desgin proces, learning goals and experiences. At the end of this chapters there are also are also Reference list and Illustration list with all the used literature and sources for this project.



Conclusion

The project of the Sámi forest kindergarten is offering a design proposal that is able to introduce the forest kindergarten approach to the indigenous people of Northern Norway, in order to help them emphasize their identity and relation to the nature.

The challenges of the project were to reach the Zero Energy Building standard in an Arctic environment, while fulfilling the contemporary demands of indoor comfort and environment.

The users and the visitors can meet a compound and flexible building which opens up to the landscape and helps them to understand and experience the teaching potential of the surrounding nature. The main aim of the building is to provide shelter for the children, while they explore numerous possibilities of the outdoor spaces. To reach the technical design criteria, many passive and active sustainable strategies were used, such as highly insulated envelope, significant amount of quality daylight, a well-combined natural and mechanical ventilation system and integrated usage of photovoltaic cells. The comfort of the indoor environment is proved by simulations and calculations in relation of indoor thermal conditions and air quality.

It was important to show examples of using local, natural or recycled materials such as turf, Norwegian timber species and granulated glass based heat insulation, aiming for a more effective life cycle approach in architectural design.

Reflection

The project's primary goal was finding the way to adapt the forest kindergarten approach into the Sámi education system in Tromsø. The project task had numerous challenges about how to deal with the Sámi integration and self-identity and at the same time fulfilling the energy requirements to reach the netZEB standard in Norway. The forest kindergarten approach is well-situated for the life and the common psyche of indigenous children and it offers a possibility to help them finding their own, nature-based identity even in a modern and continuously spreading urban environment. The project can be an important contemporary institute in Tromsø and draw attention to the importance of the area and the people who live there now.

The difficulties we faced were mainly based on the long research and analysis period. The lack of any exact examples, methods or similar projects before left many questions unanswered, especially the ones related to the current netZEB policies, and the difference compared to Danish-based methods we used. At many cases we had to make assumptions to span over the lack of information.These all took time from further development of other areas, such as proper tectonic experiences and LCA and DGNB studies.

Taking a study trip on the site location was significant help in overcoming the barriers we had had that far. Visiting Tromsø helped us to understand a lot of doubts that we had about climate, environment, social conditions and everyday life. We managed to organize meetings and interviews with excellent and relevant people, who were extremely helpful to our case, giving us information and guidance during the time there.

As architects, we consider a success that the complete design criteria were managed to be fulfilled with the final design. Our point of departure was the wish to interpret local traditional architecture without directly copying it, but looking for answers to the same questions as the "old ones", instead. These answers need to be in relation of today's building technology and the user needs for indoor and energy qualities.

The Integrated Design Process was crucial for performance studies and simulations since the early stage of the project. Softwares Be15, BSim, Ladybug and Galapagos became important tools and their usage is remarkable on the final appearance of the complex, as well.

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List of Illustrations

Illustration 27.1.
Oimat.no (2015)
http://oimat.no/pilot-pa-ung-restaurant-i-nord-trondelag/

Illustration 28.1.
Educationdenmark.wordpress.com (2015)
https://educationdenmark.wordpress.com/forest-kindergarten-in-brunderslev/

Illustration 30.1
Majkaidete.mk (2013)
http://majkaidete.mk/shto-se-toa-shumski-gradinki/

Illustration 31.1
Foxtrail.fjallraven.com (2016)
http://foxtrail.fjallraven.com/2016/07/29/come-rain-or-shine-learning-in-nature/

Illustration 33.1
Educationdenmark.wordpress.com (2015)
https://educationdenmark.wordpress.com/forest-kindergarten-in-brunderslev/

Illustration 34.1
VisitNorway.com (2016)
https://www.visitnorway.com/places-to-go/northern-norway/tromso/

Illustration 35.1
Own photo

Illustration 36.1
Arhdaily.com (2013)
http://www.archdaily.com/587556/beiersdorf-children-s-day-care-centre-troplo-kids-kadawittfeldarchitektur

Illustration 37.1
Own illustration
based on Tromso.maps.arcgis.com (2016)
[online]http://tromso.maps.arcgis.com/apps/webappviewer/index.html?appid=2e0f4fecb2574be682267eb02f9f5d74#)

Illustration 38.1
Own photo (based on Google Earth)

Illustration 39.1
Own photo

Illustration 40.1 - 43.1
Own illustration
based on Tromso.maps.arcgis.com (2016)
[online]http://tromso.maps.arcgis.com/apps/webappviewer/index.html?appid=2e0f4fecb2574be682267eb02f9f5d74#)

Illustration 44.1 - 45.1
Own illustration (based on Sancalc.net, 2017)

Illustration 46.1
Own illustration (based on Byggforsk.no, 2017)

Illustration 47.1
Own illustration (based on Yr.no, 2017)

Illustration 49.1
Own photo

Illustration 50.1
Fabricana (2014)
http://www.fabricana.com/blog-item/are-eco-friendly-and-organic-same

Illustration 51.1
DGNB system Denmark (2015)

Illustration 52.1
European Comission (2011)
http://ec.europa.eu/environment/resource_efficiency/index_en.htm

Illustration 53.1
Architizer.com (2015)
https://architizer.com/projects/ovre-forsland-og-bjornstokk-hydraulic-power-stations/

Illustration 54.1
Execuflora (n.a.)
http://execuflora.co.za/articles/interest-pieces/blog-list/added-credibility-for-using-indoor-plants

Illustration 55.1
Vecteezy.com (n.a.)
https://www.vecteezy.com/free-vector/green-earth

Illustration 57.1
Edform (2012)
https://www.edform.org/alumni-mentorwise

Illustration 58.1
R3dd.it (2012)
https://www.r3dd.it/r/imagesofnorway/new/

Illustration p. 62

Illustration p. 64
Own photo

Illustration 67.1-74.1
Own illustration

Illustration 75.1
Pinterest.com (2016)
Playgroundfinder.com (2015)
[online]http://www.playgroundfinder.com/closeplayground.php?type=playground&playgroundid=2386

Illustration 77.1 - 115.1
Own illustration

Illustration 116.1
A\ Nordus Ecospan (2016)
www.nordusdecospan.com/en/collection/vivid-spruce/
B\ CUBO (2015), by courtesy of Lars Juel Thiis, Cubo Architects
C\ Resawn Timber Co. (2016)
http://resawntimberco.com/product-category/charred-cedar

Illustration 117.1
A\ Shutterstock.com (n.a.)
B\ Arroway Textures (n.a.)
arroway-textures.ch
C\ Meyvaert Glas (n.a.)
www.meyvaert-glas.be/en_GB/pages/products-types

Illustration 118.1
Own illustration

Illustration 119.1
DGNB system Denmark (2015)

Illustration 120.1
Own illustration

Illustration 122.1
Bloggar.visitsweden.com (2015)
http://bloggar.visitsweden.com/oas/2015/12/10/

Illustration 125.1 - 135.1
Own illustration

Illustration p. 136
Sapminature.com (2016)
http://www.sapminature.com/sv/

Illustration p. 138
Flying Deer Nature Center (n.a.)
https://www.flyingdeernaturecenter.org/blog/wooly-bears-forest-kindergarten

Illustration p. 140
Foxtrail.fjallraven.com (2016)
http://foxtrail.fjallraven.com/2016/07/29/come-rain-or-shine-learning-in-nature/

Illustration p. 148
Sapmi Nature (2012)
http://www.sapminature.com/

Appendix

In this chapter all the materials were collected which contribute to better understanding of the project. All the final result charts and tables from Be15 and BSim can be found here, together with hand calculations that validates the chosen architectural solutions: PV area need, mechanical ventillation, U value.

A\ Be15 RESULTS

SBi	**Beregningskerne 8.16.1.6**												
Be15 results: South building, Climate data: Norway, Tromsø													
Energy requirement													
MWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Heating	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
El. 2015	1,27	0,85	0,30	0,05	0,02	0,01	0,01	0,01	0,04	0,52	0,99	1,21	5,29
El. 2020	1,27	0,85	0,30	0,05	0,02	0,01	0,01	0,01	0,04	0,52	0,99	1,21	5,29
Excess temperature in rooms	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total energy requirement													
MWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Existing building	3,18	2,13	0,74	0,13	0,05	0,02	0,02	0,03	0,11	1,30	2,47	3,02	13,23
kWh/m²	14,70	9,90	3,40	0,60	0,20	0,10	0,10	0,20	0,50	6,00	11,40	14,00	61,20
BR 2015	3,18	2,13	0,74	0,13	0,05	0,02	0,02	0,03	0,11	1,30	2,47	3,02	13,23
kWh/m²	14,70	9,90	3,40	0,60	0,20	0,10	0,10	0,20	0,50	6,00	11,40	14,00	61,20
Buildings 2020	2,29	1,54	0,53	0,10	0,04	0,02	0,02	0,02	0,08	0,94	1,78	2,18	9,52
kWh/m²	10,60	7,10	2,50	0,40	0,20	0,10	0,10	0,10	0,40	4,30	8,20	10,10	44,00
Heat requirement. External supply to building													
MWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Boiler/district heating	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Gas radiators	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Gas water heaters	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
kWh/m²	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
El. requirement. External supply to building. Building service													
kWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Central heating plant	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Domestic hot water	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Ventilation plant	37,00	33,00	24,00	11,00	7,00	4,00	3,00	7,00	19,00	32,00	36,00	37,00	**249,00**
Solar heat	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Room heating	1139,00	768,00	264,00	37,00	8,00	0,00	0,00	0,00	18,00	449,00	858,00	1074,00	**4617,00**
Local el. water heaters	6,00	5,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	68,00
Cooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Lighting	92,00	47,00	1,00	0,00	0,00	0,00	0,00	0,00	1,00	34,00	89,00	92,00	**357,00**
Total for building service	1273,00	854,00	295,00	54,00	20,00	10,00	9,00	13,00	44,00	521,00	988,00	1209,00	**5291,00**
kWh/m²	5,90	3,90	1,40	0,20	0,10	0,00	0,00	0,10	0,20	2,40	4,60	5,60	**24,50**
El. requirement. External supply to building. Other el. consumption													
kWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Other lighting	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Equipment	287,00	260,00	287,00	278,00	287,00	278,00	287,00	287,00	278,00	287,00	278,00	287,00	3384,00
Total for other	287,00	260,00	287,00	278,00	287,00	278,00	287,00	287,00	278,00	287,00	278,00	287,00	**3384,00**
kWh/m²	1,30	1,20	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	**15,60**
El. requirement. External supply to building. Total el. requirement													
kWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
The building	1561,00	1113,00	583,00	332,00	307,00	288,00	297,00	301,00	322,00	808,00	1267,00	1496,00	8675,00
VE-el indregnet 2015	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Resulterende elbehov 2015	1273,00	854,00	295,00	54,00	20,00	10,00	9,00	13,00	44,00	521,00	988,00	1209,00	5291,00
VE-el indregnet 2020	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Resulterende elbehov 2020	1273,00	854,00	295,00	54,00	20,00	10,00	9,00	13,00	44,00	521,00	988,00	1209,00	**5291,00**
Room heating, Heating requirement													
MWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
In rooms	1,07	0,70	0,20	0,00	0,00	0,00	0,00	0,00	0,02	0,42	0,81	1,01	4,25
Heat coil	0,07	0,06	0,06	0,04	0,01	0,00	0,00	0,00	0,00	0,03	0,05	0,06	0,37
Pipe loss	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total	1,14	0,77	0,26	0,04	0,01	0,00	0,00	0,00	0,02	0,45	0,86	1,07	4,62
Total, kWh/m²	5,30	3,60	1,20	0,20	0,00	0,00	0,00	0,00	0,10	2,10	4,00	5,00	**21,30**
Room heating, Fulfilment of heat requirement													
MWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Boiler/district heating	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Solar heating plant	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heat pump	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
El. heating of rooms	1,14	0,77	0,26	0,04	0,01	0,00	0,00	0,00	0,02	0,45	0,86	1,07	4,62
El-VF in ventilation plant	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Wood stoves etc.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total	1,14	0,77	0,26	0,04	0,01	0,00	0,00	0,00	0,02	0,45	0,86	1,07	4,62
Domestic hot water, Hot-water requirement													
m³	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Total consumption	1,10	1,00	1,10	1,10	1,10	1,10	1,10	1,10	1,10	1,10	1,10	1,10	13,00
Domestic hot water, Supply													
m³	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Central heating plant	1,00	0,90	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	11,70
Local el. heaters	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	**1,30**
Local gas heaters	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total	1,10	1,00	1,10	1,10	1,10	1,10	1,10	1,10	1,10	1,10	1,10	1,10	13,00
Domestic hot water, Heating requirement													
MWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Central water container	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,61
Local el. heater	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,07
Local gas heater	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heating total	0,06	0,05	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,68
Total loss	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total	0,06	0,05	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,68
kWh/m²	0,30	0,20	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	3,20

SBi	Beregningskerne 8.16.1.6												
Be15 results: South building, Climate data: Norway, Tromsø													
Domestic hot water, Fulfilment of heating requirement													
MWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Boiler/district heating	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Solar heating plant	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heat pump	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
El. heating of central water container	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
El. tracing of DHW pipes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Local el. water heaters	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,07
Local gas heaters	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,07
El. requirement in heating plant													
kWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Direct room heating	1139,00	768,00	264,00	37,00	8,00	0,00	0,00	0,00	18,00	449,00	858,00	1074,00	4617,00
Pumps	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total	1139,00	768,00	264,00	37,00	8,00	0,00	0,00	0,00	18,00	449,00	858,00	1074,00	4617,00
kWh/m²	5,30	3,60	1,20	0,20	0,00	0,00	0,00	0,00	0,10	2,10	4,00	5,00	**21,30**
El. requirement in ventilation plant													
kWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Heat coils	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Ventilators	37,00	33,00	24,00	11,00	7,00	4,00	3,00	7,00	19,00	32,00	36,00	37,00	249,00
Total	37,00	33,00	24,00	11,00	7,00	4,00	3,00	7,00	19,00	32,00	36,00	37,00	249,00
kWh/m²	0,20	0,20	0,10	0,10	0,00	0,00	0,00	0,00	0,10	0,10	0,20	0,20	**1,20**
El. requirement for lighting. Included in the building's performance													
kWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
General during service life	92,00	47,00	1,00	0,00	0,00	0,00	0,00	0,00	1,00	34,00	89,00	92,00	357,00
General stand-by when not in service	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Working lights in service life	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total	92,00	47,00	1,00	0,00	0,00	0,00	0,00	0,00	1,00	34,00	89,00	92,00	357,00
kWh/m²	0,40	0,20	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,20	0,40	0,40	**1,70**
El. requirement for epuipment													
kWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Equipment	287,00	260,00	287,00	278,00	287,00	278,00	287,00	287,00	278,00	287,00	278,00	287,00	3384,00
Night consumption, equipment	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Special equipment always	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total	287,00	260,00	287,00	278,00	287,00	278,00	287,00	287,00	278,00	287,00	278,00	287,00	**3384,00**
kWh/m²	1,30	1,20	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	**15,60**
Solar cells and wind mills													
kWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
The building's total el. requirement	1561,00	1113,00	583,00	332,00	307,00	288,00	297,00	301,00	322,00	808,00	1267,00	1496,00	8675,00
El. requirement for building service	1273,00	854,00	295,00	54,00	20,00	10,00	9,00	13,00	44,00	521,00	988,00	1209,00	5291,00
Solar cell performance	0,00	116,00	696,00	1489,00	1756,00	1726,00	1608,00	1144,00	604,00	185,00	23,00	0,00	**9347,00**
kWh/m²	0,00	0,50	3,20	6,90	8,10	8,00	7,40	5,30	2,80	0,90	0,10	0,00	43,20
Wind mill performance	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
kWh/m²	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
VE-el performance	0,00	116,00	696,00	1489,00	1756,00	1726,00	1608,00	1144,00	604,00	185,00	23,00	0,00	9347,00
kWh/m²	0,00	0,50	3,20	6,90	8,10	8,00	7,40	5,30	2,80	0,90	0,10	0,00	**43,20**
VE-el included 2015	0,00	27,00	161,00	345,00	406,00	399,00	372,00	265,00	140,00	43,00	5,00	0,00	2163,00
kWh/m²	0,00	0,10	0,70	1,60	1,90	1,80	1,70	1,20	0,60	0,20	0,00	0,00	10,00
VE-el included 2020	0,00	37,00	224,00	479,00	564,00	555,00	517,00	368,00	194,00	59,00	7,00	0,00	3004,00
kWh/m²	0,00	0,20	1,00	2,20	2,60	2,60	2,40	1,70	0,90	0,30	0,00	0,00	13,90
Net heating requirement in rooms													
MWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Heat loss	1,63	1,51	1,59	1,32	1,08	0,84	0,64	0,71	0,95	1,25	1,41	1,57	14,49
Incident solar radiation	0,00	0,42	1,42	2,37	2,80	2,82	2,62	1,84	1,06	0,49	0,08	0,00	15,91
Internal supplement	0,57	0,48	0,48	0,46	0,48	0,46	0,48	0,48	0,46	0,51	0,55	0,57	6,00
From pipes and water container	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total supplement	0,57	0,90	1,90	2,84	3,28	3,28	3,10	2,32	1,53	1,01	0,63	0,57	21,91
Relative supplement	0,35	0,59	1,19	2,14	3,02	3,90	4,85	3,27	1,60	0,81	0,45	0,36	
Utilization factor	0,97	0,90	0,68	0,44	0,32	0,25	0,20	0,30	0,55	0,82	0,94	0,97	0,61
Part of month with heating	1,00	1,00	0,66	0,00	0,00	0,00	0,00	0,00	0,17	1,00	1,00	1,00	
Heating requirement	1,07	0,70	0,20	0,00	0,00	0,00	0,00	0,00	0,02	0,42	0,81	1,01	4,25
Heating in ventilating heat surface	0,07	0,06	0,06	0,04	0,01	0,00	0,00	0,00	0,00	0,03	0,05	0,06	0,37
Net. room heating	1,14	0,77	0,26	0,04	0,01	0,00	0,00	0,00	0,02	0,45	0,86	1,07	4,62
Total, kWh/m²	5,30	3,60	1,20	0,20	0,00	0,00	0,00	0,00	0,10	2,10	4,00	5,00	19,60
Solar shield, forced vent., night vent. and cooling													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Solar shield, red. factor	0,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,00	
Forcing, share	0,00	0,00	0,36	0,70	0,83	0,89	0,92	0,81	0,48	0,14	0,00	0,00	
Night ventilation, share	0,00	0,00	0,00	0,00	0,24	0,32	0,39	0,24	0,00	0,00	0,00	0,00	
Mechanical cooling, share	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
Mean ventilation. Sum of natural and mechanical ventilation													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
m³/s	0,06	0,06	0,12	0,17	0,23	0,26	0,28	0,23	0,13	0,08	0,06	0,06	
l/s m²	0,28	0,28	0,53	0,78	1,09	1,20	1,29	1,08	0,62	0,38	0,28	0,28	
Share of time at 26.0 °C room temperature or above													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Time share	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

B\ U-VALUE CALCULATION

U value of the building elements are calculated as folowing:

$$U_{value} = \frac{1}{R_{se} + \frac{l_1}{\lambda_1} + \frac{l_2}{\lambda_2} \dots + \frac{l_n}{\lambda_n} + R_{si}}$$

R_{se} : external transition value 0,04 m^2K/W
R_{si} : internal transition value 0,13 m^2K/W
λ: thermal conductivity coefficient
l: material thickness

The main elements of the building envelope are:

EXTERNAL WALLS AND ROOF

Birch plywood, l = 0,02 m, λ = 0,14 W/mK
Air layer, l = 0,02 m, λ = 0,024 W/mK
Vapour barrier – negligible for the calculation
Structural insulated panel: oriented strand board (OSB), l = 0,02 m, λ = 0,13 W/mK
thermal insulation (foam glass granules), l = 0,28 m, λ = 0,031 W/mK
oriented strand board (OSB), l = 0,02 m, λ = 0,13 W/mK
Waterproof membrane (+roof barrier), protection mat, drainage layer, filter layer – negligible for the calculation
Green substrate (humid soil), l = 0,15 m, λ = 1,4 W/mK

$$U_{value} = \frac{1}{0{,}04\text{m}^2\text{K/W} + \frac{0{,}02m}{0{,}14\ \text{W/mK}} + \frac{0{,}025m}{0{,}024\text{W/mK}} + \frac{0{,}02m}{0{,}13\text{W/mK}} + \frac{0{,}3m}{0{,}031\text{W/mK}} + \frac{0{,}02m}{0{,}13\text{W/mK}} + \frac{0{,}15m}{1{,}4\text{W/mC}} + 0{,}13\text{m}^2\text{K/W}} = \mathbf{0,092W/m^2K}$$

WINDOWS

Glass units (Clima Guard nrG): 4+12+4+12+4
Gas filling : krypton
Light transmittance: 73%
U-value =0,6W/m²K
g value (solar heat gain): 0,62

Passive house wooden frame =0,7W/m²K

Total U-value of the windows : 0,66 W/m²K (also depending on the frame/glazing ratio)

C\ MECHANICAL VENTILATION

FRESH AIR SUPPLY

The requrements for the fresh air supply for kindergartens (BR2015) are following:

- 3 l/s per child
- 5 l/s per adult
- 0,35 l/s per m2 of the floor area

The input dat used for the calculation are (Dirty wardrobe, clean wardrobe, duodji workshop):

- maximum number of children: 40
- number of adults: 6
- netto floor area: 120 m2
- volume of the room =333m3

The requred fresh air supply is:

$Volume\ flow = 3 \times 40 + 5 \times 6 + 0{,}35 \times 120 = 196\ l/s$

$196\ l/s \times 3{,}6 = 691.2\ m3/h$

CHOOSING THE VENTILATION UNIT

The volume flow rate of the unit: 150-320 m3/h (average 235 m3/h)

The numer of units in the room:

$$691.2\frac{m3}{h} \div 235\frac{m3}{h} = 2.94$$

The minimum numer of requred units is **3.**

AIR CHANGE RATE

$$ACH = \frac{Volume\ flow}{Room\ volume} = 2{,}09\ h^{-1}$$

AIR VELOCITY

- inlet air opening area: 0,16m2

$$v = \frac{Volume\ flow}{Opening\ area} = \frac{235\ m3/h}{0{,}16m2} = 1468\frac{m}{h} = 0{,}4m/s$$

D\ AREA CALCULATION FOR PHOTOVOLTAIC CELLS - BUILDING A

Zero Energy balance are based on calculation definitions by Sartori, et al and the European standard EN 15603:

$$E_{net} = E_{exp,el} f_{exp,el} - E_{del,el} f_{del,el}$$

Primary energy factors for solar energy according to prEN 15603 are:

PV electricity temporary exported and reimported later:
$f_{exp,el} = 2$

Grid electricity by hydropower plant:
$f_{del,el} = 1$

$0 = 2 \times E_{exp,el} - E_{del,el}$
$E_{exp,el} = E_{del,el} \div 2$

ENERGY REQUIREMENT FOR BUILDING ENERGY DEMAND
(electric heating, DHW, ventilation, lighting)

Total energy requirement for electric heating = 5.291 kWh/ year (from Be15, appendix A)

$E_{exp,el} = 5.291\text{kWh} \div 2 = 2645{,}5kWh$

CALCULATION FOR THE PV AREA

C × D × E = energy use

$$C = \frac{A \times B}{100}$$

The chosen type of the pv panels is *SunPower X-series* (Sunpower.com, 2017)
A = total area of modules, m²
B = module efficiency, % (Average module efficency 21%, used 19%)
C = installed power, kW
D = evaluation of the system factor (Optimal system with high efficiency inverter: 0,75)
E = solar radiation intensity, kWh/m² (average sun radiation in Tromsø is 700kWh/m²)

In order to calculate total area of the solar cells, the eqasion is modified as:

$$A = \frac{2645{,}5\text{kWh} \times 100}{B \times D \times E}$$

Total requred area for the pv panels:

$$A = \frac{2645{,}5 \text{ kWh} \times 100}{19 \times 0.75 \times 700 \text{ kWh/m}^2} = \mathbf{26,52m}^2$$

ENERGY USE FOR EQUIPMENT

Predicted energy use for equipment= 3.384 kWh/year (from Be15, appendix A)

$$E_{exp,el} = 3.384\text{kWh} \div 2 = 1692kWh$$

CALCULATION FOR THE PV AREA

$$A = \frac{1692 \text{ kWh} \times 100}{19 \times 0.75 \times 700 \text{ kWh/m}^2} = \mathbf{16,96m}^2$$

TOTAL AREA REQURED FOR PV PANELS

26,52 + 16,96 = 43,48 m²

All the required area for PV pannels will be placed on the roof area with 60° angle.
Total PV area designed for buildings are:

building A: 100 m^2
building B: 20 m^2
building C: 25 m^2
building D: 10 m^2

The excess electricity production on building A will be used for the rest of the buildings to balance the need in order to reach energy neutrality.

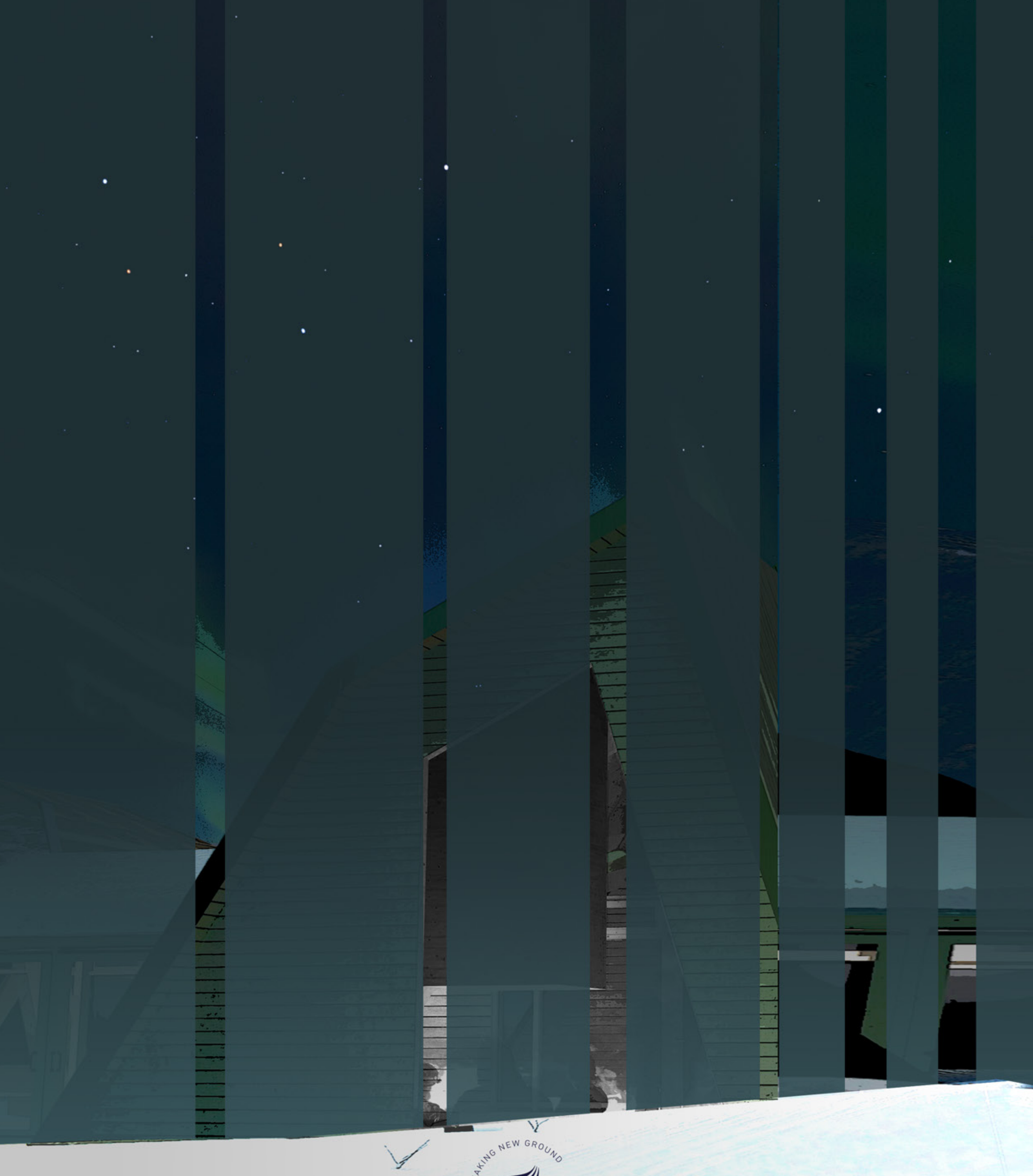
E\ BSim HEAT BALANCE RESULTS

Termal zone Wardrobe/workshop

Thermal zone *Wardrobe/workshop*	Sum/Mean	January	February	March	April	May	Juni	July	August	September	October	November	December
qHeating	3399,77	703,81	643,1	356,87	128,23	0	0	0	0	0	398,65	530,17	638,95
qCooling	0	0	0	0	0	0	0	0	0	0	0	0	0
qInfiltration	-5014,27	-481,62	-424,66	-490,3	-521,21	-463,23	-449,57	-363,25	-313,99	-286,05	-373,65	-390,54	-456,21
qVenting	-5933,98	0	0	0	0	-1388,19	-1550,67	-1388,93	-1116,43	-489,75	0	0	0
qSunRad	13855,95	10,22	144,89	1006,74	1601,45	2601,66	2858,08	2388,87	1749,62	1019,4	452,23	22,78	0
qPeople	3570,48	314,64	273,6	287,28	300,96	314,64	273,6	314,64	300,96	287,28	314,64	287,28	300,96
qEquipment	458,06	40,37	35,1	36,86	38,61	40,37	35,1	40,37	38,61	36,86	40,37	36,86	38,61
qLighting	1804	472	249	26	0	0	0	0	0	18	145	410	484
qTransmission	-10877,02	-904,21	-802,64	-1045,25	-1210,18	-1105,25	-1166,53	-991,7	-658,77	-585,73	-789,63	-757,79	-859,35
qMixing	0	0	0	0	0	0	0	0	0	0	0	0	0
qVentilation	-1262,99	-155,2	-118,4	-178,2	-337,85	0	0	0	0	0	-187,61	-138,76	-146,96
Sum	0	0	0	0	0	0	0	0	0	0	0	0	0
tOutdoor mean(°C)	3,2	-2,8	-2,8	-1,4	1,1	5,4	9,4	11,5	11,3	7	2,5	-0,2	-2,3
tOp mean(°C)	20,4	15,9	15,4	18	22,4	24,3	28,5	26,9	24,8	19,4	17,7	16,1	15,6
AirChange(/h)	1	0,8	0,8	0,8	0,8	1,2	1,3	1,4	1,2	0,8	0,8	0,8	0,8
Rel. Moisture(%)	27,2	25,1	26,5	21,5	20,1	22,2	23	31,9	33,3	38,3	32,7	25,6	26,5
Co2(ppm)	418,7	423,3	421	415,8	420,9	421,5	399	407	410,9	444,7	422,7	417,9	419,4
PAQ(-)	0,6	0,9	0,9	0,8	0,6	0,5	0,3	0,2	0,3	0,6	0,7	0,9	0,9
Hours > 21	3439	0	1	103	416	599	705	744	669	147	55	0	0
Hours > 26	1342	0	0	16	118	181	466	332	203	24	2	0	0
Hours > 27	1051	0	0	10	83	139	395	263	140	20	1	0	0
Hours < 20	4890	739	663	586	215	81	5	0	38	500	631	702	730
FanPow	718,2	108,68	94,5	99,23	103,95	0	0	0	0	0	108,68	99,23	103,95
HtRec	5976,56	1042,69	812,86	852,18	818,17	0	0	0	0	0	751,24	775,56	923,86
ClRec	0	0	0	0	0	0	0	0	0	0	0	0	0
HtCoil	866,83	193,17	155,27	111,22	39,65	0	0	0	0	0	82,45	121,38	163,69
ClCoil	0	0	0	0	0	0	0	0	0	0	0	0	0

Termal zone - Passage

Thermal zone *The Passage*	Sum/Mean	January	February	March	April	May	Juni	July	August	September	October	November	December
qHeating	0	0	0	0	0	0	0	0	0	0	0	0	0
qCooling	0	0	0	0	0	0	0	0	0	0	0	0	0
qInfiltration	-1196,83	-50,33	-44,92	-83,98	-131,63	-186,88	-209,53	-157,64	-114,5	-76,22	-51,07	-40,98	-49,16
qVenting	-4555,21	-86,15	-61,75	-109,03	-287,51	-850,77	-1067,79	-1014,43	-717,23	-138,13	-79,22	-64,06	-79,13
qSunRad	25317,54	17,82	224,84	1355,78	2748,65	4891,3	5841,14	4705,65	3312,08	1582,95	592,38	44,94	0
qPeople	1566	138	120	126	132	138	120	138	132	126	138	126	132
qEquipment	0	0	0	0	0	0	0	0	0	0	0	0	0
qLighting	1628	446	188	20	0	0	0	0	0	6	118	366	484
qTransmission	-22759,5	-465,35	-426,17	-1308,77	-2461,52	-3991,66	-4683,81	-3671,57	-2612,35	-1500,61	-718,08	-431,91	-487,71
qMixing	0	0	0	0	0	0	0	0	0	0	0	0	0
qVentilation	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	0	0	0	0	0	0	0	0	0	0	0	0	0
tOutdoor mean(°C)	3,2	-2,8	-2,8	-1,4	1,1	5,4	9,4	11,5	11,3	7	2,5	-0,2	-2,3
tOp mean(°C)	9,5	0,4	0,4	3,8	9,2	16,6	22,3	21,3	18,6	12	5,8	2,6	0,9
AirChange(/h)	0,8	0,5	0,5	0,5	0,6	1,1	1,4	1,6	1,4	0,5	0,5	0,5	0,5
Rel. Moisture(%)	57,6	72,8	75,6	57,3	47,7	36,1	33,9	44,9	48,1	60,1	73,7	66,6	74,5
Co2(ppm)	448,9	485,2	481,5	471	456,9	414,8	390	390,9	391,4	462,9	485,2	478,2	479,2
PAQ(-)	0,8	1	1	1	1	0,8	0,5	0,4	0,5	0,8	1	1	1
Hours > 21	1097	0	0	0	20	180	358	316	204	19	0	0	0
Hours > 26	541	0	0	0	0	73	222	177	69	0	0	0	0
Hours > 27	451	0	0	0	0	60	189	152	50	0	0	0	0
Hours < 20	7515	744	672	744	697	543	332	391	486	698	744	720	744
FanPow	0	0	0	0	0	0	0	0	0	0	0	0	0
HtRec	0	0	0	0	0	0	0	0	0	0	0	0	0
ClRec	0	0	0	0	0	0	0	0	0	0	0	0	0
HtCoil	0	0	0	0	0	0	0	0	0	0	0	0	0
ClCoil	0	0	0	0	0	0	0	0	0	0	0	0	0



SÁMI FOREST KINDERGARTEN
MSC ARCHITECTURE MASTER THESIS PROJECT

ANA HABIJANEC - TOTTO TAMAS RÁTKAI
AALBORG UNIVERSITY

2017