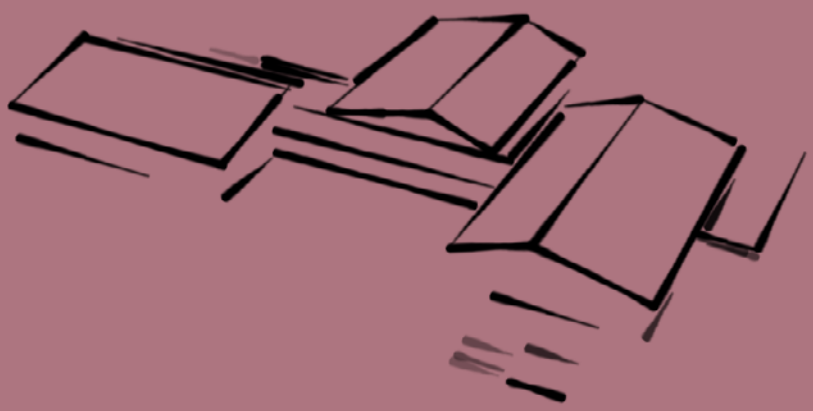
THE BARN

VISITOR CENTRE

PROGRAM



MSc04 ARC-S | Group 20
Aalborg Universitet

Project title	Visitor Centre for Skagen
Theme	Sustainability
Author	Abhay Kumar Kandula Drashti Shantiv Mehta
Semester and group number	MA4-ARK20 03/02/2020 - 19/11/2020
Supervisor	Andrea Jelic Rasmus Lund Jensen
Number of pages	180

Architecture & Design
Department of Architecture, Design and Media Technology
Aalborg University

ABSTRACT

The site is situated in the northern part of Skagen, which is a town situated in North Jutland in Denmark. The aim of the project is to a create a visitor centre to manage and educate the high rate of tourism in Skagen of the various points of interests available. The report focuses on giving the users an interactive experience simultaneously creating a fluent transition between locally available materials to minimize the environmental impact of the building. The investigation involves various steps which begin with site visits to understand the site and its surroundings. An investigative questionnaire provided to the tourist bureau of Skagen helps in understanding what the focus points and requirements are for the various types of tourists. The visitor centre aims to educate the users about Skagen through exhibitions and workshops while guiding them through Skagen. Various site analyses help in understanding the approach to the site, the site and its surroundings. To meet the Zero Energy building standard different forms of passive and active strategies are implemented. The use of renewable sources of energy and methods to reduce the energy requirements of the building help in achieving this goal. The life cycle assessment of the various materials for construction taken into consideration help in narrowing down the choice of materials while reducing the environmental impact of the building.

READING GUIDE

The report begins by understanding the aim of the project, methodology being implemented and a thorough study of the possibilities in Skagen, which lead to a problem formulation to guide the design at hand. The various case studies that are conducted help in understanding how the connectivity inside a visitor centre operates. The next phase involves a series of analyses that are conducted to study and understand the site. These analyses lead to forming a design criterion which gives us the requirements needed to be kept in mind.

The next phase includes the design process which deals with the initial sketches and concepts, building development and optimization that synthesize into a final design form. After which the presentation of the finalized design which usually deals with the layout and 3Dimensional visualization of the building with relation to the site is done. The report concludes with an epilogue that includes a conclusion and reflection of what has been achieved in the design and how it could have been done better. The appendix attached separately shows various details and interviews that are conducted.

TABLE OF CONTENTS

01 PROLOGUE

WHAT IS A VISITOR CENTRE?

A visitor centre is designed to offer the tourists a first experience of everything the city has to offer. The main function of it is to guide and inform the tourists. They help guide the tourists, educate them, promote the local sights of interest and sometimes act as the entry way to a place. Nowadays, it plays a bigger role in telling the story of the place or expressing the atmosphere of the place, many now becoming destinations and experiences themselves.

WHERE A VISITOR CENTRE?

The aim of the project is to develop a sustainable visitor centre in the town of Skagen which is the North most point of Denmark. The natural environment of the area showcases a variety of elements like land, sea, dry dunes, moist wetlands and marshy areas. This attracts millions of tourists all around the world to the place where the two seas meet. Apart from that Skagen offers a rich history of cultural and historical places which would also gather interests from tourists. Though Skagen has enormous potential, the tourists are uninformed due to the lack of a visitor centre that would direct them to experience all the qualities it has to offer.

WHY A VISITOR CENTRE?

The aim of the visitor centre is to be a multi-functional design that would help the tourists, locals and internationals while acting as a cultural centre for hosting local events of the place and neighbourhood. It would be designed in order to incorporate the site and surroundings into the visitor centre. It will serve the tourists by informing them about rich possibilities in the area. It can boost their knowledge and create more varied experiences. It will also help preserve the area of Skagen Odde while bringing awareness regarding the environment to the visitors.

Illustration 1: Site picture

INTEGRATED DESIGN PROCESS

The integrated design process is interdisciplinary method which is rooted in problem-based learning. It is not a pre-set design approach that inhibits creative iterations but allows to gauge the different design approaches with more strategies at the earliest design stage possible. It is a realization that most of the design potential is defined at the earliest stage and thus, it is necessary to have the involvement of various disciplines from the initial stages itself (Danny, 2004). The process consists of five phases with the purpose of working through the phases in an iterative loop. The five phases are: 1. Problem Formulation: states the main questions and challenges which help in developing the idea and vision of the project. 2. Analysis: helps to gain the basic knowledge about the site and its potential through investigation which assists in developing the initial strategies and define the design criteria. 3. Sketching: attempts to find a design solution, evaluated on multiple aspects: visual impression, functional, constructional, energy consumption, indoor environment by using tools like hand drawn sketches, model making, 3D simulation software. 4. Synthesis: finding the final expression of the design through detailed development of the form. 5. Presentation: illustrates the goals, design criteria, vision implemented for the project by developed drawings and model. Designing through this method ensures the designer to return to the previous phases with a better knowledge and understanding of the design. It also provides guidelines for integrating aesthetics, functionality, climatic and energy aspects early in the process which helps in creating a building with architectonic quality (Knudstrup, 2005).

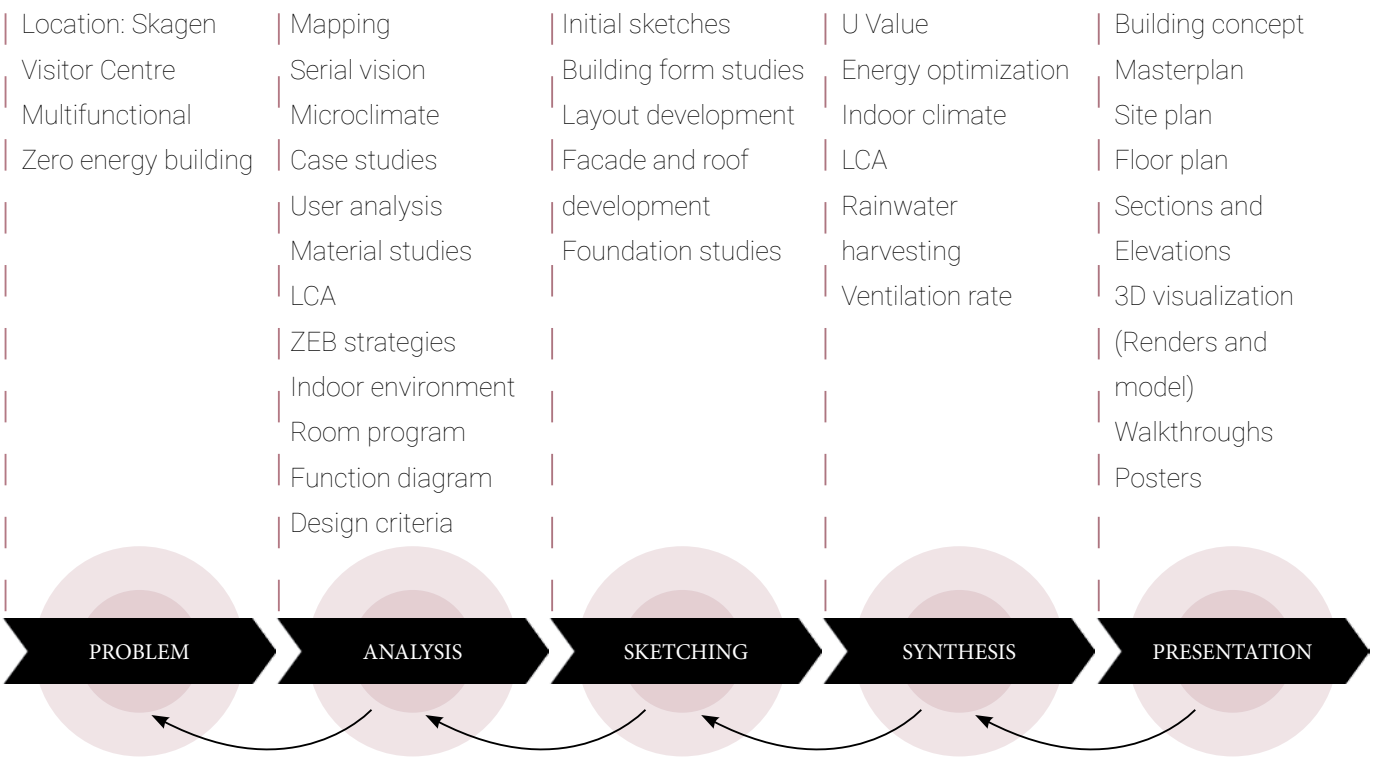


Illustration 2: Integrated Design Process

METHODOLOGY	DESCRIPTION	USAGE
INFORMAL INTERVIEW	An informal interview is conducted with the tourism bureau in Skagen for clarification and guidance of certain aspects of the project.	The answers provided by the department helps in assisting us with functions and provisions required for the design. It also gives an understanding of the potential users and seasonal traffic.
CASE STUDIES	Studies are conducted digitally and sometimes physically of similar projects as the chosen to get inspiration.	Case studies help in what are the functions provided and how are the spaced and placed in similar projects. They also give some design ideas and modern methods to tackle certain issues and how to work on the sustainable principles of the project.
MAPPING	Mapping is a method used to analyse the site and its surroundings such as site location, building typology, infrastructure etc.	This method helps in understanding the site, surroundings and context which acts as an important part of through the sketching phase.
SERIAL VISION	This is a method in which a series of pictures are taken to present a cinematic sequence in a planned route.	It helps in analysing the changes of the city scape while moving along a premeditated route. While shaping the entrances from the different access points serial vision also lets us perceive the approach and appearance of the project from the various routes.
MICROCLIMATE	This is a method in which the climatic conditions in and around the site is analysed through research and software's such as rhino and grasshopper.	The analysis of the sun path and wind which is conducted in grasshopper help in the placement of windows, openings and solar panels accordingly.
USER ANALYSIS	In this process research is done on the types of users and number of users that would be utilising the project.	This helps in classifying the users to provide functions according to the desired user group. It also helps with spatiality of the room.
MATERIAL ANALYSIS	Materials are researched which are locally or easily available and would be most suited for constructing the desired project.	The study of the materials is conducted from the initial stages itself to see which materials would be most ecological and provide the best indoor climate

METHODOLOGY	DESCRIPTION	USAGE
LCA	Lca is the life cycle assessment of various materials taken into consideration using the lcabyg tool.	Lca helps in analysing the materials with reduced carbon emissions and a low global warming potential used for the design.
SKETCHING	Sketching is one of the initial stages of designing where sketches and visualization of the design can be done through free hand sketches,doodles and conceptual ideas.	It helps in visually developing the design and assuming or working towards how the finalized designs outcome would look like. It also helps with the layout, facade and landscape ideas of the design.
3D MODELING	3D modelling can be done using various software such as SketchUp, Rhino, Revit etc. It includes placement of the planned layout in a 3-dimensional perspective.	3D modelling helps with understanding the volumes of the spaces and functions being placed in the design. The volumes of the building also help in understanding the energy cosumption and indoor climatic conditions of the design.
SIMULATION	Simulation of the design's energy or indoor climatic conditions can be done using software such as BE18 and BSim.	Simplified models help in calculating the buildings performance in terms of energy or indoor climatic conditions which help in determining alternate options if required.
RENDERS	Renders and modeling is done through softwares such as Lumion, Vray or rhino.	Renders help in visualizing how the outcome of the design can be perceived. Materials and surrounding landscape also can be visualised to see how the design would act with respect to the site and its surroundings.
WALKTHROUGH	Walk through are video clips or renders that can be done using software such as Lumion, Enscape etc.	Walkthroughs help in visualizing how a person walking through the project would see the design let it be interiors or exteriors.

Table 1: Methodology - usage and description

02 FRAMEWORK

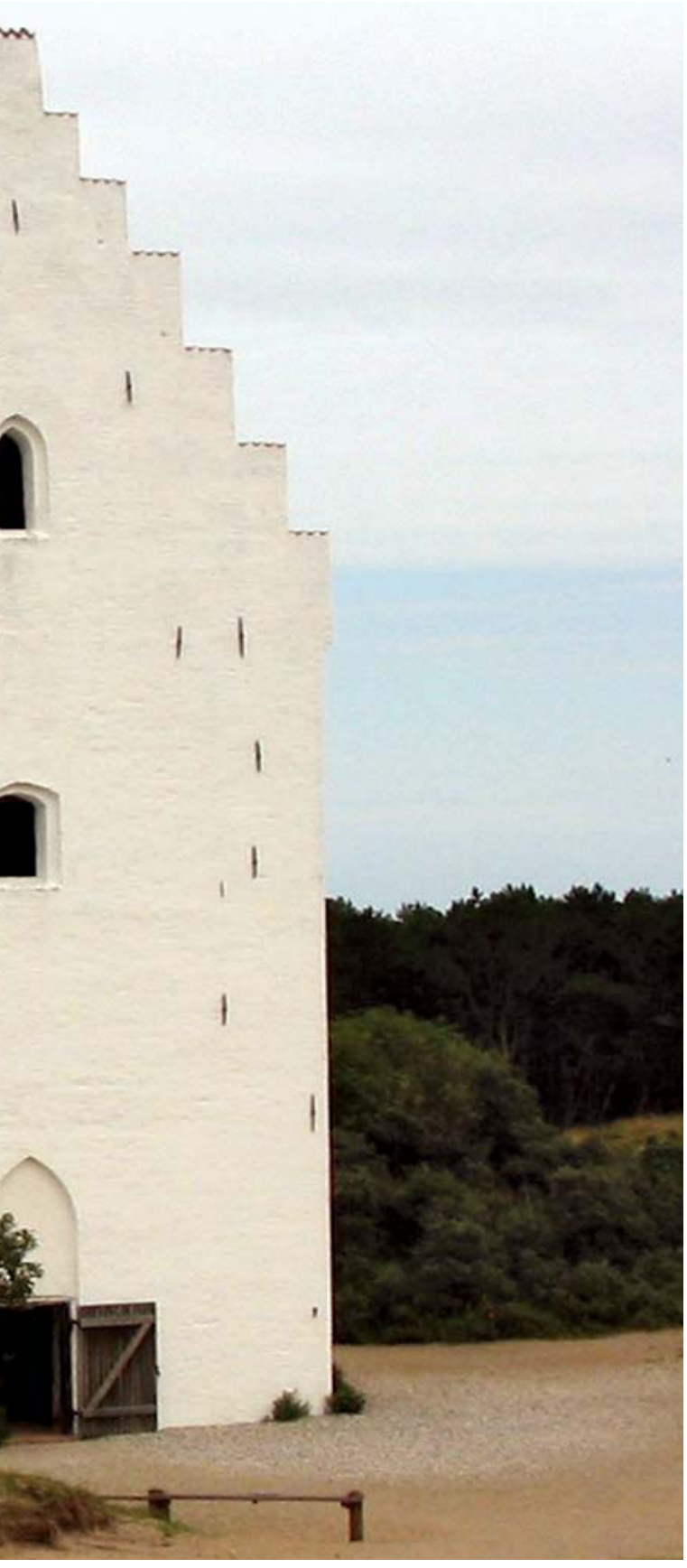


Illustration 3: The sanded church

ABOUT SKAGEN

History of Skagen

Skagen is in the northern most point of Denmark; surrounded by water on three sides and is also the point where the North Sea and the Baltic seas meet. Skagen (Tastris) has been mentioned as far back as the first century AD by the Roman author and naval commander Plinius Secundus, (Pliny the Elder). It was originally documented in 1284 as Skaffuen, which, as the name suggests, defines a narrow, high point of land. Known for being a fishing village in the middle ages, Skagen's first building which developed in the 12th century belonged to a shepherd and the first documented fisherman, Tronder.

In the early fifteenth century, it gained the status of a market town and the community grew to over 2000 inhabitants. During the 15th century AD a series of successive storms destroyed a lot of the architecture that had been constructed until that point. One of the few buildings that survived is the St Lawrence's church which was built in 14th century and is more popularly known as the sand covered church. The consecutive floods, storms and plundering by the Swedish army gradually diverted the attention from Skagen to Aalborg.

After a couple of centuries, around 18th century, Skagen was once again recognized on the map of Denmark as it was connected through rail for developing the fishing industry and was also known for its unique yellow plastered houses with red tiled roofs and Skagen museum under the guidance and architecture of Ulrik Plesner. Around the same period, the social community, the fishermen, the beautiful landscapes and seas had started attracting a lot of Scandinavian artists and soon a colony of painters were established who were famously referred to as the 'Skagen Painters'. Skagen also became an important place as the royal family, and in later years, many of the upper-class families, went there to spend their summers, making tourism one of their prime economic aspects (Wikipedia, 2020).

Art and Cultural Heritage of Skagen

The scenery, fishermen and society of the region attracted many artists to come to Skagen for inspiration. The town is best known for its prevailing presence of artists who have contributed a lot to the society of Skagen. They are more popularly referred to as 'Skagen painters. Many of their paintings have been displayed in many of the museums in Skagen and, in other famous museums around Denmark. The artists also include famous architects who have contributed a lot to the town that has given its prominence in the country. The term 'houses in Skagen' has become synonymous with the beautiful yellow plastered houses with red tiled roofs and the red warehouses in the harbour. Skagen also hosts various festivals, especially during the summer, notably 'the Skagen festival' which is known as Denmark's oldest music festival (Svanholm, 2004).

Ulrik Plesner

Ulrik Plesner is one of the most prominent and significant architects known in Skagen. He has constructed a lot of buildings in Skagen in the 40 years that he spent there, out of which he is best known for the Ancher house, redevelopment of the Brøndum's Hotel where he resided and the original museum of Skagen (Sejlund, 2012).

Thorvald Bindesbøll

Thorvald Bindesbøll was also one of the architects who flourished in Skagen along with Ulrik Plesner. Originally an architect, he turned to art during his visits to Skagen, dealing with ceramic designs and graphic design. He is most well-known for the church of Skagen and the red warehouses found on the harbour (Sejlund, 2012).

Michael Ancher and Anna Ancher

Michael Ancher and Anna Ancher are probably one of the most well-known of the 'Skagen painters. Known for their unique styles in dramatic representations at sea, and representation of natural light, respectively. A few of their well-known works are 'The drowned man' and 'Blue Ane'. The house where they stayed is a museum today, representing some of Ulrik Plesner's best work, and a lot of their paintings and interior designs. (Fabritius, 2008).

Holger Drachmann

Having fallen in love with Skagen's nature and simple way of life, Holger Drachmann was originally a writer and a marine painter. He was unclaimed leader of sorts for the title of Skagen painters as he was one of the earliest to arrive there and key to bringing many artists to the Skagen art scene. A lot of Drachmann's works are presented in the Skagen museum and at his home which is now a museum (Skagen Kunstmuseer, 2019).

Points of Interest of Skagen

Illustration 4: Map showing points of interest in and around Skagen

GRENEN

BURIED CHURCH

GREY LIGHTHOUSE

DRACHMAN HUS

ANCHER HUS

SKAGEN MUSEUM

SKAGEN NATURE ODDE

RÅBJERG MILE

Illustration 5: Skagen pictures

Skagen is rich in natural scenery and beautiful destinations that are places critical for tourism development both for their beauty and rich history.

1. Grenen

Grenen is the northmost point in Denmark where the two seas the North Sea and the Baltic Seas meet. The shallow waters and the bunker museum in Grenen attracts nearly 2 million tourists both local and non-local every year (Dan Hostel, 2020).

2. The sand buried church

One of the oldest churches in Skagen dating back to the late 14th century, the Saint Lawrence church more popularly known as the buried church, is another tourist attraction in Skagen. It is located towards the older part of Skagen which is the south. It was affected by the shifting sands and it lies half buried in sand. It was being used till the early 18th century for mass until it was decommissioned (The Danish Nomads, 2020).

3. The grey lighthouse

Standing 46 meters tall, the grey lighthouse or Det Grå Fyr was built in the 19th century. The lighthouse was key to guiding ships that crossed over from the Baltic to the North Sea as the waters were extremely shallow. The lighthouse is now a government sanctioned information hub for migratory birds and serves as a viewing deck for the many migratory birds that move through Skagen through the different seasons (The Danish Nomads, 2020).

4. Drachmann Hus and Ancher Hus

The Drachmann Hus and Ancher Hus as the names mention are the houses of the famous Skagen painters, Holger Drachmann and Michael and Anna Ancher. The houses are designed, and they stand as it was retaining the interiors of the houses, showcasing their paintings, and that of other artists and the interior design (Sejlund, 2012).

5. Skagen museum

Skagen museum is an art museum displaying the various paintings of the members of the colony of 'Skagen painters. The museum also runs exhibitions attracting many tourist and art enthusiasts to Skagen. The museum has an open garden displaying many of the sculptures that were made (Dan Hostel, 2020).

6. Skagen Odde Naturcenter

The Skagen Odde Naturcenter is a nature centre which is known for representing the effects of wind, light, sand and water. The centre is most well known for being designed by Jørn Utzon, the architect who also designed the Sydney opera house. It also has a display of some of Utzon's work in Danish and contemporary art (Skagen Nature, 2020).

7. Råbjerg mile

Råbjerg mile is the largest migrating sand dune in Denmark stretching about 1 km in length and width. The dune stands 40m above the sea providing one of the best views of the sea (The Danish Nomads, 2020).

Potential Development Plan *for Skagen*

The Frederikshavn Municipality has noticed the need for tourist traffic in the Skagen area according to the new initiatives of the masterplan. Several initiatives have been successfully carried out by the municipality such as the Grenensporet which is to catch all the important and interesting spots in the neighbourhood. They have also tried to tap into the potentials offered by the city and use it to attract tourism through seaside facilities, renting out the white lighthouse, cultural centres and international hotels (Manto A/S, LBB3 I/S, 2014). In 2015, Grenensporet was initiated by the Kommune which consisted of four routes with different sceneries offered in each. These routes are highlighted and marked on boards with brief information to have the information accessible by all. These trails highlight the natural, cultural and historical values of the area and are encouraged to be visited by the tourists. (Frederikshavn Municipality, n.d.) It is considered a unified recreational infrastructure for the entire Skagen with upcoming trails in the city, port and the existing hiking, bicycle trails in the dune plantations on the south of Skagen. (Rye & Egelund, 2018)

Other plans

Among the other initiatives is the cultural trail which is like the Grenensporet is a cycling, jogging and walking trail along all the important and interesting places. The plan is to provide the trail with facilities like eating spots, resting spots, look-out spots and observation decks (Manto A/S, LBB3 I/S, 2014). There are also a few ideas to develop the coastal area around Skagen which would be safe for the tourists to bathe and surf. There are also plans to transform the old grey lighthouse into a nature centre for the bird lovers as Skagen is one of the most important spots for bird migration. Along with these initiatives protecting, preserving and maintaining the natural balance is the main aim of the municipality. (Manto A/S, LBB3 I/S, 2014)

Tourism Development - *Skagen Masterplan*

Tourism is currently one of the main growth paths for the Frederikshavn Kommune. The authorities are thus, trying to reinforce the position of Skagen as the most popular seaside spots in Denmark. Skagen is a perfect blend of the sea, landscape, light, art, culture and heritage which creates a perfect space for visitors to spend their holidays. It is also a picture-perfect summerhouse for many Danes. It is also a popular destination for short trips. Over one million people and more come every year to see Grenen. It is also visited by many internationals from Norway, Sweden, Germany and England (Manto A/S, LBB3 I/S, 2014).

Why Skagen?

Skagen has a natural advantage of its beautiful diversity along with natural and artistic experiences which acts as a great touristic destination. It also provides prodigious local produce which includes a spread of fish as well as alcohol to incentivize the tourists and locals. It also offers a place for people who love sports and follow an active life. That apart, it attracts special groups of travellers like painters, ornithologists, geologists and people who are passionate about wildlife and nature.

Although there is a good flow of tourists, it is only the main areas of Grenen that are visited. The other lesser known picturesque spots like the Skagen Odde Nature Centre, the lighthouses and the dunes are missed out due to lack of information and publicity.

Thus, the masterplan concentrates on generating more tourism by creating an overall enjoyable experience through propagating various initiatives. It is also a challenge to create more year-round tourism due to the off seasonal weather. It places great demands on common footing and links of new and old activities with a focus to add value. It is also, about getting Skagen positioned as the natural, international meeting place for the development of coastal tourism (Andersen, et al., 2011). Today it is a sad reality that despite having so much to offer, the city of Skagen still stands forgotten and distanced from Grenen without proper connection, as it lacks a good information centre or a place where

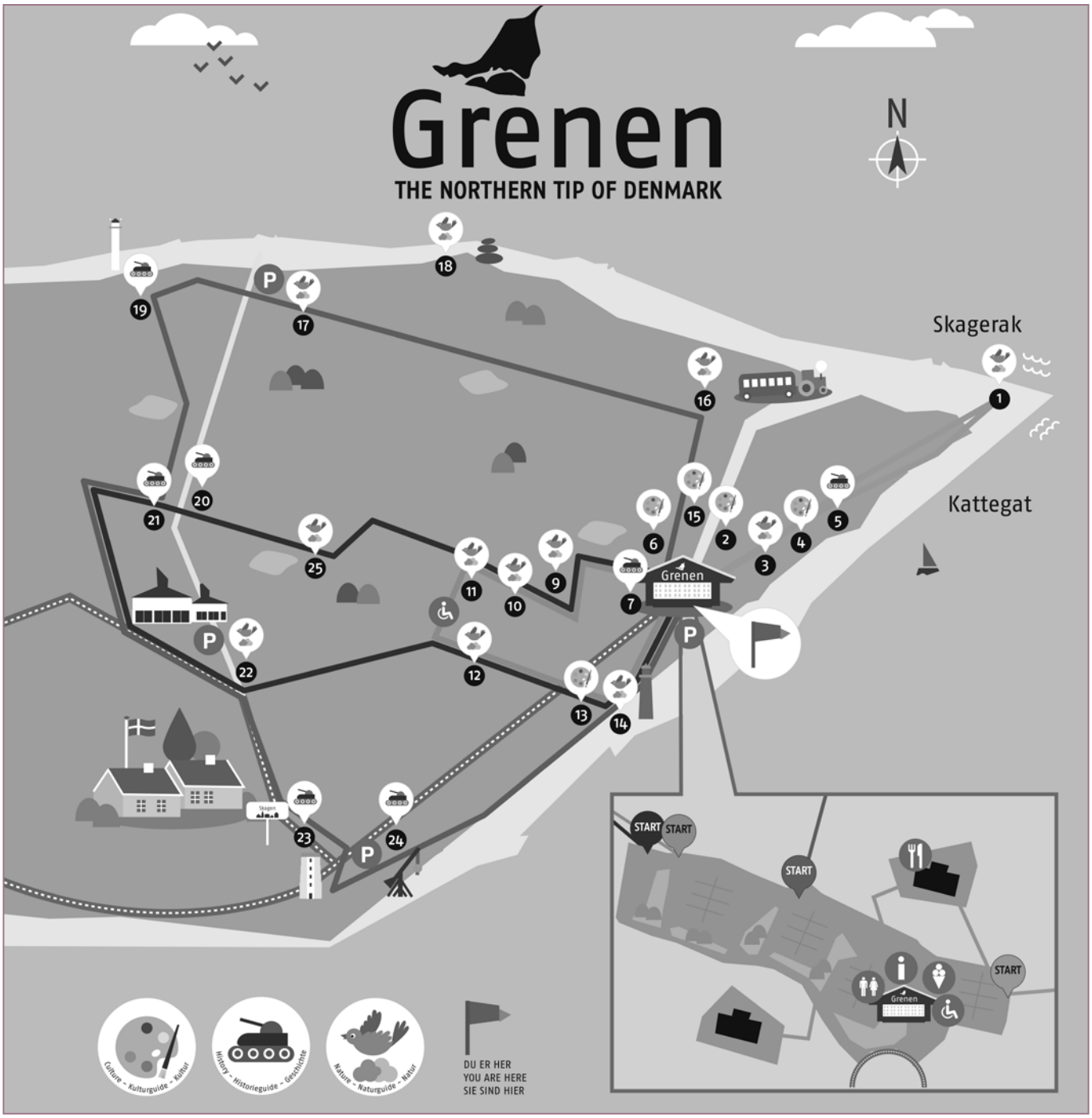


Illustration 6: Green initiative for Grenen by the Kommune

the visitors can access information and gain the vast knowledge and history of uniqueness that the place has to offer.

CASE STUDIES

WADDEN SEA CENTRE

Location: Ribe, Denmark
Architect: Dorte Mandrup

The wadden sea centre designed by Dorte Mandrup is a one-of-a-kind building that pays homage to the regional material and traditional craftsmanship of the Wadden Sea situated on a UNESCO site. The building is created in a way that it gives the impression that it emerges from the ground while maintaining a soft profile. It was redesigned to expand the existing building to a new area of 2800 square metres. It is designed with thatched roof and façade to elevate the natural robust and tactile quality of the materials. It is designed to accommodate natural light into the structure and establish contact to the surrounding landscape (Dorte Mandrup, 2017). It hosts a variety of indoor and outdoor activities like major exhibitions, learning and teaching experience for different age groups of students, provide business opportunities for the people along with café and shop for social interaction (vadehavscentret, 2017).

Illustration 7: Wadden Sea Centre

Things we can use in our design:

• The Wadden sea centre uses locally available material to reduce the environmental impact of the project.

• The site of the visitor centre is designed in such a way that there is area left around building for future development without interfering with the existing design.

• The building has shorter facades and small openings in the south facing the courtyard provided to reduce over heating of surfaces. The Northern facade is longer with one major opening near the entrance and no windows along the exhibition area.

FAZER VISITOR CENTER & MEETING CENTER

Location: Vantaa, Finland
Architect: K2S Architects

The visitor centre is designed by K2S architects for the Fazer factory in Finland over an area of 5130 Sqm in 2016. The visitor centre is made to have a close connection with the existing factory. It is a circular block that has a wooden cantilevered ceiling to give a strong identity to the visitor centre and also happens to be the first building noticed while entering the site. The open floor plan and placement of all the rooms and exhibitions and other rooms in the ground floor itself gives scope for future experimentation and ease of access. The visitor centres also uses locally available timber and solar panels to meet its sustainability goals. (ArchDaily, 2016)

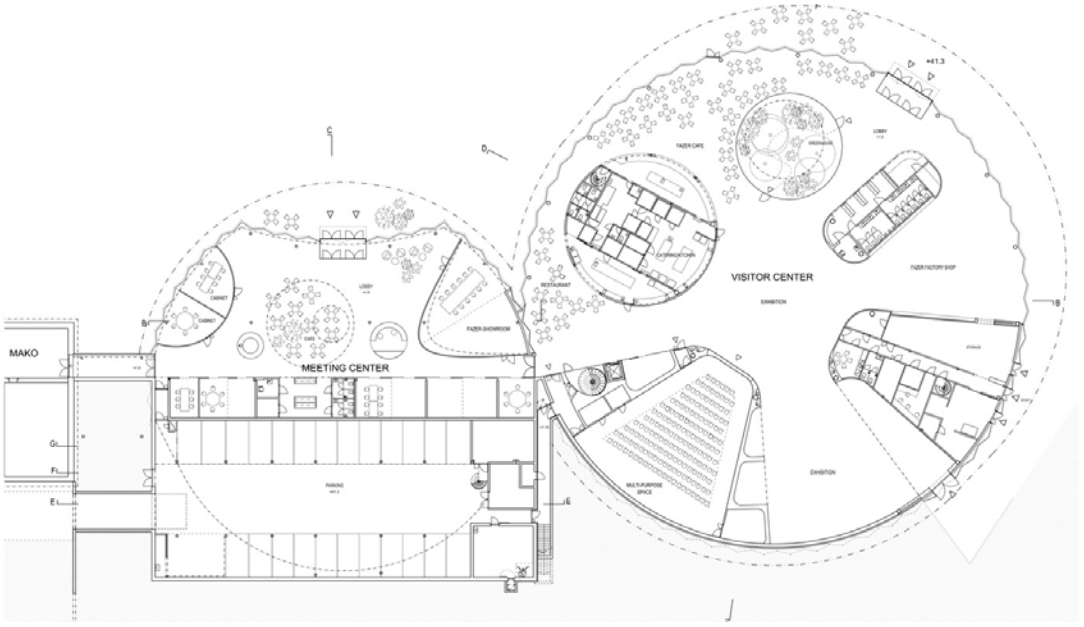


Illustration 8: Fazer visitor centre

Things we can use in our design:

• The visitor centre uses a circular design to make the project the first thing you notice as you enter the factory.

• The building uses an opening floor plan mainly in the exhibition area so that the layout can be altered suitable to the display.

• Since providing natural light towards the centre of the circle is tough unless there are large openings, which can cause overheating, the building uses a green room in the centre along with a skylight for natural light.

NATURE CENTRE HINDSGAVL

Location: Middelfart, Denmark
Architect: AART architects

Designed by AART architects the nature centre is a sustainable activity and outdoor centre that conveys that natural and cultural history of the Hindsgavl nature reserve. It is stretched over 450 square metres and houses teaching, exhibition and office functions along with a various number of facilities for school children and visitors. The building is designed to grow out of the terrain providing a vantage point on its roof. The design tried to enhance interaction between indoors and outdoors by using large window sections, solid wood internal walls and façade. To create a contrast the façade uses darker wood with change in the direction of the planks to create an interesting exterior. It is also designed according to passive house standard to create a sustainable design (ArchDaily, 2013).

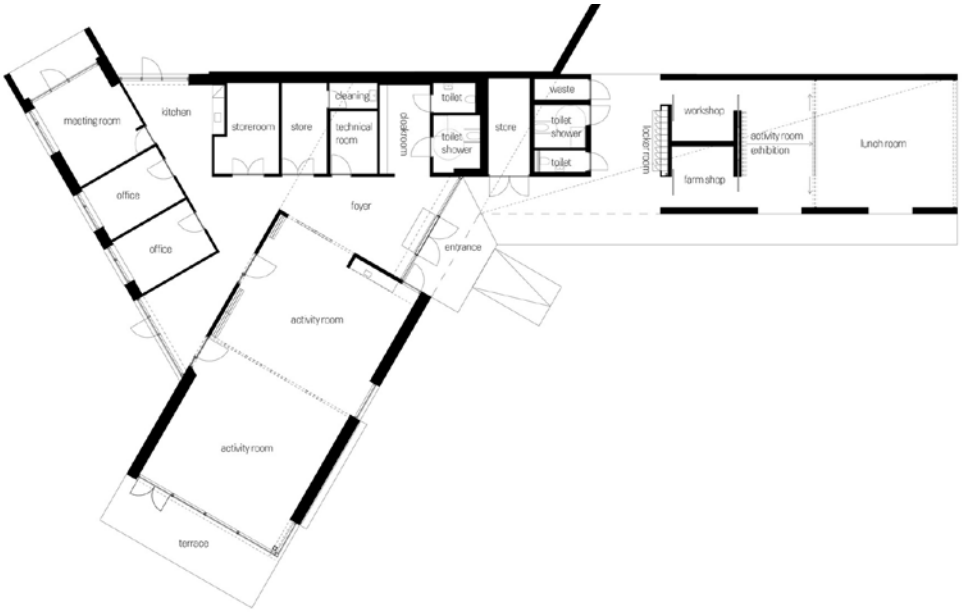


Illustration 9: Nature Centre Hindsgavl

Things we can use in our design:

• The building uses large sections of windows to let in more natural light in the large spaces.
• The Inner walls and outer facade use solid wood panels. The panels facing the outside are painted black to create a contrast to the surrounding scenery.
• The design uses overhangs to provide shading to the interiors and prevent overheating seasonally.

SNÆFELLSTOFA VISITOR CENTRE

Location: Egilsstaðir, Iceland
Architect: Arkis architects

The Snæfellstofa Visitor Centre built over an area of 750 sqm is located in Iceland and is designed by Arkis architects. The centre is built in such a way that it blends in with the surroundings and attracts the users with the provision of both indoor and outdoor activities. The building is divided into 3 parts based on the functions and the use can be changed based on the season. The design is made from locally available materials like larch and the walls and roof are made from local rock. The building is X shaped with exhibitions placed on the main axis and other functions such as foyer, receptions facilities and rooms along the other axis. The windows placed on the walls area recessed for more flow of natural light. (Teitsson, Gudmundsson, & Jonsson, 2020)

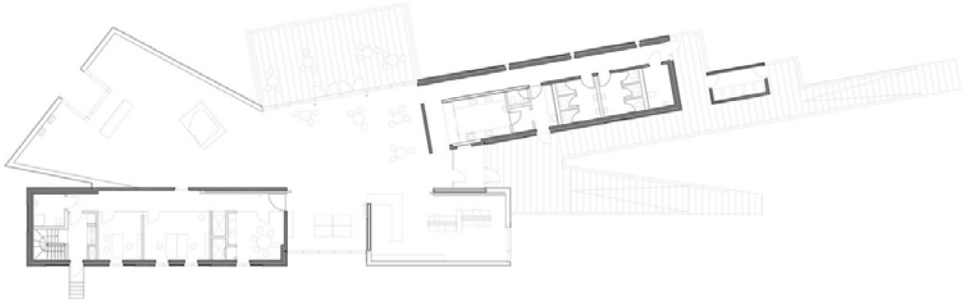


Illustration 10: Snæfellstofa Visitor Centre

Things we can use in our design:

•The centre is divided into 3 zones which can be used accordingly based on the season.
•The design uses both indoor and outdoor activities to create an interactive experience for the various users.
•They use recessed windows for providing more natural light into the spaces.

•Most of the materials used in the design are locally available materials larch accompanied by local rock.

PROBLEM FORMULATION

Potentials for a visitor centre at Skagen

Qualities offered:
Skagen is one of the important touristic places in Denmark. The natural environment of Skagen offers duality in all its elements such as the land and the sea, the dry dunes and wetlands all around which is appreciated by everyone from scientists to tourists. Every year millions of people visit the Skagen isthmus, where the two seas meet. Many of the international visitors are not aware of all the tourism facilities available in Skagen. These issues emphasize a need for a visitor centre in Skagen.

Prospective opportunities:

Skagen offers much more than just the picturesque environment such as the rich history, art and heritage for the local and international visitors. It is a disappointment that a lot of tourists do not know the story of the Skagen painters or the various activities offered by the place. It is understood as a link between many earthly resources such as the sea, nature, landscape and cultural heritage, together with museums, restaurants, activities and experiences make it a place that tourists deeply appreciate (Manto A/S, LBB3 I/S, 2014). Most of them just leave after visiting the Grenen beach and miss out the vast potential it has to offer despite being a prime vacation spot for both long and short trips. This is mostly due to the fact that the people are not well informed because the city lacks a proper visitor centre which could help them experience these qualities.

Possibilities for the new Visitor Centre:

A Visitor Centre will serve the tourists by informing them about all the rich possibilities in and around Skagen. It would guide them by giving out brochures, maps and act as an information point regarding all the interesting places in Skagen. Exhibitions, permanent and cyclical will be able to educate the visitors about the art and cultural history that Skagen has to offer. A community event space will create a possibility for organizing festivals or workshops or communal meetings and help in promoting Skagen. This will also help in attracting student trips and teach them more about the natural and cultural history of the place. A café or restaurant could serve meals made out of the local produce and generate revenue and local business for the city. These qualities would make the new visitor centre a cultural hub with great possibilities of spending their time well.

City network:

The Visitor Centre will help in encouraging the public to leave the cars at the parking and venture around the city using either local transport or through bikes that would be available at the bike rental. The centre will be well connected due to the developed walking paths.

Conclusion:

A visitor centre will influence the perception of Skagen to the public by improving their knowledge about the place and help provide an insightful experience about its history. It will also help to preserve the area better by educating the people about the environmental impacts through various seminars, workshops in the visitor centre. On the economic front, it will create business opportunities locally, and provide employment opportunities to the locals on a more permanent basis. It will also help in regulating the flow of visitors at the actual site thus helping conserve it to an extent. It covers a wider local potential which encircles the local attractions on cultural, natural and historical level. It cumulates all the opportunities of the region to facilitate the visitors with information, recommendations and will cater to related, additional needs.

FOCAL POINTS

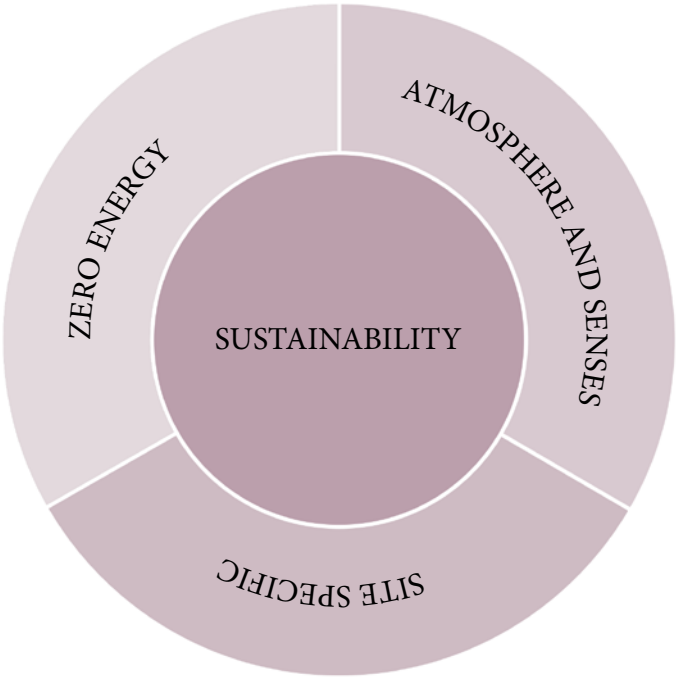


Illustration 11: Focal point in the project

Local Nordic identity: it is a theoretical expression used to categorize or specify the unique architecture practices in Scandinavian countries. Scandinavians have always been connected to nature but also experienced its severity due to strong cold winds, rainfall, temperatures which are deep rooted in the Nordic identity. This can be interpreted into architecture in a unique way where light, nature and environment is celebrated through the design. Identity is both something personal and internal, that concerns our relationship with others socially and, to the place. It is a culmination of experiences as well as our reflection, in a way we perceive and describe the place (Kjeldsen, 2012). This adheres to the new themes of social sustainability about identity and place attachment. Site specific: It is a new way of considering a place, where it is addressed as a "layered landscape" of physical, social and mental processes, resources that together create a site-specific building (Kjeldsen, 2012). It defines the architecture's relation to the place and is considered as an important starting point (Zumthor, 2006). Environmental sustainability is integrated in the elemental position by using locally available and produced materials helping reduce the carbon footprint. Atmosphere and Senses: The atmosphere of a place gives its own language and character to the site. These phenomena are perceived individually by everyone and help in engaging the user's senses and create a unique experience for each and everyone (Zumthor, 2006). Based on the reaction that is created when humans interact with the atmosphere of a place, they make connections to the site and create memories based on these interactions. The human interaction with spaces is not only through sight but also, through the other four senses and thus needs to be closely connected. The building influences all the senses and creates an embodied experience (Pallasmaa, 1996). It is also understood that quality architecture should involve and challenge its users both mentally and physically to create a memorable experience.

Peter Zumthor explained architecture as an experiential approach to design. When spaces, light, shadow and materiality interact with

one another it creates an experience that awakens all the senses in the human mind. Thus, it is important to engage various senses like odour, temperature, the nature and tactility of materials to engage human interaction and help them connect to the space (Zumthor, 2006). In other words, human identity is no longer about being present but also about being a sensible, receptive person in a place (Kjeldsen, 2012). This can be achieved by looking at an aesthetical and functional perspective by designing for a good indoor environment while providing an enriching sensory experience.
Zero energy: In Denmark, the energy demands set to be followed is the Danish standard BR2020. The continuous changes in the climate and the desire of communities and governments to reduce its negative impact, has led to an increase in sustainable thinking as a primary instinct (Birgisdottir & Rasmussen, 2015). Aiming for a zero-energy visitor centre, is by designing with the application of several passive strategies, enabling to save energy while usage of the mechanical operation devices.

CONCLUSION

A visitor centre is a place which tells a story, explains the history and forges a connection between the visitors and their surrounding; it should be able to connect to the landscape and the existing context to create a strong bond. Designing by keeping a sustainable approach in mind while trying to achieve a holistic outcome is a result of a process that requires analyses, understanding and relating to context and setting a realistic option. The aim of the project is to design a zero-energy building, which addresses the senses of the users, relates to the contextual surroundings, merges with the local identity of the neighbourhood while creating a holistic space for the visitors to know and understand the heritage and absorb the beauty of Skagen.

03 ANALYSIS

Illustration 12: View of Skagen

SITE LOCATION

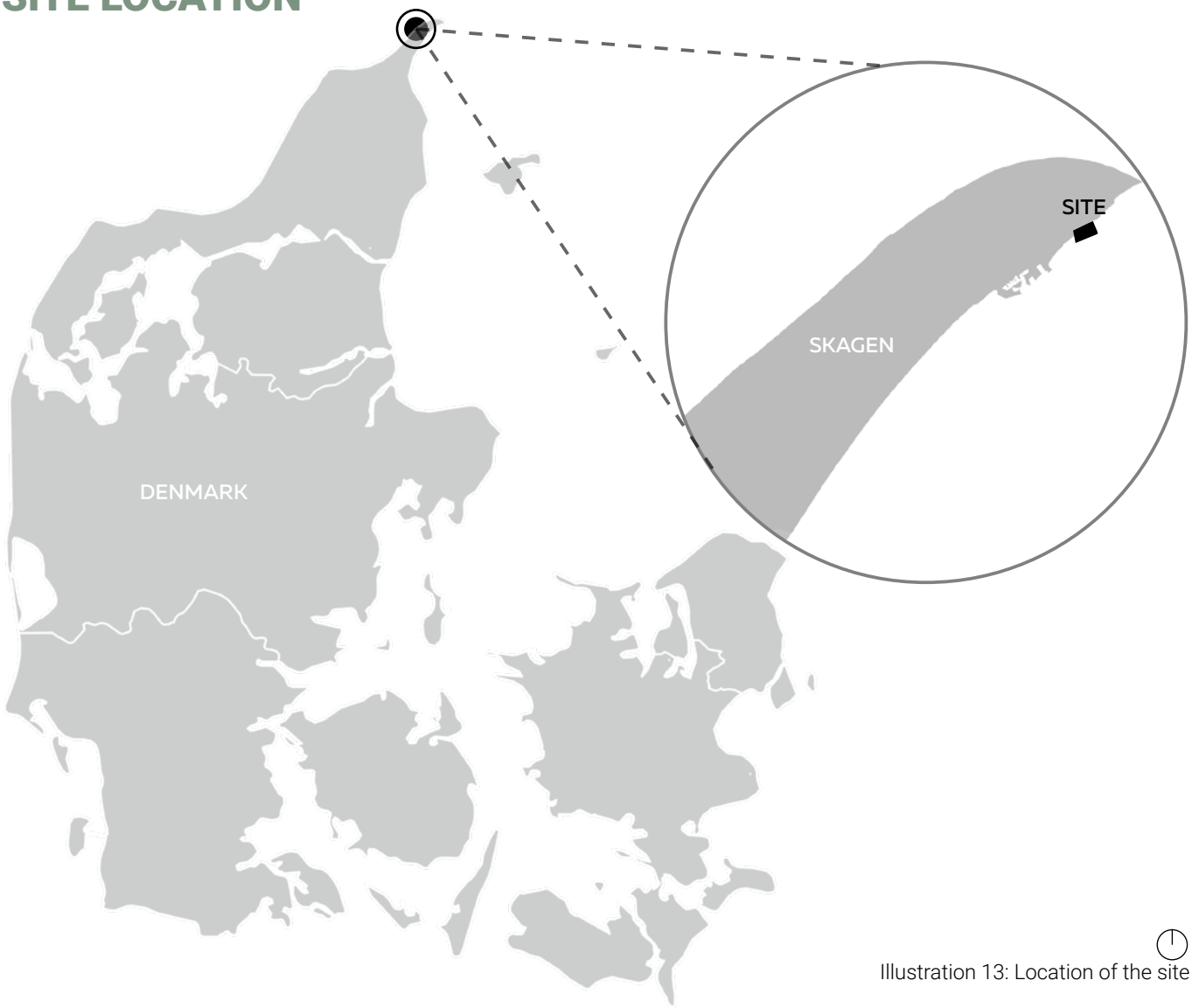


Illustration 13: Location of the site

The site is located close to the northern most part of Denmark in Skagen near Grenen. Skagen comes under the Frederikshavn municipality. Skagen can be accessed by train and from there Grenen can be accessed by a bus, vehicle or bike. Grenen is located roughly 3kms away from the centre of Skagen. The site is mostly flat and is located by the shore, it is about 1.7 kms away from Grenen and 1km away from the centre of Skagen. The weather in Skagen is mostly like the weather in the rest of Denmark, but it is slightly windier due to the proximity to the two seas. Even though the population of Skagen is only roughly 8000, there are nearly 2 million visitors who travel to Skagen annually (City Population, 2019).

The prime income of the town is through fisheries and tourism. Skagen is well known for its sea food restaurants and arts and crafts inspired from the various artists who have an historical influence in Skagen. The biggest attraction of Skagen is the access to Grenen which is very scenic with the two seas 'Baltic sea and 'North Sea' colliding at the tip over the white sand beach. The town also serves as a location for summer houses for many of the Danish families including royalty due to its scenic appeal. Although Skagen is visited by tourists round the year, it sees more tourist footfall during summer. It is also a much favoured spot for bird watching as nearly 340 out of the 420 species of birds migrate through Skagen (Visit Nordjylland, 2018).

SERIAL VISION

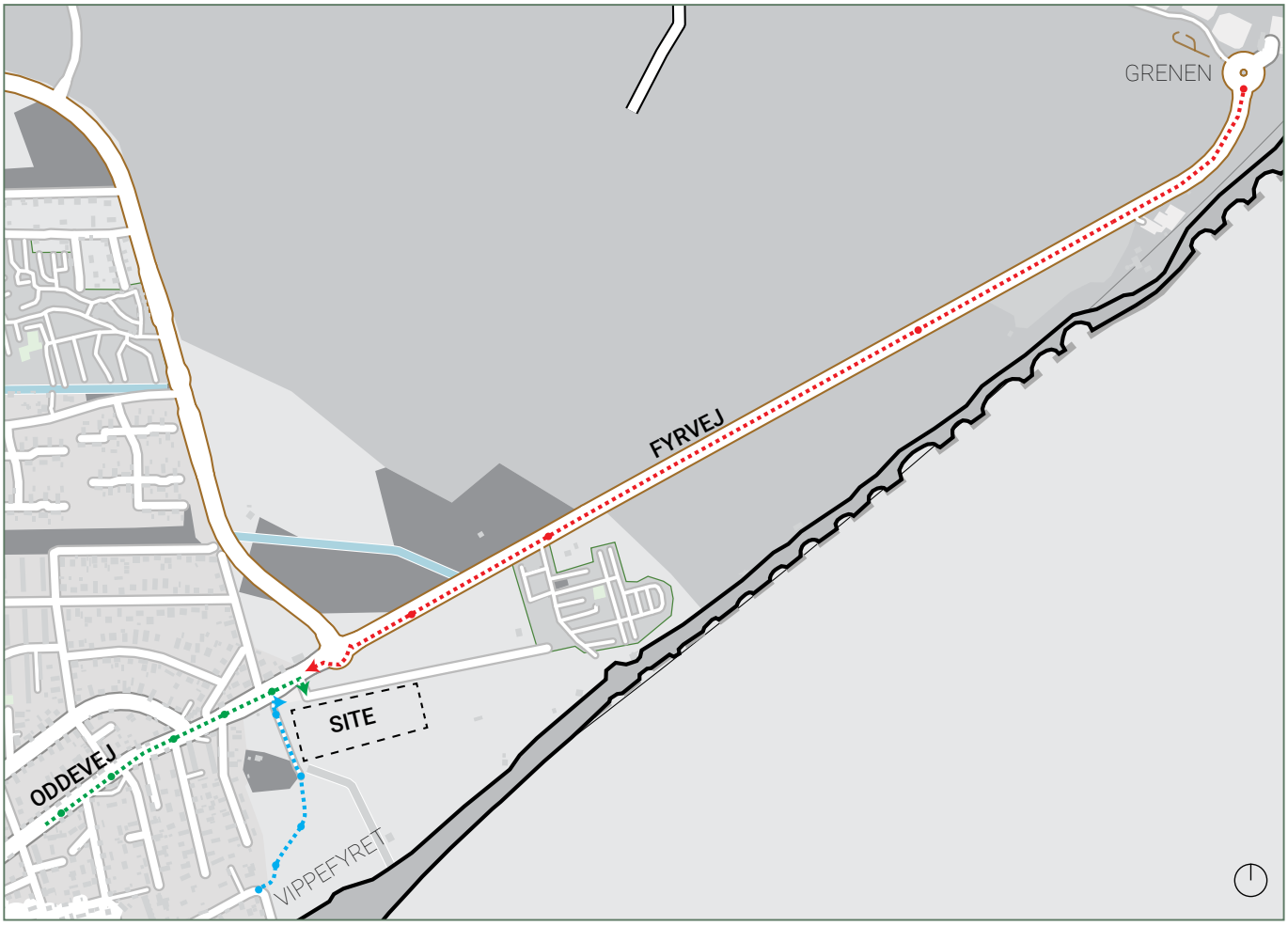


Illustration 14: Map of the different routes

The site is in Skagen, Northern Jutland and on the way to Grenen. It can be easily accessed by car or by bike. Due to the small size of the town there is no local transportation which can be seen as a limitation. Although, during the peak season, the summer bus takes visitors all the way till Grenen which can be used to access the site. The site is on the main road, opposite to the highway connection, making it easily accessible and locatable to the visitors coming from Frederikshavn. The chosen site is located near a light house with parking space which is currently used by visitors either going to the beach nearby through the footway or by people going to the camping site.

The site is surrounded by a patchwork of trees on the southwestern side. It can also be accessed by a bike using the cycle path through the Vippefyret which serves as a historical landmark. The site is easily noticeable being in the view line to the major attractions in Skagen. It also overlooks the sea forming scenic views.

The route through Oddevej.

Different residences used as holiday homes.

It is a straight road with various art galleries.

The site becomes visible after the white lighthouse.

The route from Grenen, through Fyrvej to the site.

It has multiple bus stops to access either way.

There is also a stop near the camping area.

The area is also equipped with benches to relax nearby

There is a bike route to access the site through Osterbyvej.

It is easily locatable due to the historic Vippefyret.

The site is surrounded by a gathering of trees to protect agaist harsh winds..

The gravel road leads to the left hand side of the site near Gamle Fyrvej.

Illustration 15: Pictures along the route

INFRASTRUCTURE

Illustration 16: Infrastructure mapping

Transportation in Skagen and to Skagen is limited during off season. Trains are easily available to reach Skagen from the rest of Denmark. Within Skagen, during summer there are buses that provide transportation in and around Skagen and to Grenen (Visit Nordjylland, 2020). The starting point for the bus starts in a loop from the train station and covers quite a few of the areas in Skagen that promote tourism (Nordjylland Strafikselskab, 2018). Apart from buses, one can use bicycles, cars and motorbikes, as the infrastructure of the roads and connectivity in Skagen is convenient. The infrastructure of Skagen is especially suitable for bicycles and pedestrians as there are routes along the coast and within the natural landscape, that can be accessed only by bike or on foot (Lonely planet, 2017).

BUILDING TYPOLOGY

Illustration 17: Map of the different building types

Architecture in Skagen has been inspired by English architecture executed by two of Denmark's well-known architects Ulrik Plesner and Thorvald Bindesbøll. Skagen is most well-known for its classic bricked houses with yellow plaster and red tiles (Sejlund, 2012). The residential and commercial buildings within the town vary between 1 story to 3 stories (3mts – 10 mts) with the standard brick wall construction, sometimes plastered and tiled gable roofs.

Towards the harbour area the warehouses are designed and influenced by the renowned architect Thorvald Bindesbøll. When it comes to the neighbourhood of the site the buildings are mostly restricted to a few residential buildings, which are between 1 – 2 story in height (3mts – 6mts). All the houses in the regions have gable roofs which are either black or red tiled and have white or yellow plaster on the brick walls.

MICROCLIMATE

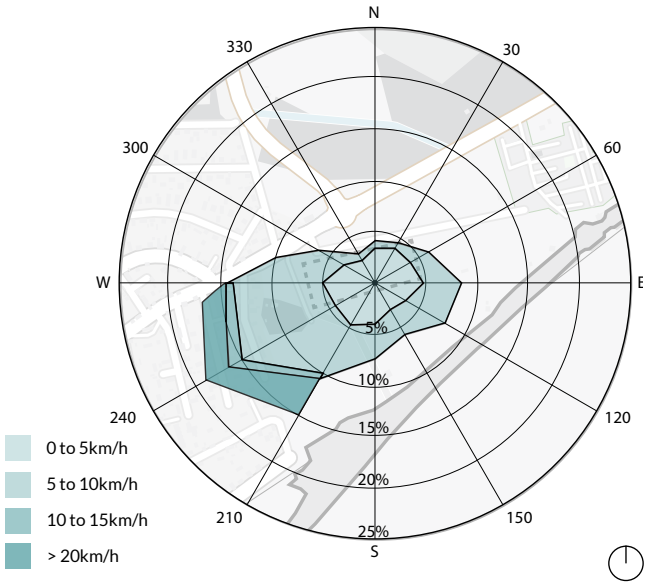


Illustration 18: Wind Analysis

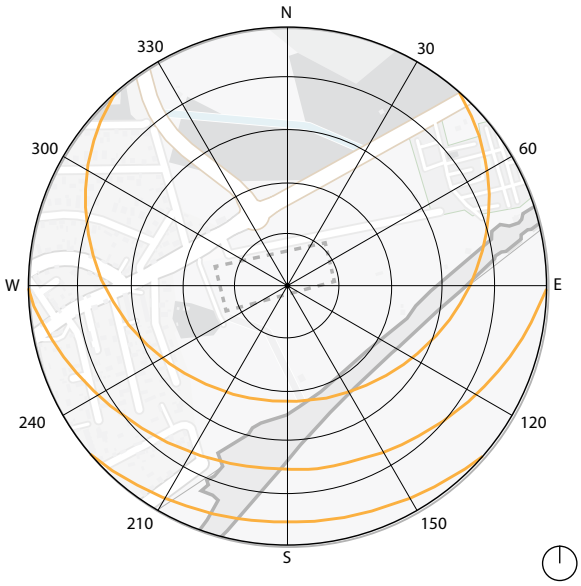


Illustration 19: Sun path

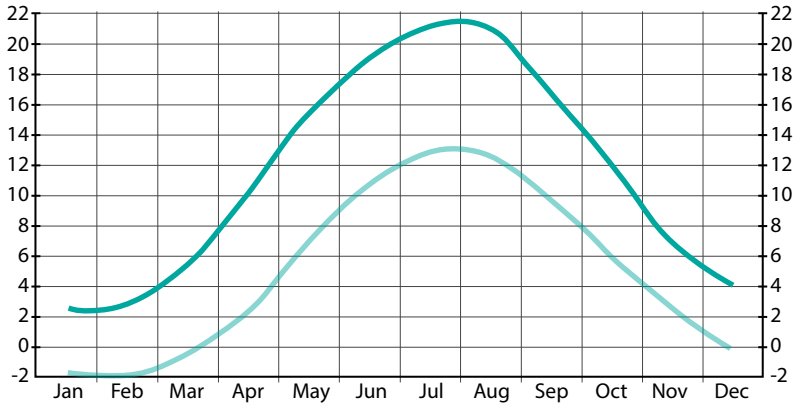


Illustration 20: Average temperatures during all year

The term microclimate refers to the atmospheric conditions of a local area. It needs to be analysed in order to understand how it effects the design. Microclimate acts as a major factor to decide the indoor environment of an area, especially in Denmark. Wind and speed analysis are important factors while designing passive strategies. The site is oriented to the north-east to face the main access road (Windfinder, 2020). It faces the sea to the south and south east. It is partially shielded from the harsh south western winds by the neighbouring buildings and greenery. The air is humid due to the presence of the sea in the site's vicinity. The ground is mostly flat with a few undulations due to the dune like landscape caused due to the harsh winds. Wind effects the trees, sand, grass growth and forms. thus, it becomes a crucial factor to be considered while designing.

Being located on the north most part of Denmark, the site has a large difference in the amount of daylight received in different seasons. In the summer the sun is at a high altitude of 57 degrees which gives approximately 17 hours of daylight. On the contrary, during winters the sun is at an inclination of 11 degrees giving very few hours of daylight per day (Lysnet, 2006). Being a little away from the neighbourhood, it is open on all sides exposing it to the natural environment, which means that natural daylight reaches the site. The area is mainly cloudless due to the fast-moving winds from the sea which helps with more daylight.

TOPOGRAPHY AND VEGETATION

Creepers | Shrubs | Helmet take roots | Almost flat site | Shorelines

Illustration 21: Vegetation on the site

The topography of Skagen is mostly flat, it ascends slightly towards the northmost point Grenen. The elevation changes within 2 miles of Skagen but is negligible with a change of 10 meters and average height above sea level of 1.5 meters (Weather Spark, 2018). The site is mostly flat and at a lower level as it is closer to the town (Elevation map logs, 2020). The waterfront can be observed towards the back of the site after a small strip of the beach. The wide range of biodiversity in Skagen are host to some pioneer plants such as creeps, shorelines and helmet roots all three of which can be noticed around the site. Towards the inland of the ocean can be observed a bouquet of rare plants growing near the dunes. Danish orchids, cucumber herbs, swamp hole lipstick and beach star are few of the more exclusive types of greenery that can be observed towards the region. A hike around the north beach gives the opportunity to observe many such rare species of plants and animals (Fredninger, 2020).

GENIUS LOCI

Illustration 22: Genius Loci Mapping

Quietness, openness, serenity is the significant characteristics of the site. It is surrounded by nature filled with seasonal migratory birds, trees, sandy beaches and its shores. There is a white light house nearby along with a historic landmark which gives identity to the site. The air is clean and carries with it the essence of sand and the sea. The ground is mostly flat with a few natural contours and is soft to walk on. All the natural elements seem to conjoin and embellish the scenery. The site is almost in isolation forming a naturally serene area for visitors to get closer to the environment.

Furthermore, being on the main highway it provides ease of access as well noticeability. There is no footprint of any past structures on it, which means it has remained inherently healthy and needs to be respected and preserved in the same way in the future.

1. White lighthouse

2. Soft shrubbery near entry

3. Vippefyret as a historical landmark

4. Existing parking

5. The walkway leading to the beach

6. Almost flat site with few dunes

7. Wild vegetation

8. Walkway to Vippefyret

Illustration 23: Skagen pictures

USER ANALYSIS

Visitors of Skagen

Skagen is visited by 2 million tourists annually, especially during summers there are more than 50,000 visitors who visit the town and the Grenen tip which increases the local population of 8000 (City Population, 2019). It is considered as a very popular vacation spot for visitors from Sweden, Norway also from Germany and Great Britain (Manto A/S, LBB3 I/S, 2014). It can be understood from statistics that majorly tourists from Norway and Sweden form more than 50% of all the hotel guests in Skagen (Manto A/S, LBB3 I/S, 2014). Skagen is known for its natural, cultural and historical values which attracts different visitors such as nature lovers who like to experience the land, hiking around the heaths, dunes and the coast. It is also visited by ornithologists who come to Skagen to observe the different migratory birds (Fredninger, 2020).

Skagen also favours an artistic colony which attracts a variety of art lovers to catch the beauty of the picturesque landscape along with the plentiful art galleries hosted by the locals. There are also groups that visit Skagen for experiencing one of the most famous places in the country – the meeting point of the two sea inlets - Skagerrak and Kattegat. (See Appendix 1- Informal interviews). The town is also thronged by many seafarers who enjoy the town, while sailing around. It is also known as a place for summer houses for the Danes. One of the biggest problems of Skagen is its demographics. Skagen lacks young people and age average increases every year. The municipality is looking for some solutions how to attract young people to the town (Frederikshavn Municipality, 2011). In conclusion, Skagen offers a unique experience to each of its visitors from kids to the elderly (Denmark Statistics, 2019).

Illustration 24: User groups

	DESCRIPTION	BUILDING USAGE TIMINGS	FUNCTIONS REQUIRED
ONE DAY VISITORS	• First-time tourists • Not familiar with the towns and sights to see • Visit the town for or a day or two	Weekdays:10.00 - 17.00 Weekends:10.00 - 19.00	• Information centre to create plan • Space to relax • Cafeteria • exhibition area to gain knowledge about Skagen • AV room for experiential education • Toilets
STUDENT TRIPS/ ORGANISED GROUP TRIPS	• Mostly large groups • Usually have a prepared and planned itinerary • Visit the town & around for a longer duration	Weekdays:10.00 - 17.00 Weekends:10.00 - 19.00	• Information centre/ help desk to plan activities • exhibition area • education rooms • AV room • Workshop area • Cafeteria • Toilets
FAMILY/ GROUPS	• Large groups of friends or families • Do not usually have a planned itinerary • Visit usually during the weekends or holidays	Weekdays:10.00 - 17.00 Weekends:10.00 - 19.00	• Information centre • Place to relax • Cafeterias/ outdoor area to have picnics • Exhibition area • AV room • Toilets
MANAGEMENT DEPARTMENT	4-5 workers responsible to man the information desk and the technical department	Weekdays: 9.00 - 18.00 Weekends: 9.00 - 19.00	• Staff/ storage room • Office area • Technical room • Toilets
MAINTENANCE DEPARTMENT	A crew of people responsible for the cleaning and maintenance of the visitor centre	Weekdays: 7.00 - 10.00, 17.00 - 19.00 Weekends: 7.00 - 10.00, 18.00 - 19.00	• Cleaning/ storage room • Staff room/ area to rest after work • Toilets
EXHIBIT CURATORS	A group of curators responsible to organise a theme and acquire the artwork for the exhibition area	Weekdays: 9.00 - 17.00 Weekends: 9.00 - 18.00	• Office to plan the themes • Technical room to arrange accessories for the exhibition • Toilets
KITCHEN STAFF	The kitchen staff consists of a chef along with helpers and servers to maintain the cafeteria in the visitor centre	Weekdays:11.00 - 15.00 Weekends:11.00 - 16.00	• Kitchen • Cold storage • Pantry • Serving station • Cash counter

Table 2: User groups- descriptions, timings and functions required

SITE ANALYSES CONCLUSION

Illustration 25: Site analysis conclusion

The location of the site shows that despite having the geographical features of dunes it is a flat land with various vegetation around. The climatic analyses show that the wind has a major effect on thesitethusbecomingacrucialfactortobeconsidered while designing. Even though the belt of trees to the southwest of the site partially protect it from wind, it is understood that an external protection must be provided.
The orientation of the visitor centre along with the placement of the openings should be such that it protects against the cold winds and helps in natural ventilation from the east during summers. The strategic placement of windows along with the sizes, glass ratio can help achieve an ideal indoor climate and daylight despite the Nordic weather conditions. The presence of various nodes and landmarks around the site makes the location distinguishable.
The location of the site provides ease of access through various means of transportation thus, connecting the different tourist activities in Skagen. Understanding that the locals are also a target user group gives a possible design implication to equip the area with open and semi open public spaces. The various analyses help in achieving a design which is integrated with solutions for the weather, user demands and design concepts.

04 ZERO ENERGY BUILDING STRATEGIES

SUSTAINABILITY

Sustainability is a study of natural systems along with the civilization trying to maintain the ecological balance in the process of production while promoting a healthy way of living. It is about finding a balance between modern technology, modern way of life and natural systems. The concept of sustainability can be explained through three core pillars of development – economic development, social development and environmental protection (Mason, 2019).

Economic development stands for achieving efficient energy consumption over the lifetime of a building along with boosting building development (BuildAbroad, 2017). Social sustainability focuses on the users' experience, health and wellness while building positive social interactions in the communities along with accessibility and safety for all. Environmental protection encompasses building solutions which help reducing, recycling power consumption, considering building materials as well as components that have lesser negative impact on the environment in the long run, not causing carbon emission enabling their reuse in the future (BuildAbroad, 2017). It makes use of materials found around the building site itself, reducing the need for energy intensive transport or manufacture of additional materials. This project will address social sustainability by researching the users' needs, experiences, behaviours in order to provide a social value to the people in and around the building. The design decisions will be based on evidence and research through various means like journals, reports, interviews, etc. to create a good welfare environment for the visitors as well as the workers. Along with this, environmental sustainability will be treated through optimal building design and material use to reach the minimal energy demands set by the Danish Building Regulations 2018. By designing a zero-energy building, the project aims to minimize carbon emissions to create an environmentally sustainable project.

LIFE CYCLE ASSESSMENT

Life cycle assessment (LCA) is a method used to evaluate the risks and impacts of different materials and services during all stages of their life cycle which is from cradle to grave which encompasses all elements of the value chain – from the raw material extraction, production, transportation, through to the period of usage to the conclusive recycling or disposal (Braune, Durán, & Gantner, 2018). It helps in making informed decisions in the planning and implementation of the design process. It stimulates innovation by highlighting opportunities to create products and buildings with higher environmental quality and better efficiency (Braune, Durán, & Gantner, 2018).

In DGNB standards, LCA is one of the requirements under environmental quality as it focuses on the life cycle of the material to reduce emissions and consumption of non-renewable resources. The environmental impact of the materials during the different life stages can be done using LCAbyg tool (only includes parts of life cycle included in DGNB-dk) such as product stage (A1-A3), replacement (B4), waste treatment (C3) and landfill (C4). The comparison of different materials are mostly based with reference to the GWP (Global Warming Potential) which has the maximum weightage of 40% in LCA when compared to other factors like ODP, PCOP, AP, EP and ADP (DGNB system – New buildings criteria set, 2016).

Using the LCAbyg tool, an assessment of the environmental impacts of different natural materials during their different life stages (according to DGNB Denmark) has been done. The assessment and comparison of different materials is mainly done with reference to the global warming potential. The graph represents the analyses which shows timber to have a positive impact on the environment during its production stage although high during waste treatment due to it being downcycled (into woodchip boards, particle boards), although being reused decreases the need for new materials (Environmental Product Declarations Hardwood Timber, 2017). Reeds also display similar results where it gives a positive affect at its production stage but is understood to have higher CO2 emissions during its waste treatment and landfill stages (Eco Platform EPD, 2017). Furthermore, straw

seems to have the lowest degree of effect on the environment as it requires minimum energy in manufacture and is available easily locally. In the end of life stage, it can be used as landfill with negligible harm on the environment (EcoCocon, 2016). In conclusion, while designing a sustainable building it is important to understand how and where the different materials of the building are produced thus affecting the environment. To further understand the impact LCA analysis can be done for various parts of the building to find the best possible, sustainable and environmentally friendly option for the structure such as wall, roof, foundation, etc.

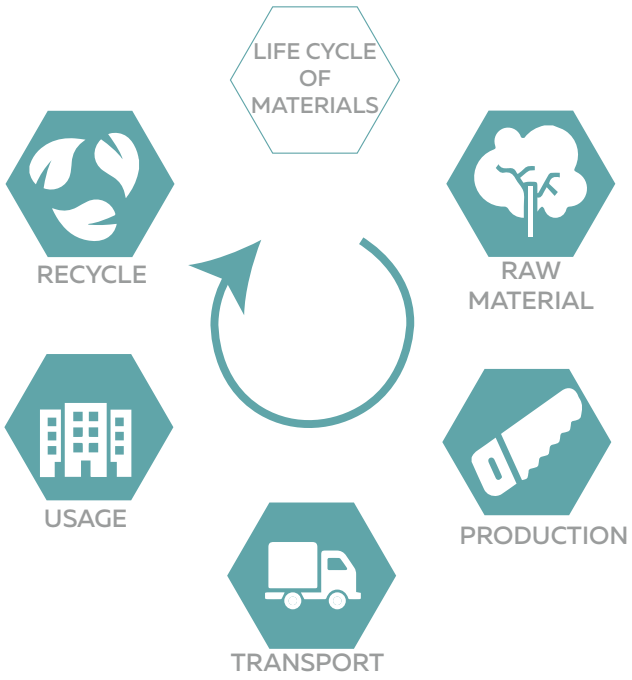


Illustration 26: Life cycle of materials

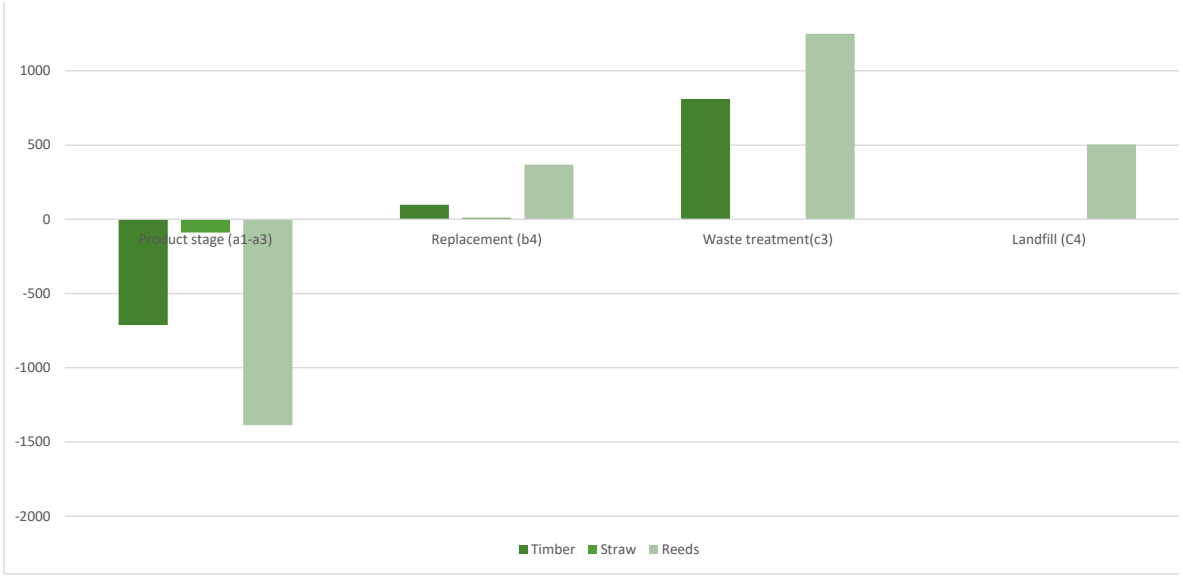


Illustration 27: : Global warming potential (GWP) impact distributed on stages of materials (based on LCAbyg)

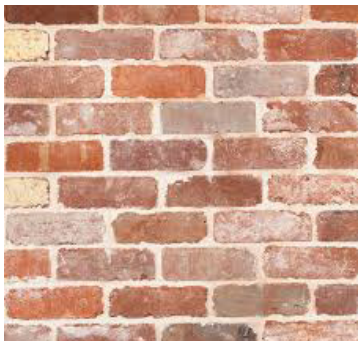
MATERIALITY

Sustainable architecture is also about understanding the materials and their life and function from the original purpose along with the reuse and recycling of materials. They must be taken into consideration from the beginning of the design phase of a structure (Garofalo, 2018). The following materials are assessed to be non-toxic, ecological and available around the site in Denmark in order to provide a healthy environment to the users of the visitor centre.

Timber

Straw

Reeds



Recycled bricks

Illustration 28: Material close up images

Timber

Timber is one of the natural resources that impacts mechanically as well as aesthetically. It has a positive impact on sustainability and environmental preservation in order to reduce emissions and increase the life cycle assessment. It also has remarkable thermal properties, acoustical qualities and the ability to be easily adaptable. It has a thermal conductivity based on the type of wood from 0.22 W/m2K and 0.14 W/m2K. It also helps in reducing the CO2 emissions by collaborating to increase the volume of sustainable managed forests (Boller, 2018).

Straw

Straw is a fast-growing biomass, an agricultural product that stores CO2 acting as a sustainable building resource. It is durable, affordable and environmentally friendly (Thompson & Walker, 2014). Straw bale offers many advantages such as insulation, reduced heating and cooling costs, use of renewable local materials, low embodied energy, healthy micro climate as well as good aesthetics. Being produced in surplus it is cheap and easily accessible. It also provides sound insulation, moisture and fire resistance and heat insulation (Milutiene, Jürmann, & Keller, 2007). It is said to have thermal conductivity similar to rockwool (0.045 W/m2K). The ease of availability makes it affordable thus reducing transportation costs.

Reeds

Reeds is Denmark's tallest grass ranging 3-4 meter in height. Its leaves are usually positioned in a row on the side stem facing away from the main wind direction. It grows in wet or damp soil conditions. In winter, it discards leaves remaining with only dry stalk which is used for thatching or base for walls or as roofing as it protects from harsh winds and rain (Kongeaastien, 2020). It is dried, cleaned and cut into lengths of 2m and tied in bundles of 16-27cm. Thatch offers thermal conductivity of 0.039 W/m2K to 0.055 W/m2K with a lifetime of 30-50 years (Schunck, 2003).

Recycled bricks

Bricks naturally durable, maintenance free, adaptable and flexible. They also provide stability from temperature changes along with mechanical resistance. It is also known to be fire resistant and provide good thermal comfort with the thermal conductivity of 0.15 W/m2K. Recycled brick seem like a good choice due to the location of the visitor centre as most of the neighbourhood is of brick construction. They can be reused after removing the remains of mortar which give the building exceptional appearance and character. They can also be used in the recycled form as filler or stabilizing agents, aggregates, plant substrates (Vandersanden group, 2016).

ZERO ENERGY STRATEGIES

The aim of the visitor centre is to achieve the zero-energy building standard for which the building must produce as much energy as it consumes. To make this possible, different modes of passive and active strategies can be integrated into the design (Hernandez & Kenny, 2010). The design not only relies on the aesthetic qualities but also depends on the strategies being implemented in the building. The passive strategies that can be implemented help the building in achieving a low energy standard reducing the energy consumption as much as possible.

Furthermore, it also helps the design with natural ventilation improving the indoor environment. The use of well insulated walls is a passive strategy used to prevent the room from low temperatures and providing good indoor thermal comfort. Various materials can be considered for using as insulation based on their thermal conductivity such as hemp, straw, seaweed etc. Despite the use of these strategies, the building usually requires more energy for supporting the various forms of electricity being utilised by the building. As the aim of the building is to have a total consumption of 0 kWh/m^2 to reach the zero-energy benchmark, methods to generate energy with renewable sources can be implemented such as solar panels and wind turbines (Crawley, 2006). The primary energy factors to be followed according to the Building Regulations 2018 stated that the primary energy for electricity is 1.9, district heating is 0.85 and other forms of heat supply is 1.0.

PASSIVE STRATEGIES

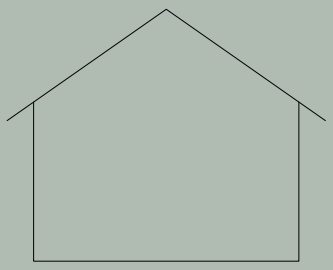
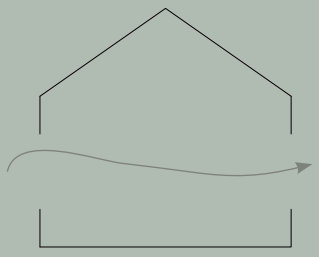
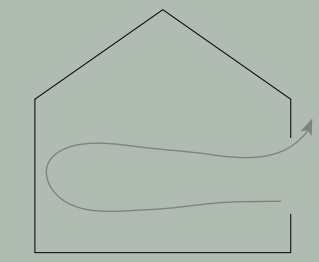
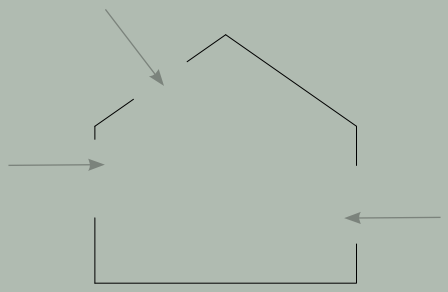
 OVER HANG	An overhang is a protruding structure that may protect the indoors from extensive heat or sunlight to provide good thermal and visual comfort. Overhangs can be extensions of the roof itself which serve the purpose or individual horizontal solar shading that can be provided over the window or opening. Blinds or louvres can be used as a replacement for overhangs if necessary. There is also the possibility of having automatic overhang which can be utilized seasonally.
 CROSS VENTILATION	Natural ventilation plays a crucial criterion for reducing the energy consumption of buildings as it reduces the required mechanical ventilation. Natural ventilation is variable based on the outdoor climatic conditions but can be manged with controlled inlet and outlet of air. Cross ventilation as the name mentions means inlet of air through one opening and outlet through another improving the air change rate inside providing good atmospheric comfort. Cross ventilation can be achieved by placement of openings on the opposite or adjacent side of the room (Dyke, 2014).
 SINGLE SIDED VENTILATION	Another method for improving natural ventilation is single sided ventilation. This method very much depends on thermal buoyancy which allows cold air to enter the room from the lower part of the opening or lower opening and hot air to rise and go out through the upper part of the opening (Heiselberg & Bjørn, 2002). The direction of wind and placement of the windows plays an important role to help improve natural ventilation.
 WINDOW PLACEMENT	Window placement plays an important role to achieve good indoor comfort, it effects atmospheric comfort and visual comfort. The placement of the openings and orientation can be manipulated according to how much daylight factor or air change rate is required for the indoors. The height of and size of the openings also play an important role (Walker, 2016).

Table 3: Passive strategies

ACTIVE STRATEGIES

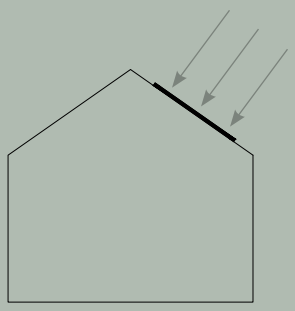
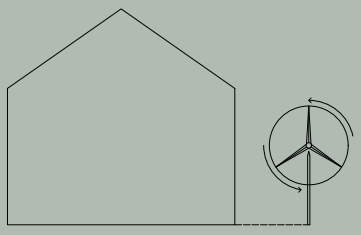
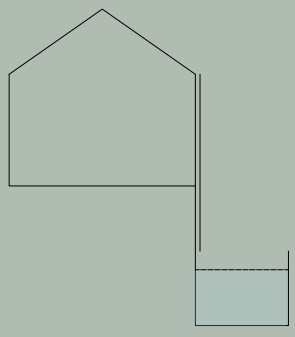
 SOLAR PANELS	Solar panels are one of the most widely used methods for utilizing a renewable source of energy to generate electricity. It is easy to use, has low maintenance, is economical and generates sufficient amount of electricity. The most used type of solar PV panel is the monocrystalline PV panel. They have a good efficiency of 18.5% (Dansolar, 2020). The monocrystalline PV panels have low maintenance and a relatively higher rate of efficiency than the other types of PV panels. These panels are also, flexible to integrate into the design as they can be placed on the roof, façade or individually. As the performance of PV panels depends on the amount of light it receives the most preferred placement of the panels is usually the south facing.
 WIND TURBINES	Wind turbines are of different types, the most conventional wind turbine thought of are the large-scale turbines that are used to generate large amounts of energy. The use of small-scale wind turbines have improved in the recent years as they are efficient and are one of the most eco-friendly means of generating energy. The small-scale wind turbines available nowadays are efficient, do not generate noise and are non-obstructive. There are also wind turbines with a horizontal axis requiring a smaller area that generate suitable amounts of electricity. Wind turbines mixed with photovoltaics and suitable storage batteries form a hybrid system of energy production and consumption (PV Europe, 2020).
 RAIN WATER HARVESTING	As the amount of rainfall in Skagen is on the higher end amounting to nearly 640 mm of rainfall annually (Weather and Climate, 2020), rainwater harvesting can be implemented to save water. The grey water that is collected through the rain can be stored in storage tanks under that ground so as they do not cause any hinderance and can be utilised for the flush systems in the toilet and also, for watering the greenery. This use of grey water reduces the demand for white water reducing the wastage of water and the economic efficiency. The pipes or gutters on the roof collect the excess water that is accumulated on the roof and transfer it to storage tanks that are usually located underground through pipes and the transferred to the flush tanks and irrigation system for active use (Genvand Aps, 2012).

Table 4: Active strategies

INDOOR ENVIRONMENT

The designed visitor centre must fulfil the requirements for air quality, thermal comfort, visual comfort, sufficient daylight and acoustic comfort according to the Danish Building Regulations (BR18).

Air quality

The perception of atmospheric indoor climate or air quality is dependent on factors such as smell, dust, fumes and humidity. To maintain a satisfactory atmospheric climate, it is necessary to supply fresh outside air and remove polluted indoor air. To maintain the ventilation rate low pollutant building materials must be used (otherwise increase air volumes). The ventilation rate should be maintained such that the CO_2 content does not increase 1000 ppm for the design conditions. The supply of outdoor air and the extraction must be at least 3.0 l / s per day per child and at least 5.0l / s per adult, and 0.35 l / s per m² floor area. In rooms with groups of people the supply air with outdoor air and the extraction must be at least 5.0 l / s per day. person and 0.35 l / s per person. m² floor area 'Ventilation (§ 420 - § 452)', (Building Regulations 18, 2018).

Thermal comfort

The thermal indoor climate must not exceed 26^{0}C except for a few hours per day per year and maximum of 100 hours above 26^{0}C and 25 hours above 27^{0}C. Buildings must be airtight in order to be able to conserve heat and avoid draft. Therefore, the requirements for airtightness is 1.0 l/s per m2 'Thermal indoor climate and installations for heating and cooling systems (§385- §392)', (Building Regulations 18, 2018).

Visual comfort

In working rooms, kitchens and social rooms the daylight is considered sufficient if the glass area is a minimum of 10% of the relevant floor area and in case of a skylight a minimum of 7% of the floor area. It could also be considered sufficient daylight in social rooms and kitchens if the daylight factor is a minimum of 2% in half of the room and the same for working rooms. Sufficient daylight can also be documented through interior lighting intensity of 300 lux levels or more for at least half of the relevant floor area for at least half of the daylight areas. Since skylights receive significantly more daylight than vertical windows, the glass area for skylights is recognized by a factor of 1.4. The glass area is calculated for each window as the free opening area, ie. the entire area of the window minus the frame, frame and splash areas. Based on the floor area of the room, the minimum glass area is determined as:
AG, min = 0.1 x Agulv, m², where
AG, min is minimum glass area, m^2
Agulv floor is the net floor area of the room, m^2
'Lys og udsyn (§ 377 - § 384)', (Building Regulations 18, 2018).

Acoustic comfort

Between the rooms of various functions in the visitor centre, the sound coming from the adjacent rooms should not exceed 48dB and the reverberation time should be regulated as per the usage of the room. The noise from the technical installations should be less than 30dB to the common areas. The requirements are fulfilled when the reverberation time T is <0.6 s in rooms with a height more than 4m 'Sound conditions (§ 368 - § 376) , (Building Regulations 18, 2018).

05 PROGRAM

ROOM PROGRAM

	ROOM	QUANTITY	UNIT AREA (sqm)	TOTAL AREA (sqm)	P E R S O N S PER ROOM	D A Y FAC
Arrival	ENTRANCE	1	10	10	-	
	RECEPTION/ INFORMATION CENTRE	1	50	50	4	
	WARDROBE	1	14	14	2	
	STAFF STORAGE/ TECH-NICAL ROOM	1	18	18	2	
Leisure	WAITING AREA/ LOBBY	1	95	95	16	
	TOILETS	7	5	50	7	
	SOUVENIR SHOP	1	30	30	5	
	CAFETERIA	1	200	200	40	
	KITCHEN & STORAGE	1	50	50	3	
	OUTDOOR TERRACE	1	200	200	20	
Exhibition	EXHIBITION AREA	1	500	500	35/40	
	TECHNICAL ROOM	1	30	30	2	
	EXPERIENTIAL EDUCATION ROOM	2	40	80	15	
	CONFERENCE ROOM	1	30	30	8-10	
	AV ROOM	1	50	50	15	
	WORKSHOP AREA	2	30	60	10	
Staff area	TOILETS	4	3	12	4	
	COMMON OFFICE AREA	1	30	30	5-6	
	LOCKER/ STORAGE ROOM	1	10	10	5-6	
	SOCIAL ROOM	1	25	25	6-8	
	MEETING ROOM	1	30	30	5	
	TOILETS	4	3	12	4	
	TECHNICAL ROOM	1	10	10	2	
	STORAGE DEPOT	1	10	10	2	
	CLEANING STORAGE ROOM	1	10	10	2	
	OUTDOOR LOCKER AREA	1	15	15	-	
			Total	1800 approx.		

DAYLIGHT FACTOR (%)	FUNCTION	IMPORTANT ASPECTS
-	-	Well lit open space
DF ≥ 2	Public	Includes space for information desk and seating
DF ≥ 1	Private	-
DF ≥ 1	Private	Area to be accessed by the management staff
DF ≥ 3	Public	Double height space to create a smooth transition into the cafeteria area
DF ≥ 1	Public	-
DF ≥ 2	Public	Open plan making it easily visible and accessible
DF ≥ 3	Public	Open space for all to create a social environment and a view to enjoy the nature
DF ≥ 3	Private	Consists of the cold storage and dry storage
-	Public	Can be accessed from the outside as well
DF ≥ 3	Semi-public	Double height area witha warm atmosphere with exhibits about the art and history of Skagen, with an informal staging area for people to take in the atmosphere
DF ≥ 1	Private	Space to store the extra elements of the exhibitions
DF ≥ 2	Semi- private	Rooms to educate the visitors about the art, historical and cultural backgrounds
DF ≥ 3	Private	For users(scientists, orinthologists) to have seminars or meetings with th group
DF ≥ 1	Semi private	Space to show movies and video clippings to the visitors
DF ≥ 3	Semi private	Space for the students and visitors to learn knowledge imparted by professionals regarding different topics
DF ≥ 1	Public	-
DF ≥ 4	Private	Common office space for various departments to do paperwork
DF ≥ 3	Private	Space for employees to store their belongings and change if needed
DF ≥ 3	Private	Space for the employees to relax, rest and recuperate
DF ≥ 3	Private	Space for the staff to organise group meetings
DF ≥ 1	Private	-
DF ≥ 1	Private	One for each block
DF ≥ 1	Private	-
DF ≥ 1	Private	-
-	Public	Space for the visitors to store thei belongings

Table 5: Building room program

FUNCTION DIAGRAM

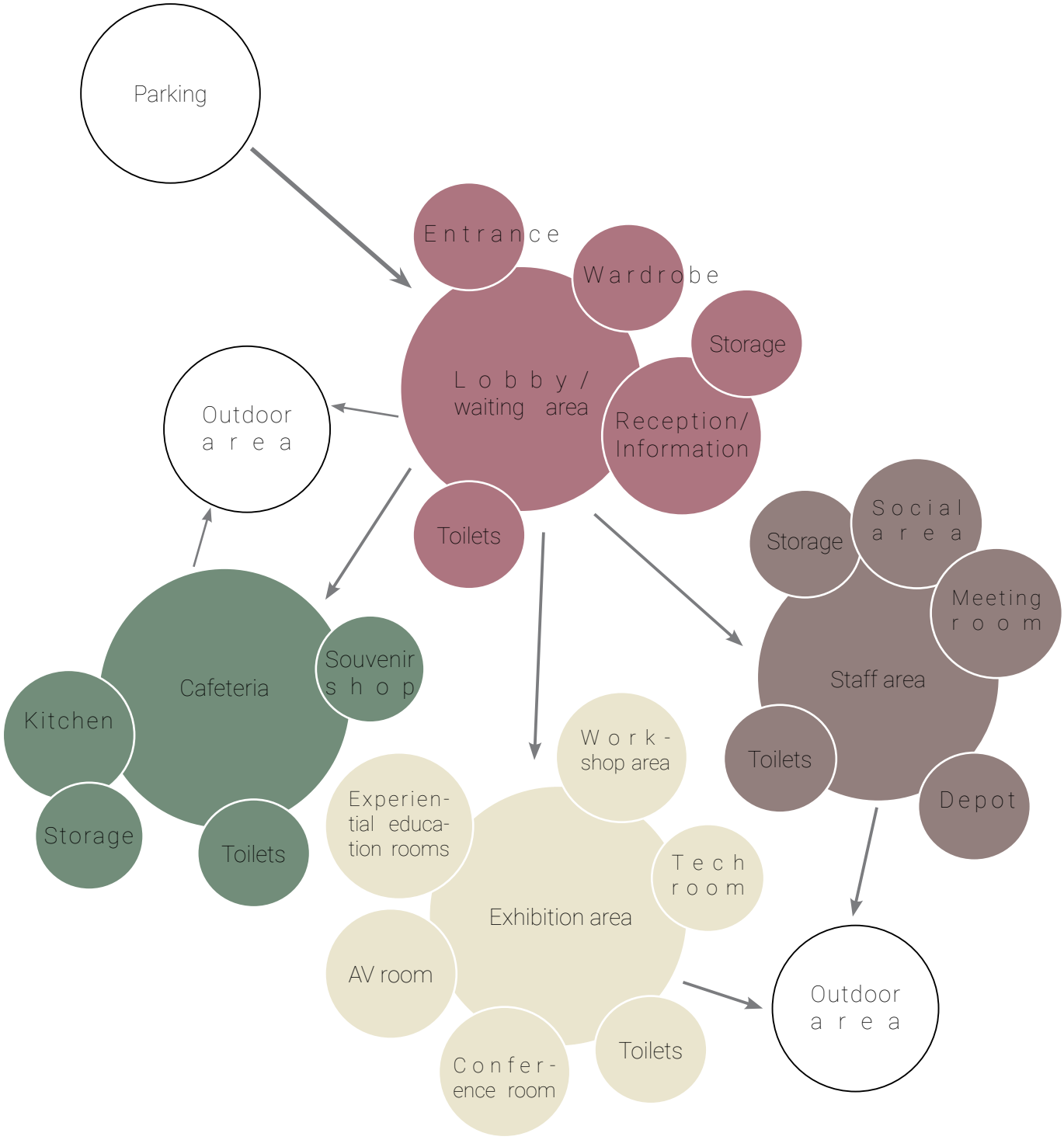


Illustration 29: Function diagram

DESIGN CRITERIA

UTILIZATION OF THE CONTEXT

The building design should fit into the neighbourhood context while utilizing the cityscape advantages such as the unique views, microclimate. It should also be an attractive place for the neighbourhood.

RELATION TO NATURE

Shaping the design in order to relate to the surrounding nature and its environment through physical expression as well as materiality.

ACTIVATION OF THE AREA

Conceptualizing public and semi-public zones close to existing tourist spots to make the area livelier.

RETAINS CHARACTER OF THE PLACE

Integrating the character and atmosphere of the plot and its surroundings to the design.

DEFINE VIEWS AND ATMOSPHERES

Divide public and private spaces to ensure good indoor atmosphere while directing towards views

ACCESSIBILITY

Ease of access to the centre using ramps for the disabled to facilitate movement throughout the building.

SEGREGATION OF SOCIAL SPACES

Separating the public, semi-public and private, open and closed with different activities, lounge areas, quiet spaces to ensure social comfort.

NAVIGATIONAL COMFORT

Open and comprehensible spaces with easy way finding paths, representations and colour schemes to identify the different social zones in the building while maintain smooth transition.

FUNCTION BASED DESIGN

The planning and provision of facilities should be based on strategic design to create a hierarchy and rhythm between public to private areas.

INTEGRATED SUSTAINABLE STRATEGIES

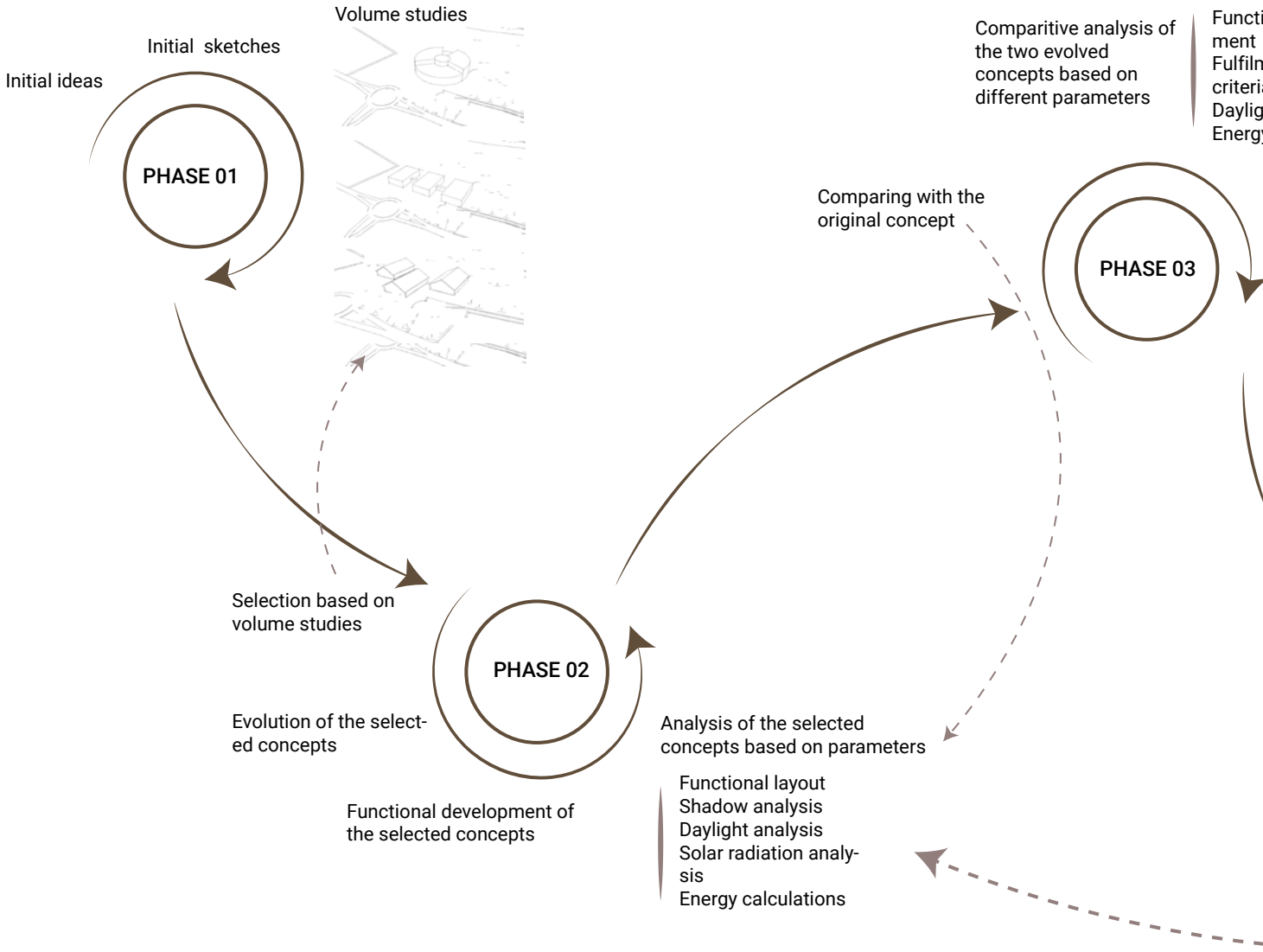
Application of passive and active strategies in the design process to achieve zero-energy standards.

VISION

The aim of the design of the visitor centre, envisions to capture the local identity by experiencing the atmosphere and activating the senses of the visitors, helping them connect and understand the history and heritage of Skagen while inspiring to be socially, culturally and environmentally sustainable. While maintaining the unique atmosphere the aspiration is to create a smooth transition for the different visitor groups to perceive Skagen with a panoramic experience. Furthermore, the use of natural and sustainable materials along with passive and active solutions merge the aesthetics of architecture along with an environmentally sustainable design.

Illustration 30:Site image

06 DESIGN PROCESS


Volume studies
Initial sketches
Initial ideas
PHASE 01
Comparitive analysis of the two evolved concepts based on different parameters
Functi
ment
Fulfiln
criteri
Daylig
Energy
Comparing with the original concept
PHASE 03
Selection based on volume studies
PHASE 02
Evolution of the select-ed concepts
Functional development of the selected concepts
Analysis of the selected concepts based on parameters
Functional layout
Shadow analysis
Daylight analysis
Solar radiation analy-sis
Energy calculations

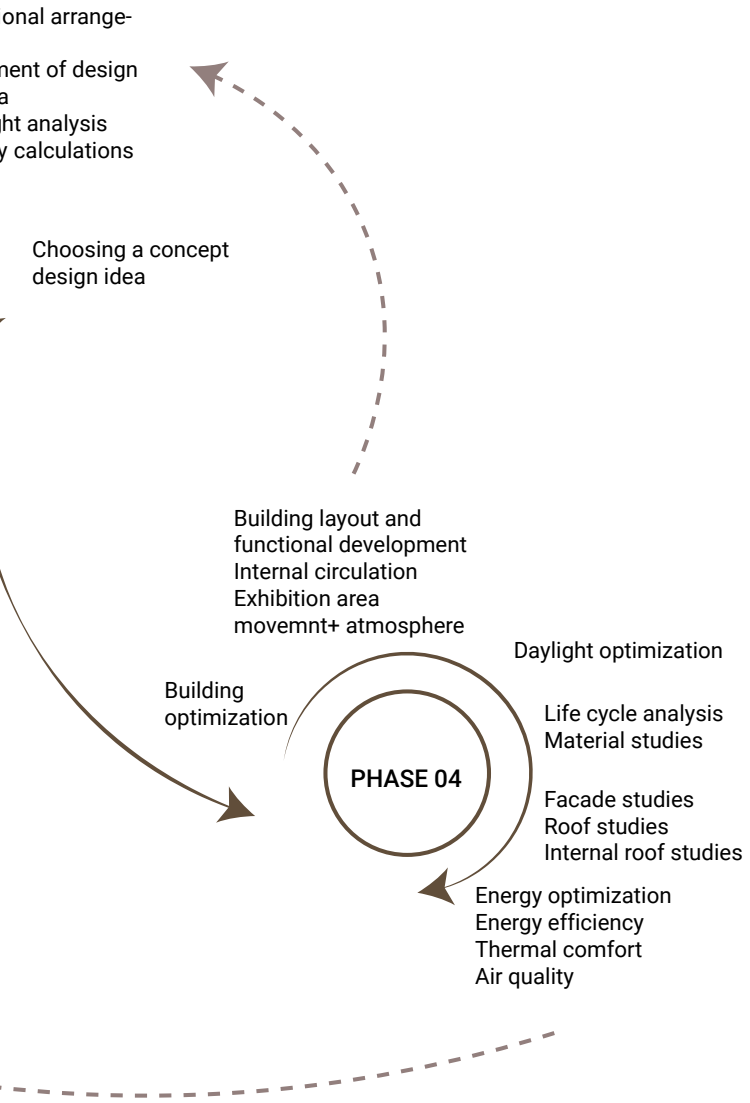


Illustration 31: Design Process phases

DESIGN PROCESS

The diagram on the left shows the complexity of the design process' phases. Withing the design process four main phases can be distinguished as:
• Initial ideas and sketches for the building form conceptual design
• Evolution of the selected concepts
• Choosing a concept based on a comparative analysis between concepts
• Building design optimization

While working on the initial ideas' different approaches were taken where the options were analysed based on their positive and negative effects on the design criteria. In order to choose a concept, the two chosen variations were further investigated with respect to different analysis like shadow, daylight, functionality, gains from solar radiation as well a preliminary energy calculation (facades, roof and floor with same U-value, similar window styles and sizes) was done to understand the design ideas' strength and weakness

.

The next step was to compare the concepts based on the fulfilment of the design criteria, energy efficiency, indoor comfort, etc.

When the concept has been chosen, the layout development phase was worked on which lead to reviewing the functional and structural challenges.

The next step was to work on optimization of the design to improve and maximize the potential of indoor environmental conditions and energy performance of the building, through layout, facade design and technical design decisions.

These steps worked on the integrated design process principle making it an iterative way to reach the final design solution.

INITIAL IDEAS

The masterplan shows the three distinct views visible from the site in order to shape the design in the next steps.

1. The south west side offers the view of the historical landmark - Vippe-fyret
2. The southern end given an open view of the beach and the waters in spite of being far away
3. The eastern side of the site gives a blend of the vast open field as well as the small forest

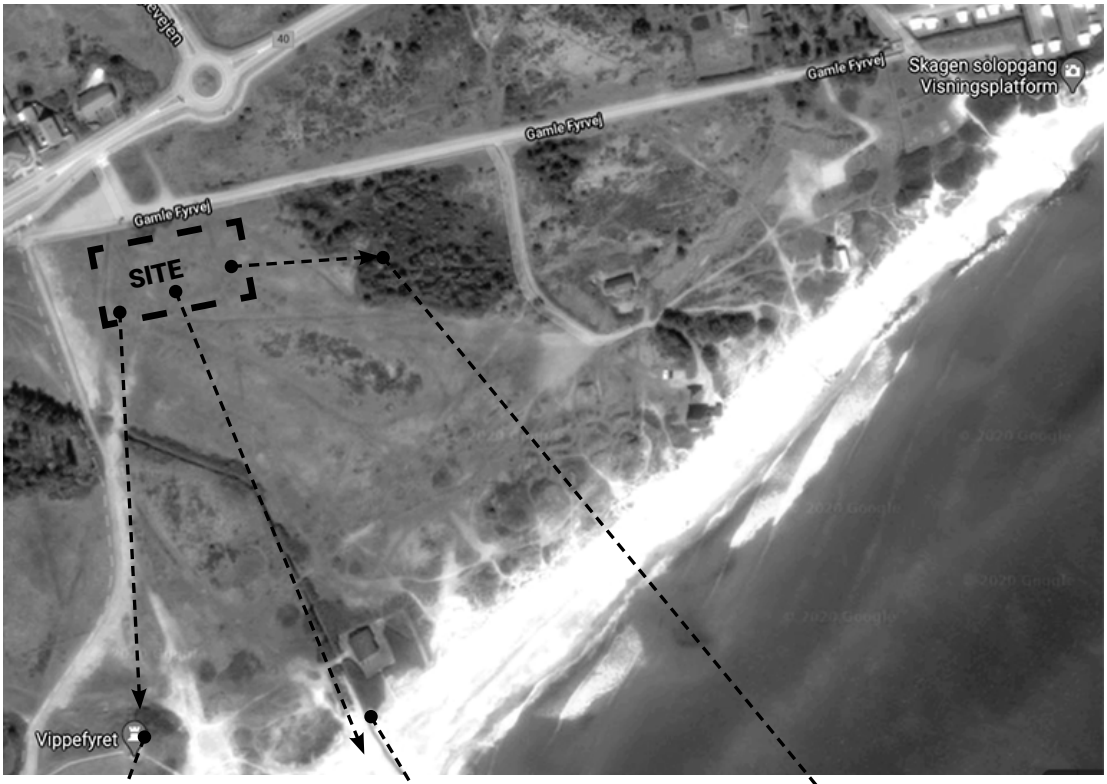
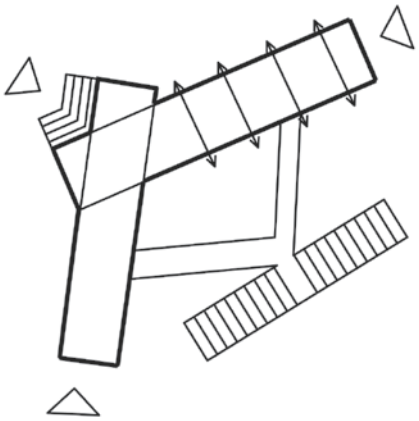


Illustration 32: Masterplan showing different views around the site

INITIAL SKETCHES

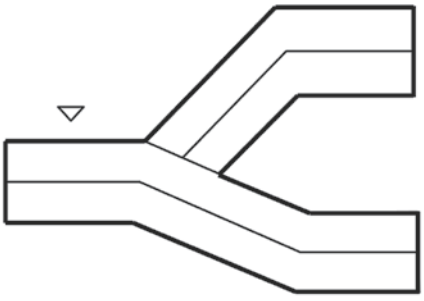
SCOPE:

The initial sketches and ideas were worked on through basic hand drawn concepts and refining them using 2D software. These sketches revolved around the fulfilment of few of the core design criteria produced from the analysis phase of the project. These sketches are divided based on the approach such as linear, central core, directional, etc. These were analysed with respect to the fulfilment of design criteria such as retaining the character of the place, functional ease, function-based design while making the most of the distinct views offered through the unique location of the site showed on page 64. The positives and negatives of few of the ideas are depicted through text under the design idea.



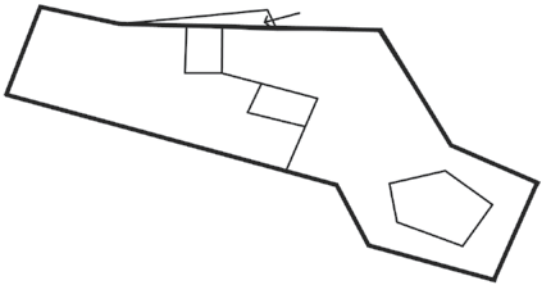
1. Based on rectangular concept

- Creates an inviting entry while leading towards two distinct views
- • Defines an open public space which bring it unique atmosphere
- Long distance makes it difficult to navigate and reach different functions
- Difficult to maintain zones and separate the functions for the users



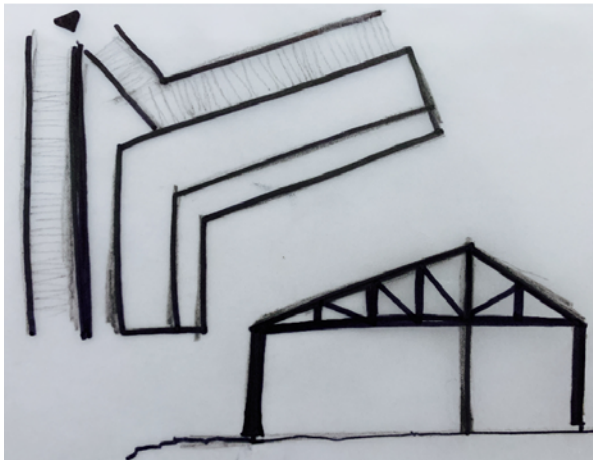
2. Y Shape concept

• Evolved from the previous X shape in order to create 3 wings
• Provides ease of navigation through segregation of spaces
• Creates a central protected courtyard
• Not oriented towards the interesting views
• (This formed the basis for the original design of the visitor centre)



3. Based on rectangular concept

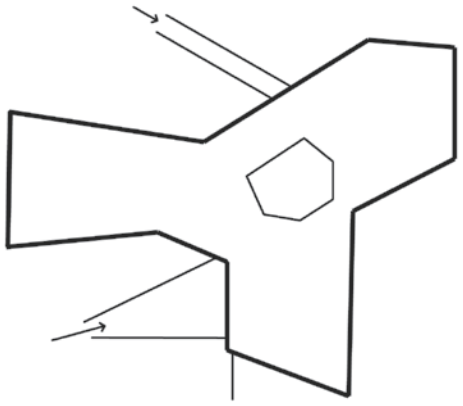
- Angular protrusion in a simple rectangle to pull towards the interesting views
- Difficult to maintain clear zones
- Jagged edges create a rough aesthetic from the
- outside



4. L Shape concept

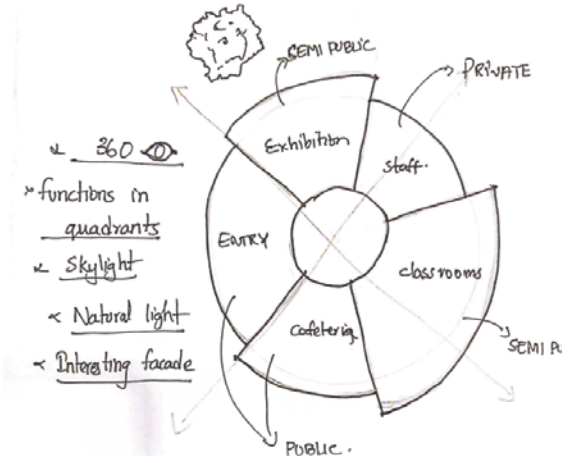
- Based on the simple rectangle, it is explored and aligned towards 2 distinct views of the forest on right and water and beach in the south
- Asymmetric pitched resembles the town style while creating some uniqueness
- The long distance again proves to have difficulties in navigation for the users
- Due to the linearity, it creates a corridor type effect which could be unappealing for the users

Core centrered approach



5. Pinwheel concept

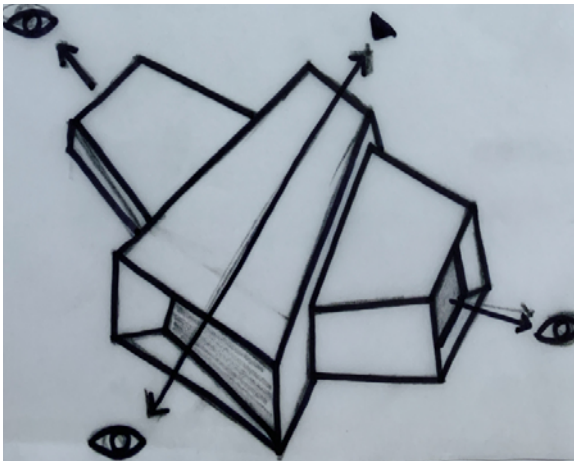
- Evolved from the Y form and rotated to accommodate according to the diverse views on the three
- sides
- Forms a central courtyard
- The three wings make it easy to divide and separate the different functional areas based on the privacy levels
- The edged ends create a rough look



6. Circular concept

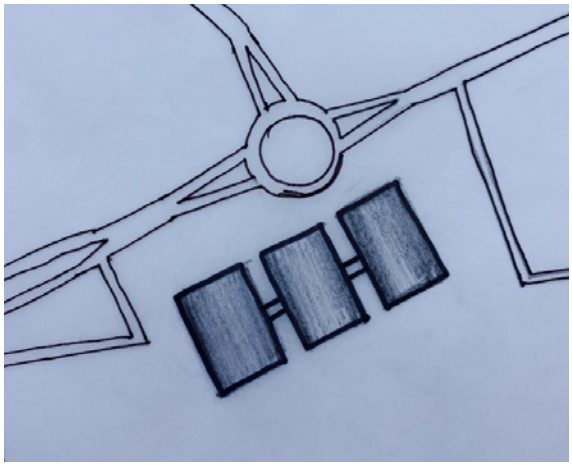
- The pin-wheel design was further experimented by developing the harsh edges into circular form to create this form with a central courtyard
- The different quadrants provide an ease of segregation as well as navigation
- The circular form gives scope for directing towards different views
- This could be further explored to accommodate privacy levels

View oriented approach



7. Irregular rectangle concept

- Evolved from rectangles to irregular ones in order to accommodate different views while creating an inviting entry for the users
- The three blocks though attached help in dividing the spaces based on the functions
- The irregular form narrows and widens at ends to create an interesting indoor atmosphere
- The irregular structure stands out and does not relate to the town and surroundings



8. Barn/town concept

- Adopted from concepts 7 and 1, while merging the positive aspects
- The structure style is similar to a barn concept giving unobstructed views form the entry to the exit with a pitched roof
- The three separate blocks help in dividing the various functional zones
- It gives scope for rearrangement in order to create courtyard and outdoor areas.

Illustration 33: Initial sketches

VOLUME STUDIES

In consequence to the initial sketches and ideas, the core centred approach was advanced to evolve into a smoother form similar to a circle where the zones are divided into quadrants based on the functional divisions to create an easy transition for the different user groups. This form also offers a panoramic view to the site making the most of the unique views of the surroundings. The design concept was further developed to accommodate the different function in two levels to create an interesting viewing point. To decide the advantages the next step has been to evolve the basic concept with detailed plans and analyse it with respect to the different parameters of the design criteria.

ANALYSIS:

By looking at the different design outlooks based on the four approaches, the pros and cons were analysed to gain a better understanding of the concepts that could be selected and worked on further in the next stage of the design process. The rectangular concept was worked on in the first attempt of the project, thus the core centred approach along with the view-oriented approach was further probed and evolved. The next step of the design process is to analyse the volume studies of the two conceptual ideas and advance the iterations.

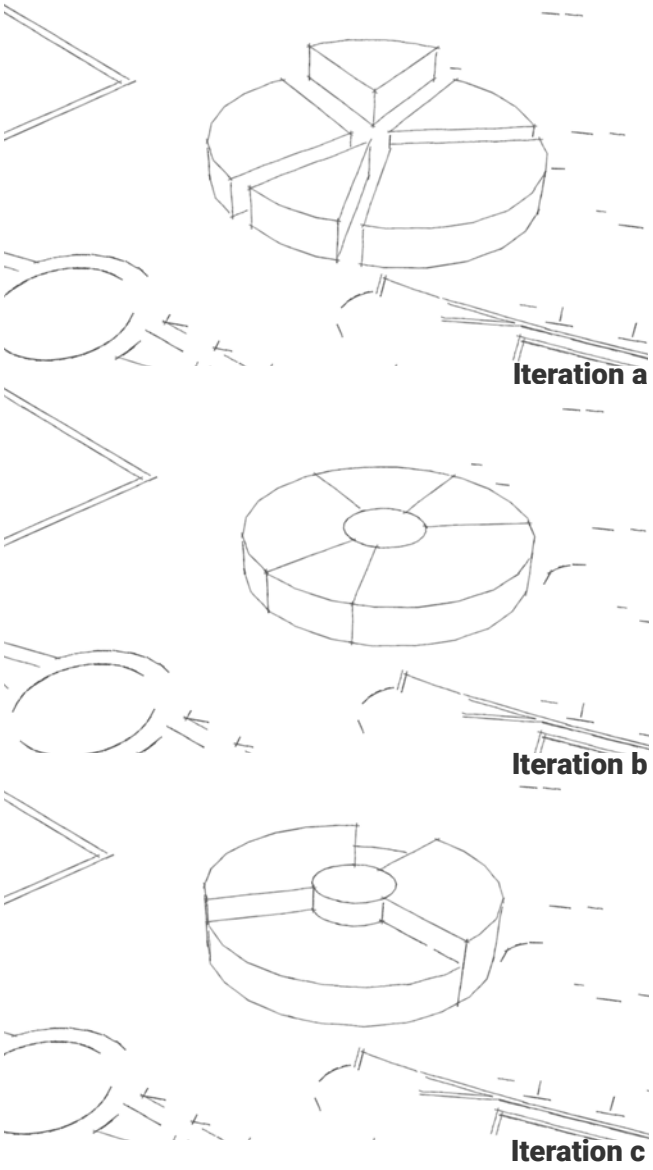


Illustration 34: Volume studies and formation of circular concept

View oriented approach has been advanced to evolve from concept 7 to 8, where the irregular form has been converted to uniform rectangular blocks in a volume study form while retaining the basic idea of directing the users towards the distinctive views of the site. The functional parameters have also been considered simultaneously which can be seen in the 8 barn concept in the initial sketches.

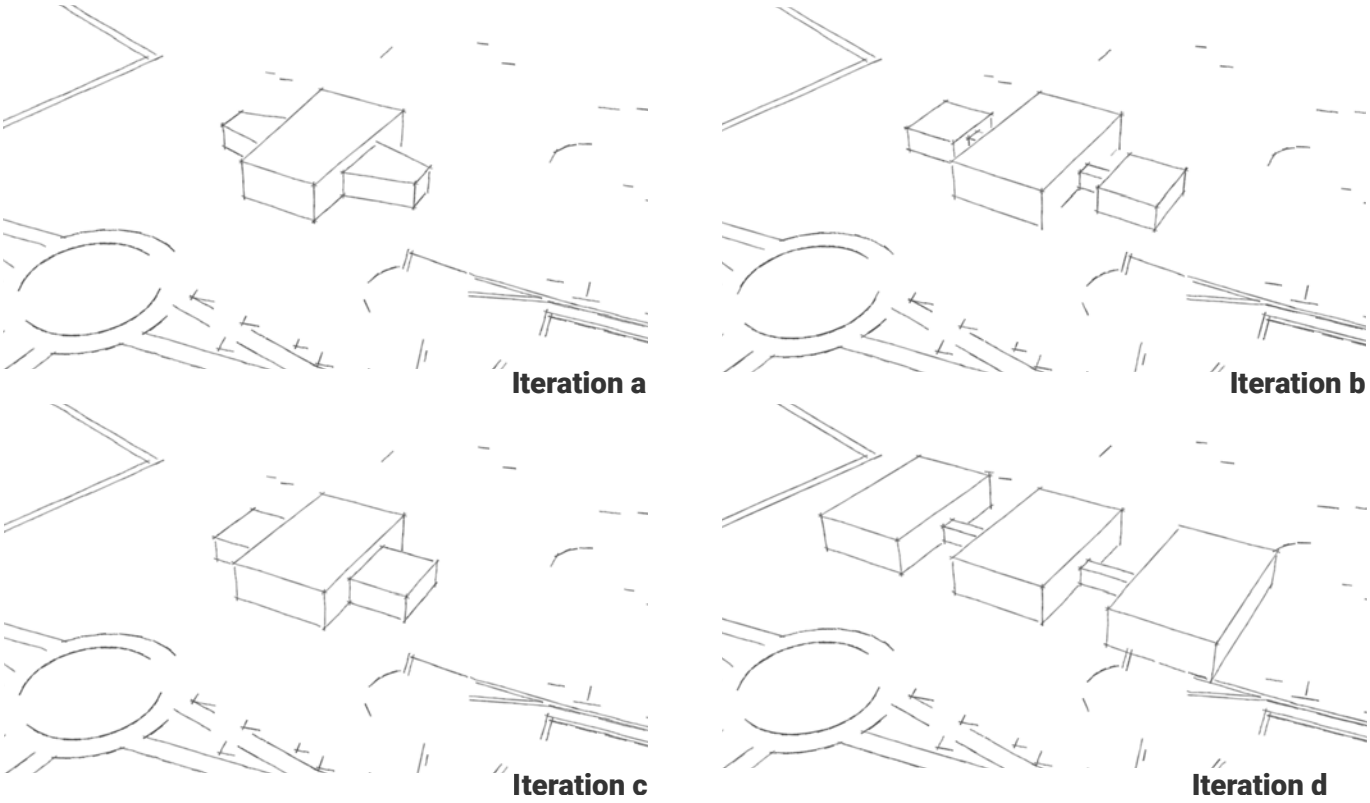


Illustration 35: Volume studies of view oriented approach 7-8

Barn concept volume studies/ iterations

In consequence to the initial sketches of the barn concept, volumetric development was also conducted in order to rule out various possible iteration of placing the 3 blocks in the site. The different variation included reorienting the blocks where in the first one, the central block was moved behind, but this created a central open area which is not protected from the harsh winds. The area of the central space was also probed to be smaller which could be further explored with relation to solar and wind analysis.

The other iterations are playing with the alignment of the blocks, the three blocks are aligned to the main entry road rather than the views of the site, which although give an interesting facade expression does not fulfil the design criteria of relating to the site and its surroundings. Although several variants are possible in this concept a few more were analysed with a few criteria kept as the deciding factors.

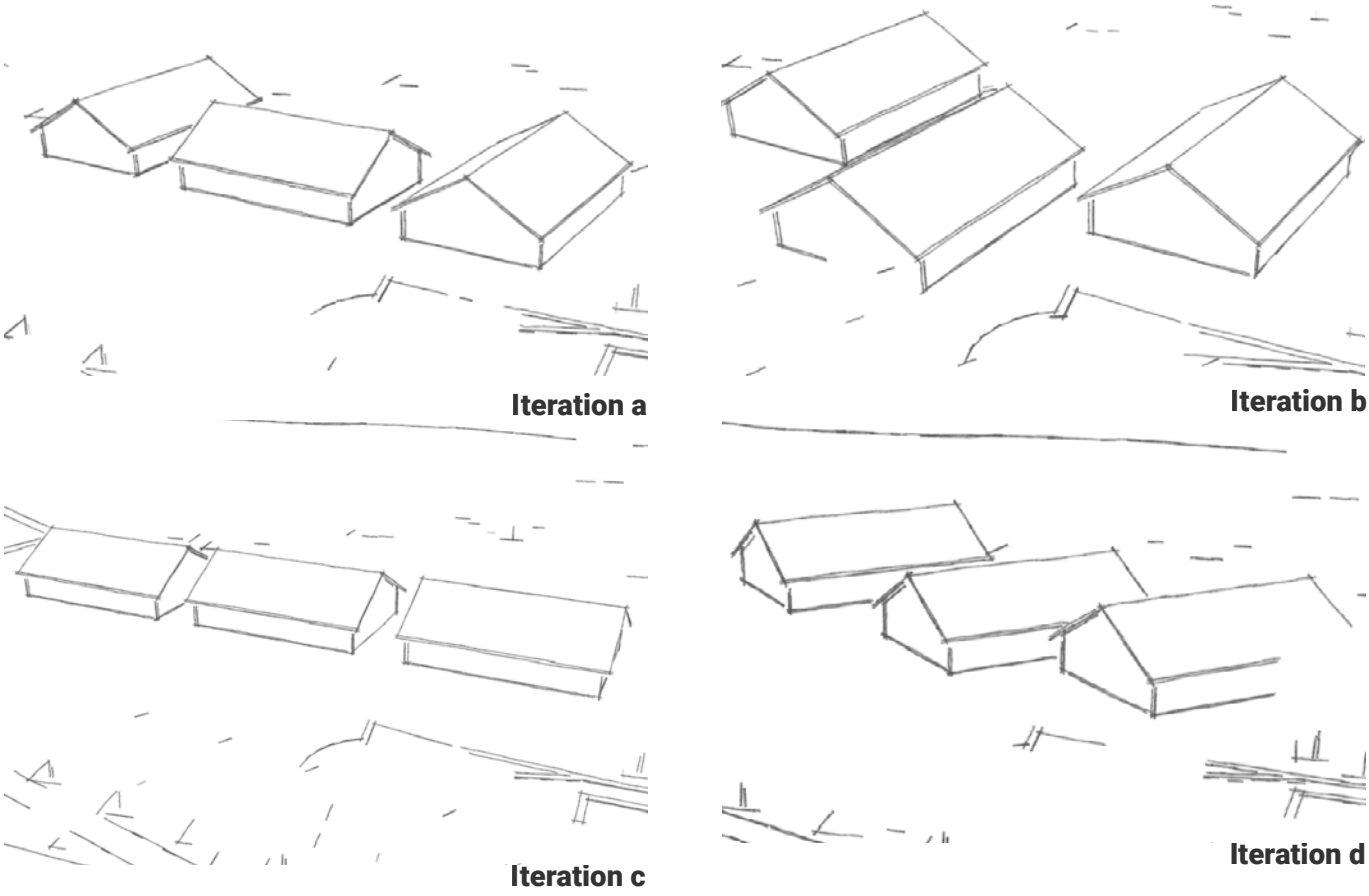


Illustration 36: Volume studies/ iterations of barn concept

PHASE 2- EVOLUTION OF THE SELECTED CONCEPTS

From the assessment of the initial ideas, sketches, volume studies and the different iterations two concepts have been selected to be evolved further into detail with respect to different parameters such as functional layout, movement, shadows, daylight analysis, solar radiation analysis and energy calculations to compare them in the third phase of the design process.
For the different parameters to be compared later, there are standards maintained, such as for daylight analysis Velux studies are done where the public and private zones are examined to reach ambient indoor daylight levels. For the solar radiation analysis, roof areas are inspected to understand the potential placement of solar panels as well as assess any risk of overheating in the building concept. The required area of solar panels also needs to be calculated to understand the energy demands.

For assessing the indoor environment and energy efficiency, calculations have been done for the basic form of the concept, where the U-values of the walls, roofs and foundation are taken to be the same. (see Appendix 13 - U-value calculations) The window sizes are maintained to be the same sizes (1.2*3m or 1.8*3m) for the different openings. All these parameters are considered for the two selected concepts (circular and barn concept) and analysed simultaneously to consider the next phase of the design process i.e. comparative analysis of the concepts along with the original rectangular concept which had been worked on in the previous attempt.

BARN CONCEPT

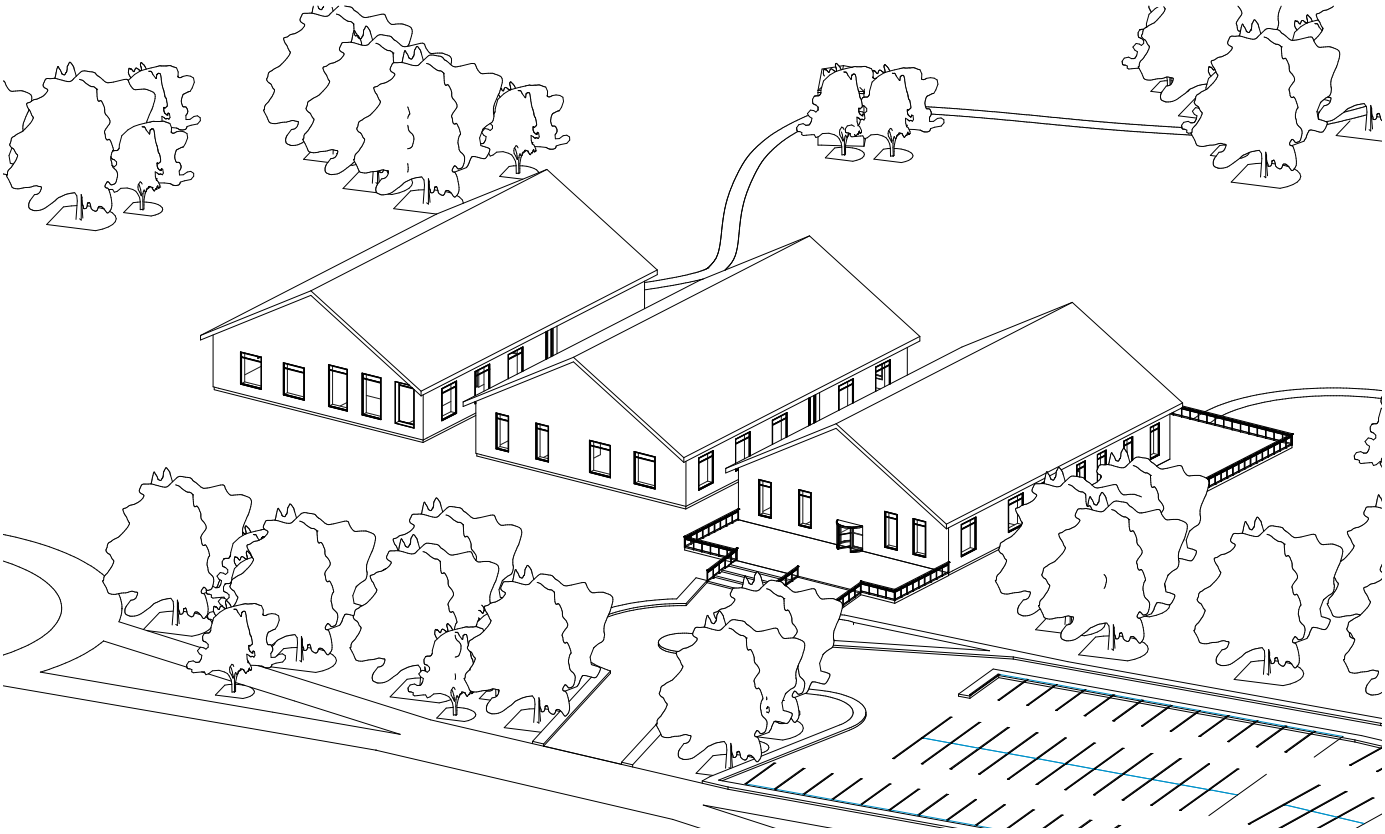


Illustration 37: View of barn concept 1

Total area: 1782sqm
Total area: 1782sqm
Atmosphere: Semi open
Views: Directional
The barn concept consists of 3 building volumes connected through a covered walkway with same volumes for each block, which through the surrounding environments focus of different views and zones of privacy. The first block acts as a social zone which caters to most of the public activities be it indoors or outdoors. The second block consists of the exhibition area which acts as a semi-public area which looks onto the beach and the waterfront. The private functions are placed strategically further from the entrance with a coverage of nearby greenery and an undisturbed view of an open area. The placement on site offers opportunity to access the beach easily through walkways. It also provides ease of access from the main road. This concept is based on the idea of barns present in towns which merges with the existing neighbourhood seamlessly. The different blocks also increase the facade and roof area for the placement of solar panels.

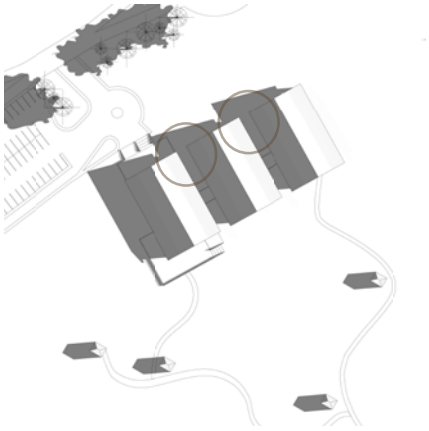
SHADOW ANALYSIS

SCOPE:
The analysis has been done with the use of the Revit software supported with the information from geo-location. The analysis allows to investigate parts of the design that are shaded by the surrounding or building itself during summer, spring and winter for the design of outdoor spaces which could be used as a public area by the different user groups.

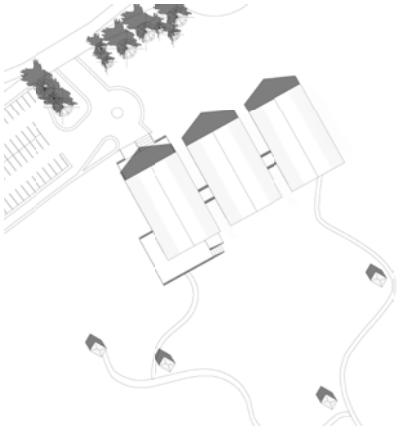
ANALYSIS:
From the analysis it can be understood that the three blocks mainly shadow each other in the morning and evening during summer and spring. No scope of outdoor area due to the arrangement of the blocks.

Summer solistice

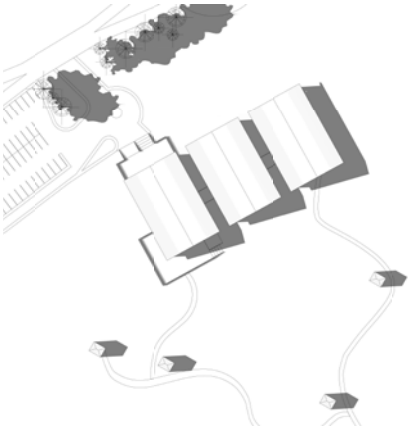
21st June, 8.00 am



21st June, 12.00 pm

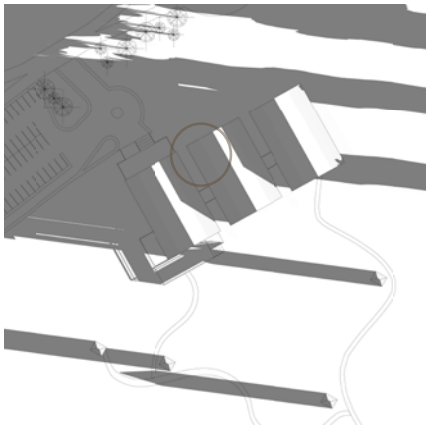


21st June, 6.00 pm



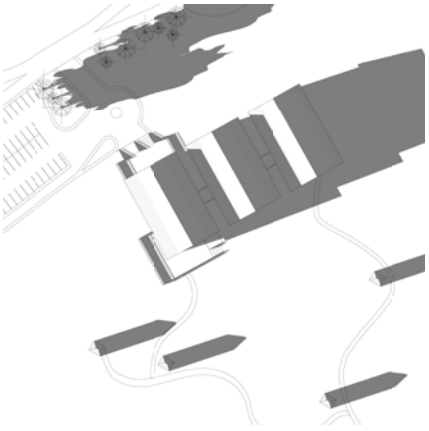
Spring Equinox

21st March, 8.00 am



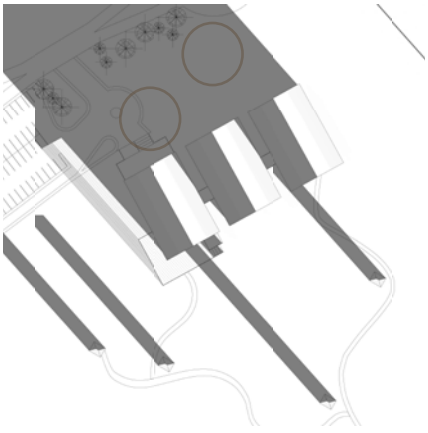
21st March, 12.00 pm

21st March, 6.00 pm

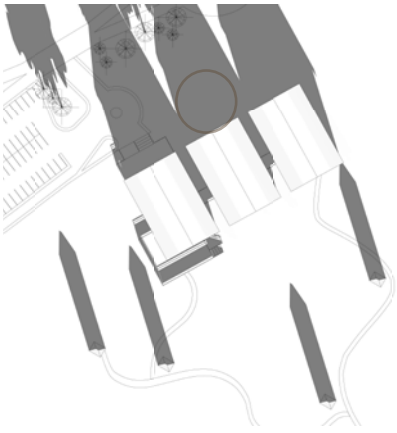


Winter Solistice

21st December, 8.00 am



21st December, 12.00 pm



21st December, 6.00 pm

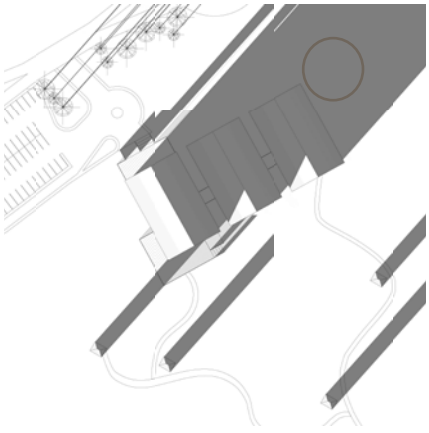


Illustration 38: Shadow analysis for barn concept 1

PLAN

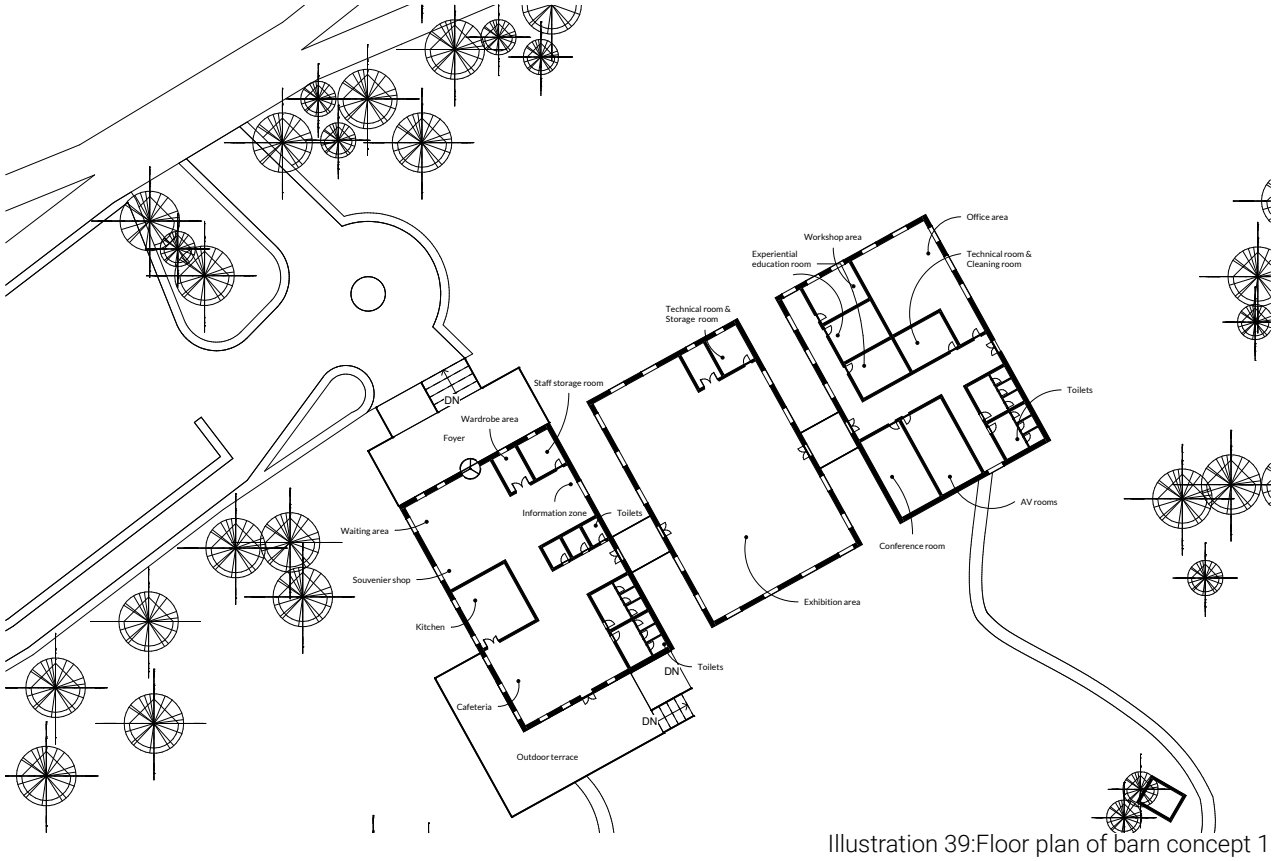


Illustration 39:Floor plan of barn concept 1

DAYLIGHT ANALYSIS

SCOPE:

The analysis has been done with the Velux Daylight Visualizer.
The analysis of the concept is done based on the ground floor level. It shows the average daylight factor in September at 12.00

ANALYSIS:

It shows an average of 2.5 in the common areas of the three blocks, but the third block is less illuminated due to the room arrangement.

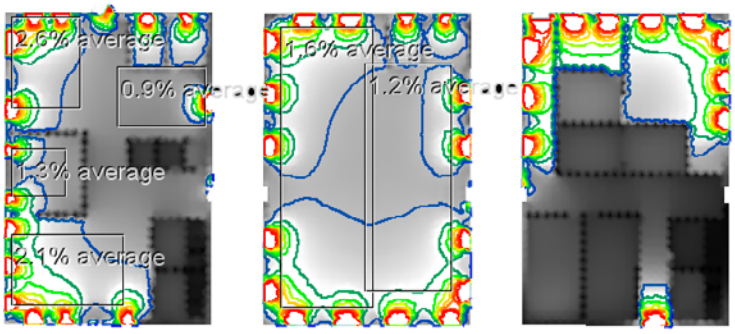


Illustration 40: Velux analysis of barn concept 1

SOLAR RADIATION ANALYSIS

SCOPE:
The analysis is done on rhino with the help of using software like ladybug and honeybee.
The illustration shows an analysis that helps assess the risk of overheating and the potential for solar gains on the roof and other surfaces of the building.

ANALYSIS:
This layout of the buildings shows that the south-west facing roofs have abundant heat useful for solar gains which could be advantageous for the placement of solar panels. The building has a total of 1165 Sqm of roof area that are highly radiated that can be used for solar panels.

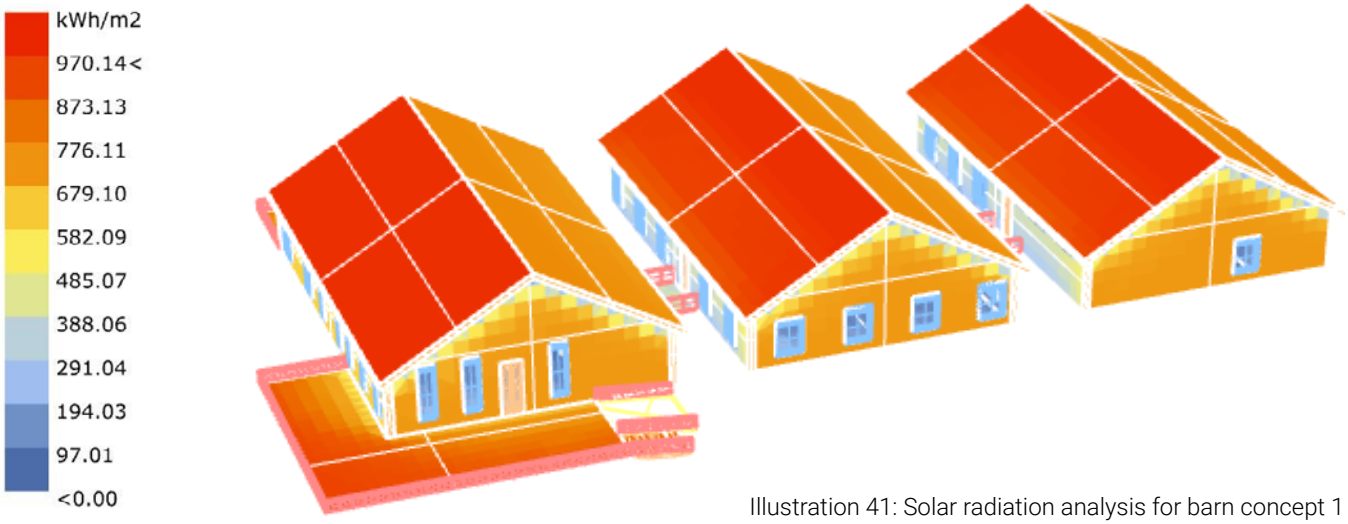


Illustration 41: Solar radiation analysis for barn concept 1

ENERGY CALCULATION

SCOPE:
The calculation has been done based on the Danish software Be 18 and the Danish weather data.
This concept has the total heated floor area of 1782 sqm. with glazed area as 30%
This is based on rough estimation not including ex-actoperation calculation.

ANALYSIS:
The energy consumption is more than the standard according to building regulations due to the large window openings of size 1.5m*3m and 1.8m*3m. To cover the required amount of energy using solar panels, nearly 712 sqm. of solar panels are required which can be utilised on the abundantly available roof area. (The solar panel calculation can be re-ferred to in appendix 8-PV panel calculation)

Total energy demand:
42.6 kWh/m^2

Contribution to energy requirement

Heat: 21.6
Excessive in room: 0
Net requirement

Room heating: 21.6

CONCEPT EVOLUTION 2

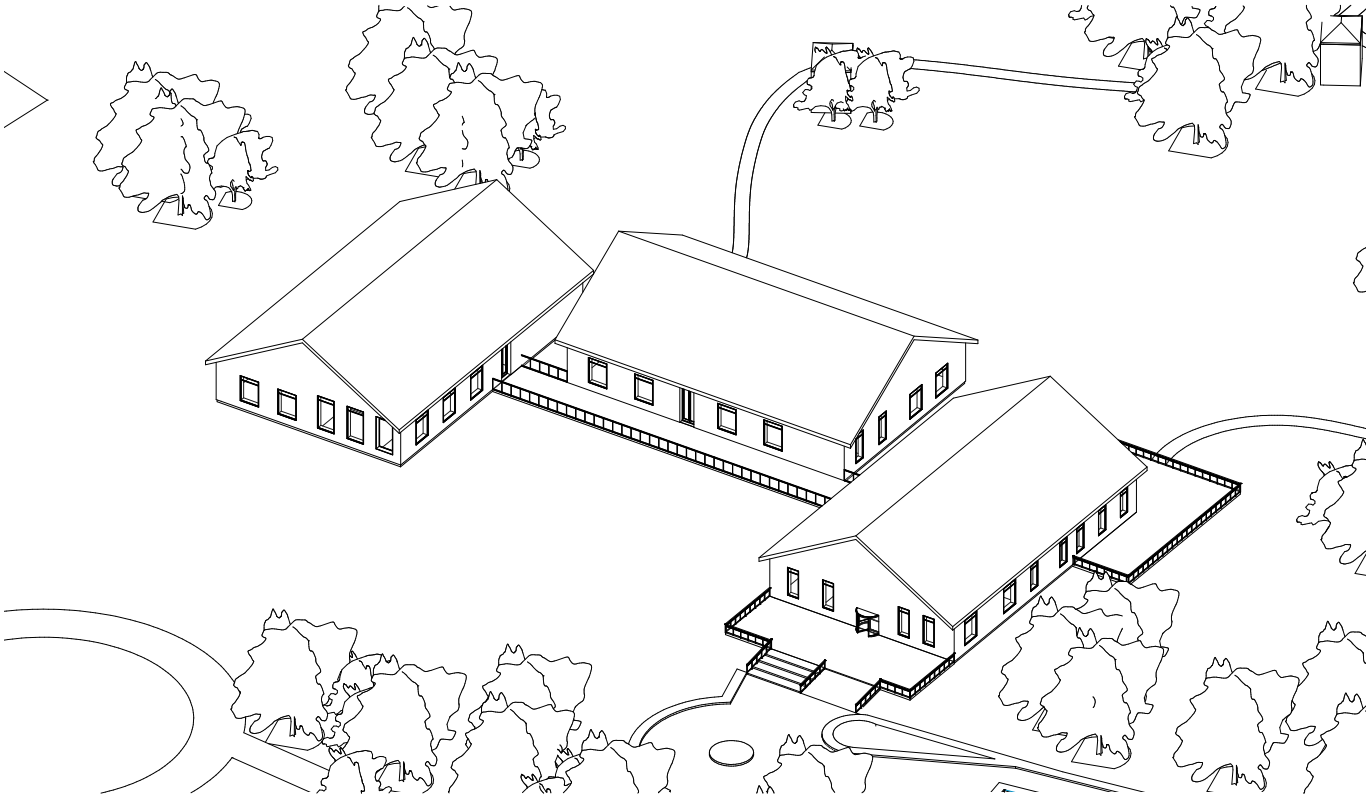


Illustration 42:View of barn concept 2

Total area: 1782sqm
Atmosphere: Semi open
Views: Directional

The three blocks are now rearranged in order to gain better daylight as well as to avoid shadows from the blocks itself. The function remains similar in the three different blocks. The provision of an outdoor walkway makes it easier to reach the different blocks instead of passing through each of them as seem in the previous version. This arrangement also gives scope to create a courtyard like space which remains protected from the south western winds.
Although, this arrangement has solved issues of daylight in the first two blocks, the distance between the entry and the private staff block is too much which could be difficult for the users (staff as well as visitors) if the walkway is uncovered.

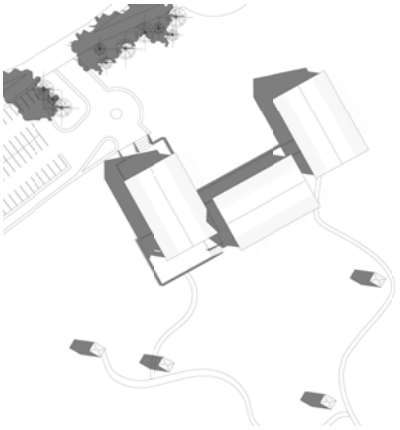
SHADOW ANALYSIS

SCOPE:
The analysis has been done with the use of the Revit software supported with the information from geo-location. The analysis allows to investigate parts of the design that are shaded by the surrounding or building itself during summer, spring and winter for the design of outdoor spaces which could be used as a public area by the different user groups.

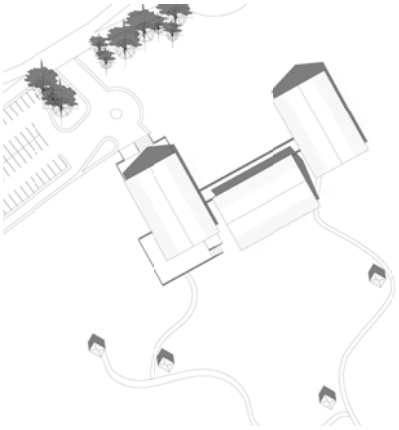
ANALYSIS:
From the analysis it can be understood that the rearrangement of the central block helped in creating a central outdoor space which receives optimum sunlight during summer and spring. The outdoor terrace in the block one also remains unshaded during most times.

Summer solistice

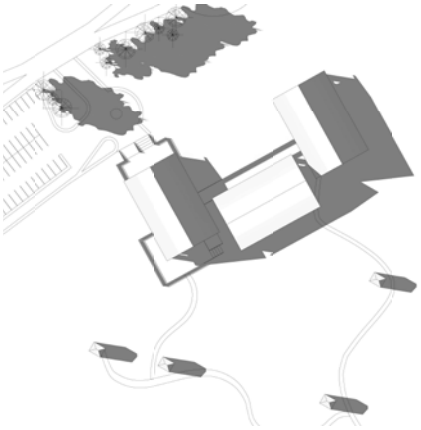
21st June, 8.00 am



21st June, 12.00 pm

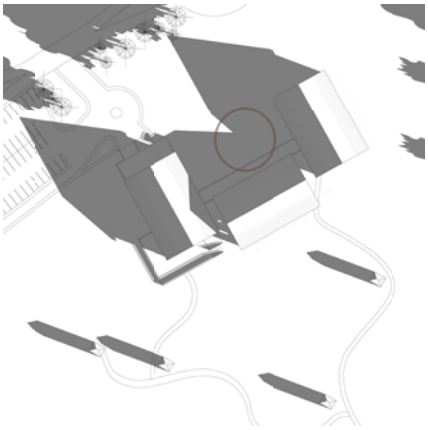


21st June, 6.00 pm

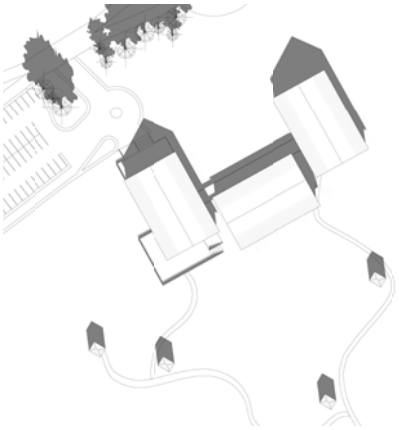


Spring Equinox

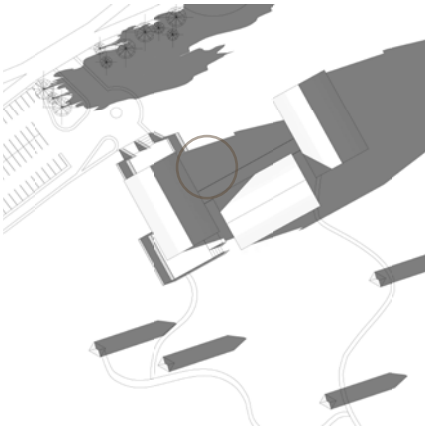
21st March, 8.00 am



21st March, 12.00 pm

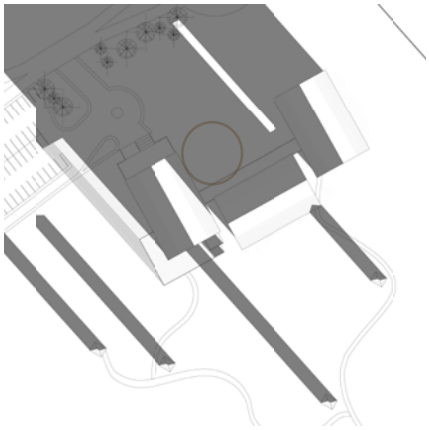


21st March, 6.00 pm

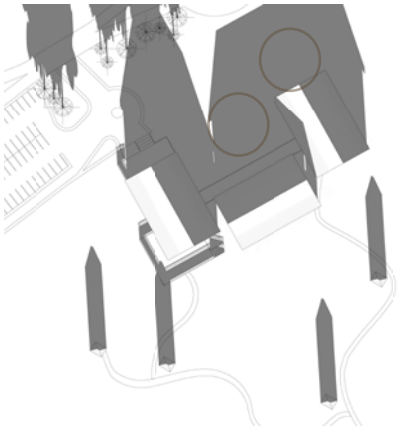


Winter Solistice

21st December, 8.00 am



21st December, 12.00 pm



21st December, 6.00 pm

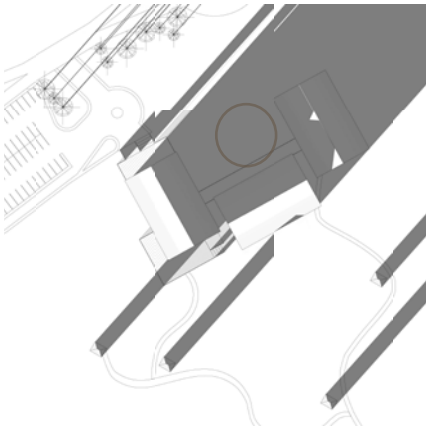


Illustration 43: Shadow analysis for barn concept 2

PLAN

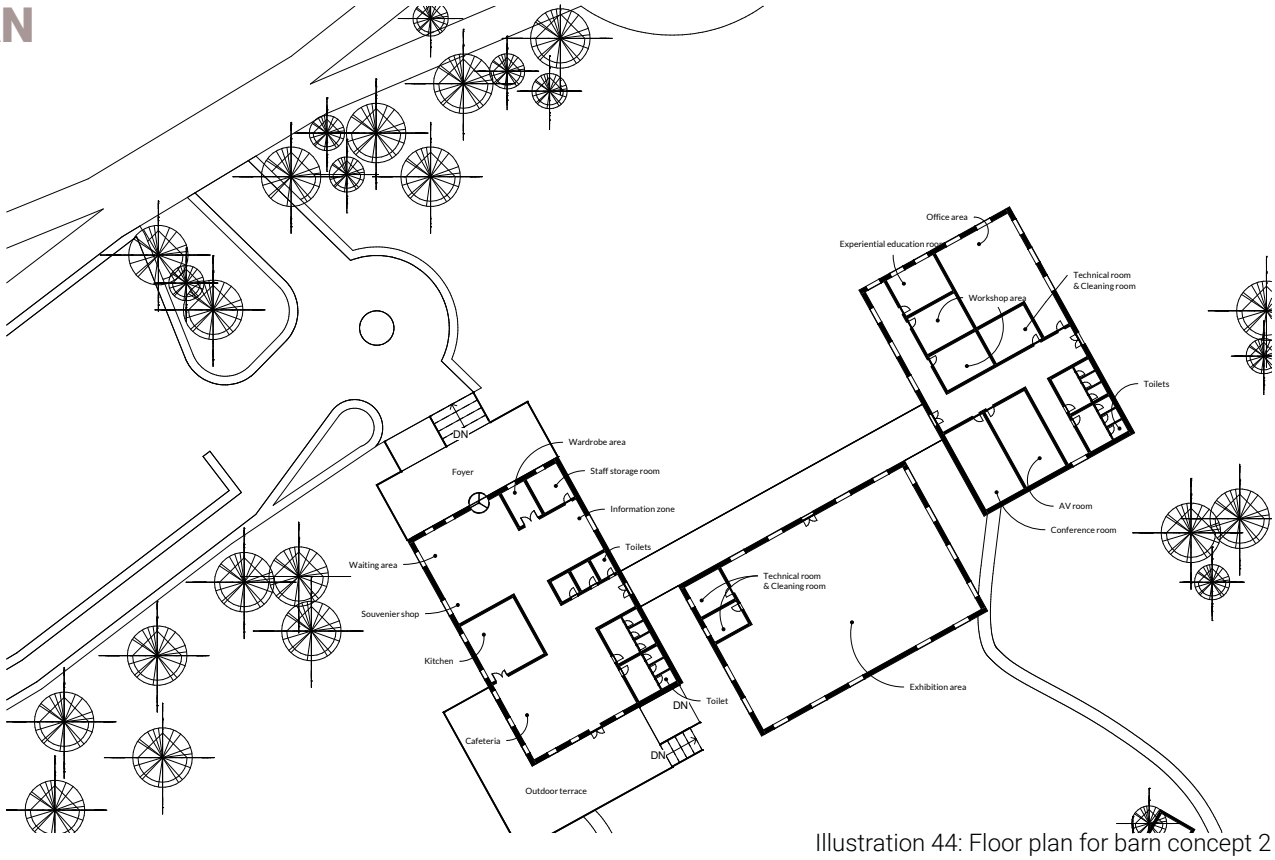


Illustration 44: Floor plan for barn concept 2

DAYLIGHT ANALYSIS

SCOPE:

The analysis has been done with the Velux Daylight Visualizer.
The analysis of the concept is done based on the ground floor level. It shows the average daylight factor in September at 12.00

ANALYSIS:

It shows an average of 3% in the public areas which is better from the previous version, in the common areas of the three blocks, but the DF in the third block still remains low.

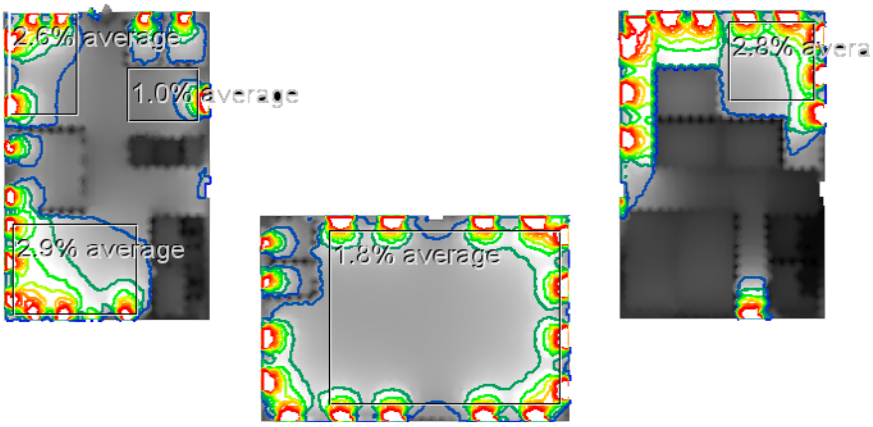


Illustration 45: Velux analysis for barn concept 2

SOLAR RADIATION ANALYSIS

SCOPE:
The analysis is done on rhino with the help of using software like ladybug and honeybee.
The illustration shows an analysis that helps assess the risk of overheating and the potential for solar gains on the roof and other surfaces of the building.

ANALYSIS:
In this version of the layout, the central block is rotated which even though creates a central courtyard, gives a larger surface area on the southern side which could lead to overheating thus causing higher energy consumption. The building has a total of 1165 Sqm of roof area that are highly radiated that can be used for solar panels.

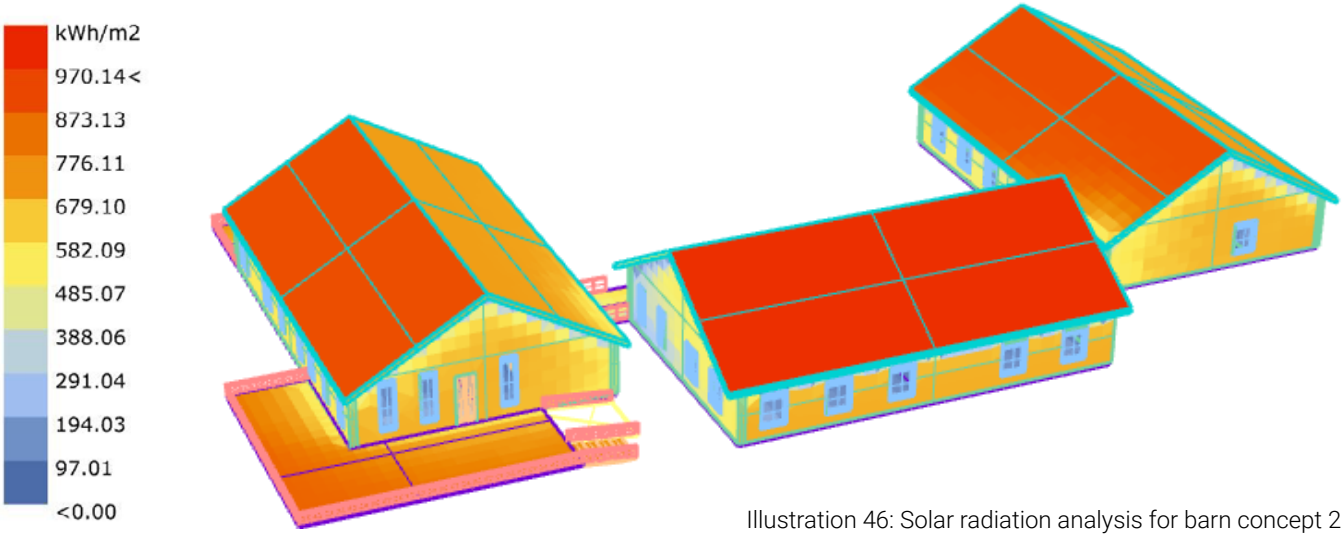


Illustration 46: Solar radiation analysis for barn concept 2

ENERGY CALCULATION

SCOPE:
The calculation has been done based on the Danish software Be 18 and the Danish weather data.
This concept has the total heated floor area of 1782 sqm. with glazed area as 35% approximately.
This is based on rough estimation not including exact operation calculation.

ANALYSIS:
The energy consumption is lesser than the previous version due to changes in window sizes from 1.5*3m to 1.5*2.7m and 1.8*3m to 1.8*2.7m and its positions. The area for placing solar panels to cover the required energy frame is 679 Sqm which can be easily placed on the abundantly heated roof area. (The solar panel calculation can be referred to in appendix 8 - PV Panel calculation)

Total energy demand:
40.6 kWh/m^2

Contribution to energy requirement

Heat: 21.6
Excessive in room: 0
Net requirement

Room heating: 21.6

CONCEPT EVOLUTION 3

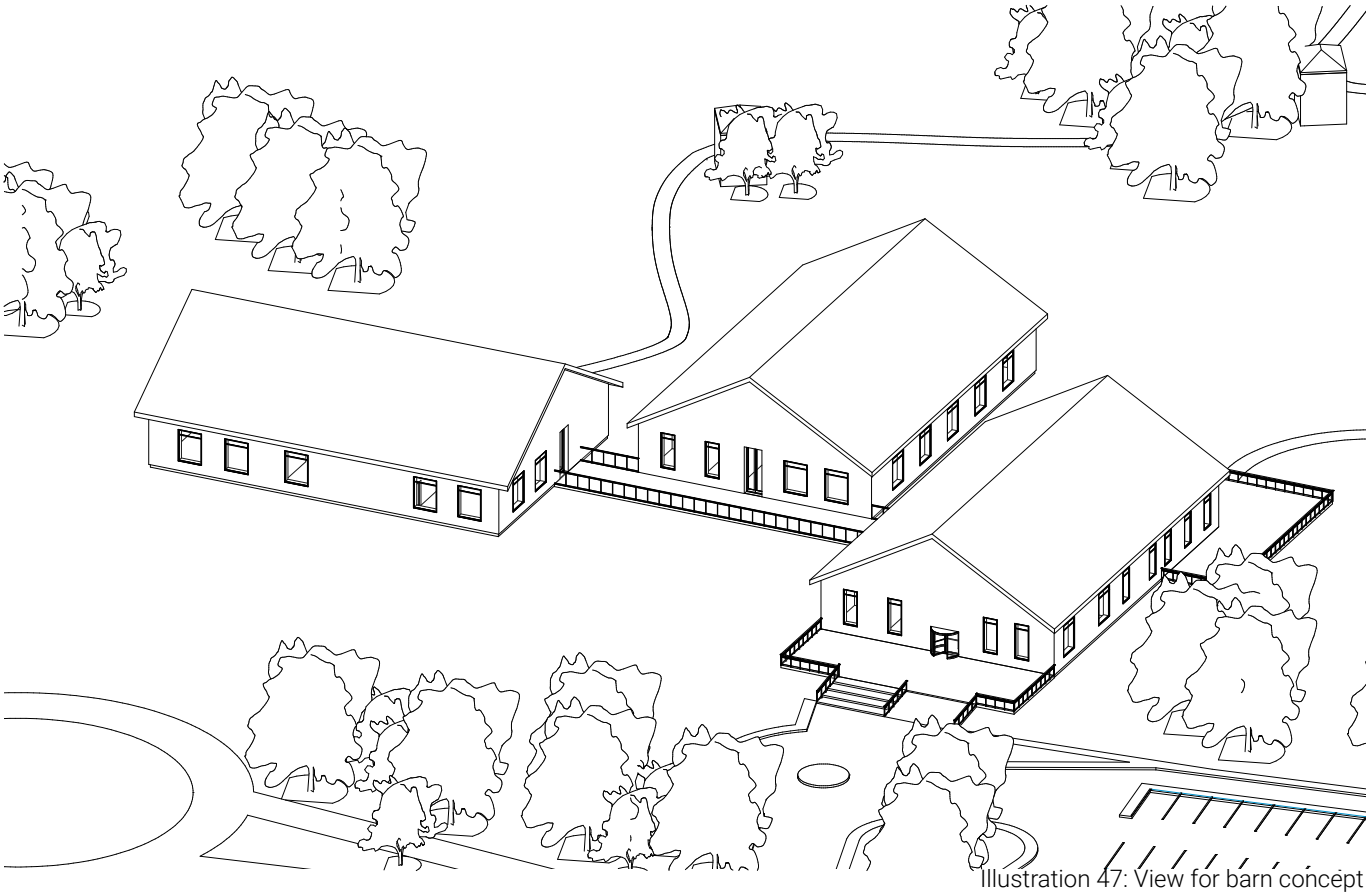


Illustration 47: View for barn concept 3

Total area: 1782sqm
Atmosphere: Semi open
Views: Directional

In the third evolution the last block is rotated as after analysis it has the lowest daylight factor which could be solved through changing its orientation. This also reduces the distance from the first block to the third block. The outdoor walkway is now covered and the three separation of functions going from public to private at the furthest are maintained to be the same.

SHADOW ANALYSIS

SCOPE:

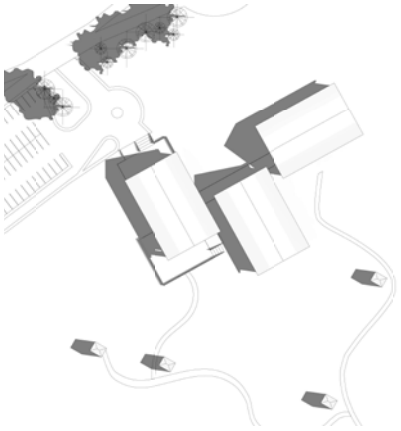
The analysis has been done with the use of the Revit software supported with the information from geo-location. The analysis allows to investigate parts of the design that are shaded by the surrounding or building itself during summer, spring and winter for the design of outdoor spaces which could be used as a public area by the different user groups.

ANALYSIS:

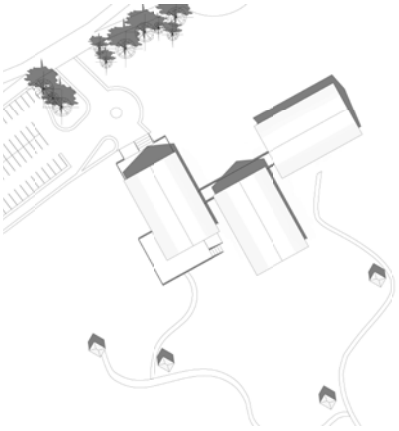
This analysis also shows an improvement in shadowsduring spring in the central courtyard. The change in orientation also reduces the shadows formed by the blocks on each other. The outdoor area of block 1 remains unaffected with the change in the orientation.The central courtyard is still formed which is protected from the winds as the previous version. This orientation also helps in directing the users towards distinct views which helps in creating an interesting indoor atmosphere.

Summer solistice

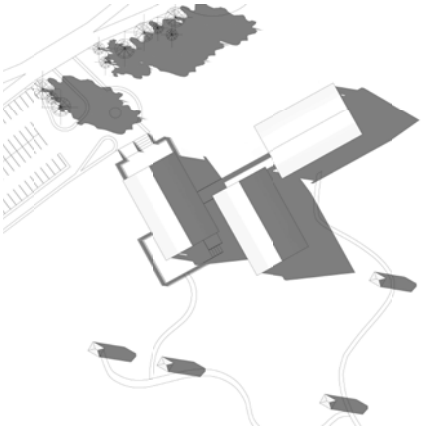
21st June, 8.00 am



21st June, 12.00 pm

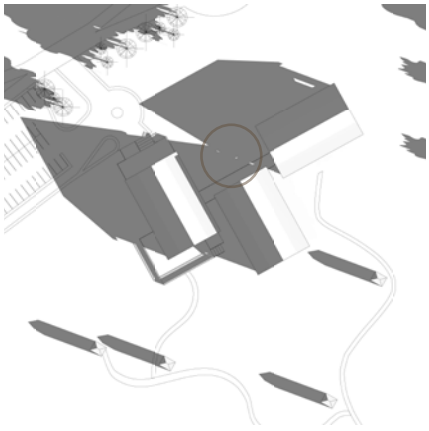


21st June, 6.00 pm

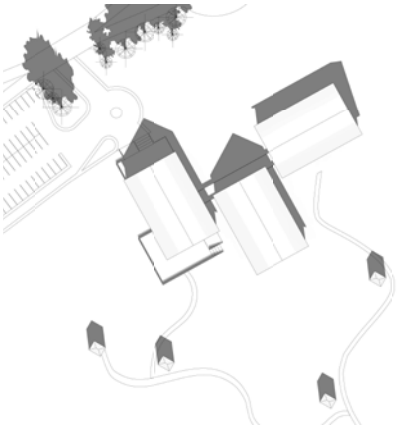


Spring Equinox

21st March, 8.00 am



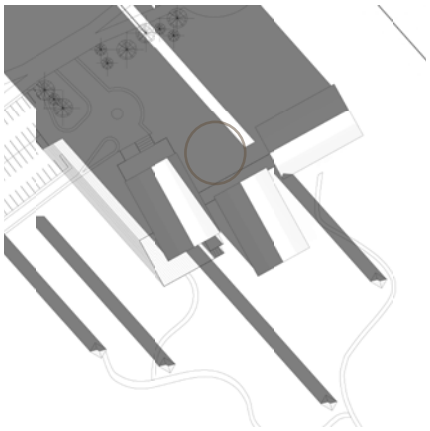
21st March, 12.00 pm



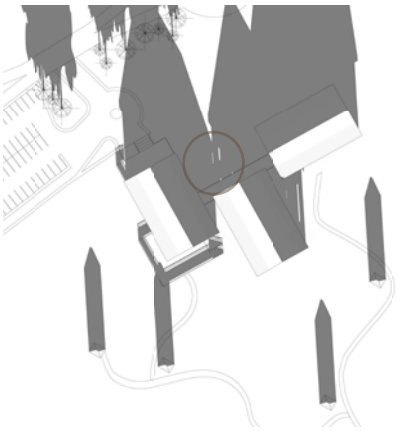
21st March, 6.00 pm

Winter Solistice

21st December, 8.00 am



21st December, 12.00 pm



21st December, 6.00 pm

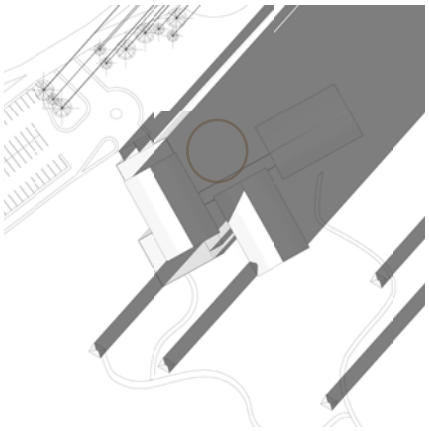


Illustration 48: Shadow analysis for barn concept 3

PLAN

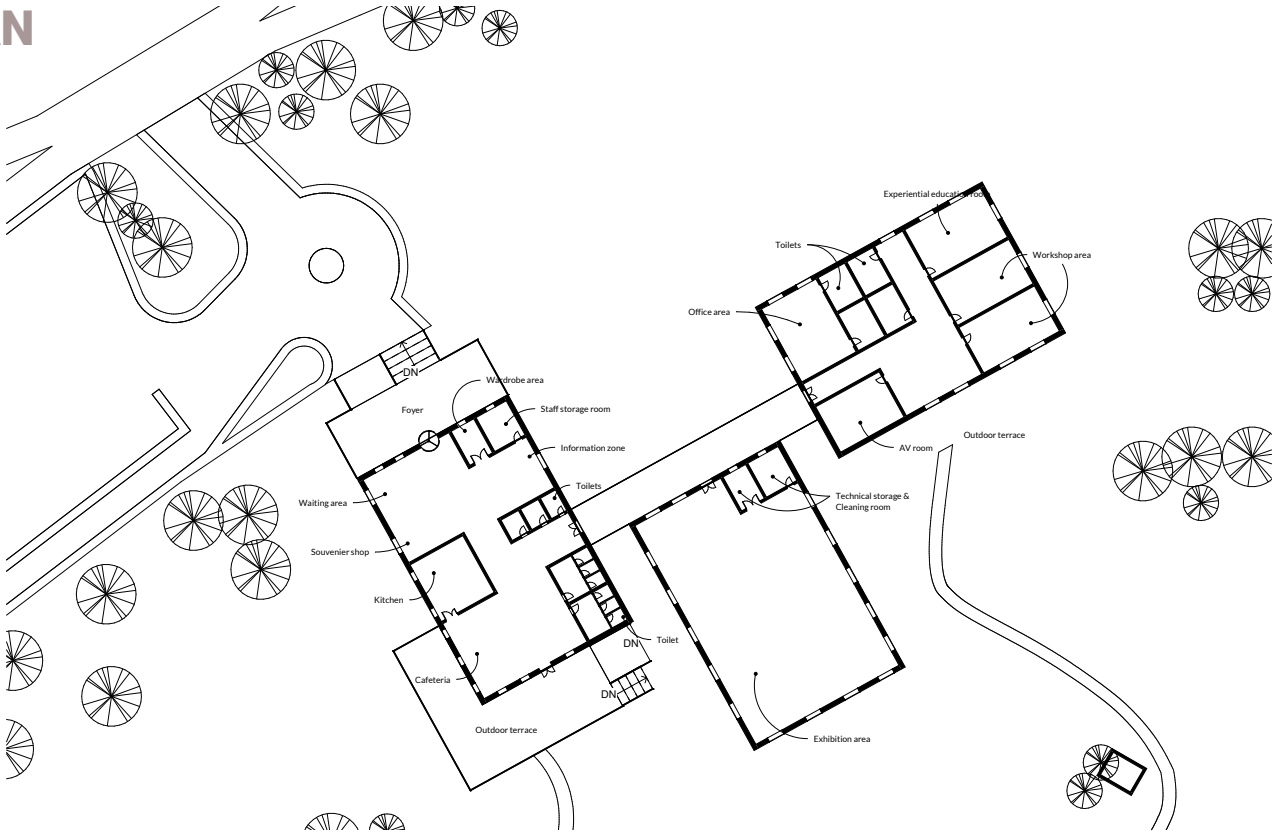


Illustration 49:Floor plan for barn concept 3

DAYLIGHT ANALYSIS

SCOPE:

The analysis has been done with the Velux Daylight Visualizer.
The analysis of the concept is done based on the ground floor level. It shows the average daylight factor in September at 12.00

ANALYSIS:

It shows an average of 3.5 which is optimal required daylight in the first and second blocks. There is a significant improvement in the third block where the office areas have slightly higher than required DF, but the passageways seems less than required.

Illustration 50: Velux analysis for barn concept 3

SOLAR RADIATION ANALYSIS

SCOPE:
The analysis is done on rhino with the help of using software like ladybug and honeybee.
The illustration shows an analysis that helps assess the risk of overheating and the potential for solar gains on the roof and other surfaces of the building.

ANALYSIS:
The rearrangement of the third block to a horizontal position compared to the flow of the building provides a roof that can be heated by the south and south-east sun. The building has a total of 1165 Sqm of roof area that are highly radiated that can be used for solar panels.

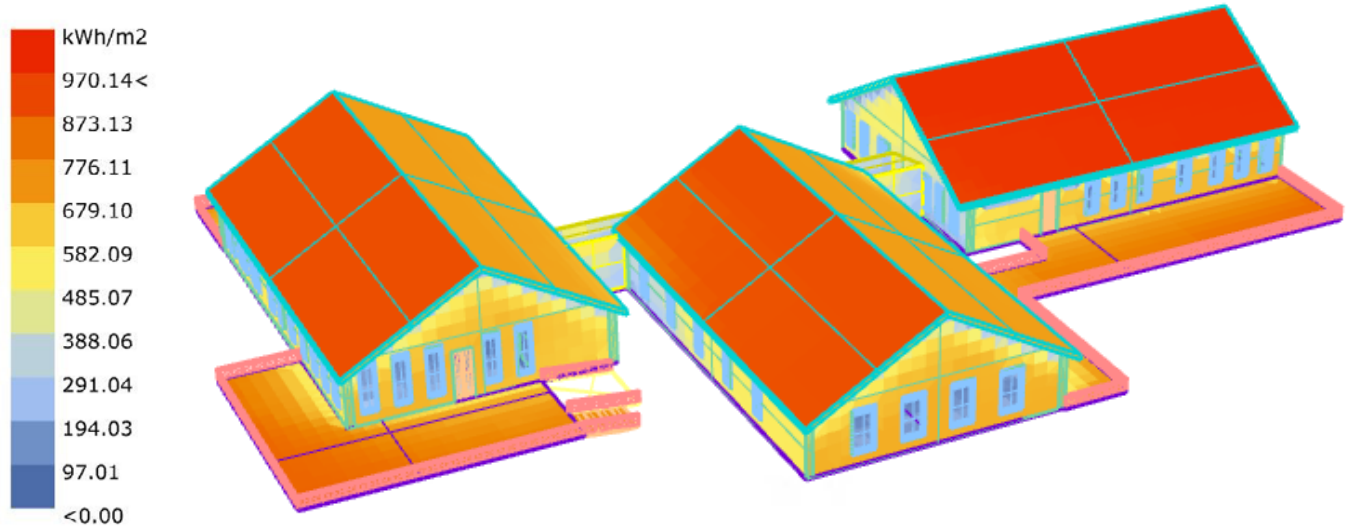


Illustration 51: Solar radiation analysis for barn concept 3

ENERGY CALCULATION

SCOPE:
The calculation has been done based on the Danish software Be 18 and the Danish weather data. This concept has the total heated floor area of 1782 sqm. with glazed area as 35% approximately.
This is based on rough estimation not including exact operation calculation.

Total energy demand:
33.0 kWh/m^2

Contribution to energy requirement

Heat: 22.3
Excessive in room: 0.0
Net requirement

Room heating: 22.3

ANALYSIS:
The energy consumption is the least in this version while trying to maintain optimal indoor visual comfort by changing to window sizes further to 1.2*2.7m and 1.8*2.7m with accordance. The area for placing solar panels to cover the required energy frame is 552 Sqm which can be easily placed on the heated roof area. (The solar panel calculation can be referred to in appendix 8 – PV Panel calculation)

CIRCULAR CONCEPT

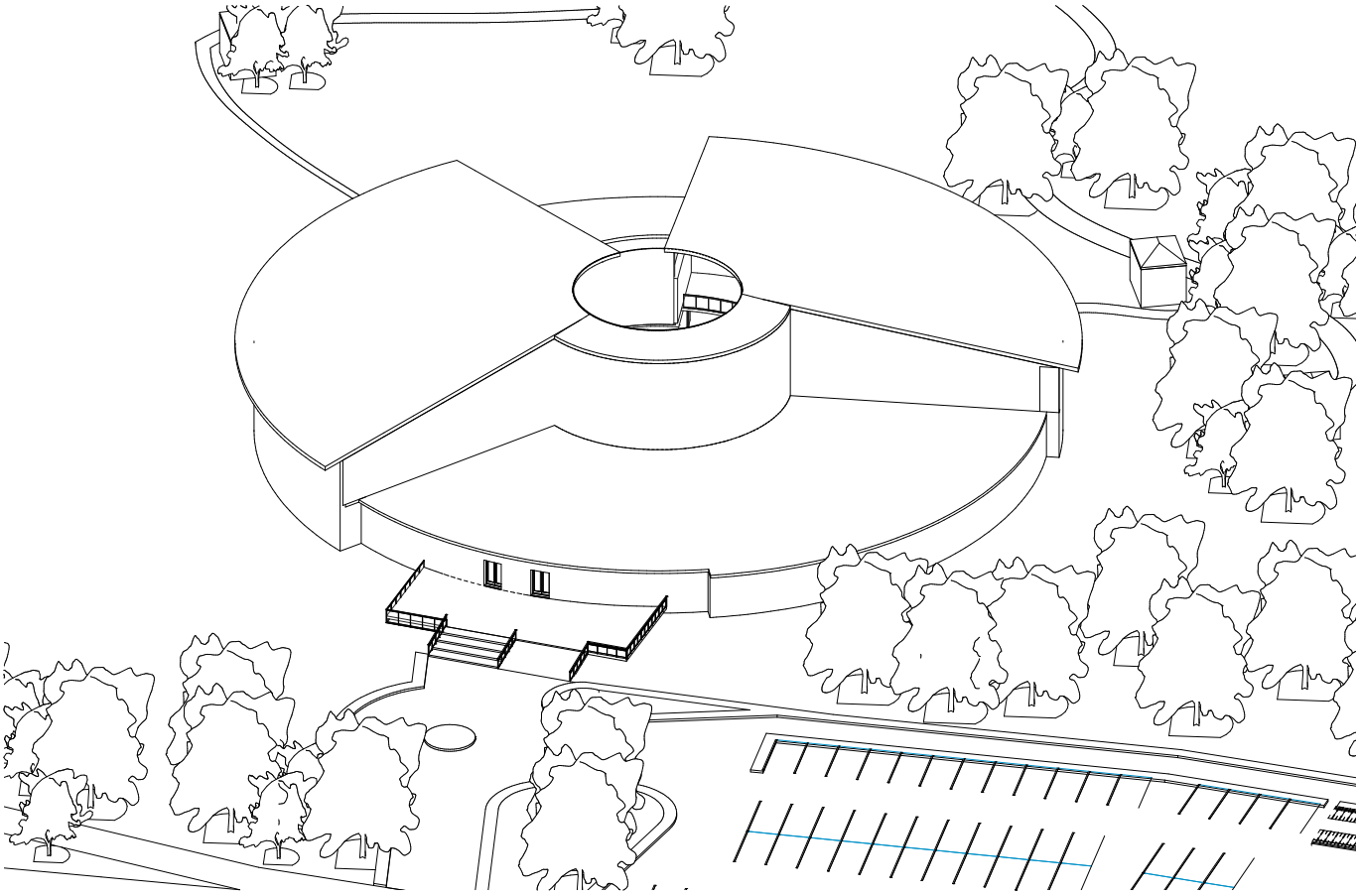


Illustration 52: View for circular concept 1

Total area: 2750sqm
Atmosphere: Closed
Views: Panoramic

The circular concept is inspired from the pin wheel concept where the form is changed to a circle in an attempt to make a visitor centre which provides views to all directions. The design segregates the circle into quadrants based on functions and zones according to the levels of privacy required. The idea of skylights are also worked on to allow light to travel into the centre of the circle to provide light to the corridor and circulation areas. The building roof is elevated according the functions creating an interesting elevation where the levels are played with. This arrangement also allows the zones to have more light inside. The circular design allows views towards all sides of the building making it possible to orient the functions accordingly and providing ease of access towards the outdoors.

SHADOW ANALYSIS

SCOPE:

The analysis has been done with the use of the Revit software supported with the information from geo-location. The analysis allows to investigate parts of the design that are shaded by the surrounding or building itself during summer, spring and winter for the design of outdoor spaces which could be used as a public area by the different user groups.

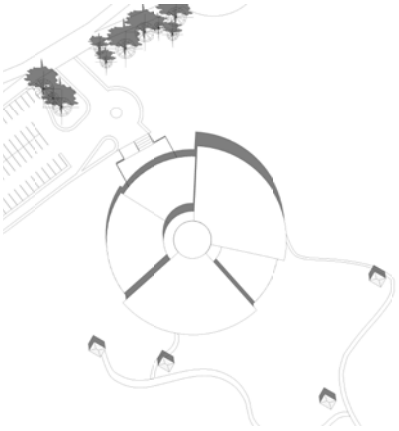
ANALYSIS:

The analysis of shadow shows that the building as such is not affected much by the surroundings as the other buildings are located farther from the said site and the building itself does not affect the other parts of the design in extreme ways. The surrounding greenery affects the design only during later evenings especially in the colder months.

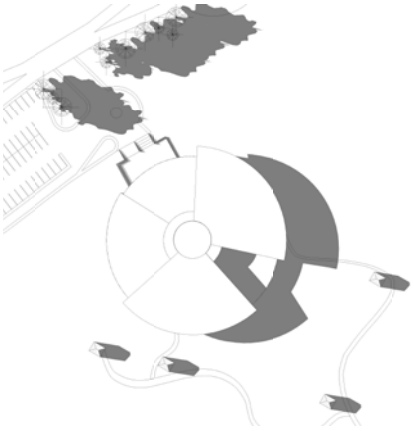
Summer solistice

21st June, 8.00 am

21st June, 12.00 pm

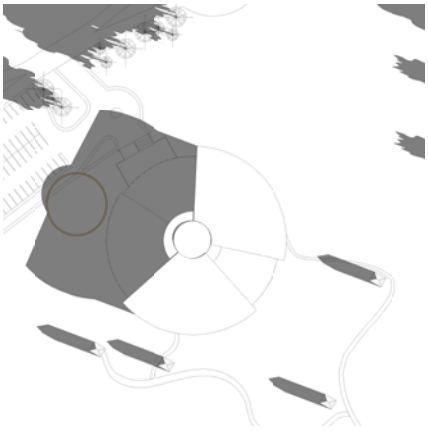


21st June, 6.00 pm



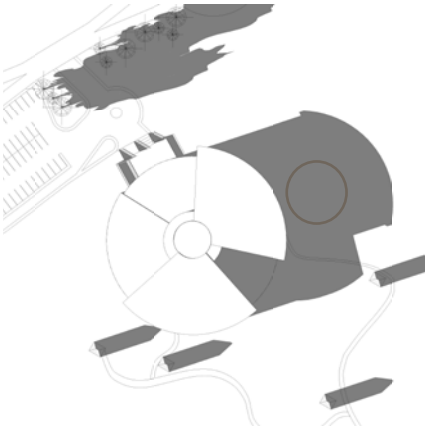
Spring Equinox

21st March, 8.00 am



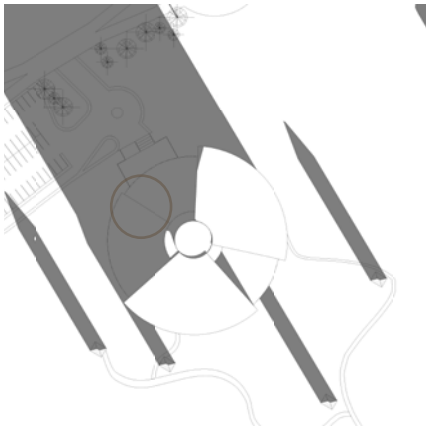
21st March, 12.00 pm

21st March, 6.00 pm

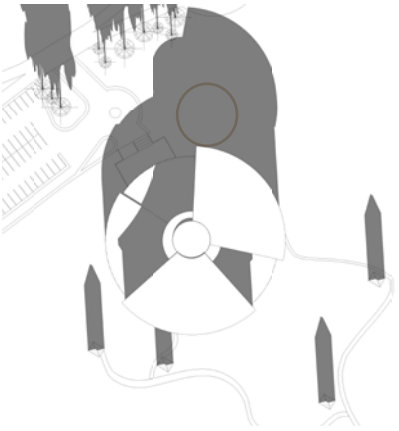


Winter Solistice

21st December, 8.00 am



21st December, 12.00 pm



21st December, 6.00 pm

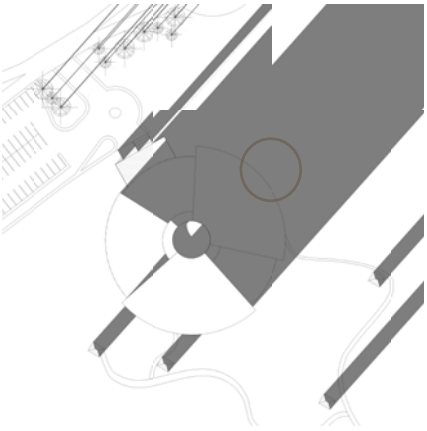


Illustration 53: Shadow analysis for circular concept 1

PLAN

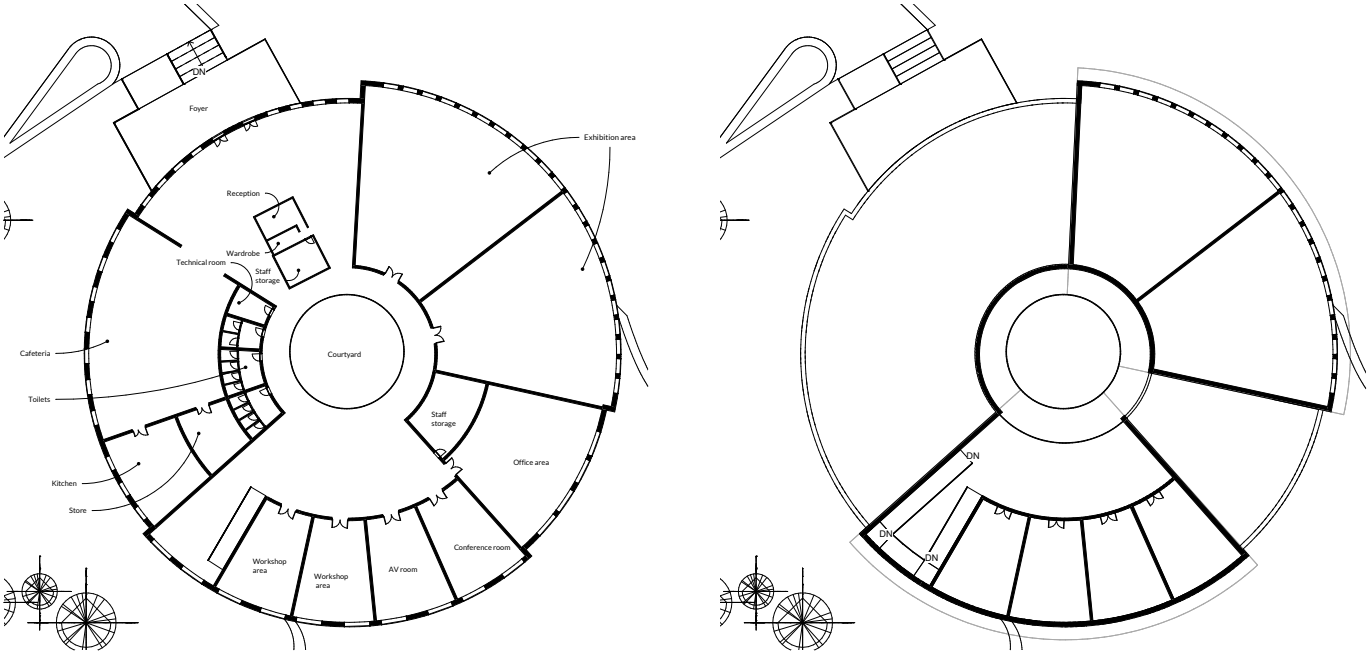


Illustration 54: Floor plans (ground floor and level 1) for circular concept 1

DAYLIGHT ANALYSIS

SCOPE:

The analysis has been done with the Velux Daylight Visualizer.

The analysis of the concept is done based on the ground floor level. It shows the average daylight factor in September at 12.00

ANALYSIS:

It shows an average of 5.5 in the exhibition area which is more than required light and can cause overheating. The educational rooms and cafeteria have a gentler 3.5 daylight factor which is suitable for reading other purposes. The corridors have a suitable 2.5 with the help of light from the skylight, although the distance from the core reduces the optimal light conditions

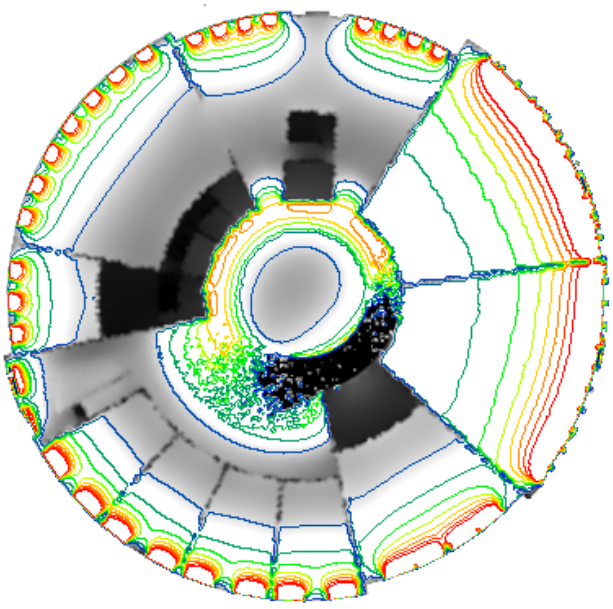


Illustration 55: Velux analysis for circular concept 1

SOLAR GAINS

SCOPE:
The analysis is done on rhino with the help of using software like ladybug and honeybee.
The illustration shows an analysis that helps assess the risk of overheating and the potential for solar gains on the roof and other surfaces of the building.

ANALYSIS:
IIn the initial attempt the roof is raised on two sides, the south and the south east to make the most of the solar gains. However, there is risk of over heating in the southern facade due to the large sizes and number of windows. The building has a total of 1650 Sqm of roof area that are highly radiated that can be used for solar panels.

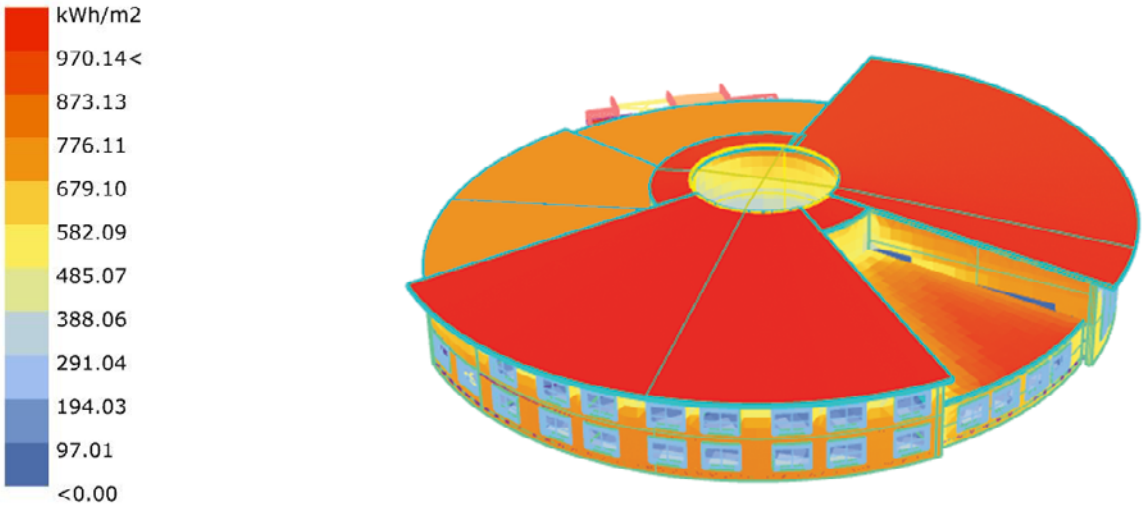


Illustration 56: Solar radiation analysis for circular concept 1

ENERGY CALCULATION

SCOPE:
The calculation has been done based on the Danish software Be 18 and the Danish weather data.
This concept has the total heated floor area of 2750 sqm. with glazed area as 25% approximately.
This is based on rough estimation not including exact operation calculation.

Total energy demand:
39.2 kWh/m^2

Contribution to energy requirement

Heat: 22.0
Excessive in room: 0.0
Net requirement

Room heating: 21.6

ANALYSIS:
The energy consumption of the design is quite high due to the large size and number of openings (1.8*3m and 1.5*3m) mainly to the east and south. The building being in 2 levels also adds to the energy consumption. The area for placing solar panels to cover the required energy frame is 656 Sqm which can be easily placed on the abundantly heated roof area. (The solar panel calculation can be referred to in appendix 8-PV Panel calculation)

CIRCULAR CONCEPT 2

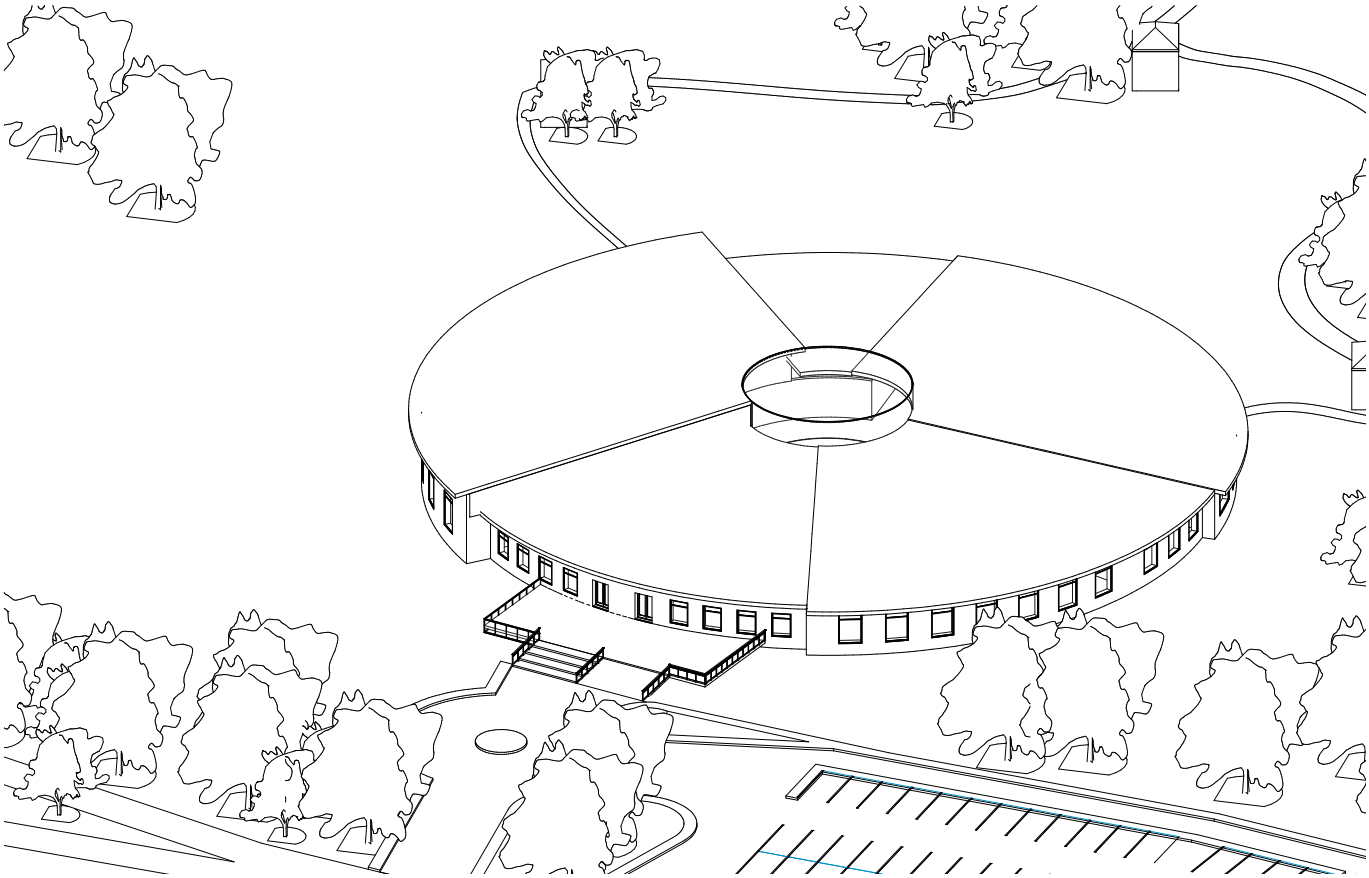


Illustration 57: View for circular concept 2

Total area: 1980 sqm
Atmosphere: Closed
Views: Panoramic

Because of the analysis of the circular concept, the next iteration was made by reducing the number of openings while maintaining the optimal daylight conditions in the exhibition areas. The window sizes were also optimized to reduce the risk of over heating. The structure was further made compact by removing the level 1 and rearranging the spaces in the ground floor level in order to improve the energy efficiency which was analysed to be rather high in the previous version. The other rooms were maintained as it is as they did not pose as an issue.

SHADOW ANALYSIS

SCOPE:

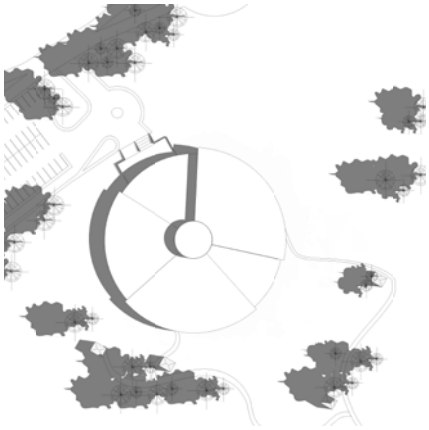
The analysis has been done with the use of the Revit software supported with the information from geo-location. The analysis allows to investigate parts of the design that are shaded by the surrounding or building itself during summer, spring and winter for the design of outdoor spaces which could be used as a public area by the different user groups.

ANALYSIS:

The analysis of shadow shows that the building did not see a significant change from the first iteration, although there is a change in the height of the structure. The height did not impact the shadow imminently.

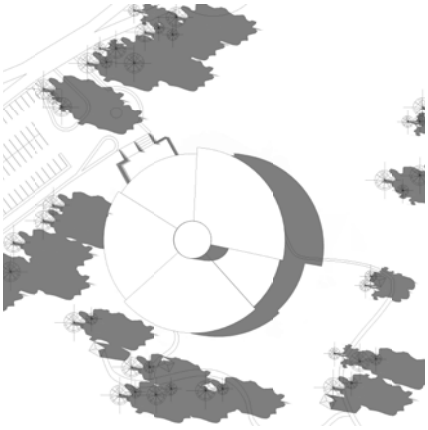
Summer solistice

21st June, 8.00 am



21st June, 12.00 pm

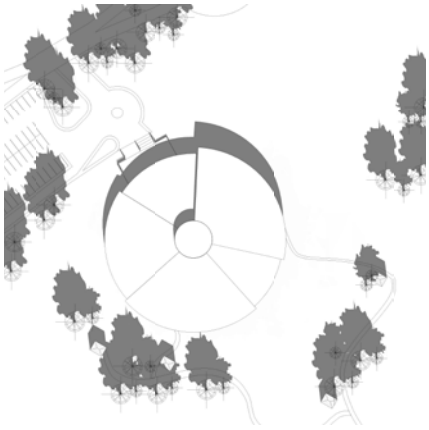
21st June, 6.00 pm



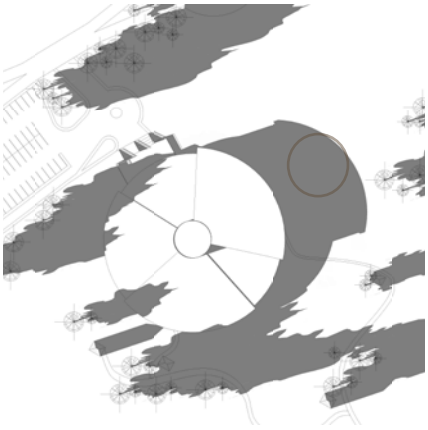
Spring Equinox

21st March, 8.00 am

21st March, 12.00 pm

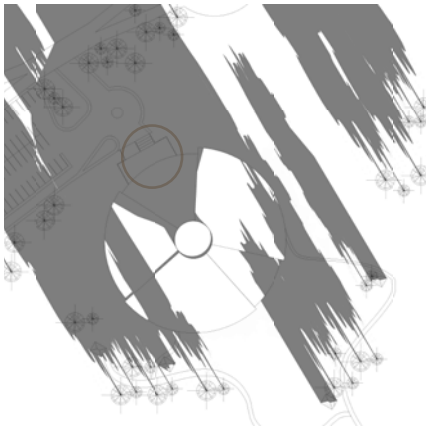


21st March, 6.00 pm

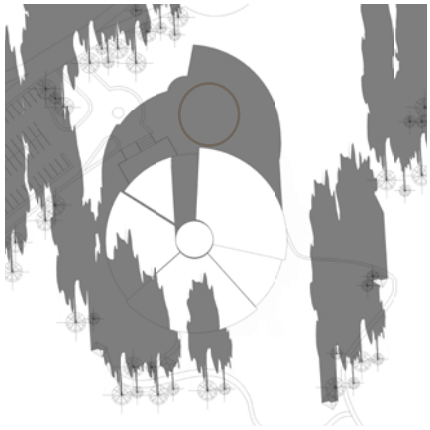


Winter Solistice

21st December, 8.00 am



21st December, 12.00 pm



21st December, 6.00 pm

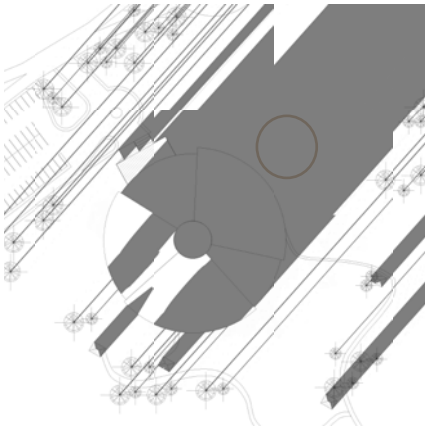


Illustration 58: Shadow analysis for circular concept 2

PLAN

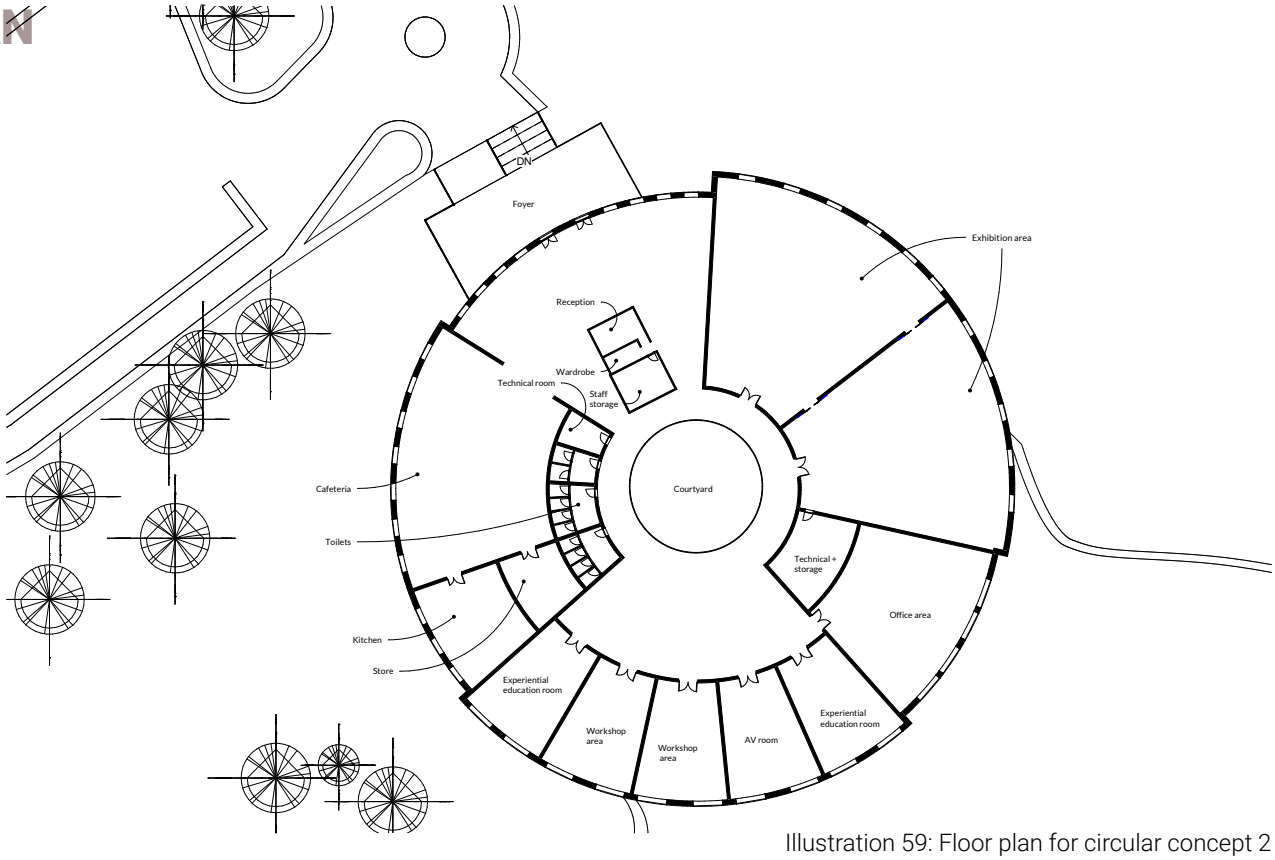


Illustration 59: Floor plan for circular concept 2

DAYLIGHT ANALYSIS

SCOPE:

The analysis has been done with the Velux Daylight Visualizer.

The analysis of the concept is done based on the ground floor level. It shows the average daylight factor in September at 12.00

ANALYSIS:

It shows an average of 2.8 in the exhibition area which has a better visual comfort for the interiors. This is reduced by reducing the number of openings and sizes of them in the exhibition area.

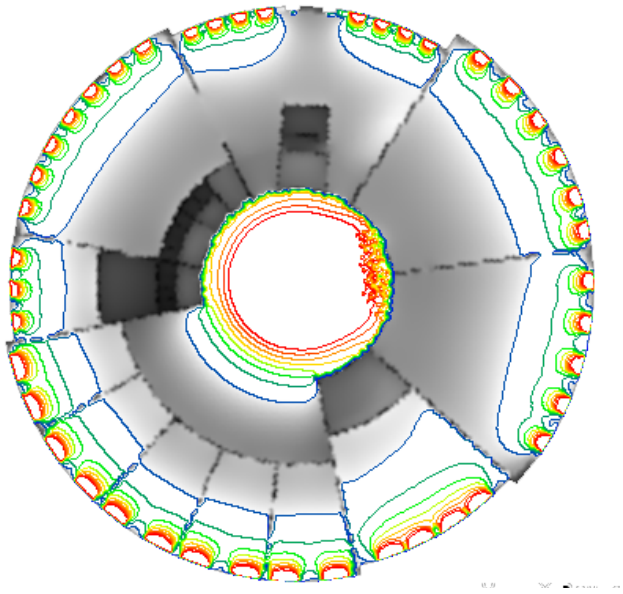


Illustration 60: Velux analysis for circular concept 2

SOLAR GAINS

SCOPE:

The analysis is done on rhino with the help of using software like ladybug and honeybee.
The illustration shows an analysis that helps assess the risk of overheating and the potential for solar gains on the roof and other surfaces of the building.

ANALYSIS:

When the roof is lowered to a same height, the southern and south western roof receive slightly less solar gains but the issue of overheating is tackled. The building has a total of 888 Sqm of roof area that are highly radiated that can be used for solar panels.

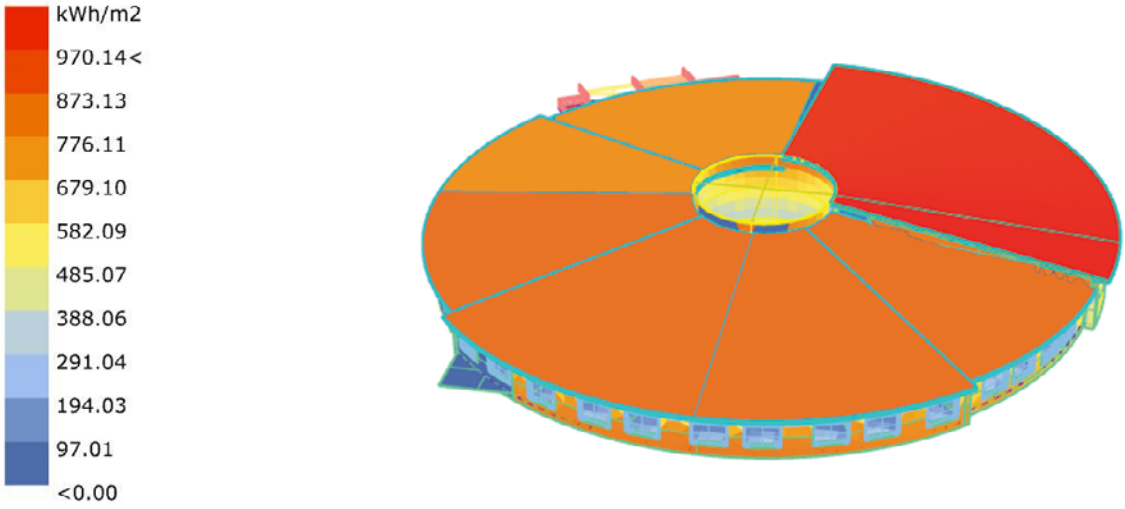


Illustration 61: Solar radiation analysis for circular concept 2

ENERGY CALCULATION

SCOPE:

The calculation has been done based on the Danish software Be 18 and the Danish weather data.
This concept has the total heated floor area of 2750 sqm. with glazed area as 19% approximately.
This is based on rough estimation not including exact operation calculation.

Total energy demand:

34.6 kWh/m^2

Contribution to energy requirement

Heat: 12.8
Excessive in room: 0.0

Net requirement

Room heating: 12.4

ANALYSIS:

As it can be seen the energy consumption of the building reduces exponentially as the number and sizes of openings (1.2*2.7m and 1.8*2.7m) to the south are reduced preventing heat loss. Simultaneously the education rooms to the south have been reduced to a single storied reducing the amount of heated surface area. The area for placing solar panels to cover the required energy frame is 578 Sqm which can be easily placed on the abundantly heated roof area. (The solar panel calculation can be referred to in appendix 8 – PV Panel calculation)

ORIGINAL CONCEPT

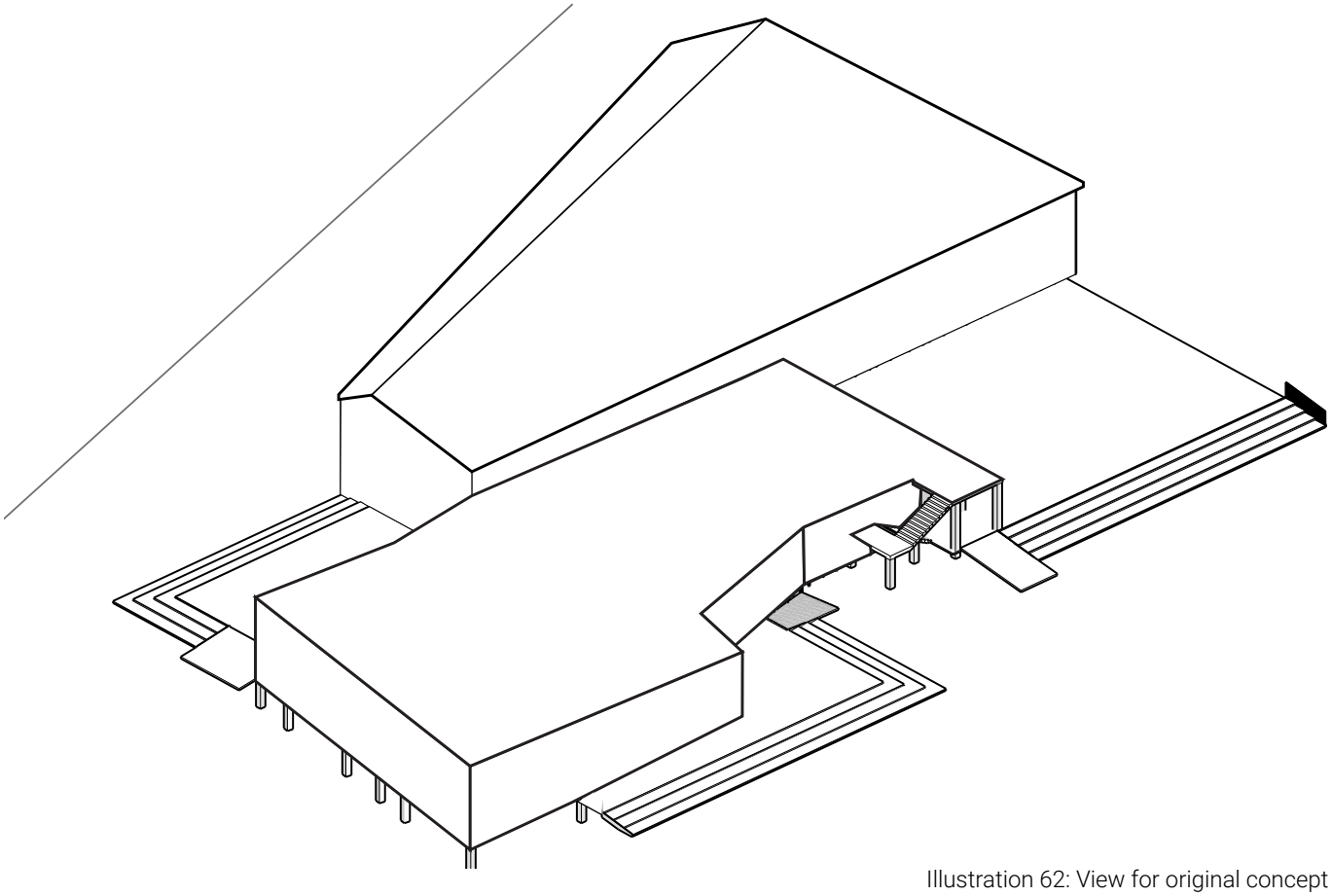


Illustration 62: View for original concept

Total area: 2700sqm
Atmosphere: Closed
Views: Directional

The original concept was developed from a rectangle. The rectangle was divided into two halves and arranged adjacent to each other in a way to segregate the exhibition and education rooms from the public areas like cafeteria, lobby and souvenir store. The design aims to focus the large openings and outdoor areas towards the views. The design has a roof that is accessible to relate to the surrounding nature and to provide an elevated view towards the sea.

SHADOW ANALYSIS

SCOPE:

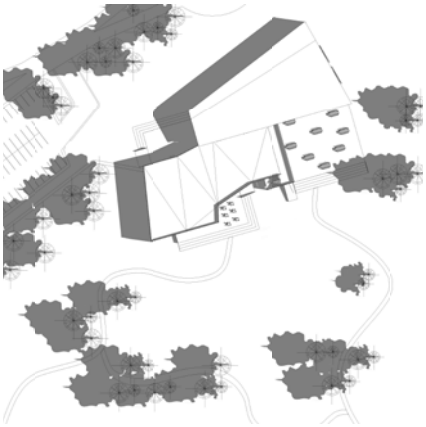
The analysis has been done with the use of the Revit software supported with the information from geo-location. The analysis allows to investigate parts of the design that are shaded by the surrounding or building itself during summer, spring and winter for the design of outdoor spaces which could be used as a public area by the different user groups.

ANALYSIS:

The shadow analysis shows that the outdoor areas are open in the warmer months but slightly shaded during winter. The absence of any major structures around the site thus does not cast any harsh shadows on the building.

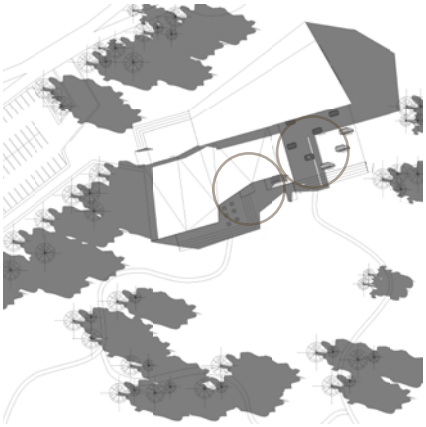
Summer solistice

21st June, 8.00 am



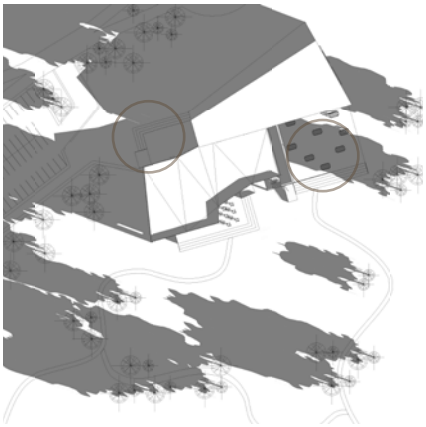
21st June, 12.00 pm

21st June, 6.00 pm

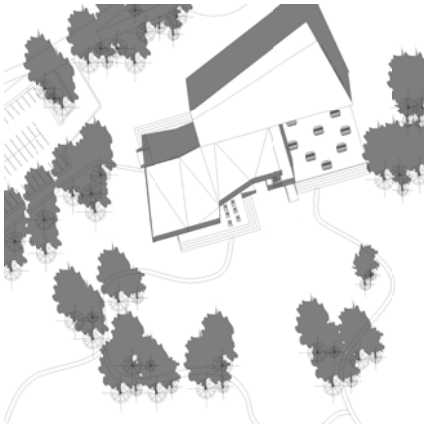


Spring Equinox

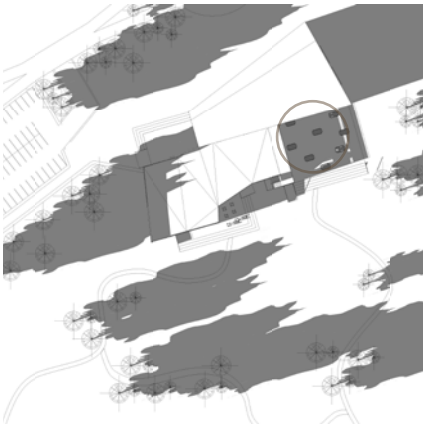
21st March, 8.00 am



21st March, 12.00 pm

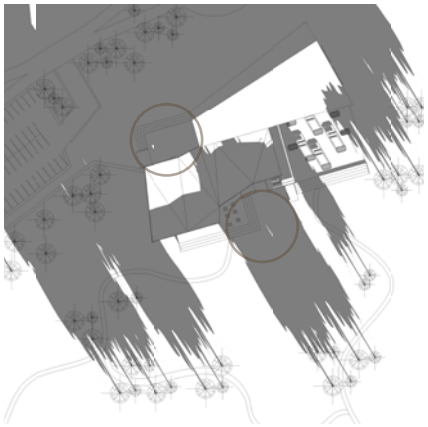


21st March, 6.00 pm

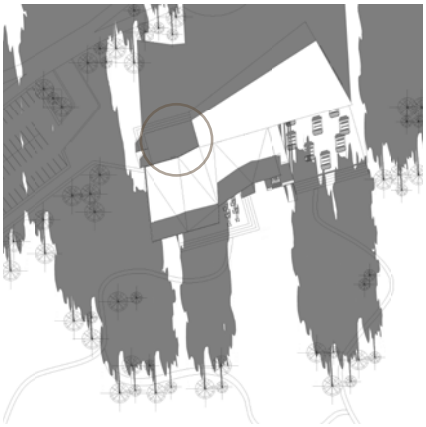


Winter Solistice

21st December, 8.00 am



21st December, 12.00 pm



21st December, 6.00 pm

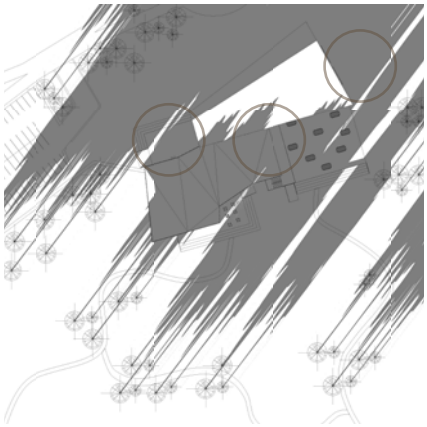


Illustration 63: Shadow analysis for original concept

PLAN

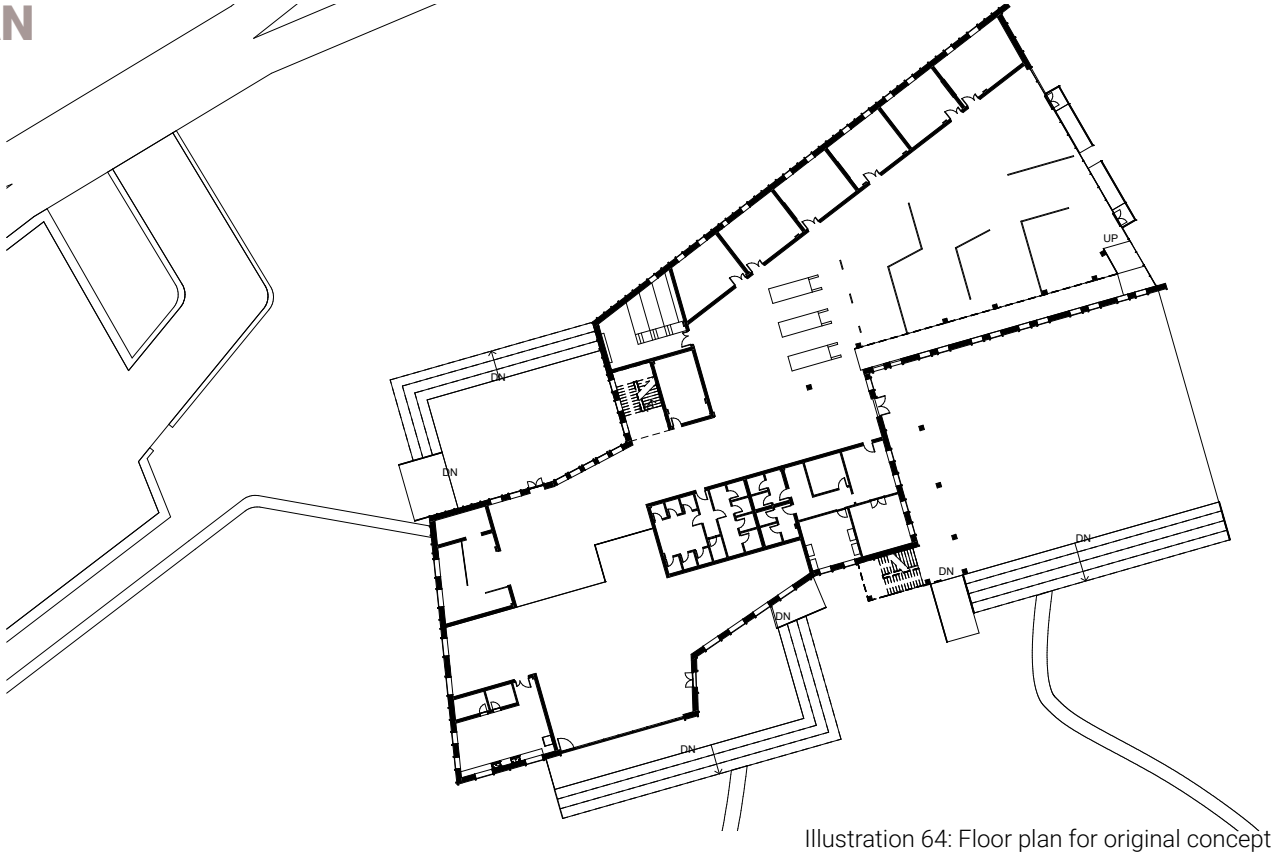


Illustration 64: Floor plan for original concept

DAYLIGHT ANALYSIS

SCOPE:

The analysis has been done with the Velux Daylight Visualizer.
The analysis of the concept is done based on the ground floor level. It shows the average daylight factor in Septem
ber at 12.00

ANALYSIS:

It shows an average of 4.8 in the exhibition area which is more than required light and can cause overheating. The educational rooms have a daylight factor of 2 which is less than suitable. The cafeteria has a daylight factor of 3.8 which is a little high which is caused by the openings facing the sea on the south side.

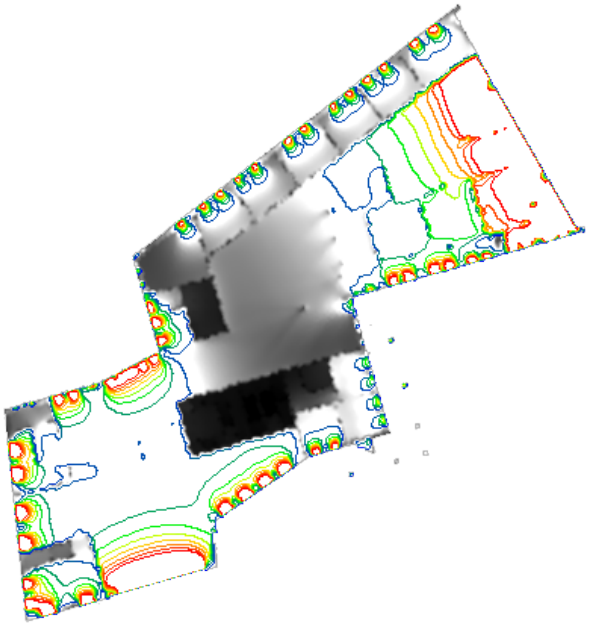


Illustration 65: Velux analysis for original concept

SOLAR GAINS

SCOPE:
The analysis is done on rhino with the help of using software like ladybug and honeybee.
The illustration shows an analysis that helps assess the risk of overheating and the potential for solar gains on the roof and other surfaces of the building.

ANALYSIS:
In the first design both the roofs are facing south and have a large surface area which makes it conveneient for the palcement of solar panels. The building has a total of 865 Sqm of roof area that are highly radiated that can be used for solar panels.

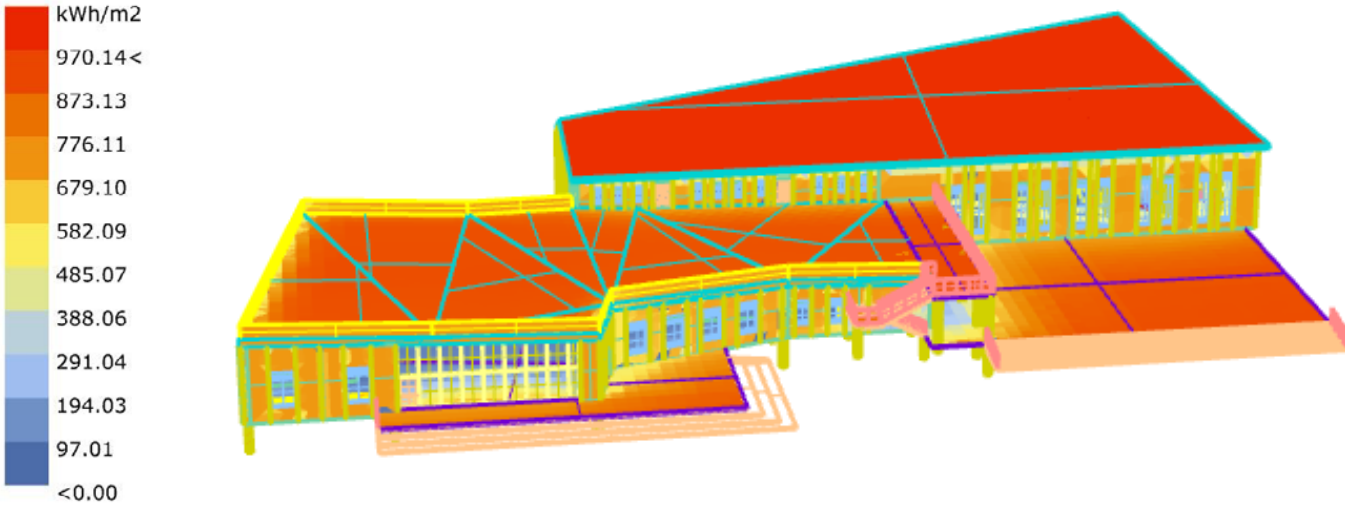


Illustration 66: Solar radiation analysis for original concept

ENERGY CALCULATION

SCOPE:
The calculation has been done based on the Danish software Be 18 and the Danish weather data.
This concept has the total heated floor area of 2300 sqm. with glazed area as 38% approximately.
This is based on rough estimation not including exact operation calculation.

Total energy demand:
32.7 kWh/m^2

Contribution to energy requirement

Heat: 8.5
Excessive in room: 0
Net requirement

Room heating: 8.5

ANALYSIS:
The Be 18 calculation gives the most appropriate results as the building is optimized by the use of small windows to reduce heat loss. Being a unified structure the heat loss is also limited. The area for placing solar panels to cover the required energy frame is 547 Sqm which can be easily placed on the abundantly heated roof area. (The solar panel calculation can be refered to in appendix 8- PV Panel calculation)

DESIGN CRITERA

SCOPE:
The analysis of the 3 concepts is based on the design criteria derived from the different mappings and the user analysis.

The original concept is not taken into consideration as it has been optimized in all aspects in the previous attempt and more importance is given to the comparison between barn and circular concept.

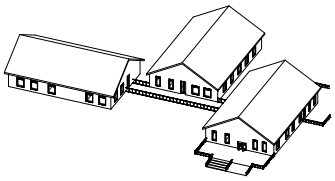
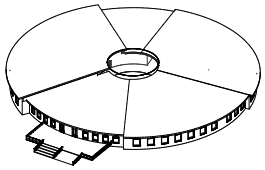
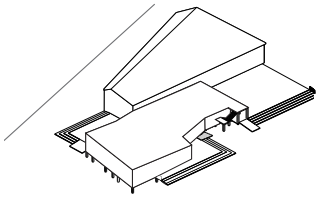
CONCEPTS / DESIGN CRITERIA	BARN CONCEPT	CIRCULAR CONCEPT	ORIGINAL CONCEPT
			
UTILIZATION OF THE CONTEXT	The directional nature of the design makes use of the distinct views thus making it an attractive place in the neighbourhood	The circular shape provides panoramic views of the site and the unique shape also adds to the value	The orientation as well as the garden roof offers great view of the site and surroundings
RETAINS CHARACTER OF THE PLACE	The barn type structure blends into the neighbourhood style while serving a unique purpose	The unique form of the design makes it tough to retain the character of the place	It gives a modern effect which while aesthetic does not retain the character of the place
SEGREGATION OF SPACES	The form is divided from the beginning based on the different functions and privacy levels for each block	Being one entity, it is difficult to separate the areas thus causing the spaces to blend	While it does segregate the spaces, being one single entity does make it a bit confusing
RELATION TO NATURE	Despite being divided into three blocks, the simple structure makes it easy to use local materials as well relating to the physical expression of the site	Limited in terms of the types of materials that could be used due to the circular form	The materials used were locally available
NAVIGATIONAL COMFORT	Provides an easily readable environment with clear distinction of the functions due to simple circulation	Circular movement and therefore a clear circulation and orientation system	No clear division of spaces which makes the navigation little confusing
ENHANCEMENT OF SOCIAL INTERACTION	The outdoor area as well as the protected central courtyard offers scope of social interaction	Lack of an outdoor space does not help enhance social interaction	The two outdoor areas help in enhancing the social interaction among the different user groups
ACTIVATION OF THE AREA	The mix of the public and social spaces boosts the experience as well as activates the area	-	-

Table 6: Design criteria comparison of three concepts

VELUX DAYLIGHT ANALYSIS

SCOPE:
The analysis has been done with the Velux Daylight Visualizer.
The analysis of the 3 concepts is done based on the ground floor level. It shows the average daylight factor in September at 12.00
(The window sizes are maintained to be the same in all 3 concepts with the usage of sizes 1.2*2.7m or 1.8*2.7m in all openings)

Barn concept

ANALYSIS:
This concept shows an average of 3.5 in the main areas of the three blocks, where some areas of the corridor of block 3 have a low daylight of 0.8/1.0

Circular concept

ANALYSIS:
The circular design overall has better daylight of 3.5 on an average in the main areas whereas the core remains with a low 2.8 which is a suitable daylight factor for a visually pleasing ambience.

Original concept

ANALYSIS:
The original design shows an average of 4.5 in the main areas whereas the core remains on the lower end with 2.8.

SUB CONCLUSION: The three design concepts have average required daylight in the social spaces, but in the circular concept and the original concept the core areas the daylight factor is lower than the required optimal factor. The barn concept also has areas with less than optimal light but in comparison it shows to work better than the two other concept ideas. The exhibition areas have relatively high daylight levels which need to be reduced in order to maintain ambient indoor daylight levels. In conclusion, both the barn and circular concept have similar levels, thus the next parameters have been worked on to choose a final design concept.

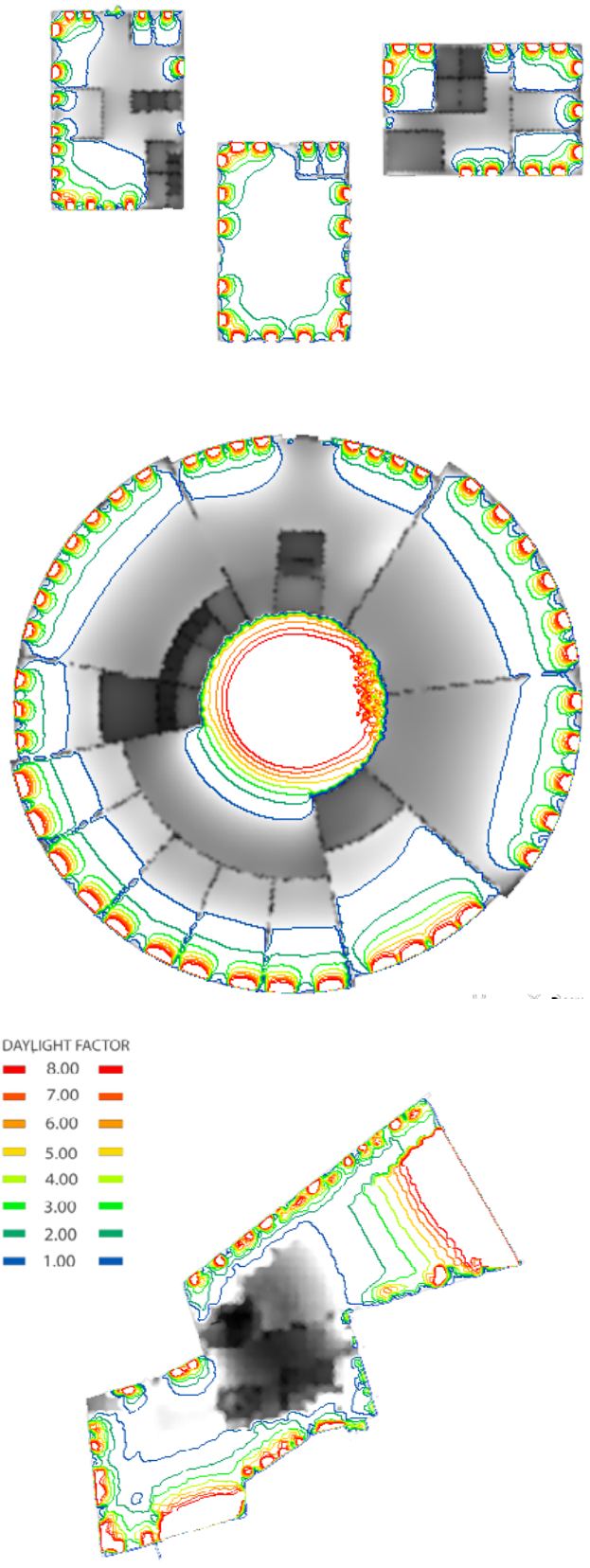


Illustration 67: Velux analysis

ENERGY CALCULATIONS

GOAL: The low energy requirement is 33 kWh/m^2 year according to Be 18

SCOPE:
The calculation has been done based on the Danish software Be 18 and the Danish weather data.
This is a rough estimation not including exact operation calculation.

ANALYSIS:
The barn concept has 1800sqm of gross area whereas the circular concept, despite the compact form has a higher gross area of 2200 sqm which results in lesser energy efficiency. The original concept shows the most energy efficiency as it has been optimized to gain the most optimal indoor environment.

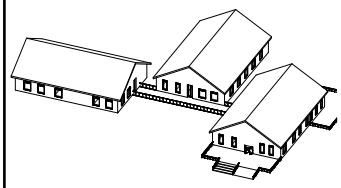
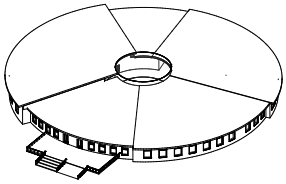
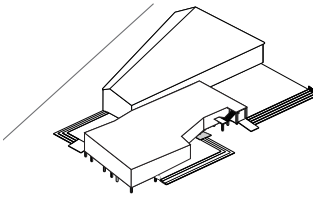
	BARN CONCEPT	CIRCULAR CONCEPT	ORIGINAL CONCEPT
			
ENERGY CALCULATIONS FOR INITIAL CONCEPTS	The compact form of the design helps in reducing the energy consumption. The changes in the orientation as well as the window placement, sizes helped in lowering the initial high energy consumption. ***Total energy demand:*** 33.0 kWh/m^2 ***Contribution to energy requirement*** Heat: 22.3 Excessive in room: 0.0 ***Net requirement*** Room heating: 22.3	The concept occurs to be less energy efficient inspite of reducing the number of windows as well as the sizes. The concept works better than its previous multi levelled design. ***Total energy demand:*** 34.6 kWh/m^2 ***Contribution to energy requirement*** Heat: 12.8 Excessive in room: 0.0 ***Net requirement*** Room heating: 12.4	The original design shows the most optimal energy consumption due to the unified structure, small windows on the south and minimal glazing in that area. ***Total energy demand:*** 32.7 kWh/m^2 ***Contribution to energy requirement*** Heat: 8.5 Excessive in room: 0 ***Net requirement*** Room heating: 8.5

Table 7: Energy calculations comparison of three concepts

SUB CONCLUSION

Barn concept

- The concept related to the site and the neighbourhood
- The compact blocks have relatively higher energy efficiency
- the daylight can be improved in certain areas through skylights or larger openings
- offers possibility for a protected courtyard
- The form offers possibility of natural ventilation as well as cross ventilation due to the compact areas and suitable openings towards the south western and north eastern side
- Due to the open floor plan the exhibition area offers adaptability depending on the exhibits.
- The sloped pitched roof also offers possibility for the placement of solar panels on the southern side.

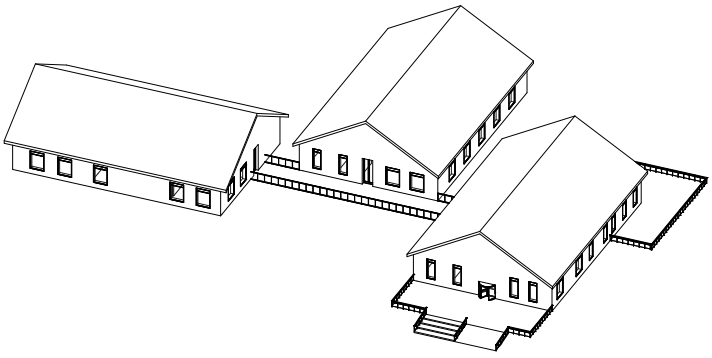


Illustration 68: Barn concept view

Circular concept

- Although the circular form is often known to be soothing to the eye, this form does not relate to the neighbourhood on a similar level
- Due to the larger areas provided to accommodate the curved surface the energy consumption is higher
- The daylight factor of the design is good due to the large openings and the central skylight
- The possibility of cross ventilation is reduced due to its large size

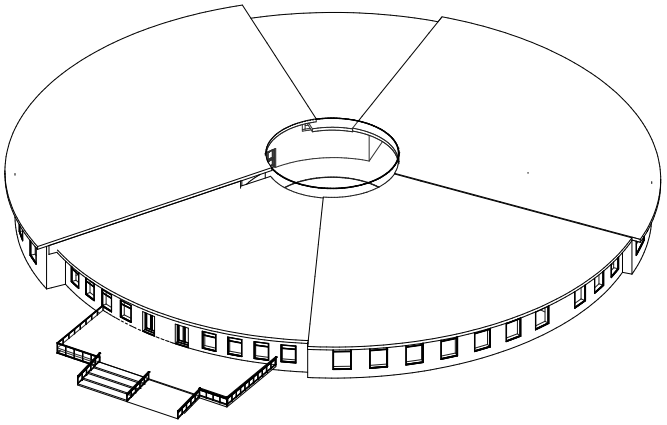


Illustration 69: Circular concept view

FUNCTIONAL DEVELOPMENT

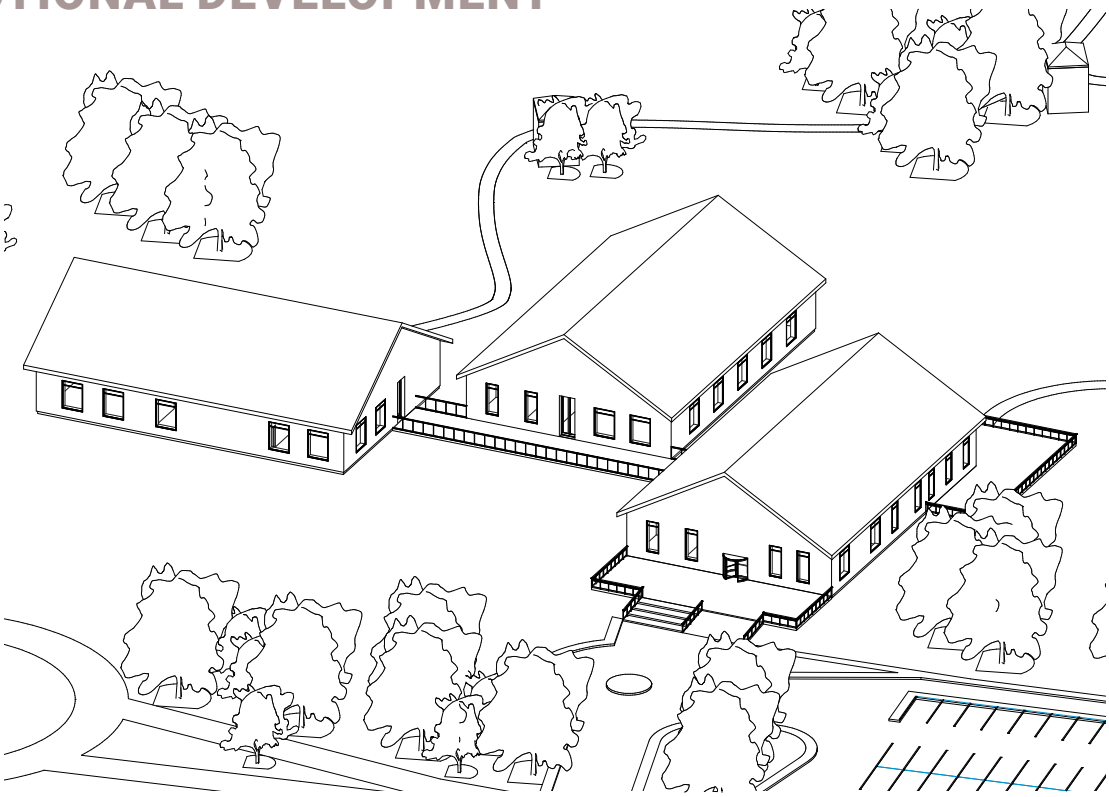


Illustration 70:Barn concept view

Original plan version 2.1

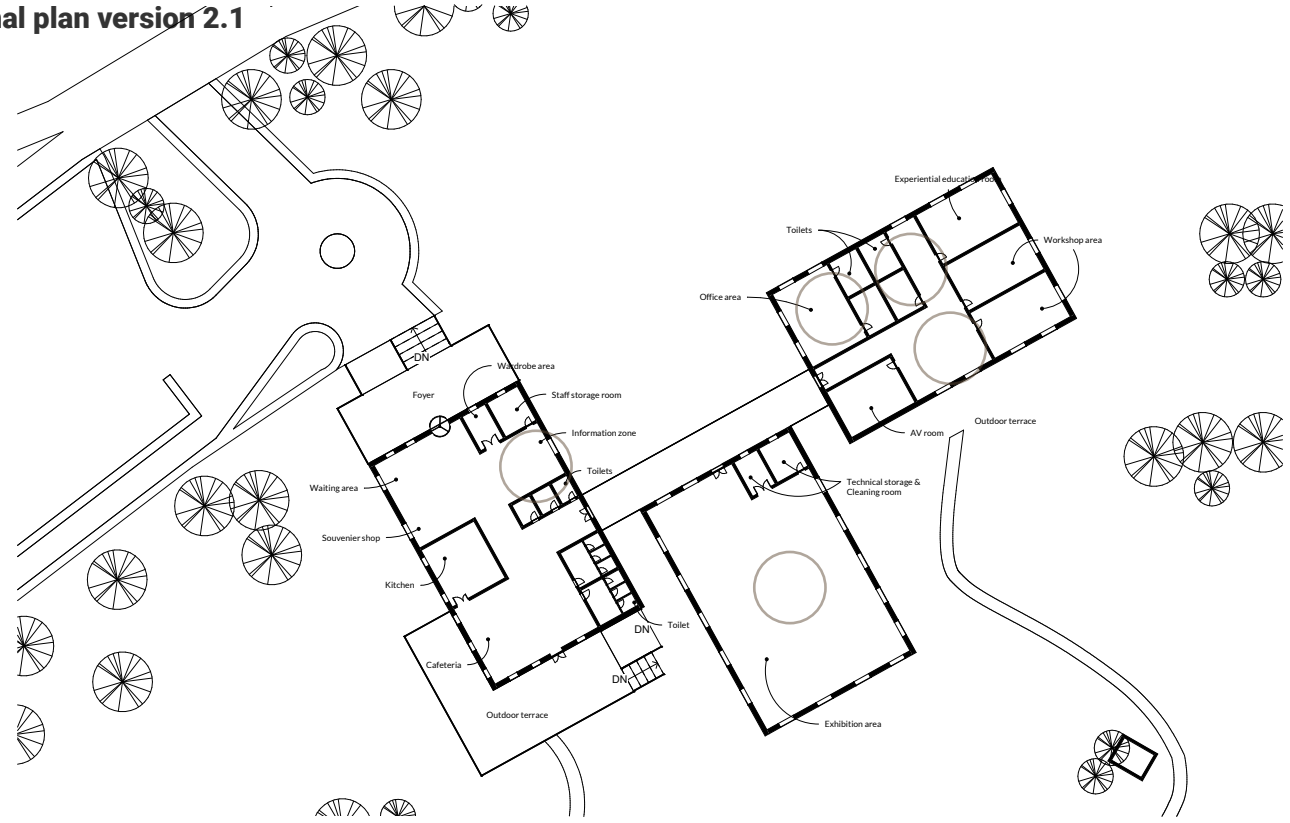


Illustration 71:Barn concept floor plan version 2.1 highlighting the issues

Plan version 2.2

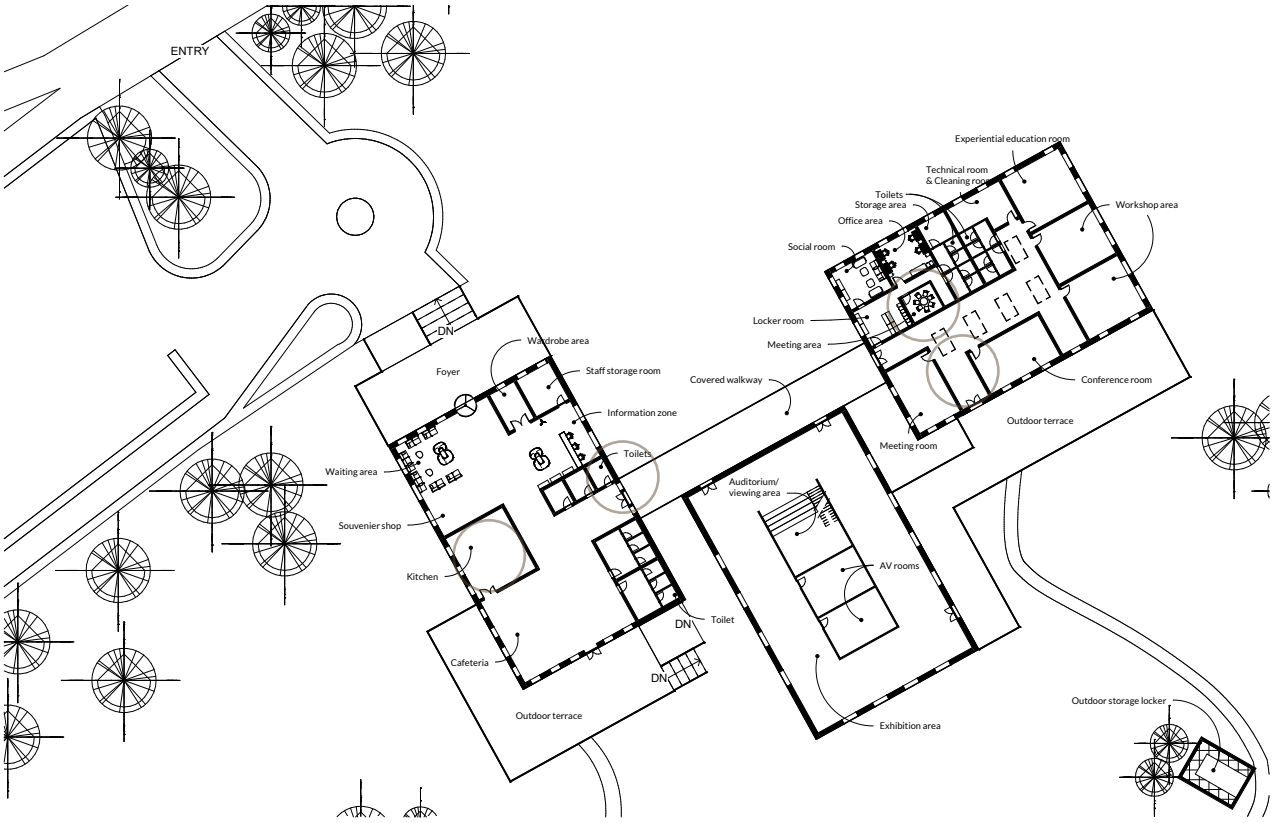


Illustration 72:Barn concept floor plan version 2.2 highlighting the issues

In the initial layout, there were a lot of issues that were addressed that had to be resolved such as a cluttered floor plan, no designed exhibition area and clustered office area in the third block. As the requirement was to have an open floor plan, the enclosed reception area was developed into an open reception with an enclosed storage space.

When it comes to the exhibition block, the block was very basic, to make it more interactive and space efficient, a room and technical room are placed in the centre of the room along with a staircase to give it an atrium type of ambience and a little more interactivity.

The office area in block 3 is rearranged to accommodate the required room more efficiently with proper circulation. The provision of an additional education room in the third block reduces the amount of daylight reaching the corridor. The provision of a technical room required for the third block is also made possible by rearranging the toilets area.

However, even after these changes there have been a few issues which are further worked on to make an efficient design. As one of the criteria of the design is to activate the area through public spaces in the design the fact that the positioning of the kitchen and toilets do not serve the purpose. The meeting room in the office area in the third block does not receive any natural light. The education rooms to the south of the third block create too many sharp edges due the way the rooms are placed. These points are further worked on and improved in further stages.

LAYOUT DEVELOPMENT

In the first block, the functions are rearranged to create a smooth transition from the waiting area to the cafeteria and towards the outside. The movement from the first block to the other is also made cleaner and keeping the doors clear to provide an ease of navigation.

An outdoor terrace was also designed in the protected area to divert crowd to the outside. The cafeteria opens to an outdoor space which can also be used to organise picnics in the warmer months. The kitchen and the toilets are kept close to each other sharing a wall to help in the arrangement of the exhaust ventilation in the next stages of design.

In the second block the movement was analysed with the ambience of the exhibition hall in mind. The windows were removed and designed at a height of 2.5m for minimal light inside the room while giving scope to utilize the walls better to highlight the exhibitions and the artwork. The doors at the end of block provide access to the outdoor area which can be utilised as a viewing deck, giving the visitors unobstructed view to the beautiful site and surroundings.

This deck also joins to the third block which hosts the education and workshop areas. The third block is also redesigned to create an easy flow between the different areas of the office area as well as the educational areas. The meeting area as well as the social room in the office is rearranged to provide an ease of movement for the workers. The education as well as the workshop rooms which have semiprivate function can also be easily accessed by the visitors. The inclusion of a waiting area was done to have a space for the visitors to relax before and after any sessions in the block.

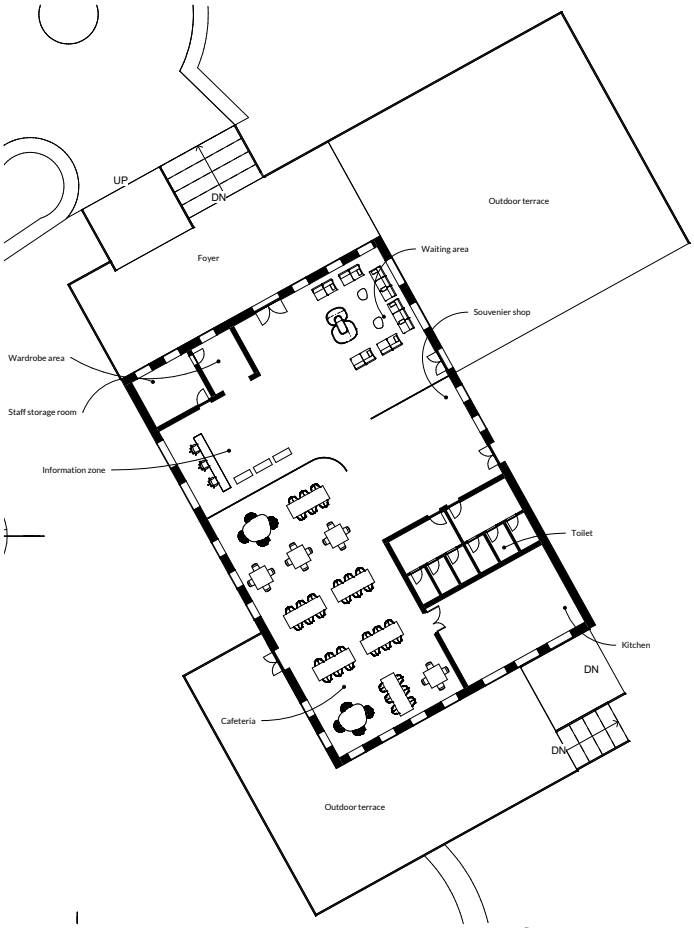


Illustration 73:Barn concept floor plan- Block 1

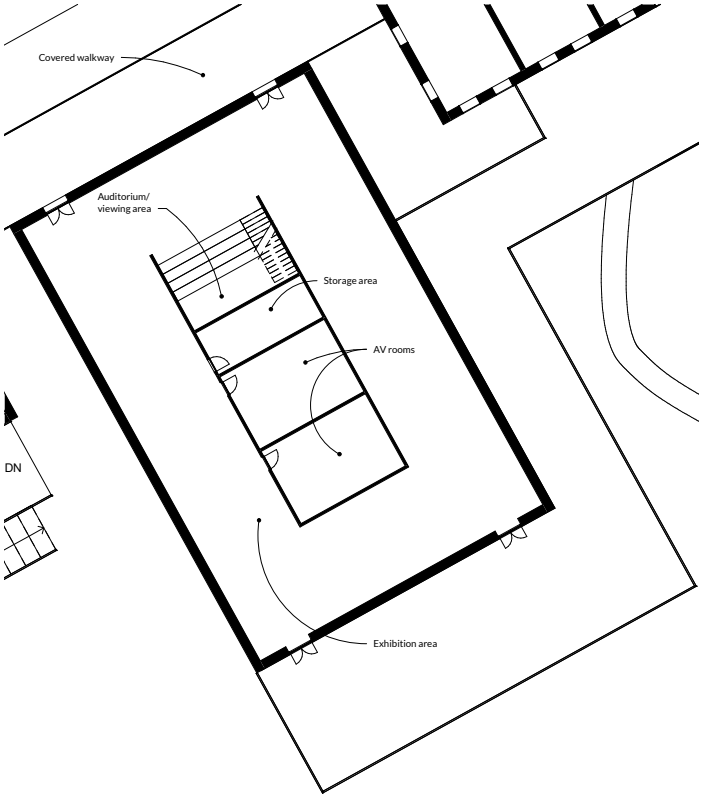


Illustration 74:Barn concept floor plan- Block 2

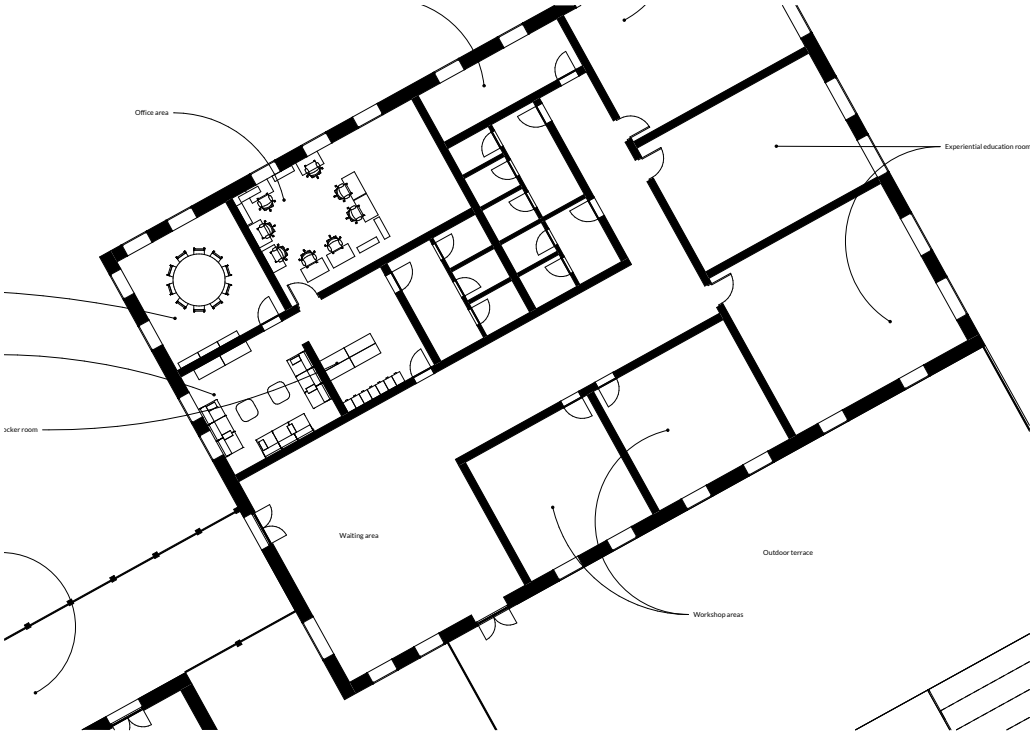


Illustration 75:Barn concept floor plan- Block 3

INTERNAL CIRCULATION BETWEEN BLOCKS

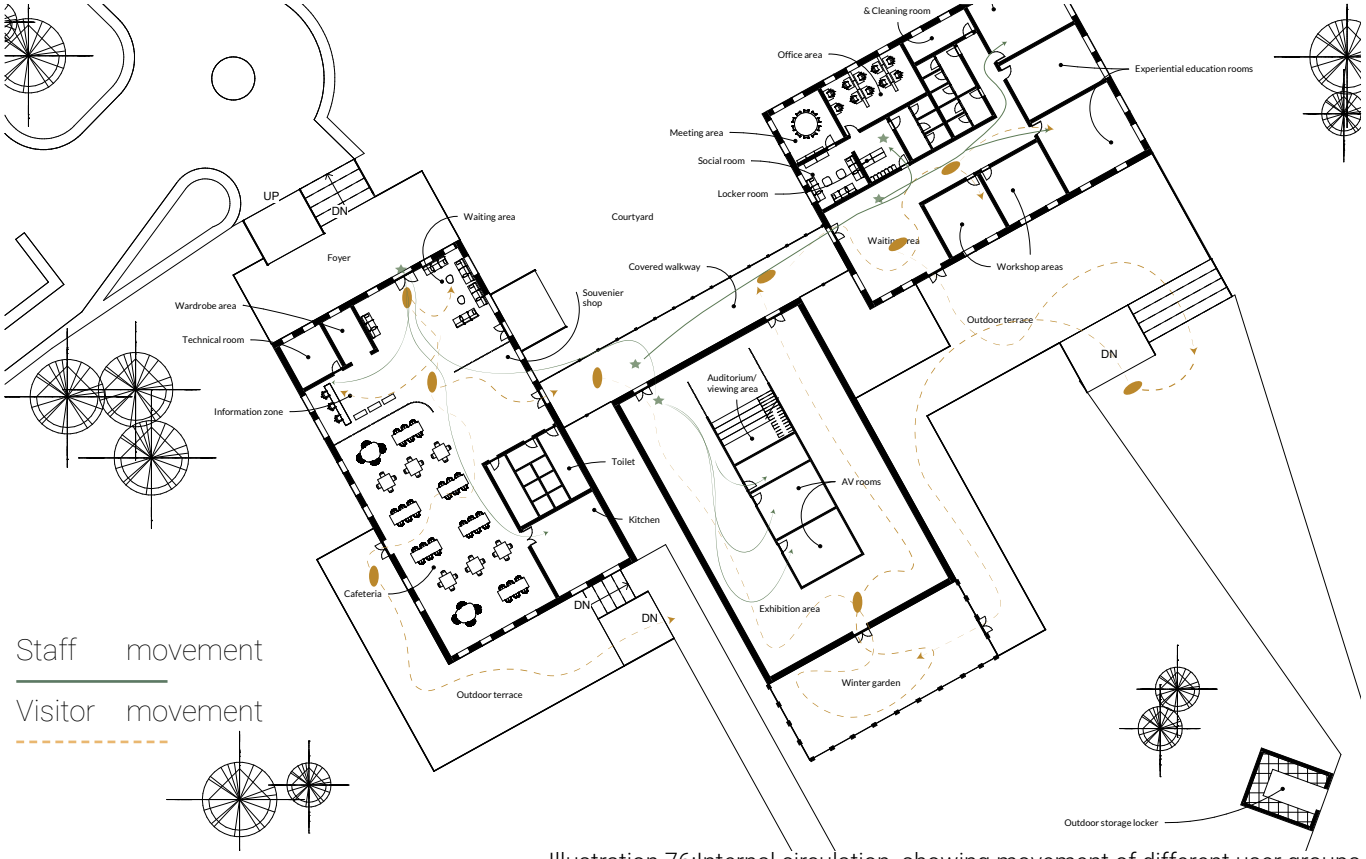


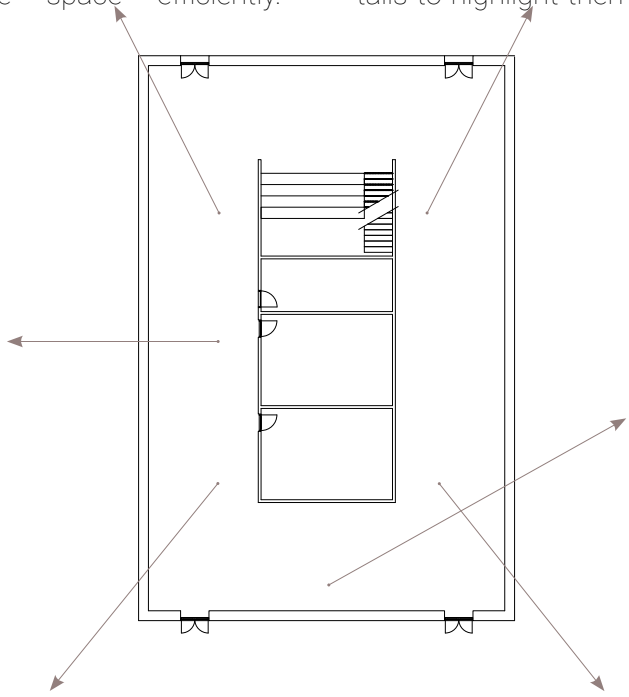
Illustration 76:Internal circulation showing movement of different user groups

INSPIRATIONS FOR THE EXHIBITION

Exhibits can be placed on the walls and on platforms to utilize the space efficiently.

The exhibits can also be placed amidst the wall details to highlight them and use the area efficiently.

An interesting roof detail can emphasize the aesthetics of the walkway.



Skylights can be placed on the roof to provide more natural light indoors.

Ribbon windows can be provided to provide light inside without causing hinderance to the exhibits.

Internal modular partitions can be provided inside to make more space for the exhibits.

Illustration 77:Inspiration for exhibition area

EXHIBITION LAYOUT AND FLOW

A layout has been worked on based on the inspirations to understand the flow of the users through the exhibition area from the entrance to the exit. The exhibition area is arranged with different viewing areas, such as the exhibition area for the various exhibits or displays. There are intervals of displays which are laid out on platforms which also acts as a transition point for the different exhibition areas. A viewing or seating area can provide a space for viewing a digital presentation or just as a seating. Av rooms provide enclosed rooms for viewing digital presentations. A lounge or seating area is provided where the users can relax while transitioning from the entrance to the exit of the exhibition.

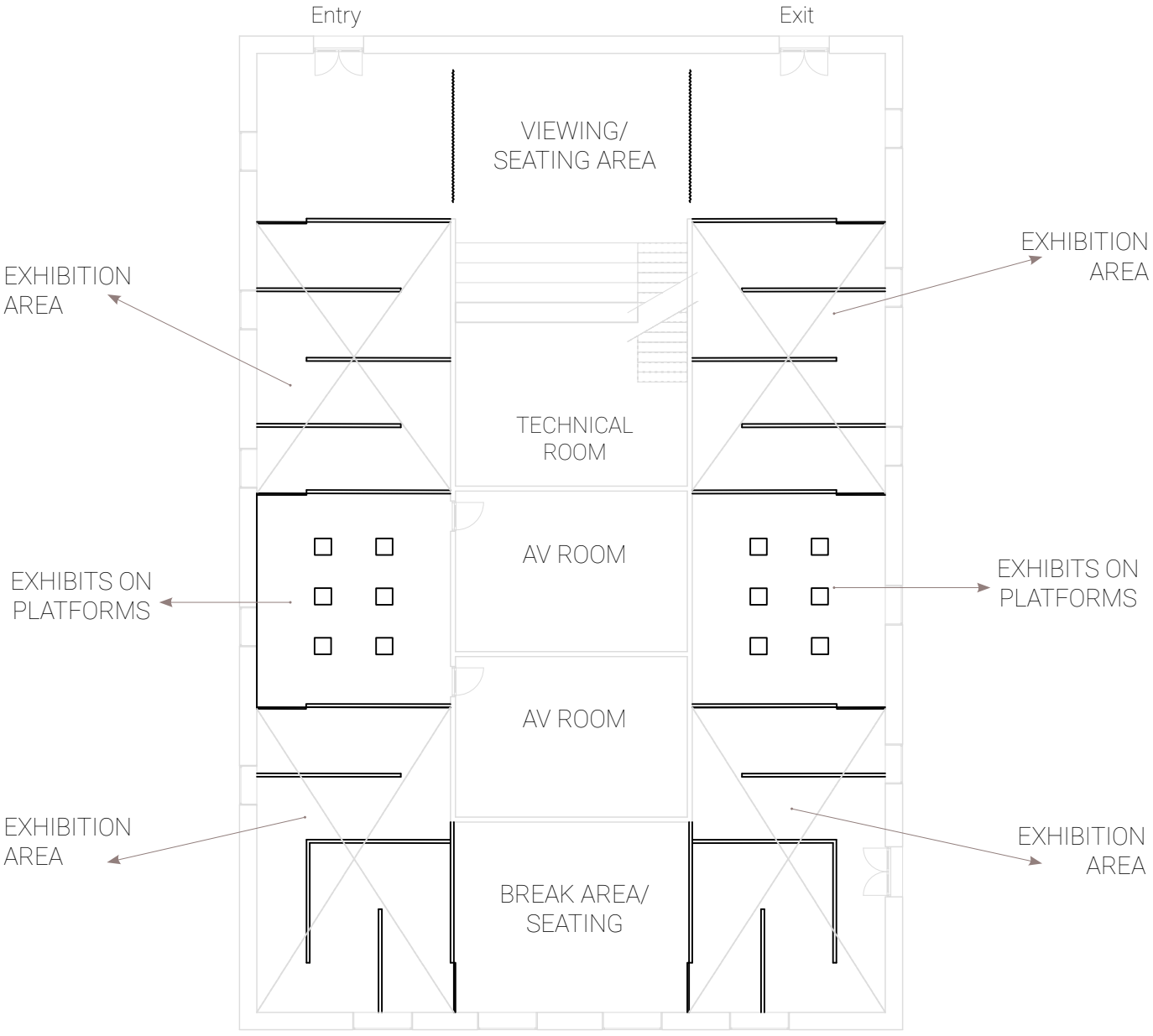


Illustration 78:Layout plan for exhibition area

DAYLIGHT OPTIMIZATION

The consequences of the layout development directed towards changes in window placement as well as sizes. The first block had optimal daylight in the critical spaces such as cafeteria, waiting areas and reception area had a slightly less DF, which was resolved when the areas were moved to the south west.

In the second block, the atmosphere was made more ambient by reducing the number of windows and its sizes to make it comfortable in the auditorium/ viewing area, while maintaining optimal required daylight.

In the third block, keeping function zones in mind certain areas are rearranged to illuminate the education zones while also creating a social waiting area in the block which was earlier missing.

.

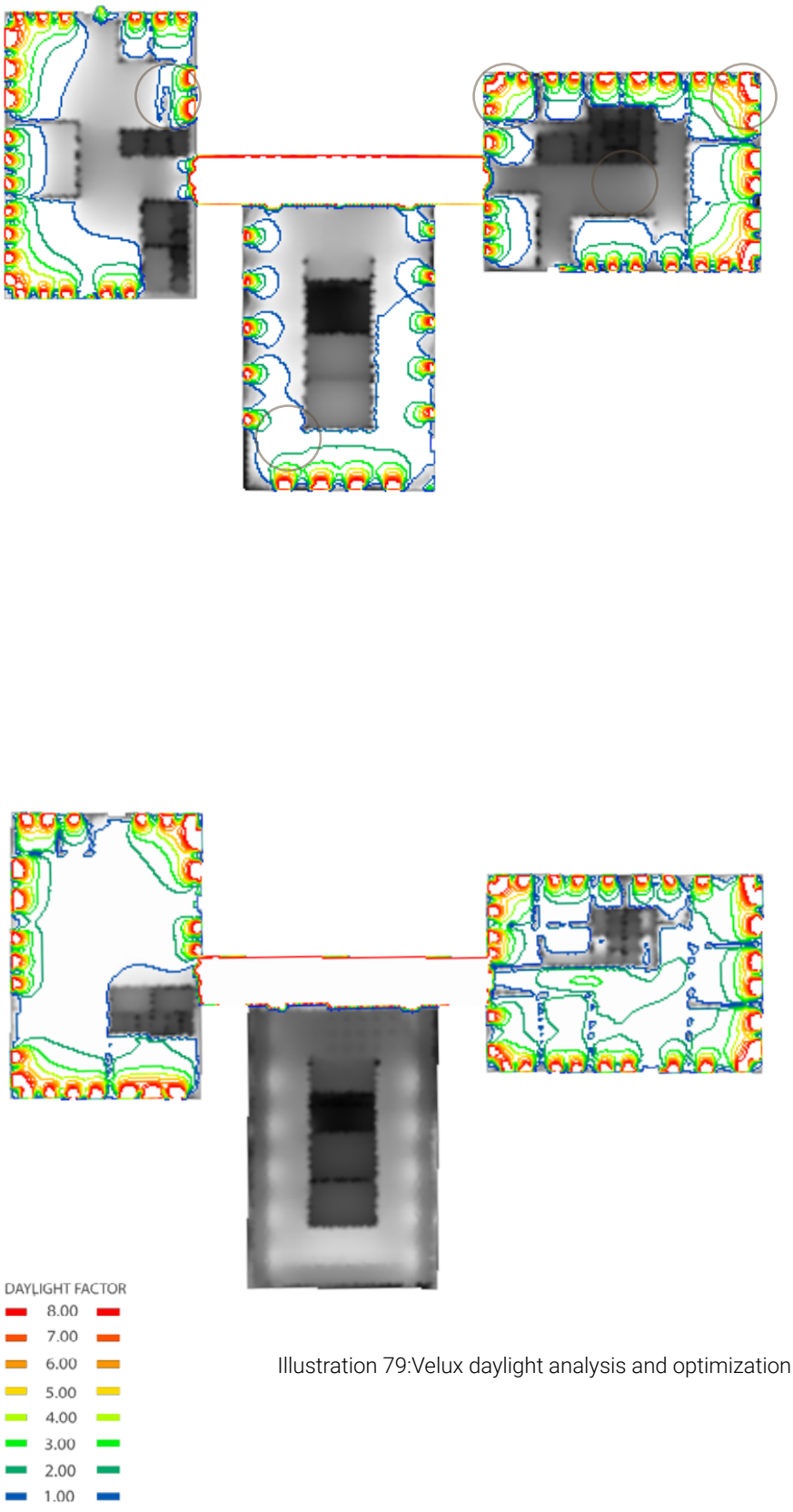


Illustration 79:Velux daylight analysis and optimization

LIFE CYCLE ANALYSIS

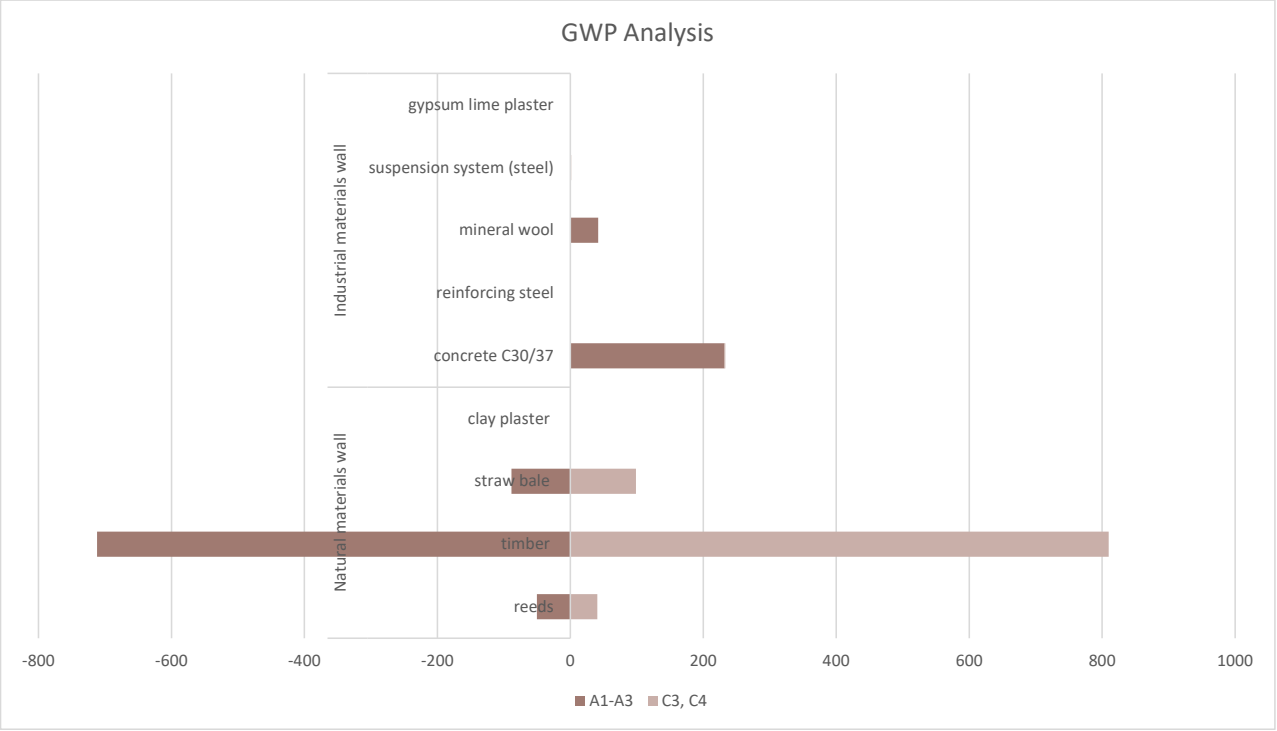


Illustration 80: Comparison of global warming potential (GWP) impact distributed on stages of materials between wall made of natural materials and wall made with industrial materials

Using LCAbyg tool, initial life cycle assessment of various construction materials was done. The main comparison was between the conventional industrial construction materials and natural materials to recognize the implementation of materials that are less harmful to the environment (based on the different life stages of the materials) into the design. It is understood from the graph that timber, reeds and straw seem to have the least harmful effect.

The next step of the analysis was to design an exterior wall with good U value and still maintain positive impact on the environment. To understand this using the LCAbyg tool comparisons were made between mainly three types of walls i.e. wall 1 with hardwood timber as cladding, wall 2 with recycled bricks as cladding and wall 3 with reeds as cladding. With different walls straw bale is maintained as the common insulation material along with the thickness of the wall as constant.

Additionally, another set of analysis was done by comparing the GWP factor at different stages of the three walls that is the product stage (A1-A3), waste treatment stage (C3) and landfill (C4). From this assessment it can be understood that the exterior wall with hardwood timber as cladding not only has the least GWP effect as a wall but also individually at different life stages impacts in a positive way.

In conclusion, it can be understood that natural materials have a lesser impact to the environment when compared to the industrial materials. Furthermore, different natural material in combination with different materials while creating the exterior wall give another result. From the three wall combinations it can be understood that a timber construction proves to be the most advantageous with reference to the CO2 emissions as well as the U values.

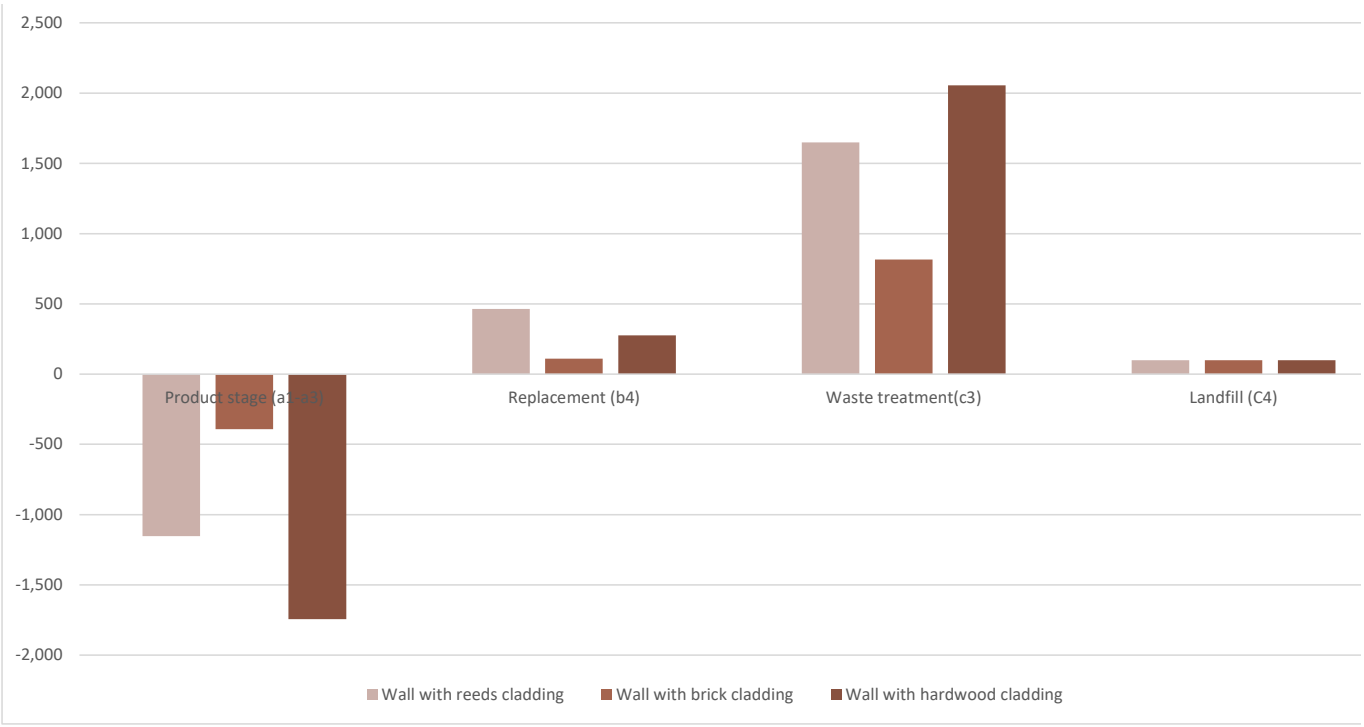


Illustration 81: Comparison of global warming potential (GWP) impact distributed on stages of materials of three wall options

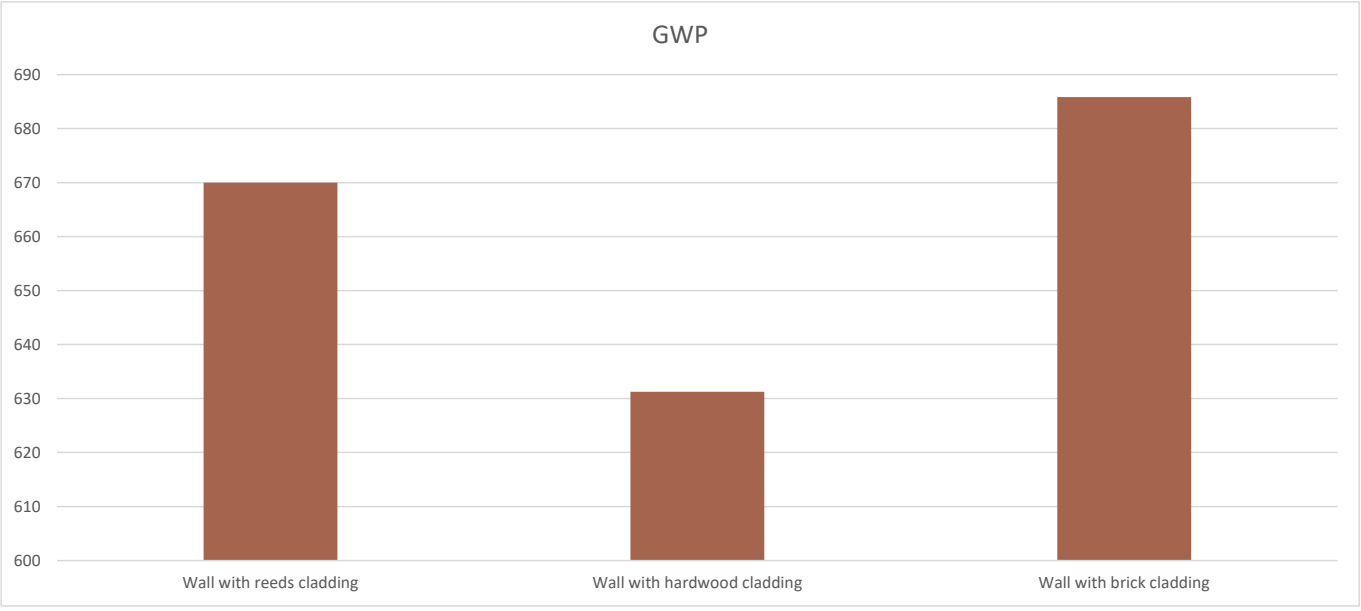


Illustration 82: Comparison of global warming potential (GWP) factor of three wall options

FACADE STUDIES

SCOPE:

The aim of this study of facades is to compare the different materials that can be used on the facade such as timber planks (recycled), recycled bricks and reeds; based on various parameters like LCA, materials' relation to nature and how it retains the character of the surrounding neighbourhood of the Skagen town.

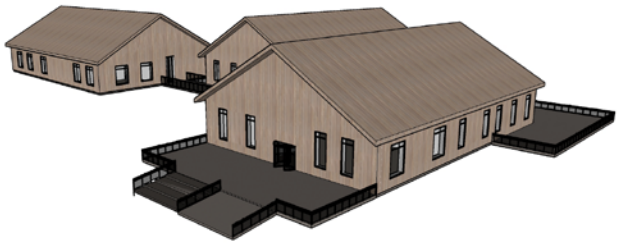
The ratings are provided with 1 being the least appropriate and 5 being the better of the options.

ANALYSIS:

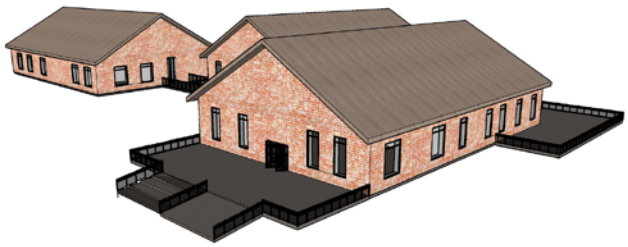
As it can be seen timber used as cladding for the facade would be the best solution in this case as it has optimal results based on the LCA calculations (see appendix -LCA). It also relates the closest to the surrounding site which is an expanse of forest area along with a clear open field. The timber planks also resonate with the town of Skagen where many of the houses have timber roofing or timber facades.

	TIMBER	RECYCLED BRICKS	REEDS
LCA	●●●●○	●●●○○	●●●●●
RELATION TO NATURE	●●●●●	●●●○○	●●●●○
RETAINS CHARACTER OF THE SPACE	●●●●●	●●●●○	●●●○○

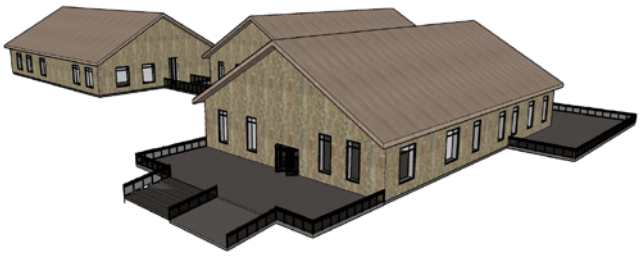
Table 8: Comparison of three material for facace



TIMBER



RECYCLED BRICKS



REEDS

Illustration 83: Facade variations for the barn concept

SCOPE:

The aim of the next step in this phase is to look at different variants of using timber planks or timber elements in the facade option of the visitor centre. The elements assessed are vertical timber planks used to create a board batten facade, the planks can also be arranged horizontally and timber shingles which give the effect of the tree bark which represents the surrounding forest.

ANALYSIS:

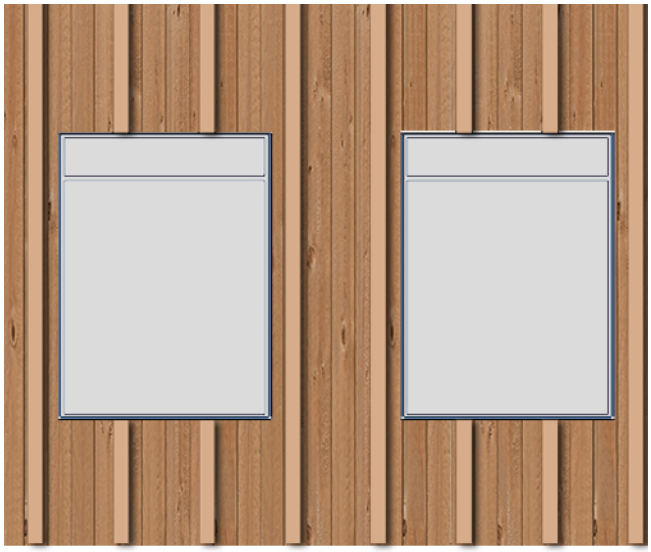
The visitor centre is situated at the edge of the neighbourhood, near the beach, amidst an open field with large forest area around it.

The vertical pattern of the wooden facade is designed to emphasize the blend with the surroundings, where the vertical pattern would imitate the presence of the rhythm of the tall trees around. The lamellas at regular intervals create a calm reflectance of the surrounding tall trees.

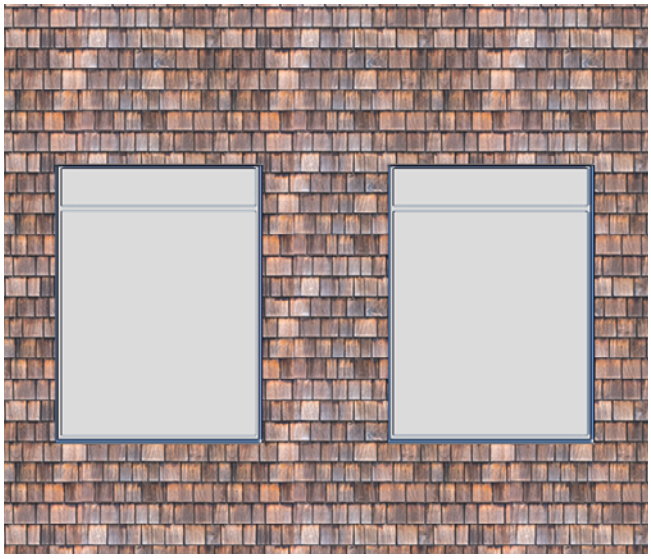
The timber shingles were used to camouflage the facade which would represent the timber bark with variants of colour an pattern.

The horizontal wooden planks would mimic the flat site and the surrounding. It would also have a similar effect to that of the horizontal laying brick facade of the nearby buildings.

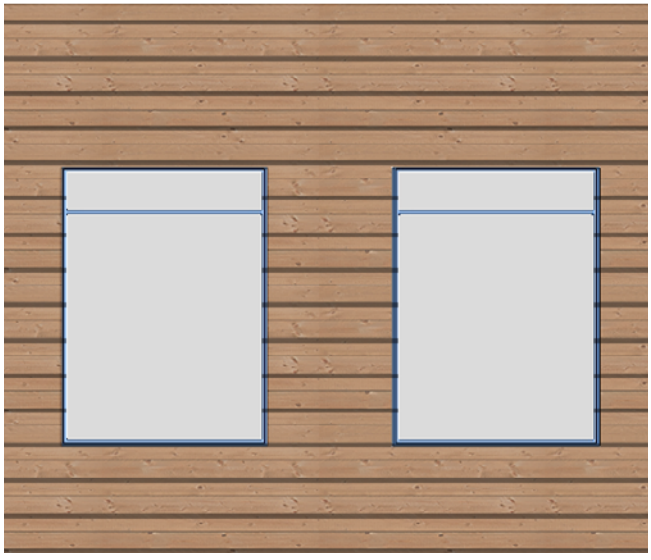
Although all three options are aesthetically pleasing, the timber planks creating the board batten facade create the most aesthetically pleasing outcome.



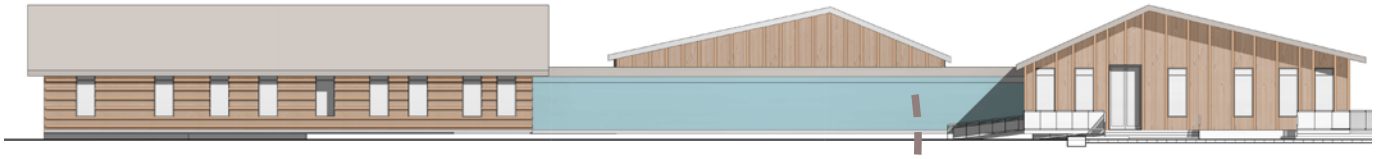
VERTICAL TIMBER PLANKS WITH LAMELLAS



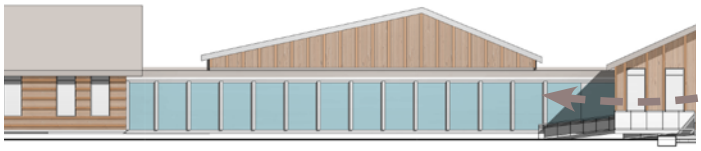
TIMBER SHINGLES



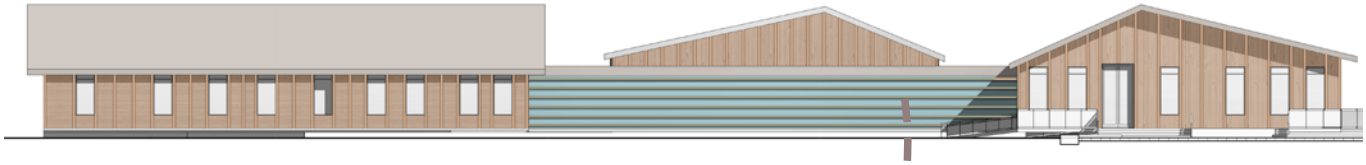
HORIZONTAL TIMBER PLANKS



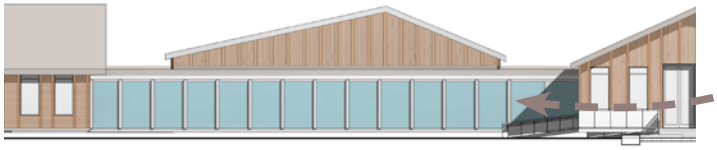
Vertical timber battens on block 1& 2 with horizontal batten placement in block 3



Vertical timber battens on block 1& 2 with horizontal batten placement in block 3 with vertical lamellas on the walkway



Vertical timber battens on block 1,2 & 3 with horizontal batten placement ion the walkway



Vertical timber battens on block 1,2 & 3 with verticall batten placement ion the walkway

Illustration 84:North elevation of all 3 blocks with different patterns

SCOPE:

While wood as facade cladding, poses a great variety for the placement as well as the patterns. Considering the LCA, wooden facade with lamellas is preferred while finding a balance between the aesthetic expression as well as the surroundings. Different combinations were worked on to create a unique expression on the facade, where all three blocks were looked at in an elevation keeping the cohesive idea of aesthetics in mind.

ANALYSIS:

In the first pattern, the vertical elements were expressed in the first two blocks while the third block used horizontal timber planks with horizontal self-shadowing patterns which made the building look elongated, although it does not emphasize a verticality that resonates with the surrounding trees. In the next two variations, the walkway is also covered in wooden lamellas that add to an interesting movement between the blocks. The fourth variation is the most preferred as it blends with the sites' clean and open look while adding an expression of verticality which merges with the surrounding forest area making the visitor centre stand out in a connected neighbourhood setting.

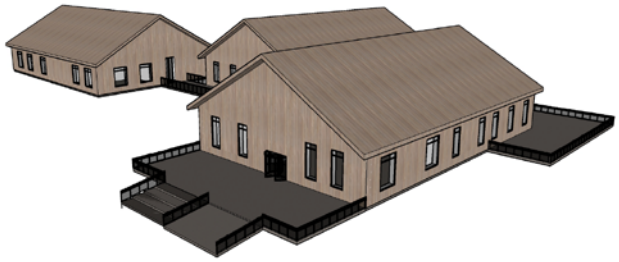
ROOF MATERIAL STUDIES

SCOPE:
The aim of the study of roof is to compare the different materials that can be used on the roof such as timber, sedum and reeds with respect to different parameters such as LCA, relation to nature, retaining character of the space and integrating sustainable strategies.
The ratings are provided show the potential of the options with 1 being the least and 5 being the better of the given options.

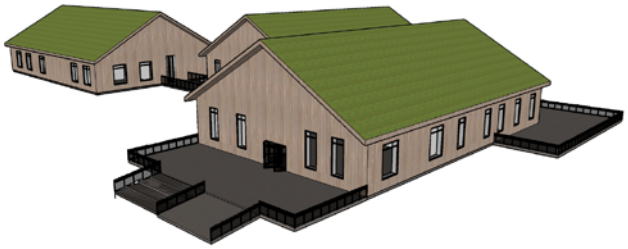
ANALYSIS:
As it is seen timber once again is the most apt solution for this case and sedum roof can be used as well. In terms of a roof for integrating sustainable strategies timber is the best solution to implement skylights and solar panels. A solution can be made to use sedum roof in the northern side of the design and timber roof used in the southern side of the design.

	TIMBER	RECYCLED BRICKS	REEDS
LCA	●●●●○	●●●○○	●●●○○
RELATION TO NATURE	●●●●●	●●●○○	●●●●○
RETAINS CHARACTER OF THE SPACE	●●●●●	●●○○○	●●●○○
INTEGRATING SUSTAINABLE STRATEGIES	●●●●●	●●●●○	●●●○○

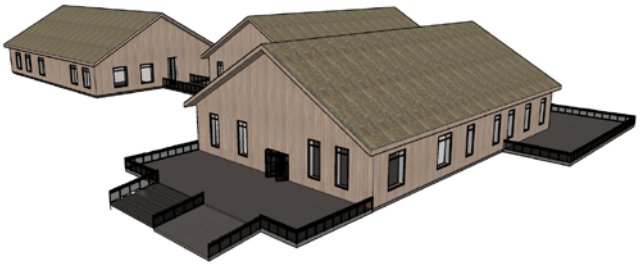
Table 9: Comparison of three material for roof



TIMBER



SEDUM



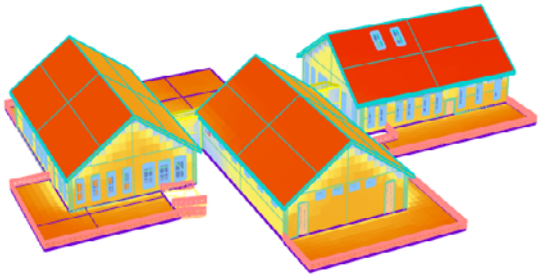
REEDS

Illustration 85: Roof material variations for the barn concept

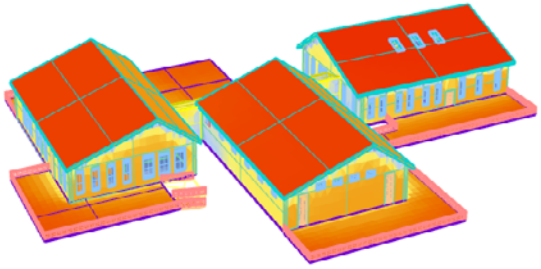
ROOF DESIGN STUDIES

SCOPE:
The aim of the study is to analyse various types of roofs such as pitched roofs, asymmetric pitched roofs and single sided sloped roofs to see how the solar gains reflect on the different types of roofs taken into consideration.

ANALYSIS:
As we can see all the roofs obtain more of less the same amount of solar gains, but the single sided roof has the most area with solar gains. However, to retain the character of the location, the use of a pitched roof would be more suitable. To satisfy this criteria the choice of an asymmetric roof is taken into consideration and is deemed to be the most appropriate for the requirements of a visitor centre.

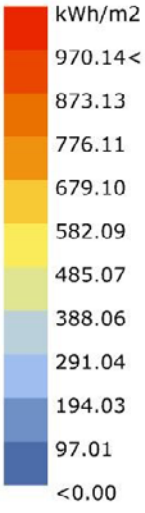


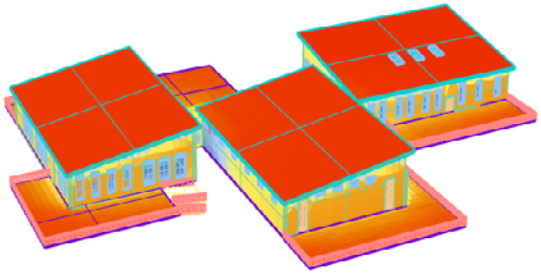
PITCHED ROOF



ASYMMETRIC ROOF

LEGEND:





SINGLE SIDED ROOF

Illustration 86: Solar radiation analysis for different roof styles

INTERIOR VIEW OF ROOF DESIGNS

SCOPE:
The roof options which have been narrowed down to pitched roof and asymmetric pitched roof are viewed from the interior to see how the users would perceive the design.

ANALYSIS:
As it is seen, the pitched roof has a longer height in the centre of the building making the overall atmosphere of the design more spacious. The truss structure can also be viewed in the given illustrations to see how the roof would be held up. The asymmetric roof though not of the same height still make the design feel more spacious and provides an interesting aesthetic to the interiors. Apart from this the asymmetric roof design also provides a larger surface area for solar gains on the roof to be utilised for solar panels. This roof also has an aesthetic appeal to it when viewed from the exterior.

Cafeteria view pitched roof

Exhibition view pitched roof

Exhibition view asymmetric pitched roof

Cafeteria view asymmetric pitched roof

Illustration 87: Interior view of cafe and exhibition with different roofs

ENERGY OPTIMIZATION

Energy efficiency

SCOPE:

The calculation has been done based on the Danish software Be 18 and the Danish weather data. This is based on rough estimation not including exact operation calculation.
This concept has the total heated floor area of 1905 sqm. with glazed area as 25% approximately. The wall, roof and foundation U-values are taken as the previous iterations as they are optimal. The window sizes are changed from 1.2m*3m to 1.2*2.7m and 1.8*3m to 1.8*2.7m in the southern areas.

The windows in the exhibition areas were also changed to create an effect of ribbon windows which allows to create an ambient indoor atmosphere where controlled artificial lighting can be used based on the exhibits and creations.

Total energy demand:
27.3 kWh/m^2

Contribution to energy requirement

Heat: 19.7
Excessive in room: 0
Net requirement
Room heating: 19.7
Total electric consumption: 5.7

Thermal comfort and air quality optimization

SCOPE:

The ideal room temperature for indoor areas is above 20°C, where the maximum hours above 26°C is 100 hours per year and the maximum hours above 27°C are 25 hours per year. The recommended temperature range is 23-26 degree Celsius in summers and 20-25 degree Celsius during winters. The CO_2 concentration should be maintained to a maximum of 850ppm in the indoor spaces. (DS/EN 15251)

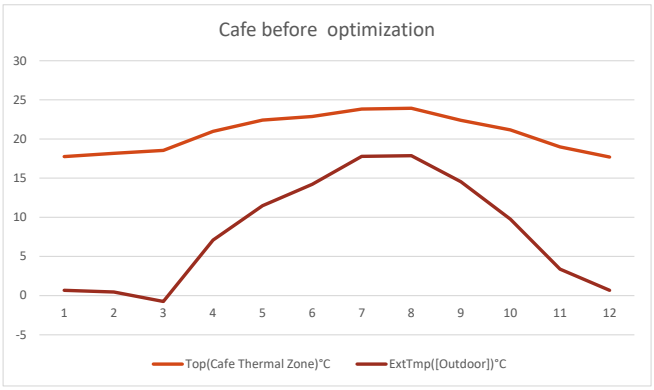
The analysis is done by calculating the 24-hour average temperature through BSim simulation. The simulation is done for the cafeteria and the kitchen area of block one and the meeting and staff room from block three of the visitor centre. (See Appendix 8- BSim results)

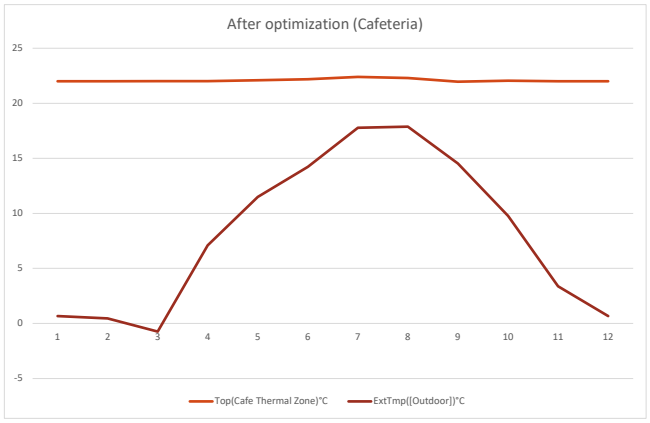
Window openings and natural ventilation study

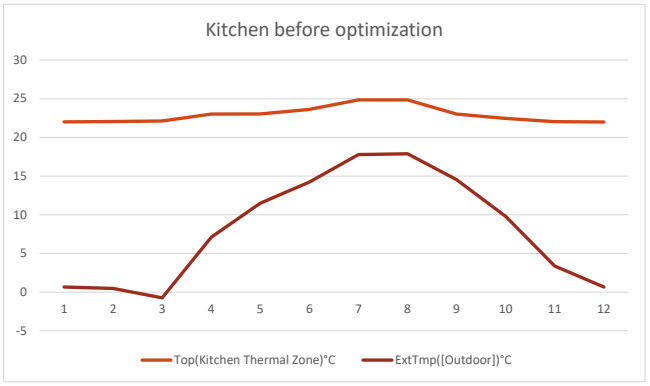
For optimal thermal and atmospheric performance, the glass opening areas like big windows and curtain wall on the facade are avoided. This helped to avoid over heating in the summer months and limit the heat loss during winter. For better efficiency, the orientation and the number of openings is analysed with the dimensions of the window opening being calculated based on that. (see Appendix 5- Ventilation calculation)

Use of natural and mechanical ventilation

In the initial model, the mechanical ventilation had been designed to operate between October-April and natural ventilation between May-September. The results show that there is a greater need for heating during November-April due to the temperature drop below 20°C in the cafe. In the kitchen area, overheating is seen during the months of June- August, although the temperature is below 25°C.







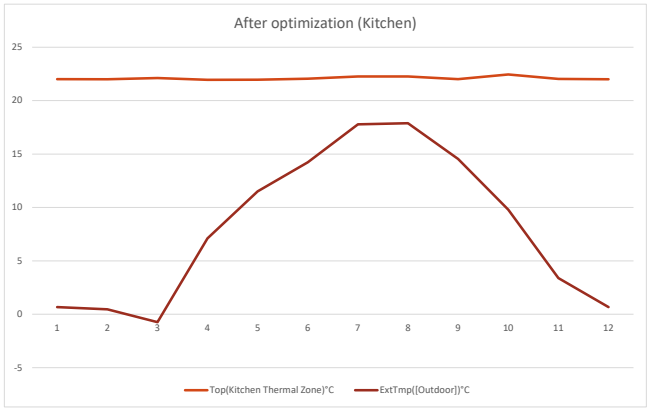
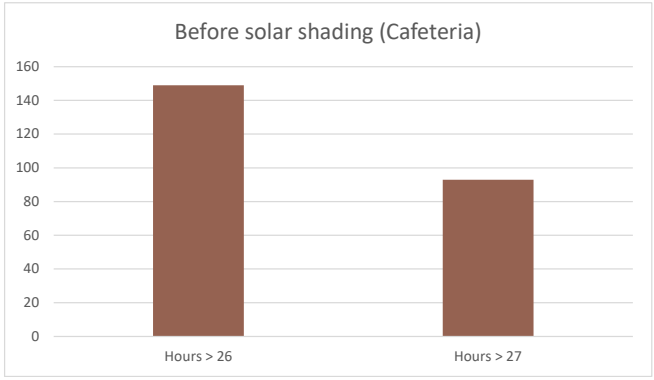


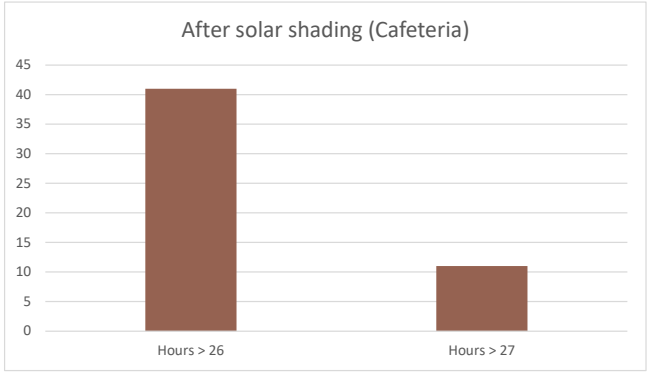
Illustration 88: Graphs showing operative temperatures in Cafe and kitchen

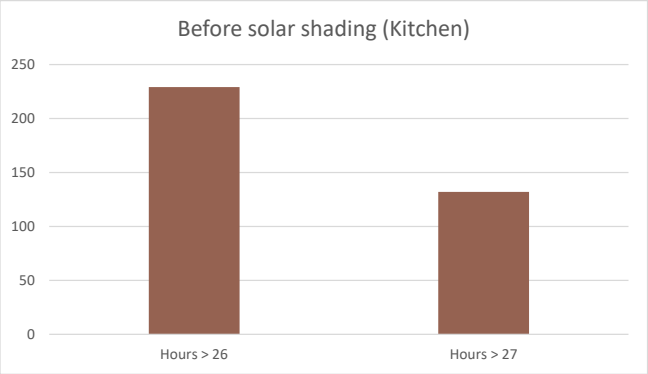
Implementing solar shading

In order to achieve the optimal thermal comfort for the user groups, some of the southern openings will be equipped with solar shading in the form of overhang through the pitched roof. The simulation shows that through the implementation of solar shading the room is protected from excessive solar gains during the summer, which in turn lowers the indoor temperature. As a result, the number of hours above 26°C during the year has decreased from 148 to 41 and the number of hours above 27°C had decreased from 89 to 12 in the cafeteria. The number of hours above 26°C during the year has decreased from 221 to 15 and the number of hours above 27°C had decreased from 110 to 2 in the kitchen as both the areas were facing the southern side which majorly caused overheating.

Other areas such as meeting room (office area) and staff room are also analysed (see Appendix 7- BSim Analysis)







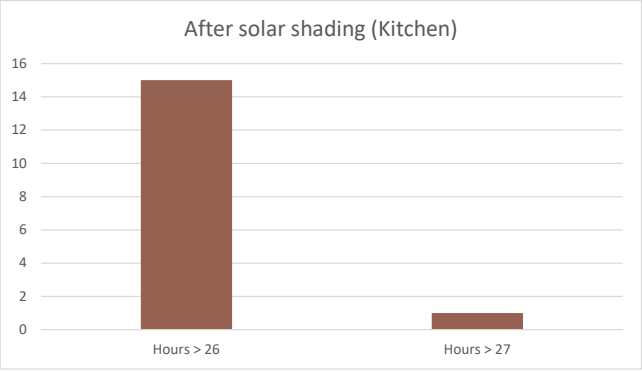


Illustration 89: Number of hours above 26 and 27 C before and after the implementation of solar shading through overhang

CONCLUSION

The integrated design methodology helped in obtaining a functional as well as energy optimal design through the various iterations in the different phases of the design process.

The analysis of phase 01 provided a direction to advance the design process through the selection of the two concepts based on their volume studies and iterations.

In the phase 02 of the design process, these concepts were further assessed through various parameters.

The next phase 03 helped in weighing the positives and the negatives of the two designs along with the original design through different guidelines to narrow down the most optimal design solution among the three.

The final phase 04 of the design process was to work on the selected barn concept to find the most optimal solution in terms of the functional layout, daylight quality, materiality, tactility, energy efficiency while simultaneously considering the aesthetics of the visitor centre design.

Throughout all the phases, the method of integrated design process has been used where different parameters like neighbourhood and site, function, daylight, solar radiation, shadows, thermal comfort and energy efficiency were continuously considered and analysed simultaneously to reach the final design solution.

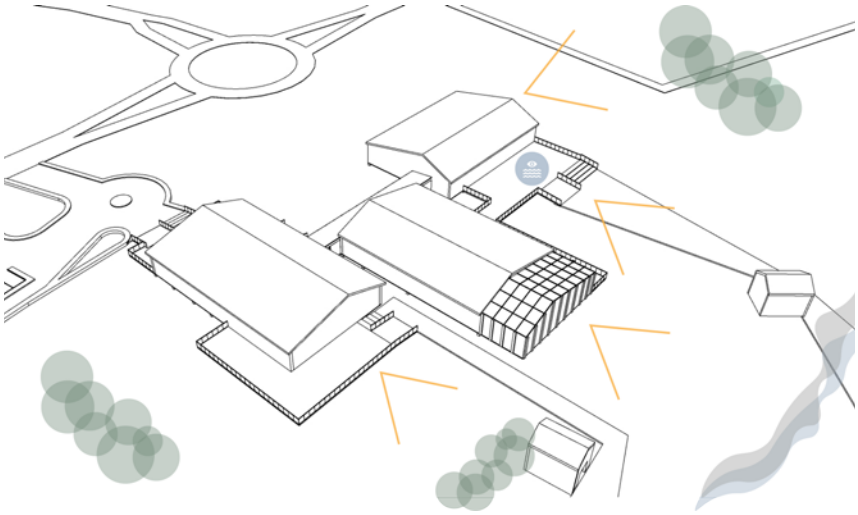
07 PRESENTATION

Illustration 90: View to the entrace of the Visitor Centre

BUILDING CONCEPT

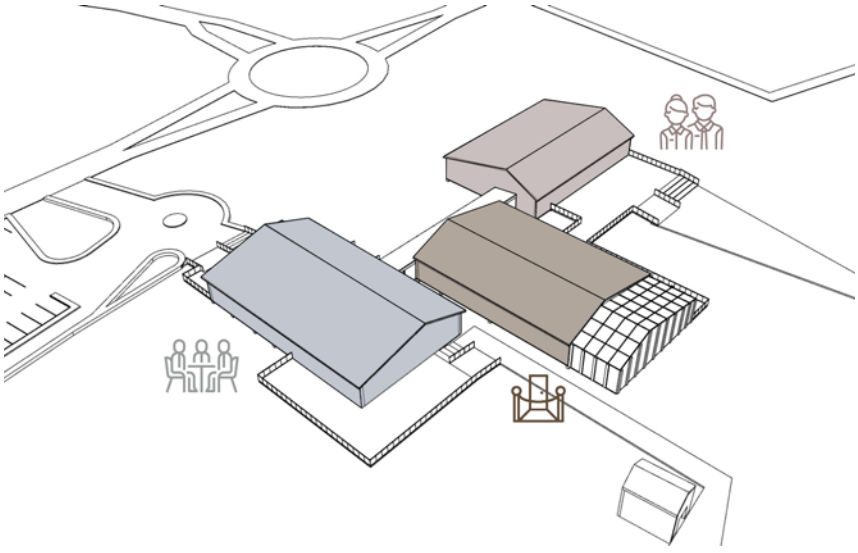
VIEWS

The interaction of the users to the site and its naturistic surroundings is implemented to connect them to nature. The provision of socially interactive spaces outdoor such as the pathways and decks provide good views to the greenery and the beach. There is abundance of greenery at a slight distance to the west and east of the design. The Vippefyret can be viewed to the south east of the project and is at a walking distance. Towards the south is a view of the beach with pathways leading to it.



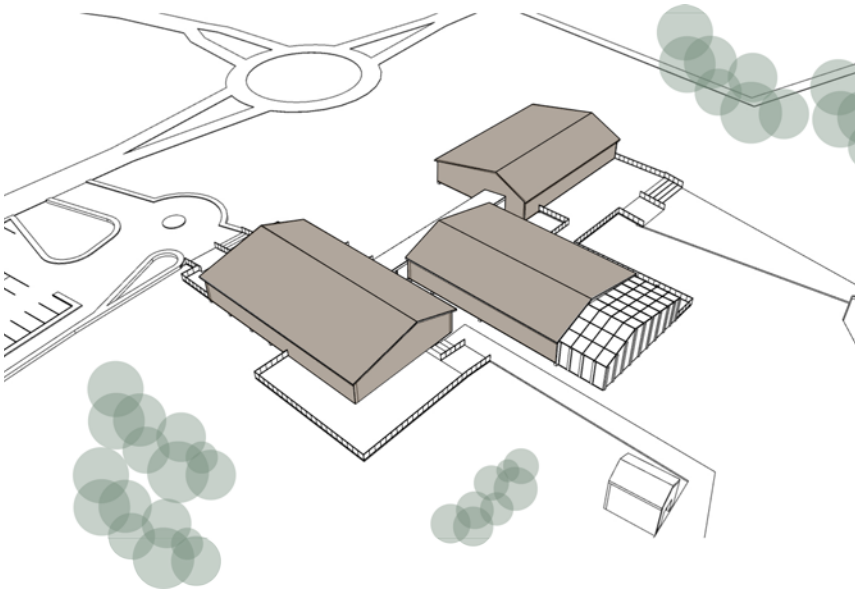
FUNCTIONS

To make the segregation of spaces more convenient the distribution of the functions between the three blocks is implemented. Block one which is public houses the social spaces like cafeteria,souvenir store, outdoor deck, waiting area along with the outdoor pathwaus and shelters which can be used by all.
Block two is a semi private are which hosts the exhibition area along with an auditorium and AV rooms for the visitors. The third block which is the staff zone and education rooms come under private area due to the restricted / permitted access.



MATERIALITY

The design uses a timber facade and roof design to compliment the surrounding greenery and reflect the vertical rhythm of the surrounding trees and forest areas. Apart from that the timber structure also allows the project to implement the asymmetric pitched roof style and correspond to the surrounding building typology and materiality. As timber is locally available the carbon footprint also reduces. The thermal conductivity of timber being low adds to the potential of providing a good indoor climatic condition.



ACTIVATION OF THE AREA

The use of outdoor and semi sheltered social spots are created to activate the area. The provision of a courtyard among the various blocks gives a spot for outdoor seating during warm seasons and even otherwise, while the winter garden with access to the outdoors gives a climate-controlled experience of the nature. The provision of outdoor decks creates zones where it gives the user the benefit of connecting to the nature as well as environment while offering a view towards the backdrops.

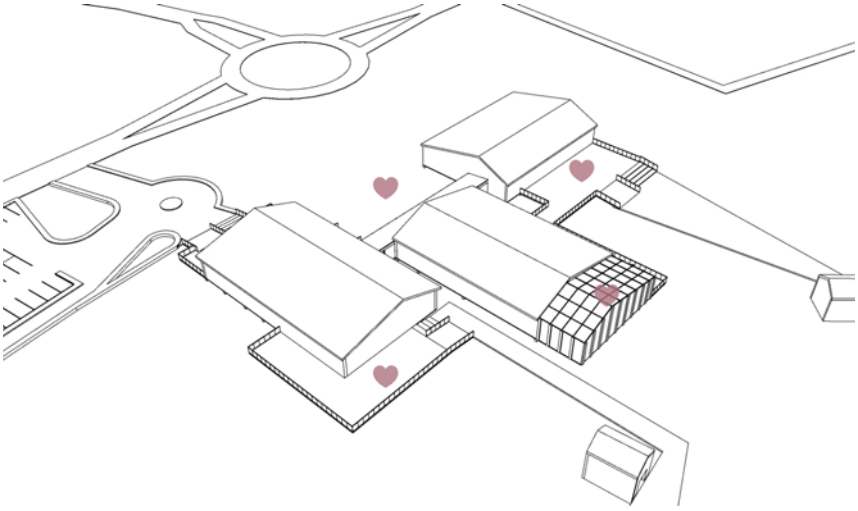
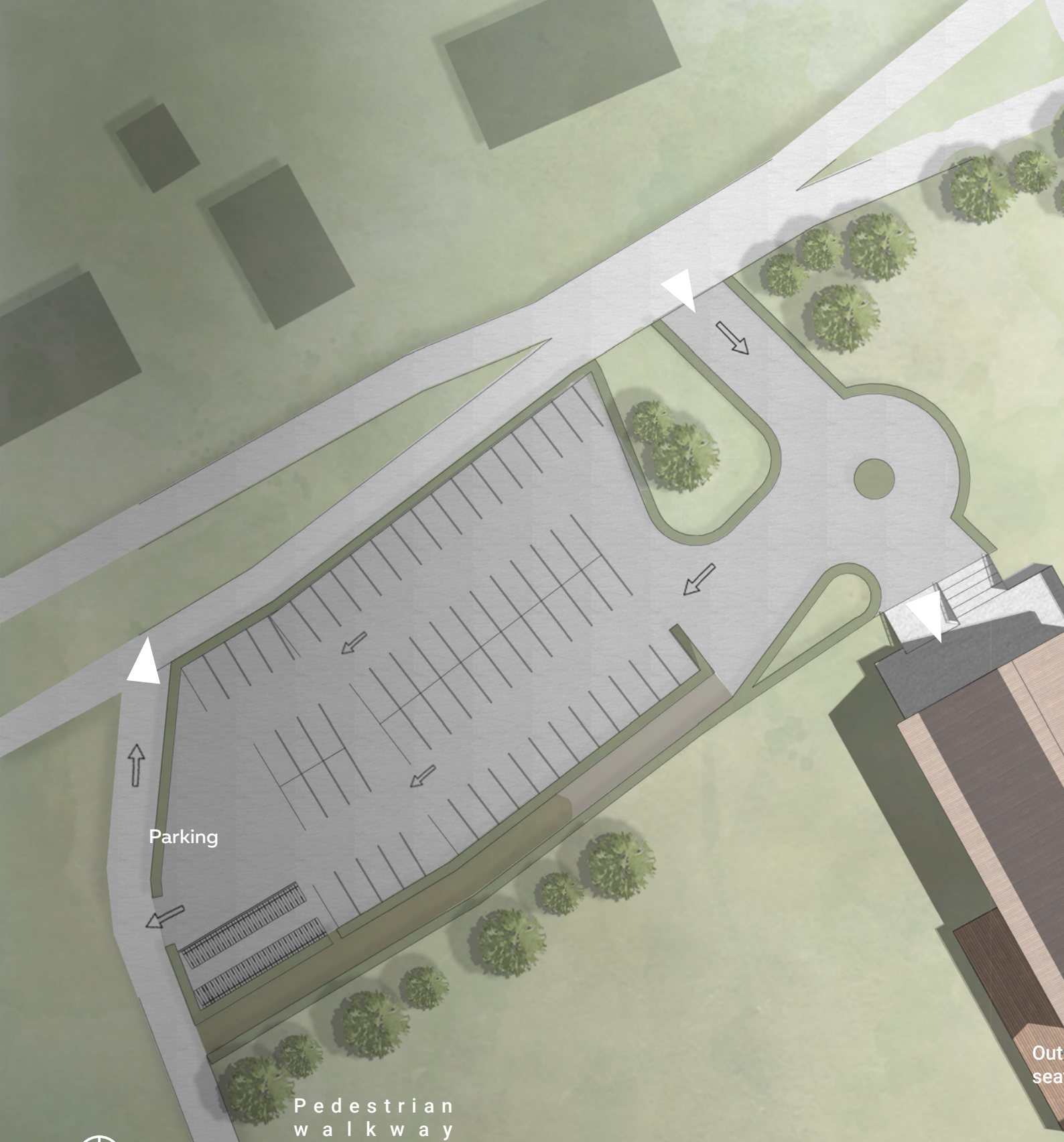


Illustration 91: Building concept diagrams

MASTERPLAN
1:1500

Illustration 92: Masterplan, 1:1500

The site which is located on the edge of Skagen between Skagen and Grenen, is surrounded by views towards the wilderness- such as greenery and the sea. The adjoining roads towards the site show the ease of access and connectivity to the site. The existing parking lot which was not much to begin with is made to accommodate more vehicles in the same area with more defined spaces and placements for the different vehicles. Pathways are also designed to lead towards the beach with shelters along the way which can be useful for the public to use as lockers. The placement of the deck facing the beach and adjacent to the greenery gives a very calm and holistic atmosphere.



SITEPLAN 1:500

Illustration 93: Siteplan, 1:500


Courtyard
Walkways
to the beach
Shelters

GROUND FLOOR PLAN
1:300

Illustration 94: Ground floor plan, 1:300


B
Conference room
Technical room & Cleaning room
Experiential education room
Meeting area
Office area
Social room
Locker room
Workshop area
Workshop area
Experiential education room
A
Waiting area
Outdoor terrace
+0.60
ed walkway
Auditorium/ viewing area
Technical room
AV Room
AV Room
Waiting area
Winter garden
0.00
B
D
Outdoor storage locker

The cafeteria and the waiting area are one of the most used function of the visitor Centre. It is an area where the visitors will gather information, relax and prepare an itinerary to visit the points of interest in Skagen. It is a public area with an open floor plan leading to the souvenir store and the cafeteria area. The café leads to an outdoor deck with the view towards the Vippefyret and the beach. The asymmetric pitched roof creates an interesting volume for the users to perceive this area. The timber structure with large openings makes the space comfortable for the users.

Illustration 95: Interior view -Waiting area and Cafeteria

SECTIONS

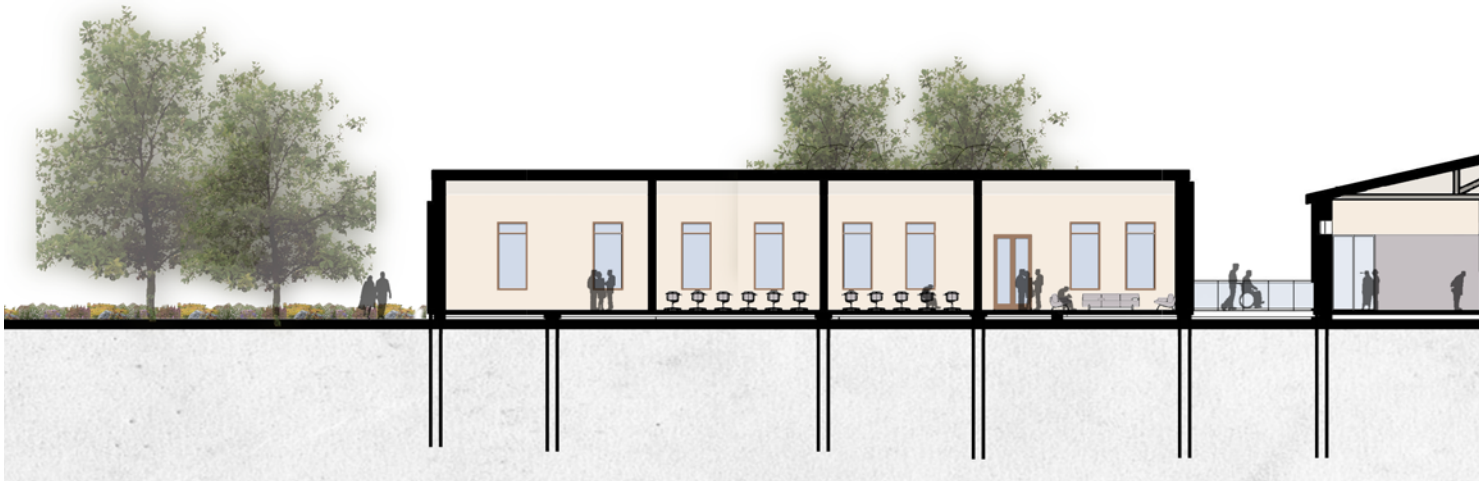
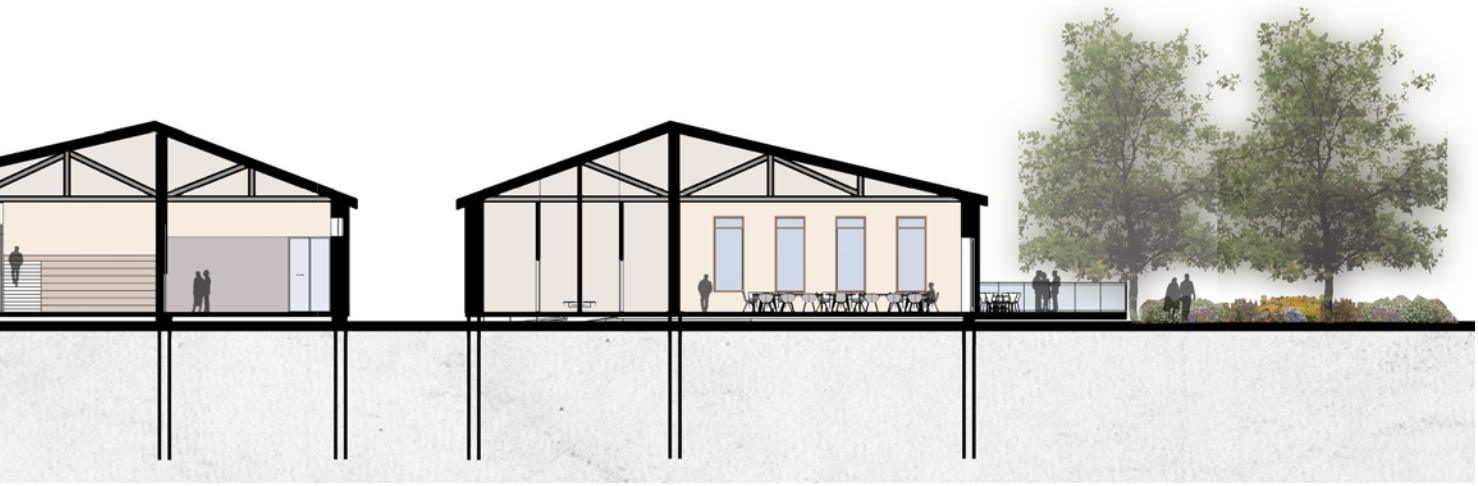
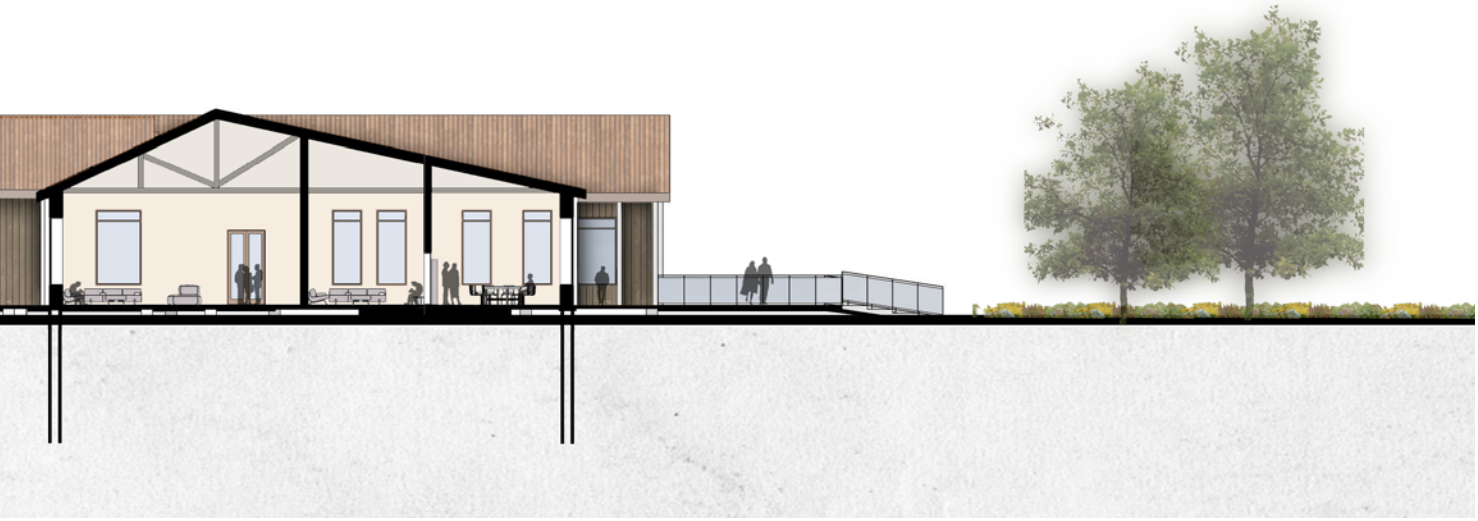


Illustration 96: Section AA, 1:300

Illustration 97: Section BB, 1:300





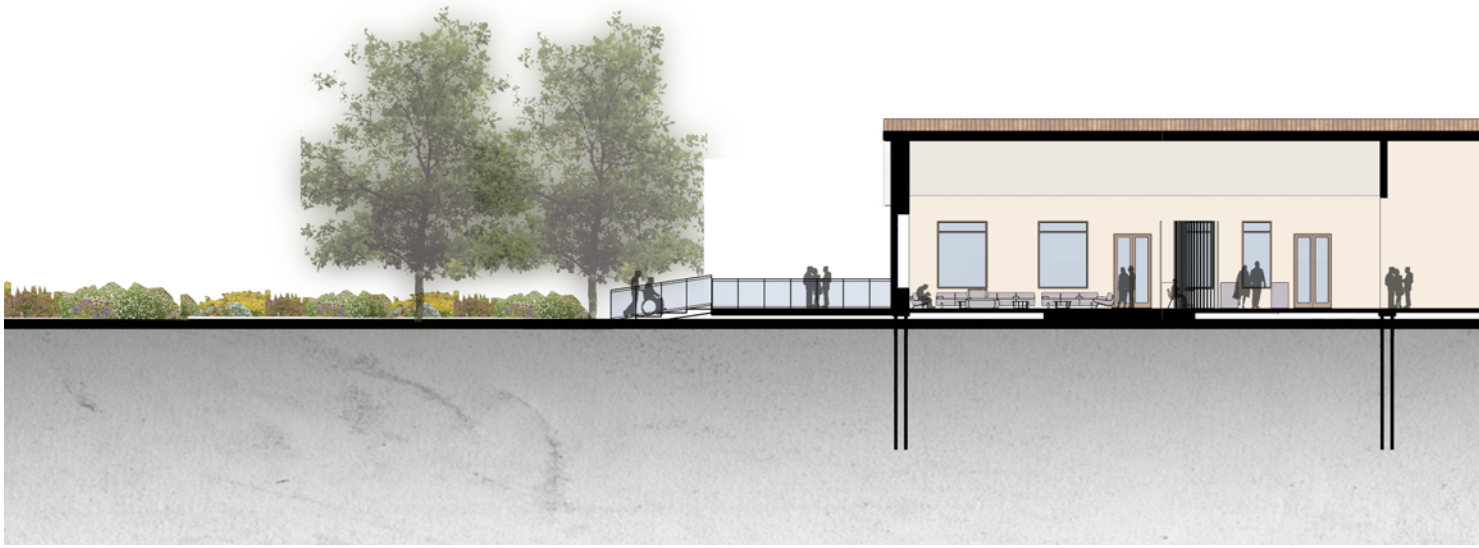


Illustration 98: Section CC, 1:300

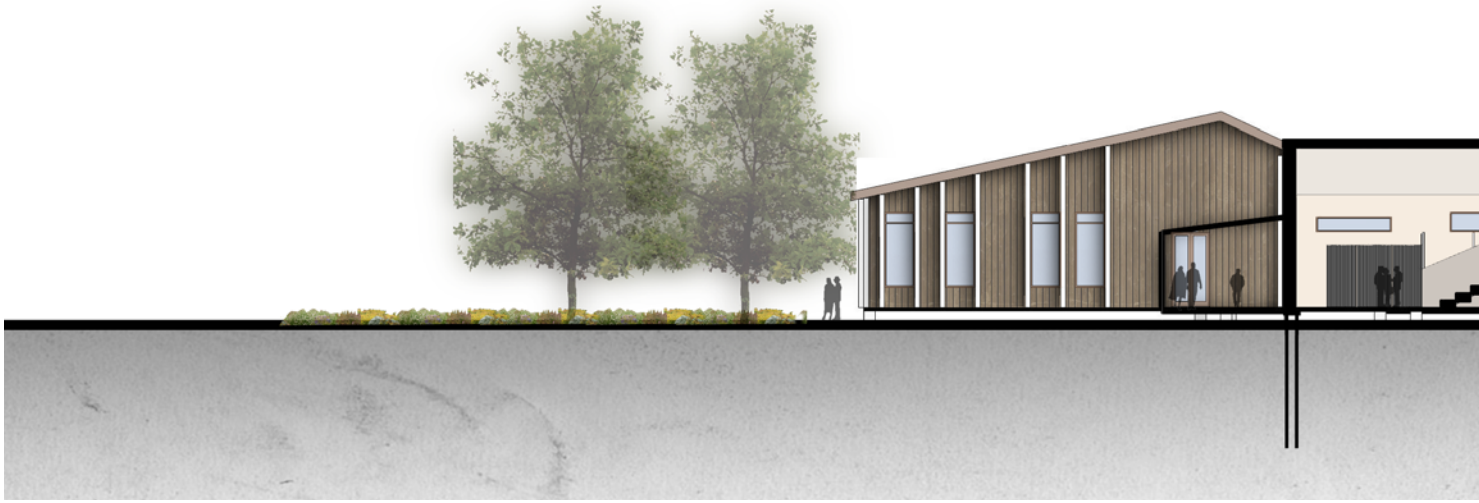
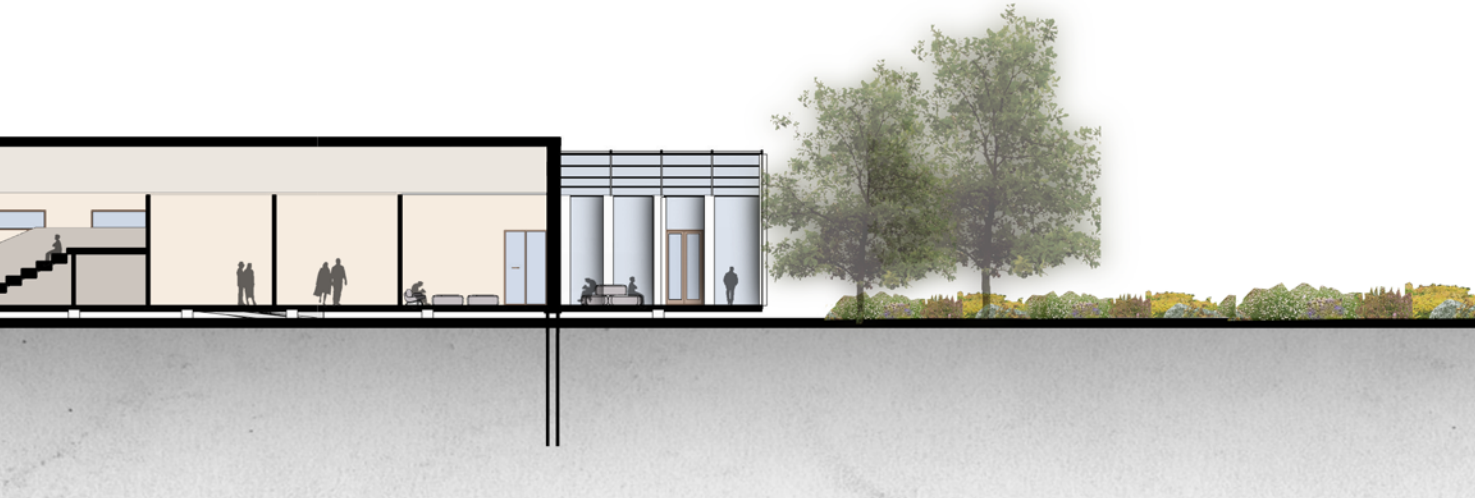


Illustration 99: Section DD, 1:300



The auditorium/ viewing deck in the exhibition block is a unique space, designed to view videos or movies to educate the users about the culture and history of the unique site. During regular hours, the space is an informal setting for visitors to view and leave. It could also function as a cultural Centre to hosts events for the different user groups, such as meetings with local artists, teachers or other representatives of culture, history and art. The area is also made to be interactive with the way the partitions and displays are placed forming a progressive series. The possibility of modular partition walls and displays in the area gives it the potential to be used as a larger space depending on the type of event taking place. The use of timber structure and the asymmetric pitched roof provides the exhibition space with a very warm ambience of being amidst nature.

Illustration 100: Interior view -Auditorium in the exhibition area

ELEVATIONS

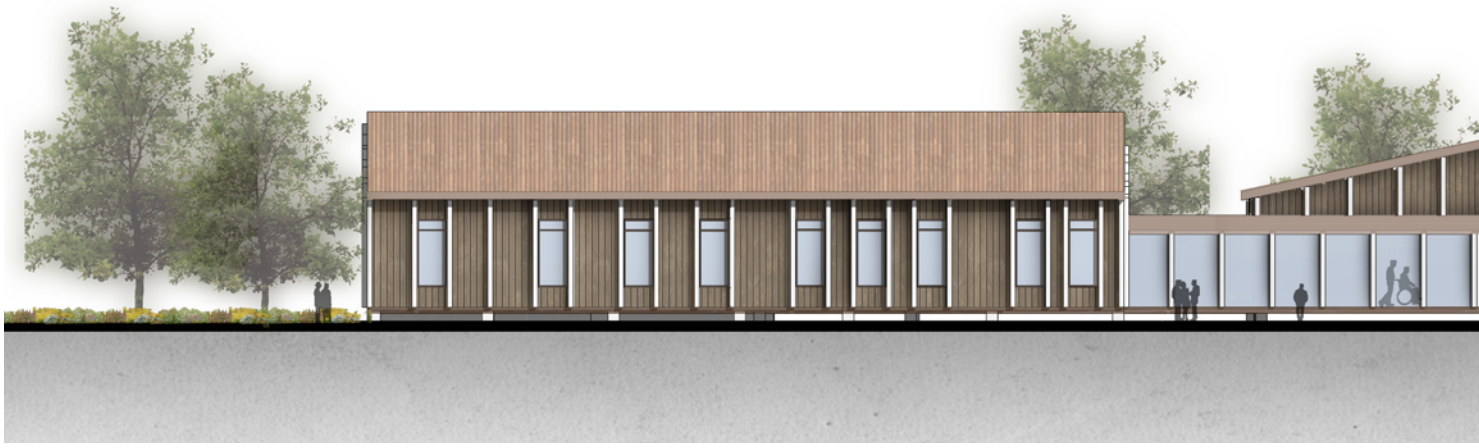


Illustration 101: North elevation, 1:300

Illustration 102: South elevation, 1:300

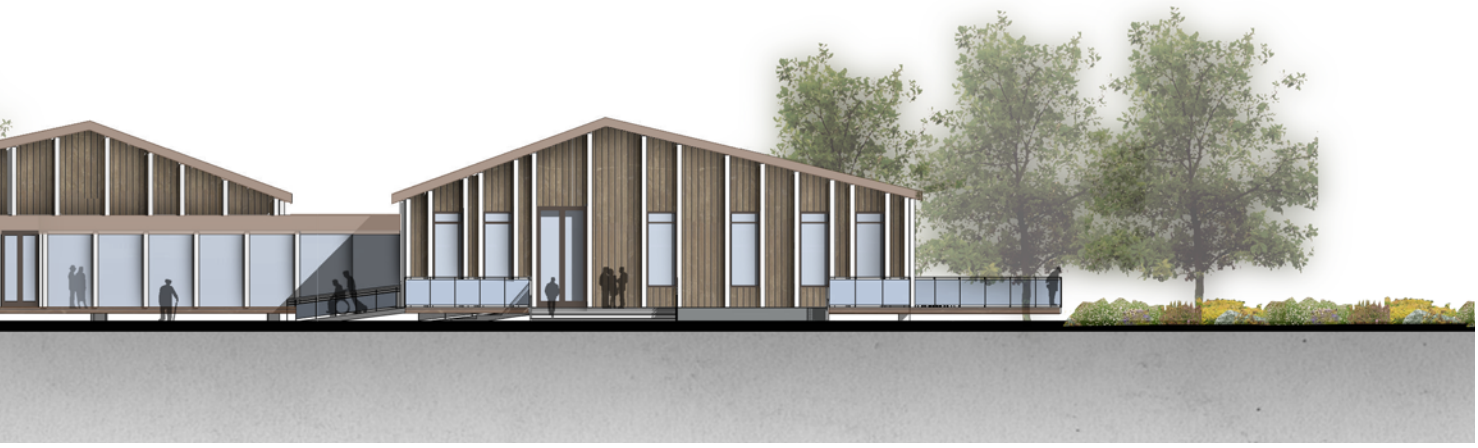


Illustration 103:East elevation, 1:300

Illustration 104: West elevation, 1:300

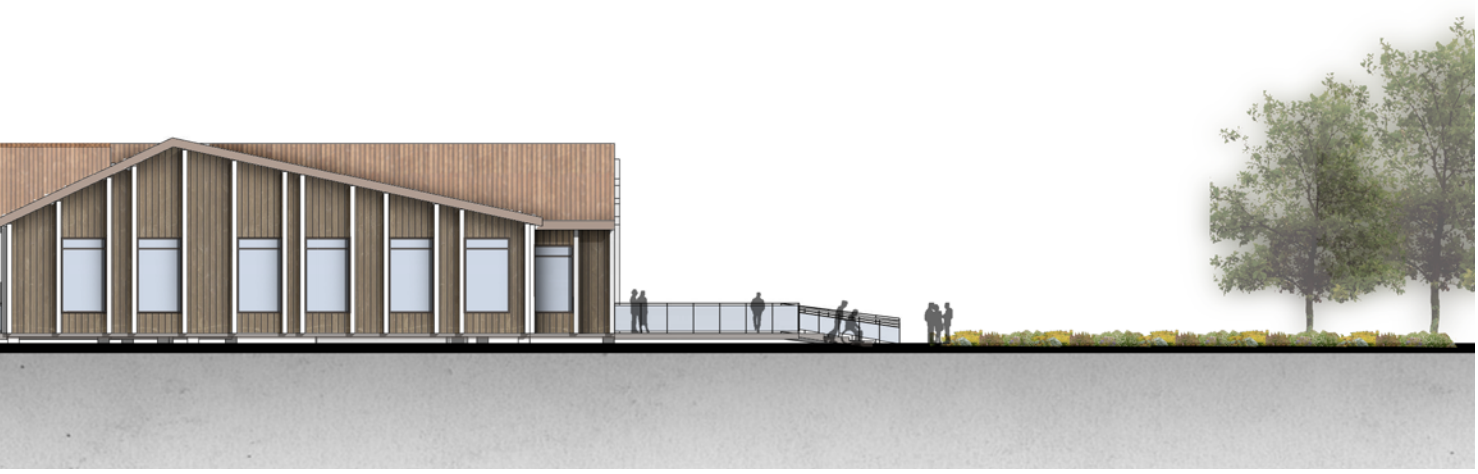


Illustration 105: Exterior render of the outdoor area

MATERIALITY AND CONSTRUCTION

The overall structure of the design focuses on retaining the essence of the surrounding building typology and using materials with a low environmental impact.

The project uses naturally available materials which have low carbon emission such as timber, straw, hemp, fibre board and wood chip board.

Timber and straw are used in the roof which is supported by a truss system to distribute the load to the walls and the columns. The roof has a gutter that is concealed in the design to make it seamless.

The wall structure which uses timber and straw also has timber lamellas on the outside placed in a variation of intervals to form an aesthetic appeal from the exterior. The load of the building is supported on columns that lead down to a foundation made of recycled concrete with steel piles going into the ground.

The good thermal properties of the materials that have been used give the roof and wall a good U-value to maintain a good thermal comfort because of the low heat loss.

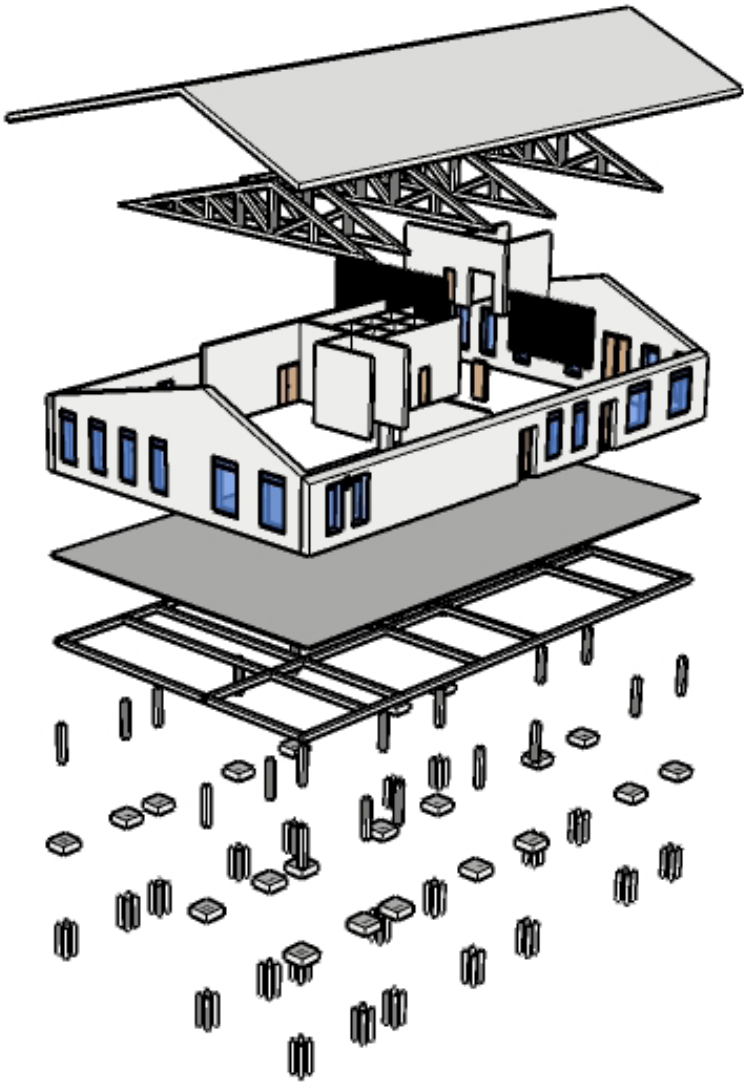
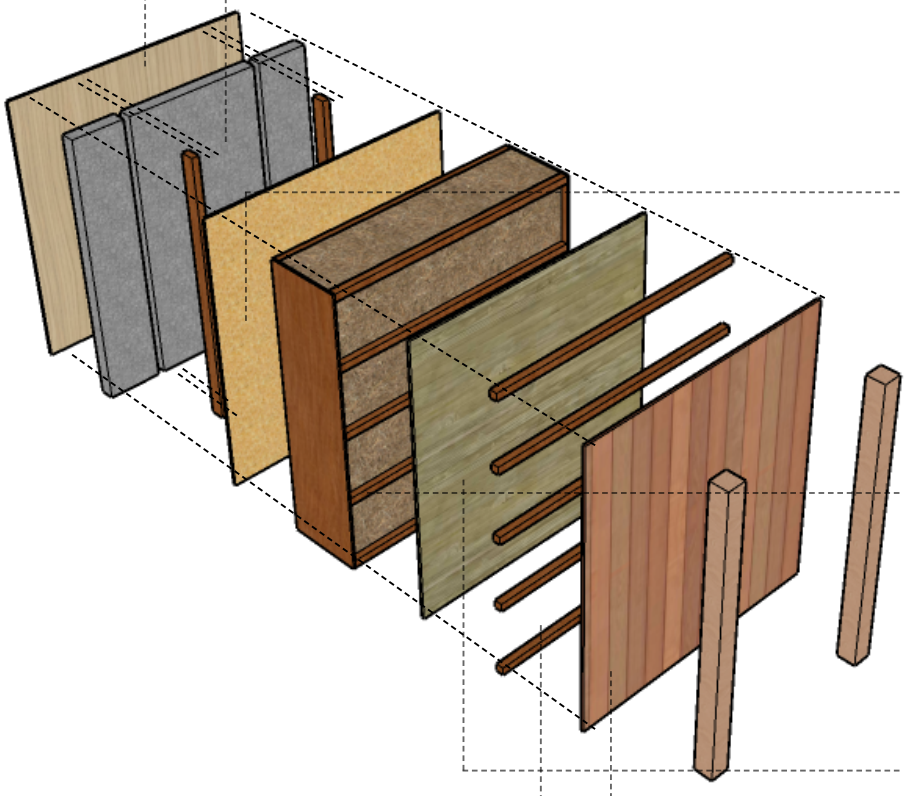


Illustration 106: Exploded view of block 1

EXTERNAL WALL DETAIL



3-layer wood chip board: High density wood chip board is used for the interiors due to its thermal and aesthetic properties. With proper treatment it also provides resistance to fire and water.

Hemp: Hemp is used as an insulation layer beyond straw bales, in the installation layer. It serves as a good flame retardant and as an acoustic barrier providing a good indoor climate.

OSB board vapour barrier: OSB board serves a good purpose as a vapour barrier. Sized at 10mm it has good thermal properties and prevent chances of forming thermal bridges.

Straw bale: Straw bales of dimension 350X900X500 mm are used as insulation due to it thermal properties. The tightly packed straw also ensure resistance to fire.

Wood fibre board: Wood fibre board which is coated with resin and wax produces properties for better wind and weather protection.

Timber batten: Timber battens sized at 40X40 mm are placed between straw bales and their adjacent layers to hold them together.

Wood cladding: Locally available timber is used for external cladding and for wooden façade elements (lamellas).

Illustration 107: Structure and materiality of designed external wall

ROOF DETAILS

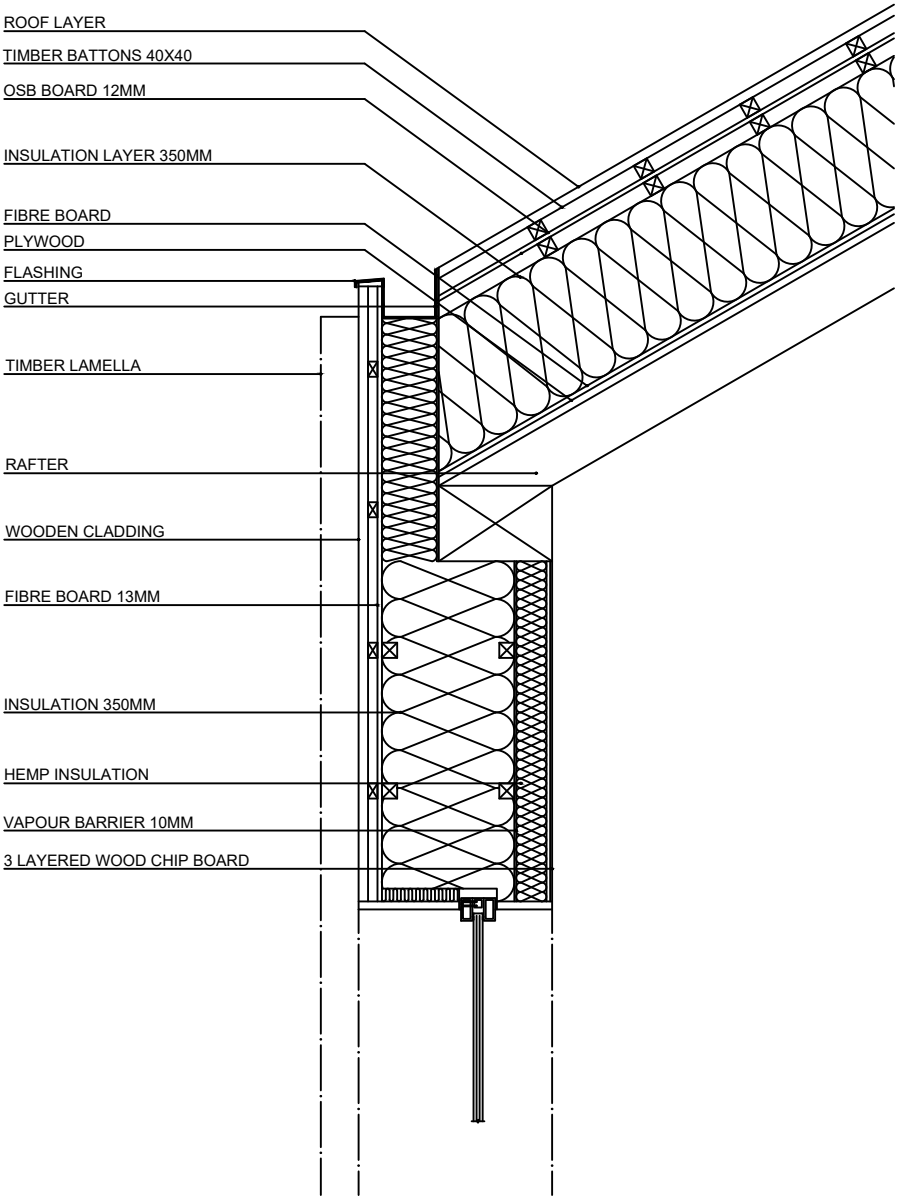


Illustration 108: Construction detail - Roof and exterior wall connection, 1:20

FOUNDATION DETAILS

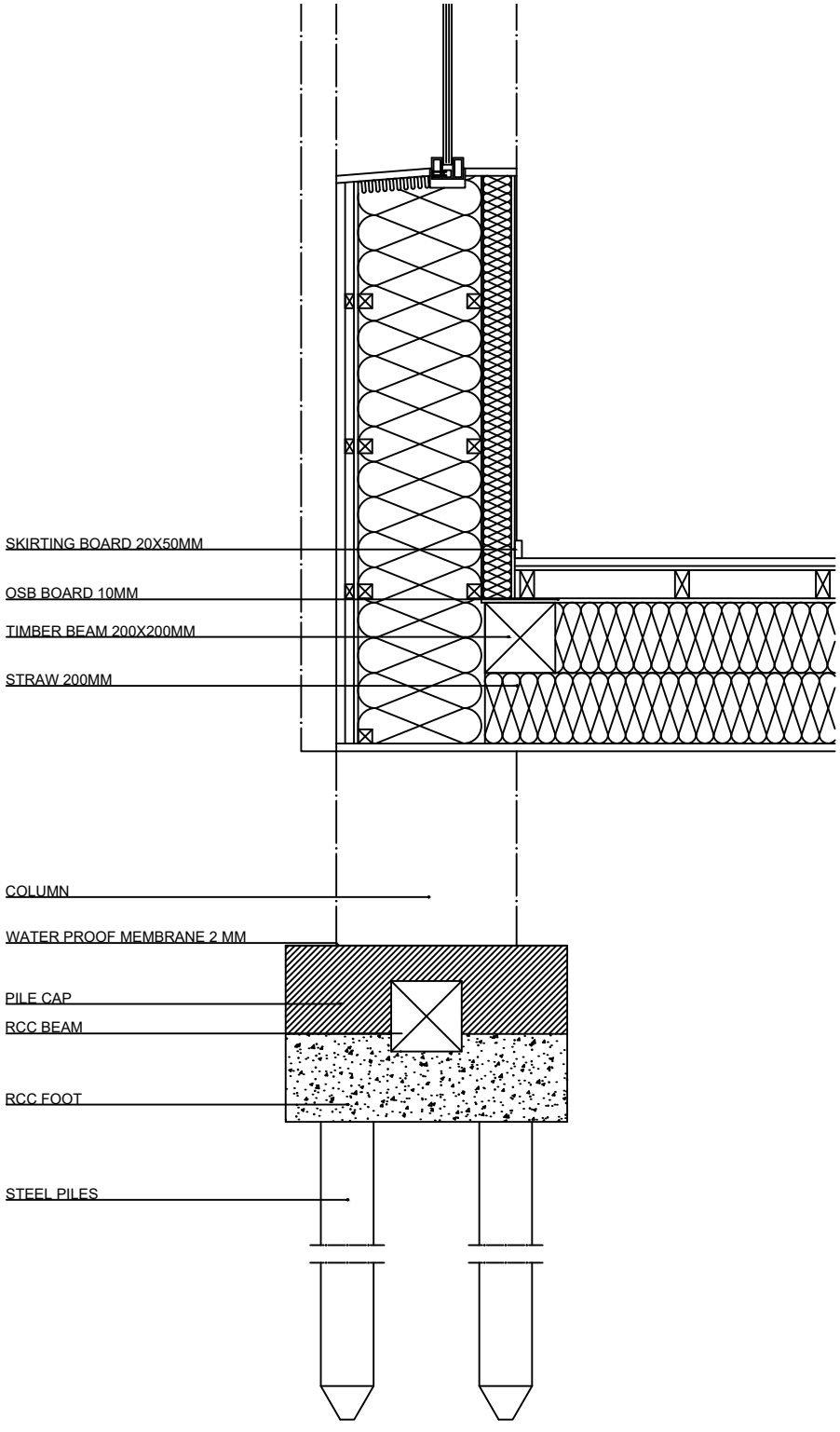


Illustration 109: Construction detail - Wall and foundation, 1:20

PRESENTATION

INDOOR ENVIRONMENT

Thermal comfort

To ensure satisfying indoor comfort the temperatures of the indoor areas plays a major role. To achieve this the building is designed with minimum energy input, hybrid ventilation system along with passive strategies to maintain optimal temperature. Using the simulation software BSim, the thermal environment has been studied and developed to reach the highest level of comfort for critical rooms (cafeteria+ kitchen in block 1 and meeting room+staff room in block 3). Moreover, solar shading in the form of overhang is used to avoid excess heat in critical areas of the building. The results show that no rooms reach temperature lower than 20OC, along with no more than 100 hours per year above 26OC and no more than 25 hours per year above 27OC. (See Appendix 8: BSim)

Atmospheric comfort

The usage of low polluting natural materials, hybrid ventilation throughout the for ventilation in the rooms to avoid excessive heat and maintain low level of CO2 levels at all hours. The calculations for the required ventilation were done for the building to investigate this. The ventilation rate required for the critical areas like the kitchen, cafeteria, exhibition room and workshop area were also calculated. (See appendix 7: Calculation of Ventilation rate)

Visual comfort

The daylight factor for all the building areas have been investigated using Velux Visualizer. For the public areas. The factor of 4.6% has been reached while for the semi-private and private areas an average of 3%. (See Appendix 5: Daylight Analysis)

Acoustic comfort

The function of the visitor centre being varied although does not need privacy in all areas, requires acoustic comfort in the form of no echoes to maintain the atmosphere of the place. To ensure this hemp wool is used as insulation in external as well as internal walls as it is known to have good acoustic insulation.

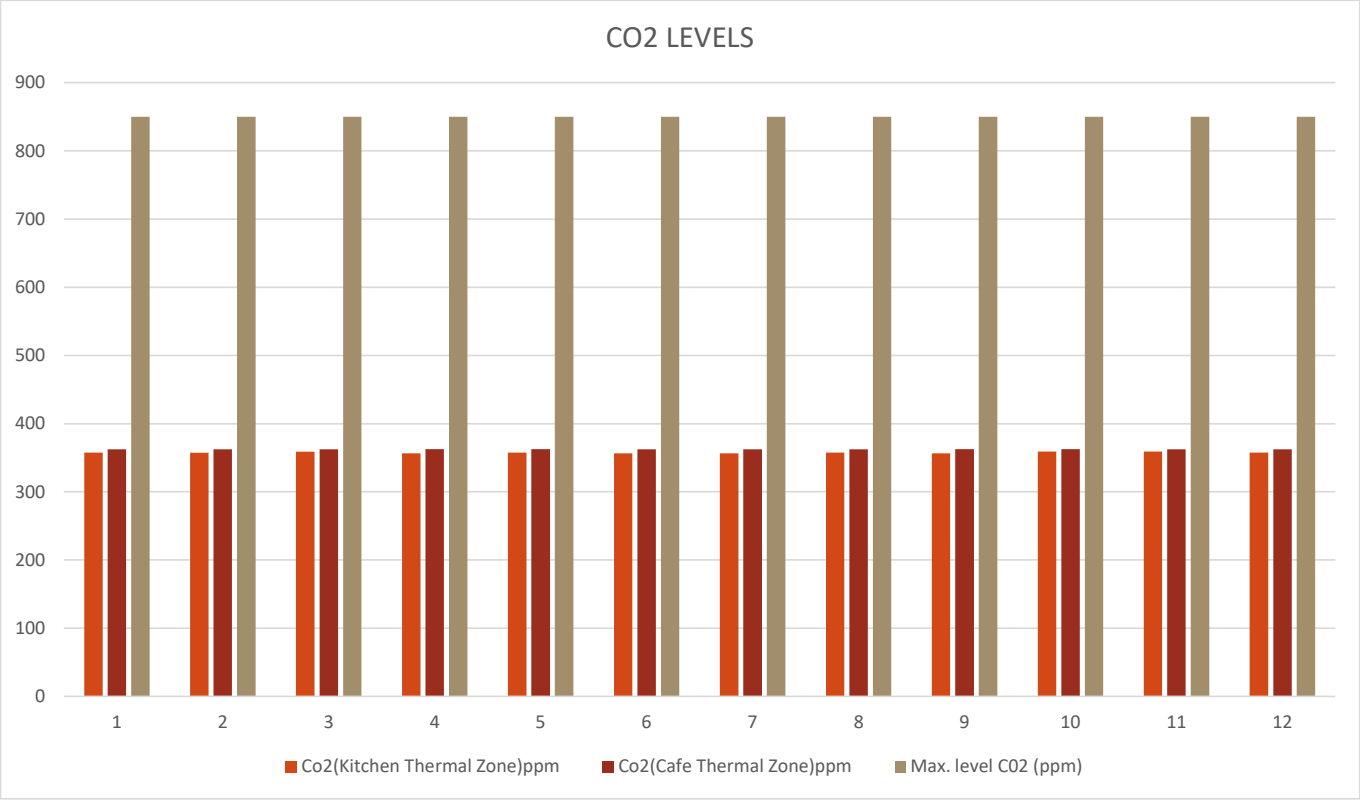


Illustration 110: CO_2 levels all year around for cafeteria and kitchen

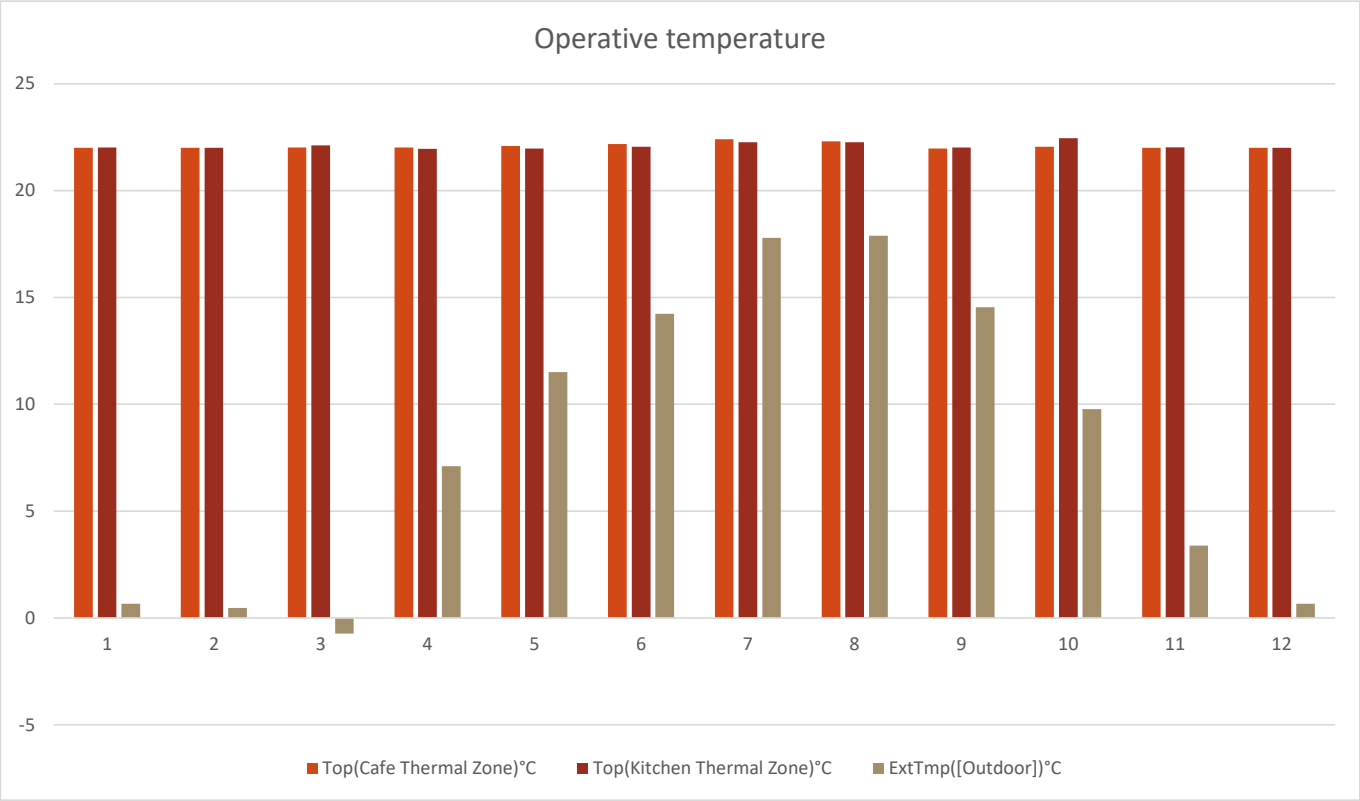


Illustration 111: Operative temperature during the entire year for cafeteria and kitchen

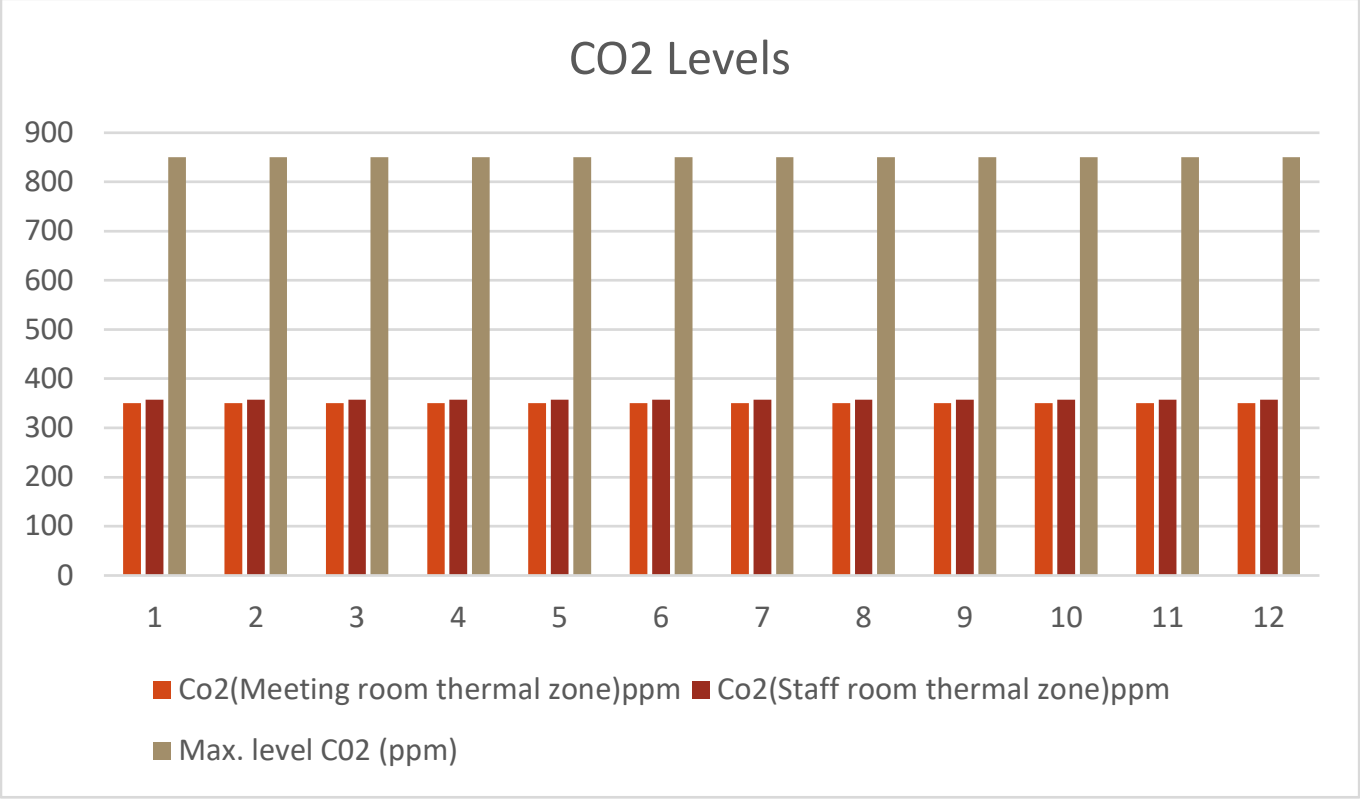


Illustration 112: CO_2 levels all year around for Meeting room and staff room

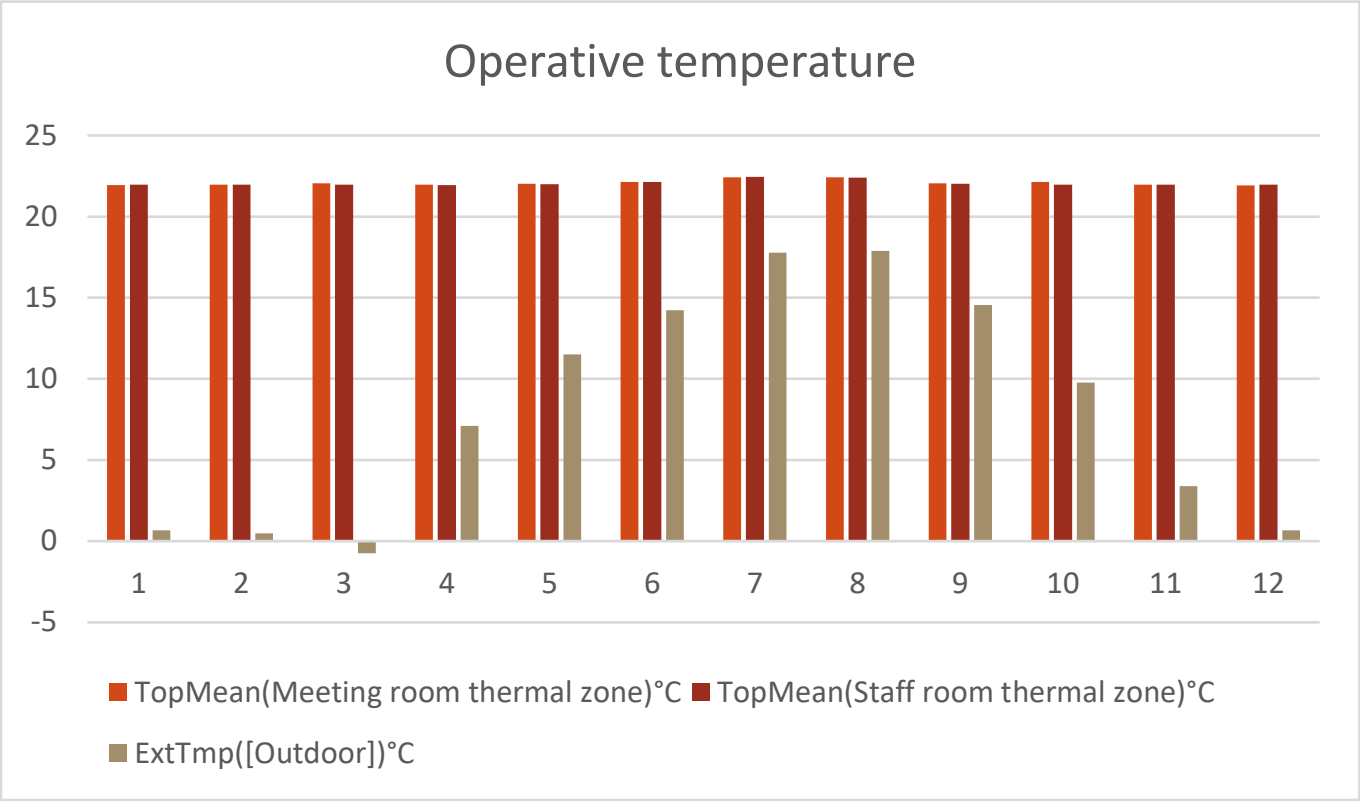


Illustration 113: Operative temperature during the entire year for Meeting room and staff room

ZERO ENERGY STANDARD

The goal of the project is to meet the zero-energy building standard. To make this possible different active and passive strategies have been implemented. The initial stage to achieve this involved the development of the building envelope after an analysis of the locally available materials to construct a wall with a low U – value. The management of having a good indoor thermal comfort is made possible through this and the implementation of hybrid ventilation (natural ventilation and mechanical ventilation). The combination of these reduces the amount of cooling required during the summers and heating required in the winters. The aim of achieving low energy building standard is made possible as the calculations done on BE18 show that the building requires 27.3 kWh/m^2 annually.

The later stage involves the implementation of active strategies to make building produce as much energy as it consumes making it a zero-energy building. The ample south facing roof options gives the opportunity of placing solar panels to support the energy requirements of the building. The BE18 calculations show that the energy requirement of the building after the application of solar panels reached 0 kWh/m^2 making is a zero-energy building. (See appendix 8- PV panels calculation and appendix 9- Energy calculation)

08 EPILOGUE

CONCLUSION

The aim of the thesis project was to create a visitor centre in the town of Skagen, between Skagen and Grenen in the northern part of Jutland with an approximate built up area of 2300 m^2. The main goal of the design was to guide tourists through Skagen and its surroundings, while simultaneously serving the purpose of an exhibition area for propagating and educating the users about the art and history present in Skagen. The building form has been designed to make use of the distinct views offered by the site while simultaneously relating its architectural expression to the neighbourhood and its environment. The users' experience and activating the area for them was one of the key criteria which required knowledge acquired from the different analyses and informal interviews. During the development and evolution of the design, the main focus was to incorporate the views of the site with regards towards daylight, openness of spaces, materials as well as segregate the spaces based on the functions and their corresponding privacy levels in order to create a smooth transition for all the user groups. A thorough analysis helped in understanding the potential of the site while keeping in mind the limitations offered. The wealth of local materials such as reeds, straw and timber along with the scope of using recycled elements like bricks provided a great opportunity to be utilized in the design and construction. To understand their environmental impact life cycle assessment was done of the individual materials amongst of the structural elements such as external wall and roof. The approach to nature and use of local materials gives a holistic phenomenological user experience. The use of passive and active strategies such as solar shading, cross ventilation and PV panels help in achieving the zero-energy building standard while providing good indoor climatic conditions. The implementation of these strategies is planned from the developing stages of the design process itself. The project gives an opportunity to utilize the skills and knowledge gained through the previous years in a cohesive manner by understanding and implementing the three pillars of sustainability in the design. It also gave a chance to understand the intricacies of materiality, construction and the psyche of the different user groups.

REFLECTION

Reflecting on the whole process, from the problem formulation to the end result brings to light some aspects for improvement. Considering the current scenario due to Covid-19, we were lucky enough to have visited the site and its surroundings before the limitations on transport and travel restriction. The lack of freedom to access labs and workshop areas narrowed down our working ability to virtual visualization of the design from the design process stages. As it can be noticed in the design process the spatiality and placement were limited to be understood through software alone causing a drawback to understand the physicality of the design. Despite this situation the project continued along the length of the course and we managed to work around these conditions and come up with the most optimal solution by using digital software for volume studies and do more of hand sketches. Various analyses were done to gain a better understanding of the site before starting the design process, but the amount of wind and sun analysis was limited only to support the orientation of the courtyard, solar panels and ventilation. Despite achieving a suitable design criterion through the various analyses conducted, some types of analysis may have been overlooked due to not be able to conduct multiple site visits. Even though we had formed questionnaires and acquired inputs from the tourist bureau directly, we were not able to get the inputs from the most visited tourist attractions as they were scheduled to open only in the month of April. The design process shows the various ideas and stages that led to the design that had been deduced. In this stage we did not concentrate much on the landscape aspect of the design as the focus was the visitor centre and how it relates to the existing views and nature around the site. The drawback of having shifting sand in the location of the site lead us to have to work with a slightly raised platform which took up some time to understand the construction. The use of the locally available materials shows that an effort was put in to understand and compare the benefits and drawbacks of the materials selected and the materials which are used locally. After analyzing all this it shows that there was scope for improvement, however, the design achieved with the factors that played a priority feel like an accomplishment.

REFERENCE LIST

Adolfsen, L. D. (2019, May 23). Licitation. Retrieved from Licitation: (https://www.licitationen.dk/article/view/662243/trio_vinder_pa_ny_i_skanderborg?rel=related)

Amoroso, N. (2012, March 1). Creative Mapping. Retrieved from CANADIAN ARCHITECT: https://www.canadianarchitect.com/creative-mapping/

Andersen, A. K., Stig, F., Rosenkjær, J., Hansen, W. B., Kappelborg, L., Borup, J., . . . Sloth, C. (2011). Masterplan Skagen. Masterplan Skagen. Skagen, Denmark: Fredrikshavn Kommune.

ArchDaily. (2013, March). Nature Centre Hindsgavl. Retrieved from ArchDaily: https://www.archdaily.com/339866/nature-centre-hindsgavl-aart-architechts?ad_source=search&ad_medium=search_result_projects

ArchDaily. (2016). Fazer Visitor Center & Meeting Center / K2S Architects. Retrieved from ArchDaily: https://www.archdaily.com/796321/fazer-visitor-center-and-meeting-center-k2s-architects

ArchDaily. (2020). Wade sea centre Dorte Mandrup. Retrieved from ArchDaily: https://www.archdaily.com/868361/wade-sea-centre-dorte-mandrup-a-s?ad_source=search&ad_medium=search_result_all

Birgisdottir, H., & Rasmussen, F. N. (2015). Introduction to LCA on buildings. Copenhagen: Danish Energy Agency.

Boller, A. (2018, Februaury 6). Timber construction in Denmark: a sustainable solution for affordable accommodations. Retrieved from Linkedin: https://www.linkedin.com/pulse/timber-construction-denmark-sustainable-solution-andrea-boller/

Braune, D., Durán, C. R., & Gantner, J. (2018). Life Cycle Assessments - a guide on using the LCA.

BuildAbroad. (2017, 08 15). Sustainabilty in architecture. Retrieved from BuildAbroad.org: https://buildabroad.org/2017/08/15/sustainability-in-architecture/

Building Regulations 18. (2018). Ventilation (§ 420 - § 452). Retrieved from Building Regulations : https://bygningsreglementet.dk/Tekniske-bestemmelser/22/Krav

City Population. (2019, January 01). Citypopulation denmark nordjylland. Retrieved from City Population Denamark: https://www.citypopulation.de/php/denmark-nordjylland.php?cityid=10983

Coates, G. J., & Seamon, D. (1984). Toward a Phenomenology of Place and Place-Making: Interpreting. OZ.

Corner, J. (1999). the agency of mapping. In D. Cosgrove, Mappings (pp. 213-52).

Crawley, D. (2006). Understanding Zero-Energy Buildings. Ashrae Journal , 62-69.

Dan Hostel. (2020). Guide Skagen everything tourist wants. Retrieved from Dan Hostel: https://www.danhostel.dk/en/news/guide-skagen-everything-tourist-wants

Danish Architecture Center. (2018). Hammershus Visitor Center. Retrieved from Dac: https://dac.dk/en/knowledgebase/architecture/hammershus-visitor-center/

Danny, P. (2004, JUNE 1). An Integrated Design Process (IDP). Retrieved from CANADIAN ARCHITECT: https://www.canadianarchitect.com/an-integrated-design-process-idp/

Dansolar. (2020). Solar panels. Retrieved from Dan solar.dk: http://dansolar.dk/en/products/solar-panels/

Denmark Statistics. (2019). Statistik Bannken. Retrieved from StatBankDenmark: https://www.statistikbanken.dk/statbank5a/Selectout/pivot.asp

Dezeen. (2020). Trollstigen . Retrieved from Dezeen: https://www.dezeen.com/2012/07/07/trollstigen-by-reiulf-ramstad-architects/

DGNB system – New buildings criteria set. (2016). Building life cycle assessment. DGNB.

DK- GBC- Green Building Council, Denmark. (2018). DGNB-Denmark. Retrieved from dk-gbc: https://www.dk-gbc.dk/english/dgnb-in-denmark/

Dyke, A. (2014, July 11). AUTOMATIC NATURAL VENTILATION. Retrieved from ABEC.UK: https://www.

abec.co.uk/info-centre/blog/blog/automatic-natural-ventilation-simple-or-complicated#.Xs6HIzozZPZ
Eco Platform EPD. (2017). VERIFIED ENVIRONMENTAL PRODUCT DECLARATION. EPD Danmark.
EcoCocon . (2016). EcoCocon Straw Modules (Panels). Finland: Eco Cocon.
Elevation map logs. (2020). Skagen Denmark. Retrieved from elevation.maplogs: https://elevation.maplogs.com/poi/skagen_denmark.6467.html
Environmental Product Declarations Hardwood Timber. (2017). Environmental Product Declarations Hardwood Timber. Australia: thinkstep Pty Ltd.
Fabritius, E. (2008). Anna Ancher: The Pastels. Forlaget Vandkunsten.
Frederikshavn Municipality. (2011). FrederikshavnKommune. Retrieved from frederikshavn.dk: https://frederikshavn.dk/et-godt-sted-at-bo/noget-vi-samles-om/ud-i-det-blaa/friluftsliv/naturen-venter-paa-dig/grenensporet/
Fredninger. (2020). Skagen Gren. Retrieved from Fredninger: https://www.fredninger.dk/fredning/skagen-gren/
Garofalo, F. (2018, 04 27). Sustainable architecture. Retrieved from Lifegate: https://www.lifegate.com/people/lifestyle/sustainable-architecture-definition-concept-projects-examples
Genvand Aps. (2012). Rainwater Harvesting Systems. Retrieved from genvand: https://www.genvand.dk/CustomerData/Files/Folders/2-pdf/7_genvandcatalogenglish.pdf
Gordon, C. (1961). THE CONCISE TOWNSCAPE. Great Britain: Reed educational and professional publishing limited.
Greenspec. (2020). Solar shading. Retrieved from Greenspec.co.uk: http://www.greenspec.co.uk/building-design/solar-shading/
Heiselberg, P. K., & Bjørn, E. (2002). Impact of Open Windows on Room Air Flow and Thermal Comfort. International Journal of Ventilation, 91-100.
Hernandez, P., & Kenny, P. (2010). From net energy to zero energy buildings: Defining life cycle zero energy buildings (LC-ZEB). Energy and Buildings, 815-821.
Hudevad. (2020). Wadden Sea Centre. Retrieved from Hudevad: https://hudevad.com/en/wadden-sea-centre
Insulation-info. (n.d.). Hemp insulation: properties & advantages. Retrieved from Insulation-info: https://www.insulation-info.co.uk/insulation-material/hemp
Kjeldsen, K. (2012). New Nordic: Identity and Architecture. Humlebæk: Louisiana Museum of Modern Art.
Knudstrup, M.-A. (2005). The Integrated Design Process (IDP) – a more holistic approach to sustainable architecture. Action for sustainability - The 2005 World Sustainable Building Conference (pp. 894-901). Tokyo: Tokyo National Conference Board.
Kongeaastien. (2020). Reeds. Retrieved from Kongeaastien: http://www.kongeaastien.dk/en/content/reeds
Larsen, M., Charlotte, L., Birgisdottir, H., & Birkved, M. (2019). Potential of Circular Economy in Sustainable Buildings. Prague, Czech Republic: World Multidisciplinary Civil Engineering, Architecture, Urban Planning Symposium.
Lonely planet. (2017). Transport/getting around. Retrieved from Lonely planet: https://www.lonelyplanet.com/denmark/skagen/practical-information/transport/getting-around/a/nar/d935df90-a0d3-4d77-9d9b-27c2b2254fd1/358854
Lysnet. (2006, September). Cph_skitseringredskaber. Retrieved from lysnet: http://www.lysnet.com/download/Cph_skitseringredskaber.pdf
Manto A/S, LBB3 I/S. (2014). Potentialeplan for Skagen som international kystferieby. MANTO.
Mason, M. (2019). Sustainability. Retrieved from environmentalscience.org.
Milutiene, E., Jürmann, K., & Keller, L. (2007). STRAW BALE BUILDING – REACHING ENERGY EFFICIENCY

AND SUSTAINABILITY. North Sun.
Norberg-Schulz, C. (1980). Genius Loci: Towards a Phenomenology of Architecture.
Nordjylland Strafikselskab. (2018). Timetables. Skagen.
Pallasmaa, J. (1996). The eyes of the skin.
Pearce, P. L. (2004). The Functions and planning of visitor centres in regional tourism. THE JOURNAL OF TOURISM STUDIES, 10.
PV Europe. (2020, 3 25). Special focus on small wind turbines. Retrieved from PV Europe: https://www.pveurope.eu/News/Markets-Money/EM-Power-2020-Special-focus-on-small-wind-turbines
Rye, P., & Egelund, M. (2018, April 19). Accessibility at the branch - Extension of the branch track. Skagen, Fredriskhavn, Denmark.
Schunck, E. (2003). Roof Construction Manual : Pitched Roofs. Princeton Architectural Press,.
Sejlund, H. (2012). Houses of Skagen. Denmark: Corbiz Publishing Housing.
Sejlund, H. (2012). Houses of Skagen. Corbiz publishing house.
Sejlund, H. (2012). Houses of Skagen. Corbiz publishing housing.
Skagen Art Museum. (n.d.). Artists: Skagen Art Museum. Retrieved from Skagen Art Museum: https://skagenskunstmuseer.dk/en/artists/
Skagen Kunstmuseer. (2019). holger-drachmann. Retrieved from Skagen Kunstmuseer: https://skagenskunstmuseer.dk/en/artists/holger-drachmann/
Skagen Natur. (2020). Skagen Natur. Retrieved from Skagen Odde Nature Center: http://www.skagen-natur.dk/
Skovgaard, M. R., Rhodes, M. K., & Larsen, T. S. (2018). DGNB building certification companion: sustainability tool for assessment, planning, learning, and engaging (STAPLE). International Journal of Energy Production and Management.
Svanholm, L. (2001). Northern Light: The Skagen Painters. Copenhagen.
Svanholm, L. (2004). Northern Light: The Skagen painters. Gyldendal A/S.
Teitsson, B., Gudmundsson, L., & Jonsson, A. T. (2020). Snæfellsstofa visitor center. Retrieved from miesarch: https://miesarch.com/work/3028
The Danish Nomads. (2020). your itinery for visiting skagen. Retrieved from The Danish Nomads: https://thedanishnomads.com/your-itinerary-for-visiting-skagen/
Thompson, A., & Walker, P. (2014, July 15). Straw scientifically proven as viable building material. Construction and Building Materials, 7. Retrieved from Bath UK.
Twisted lifestyle. (2020). TROLLSTIGEN VISITOR CENTRE IN NORWAY. Retrieved from Twisted lifestyle: http://www.twistedlifestyle.com/trollstigen-visitor-centre-in-norway/
Ubakus. (2020). Ubakus. Retrieved from Ubakus: https://www.ubakus.de/u-wert-rechner/?lang=en
Vadehavs Centret. (2017). The Wadden Sea Centre. Retrieved from Vadehavs Centret: https://www.vadehavscentret.dk/en/about-us/the-wadden-sea-centre
Vandersanden group. (2016). BRICK, A SUSTAINABLE PRODUCT. Retrieved from Vandersanden group: https://www.vandersandengroup.dk/group/en/eco/bricks-durable-and-ecologically
Visit Nordjylland. (2018). Things to do; Skagen painters; north Jutland; Visit Nordjylland. Retrieved from Visit Nordjylland: https://www.visitnordjylland.com/north-jutland/things-do/skagen-painters-north-jutland
Visit Nordjylland. (2020). City bus Skagen. Retrieved from Visit Nordjylland: https://www.visitnordjylland.com/north-jutland/plan-your-trip/city-bus-skagen-gdk1093922
Vogler, A., & Vittori, A. (2006). Genius Loci in the Space-Age.
Walker, A. (2016, 02 08). Natural Ventilation. Retrieved from WHOLE BUILDING DESIGN GUIDE: https://

www.wbdg.org/resources/natural-ventilation
Weather and Climate. (2020). Average Monthly Snow And Rainfall In Skagen (Nordjylland) In Inches. Retrieved from Weather and Climate: https://weather-and-climate.com/average-monthly-precipitation-Rainfall,skagen,Denmark
Weather Spark. (2018). Average weather in skagen. Retrieved from Weather Spark: https://weatherspark.com/td/68646/Average-Weather-in-Skagen-Denmark-Today
Wikipedia. (2020, January). Skagen History. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Skagen
Windfinder. (2020). Wind statistics Skagen Fyr. Retrieved from Windfinder: https://www.windfinder.com/windstatistics/skagen_dk
Zumthor, P. (2006). Thinking architecture.

ILLUSTRATION LIST

Illustrations not presented on the list have been produced by the group.

Illustration 3: The sanded church
Sienicki, T. (2007). The sanded church in Skagen. Retrieved from Wikipedia: http://da.m.wikipedia.org/wiki/Fil:Den_tilsandede_kirke_i_Skagen_2007_ubt.jpeg

Illustration 6: Skagen pictures
EUmies. (n.d.). skagen odde nature centre. Retrieved from miesarch: https://miesarch.com/work/368
Kristeligt-dagblad. (2016, february 13). new skagen museum. Retrieved from Kristeligt-dagblad: https://www.kristeligt-dagblad.dk/kultur/paa-det-nye-skagens-museum-forenes-tradition-og-fornyelse
Sienicki, T. (2007). The sanded church in Skagen. Retrieved from Wikipedia: http://da.m.wikipedia.org/wiki/Fil:Den_tilsandede_kirke_i_Skagen_2007_ubt.jpeg
Skagen Art Museum. (n.d.). Artists: Skagen Art Museum. Retrieved from Skagen Art Museum: https://skagen-skunstmuseer.dk/en/artists/
skagen onsdag. (2019). rabjerg mile. Retrieved from skagen onsdag: https://skagenonsdag.dk/nyheder/protestmoede-paa-raabjerg-mile-20-januar/11338d10-2963-43a6-8208-cddf8274188d
Visit Nordjylland. (n.d.). anchers hus og saxild gaard. Retrieved from VisitNordjylland: https://www.visitnordjylland.com/north-jutland/plan-your-trip/anchers-hus-og-saxilds-gaard-gdk1043794

Illustration 7: Green initiative for Grenen by the Kommune
Frederikshavn Municipality. (2011). FrederikshavnKommune. Retrieved from frederikshavn.dk: https://frederikshavn.dk/et-godt-sted-at-bo/noget-vi-samles-om/ud-i-det-

Illustration 8: Wadden sea centre,
Vadehavs Centret. (2017). The Wadden Sea Centre. Retrieved from Vadehavs Centret: https://www.vadehavscentret.dk/en/about-us/the-wadden-sea-centre

Illustration 9: Fazer visitor centre
ArchDaily. (2016). Fazer Visitor Center & Meeting Center / K2S Architects. Retrieved from ArchDaily: https://www.archdaily.com/796321/fazer-visitor-center-and-meeting-center-k2s-architects

Illustration 10: Nature Centre Hindsgavl
ArchDaily. (2013, March). Nature Centre Hindsgavl. Retrieved from ArchDaily: https://www.archdaily.com/339866/nature-centre-hindsgavl-aart-architechts?ad_source=search&ad_medium=search_result_projects

Illustration 11: Snæfellstofa Visitor Centre
Teitsson, B., Gudmundsson, L., & Jonsson, A. T. (2020). Snæfellsstofa visitor center. Retrieved from miesarch: https://miesarch.com/work/3028

Illustration 13: View of Skagen,
Awe 365. (2017). guide to denmark hiking holidays and danish trecking trails. Retrieved from Awe 365: https://www.google.com/url?sa=i&source=imgres&cd=&cad=rja&uact=8&ved=2ahUKEwiE-v6Wh9XpAhXSwKQKHYKTCUkQjRx6BAgBEAQ&url=https%3A%2F%2Fawe365.com%2Fguide-to-denmark-hiking-holidays-and-danish-trekking-trails%2F&psig=AOvVaw1ES4mXCslaU97_GtkzYuGF&ust=159070369

Illustration 14: Location of the site,
Rasmus. (2011). denmark map. Retrieved from clker: http://www.clker.com/clipart-danmark-denmark-map.html

Illustration 19: Wind analysis, Windfinder. (2020). Wind statistics Skagen Fyr. Retrieved from Windfinder: https://www.windfinder.com/windstatistics/skagen_dk

Illustration 20: Sun path, Lysnet. (2006, September). Cph_skitseringredskaber. Retrieved from lysnet: http://www.lysnet.com/download/Cph_skitseringredskaber.pdf

Illustration 21: Average temperature during all years, yr.no. (n.d.). weather forcast for aalborg. Retrieved from yr.no: https://www.yr.no/place/Denmark/North_Jutland/Aalborg/

Illustrtion 29: Materials
Timber, build. (n.d.). popularity of timer constrution. Retrieved from build-review: https://www.build-review.com/understanding-the-booming-popularity-of-timber-construction/

Straw, jaybro. (n.d.). strawbales for construction and landscaping. Retrieved from jaybro: https://www.jaybro.com.au/hay-bale.html

Reeds,
the lapa company. (n.d.). thatch option. Retrieved from the lapa company: https://www.thelapacompany.co.uk/commercial-finishes/thatch-options?fbclid=IwAR0jNSt_y9KaFwy4kv4GQWmfu3vpEAui7Ms9qPLnzq9tM0O-iOK_BUFqD4_Y

Recycled bricks, brikmakers. (n.d.). recycled face bricks. Retrieved from brikmakers: http://brikmakers.com/product?type=recyclee&colour=RECYCLED

Illustration 77: Inspiration for exhibition area
(AD Editorial Team, 2020) AD Editorial Team. (2020, April 26). Spotlight: Peter Zumthor. Retrieved from ArchDaily: https://www.archdaily.com/364856/happy-70th-birthday-peter-zumthor

The Metropolitan Museum of Art, New York. (2020). Exhibition Galleries. Retrieved from Metmuseum: https://www.metmuseum.org/exhibitions/listings/2020/making-the-met-1870-to-2020/exhibition-galleries

Comberg, E. (2018, May 25). AD Classics: Yale University Art Gallery / Louis Kahn. Retrieved from ArchDaily: https://www.archdaily.com/83110/ad-classics-yale-university-art-gallery-louis-kahn

United Nations Geneva. (2020). Exhibition Facilities. Retrieved from United Nations Geneva Sustainable development goals: https://www.unog.ch/80256EE600594458/(httpPages)/993E61908ACC7A01C12576BA0048523A?OpenDocument

The University of Whitworth Manchester. (2020). The Gallery in the Park. Retrieved from The Whitworth: https://www.whitworth.manchester.ac.uk/visit/thenewgallery/thegalleryinthepark/

JANUSZCZAK, W. (2017, January 11). A new art gallery in Walsall. Retrieved from Waldemar's review on the new gallery: http://waldemar.tv/2017/01/a-new-art-gallery-in-walsall/