“Havstok“ sb., -ken
A border between sea and land

TITLE PAGE

Titel	Hawstok
Theme	Sustainability, community life & plastic pollution
Project period	1st February - 25th May 2022
Group	ARCH - 14
Semester	MSc04 - Architecture
	Master of Science in Engineering (cand.polyt)
	Department of Architecture, Design and Media technology
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Pages	161
Appendix	43

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ABSTRACT

The following report will outline and present the design development of HAWSTOK a contextual mediation centre and community meeting point, located on the beachfront in Nørre Vorupør at the Danish west coast. The report is written in relation to the master thesis assignment of the Master of Science in Engineering education at Aalborg University and is based upon the interdisciplinary work between engineering and architecture.

In accordance with the Integrated Design Process, interdisciplinary and iterative studies are conducted together with preliminary and continuous research to reach a holistic and well-informed design, based upon knowledge of engineering, architecture, sustainability theories, and methodologies.

With the point of departure in the context of the site, the centre mimics and adapts to the natural flow of wind and dunes to create a building design, which combines the qualities of the vernacular longhouse farms together with a modernistic approach.

As the centre both encompass the local surf mentality and mediate the effects of plastic waste upon climate change, attention is also brought to the climatic impact of the construction of the centre, and actions to minimize both environmental and micro climatic impacts, through tools such as Autodesk Computational Fluid Dynamics and Life Cycle Assessments.

Finally, as part of this focus, the reusability of fibreglass from wind turbine blades is investigated due to its great durability in coastal areas, but also its questionable disposal method after the decommission of a wind turbine.

CONTENT

07 DESIGN DEVELOPMENT

08 EPILOGUE

09 APPENDIX

Ill.1: Beach in Nørre Vorupør

READER’S GUIDE

The following content of this thesis has been divided in three chapters: Program, Presentation and Process, and are based upon the main methodological approach of The Integrated Design Process (IDP). The program presents the compilation of all preliminary research, studies and analyses, which set the framework for the design process, corresponding to the first two to three phases of the IDP.

The presentation hereafter follows the program, and showcase the final building design through plans, sections, and elevations, as well as chosen visualisations and diagrams to support the storytelling of the chapter. All plans will be oriented towards north unless a north arrow is located at the illustration. Furthermore, for enlarged scale presentation material, see the attached drawing folder.

The design process will present the development throughout the making of the final design proposal. Through the three chapters, references and illustrations will be noted continuously to support credibility of content of the report or showcase further detailing within the appendix.

Lastly, it is important to note that, the IDP is an iterative approach, continuously building upon knowledge, using various theories and methods throughout all phases. However, the process presented within this thesis paper, will be by a chronologically perspective, despite having been highly iterative, in order to communicate the project development as best as possible.

Ill.2: Fishing boats in Nørre Vorupør

01 PRELIMINARY

Motivation

Introduction

The scope

Ill.3: Plastic waste

MOTIVATION

EDUCATIONAL

Based on an interdisciplinary approach to architecture and engineering, which has been the predominant focus of the education in Architecture & Design at Aalborg University, we are now completing our education with knowledge in each field of work. With the increasing global focus on sustainability, this also adds a third subject to our profile, with the building industry having a big part in the changes. For this thesis, this issue has led to a wish for a new approach to a holistic sustainability within the realms of architecture, which can challenge and take part in the discussion about methods and mindsets for a future world that will never again be like the one our parents knew as children. In concrete terms, this means a dissertational focus on both the spoken and unspoken mediation, education, and integration of the problems in the building's structure, design, and functional offerings.

THEMATIC

"Humans are increasingly influencing the climate and the earth's temperature by burning fossil fuels, cutting down forests, and farming livestock. This adds enormous amounts of greenhouse gases to those naturally occurring in the atmosphere, increasing the greenhouse effect and global warming." (European Commission n.d.).

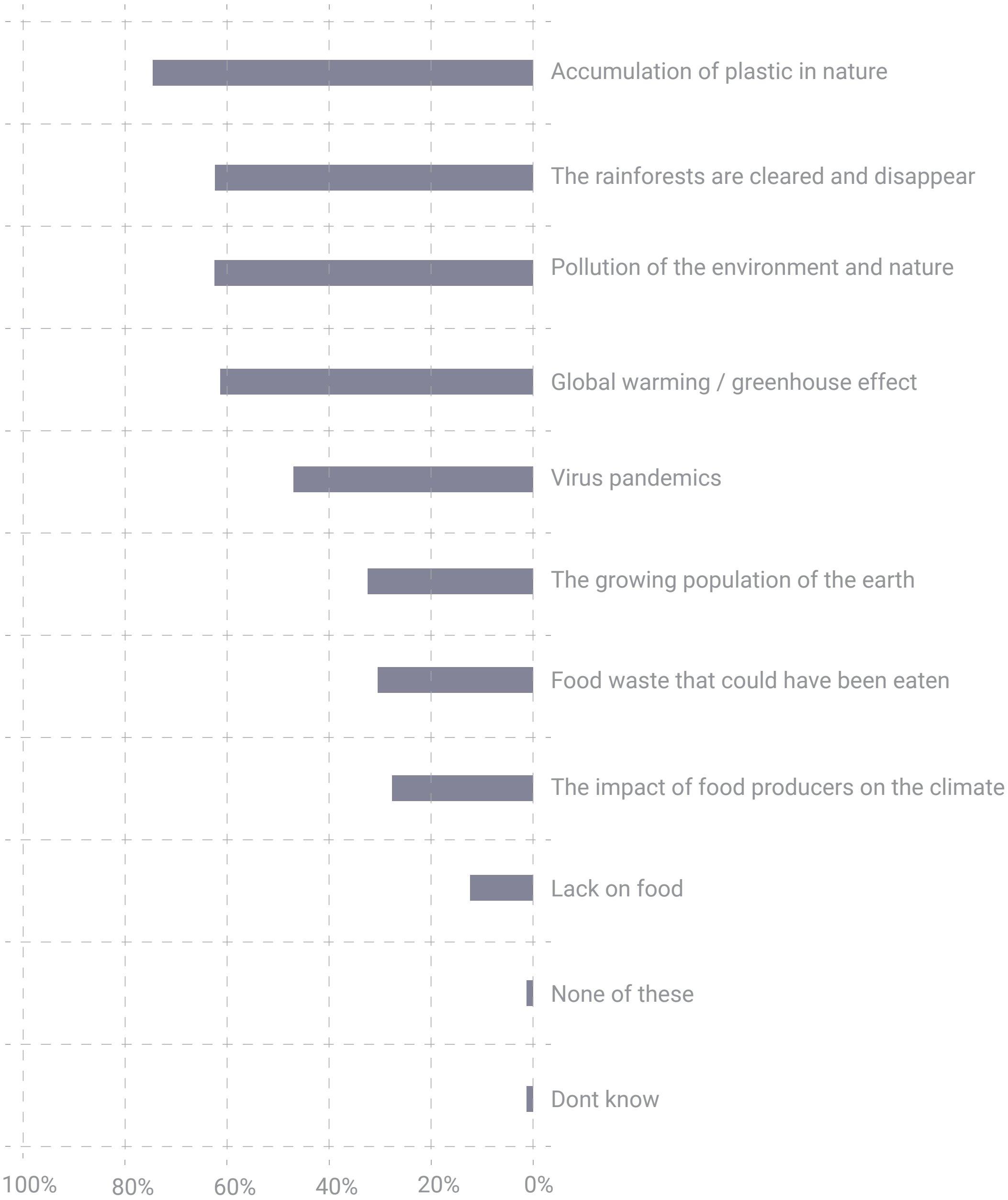
Even though many people are aware of the plastic-problem, most do not know that plastics originate from fossil fuels. In fact, the plastic industry is accountable for about 6 percent of global oil consumption and is expected to reach 20 percent by 2050. As a result of the energy-intensive processes needed to extract and distil oil, the making of plastics generates enormous amounts of greenhouse gas (GHG) emissions (Tsydenova and Patil, 2021).

Every minute the equivalent of a garbage truck full of plastic is dumped in the ocean. This is not only an eyesore on the exotic beaches, but marine plastic pollution eventually breaks down into microplastic and contributes to climate changes worldwide, both through direct GHG emissions when exposed to solar radiation in air and water, and indirectly by negatively affecting ocean organisms and wildlife, dying of hunger when their stomachs are full of plastic or of injuries from being trapped in discarded fishing nets or plastic packaging (Leeson 2016).

The impacts of mishandled plastic waste on the world, as well as on our quality of life and ecosystems, are a critical developing challenge. Globally to date, there are about 8.3 billion tons of plastic in the world with some 6.3 billion tons of this having served its purpose as single-use plastic, now left as trash (Recycle Coach, 2021) and we are only still producing more and more. Therefore, we not only need to slow the flow of plastic at its source, but also need to better the way we deal with our plastic waste.

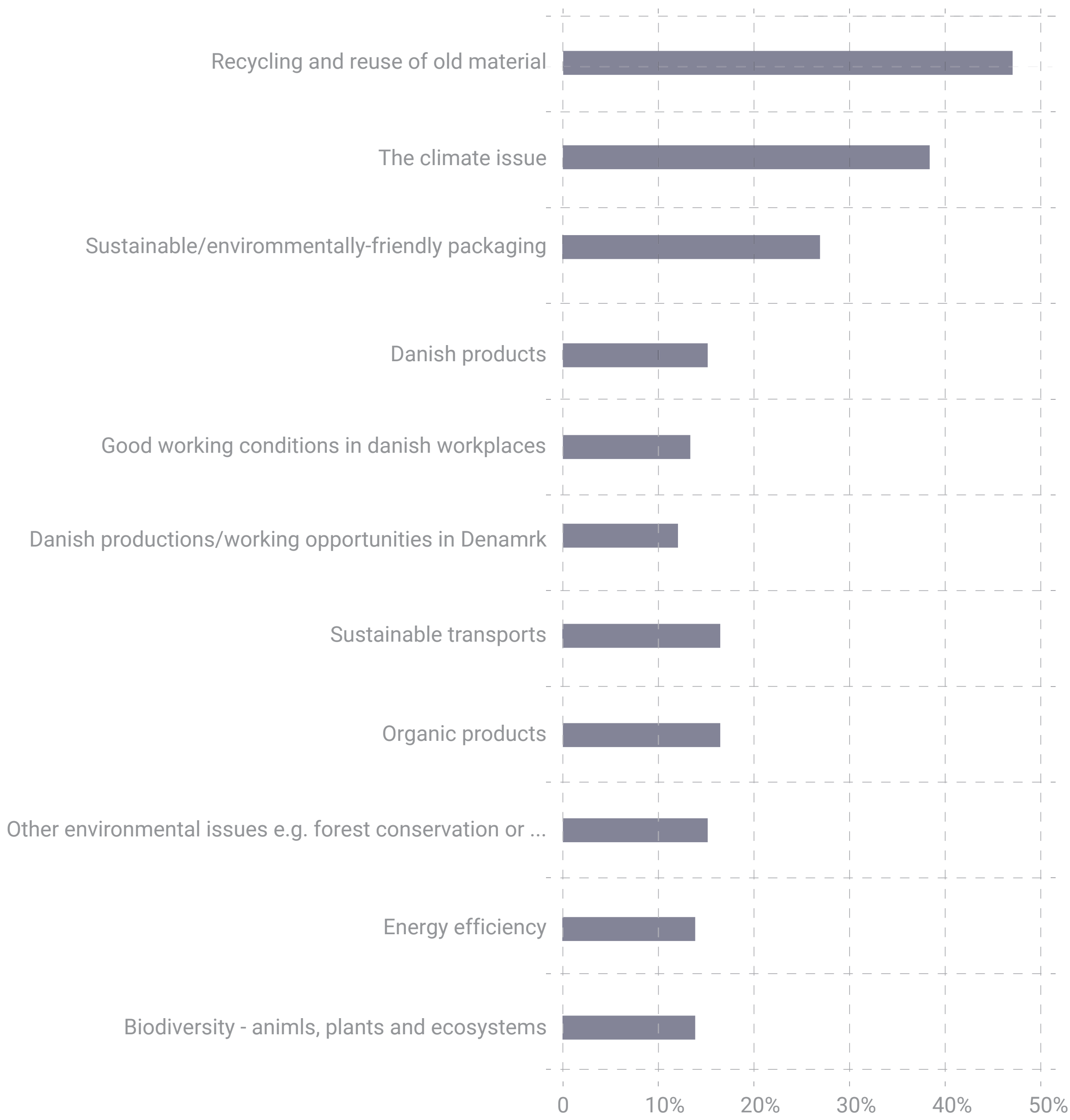
To handle this problem, specific, innovative circular economic approaches are needed. A circular economic approach begins at the stage of sketching a design and by the selection of chosen raw materials with a goal of developing products, which are optimised for reuse or recycling, creating 'renewable resources' and minimising the need for both the end-of-life disposal of waste and the mining of virgin materials (Tsydenova and Patil, 2021). Furthermore, a larger variety of possibilities for reuse of plastic is also needed to encourage and inspire more companies to choose recycled plastics instead of new plastic in their productions, to just as much deal with the already existing problem, as well as the continued future one.

"Some will argue that the world may face the challenges below in the next 10-15 years. Are there any of these that you yourself are particularly concerned about?"

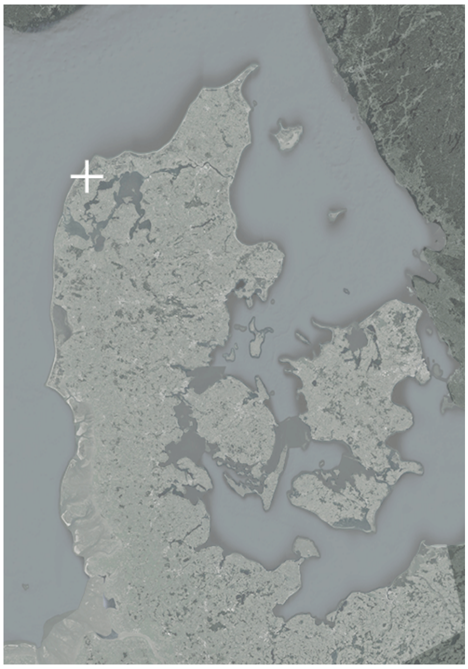


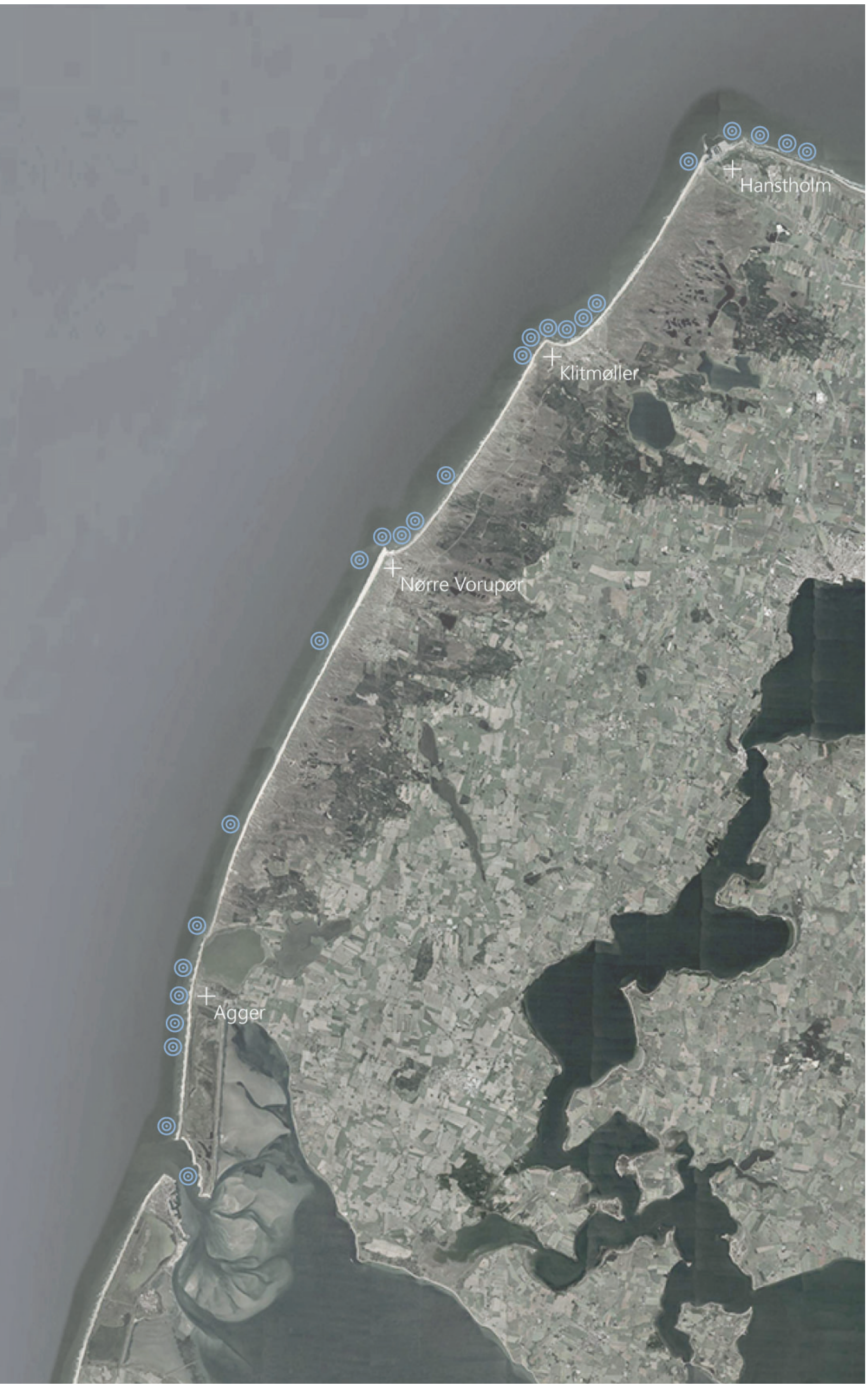
Ill.4: Questionary with the danes (Vesterbæk et. al. 2021)

“When it comes to environmental responsibility, social responsebility and other sustainability issues. Which of the following do you GENERALLY think that A COMPANY should prioritize to work with?”



Ill.5: Questionary with the danes (Vesterbæk et. al. 2021)





Ill.6: Surf spots in Cold Hawaii

INTRODUCTION

Though most global plastic waste stems from household waste, produced and discharged in rivers and oceans in Southeast Asia (Leeson, 2016) a scientific report of beach litter from 2015, states that waste from the fishing industry, tourism and other recreational activities are considered to be the dominant source of waste on Danish beaches (Strand et. Al, 2016). Furthermore, much higher amounts of litter were found washed ashore on the north-western beaches of Jutland, than any other areas, with a composition of the litter being dominated by plastic materials up to 84%. (Strand et. Al., 2016)

Having strong maritime roots as a seafaring nation, the ocean has always been a corner stone of Danish identity and the west coast have been immensely important to the Danish seafarers ever since the Viking ages up to the many settlements of smaller fishing communities along the harsh shores some 200 years ago, (Schwenn, 2018). However, as the passageway of Agger Canal slowly grew in size during the mid-1800's, the opportunity arose to load and dock in protected, calm waters. Together with the inauguration of Thyborøn Harbor in 1918 and Hanstholm Harbor in 1967, almost all coastal shipping and fishing slowly migrated away from the smaller communities such as Klitmøller and Nørre Vorupør, and instead life on the beaches as we know it today slowly began to take shape (Cold Hawaii Rådet, 2019).

Along the shores from Agger to Hanstholm, the coast groins form an angle of almost 90 degrees. This provides many separate surf spots that operate under different wave and wind conditions suitable for different water sports, but all put together, creates the stretch of coastline known as The Cold Hawaii of Denmark (ill. 6) (Christensen, 2021). How this name came to be is unknown, but it seems to have been in use since the mid-90s. Some believe that there is a connection to the name appearing in the "DR-Derude" documentary "The Hawaii of the Jutland Surfers" from 1994, while others say: *"We call it Cold Hawaii because it's like Hawaii - just colder."* (Cold Hawaii Rådet, 2019).

This also supports the notion that "Cold Hawaii" is a relatively new phenomenon. Windsurfing has been enjoyed for 40 years on the West Coast before this designation occurred. There has been surfing tourism to some extent for just as long. Even settlements due to surfing can be traced back 30 years. The European Championships in windsurfing wave performance were held in the area in 1996, a World Cup in 1998 and much more (Cold Hawaii Rådet, 2019). Since then, the area has also gained further interest due to its distinctive coastal nature driving forwards the appointment of a 244 square kilometre area as Denmark's first national park on the 22nd of August 2008, adding attractive activities such as hiking and biking to the existing offers to all nature loving visitors.

The amount of surf spots along the coastal line are still the main attraction of the area. Here multiple types of water sports are enjoyed on the different locations, all with their own specific conditions, best suited for the specific sport of either paddle surf, stand-up paddle surf, windsurfing or kitesurfing.

PADDLE SURF

Paddle surf (PS) is the most simple type of surfing that only involves the surf board it self. Characteristic of paddle surf is that the waves are the only necessity to get the surf board moving towards the beach as the paddle surfer brings it to the sea, places himself on the stomach and paddles with the arms to catch the wave in order to surf towards the mainland again. When depended on the waves for paddle surf, the best waves usually occur in the early morning around sunrise and in the late evening around sunset. This is mainly due to offshore winds or no wind in those times of the day, thus, it is not a general thing it is often the case. The offshore winds occur when the temperature drops which leads the air to sink and facilitating these wind conditions and the ideal waves. (ill. 7)

STAND-UP PADDLE SURF

Just like regular paddle surfers, stand-up paddle surfers (SUP) are dependent on the perfect waves in order to practice this type of surfing. Opposite of the paddle surfer, the SUP is standing upright on the surf board meaning that the board is considerably larger than the regular board to withstand the weight of the surfer. To gain traction the surfer is using his paddle instead of the arms.
The case of ideal times to do SUP surfing are equivalent to when doing paddle surf. (ill. 8)

WIND SURF

The wind surfer (WS) is dependent on two factor to gain traction: The waves and the wind, where the wind is the main one that is allowing the surfer to surf even in flat water as long as the weather is windy. The wind surfer uses a larger board like the SUP to withstand the weight of the surfer and the sail that catches the wind and creating the traction. (ill. 9)

KITE SURF

The kite surfer (KS) is likewise dependent on the wind when surfing. Compared to the other types of surfing the kite surfer uses a significantly smaller board, also called a wake board, which is attached to a kite-like piece of fabric that catches the wind to gain traction. The kite surfer can surf in flat water as long as the wind is present while the waves mostly are used as obstacles and to do tricks (ill. 10) (Mohr 2022).

BEST TIME TO PRACTICE - PS

	Spring	Summer	Autumn	Winter
Beginner		+		
Advanced	+			+

BEST TIME TO PRACTICE - WS

	Spring	Summer	Autumn	Winter
Beginner		+		
Advanced			+	

Ill.7: Paddle surfer

Ill.8: Stand-up paddle surfer

BEST TIME TO PRACTICE - SUP

	Spring	Summer	Autumn	Winter
Beginner		+		
Advanced	+			+

Ill.9: Wind surfer

Ill.10: Kite surfer

BEST TIME TO PRACTICE - KS

	Spring	Summer	Autumn	Winter
Beginner		+		
Advanced			+	

Ill.11: Placement of site in Nørre Vorupør

THE SCOPE

In the middle of the Cold Hawaii coastline stretching from Agger Canal to Hanstholm, lies the small authentic coastal village of Nørre Vorupør, home to about 600 full-year inhabitants, and an estimated 150.000 number of yearly overnight stays (VisitNordjylland, n.d.). Fishing plays a special role in the city's history and identity, and even though fishing no longer is an active profession in the city, it is still present in the urban environment. Locals as well as visiting recreational anglers use the city as a base for coastal fishing. The old fishing boats on the beach are still used for tourist trips, and one of the city's mature tourist attractions is the North Sea Aquarium, where you get the chance to see, touch, and learn about the fish in the North Sea. Old fishermen's huts surround the landing site at the beach and is today used for sales of fresh fish, places to eat your packed lunch, a clubhouse for the local surfers and much more. From the landing site on the beach runs a paved beach promenade, called "Foreningsvejen", which in one direction leads down to the harbour bath, where visitors can take a dip in the North Sea, in other leads to the newly inaugurated National Park Centre of Thy and in a third direction leads further inland to the main road, connecting to the rest of the town (VisitNordjylland, n.d.). It is within this context, at the merging point of town, beach and dune, that the site of this project is located.

After the migration of the commercial fishing industry, surfing enthusiasts have slowly claimed the beaches of Nørre Vorupør and Klitmøller as their own and have helped spread the delight for the water sports along the rest of the coastal stretch, nicknaming it the Cold Hawaii as we know it today. Together with their appreciation for the ocean, surfers are often also depicted as having a unique relationship with nature—a relation so valued that it almost per se can label surfers as environmental stewards for a sustainable way of life (Langseth & Vyff, 2021). Whether, or to what extent, participating in nature sports and outdoor activities, does make people more concerned about environmental issues than people not participating in these activities, is still to be proven. However, according to the general belief, as people have personal experiences in and with nature, they also take care of it. In a study from 2021 done on surfers' environmental attitudes and actions Langseth and Vyff show how 84% of their survey's participants state that they either agree or strongly agree that they perceive themselves as environmentally conscious. Many of the participants even claim that the close relation with nature that surfing provides gives rise to environmental thoughts. As expressed by one of them:

"It is clear that as surfers, we are especially close to nature. Compared to football, for instance, the cause is obvious why surfers are more environmentally conscious. It is because we are directly confronted with nature in the activity itself." (Langseth & Vyff, 2021).

The results of their study, however, show a gap between surfers' attitudes and actions. It is really only when their local surf spot becomes affected that their environmental attitudes are translated into environmental actions. Compared with other environmental threats, such as great GHG emissions from air traffic and non-biodegradable chemicals from surfboard and wetsuit production, which are abstract and distanced, the waste on the beach is concrete and experienced directly. On one side, surfing is deeply connected to emission-heavy travel and exploration: on the other, the culture highly values connection to nature and "green" thinking. Hence, values within surf culture guides surfers to conflicting actions, a somewhat attitude-action gap according to Langseth and Vyff.

This dilemma, therefore, leads us to interesting possibilities for the development of this thesis:

Could the utilization of surfers' local environmental actions, help the awareness of the plastic problem by creating a centre that mediate both surfing and the plastic waste problem, by presenting itself as a solution, through the use of upcycling waste as part of the building components?

02 METHODOLOGY

The methodological approach
Life cycle assessments

THE METHODOLOGICAL APPROACH

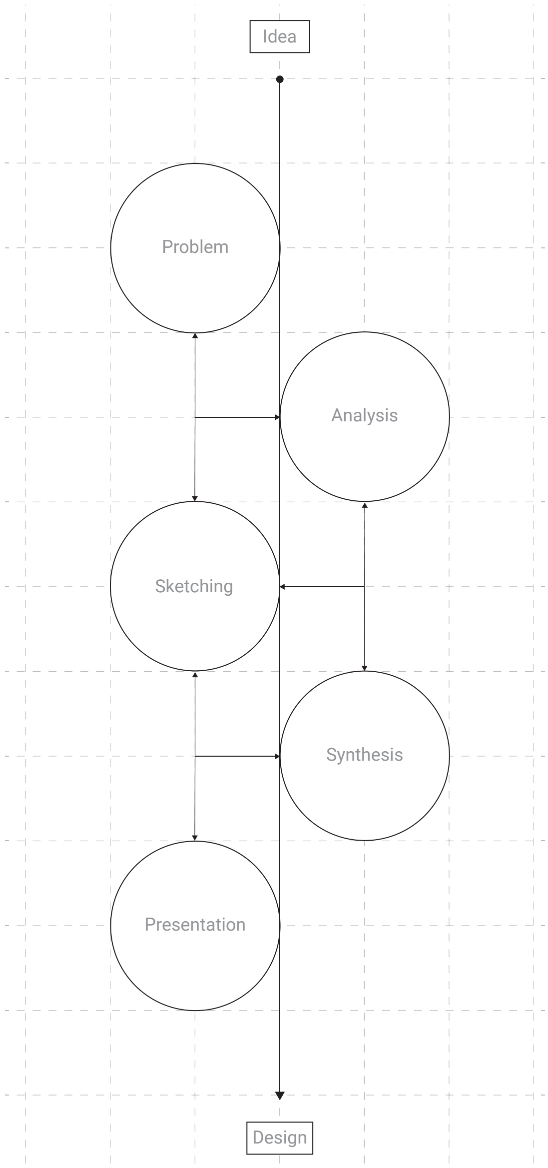
"The act of making an architectural decision can perhaps be stripped of its mystique, while some far more viable set of operations is seen to add up to something – not a style, not even a discipline, but some indefinable aggregate of operations which have been intelligent and appropriate and have given a situation its fourth dimension." – Peter Cook (Lawson 2014, p. 181).

The process of designing architecture is a complex task that needs to be combined with the field of engineering to achieve holistic designs (Knudstrup, 2004). When approaching the design problems, it can be done through a structured set of techniques and processes that can guide the architect in the development of the design from initial idea to final design. To apply the approach and ensure common grounds for the design team a methodology can be introduced and used as the tool to manage the design process.

At Aalborg University, we are through the entire studies at Architecture and Design thought how to apply the iterative methodology, the Integrated Design Process, as the foundation of projects to structure and guide the design process to ensure the interdisciplinary interaction between the fields of architecture and engineering. The IDP is divided into five phases: Problem, analysis, sketching, synthesis and presentation and is designed to include functional aspects, indoor environment, technology, energy consumption and construction alongside the architectural design. (Knudstrup, 2004)

Indeed, the IDP is going to structure the design process, but to allow the design to reach the full potential, an additional mindset based on the design tactics of Bryan Lawson is to be applied, in combination with the main methodology, to create a more nuanced approach to the design process. Lawson points out that the way of thinking of design problems is often thought of as the problems being considered with an expectation of the outcome in mind, thus there will presumably be a limiting way of exploring problems and potential design solutions (Lawson, 2014). While this usually applies to the IDP because the technical aspects can limit design investigations, the combination of methodology and the design tactics are assumably articulating the design, when allowing the design team to explore the architectural expression, design solutions, and potentials with a less restricted approach. The fusion of these approaches is going to enhance the creative freedom and allow 'the gut feeling' to be a part of, at least, the sketching phases of the design process as seen in Malaysian Architect Ken Yeang's design approach.

"I trust the gut feeling, the intuitive hand, the intuitive feel about the project (...) you can technically solve accommodation problems, you can solve problems of view and so on but which problem to solve first is a gut feeling (...) you can't explain it, but you feel that's right and nine times out of ten you are right." (Lawson 2014, p. 203)



Ill.12: Methodology

APPLIED TOOLS AND SUB-METHODOLOGIES

With the use of these techniques and processes to structure the overall project and design process, it is important to have a thorough understanding of the tools and sub methodologies applied, when working through the different phases. When dealing with various kinds of problems with varying objectives the tools and methodologies serve purposes of clarifying and eventually solving them in adequate ways resulting in a design proposal that fulfils both the architectural- and engineering aspects. The tools and methodologies available are numerous and widely distributed regarding subject and expected results. Indeed, it is why the chosen ones are found to be the ones suited to shape the project.

KNOWLEDGE

LITERATURE To create the basis of every given investigation it is vital to gain a thorough understanding of the given subject to be able to use it actively as a tool and reflect upon it. This can be done through reviews of literature such as scientific publications, books, articles and so on, that eventually can be used as framework or to structure following investigation of the project.

INTERVIEWS Face-to-face communication with experts or user groups can provide usable information on a different level than academic literature. A method like this provides highly subjective results but can be used to reaching into a smaller scale or providing first-hand experience in a certain situation linked to a problem or project.

REFERENCES Studies of existing cases initiate incentive and aim to gather knowledge of effective or ineffective solutions. For this method, it is crucial to establish the purpose of the study with a critical eye, framing the analytical goal and omitting irrelevant information. This method often functions parallel to literature studies.

TOOLS: Articles, databases, books, field trips, contracts.

ANALYSES

MAPPING By mapping, on site or digital, it is possible to gain significant information about the site and surroundings, helping to address qualities and obstacles. Data such as infrastructure, geology, functions, etc., have been presented through mapping in the analysis phase providing an insight into the setting of the context.

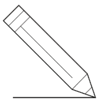
MICROCLIMATE Including climatic conditions can help integrate a design into its context and might inform upon subjects such as foundational supports for certain geology, or potentials for passive strategies like natural ventilation, solar energy etc.

SITE VISIT A physical visit to the site of a project can provide a much more in-depth understanding of scale, mapping and microclimate. By experiencing the area with all one's senses, it is possible to register atmospheres, details and characteristics which might not be possible to observe through digital programs.

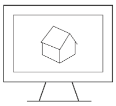
TOOLS: Observations, Klimatilpasning.dk, QGis, photographs, notes, sketching.

Ill.13: Sub methodologies

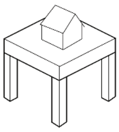
SKETCHING



HAND SKETCHING Hand sketching consists of generating ideas based on the prior analyses conducted in cooperation with other methods such as brainstorming, mood boards and mind mapping from the first stages. The sketching is intuitional and based upon a vision and considers different boundaries and criteria as part of an iterative process.



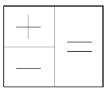
3D MODELLING Going back and forth between a 2D drawing and a 3D model can unveil potentials and challenges with a proposed design. Working with digital models is a highly useful tool throughout the entire process, as it allows for quick considerations of details in connection to one another, granting a larger perception of the proposed spaces.



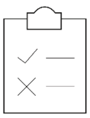
PHYSICAL MODELLING Like the digital 3D model, a real-life model can provide a quick understanding of scale and connectivity. By use of physical model, touch, texture and atmosphere can be mediated in a way set for all senses, and not just the eye.

TOOLS: Sketching, Rhino, Revit, Sketch-UP, analogue model making.

VALIDATION



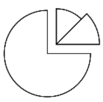
CALCULATIONS To reinforcing the IDP-process it is largely beneficial to include fast calculations from the beginning to test if the design has potential to fulfill various goals and requirements in terms of energy structure, indoor comfort, and energy use. The tools at hand can vary between quick hand calculations to complicated validating calculations.



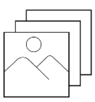
SIMULATIONS Simulations are used as part of the analysis, sketching and synthesis phases. By doing this, you can gain extensive knowledge of both interrelations between building part and microclimate, granting awareness of the total performance.

TOOLS: Rhino+plugins, BSim, BE18, Excel, LCA-byg, handcalculation.

PRESENTATION



INFOGRAPHICS Infographics provide an opportunity to graphically communicate information and concepts swiftly yet coherently. They can enhance insight and understanding of subtle details and thoughts behind the end results through means of graphic design.



RENDERS By the use of renders you work with a focus on generating photorealistic illustrations from 3D constructions and models. Renders allow for the project to be visualised, and presented through chosen interior and exterior views, communicating intended atmospheres, functions, and relations to other spaces.

TOOLS: Illustrator, Photoshop, InDesign, Rhino, Revit, handdrawings.

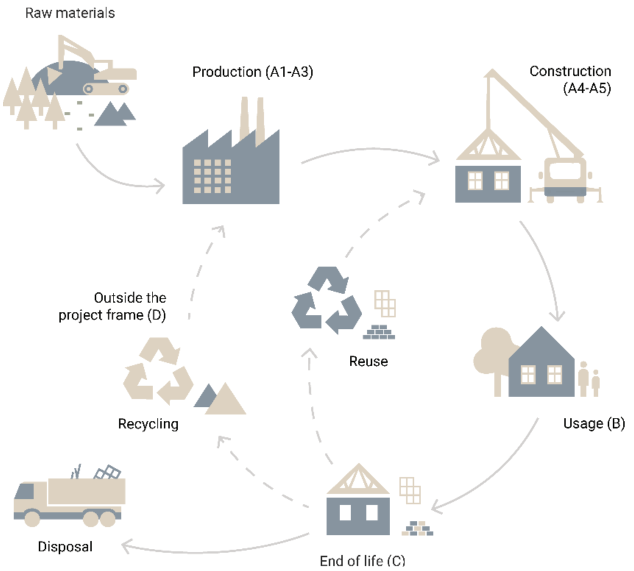
LIFE CYCLE ASSESMENTS

LCA AS A METHOD

Sustainability is an increasingly greater subject in the discussion about maintaining a high quality of construction. Sustainability as a whole in the building sector deals with a building's environmental, economic and social impacts and can therefore be seen as a supplement to a building's traditional aesthetical qualities. However, with the rising threat of global warming, there is a strong focus on finding solutions for how society's climate footprint can be reduced. In the construction sector, Life Cycle Assessments (LCA) have now become a wider spread tool to document the environmental impact of different building designs. To perform an LCA on a building, there is a great need for good documentation of the environmental impact of each material used in the construction (Zimmermann et al. 2020).

Globally, construction contributes with almost a third of the total climate impacts (Dansk Industri, 2020). These impacts and other environmental impacts from both operating energy consumption and from building materials can be determined, reduced and categorized using life cycle assessments based on the EU standard DS/EN 15978: 2012. To support the quality of the construction of a building, it is necessary to set certain demanding and long-term goals, to best accelerate development and achievement of the needed restructuring of the construction sector towards the new sustainable goals. Working with a sustainable method can be summarized in two basic notions, which can provide an overall understanding of the goals and be used as a common vision and starting point in concrete project developments. To ensure sustainability in construction one must therefore think long-term and think broadly:

Thinking long term revolves around the use of a life cycle perspective by observing the entire life cycle of the building - not just looking at the building and this very moment. The life cycle perspective is an essential part of understanding sustainable construction. Regarding the environmental quality, the life cycle perspective is about considering environmental impacts and resource consumption throughout the life of the building - from construction to operation, disposal and recycling. Regarding the social part, it is about ensuring the framework of health and well-being for everyone in contact with the building. And lastly, regarding the economic quality, it is about considering the economic conditions associated with construction, operation and maintenance throughout the life of the building, and about considering the building's ability to maintain its economic value despite diverse needs and societal changes (Dansk standard 2012).



Ill.14: Phases in LCA

Thinking broadly revolves around the use of a holistic perspective by observing the building as a whole and as part of its larger context, which it is a part of with local, regional, and global consequences. Sustainability is thereby an overarching vision to create quality in all parts of the building, where an appropriate balance must be found between the environmental, social and economic considerations, but also with the physical context in which the building is part of, e.g., the city or the community (Energistyrelsen 2015).

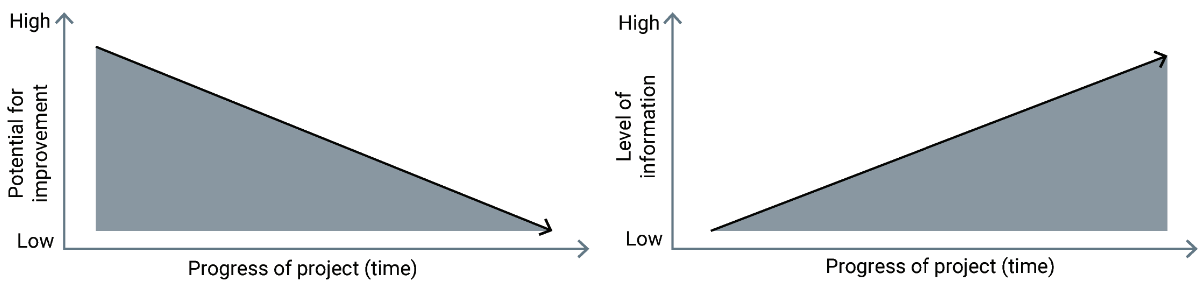
LCA IN PRACTICE

The construction and planning of a building are constantly changing, and each project is unique in terms of the process it goes through. A low climate impact is best achieved if LCA is regarded from the start of the project in an integrated and iterative design process. Although it is difficult to predict all decisions, which could have an impact on the building's climate impact, it is recommended to carry out LCA at the beginning phases of a design development, since this is where the greatest possibilities lie for optimization and changes of the climatic performance of buildings.

Construction projects usually start at a generalised level in the form of a concept or similar. Although there is a long way to go from the concept proposal to the specific building, the general lines are often determined early on if one is building according to normal practice and regulations. Therefore, the proposal must be analysed early on, so that the climatic impact becomes part of the decisions. Initial analyses of material options for the specific site and project are therefore an example of approach to inform upon the following choices. Overall, it can be assumed that all activities, materials and energy consumption contribute to the building's climatic performance. During the course of the project, clarifications will then take place, and more and more decisions will be made about the design of the building. In line with the project's development, the LCA model should also be developed, so that the preliminary results in the design phase approach the final LCA, by continuously sharing and improving on data results between different studies (Kanafani and Birgisdottir 2021).

The usage phase (B) is a good starting point if one is to imagine a building's impact on the environment. During the usage phase, the building uses energy, and some building parts might need replacing if the expected service of life is shorter than the standard consideration period of 50 years. The step before the use-phase is referred to as the Product Phase (A1-A3) and the Construction Phase (A4-A5). Both the material use of phase A and the energy use of phase B can be informed upon through calculations in Be18 and indoor comfort studies of BSim, which provide a knowledge of specific amounts of certain materials needed and their respectively thermal and energy results linked to different concept ideas.

After the Use Phase (B) the building will enter the End-of-Life phase (C), where considerations toward demolition, disposal or recycling is made. The phase of Outside project framework (D) informs upon different potentials which might be left at demolition, such as excess renewable energy production or materials for reuse and recycling in new contexts. The D-phase is by standard currently not included in the LCA result, but considered separately, due to too many uncertainties varying from project to project (ill.14). Furthermore, as an LCA for an entire building's life cycle is an extensive task, a possibility is to only include those phases which are at disposal with a sufficient data set. This selection of certain calculation phases is defined as a system delimitation set-up, and is then supported by calculation estimates based on similar constructions on the remaining data (CEN, 2012).



Ill.15: Impact of LCA

03 THEORY

INTRODUCTION

The new wave of Danish architecture has in recent years become a term of international recognition, as a number of projects by Danish architectural studios reap honors and appreciation on the global scene of architecture. The new wave of Danish architecture is highly inspired by the Dutch movements in architecture defined by well-knowns figures like Rem Koolhaas and his architectural studio OMA. They approach the design problems with a new and innovative approach based on the ideals of solving socioeconomic and environmental issues through the means of architecture (Weiss and Vindum 2012). Indeed, it is a result of studios like BIG, EFFEKT, APEDT etc. that Danish architecture are gaining recognition in the exact sense as in the time of Jørn Utzon's heyday. Even though the approach is innovative and groundbreaking in many ways it is nowhere near being perfect. They are working with easy-to-read concepts with iconic value, however these projects are not relating to aspects like context, local traditions and materials, topography or the site-specific qualities (Kallesø 2020). Thus, it would naturally result in questions about whether this approach of problem solving of design with a starting point in sustainability, circular economy etc. which contradicts the basic idea of the Danish tradition regarding regional aspects is the best way of doing design in recent times.

THE DANISH FUNCTIONAL TRADITION

When looking back in time of the Danish architectural positioning it proves that when new international trends occur, Danish architects tends to be able to challenge the ideas of these trends to adapt them into a local context (Millech 1951). This is seen in the early 1930s where the international functionalism was spreading though the architectural environment in Europe and was built upon the ideal of clean shaped, straight lines, flat roofs and a minimum of decorating. The mantra of the functionalism could be outlined in the saying "form follows function" meaning that the architecture had to be designed in a rational and simplistic way with the use of the modern and groundbreaking materials that in a Danish context broke tradition and building customs (Dansk Arkitektur Center n.d.). As a result of the international movements, a conflict of approach in Danish architecture occurred when working with functionalism. Some architects were dazzled by the new wave of buildings stripped to the bone while the majority was keeping a critical thinking to this architectural expression. In this perspective, it was important to include elements of the tradition and view of human nature that was neglected by the functionalist thoughts, thus it meant that bricks were the preferred building material compared to prefabricated concrete elements. Indeed, the new trend's results was not avoided by rather used and merged with tradition to fit into the Danish context. The Danish functional tradition encapsulated the thought of objectivity in the sense that the building should be presented as a holistic spatial entity while the materiality of elements was ensured as an opposition to the international trends (Millech 1951).

THE NECESSITY OF A NEW DANISH CONTECXTUALISM

Ill.16: Architectural positions

THE DENSE LOW-RISE HOUSING

The dense low-rise movement occurred in the 1970s as a result of the thoughts of the Nordic regionalism and specified the focal points of the built environment for the near future to ensure a better living standard and wellbeing for the inhabitants (Lund 2001). The community should be enhanced by how the build environment was organised in small clusters and the human scale creating close relation to the landscape. It was a technique to stage the experience of small urban communities with a network of paths and gathering spaces primarily intended for human movement, interaction and stay while the cars was hidden away in the periphery of these neighborhoods (Alexander et.al. 1977). Most elements of the typology like the width of the streets, proportions of houses and building height was greatly inspired by the scale of small villages in the Nordic countries and the British garden cities with a variety of compositions based on different focal points. For instance, passive strategies and the sun as an active design tool as seen in the living community of Hjortshøj, which is a district of the city addressing the vision of social and sustainable living (Lund 2001). Further, the dense low-rise typology is often designed based on theories and practice stating how to create spontaneous interactions as a result of the built environments designs, organisation and detailing. The detailing is an important aspect of how the building are enhancing the human scale and embracing the diversity of a community which is often seen in different building heights, differentiated façade expressions and a combination of multiple materials and colors that facilitates informal environments for informal interaction and gathering (Alexander et.al. 1977).

CRITICAL REGIONALISM

"Critical regionalism is an approach in architecture that strives to oppose the universality and lack of meaning common in modern architecture by using the elements and influences of the environment which contribute to the feeling of belonging and meaning." (IGI Global n.d.)

According to Kenneth Frampton, as presented in Critical Regionalism - Modern Architecture, it is crucial that the architects are able to analyse and utilise the local character of the context, not by adapting directly to it but rather to redefine it with terms of a modern approach. Based on Paul Ricoeur's question of how to become modern while enhancing the old civilisation and revive local tradition, Frampton referenced to buildings by architects like Utzon and Alto which he meant where succeeding in combining local traditions with other cultures (Frampton 2007). Further, he explores the contradiction between the periphery and center, where he implies that the architecture should characterise the periphery as contrast to the dominant elements unfolding in the center. This is to eliminate the issue of the architecture often are shaped by the modern technology and capitalism overshadowing the essence of the architecture revolving around the sense of place and social values and avoids including the meanings of the past. He expresses the necessity of understanding critical regionalism as an approach enhancing both the ancient local cultures as well as modern cultures while including the means of microclimatic conditions, heritage, and the

traditional craft of a place to create well-argued architecture that relates to the area while including new and innovative means to articulate the design (Foster 1983).

To exemplify and clearly convey his ideas, he uses the work of Tadao Ando, which is to be considered a master of embracing the ideals of the critical regionalism. Ando's work with geometric shapes creates a clear definition of spaces that relates to the environment and its cultural qualities in a refined way. This not defined by using the right materials based on tradition and history, but rather to incorporate these in a way that respects place. Ando often works with concrete and solid masses, thus this often would be thought to conflict with natural settings, it is done in a way where the architecture highlights the site-specific qualities in a sympathetic and intelligent way. For instance, through working with light and shadows to set an appropriate atmosphere and activate the senses, as he explains (Frampton 2007).

"Light changes expressions with time, I believe that the architectural materials do not end with wood and concrete that have tangible forms but go beyond to include light and wind which appeals to the senses. Details exist as the most important element in expressing identity. Thus to me, the detail is an element which achieves the physical composition of architecture." (Frampton 2007, p. 325)

NEW TRENDS IN CRITICAL REGIONALISM

In recent years the critical thinking has regained ground in some parts of the world of architecture. If the categories outlined by Frampton are to be reconsidered in a contemporary perspective, it clearly relates to the present way of thinking architecture by professionals. They are seen as criteria of qualitative design approaches and seems to be an integrated part of architectural practice and pedagogy (Avermaete et al. 2019). Indeed, critical regionalism has entered a new stage in the evolutionary process in which the focus has gradually shifted from a slightly conservative approach revolving around the site-specific awareness, local tradition and modern technology to further to include a special focus on socioeconomic and environmental challenges as seen in the pragmatism (Zogni et al. 2018).

The movement of architects that worship the pragmatic thoughts are embracing the ideals of aesthetics and technical innovation that reach beyond borders, unique identity and local traditions. The clear strength of this and the appealing distinctiveness lies in the ability of creating an international architectural language. On the other hand, its defects lie in the fact that this approach do not include thoughts of entwinement of specific location of structures and the society using the architectural environment (Weiss and Vindum 2012). Based on reviews of the theory of Critical Regionalism, new trends occur as interpretations of Frampton's original thoughts transferred to a present time.

"(...) It pays attention to characteristics of regionalism, pertaining to local culture, environmental concerns, economic crises and technology. It defines the explicit or implicit results between society and architectural statement in a wide range of aspects such as identical, economic,

Ill.17: Architectural positions

semantic, temporal, cultural, technologic and ecological aspects." (Zogni et al. 2018, p. 3)

In the book Architecture of Regionalism in the Age of Globalization, Lefaivre and Tzonis states that the trends include investigations of ecology, culture and technology to create a new identity expressed through the designed structure. They argue that the regionalist approach goes beyond the ideal of having a minimum impact on for instance the landscape and in that sense, it is not about hiding or blending the meeting between architecture and topology but rather to engage the new structure in a critical dialog with the surroundings. Further, they claim that the resurrection of the new identities can be greatly affected by the current trends of sustainable living and evolutionary adaption (Zogni et al. 2018). Thus, these new trends as mentioned early do not comply for all regions and especially in Denmark and the Nordic countries we are not following the trend of the reinterpreted critical regionalism.

THE NEW DANISH POSITION

In the first decade of the 2000s, the Danish architecture was exposed to a movement of architects approaching design in a new and innovative way mainly inspired by the Dutch architectural trend of new pragmatism with Rem Koolhaas as the leading figure for this point of view. Pragmatism is revolving around an excitement of the opportunities new technologies allows to utilise in projects to solve complex design problems with a specific focus on the welfare design in combination with a Scandinavian sensibility and rationalism with a clear expression of conceptualism. Yet, this approach was not seen as the right approach by the entirety of the Danish field of architecture (Dansk Arkitektur Center n.d.).

"This new wave was met with profound skepticism from day one (…) It was accused of ignoring essential values in the Danish architectural tradition, including the basic understanding of and emphasis on the building as construction, the sensitivity to context, the focus on execution, the careful finish and the grasp of texture and detailing" (Weiss and Vindum 2012, p. 11)

According to the Danish architecture professor Carsten Thau, this approach to architecture is a reaction to the basic assumption of the Danish tradition which are facilitating discussions of the need of including traditions to root designs rather than creating new tradition based on the newest available technologies and building methods. Indeed, the new Danish position regardless of the unsympathetic approach to building tradition, materials and context, is the Danish architectural scene receiving attention and appreciation on an international level not seen since the time of Jørn Utzon. The focus on the easy-to-read concept with iconic values are tearing down the boundaries between the professionals in the field of architecture and the common consumer, thus, it is making architecture a topic of discussion for everybody rather than the stereotypical architecture enthusiast. In other words, creating a new livelihood for architecture and design in a common language that majority of people can relate to (Weiss and Vindum 2012. Further, it could be argued that the reason of the present state of architecture is due to progression in dissemination of design through

crystal clear concepts and presentation tools provided by the latest technologies to create utopian images of perfection, that limitation eventual flaws of the architecture in order to convince and persuade the common consumer into appreciating these projects. In this perspective, the studios have been doing good on the commercial aspect due to the approach of making architecture popular compared to some of the competitors that are embracing the Danish tradition and targeting the architectural upper class. Even though the new Danish position is great in many ways, it has reached a point in which there is a need for a new criticism and interpretation of the approach to eliminate the tendency of many similar looking projects stripped of creativity regarding use of material, idiom and the limited difference in architectural expression and concepts (Jensen 2012).

THE NEW DANISH CONTEXTUALISM

To deal with some of the main issues of the present movements in Danish architecture, it is relevant to take a step back and investigate what have shape the tradition through history. Until recent years the Scandinavian, as well as the Danish architectural tradition have been known for its approach of creating designs rooted in the culture of site-specific and human centered architecture to utilize the local character of an area. Especially the thoughts of including these aspects alongside issue of sustainability and socioeconomic challenges are for many critics seen to be the solution to the shortcomings in the present Danish position.

Danish architect Martin Kallesø states, in a subjective article, that pragmatism is missing the essentials of good architecture, like the craftmanship and the work with the site, in the majority of the projects developed. The main critique is revolving around the fact that a diagrammatic representation often not can be translated into architecture in the way the that the studios are trying to persuade people into thinking. He points out some focal points to be aware of when designing in order to break with the utopian ideals that are trying to solve complex problems beyond the possibilities of what architecture is capable to do. This reaction to the pragmatistic approach, he argues, should be based on an architecture concerning aspects of site-specific thoughts, the context, the topography, the building culture, craftsmanship and sustainability to articulate the design and convey elements of the history through it (Kallesø 2020). Further cirticism occur through questioning elements of the pragmatism and pointing out that it is often not clarifying why and which ideals the pragmatic approach is intending to solve.

"Cultural pluralism will always imply intense complexity and many contradictions, but new explorations in this area of diversity require both a good portion of sensibility, a developed ability for cultural orientation and a reference point in terms of value (...) And there are a number of unpleasant pitfalls that frequently recur: dissociated irony disguised as analysis; immaterial provocations of counter-cynicism without any reals standpoint; uninhibited utopias of galloping 'what-if' scenarios and self-conscious hedonism of glistening 'fun' architecture." (Jensen 2009, p. 5)

Ill.18: Architectural positions

Indeed, it seems that the need of a new Danish contextualism have been justified through the recent years of positions, movements and debates. The approach must not neglect the fact that elements of the of the Danish tradition is still relevant to discuss in the present situation in Danish architecture. Nor can the pragmatic thoughts be denied having relevance in the way of designing by 2022. It is important to apply a critical thinking approach to the thoughts of yesterday meaning that in the practice of tomorrow will be based on experiences done by pioneers in the architectural history. That being said, the time has come for the implementation of the New Danish Contextualism. Never has it been more important to show that architects are able to embrace the design process and implement the elements of critical regionalism in a combination with the main focal points of the Danish pragmatism to articulate in a rational and sympathetic way.

SUSTAINABILITY

According to the Brundtland report, sustainability can be divided into three pillars: environmental, economic, and social sustainability (United Nations, 1987). This study will focus on the social and environmental part, looking into strategies such as climate mitigation, adaptation, and circular economy.

As humans we spend about 90% of our days inside buildings. 40% of all energy used in Denmark is linked to these buildings and furthermore, 30% of emissions are linked to the building sector either as energy for heating, energy embedded in building materials or energy used in manufacturing processes. Therefore, a sustainable building strategy can be a big part of lowering future CO2 emissions and helping the mitigation of climate changes (Dansk Industri, 2020).

The inclusion of sustainable building strategies has been dealt with for many years, focusing on mitigation in the past decades, by tightening energy consumption regulations in buildings and lowering CO2 emissions in the construction phases. This strategy might soon not be enough as the climate is still changing, creating more extreme weather and rising sea levels as a consequence. Therefore, other complimenting strategies such as climate adaptation and a circular approach should also be included in the building design to prepare for new situations in the future (Poulsen et al., 2019).

"The challenge humans have to face today is thus to put in place mitigation actions necessary to prevent the planet crossing the threshold into a process of irreversible global warming that could have disastrous impacts on many aspects of life, and also to develop strategies to make their settlements and activities adapt to forthcoming new climate conditions which, according to the evidence available, seem now unavoidable." (Altomonte, 2009, p 100).

Ill.19: Beach in Nørre Vorupør

SUSTAINABILITY

CLIMATE MITIGATION

The mitigation part of sustainability is a simple theme that is proven difficult to put in motion. To include climate change mitigation, means to avoid and reduce emissions of damaging greenhouse gases into the atmosphere, thus preventing the temperatures of our planet to rise to damaging extremes. This strategy has been dealt with for many years through new legislations and regulations placed by governments to direct the building industry towards low energy frames and consumptions (Poulsen et al., 2019). The task of doing so include the transition from powering our world with fossil fuels to using clean, renewable energy, such as the energy we get from the growing amounts of offshore wind turbine farms along the west coast of Denmark. Years of political focus and investment in these fiberglass giants has started to pay off, as onshore and offshore wind turbines produced just over 46% of Denmark's electricity consumption of 2020 (State of Green, 2021).

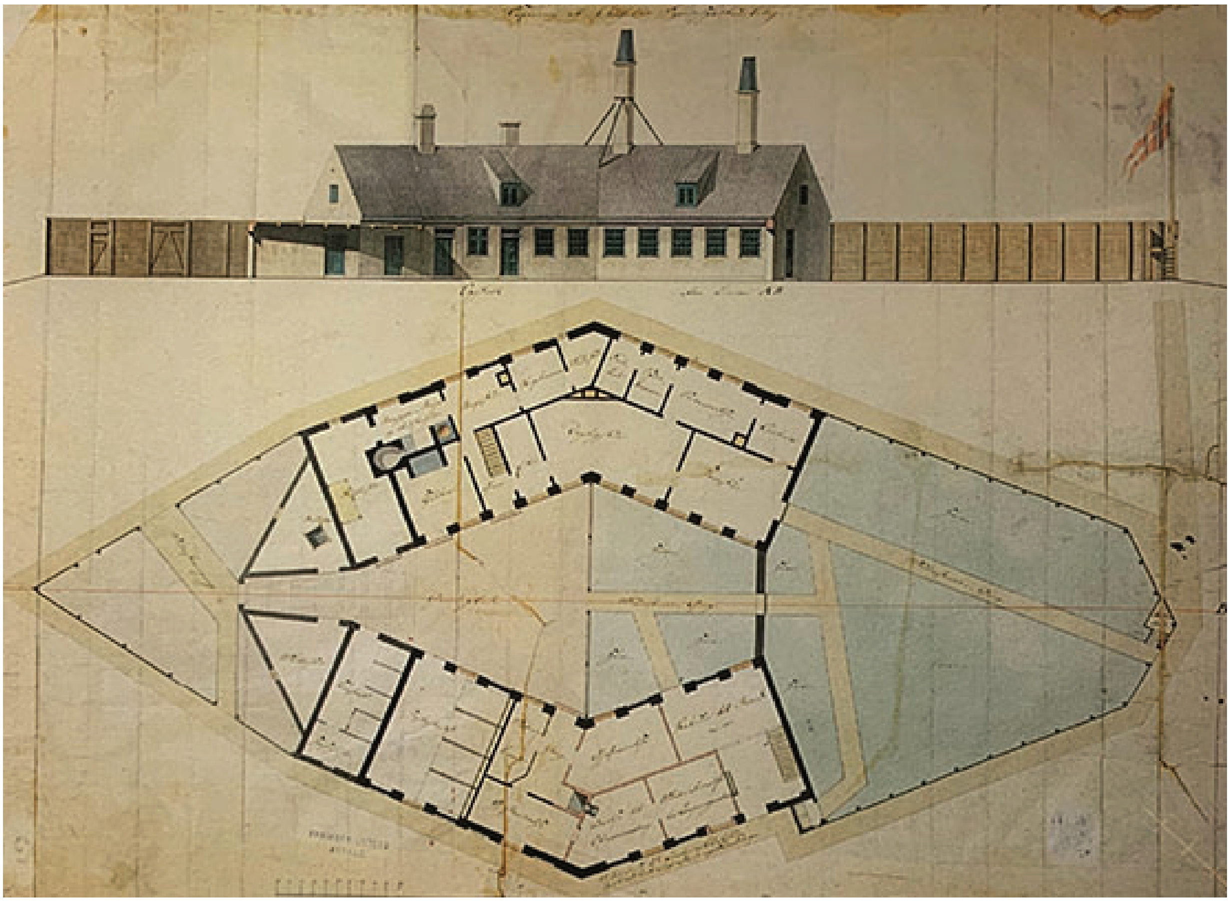
Further ways of working with mitigation include the general increase of biodiversity and restoration of natural habitats to help balance out the release of gases by increasing the possibilities to capture and store those gases in the vegetation. Assessing one's choice of materials also becomes a crucial factor, as many naturally occurring materials, along with recyclable ones, can add to low energy consumption and emissions of the building. This can be done though different assessment tools such as Life Cycle Assessments or DGNB analyses, which alongside passive or active design solutions further can lower the impacts without damaging the indoor environment (Poulsen et al., 2019).

CLIMATE ADAPTATION

Climate change not only affects the rising temperature, but also the amount of rainfall, it affects where we can grow food, where we can build our homes and many more challenges are only on their way (State of Green, 2021)

Adaptation solutions therefore vary from place to place, are difficult to predict, and might involve many compromises along the way. Adaptation in itself can be described as an organism response to the repeated exposure to a certain challenge, and include all reactionary actions that make the organism, meaning us, better equipped to survive in the changing environment (Nikolopoulou & Steemers, 2003). The first step to adapting to climate change is understanding local risks and developing plans to manage these. The next step is to take action - putting strategies in place to respond to these impacts which we are experiencing today, so as to prepare for the uncertainty of tomorrow. Strategies regarding climate adaptation can be used in an array of combinations, as one strategy cannot cover all effects of climate change. Therefore, multiple strategies should be used as to also adapt to both regularly and millennial events (Dave et al., 2016). When discussing adaptation, three main approached can be mentioned: The defensive, the reactive and the embedded approach (Poulsen et al., 2019).

The defensive approach aims to protect the interior conditions from the changing exterior ones. Thereby, the inhabitants will not feel the climates impact when indoors, as this remains the same as always. Reactive solutions use technology to response as climate changes occur. They can react throughout the building's lifetime to the changing climate. Here many passive design solutions such as solar shading can be categorised as part of the reactive strategies. These changes are done by manmade solutions and are mostly possible due to the incorporation of sensory advanced technology. Other reactive solutions can be modular constructions or changeable building design, where the flexibility of the building can change as needed over time (Poulsen et al., 2019).



Ill.20: Anholt lighthouse residence

Finally, embedded solutions aim to embed the building design into the ecology of the local landscape. Here buildings are designed to adapt to the specific conditions of each site. An example of general embedded design is Vernacular design, which takes the local tradition and history into account as the local building tradition has been developed within the giving climate throughout hundreds of years (Poulsen et al., 2019). Such an adaption can be seen in the old lighthouse residence of Anholt, where the strong winds of the island have greatly affected the design and shape of the building and its connecting garden areas.

The Anholt lighthouse, by Georg Holgreen, residence is located in the “dessert” on Anholt, which is isolated on the north-east end of the island. Here, the building has no shelter from the winds and sand as the flat land lies naked of trees. The architect designed therefore set out to design a building which adapt to the situation, through a reshaping of the classical Danish longhouse. Here two housing units are made with an angle after a streamline principle, creating a shielded yard protected from the wind. To further secure the building a garden wall was constructed following the building shape (Sommer, 2014). The building thereby showcase how climate adaption is a local problem and therefore should be design locally, as this is the only building with this approach on Anholt, but also the only building in that part of the island. Some of the same problems on Anholt can be located on the west-coast regarding the challenge of strong winds.

CIRCULAR ECONOMY

Today, much of the economy of the building sector is designed in a linear way, where products are discarded after use leading to valuable materials ending up in landfills (Mcdonough & Braungart, 2009). However, as more and more sustainable approaches are included in the building process the world slowly moves towards the idea of a circular economy, where the products are to be reused in some way. Through the integration of sustainable approaches, such as both mitigation and adaptation, the building industry can slowly change from a cradle-to-grave mentality towards a cradle-to-cradle one (Lendager, 2018).

"In the transition from a linear to a circular economy we must carry out two tasks at once. First, we have to start reactivating the enormous amount of waste humankind has accumulated over the past many decades, centuries and millennia. And while doing so, we must also start designing for circularity, that is, making sure our resources never become waste in the first place." – Anders Lendager (Lendager, 2018, p 63).

One of the focal points of this concept is to think in loops when it comes to raw materials and waste processing. In circular buildings, it is critical to avoid waste and reuse the resources in new products (Lendager, 2018). This mentality is also a necessity for the future, especially in Europe, where the building sector is responsible for approximately 25-30% of the general waste production (Beim & Ejstrup, 2019).

Furthermore, every year 8 million tons of plastic are dumped into the oceans and have the degradation time of up to 400 years due to their additives (Parker, 2017). If this tendency continues, the amount of plastic in the ocean will by 2050 be greater than the amount of fish in the sea (Bertelsen & Ottosen, 2016). Each year alone, 355 million tons of plastic is produced, meaning that recycling can take part in conversion to a new sustainable approach (Eriksen et al.,2020). Therefore, the waste should also be part of the future of designing buildings with upcycled materials from ocean waste. This could, in the future, be part of the aesthetics - the circular ornament that tells the story of the building by using the details and showing the logic of the building technical principles (Beim & Ejstrup, 2019).

PLASTIC FANTASTIC

It's hard to imagine a world without plastic. We dress in plastic fabrics, sleep on plastic foam, store and prepare our food in plastic containers. We surround ourselves with plastics in our homes, transport ourselves in cars made of plastic, let ourselves be entertained and get help from plastics when we get sick. However, this has not always been the case.

The history of the plastic industry begins about 150 years ago, shortly before the year 1900, and after a difficult start, the production of plastic took off in the 1930s, with the emerging of new plastic household items making the everyday life of the stay-at-home housewife easier. By the time of the 1950s and 1960s the golden age of the early plastic industry was upon Denmark. New experiments and prototypes were cast and pressed all over the country, and the world was interested in everyone with a good idea. The first LEGO-brick was made in 1949, the first Coca-Cola bottle was sold in 1958, by the year of 1967 the world's plastic production had reached 25 million tons, and by 2010 a production of 250 million tons had been reached (Plast industrien, n.d.).

Today, the plastic consumption of a country is just as good an indicator of its prosperity as the gross domestic product. The richer a country is, the more plastic it consumes. And vice versa: The more plastic a country consumes, the richer it becomes, since the use of plastic helps to create added value in the economy, as plastics in many cases is cheaper and better to use than other materials. However great plastics might be, they are also pretty much ubiquitous. Unfortunately, this also applies in nature. A particular pollution problem arises in the world's oceans, where plastics and other waste accumulate in large areas due to the oceans' wind and current systems, due to the non-degradable properties of the material.

The main ingredient in most plastic materials is a derivative from crude oil and natural gas. There are many different types of plastics, but many products are often made up of a polymer resin, mixed with a blend of additives for the specific use of the product (Plast industrien, n.d). The plastic production of today can be divided in two categories: Thermoplastics and Thermosetting plastics.

Ill.21: 1950's advertisement

THE PAST, PRESENT, AND FUTURE OF PLASTIC

THERMO PLASTICS

Thermoplastic is a common term for types of plastics, which can be formed and casted when heated and which, when cooled, become solid again. Thermoplastics make up 85 % of the general plastic consumption, it is often used to make household and everyday items, and therefore is also the majority of the plastic pollution of the oceans. In thermoplastics, the molecules are more or less entangled between each other. They are held together by this entanglement and by relatively weak chemical bonding forces. The number and strength of these bonds, compared to the length of the individual molecules, co-determine the physical and chemical properties of the material, making it possible to create a large variety of thermoplastics, from plastic bags to drainpipes. However, by adding tension, pressure or heat, the bonds are not stronger enough to prevent the molecular chains from sliding between each other, causing the material to melt at certain temperature levels (Plast industrien B, n.d.).

Ill.22: Thermoplastic granule

THERMOSETTING PLASTICS

Thermosetting plastics is the term used to describe types of plastics, which cannot be melted down after shaping. This type of plastic is therefore contrasts to the other main plastic type, thermoplastics. The fact that thermosetting plastics cannot be remelted after moulding is due to the fact that the final polymerization takes place during the curing and that the polymerization of these materials leads to the formation of very large three-dimensional network structures. The individual polymer chains of these structures are bonded together with very strong chemical bonds, in contrast to the weaker bonds in thermoplastics. When heated, the chains will therefore not slide between each other, which means that the material typically cannot melt, and if heated to very high temperatures, the material is instead only charred. Thermosetting plastics can therefore traditionally not be recycled in the same way as thermoplastics, but does however, perform much better with regards to resistance to abrasions, impacts and chemicals (Plast industrien C, n.d.).

This is for example the case of fiberglass components used to make wind turbines. Fiberglass (also called fiberglass-reinforced plastic) is a plastic material in which fiberglass is embedded in the plastic as transverse glass fibres making certain strength properties significantly greater than the plastic could achieve alone. Fiberglass-reinforced plastic is therefore also known as a composite material, since the plastic is mixed with another component, in this case the fiberglass fibres made of sand and crude oil. (Plast industrien C, n.d.)

WIND TURBINES

Due to this difficulty of recycling composites, these types of plastics are more likely to end up un landfills, since the materials have to be separated beforehand (Plastviden, n.d.). This creates a great waste disposal problem, especially in the wind industry, where despite of an increase in the use of fiberglass and still massive investments in green energy from wind turbines, an actual recycling of the fiberglass material has not yet been developed properly. Therefore, the disposal of the massive wind turbine blades, not lasting more that 20 years due to the harsh environmental tolls, is mainly done in the traditional way of either incineration in power plants or by burial in massive landfills – neither great environmental solution (Mortensen and Richards 2021).

In the last 23 years 8.000-tons of decommissioned wind turbine blades was deposited in Denmark, and in the coming 23 years the amount will reach up to 61.000-tons of waste, meaning a rise of 7 times more waste in the future needing to be dealt with (Jensen & Bregendahl, 2020).

The problem until today has been that only 85% of the wind turbines has been possible to be recycled, where the composite materials of the wind blades make up the bulk of the last 15%. To deal with this notion, the company of Siemens Gamesa is currently developing a new and more sustainable blade, which makes it possible to recycle both the glass fibres and the resin of the fiberglass material in the wind turbines. However, by any recycling it is always expected that the strength properties will be somewhat degraded, affecting whether or not the material can be used to the same or different purposes, other than wind turbine blades (Wind Denmark, 2021).

Though the Danish wind industry is far along in the process of finding a way to directly reuse or recycle the materials into new fiberglass, the Danish company of "Miljøskærm" has already developed another method of recycling the specific fibreglass of the wind turbine blades into insulative granulates used in new noise-reducing walls. By doing so they are able to offer noise reduction by 7 dB to people living close by highways and other heavy traffic areas with products made of up to 90% reused material, alongside reducing the environmental impact by 60% and energy use by 40% compared to the establishment of a traditional noise screen (Miljøskærm, 2021). The company is currently also in the development of using this principle to create a new type of building insulation, which will be both cheap to make, have low environmental impacts due to the recycling of the material, and provide just as great thermal properties as new mineral wool alternatives (Nielsen 2022).

Ill.23: Wind turbine blades disposal

ARCHITECTURE AND PLASTIC

The world has since the birth of plastics come to rely on the versatile material for just about everything. However, within the field of architecture, until recently, only materials with more perceived qualities, both physically and aesthetically, such as wood, metal, glass, and stone, have been utilised. Plastic has long carried the branding of disposable or cheap, but as modern architects have come to recognise, it is anything but. Whether used as a thin isolating film, a pliable board for construction, or as a piece of sculpture, plastics, in its many forms, can adapt to the desires of the creator and the wishes of a project (Nast 2016).

Even more so, it inherently possesses a streamline, modern look that natural materials cannot match, along with endless possibilities of stretching and shaping into eccentric shapes, possible to reach by no other material, as seen on the National Aquatics Center of Beijing. The façade of this building features a skin-like shell made by the use of ETFE - a durable plastic used for roofing - and a design inspired by the shapes of soap bubbles. Informally known as the Water cube, the structure was designed by PTW Architects and Arup Engineering for the 2008 Summer Olympics. The use of the plastic skin not only allows for the architecture to create a visual seduction, but also tell, convey, and project the intentions and usage of the build. The use of the ETFE, as also seen on the Munich Allianz Arena, furthermore, weighs just 1% of glass and is a better thermal insulator, contributing to lower emissions and smaller loads (Arup 2022).

Arup praises their build and concept for providing possibilities of a high repetitive and buildable modern structure, while, according to them, also appearing organic and random, the critical question arises if something so synthetical and massive can be categorised as organic.

Ill.24: National Aquatics Centre of Beijing

THE RELATABILITY OF PLASTIC

SCENOGRAPHY

To some extend 'organic' can also translates to 'relatable', since the human senses in correlation to the rules of nature in general create a greater awareness of and relationship to the environment. As an expert on the senses, Juhani Pallasmaa believes that good architecture should stimulate the entire sensory system, imprinting the clearest image in the spectators' mind, and thereby breaking with the ocular bias of the modern time (Pallasmaa 2015). Therefore, without texture, dimensions or details that are adapted to the human body, architecture, such as the Watercube, can become uncomfortably immaterial, and unrelatable, however impressive it might seem upon first glance. As Pallasmaa puts it:

"A construction's lack of anchoring in the reality of the material or the readability of the craftmanship involved reduces the architecture to scenery for the eye - a mere tool of scenography" (Pallasmaa 2015).

CHANGE

In these modern and pragmatic times this might seem like a line of thought from a long time ago, and though Pallasmaa was born in the mid 1930's, his 8 years younger counterpart of Rem Koolhaas, see the glass as very much full instead of half empty. If Koolhaas' architectural work across the globe has a unifying theme, it is his vision of the metropolis as a world of extremes - open to every kind of human experience. As he expresses in an interview with journalist Nicolai Ouroussoff:

"Change tends to fill people with this incredible fear (…) We are surrounded by crisis-mongers who see the city in terms of decline. I kind of automatically embrace the change. Then I try to find ways in which change can be mobilised to strengthen the original identity. It's a weird combination of having faith and having no faith." (Ouroussoff 2012).

Ill.25: Plastik House

Unlike many of his associates, who embrace a personal aesthetic, Koolhaas has not establish a constant look from project to project. Instead, he creates architecture that utilises the best of modern technology and materials and speaks to the needs of a particular site and user. Koolhaas refuses to refer to past styles and even calls for an "end to sentimentality" through these unique mixtures of styles and multi-layered spaces (Zelazko 2020).

This new take on human experience and site-specific design are also visible in multiple smaller-scale buildings, where the technologic advancements of our materials are needed to deal with unique challenges of durability, form or weight. This is the case for the Plastic House by Architecture Republic. The project's concept is based on a cruciform object that is inserted into an old Georgian townhouse; a piece of architectural furniture, which spreads treelike from the centre of the house. Functions like kitchen, toilet, storage and stairwell are then placed within this trunk - providing for more quality of living and dining in the spaces around it.

The addition is constructed by polycarbonate and steel. This lightweight structure also acts as an additional source of light in the evening, illuminating both the everlasting plastic structure and the original weathered old stonework, underlining the clear difference (Architecture Republic 2010).

Ill.26: Olympic stsdium in Munich

AGEING

In relation to this notion, it is further said that the process of ageing, happening to all natural materials enhances the textures and understanding of age of the materials. Wood, as an example, ages and becomes almost grey when exposed to continuous weather. The same happens for people, whom can be said to gain more characteristics features when ageing, a unique patina, which is specifically designed to never happen to be moulded materials like plastics. Instead, the material will continue to look almost new to the end of its life (Rasmussen, 1966).

Patina of a material expresses the history of a material or a building, enriching the story of it, instead of the machine-made materials aiming for an everlasting perfection. This fear of patina is, as Pallasma describes it, a related fear to the fear of death. (Pallasmaa, 2015)

A similar statement is linked to the Danish sculptor Thorvaldsen, when he states that moulded materials are the death, as noted by Steen Eiler Rasmussen. He, himself, further also categorises concrete as a moulded material, criticizing this material too for its poor tactile properties. However, recognises that by giving a moulded material a tactile treatment, as Le Corbusier did in his later concrete buildings by using raw wooden formwork to create the sense of fibres in the surface, it could increase the sensibility of the material (Rasmussen, 1966).

POSSIBILITIES

Another icon known for his work with plastic structures is the German architect Frei Otto, who worked with the great tensile properties of plastic structures. His many famous structures, such as the Munich Olympic stadium of 1972, make use of the properties of the materials to his advantage. Concrete and wood always have the same specific properties, while plastic can be designed with different properties as needed. In his studies and construction of tent structures, his constructions utilise the possibilities of the lower density of plastics as compared to other materials like steel or concrete and creates a new architecture by looking into the physical laws of nature and by using old traditions in new ways, making an example of how to open up the traditional architecture to new possibilities (Rawn, 2020).

"The majority of architects don't understand that there are infinite possibilities for architecture in the future. There are no limits" - Frei Otto (Hassel 2015).

Plastics thereby has the ability to provide unique possibilities to design and mimic shapes and forms seen only in nature, creating a closer relation to these. This notion was also used by the Spanish architectural office of Selgas Cano, when designing their Serpentine Pavilion of 2015, as an amorphous, double-skinned polygonal structure consisting of panels of a translucent, multi-coloured fluorine-based polymer (ETFE) woven through and wrapped like the system of natural webbing (Frearson, 2016). By comprising these examples, it gives the impression that an artificial material like plastic, to some extent, can be used to mimic the shapes of nature just as the use of stone walls or wooden structures could do. This is especially true due to the limitations of traditional materials compared to the properties of plastics, offering more possibilities in different settings.

04 ANALYSIS

Atmospheric studies
Mapping
Initial LCA studies
The community
User groups

ATMOSPHERIC STUDIES

BEING ON-SITE

On this cold February day, the winds are blowing at 15-20 m/s and the exhilaration of the strong gusts of wind, the impressiveness of the large thundering waves and the playfulness of the foam running across the beach, has soon disappeared. The moment you exit the warm comfort of the car the brutal west wind hits you like a wall, providing a taste of the environment by the smell of salty sea water and the feel of the coarse sand flying and scratching on your cheeks. A bit of admiration hit you, towards the people living, thriving, and surfing in these conditions all year around. Here you feel the premiss of nature, as it controls you and pushes you inland across what feels like the last piece of untamed land in Denmark.

The city is empty. Signs tell you that you are at least 4 weeks from the start of any activity, and even the newly inaugurated visitor centre of the Nationalpark Thy is showing signs of the tiresome weather only 9 months into its use. Sand is filling up every nook and cranny, wooden details are faded, grey and dry, and the large windows framing the beautiful views of the area rather look like the last wash was 1 month ago, and not 1 day.

Hoodies up and gloves on, we walk west through the city and onto the dunes as the landscape provides a duality of experience between the harsh environment on the dune tops, and the sheltered calm at the bottoms. The pathway pattern is organic, flowing and criss-crosses through the golden grasses bend low in the strong winds, until slowly vanishing onto the beach, where no mercy is found. The big waves come crashing onto the shore as foam, rocks and sand create patterns on the wet beach. A piece of washed-ashore-rope and a lump of driftwood is picked up along the short distance towards the pier. Foamy waves come crashing into the solid structure, erupting, and splashing high up in the sky. Daredevils are caught by surprise and stranded on emerging rocks to not get their shoes wet, as water rushes down the pier towards the harbour bath. Only the top of the steps is left visible as the bath has doubled in size due to the large bodies of water being pushed ashore.

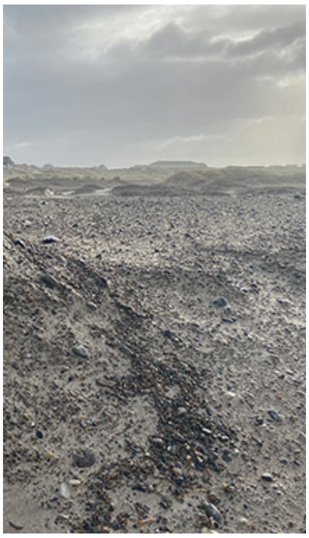
Reaching the landing site of the old fishing boats the history of the area comes into view. The white cottages of the old fishermen are orientated toward the water and the vibrant blue-red boats, giving the area a unique atmosphere, seemingly untouched by modern times. However, as you move along the concrete paving towards the warmth of the car, you truly get a feeling of a steadfast city and a steadfast people who have always had a unique relationship with the sea as either part of their livelihood or their passion for water sports.

NATURE-MADE PATTERNS AND VEGETATION

Historically it is also known that the microclimatic conditions have had a major impact on the livelihood on the windy west coast of Denmark. When experiencing the area physically, one is met by lots of references to the dominance of the weather and how this is shaping the area. At the meeting point between sea and dunes, various nature-made patterns occur, as a representation of nature's organic and optimised flows and movements. The combination of sand, water and stone create mesmerising compositions that on its own convey a story of hierarchy of the elements of natural environment at such a location. These patterns clearly stand out as aesthetically pleasing, calm and docile towards the wind as an overall shaping driver. The same thing is seen in the flora, where vegetation adapts to the microclimatic situation with strong wind and rough living conditions creating formations as they dance in the wind. A clear hierarchy, or dynasty, of such an area is thus defined, by the wind as the brutal ruler of nature.

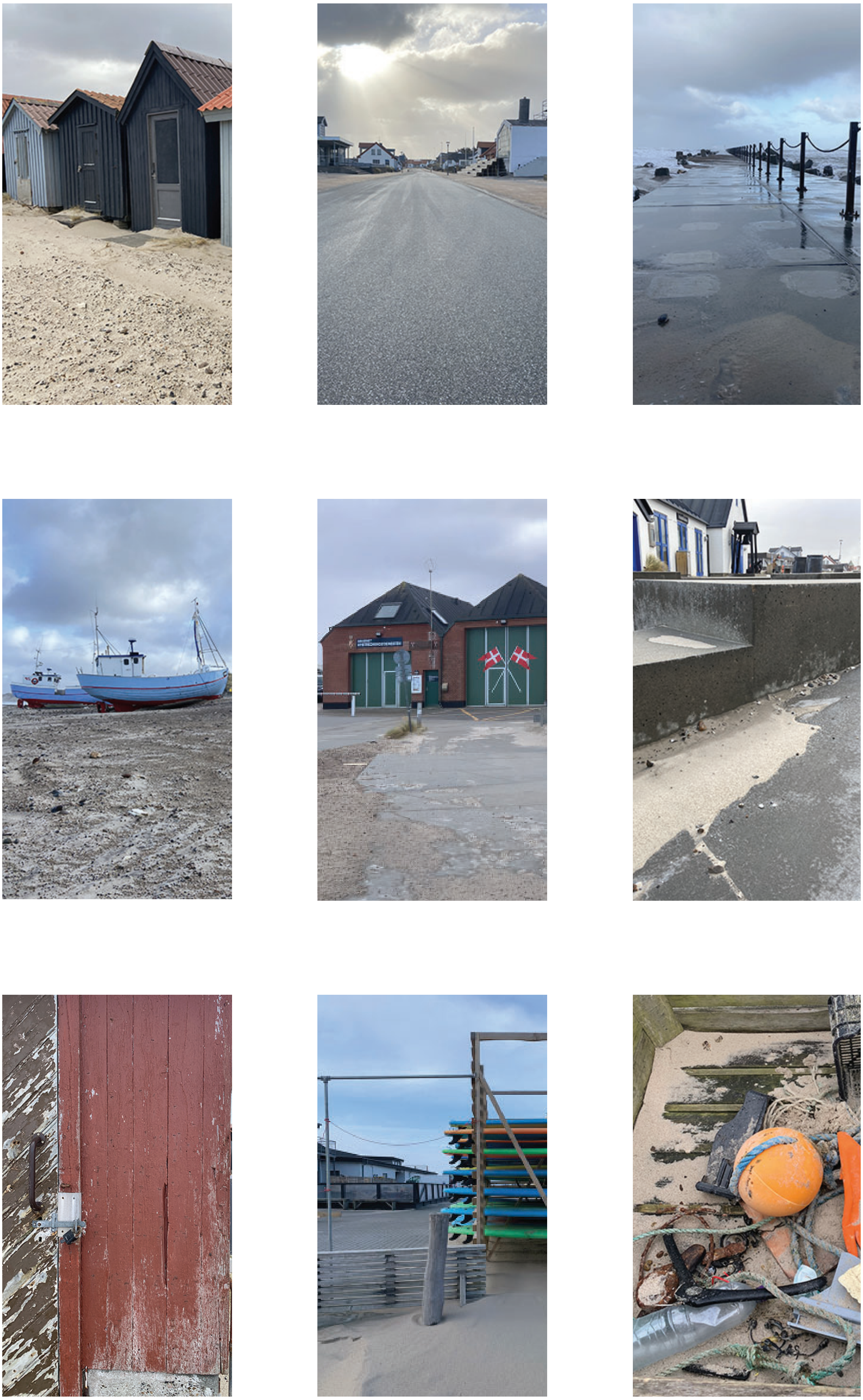
Ill.27: Route, 1:10.000

Focalpoints
Route
Site

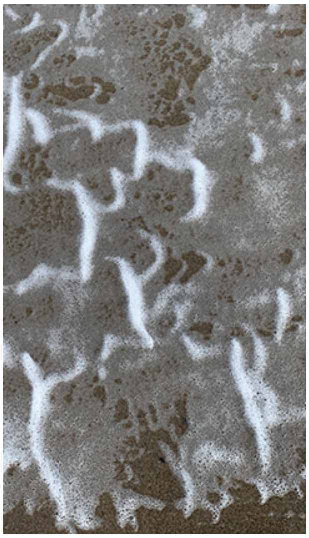



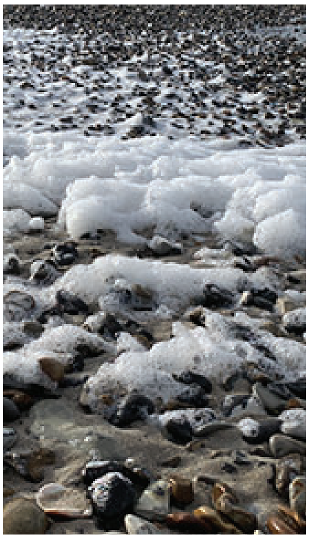


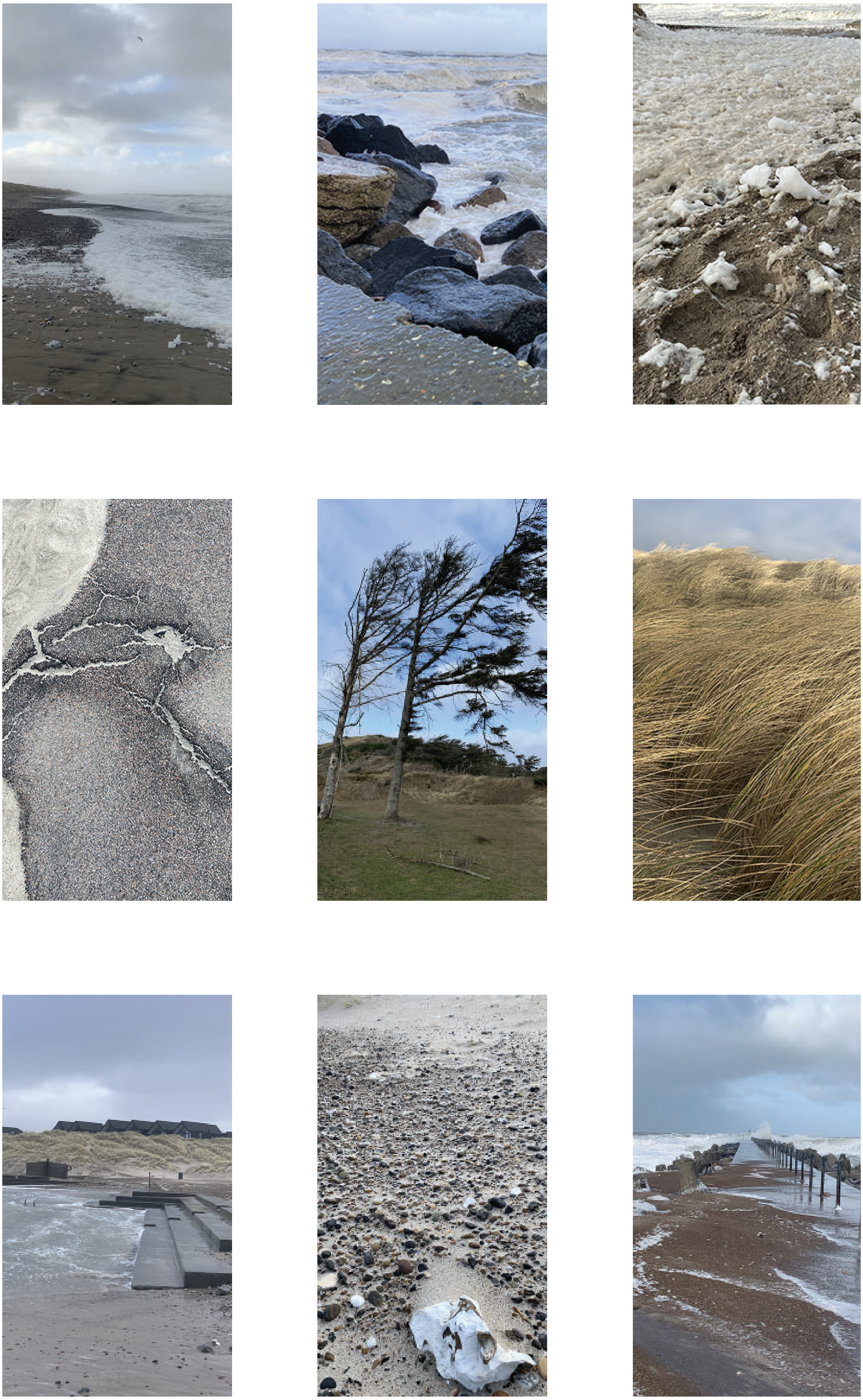


Ill.28: Pictures of the context







Ill.29: Patterns and vegetation

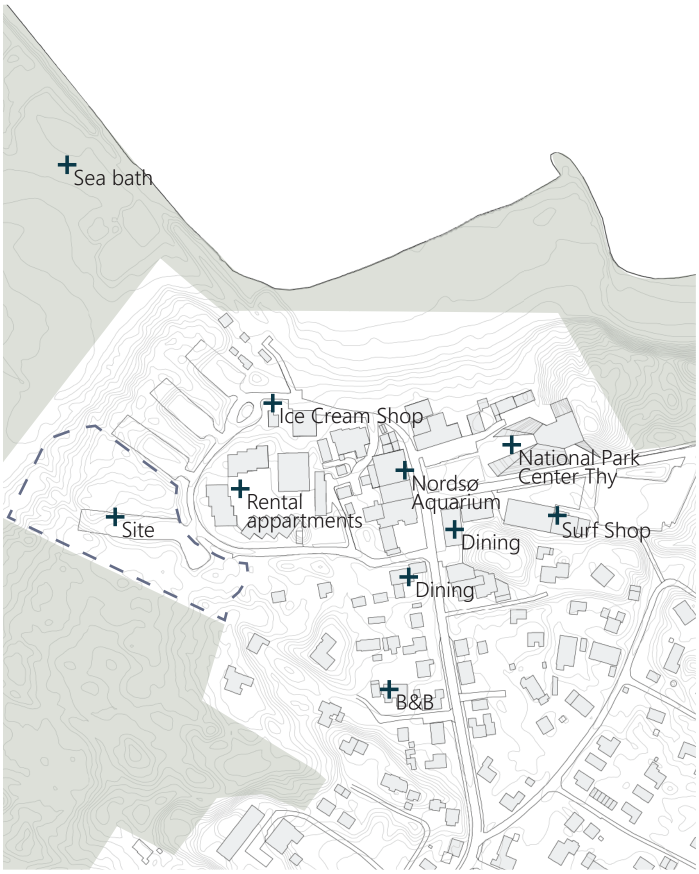
MAPPING

Ill.30: Infrastructure, 1:10.000

Parking
Main roads
Costal pathways
Bus stops

INFRASTRUCTURE

Nørre Vorupør is situated 25 km from the main city of the municipality: Thisted. A regional bus arrives and departs from the city once every hour. The site is located at the very end of the main roads leading into town and towards the beach. All main roads are paved, whereas most of the smaller ones are made up of a mixture of gravel and sand. The same goes for most of the costal pathways leading from the main roads through the dunes to the beaches. At the site of this project, a parking lot of approximately 70 parking spaces is currently located. During the design process the relocation or re-establishment of these therefore needs to be taken into account, either on- or off site.



Ill.31: Functions, 1:10.000

Dune protection zone

Functions

FUNCTIONS

The city of Nørre Vorupør extends from the beach front and 2,5 km inland. The nearby context of the site consists mainly of tourist attractions and social functions, creating a lively urban feel in spring, summer and fall, and a feeling of hibernation in the winter. Further inland along the main road more seasonal functions such as a local campsite and hotels are located, and further inland again, the local everyday functions of grocery shopping and the few community meeting points are concentrated.

In the off-season for the tourists, the main area closest to the ocean therefore appear empty and desolate, without use for the locals.

Ill.32: Sea rise of a 100-year event, 1:10.000

Sea rise of 2,24 m

SEA-LEVEL RISE

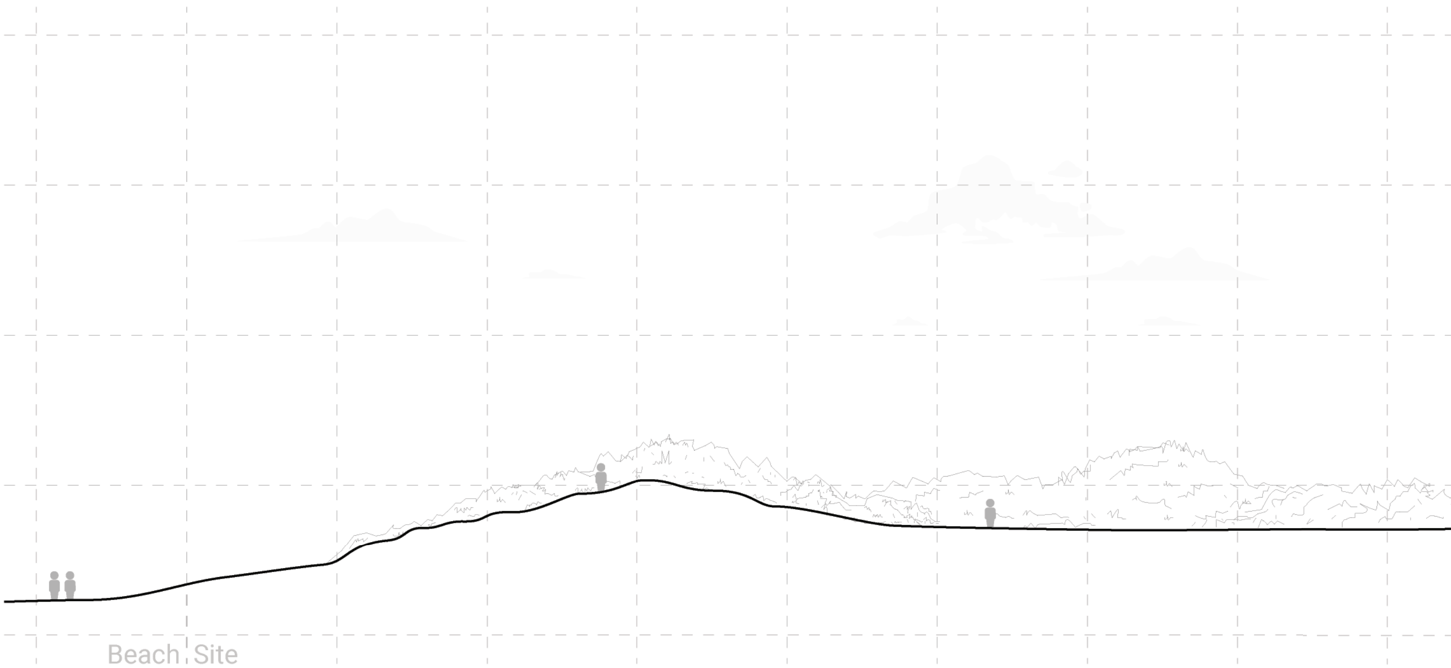
With the growing climate changes sea level rises are a real and expected change to the local environment. Along the north-west coast of Denmark, a prediction for a 20-year flood event is expected to involve a sea rise level of 2,12 m. A 50-year event will cause a rise of 2,19 m, and a 100-year event will lead to a rise of 2,24 m, (ill. 32). (Klimatilpasning, 2021), furthermore the mean water level will rise about 0,52m around Thy in the end of this century (DMI, 2022). With a placement safely behind the outer dunes, the site should be unaffected by the rising sea levels but is still receptive to general wear and tear from the strong winds, moving sand and water sprays.

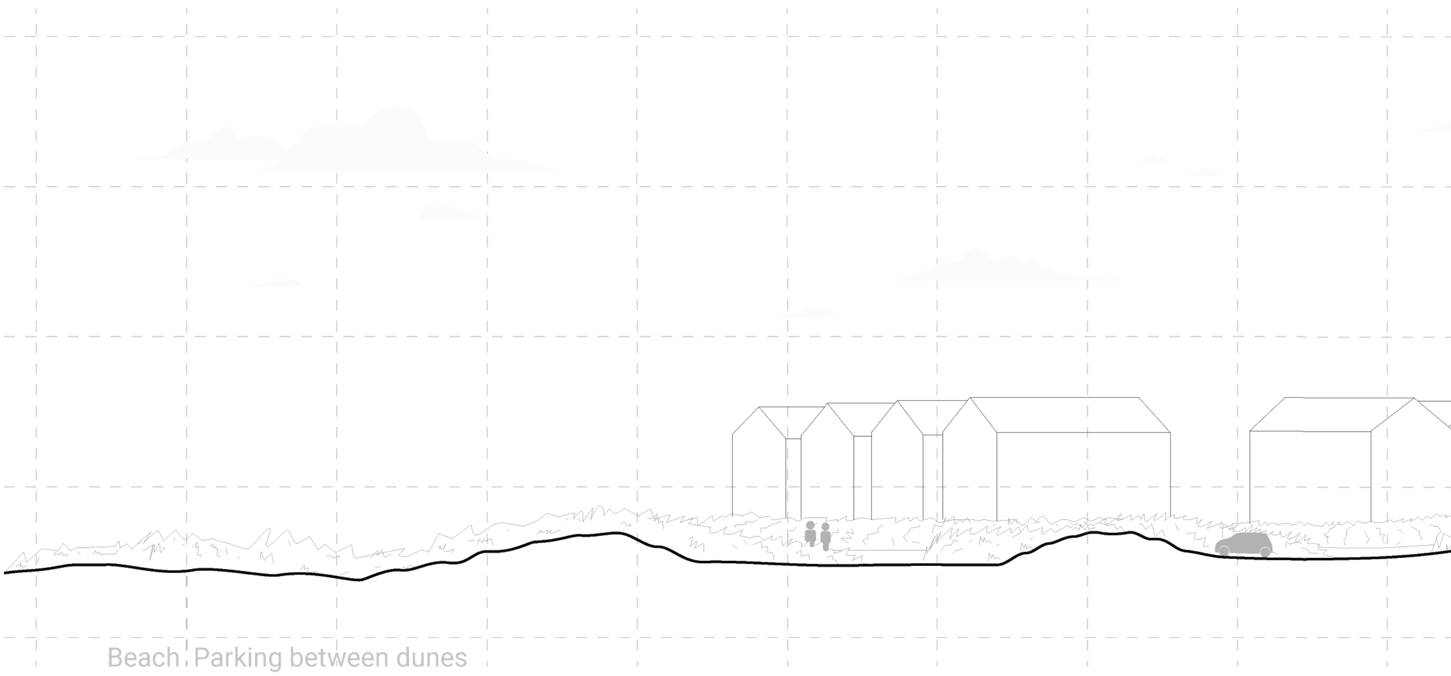
Ill.33: Contour lines, 1:10.000

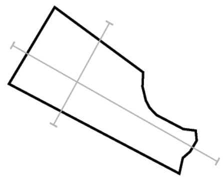
Contour lines - 0,5m

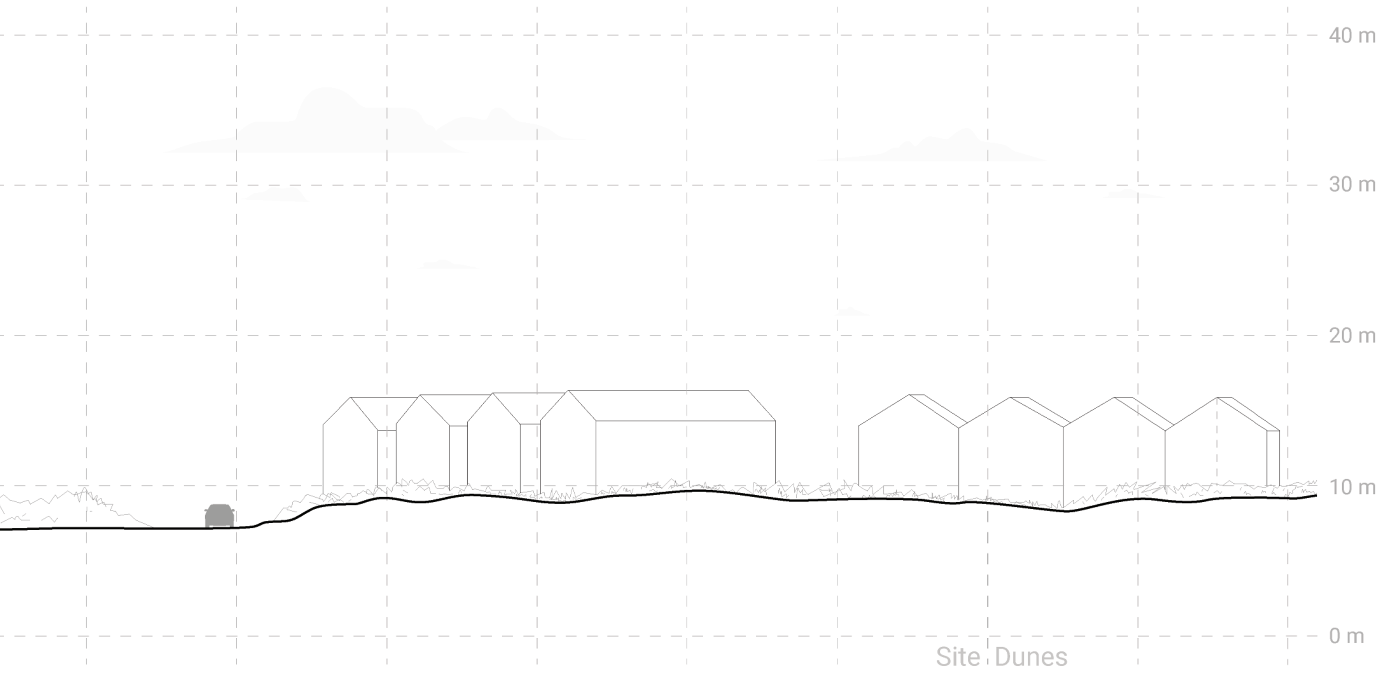
LANDSCAPE

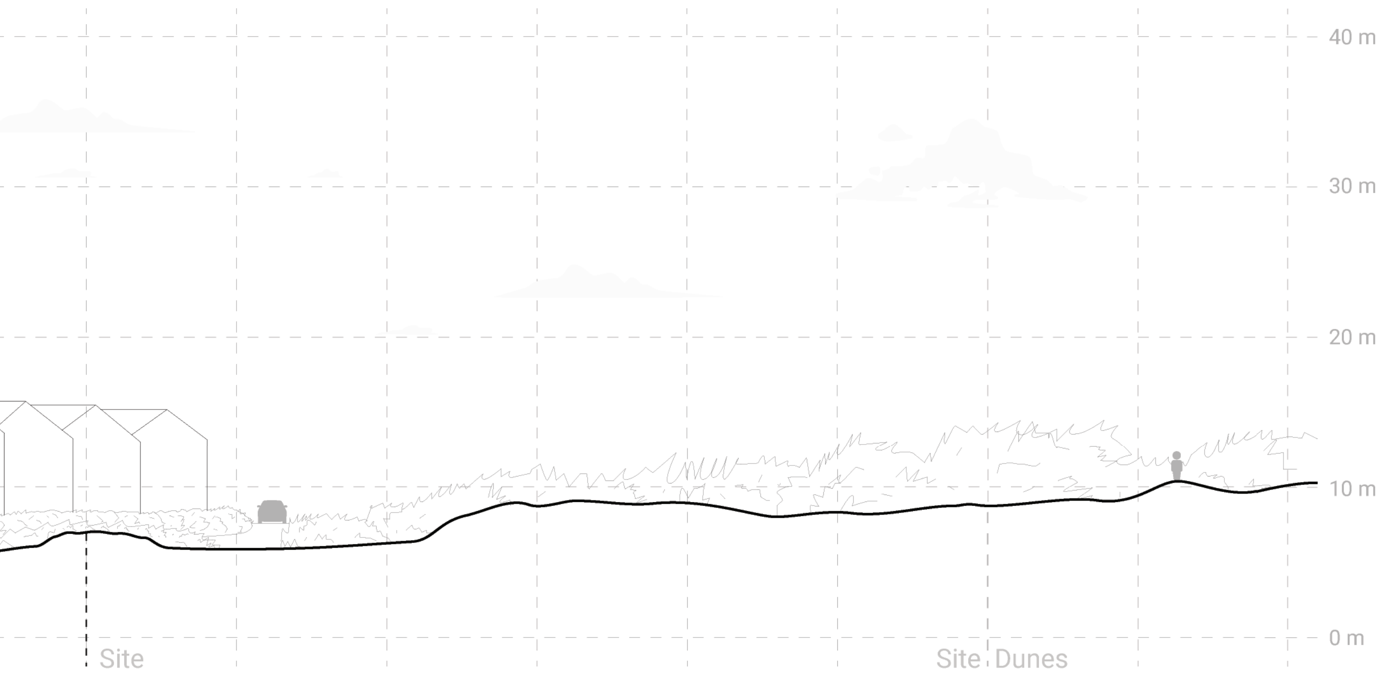
The mapping of the topography near the site shows a large amount of rising and falling in the landscape. The curvatures rise from 0-2 meters along the stretch of the beach to the top point of the dunes at 9 meters, and then again down to 6-7 meters along the parking lot, currently placed at our site. These changes of height provide solemn rest and lee from the strong winds when at the bottom of the dunes, and thereby showcase how the concept of an angled shape, which pushes the winds upwards, could be used to create calm outdoor recreational spaces in out further design.


Beach
Site


Beach
Parking between dunes







Ill.34: Terrain sections

Calm (0 m/s)
Light Air (0,3 m/s)
Light Breeze (1,6 m/s)
Gentle Breeze (3,4 m/s)
Moderate Breeze (5,5 m/s)
Fresh Breeze (8 m/s)
Strong Breeze (10,8 m/s)
Near Gale (13,9 m/s)
Gale (17,2 m/s)

WIND

Denmark's geographic location in northwest Europe causes winds from the west to be predominant. In addition, the flat coastal areas of Denmark are further exposed to winds due to the differences in temperature between land and sea, and often reaches the highest peaks within Denmark.

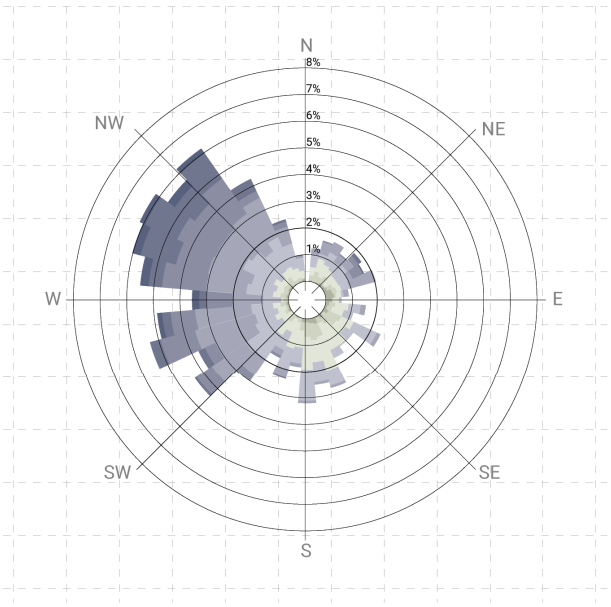
This highly affects the atmosphere of our site, since wind and waves create a significant amount of wear and tear of all materials and vegetation in the area. Furthermore, the fierce winds also move a large amount of seawater, creating large waves along the beaches, perfect for many water sports activities (Bjerg, 2012).

Furthermore, both topography and buildings can create new wind patterns, changing the general wind conditions to more site-specific micro climatic conditions. The wind data showcased on ill. 35-38 is from the city of Tryborøn as it is the closest relatable city to the site, available in the program Climate Studio when investigating wind conditions.

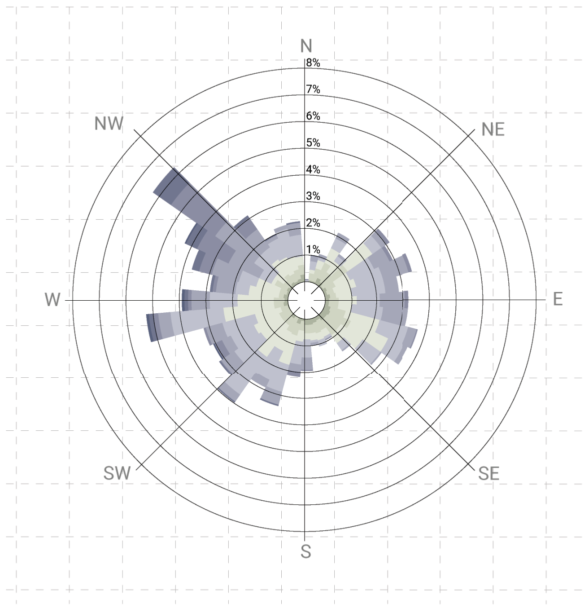
Based on the showcased analysis, it can be concluded that the conditions of wind and waves are different for each of the changing seasons. The analysis shows how the waves are bigger in the winter and autumn, which might attract more experienced surfers, and how the waves of the summer and spring are smaller, that would be more suited for beginners.

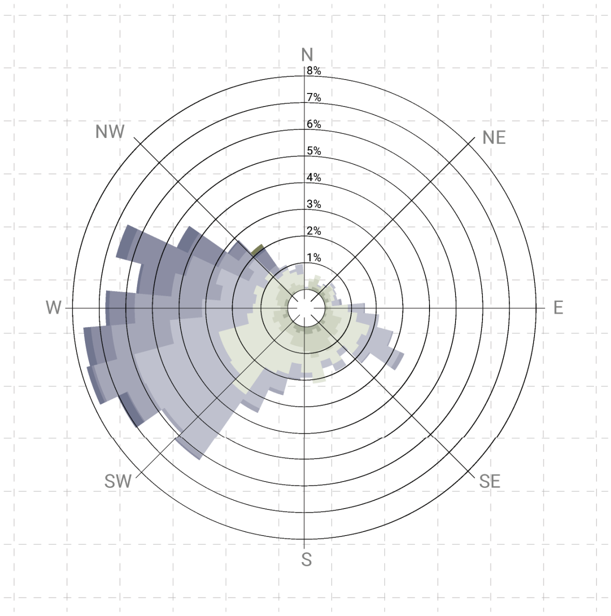
Furthermore, it is also possible to use the changing winds in the design process, when looking at outdoor recreational areas. Here the changing of the seasons and the hours of the day, can help inform upon where certain outdoor deck areas or sheltered spaces should be placed to create the best possibilities for a greater use of outdoor functions or areas.

Ill.35: Windrose of Thyborøn, spring

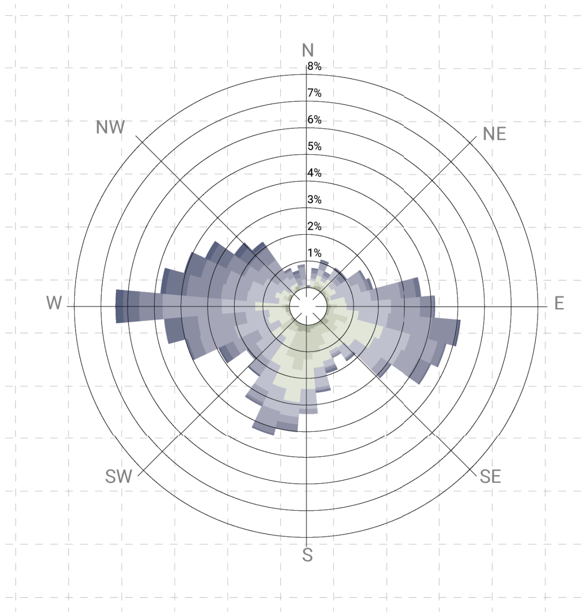


Ill.37: Windrose of Thyborøn, autumn





Ill.36: Windrose of Thyborøn, summer



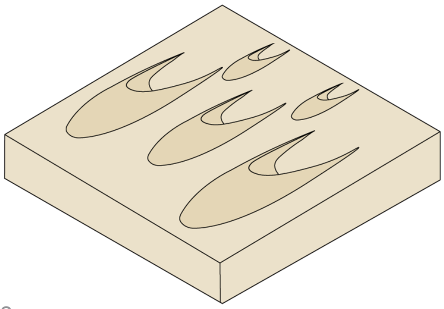
Ill.38: Windrose of Thyborøn, winter

DUNES

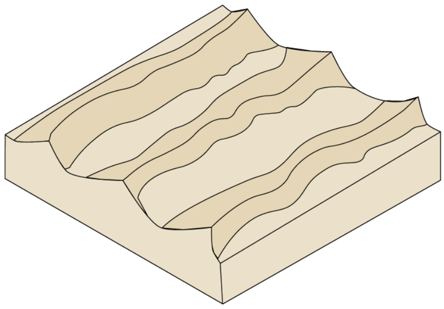
"A dune is a mound of sand formed by the wind, usually along the beach or in a desert. Dunes form when wind blows sand into a sheltered area behind an obstacle. Dunes grow as grains of sand accumulate." (Society, 2011).

Dunes can structurally be divided into two parts in, consisting of a windward side and a slip face one. The windward side is, where the sand builds up and creates patterns made by the wind, while the slip face is the area not receiving wind, meaning these are often smoother than the side exposed to the wind. The dunes appear in different shapes and sizes that vary from small built ups in a human scale to large geographic elements covering several square kilometers. In general, dunes can be divided into to four main shapes: Crescentic, linear, star and dome (Society, 2011).

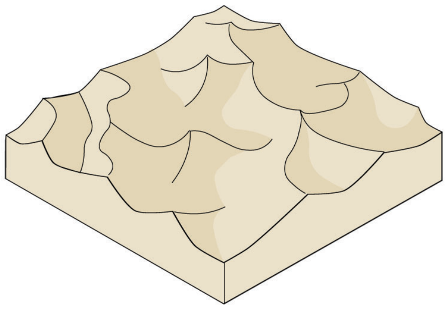
The Dunes are shaped after the wind, therefore, different wind conditions result in different formations of the dunes. In Denmark, most of the types are represented and located in all of northwestern Jutland. The shape of a dune can also change over time, where mostly the first dune shape is the dome, which then, over time, turns into the Crescentic dune. These forms are not that common in Denmark as the conditions constantly change, regarding vegetation and the changing wind direction. The linear dune is the most widespread dune formation in Denmark and is often seen along the coast. Whenever the vegetation fades away or the wind makes a hull into the dune a linear dune can be transformed into a Parabolic dune, mimicking a mirrored version of the Crescentic one (Binderup, 2013).



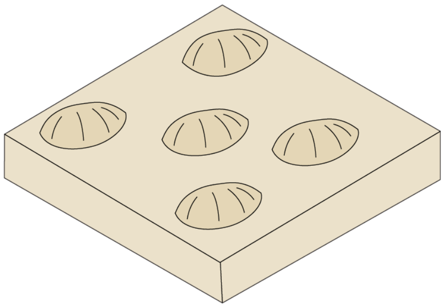
Ill.39: Crescebtic dunes



Ill.40: Linear dunes



Ill.41: Star dunes



Ill.42: Dome dunes

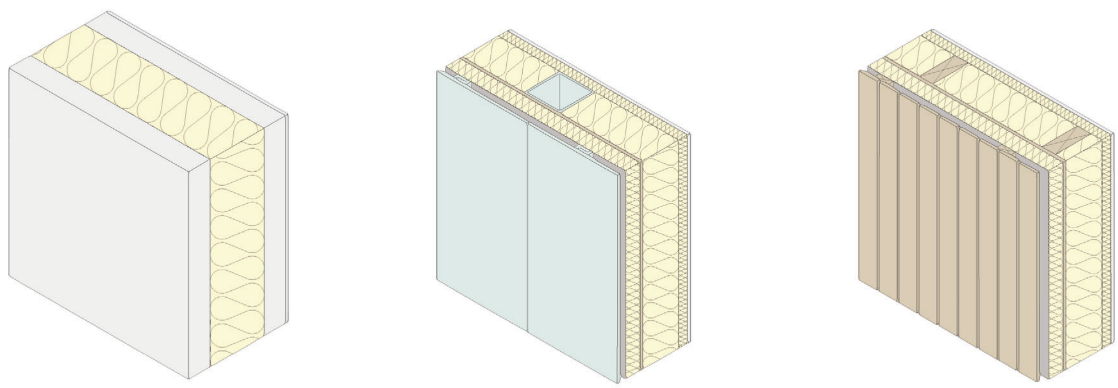
INITIAL LCA STUDIES

To build sustainably means to consider both an environmental, a social and an economic dimension. In sustainable construction, these three dimensions are seen as equal pillars which must be balanced from a life cycle perspective to reach a holistic design. As for the environmental sustainability, there is a strong focus on finding solutions for how society's climate footprint can be reduced (Energistyrelsen 2015). This includes circular economy as one of the approaches that is highlighted as a solution proposal. Circular economy entails a focus on increasing the degree of reuse and recycling of the building products and building parts that have sufficient quality for this. By doing so, we are expected to be able to reduce both the construction's environmental impact, resource consumption and waste generation. The adoption of a circular economy-mindset in society, including in the construction sector, has led to the initiation of various development and testing projects which involve reuse and recycling to various degrees. (Andersen et al. 2019).

With a context so well known for the strong winds, both for the benefit of surfers and for the wind turbine industry, long-term sustainable solutions are needed to withstand the impact of the elements at the Danish west coast cities such as Nørre Vorupør. In addition, fiberglass has for many years acted as a go-to solution due to its great durability and low need for maintenance, and with the increasing support for wind energy, only more and more turbines are appearing. However, this also means that more and more discarded wind-turbine blades will also be appearing, leading to a large disposal problem, due to the single-minded use of the fibreglass blades, which the industry only now are slowly finding a solution for (Jensen & Bregendahl, 2020).

In the spirit of this notion, fibreglass facade panels and loadbearing elements from the Danish company Fiberline Composites, have been investigated and compared with alternative and more traditional constructions choices, to explore the possibility of a usage within the everyday use and construction. To do so, three 1-by-1 meter wall sections have been investigated to best compare realistic compositions of a wall construction. These comprise of a fibreglass structure and façade-, a concrete structure and façade-, and a wooden structure and facade combo - all reaching a thermal U-value of 0,1 W/m^{2}K (ill. 43).

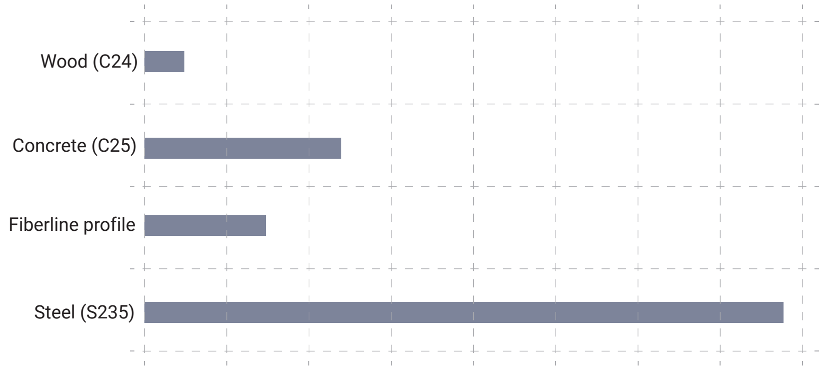
As seen on the graphs on the right (ill. 44), fibreglass construction profiles provide a lower density than concrete and steel - easing in the transport of the material, and just as great a strength as steel. With a great durability in the harsh weather of the west coast, where the durability of wood is estimated to decrease from 50 to only 20 years, fibreglass might present itself as a suitable alternative, whose environmental impact can only become better, through a potential in recycled or somewhat reused fibreglass from decommissioned wind-turbine blades. For further details, see appendix 1.



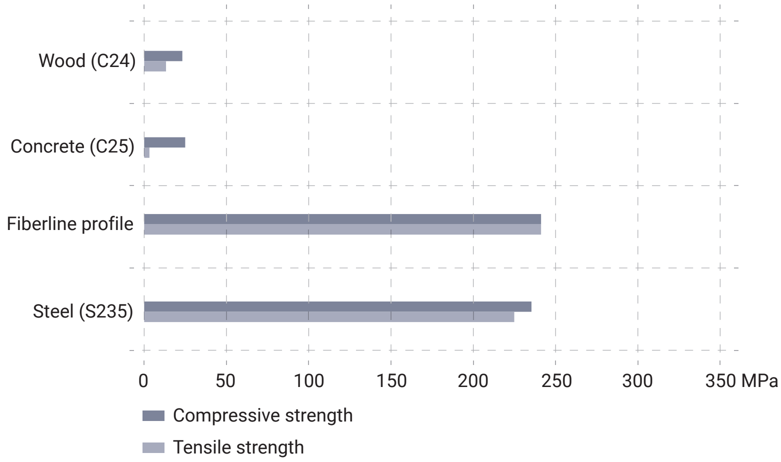
Ill.43: Material compositions

MATERIALS

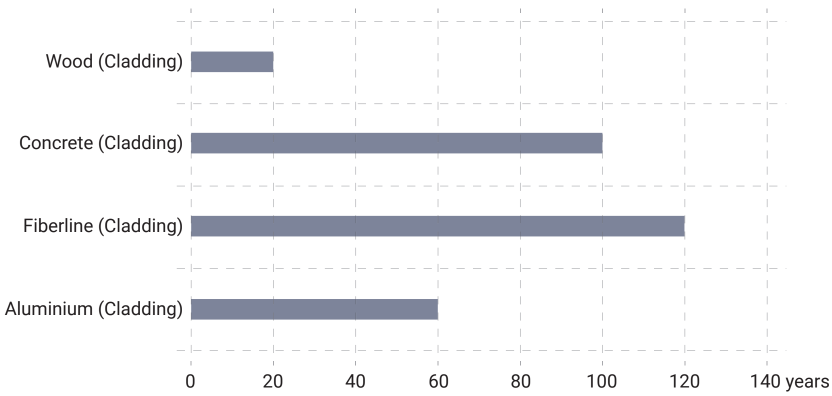
Density - structure



Strenght - structure

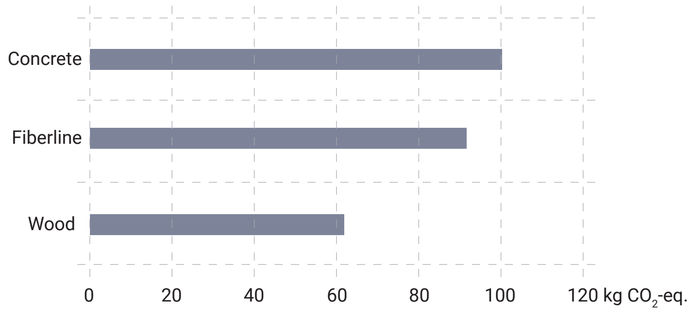


Durability - cladding



MATERIAL COMPOSITIONS

GWP



Ill.44: Comparison of materials and compositions

THE COMMUNITY

THE AUTHORITIES

The development of the coastal area surrounding Vorupør and neighbouring cities of the northern west coast is no new trend. For many years local zealots have pushed forwards for positive change, and since the early 2010's the municipality has been an active participant in the movement. In recent years, the 'Visit Northern Jutland' corporation, in collaboration with Thy Tourist Association and Thisted Municipality carried out the development of multiple projects revolving around the cities of Klitmøller and Vorupør. The goal of the projects was to create experiences and ideas that could promote and attract more high-consumption guests to the area (Cold Hawaii Rådet 2019).

In 2019 Thisted municipality continued this progress and joined forces with the foundation of RealDania and the office of Arkitema Architects to conduct a further detailed development plan for the area, mainly focusing on Vorupør and Klitmøller yet again. This time also highlighting the differences of the cities, with Klitmøller having the centred focus on the water sports, and Vorupør engaging with a broader profile. The plan further focuses on extending the season of activity and adding to a more vibrant urban environment, for the benefit of both visitors and locals. This has since then led to the architectural competition and later build of the new National Park Center of Thy in Vorupør, setting the precedence for a new architectural style and further development of the area. (Thisted Municipality 2020).

Thus, National Park Thy and a number of other initiatives, has played and will continue to play a role in Thisted Municipality, in addition to agriculture, fisheries, and industry, among others and through these initiatives also make an active effort to promote local community and culture, in addition to the nature-based attractions. An increasing part of the work has already taken place and is happening across disciplines, where the municipality, state, and local actors come together to develop and complete projects. The starting point has been and continues to be, the geographical location and the potential it has.

THE SURFERS

Surfers see themselves as part of a big community where they all have a common goal on getting a good wave. They feel the social part and the community is a big part of being a surfer. Surfers think of themselves as environmental conscious and think about the environmental part of surfing. Surfers contributes to beach clean-ups, in a way to help the environment. This is because of they see it and are reminded constantly about the problem. A Norwegian study about their local surf culture states that 69% of the surfers clean beaches (Langseth & Vyff, 2021). These clean-ups are seen in many places from Nørre Vorupør in Denmark (Strandet, n.d.) United Kingdom (Surfers Against Sewage, 2022) and in the Philippines (4ocean, 2022).

In Nørre Vorupør, the firm Strandet are arranging the clean-ups of the beaches. They have made a business creating accessories out of the gathered plastics and educating both companies and people about the plastic problem and the possibilities of reuse. They state their mission as:

"Holding the beaches along the Westcoast clean for plastic and create focus on plastic pollution locally as well as globally" (Strandet, n.d.)

Ill.45: Road sign of Nørre Vorupør

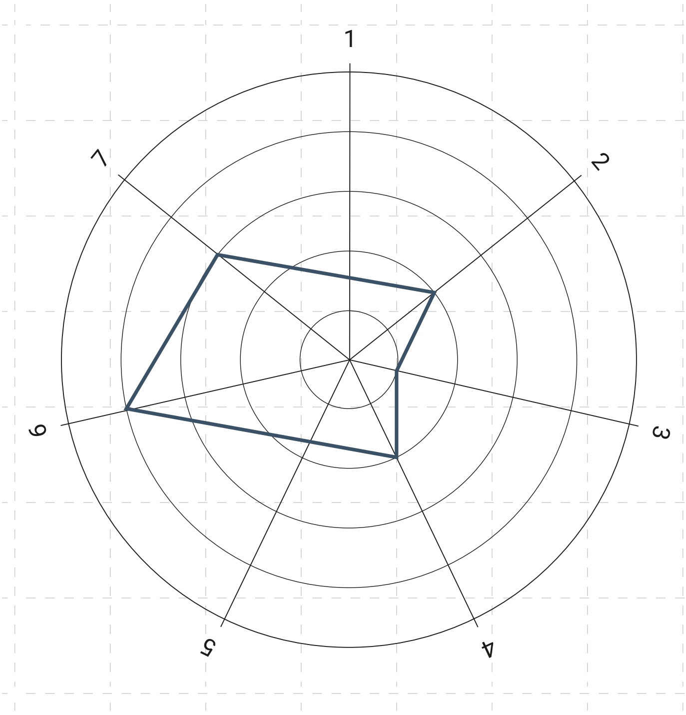
The surf mentality is known for a submissive approach to nature and a mindset revolving around catching the perfect waves. The commitment of the surfer is outstanding, and these people often tend to relocate from cities to coastal areas and take devoted breaks in their everyday life in order to improve the possibility of ideal surfing conditions. This is especially seen in the countries known for their great and steady quality of surfing spots. It is also a rising trend in the area of Cold Hawaii, although the changing quality of the waves, might require the practice of techniques to be done on land. In brief, most surfers are living by a mantra in which surfing is the highest priority and daily routines have to be adjusted to the ocean, wind and waves (Jørgensen 2022).

THE LOCALS

Nørre Vorupør is, as mentioned earlier, a small coastal village that have its cultural heritage in the fishing tradition of the 1960's. Today, only a minority of the population are these fishermen and their families while in recent time the population is growing towards a new diverse constellation of people, ranging from the locals born and raised in the area, to newcomers, mainly relocating from the larger cities of Denmark to get back to basics and live in close connection to nature and the sea. There is a strong community feeling in Nørre Vorupør and most of the newcomers are families with children that flees from the rush of the everyday life in a vivid city revolving around career to gain independence through start-ups and entrepreneurship. This, in order to settle down and be able to utilize the possibilities of nature and the sea, especially with regard to surfing.

Indeed, a setting like Nørre Vorupør provides not only pleases the locals in the community. The western coast of Denmark is one of the most visited tourist areas in the country meaning hundreds of thousands of tourists are visiting the area throughout the year. In one perspective it is the livelihood of the locals, though in another it is simultaneously the greatest burden for them, because the state of the everyday life is changed from the silent and idyllic to high-pace, tourist oriented living situation. In this case, the locals are desperately in need of a refuge from the tourists in which they can take care of the interests of the community (Jørgensen 2022).

USER GROUPS

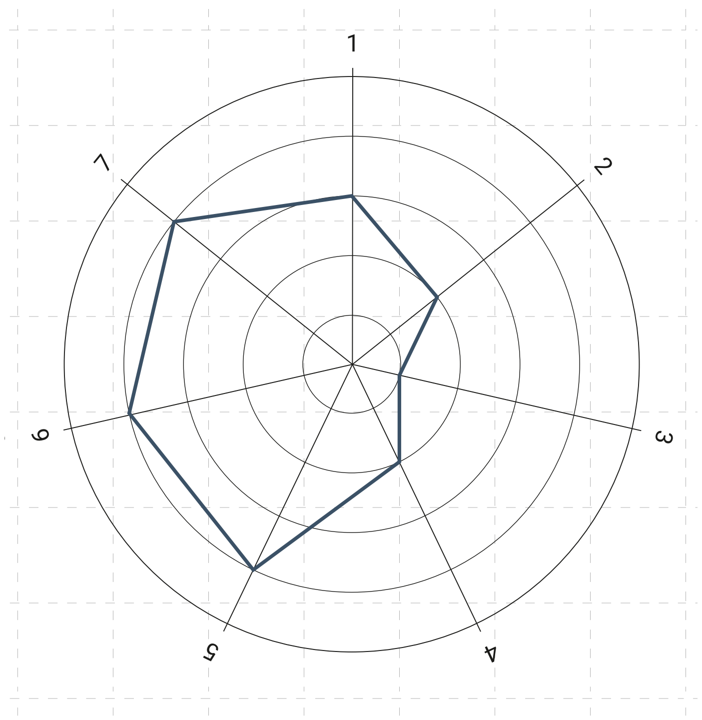


Ill.46: Current evaluation

To best orientate and specify the approach and implementation of the chosen topics of sustainability and plastic-waste, studies of user groups of certain locations and associated function as well as the general tourism trend of the Cold Hawaii coastline can be applied to inform upon usage and target user groups of Hawstok.

TOURISM TRENDS

As tourists, as well as locals, slowly realise the distinctiveness, and potential of the Cold Hawaii coastline, more of them come to the area to take part in the activities offered by the sea and cities nearby. This is a new but apparent trend which has become more noticeable in the numbers of commercial overnight stays in the area, rising alone from 2017 to 2019 by 9%. This development confirms that the planning and work done to enhance the outdoor and experience-oriented tourism of the area over the last 10-20 years has worked. To further continue with this trend, the municipality continues to aim towards a high-quality development in harmony with nature, landscape and local distinctiveness through long-term projects and a wider range of accommodation and experience-oriented offers. Nature tourism and sustainability as megatrend has therefor become the driving force of the municipal profile and provide ample possibilities to be exploited in different ways. The 6 towns down the Cold Hawaii coastal line continue to provide something different - they are each unique to their own setting and identity, but together they create a varied whole for several target groups. Together residents, businesses and tourists can benefit from each other as they use some of the same facilities and same infrastructure across a multitude of offers (Thisted Municipality 2020).



Ill.47: Target evaluation

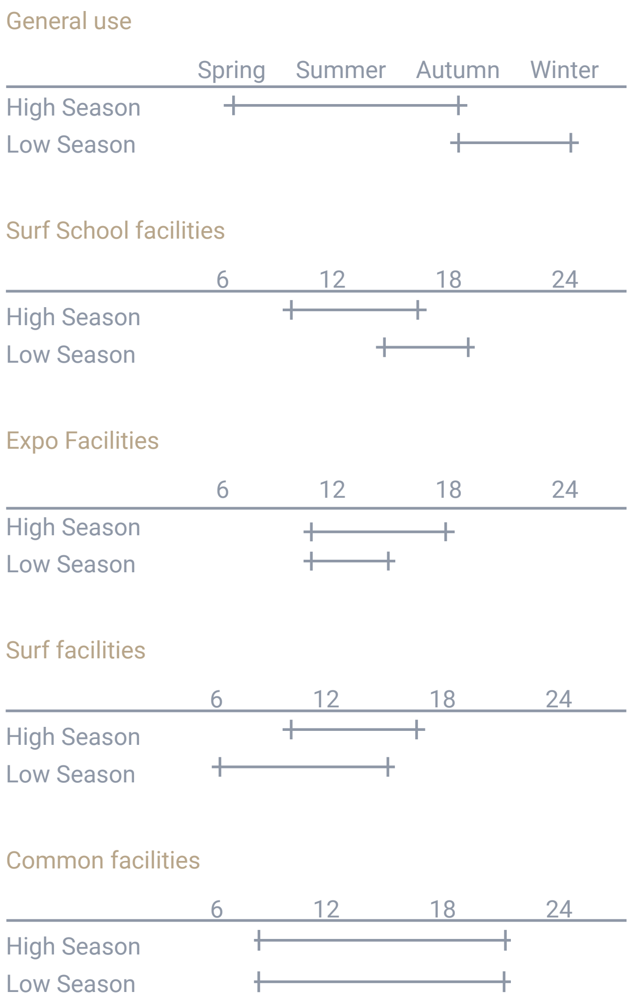
1. Sights & activities
2. Shopping & food
3. Coastal culture
4. Local charm & values
5. Life at the beach
6. In harmony with nature
7. Active togetherness in nature

TARGET GROUPS

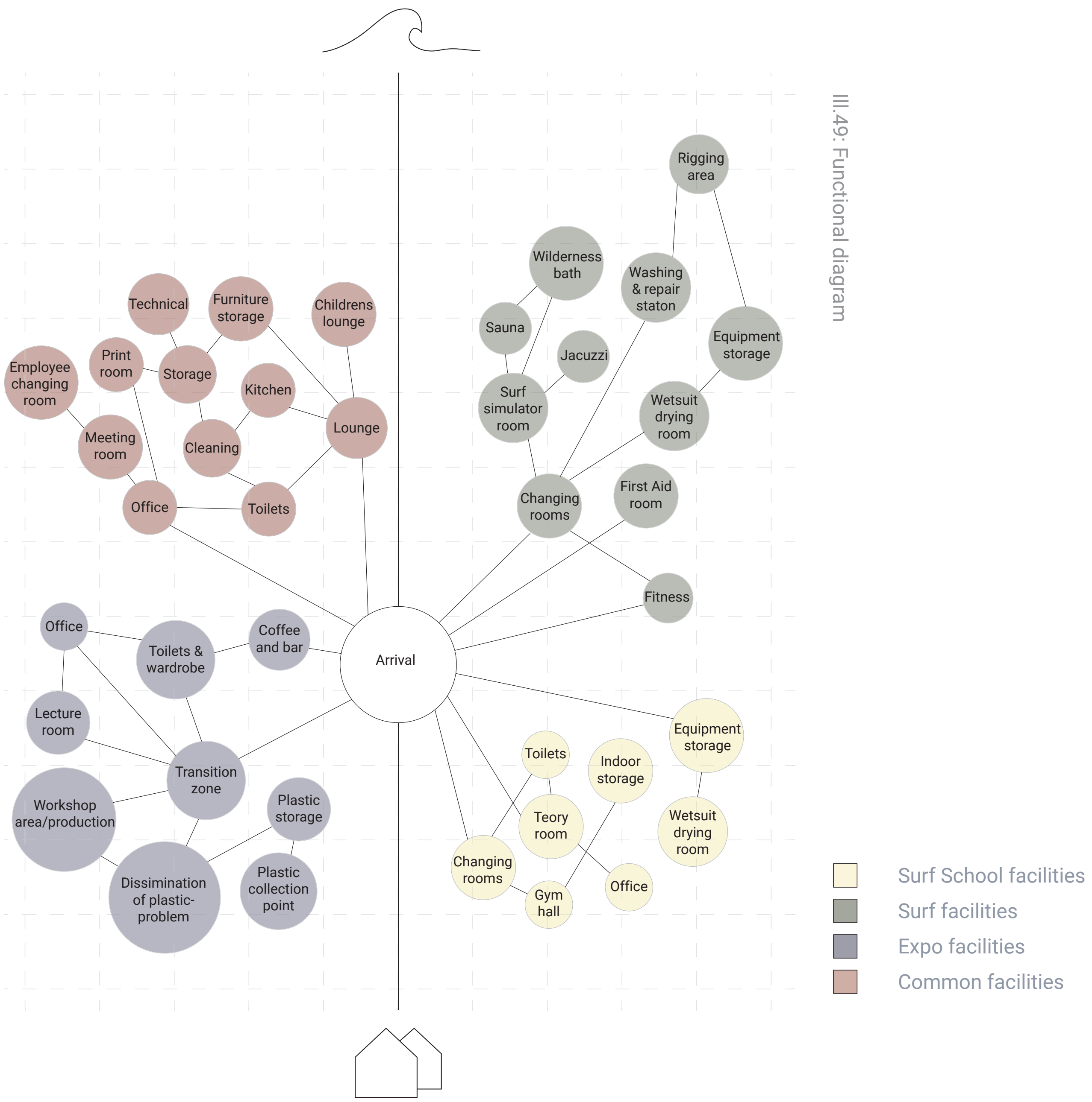
With knowledge gained from the preliminary studies of the area, along with the theories and investigation of tourism, the users and user related function are defined based on the local development plans of the area, concluded potentials and quantitative data of tourism in Cold Hawaii – specially in Nørre Vorupør. In general, the tourists of the Nørre Vorupør are visiting the area because of the nature and sea-based activities. Compared to the surrounding cities, Nørre Vorupør offer unique opportunities of being active in close relation to the nature and generally being in nature and experiencing the simple lifestyle that adapts to it in the area. Furthermore, as seen on ill. 47, the tourists are currently not weighting the beach-related activities that highly – meaning that the potential of increasing the surfing awareness for the tourists can be a valuable goal to outline the activities and nature-based potentials of a visit to Nørre Vorupør. By appealing to a new potential group of tourists the activity in the area will increase and the tourist season can be extended further than it is at present. In correlation to the water-based functions and the expanded focus on the sea, a possibility also arises to inform upon the sustainability crises the world and especially the sea is experiencing, though a knowledge centre revolving around plastic waste and the issues and potentials of this. This would presumably also appeal to a broader tourist segment and attract existing visitors along with other parties who might also be interests in the subject – both regarding the general population, students, professionals etc.

USAGE

Since the centre is going to be placed in the transition zone between sea, dune and city the building aims to embrace a variety of different usage targets facing the elements of the nearby context. Towards the sea, the functions will revolve around the closeness of the water for the surfers and the great views for the community functions, while the pull of the exhibition will be placed towards the city. The centre is used throughout the day and seasons, where the different functions are used at different times giving life to the city all year around.



Ill.48: Usage diagram



Ill.49: Functional diagram

05 SUMMARY

Analytical conclusion
Schedule of accomodation
Design drivers
Vision

Ill.50: Arterial roa d of Nørre Vorupør

ANALYTICAL CONCLUSION

As stated, waste in the environment is one of the biggest problems, allowing us to work with both the plastic waste of different industries and create a more sustainable building industry. This will be done by working with a New Danish Contextualism that is built on multiple aspects.The building will be designed with different users in mind, creating an environment both for the locals, surfers, and tourism, ensuring urban life in multiple seasons.

The focus of the design development will revolve around climate mitigation in lowering energy consumption and climate adaptation in the rising plastic waste problems by incorporating recycled plastic materials from decommissioned wind turbine blades lowering the environmental impact on the climate and giving unique properties to the building.

As the ocean level is expected to keep rising and the beach erodes away, the building should be designed, adaptable to the changing landscape. The landscape rising towards the coast on the site create opportunities to work with the curvatures of the landscape and create a building that can enhance this. The building design should therefore be inspired by the strong western wind used as a form giving tool, thereby creating a building that is rooted in the local environment and creating spaces that are comfortable doing strong winds. The nature of the site provided different patterns that will be integrated into the design, making a design that's rooted into the local environment in a different way. Last, but not least, the building should aim to encompass the main user groups of surfers, locals, and tourists to ensure a flexible use of the building.

FUNCTION (-)	QUANTITY (-)	SIZE (M²)	TOTAL SIZE (M²)	CEILING HEIGHT OVER UNDER 3 (M)	NOTES
Surf School					
Theoretical classroom	1	50	50	Under	
Physical classroom / Gym hall / Event space	1	200	200	Under	Should be able to be rented by locals after hours
Indoor storage	1	20	20	-	
Office	1	15	15	Under	2-person part time workstation
Wetsuit drying room	1	15	15	Heated	
Equiptment storage	1	30	30	Unheated	

Surf Facilities					
Changing rooms	2	40	80	Under	Incl. bath, wc and lockers
Sauna	1	20	20	Under	Unisex
Surf Simulator room	1	300	300	Over	“Wet-room”
Wetsuit drying room	1	15	15	-	
Fitness	1	100	100	Under	Accessible to all public
Surf equiptment storage	1	50	50	-	
First Aid room	1	15	15	Under	
Shapers bay / repair station	1	60	60	-	
Washing/repair station	1	60	60	-	Incl. outdoor shower for quick rinse
Rigging area	1	-	-	-	Near the beach

The following schedule of accommodation, showcase the initial functions chosen for each user group. The mentioned functions and sizes are to be seen at estimations and guidelines to support the further work of the design development, ensuring that the final design live up to the goals of the framework of this project.

SCHEDULE OF ACCOMODATION

Community facilities					
Lounge/event room	1	100	100	Heated	Possibility to close off for private events and open up for public events
Childrens lounge	1	30	30	Under	
Storage for lounge	1	20	20	-	
Toilets	3	3	15	Under	Incl. wardrobe space
Cleaning room	1	10	10	-	
Technical	1	50	50	-	
Storage for administration	1	20	20	-	
Staff meeting room	2	10	20	Under	
Office space	1	40	40	Under	
Staff printer room	1	10	10	Under	
Staff toilets and wardrobe	1	20	20	Under	
Connecting hallway area	-	400	400	-	

Interactive plastic expo					
Arrival hall / area	1	80	80	Over	
Workshop / production area	1	80	80	Over	
Auditorium	1	80	80	-	
Dissimination of plastic problem expo	1	450	450	Over	Separated in everyday- and ocean-plastics
Storage of plastic waste	1	80	80	Over	
Office	1	20	20	Under	
Toilets	6	3	18	Under	
Coffe-shop and bar	1	100	100	-	

Total area:	2643 m^2

DESIGN DRIVERS

AESTHETIC DRIVERS

New identity // By incorporating new methods of recyclability, without compromising on the site-specific characteristics, a new identity will be added to the area

Atmospheres // The use of different materials should reflect the material properties creating varying atmospheres

FUNCTIONAL DRIVERS

Access // Level-free access must be possible at all entrance points

User segments // To best increase the current visitor profile of Nørre Vorupør, a combination of surf-related, and plastic informational functions offer activities for both tourists and locals.

Functionality // Through a multifunctional plan the building should offer a flexible usage, fitted for different activities related to both tourists and community

Comfort // The site must be designed with a courtyard that's shields form the wind all seasons

SUSTAINABLE DRIVERS

Adaptation // The building should adapt to the harsh climatic environment of the site, by working with a durable façade material and a building design optimized for outdoor use as well

Mitigation // The building should comply with the Energy Framework and indoor climate levels of the Danish building regulation of 2018

Circularity // The recycling of plastic waste should be used as part of the construction of the building envelope

VISION

The vision of this thesis, endeavours to investigate the possibilities of transforming the global problem of plastic-waste, into the solution of the problem it-self. This is explored within a local context of the Danish west coast and a local issue of the disposal of decommissioned wind turbine blades. By mitigating and adapting to the problem of plastics in the world, a new building methodology can be created which utilizes the very high durability properties of the plastic waste to prolong the life of buildings in harsh environments like the one on the windy west coast of Thy. By creating a combined Surf and Plastics Knowledge Center, which can both support activities of the local community and inform upon the actions needed to tackle the plastic problem, it will then be possible to promote both a sustainable mindset and method, build upon the work of local zealots and hopefully for the inspiration of others. Lastly, a building like this will furthermore add another attraction to the current nature and surf-oriented activities, expanding the user profile and tourist season of the area.

06 PRESENTATION

Hawstok
Masterplan
Merging with landscape
An asset for the community
Plans
Interior comfort
Sections
A multitude of offers
Life Cycle Assessments
Construction
Ventilation
Indoor enviroment
Wind

HAWSTOK

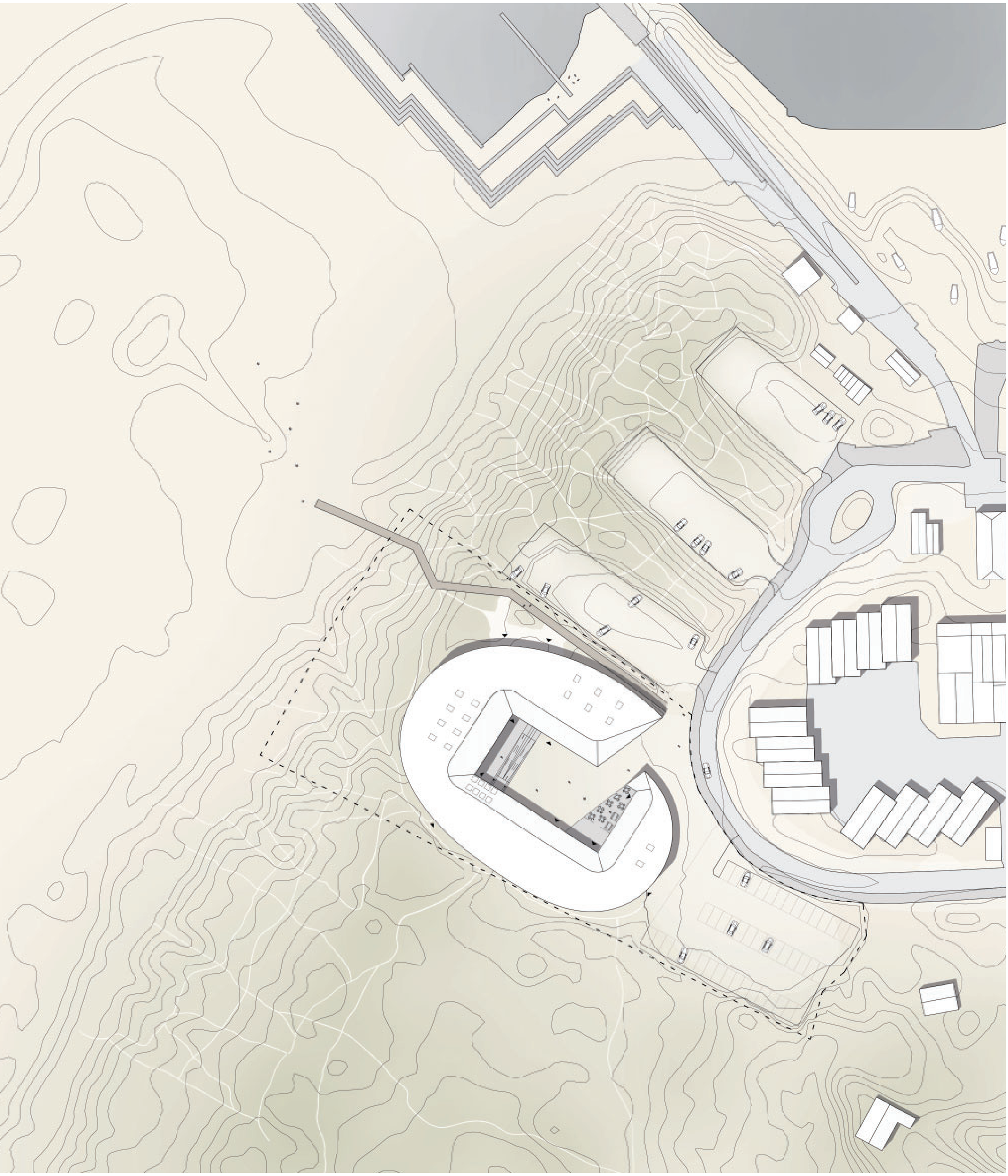
In the crossroads of where dune, sea and city meet, where winds determine rather you find yourself in the most peaceful or most hostile environment, and where the movement of sand, stone and grass is ever so enchanting, lies Hawstok. Within its hardened shell, made of recycled fiberglass from decommissioned wind turbine blades, Hawstok strives to set an example of how to innovatively reactivate the use of otherwise discarded plastic waste, through both its design and functionality.

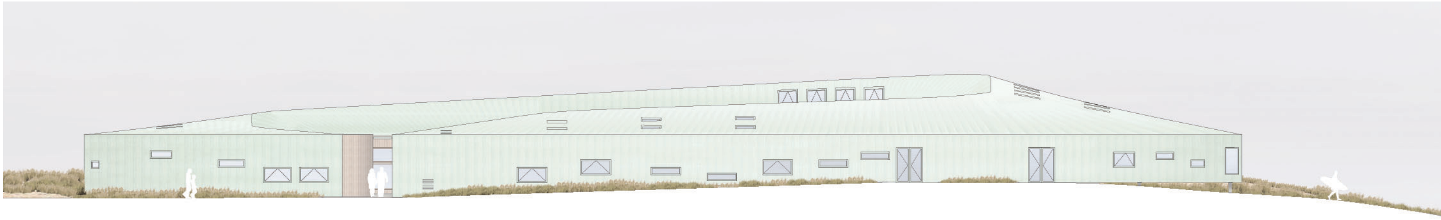
By opting for the use of materials, whose potential for recycling within the building sector has not yet been fully explored, the design of this building aims to showcase the aspects of a sustainable approach dealing with a current problem with existing materials, rather that the reduction of a future one, which still need the incorporation of new ones.

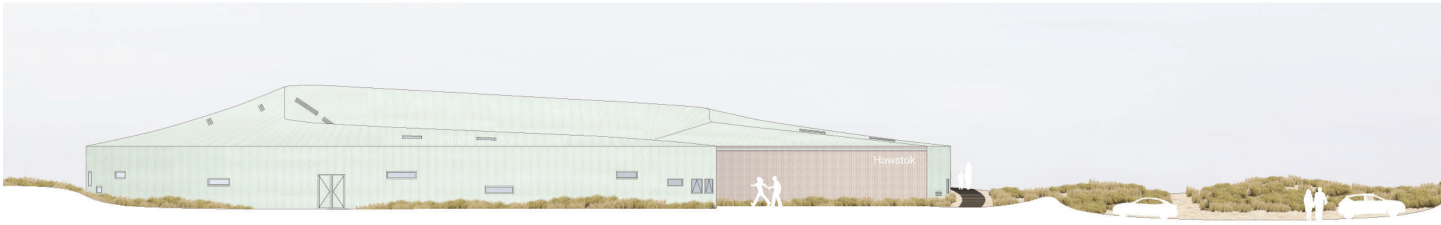
By the use of a wind-optimized elliptically shaped structure, the building furthermore, interacts with its context at all 360 degrees, and internally offer multiple uses to visitor and resident, supporting the growth of the great community qualities, both in- and out of tourist season.

Ill.51: Hawstok approached from the beach

Ill.52: Masterplan, 1:1500



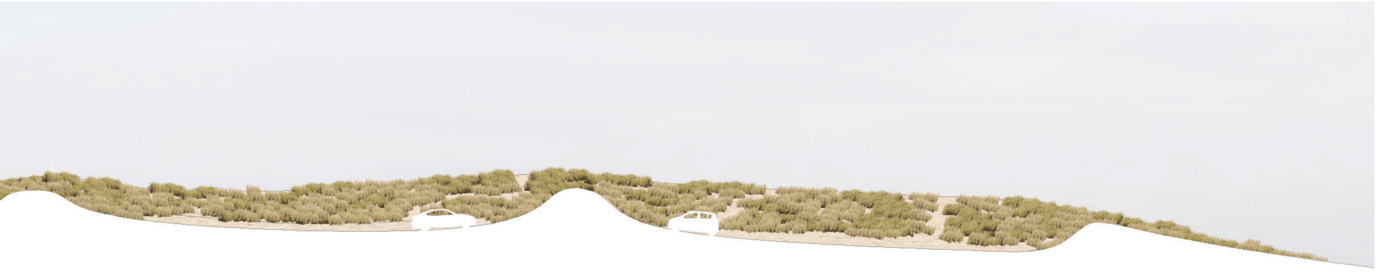




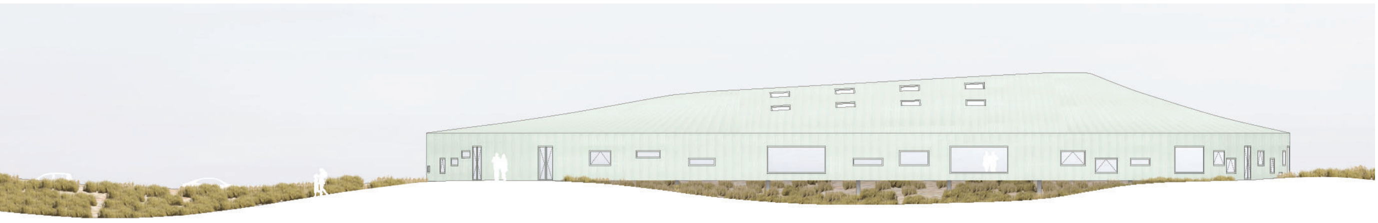
MERGING WITH THE LANDSCAPE

Located in the midst of shifting dunes, the building is placed on top of deep-reaching pillars to allow for the everchanging of the sandy landscape. Across the 200 metre stretch of beach the context slowly rises until transformed into grassy dune tops moving in the wind and shielding the city from the strong wind. Here the building tucks itself into the curves of the dune, mimicking their flat and steep, windward and leeward side shapes in the construction of the roof. As the dunes then fades and sinks into the flatness of the city, the floorplan of the building follows, conveying the movement to the interior experience through the flow and shifting room heights.


Ill.53: Elevation, north


Ill.54: Elevation, east

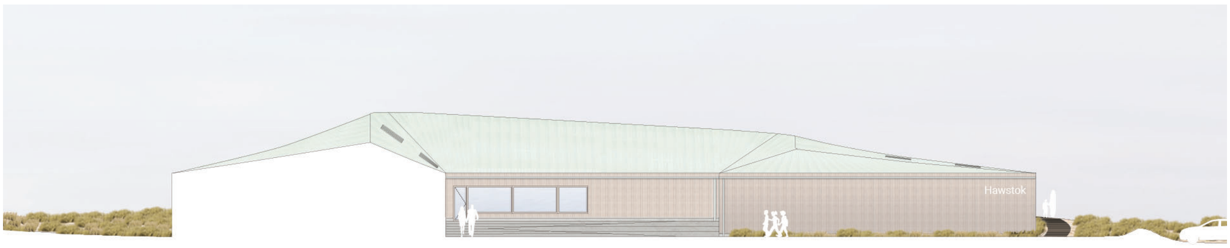

Ill.55: Elevation, south


Ill.56: Elevation, west

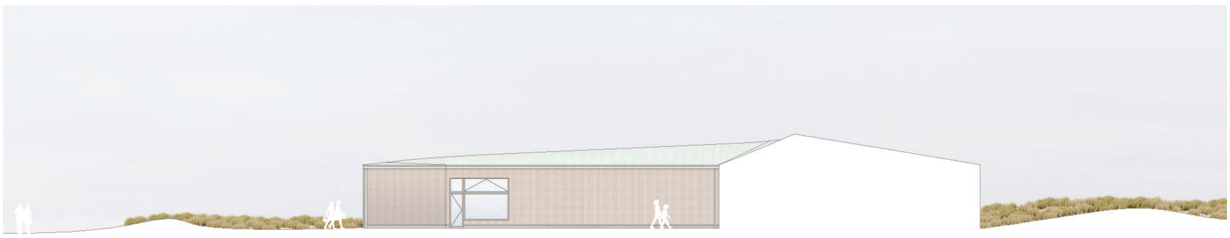
Elevations, 1:500

Ill.57: Elevation, north

Ill.58: Elevation, south



Ill.59: Elevation, east



Ill.60: Elevation, west

Elevations, 1:500

AN ASSET FOR THE COMMUNITY

To support a growth in the amount of urban life in the city, the building wraps itself around a courtyard, shielded from the heavy winds by the high-reaching roof structure. This protected oasis is fitted with wooden cladding to soften the atmosphere with natural warmth and texture compared to the hardened shell of the exterior fiberglass cladding. The 600 square metre courtyard offers a multitude of possibilities as a great gathering place, for the community life, which have not yet been an asset of the city.

Ill.61: Hawstok approached from the landing site

01	Café & shop (84 m²)	09	Cleaning (10-13 m²)
02	Restrooms (10-37 m²)	10	Technical rooms (28-33 m²)
03	Storage (12-80 m²)	11	Kitchen (19 m²)
04	Dissemination of the Everyday Plastic-problem (165 m²)	12	Lounge (123 m²)
05	Workshop area (87 m²)	13	Childrens Lounge (35 m²)
06	Dissemination of Ocean Plastic-problem (234 m²)	14	Wet room - surf simulator and jacuzzi (328 m²)
07	Arrival area (83 m²)	15	Sauna (20 m²)
08	Auditorium (86 m²)	16	Wet room - Equipment area (108 m²)

Ill.62: Plans, 1:400

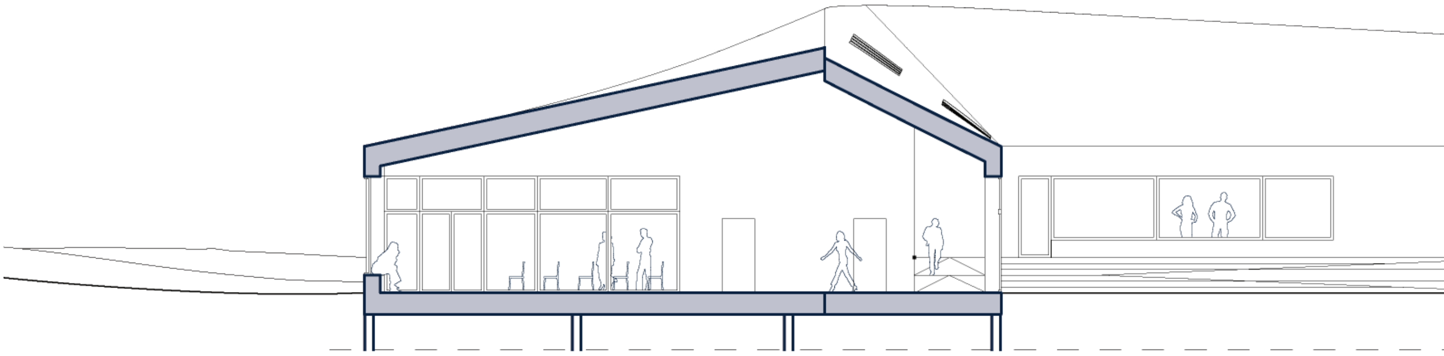
17 Changing rooms (45 m²)
18 First Aid (18 m²)
19 Shapers Bay workshop (52 m²)
20 Fitness (88 m²)
21 Activity space (203 m²)
22 Classroom (58 m²)
23 Meeting room (10-20 m²)
24 Office space (117 m²)

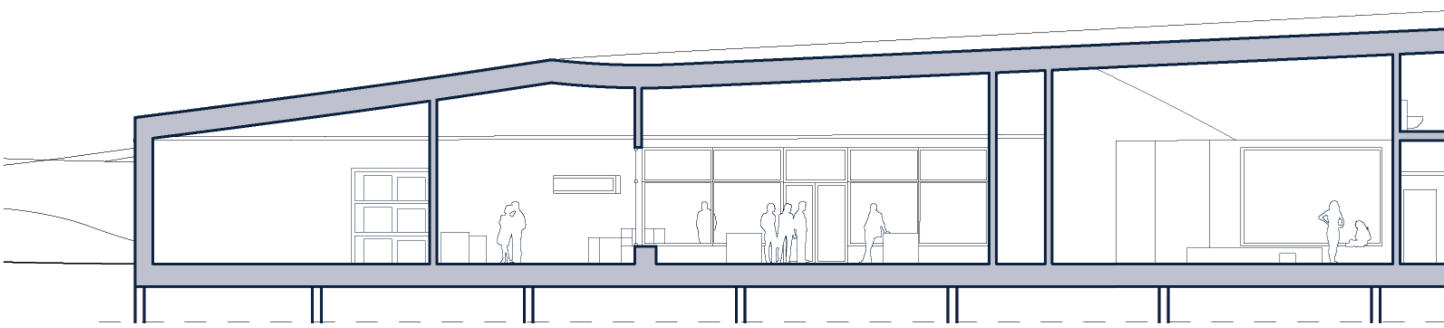
INTERIOR COMFORT

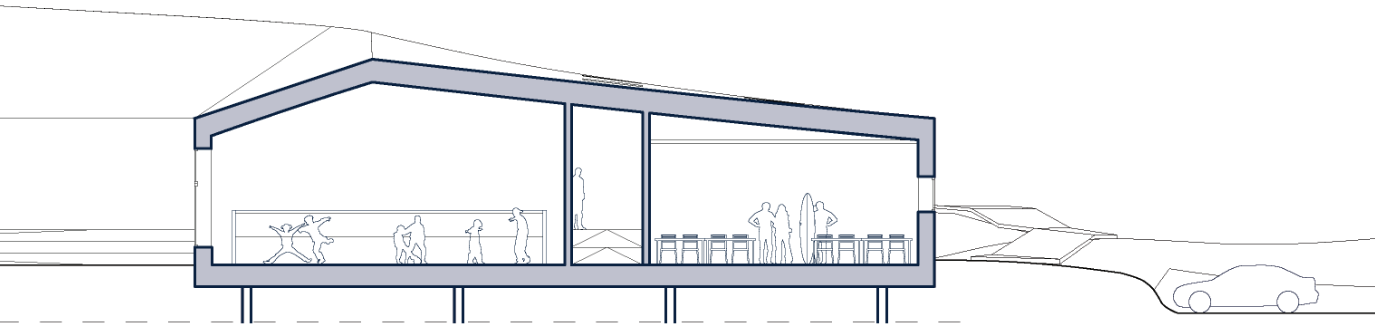
Inside the building, details of fiberglass and wood continue to convey the properties of the exterior facades. Fiberglass windowsills and construction showcase the plastic theme of the building, meanwhile wooden fittings transform the curtain walls of the courtyard façade into integrated furniture, providing spaces for immersion or rest.

Together with acoustic ceiling panels underlining the flow of the building, and the terrazzo-like concrete floor giving associations to the scattered pebbles of the beach, the material combination ensures a modern yet comfortable frame for the life which is lived within the space. This mixture of purpose and intent is also seen in the general functions of the building, welcoming four different user groups into its space, mixing young, and old, locals and visitors, inspiring both a heightened social and environmental consciousness after a visit to Hawstok.

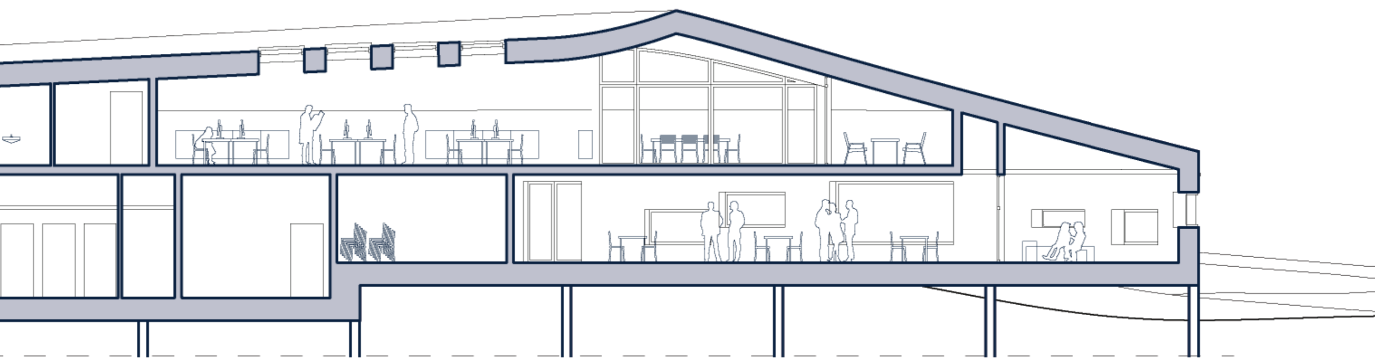
Ill.63: View from hallway are towards the surf simulator







Ill.64: Section AA



Ill.65: Section BB

Sections, 1:300

Ill.66: View through the disimination centre

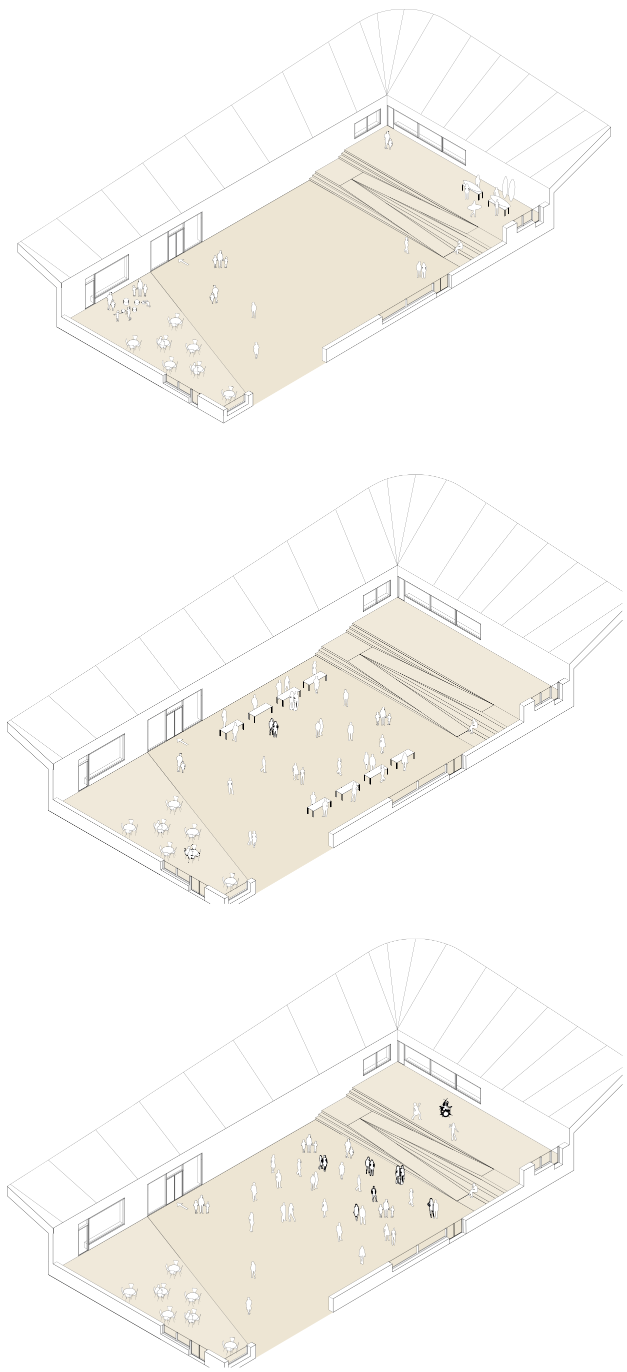
Presentation

A MULTITUDE OF OFFERS

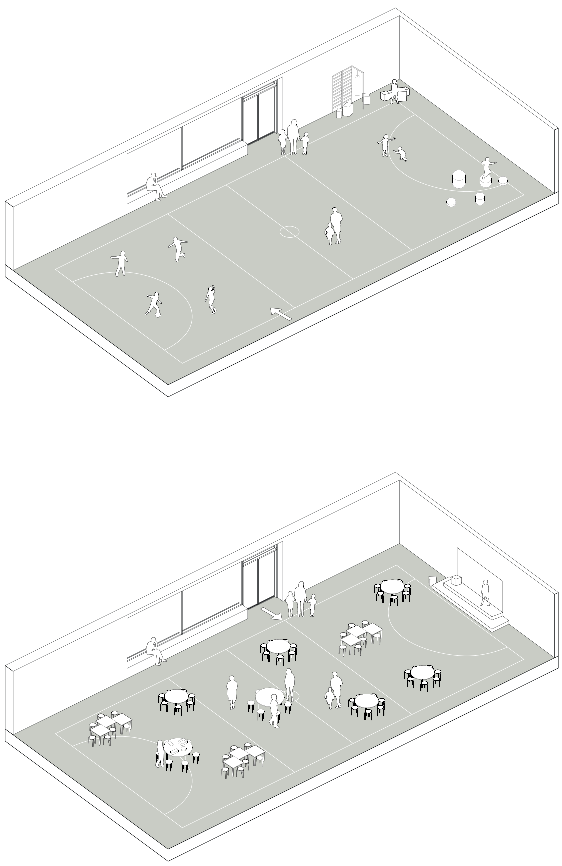
With the intent of the building to span upon a broad user profile, multiple spaces are designed with a flexible use in mind. As a gathering space for the whole community, the courtyard is furnished to a minimum to leave room for informal meetings in the everyday, or larger gatherings for event when needed. The terrace in the south of the courtyard can support both activities of the workshop or beach clean-ups, as well as provide a nice service area to the coffee shop and bar. To the same extent, the raised deck of the north of the courtyard, support outside workspace for the tinkerers of the shapers bay, as well as a great seating area on the stairs or the use of the deck as a great speaking platform for gatherings or intimate concerts.

In close connection to the courtyard, the entrance of the activity space can be shifted from internal to external to support both everyday sports facilities and extraordinary events needing its own entrance in connection to activities going on in the courtyard.

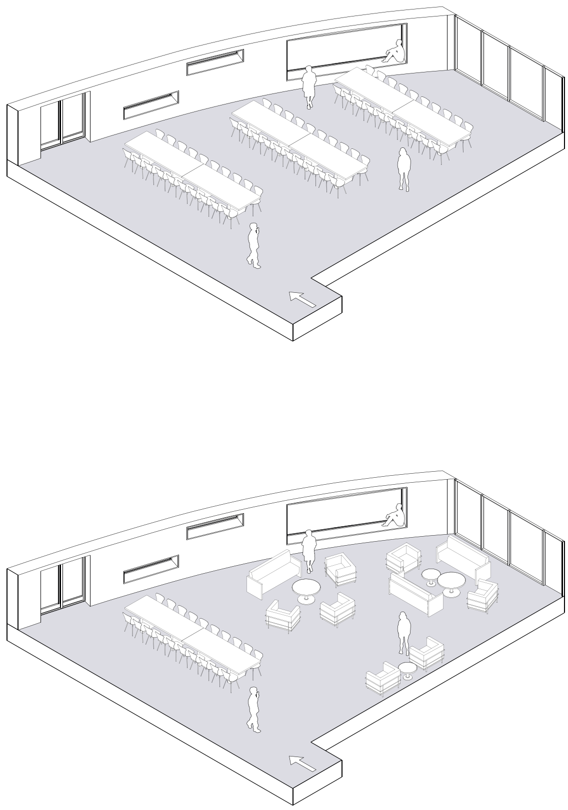
To the same notion, the lounge area also offers a multifunctional use, embracing all of the local community. Within the hours of a normal workday, the space can be used as a gathering spot for local clubs or a comfortable break room for the office workers of the second level of the building. By night or weekend the space can be transformed into a comfortable space to gather for social community dinning, parties or smaller community events.



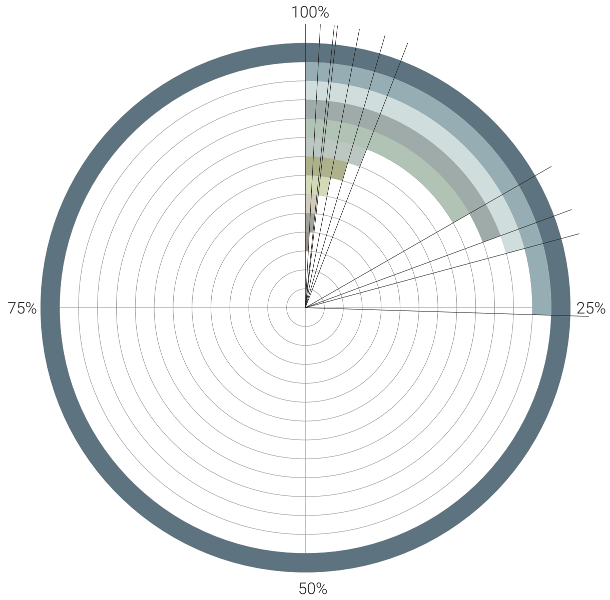
Ill.67: Scenarios in the courtyard



Ill.68: Scenarios in the activity space



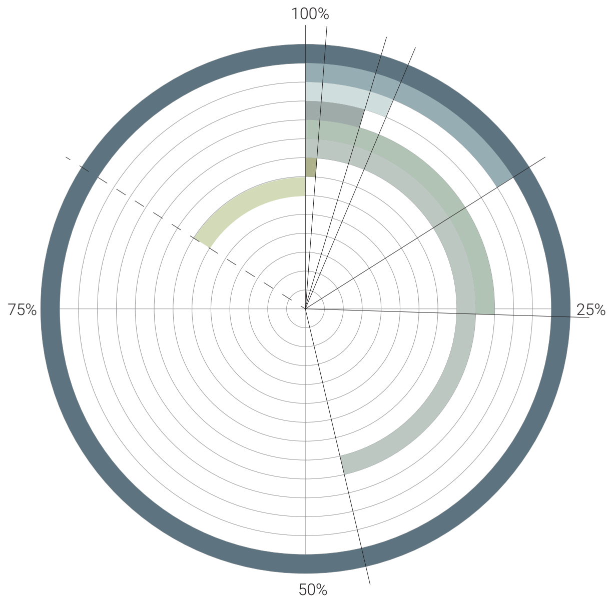
Ill.69: Scenarios in the activity space



Building parts

■	Total GWP score	(100 %)
■	Groundfloor deck	(25,77 %)
■	Operation	(21,23 %)
■	Roof	(19,53 %)
■	Remaining	(16,67 %)
■	Outer walls	(5,09 %)
■	Doors & windows	(4,50 %)
■	Inner walls	(2,99 %)
■	Foundational pillars	(1,89 %)
■	Beams & columns	(1,54 %)
■	1st floor deck	(0,79 %)

Ill.70: Building parts distribution



LCA phases

■	Total GWP score	(100 %)
■	A1-3	(16,08 %)
■	A5	(6,32 %)
■	B4	(4,59 %)
■	B5	(25,48 %)
■	C3	(46,34 %)
■	C4	(1,20 %)
■	D	(-15,91%)

Ill.71: LCA phases distribution

LIFE CYCLE ASSESMENTS

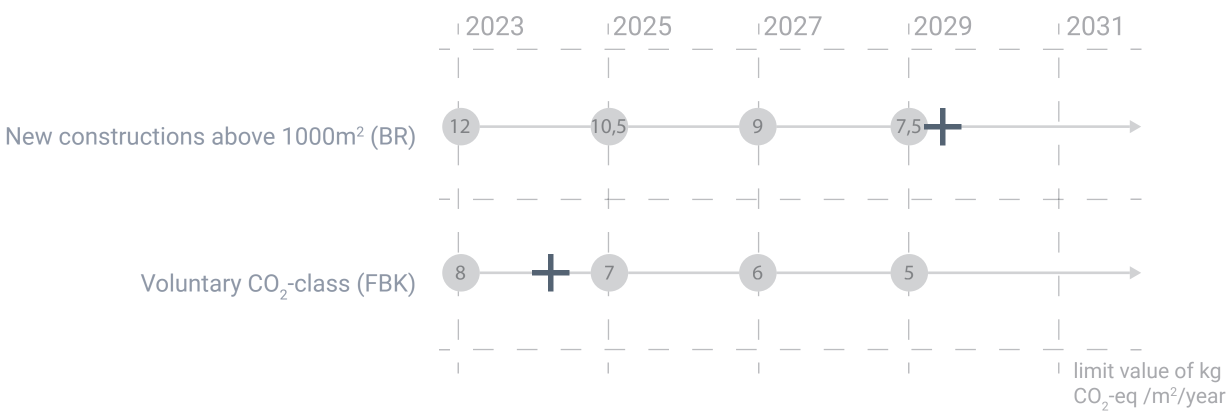
A Life Cycle Assessment of the final building design provides a holistic evaluation of the potential environmental impact of the building. As noted to the left, knowledge of given constructive elements have been included (App. 1), alongside the given key numbers of operation needs from Be18 (App. 3) and an estimate of the then remaining elements' impacts based upon the European LCA standards (DS/EN 15978:2012).

The total amount of environmental impact for the building design of this thesis, when looking only at the Global Warning Potential (GWP), results in a score of 7,40 kg CO_2-eq / m² /year. Compared to the same building structure before the use of recycled fiberglass, the result is 14% better, and compared to the building made of traditional concrete sandwich elements, the result is 25% better.
With a score of 7,4 kg CO_2-eq /m² /year, the building design of this thesis upholds the limit values of the Building Regulations of new construction above 1000 m² until 2031, and it upholds the limit values of the voluntary CO_2-class regulations until 2025.

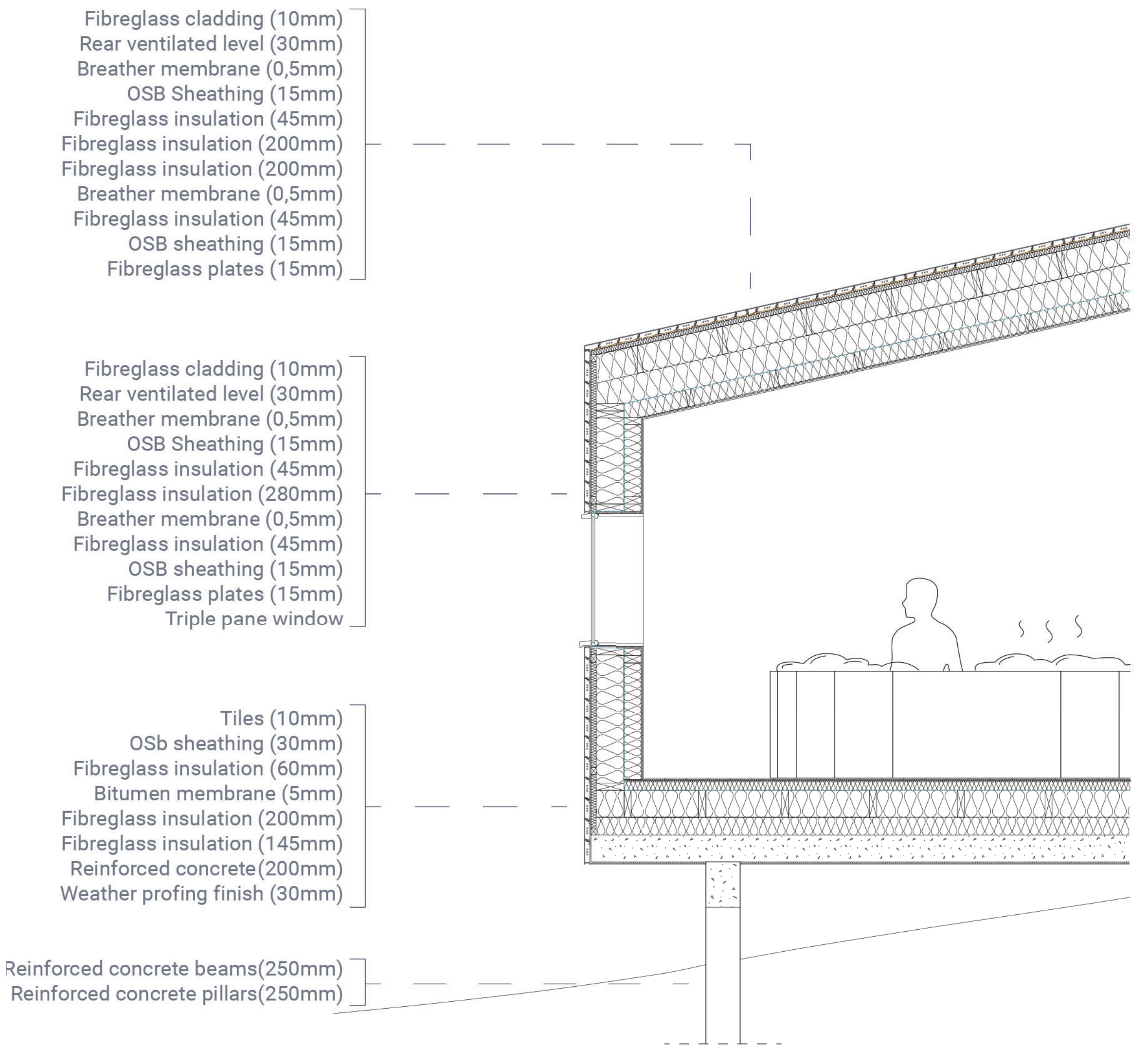
The greatest contributor to the total GWP score is found to be the structure of the ground floor deck at 25,77 % of the total score, followed by the impacts of the operation needs at 21,23 %. This is no surprise, since a big flat building like this requires a large amount of concrete for the deck and this design too brings a larger operational need, compared to a more compact building.

Looking at the phases of the LCA, the C3 phase is found to be containing the biggest impact. To the best of our knowledge this is the case, due to the big amounts of wooden support structures used in walls and roof, which when the end-of-life and end-of-waste state is reached, is expected to go through a certain procedure of waste processioning with the intent of either reuse, recycling or energy recovery (DS/EN 15978:2012).

	With recycling	Without recycling	In concrete
kg CO_2-eq /m²/year	7,40	8,55	9,96



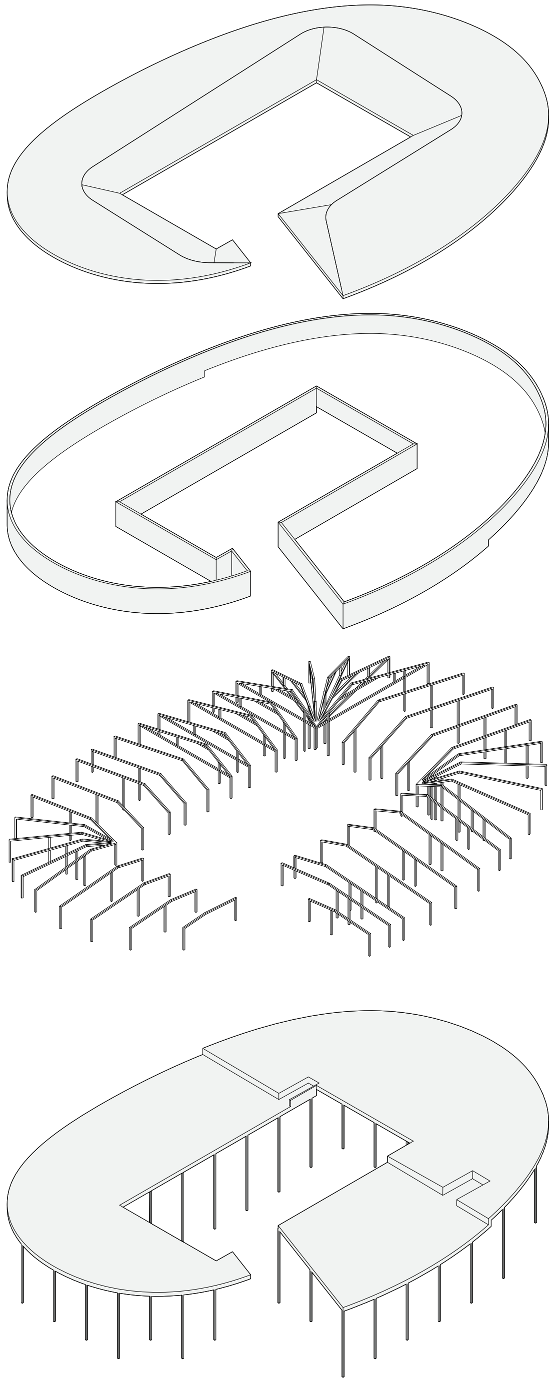
Ill.72: Environmental classes



Ill.73: Detail section , 1:20

CONSTRUCTION

The load-bearing structure of the building is made entirely of fibreglass profiles supported by wooden structures and insulated with 50 precent recycled fibreglass insulation, to uphold the total building energy frame and provide a comfortable indoor climate. By choosing materials depending on their properties, fibreglass has also been used as cladding on the exterior facades facing the context, and wooden cladding of oil-treated pine has been used on the exterior courtyard facades. Most of the 20 by 20 cm fibreglass frame structure is hidden in the depth of the 450 mm building envelope and 650 mm roof structure, and have been optimized to withstand the stresses caused by both internal and external loads (App. 2). To provide a steadfast base of the building, a concrete slab-based foundation of 650 mm and underlying concrete pillars, in a six-by-six metre grid, have been used, to allow for the everchanging surrounding landscape to keep moving, without compromising the building in the future.



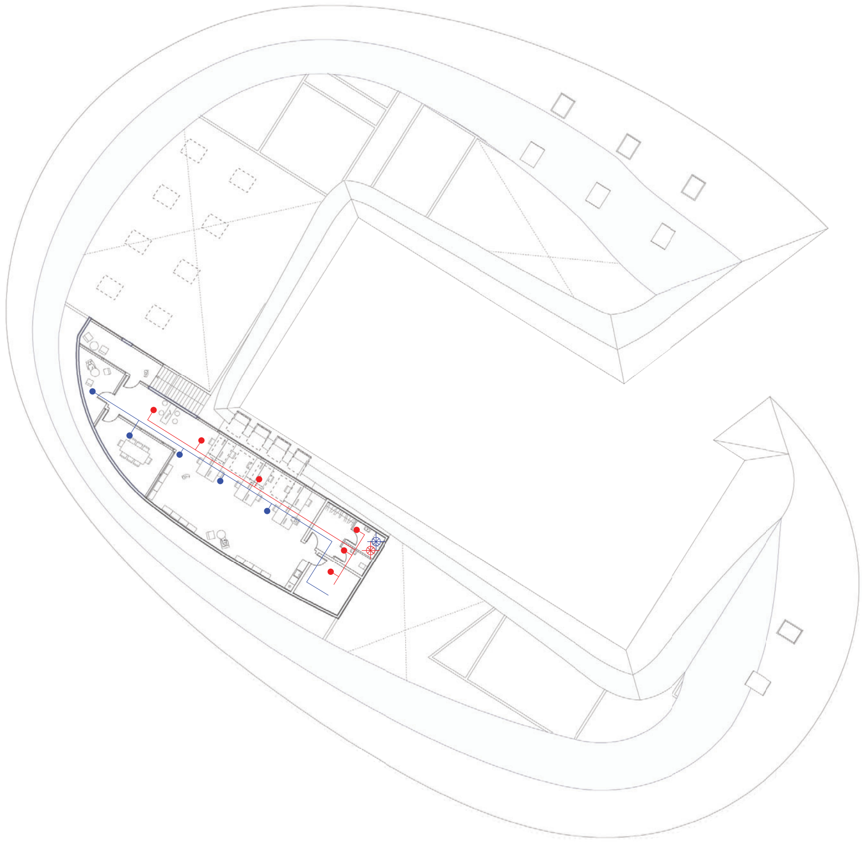
Ill.74: Exploded building

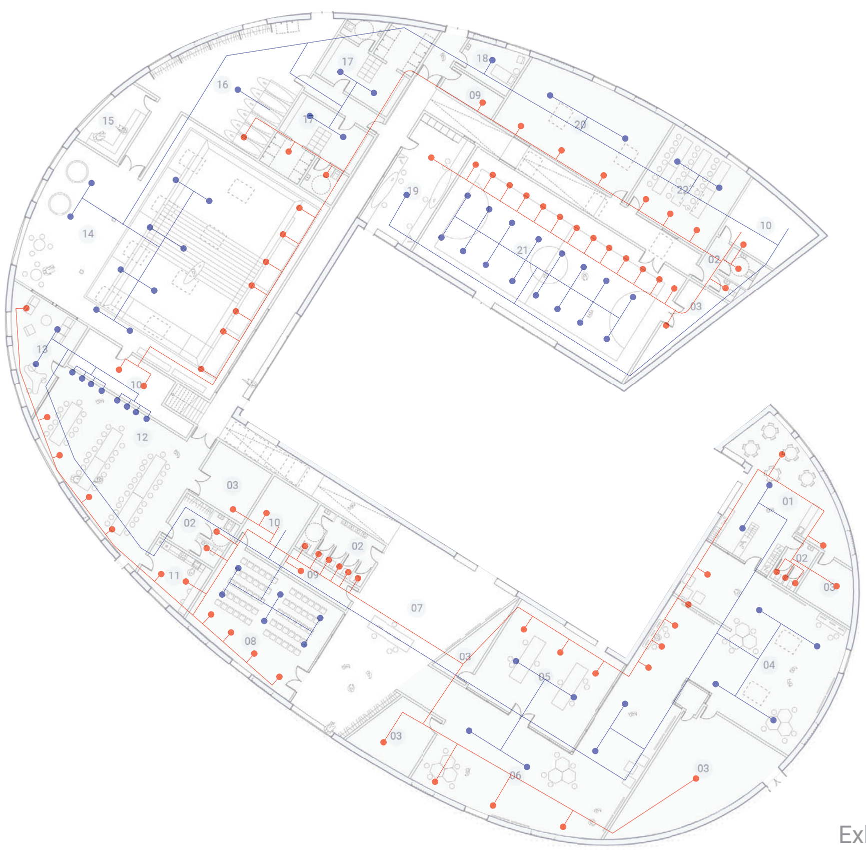
Key numbers	kWh/m² year
Total Energy frame	29,5
Heating for operation	24
Electrics for operation	3,9
Excessive in rooms	1,3

VENTILATION

To support a comfortable indoor climate, mechanical ventilation is included to support the possibility of natural ventilation, ensuring the regulations and comfort levels are met. Where the roof shape provide an acceptable room height, a 1st floor office is included. Where the slope is too flat for such a purpose, a lowered ceiling has been implemented to hide away the ducts, only leaving the systems visible in the rooms requiring a taller room height, such as the wet-zone and activity space. To minimize the length of the ducts, and thereby the pressure losses they provide, two separate aggregates have been placed in different areas, both as VAV systems providing mixed ventilation to all rooms. The placement of the ducts has strategically been developed to bypass the hallways, ensuring the quality of the heigh ceiling and unique roof shape in these areas (App. 4).

Key numbers	Aggregate 1	Aggregate 2
Total Airflow	10264	12338
Supply pressure loss	279,5	152,7
Extract pressure loss	153,7	131,3
SEL	1,75	1,48
Biggest pipe diameter outside of techical room	630	630



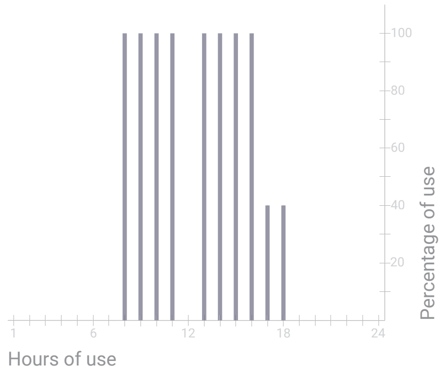


Exhaust air
Supply air
Lowered ceiling

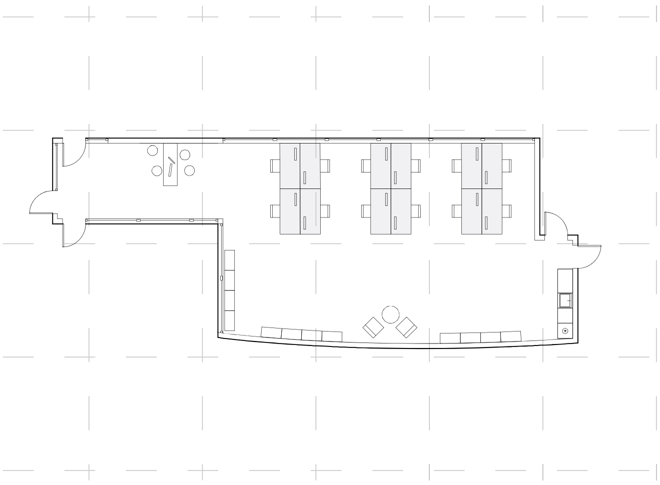
Ill.75: Conceptual ventilation diagrams

INDOOR ENVIRONMENT

OFFICE

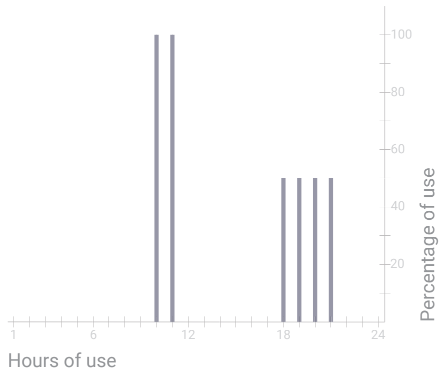


Ill.76: Dayprofile, office

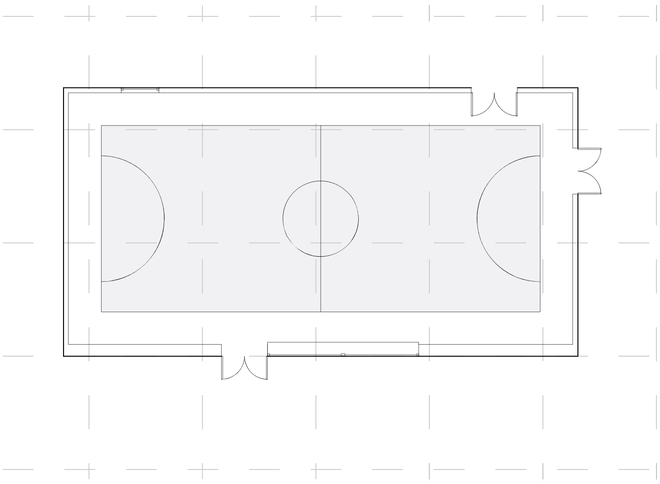


Ill.79: Situation, office

ACTIVITY SPACE

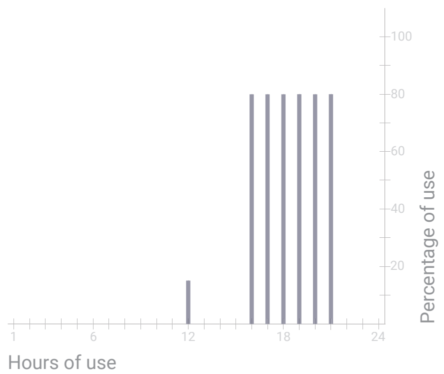


Ill.77: Dayprofile, activity space

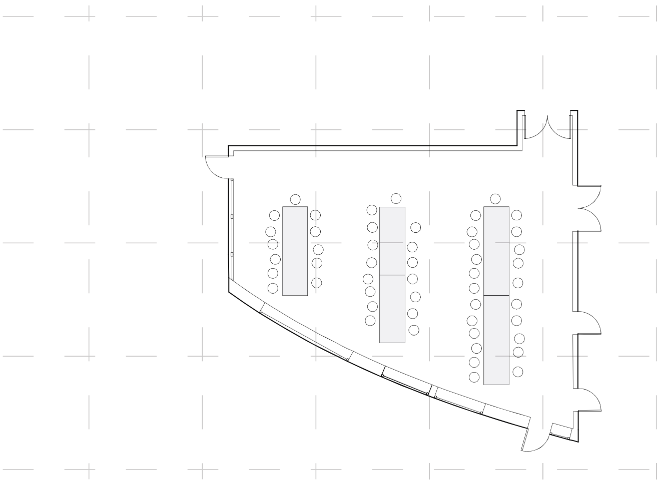


Ill.80: Situation, activity space

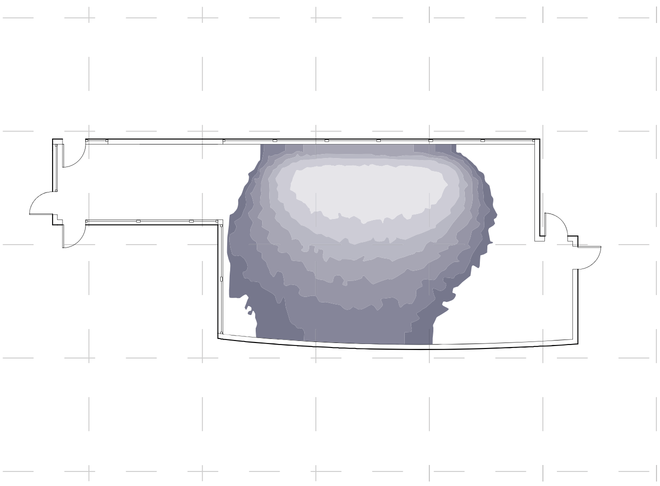
LOUNGE



Ill.78: Dayprofile, lounge



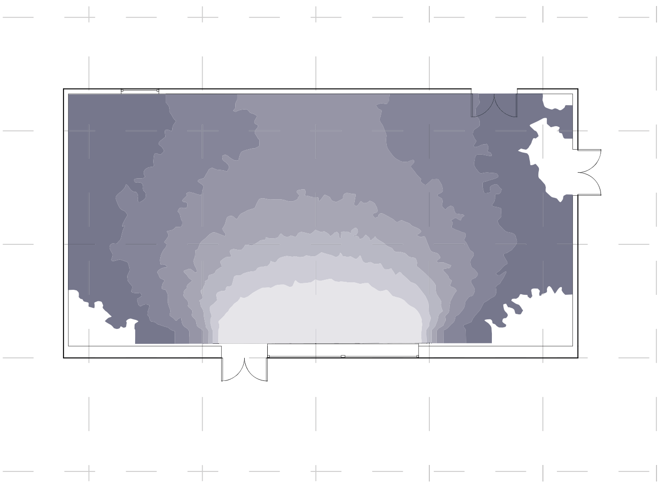
Ill.81: Situation, lounge



Ill.82: Daylight, office

The north facing skylights of the office are situated above the desk space, providing great conditions for screen work. The daylight results comply with the conditions of 300 lux in 50% of the daylight-hours, in 50% of the working area, as required by the DS/EN 17037. The air quality of the room, stays between 430 to 450 ppm, as recommended by DS/EN 447. The mean temperature of the different month in the office is under 23,4 degrees Celsius, complying with the regulations of DS/EN 474.

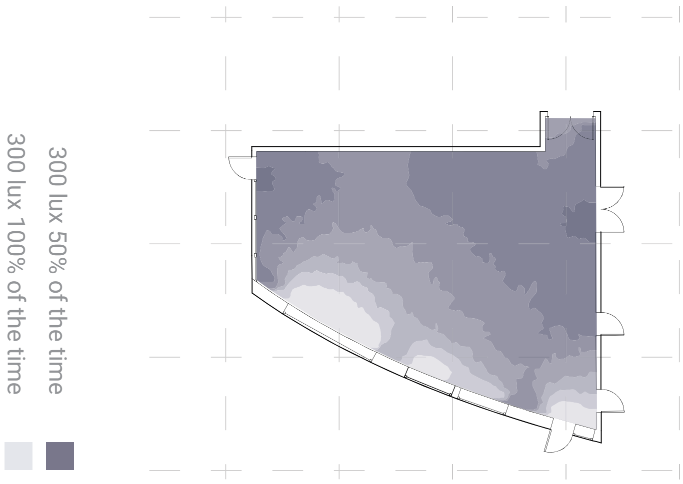
Hours > 26	12
Hours > 27	0



Ill.83: Daylight, activity space

As the activity space is placed in the northern part of the building, big windows are situated to the south, providing great daylight inside the Activity Space securing 300 lux in 50% of the daylit hours in most of the room. The operational temperatures are kept at a mean temp of the month between 20-21 degrees Celsius, and the CO2 levels lies in between 350 to 400 ppm.

Hours > 26	24
Hours > 27	1

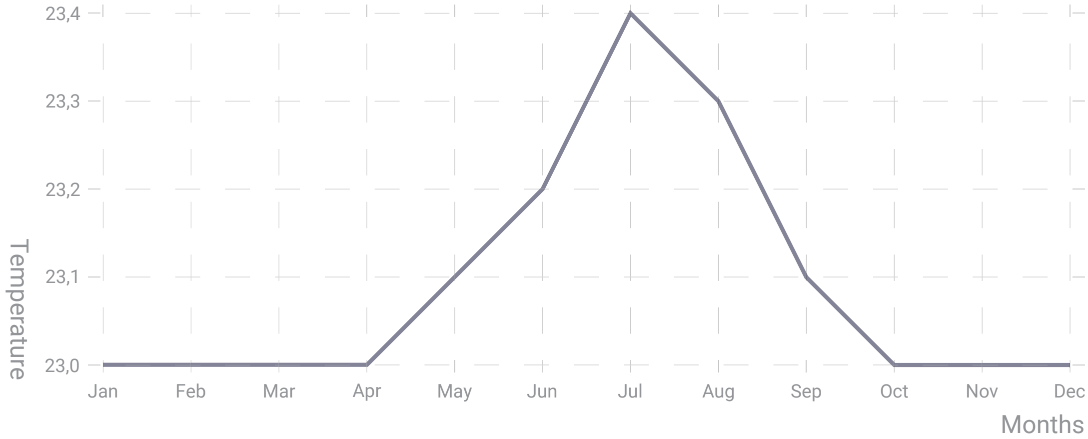


Ill.84: Daylight, lounge

As a close connection to the nature is important, large windows towards south have been placed in the lounge area, providing both a great daylight amount and a greater amount of passive solar gains within these rooms. Despite this notion, a comfortable PAQ value is still reachable, and temperatures of room is able to stay between 22-23 degrees during the year. The CO2 level is further kept between 350 and 400 ppm.

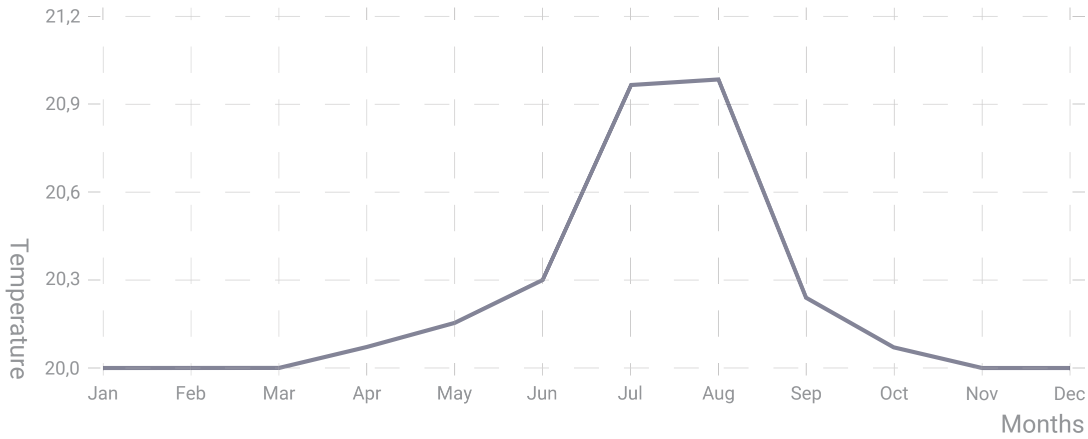
Hours > 26	25
Hours > 27	0

OFFICE



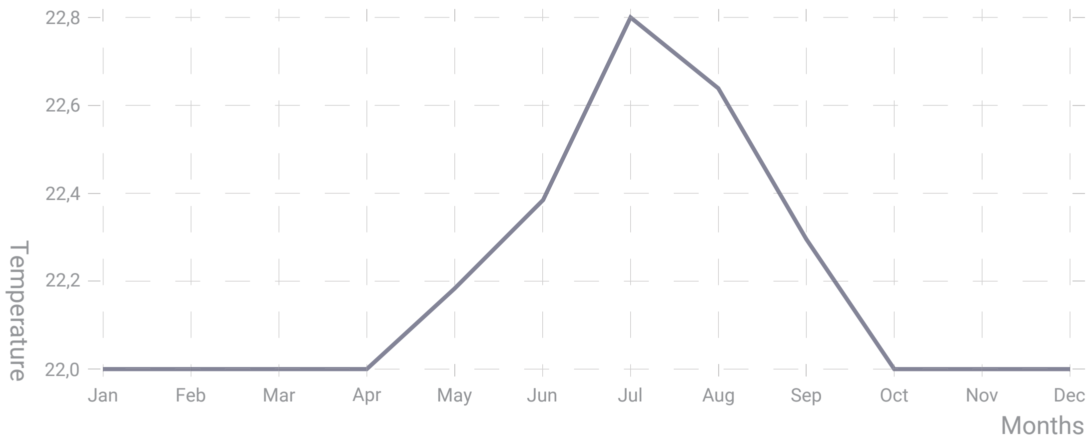
Ill.85: Temperature, office

ACTIVITY SPACE

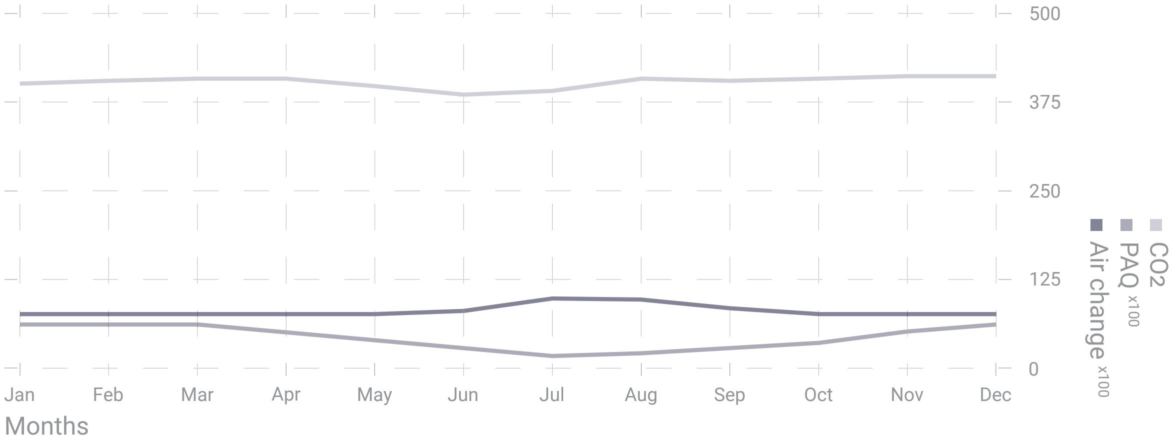


Ill.86: Temperature, activity space

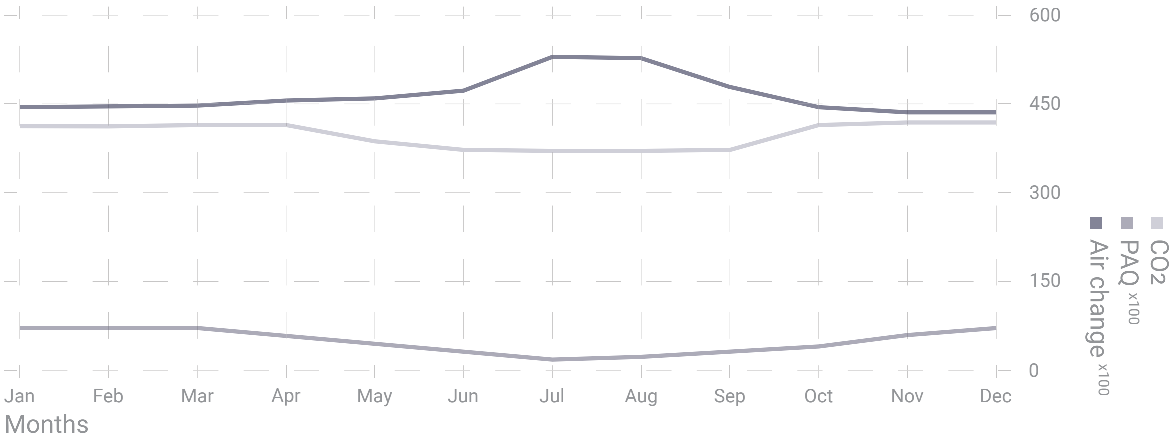
LOUNGE



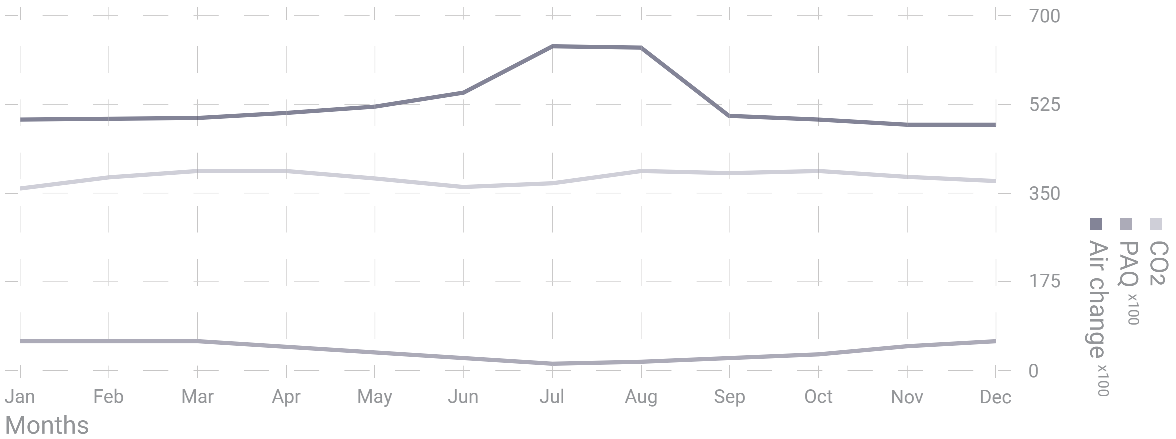
Ill.87: Temperature, lounge



Ill.88: Air quality, office

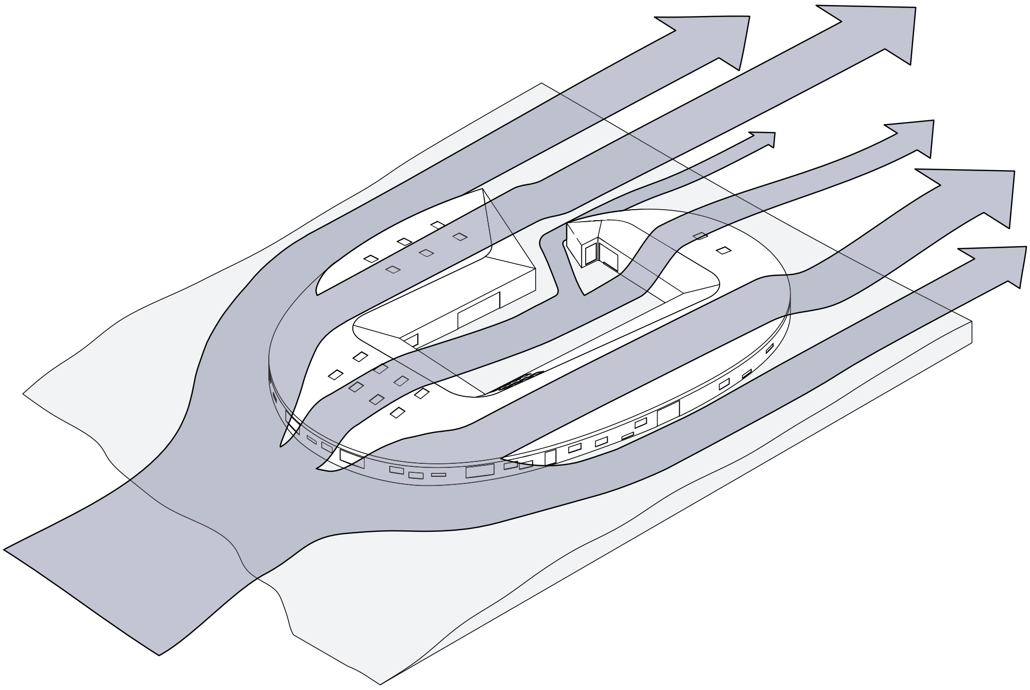


Ill.89: Air quality, activity space



Ill.90: Air quality, lounge

Ill.91: CFD wind simulation result



Ill.92: WInd concept diagram

WIND

By the construction of a roof shape mimicking the slopes of a traditional dune, the elliptical shape of the building is optimised to direct the strong winds upwards and around, thereby creating a nice pocket of lee within the courtyard of the building.

When the winds are strongest at 17 m/s from northwest, the windspeed of the courtyard drops down to a comfortable 5 m/s within most of the area, providing a perfect outdoor setting for use all year around, adding a unique public gathering place for the community of Nørre Vorupør as well as tourist visiting the area.

07 DESIGN DEVELOPMENT

APPROACH

During the following section of this thesis, the design process will be presented.

Although the development of a process is done iterative and through a fluid transition back and forth between topics, the following content has been selected and divided into certain categories to best inform any reader of the progress of different choices and studies. The design process can furthermore be comprised into three phases of development: Sketching, optimization and detailing, with similar or differentiating content and methods, building upon the knowledge gained in the preliminary studies of thematic and theories.

PHASE 1 SKETCHING

CONTENT
+ Placement of site
+ Concept-development
+ Connectivity
+ Plans
+ Initial LCA of materials
+ Initial user profiles
+ Building envelope build-up

METHODS & TOOLS
+ Analogue Sketching
+ 3D modelling
+ Site visits
+ Literatur searches
+ LCA Byg
+ Rhino
+ Revit
+ Ubakus online
+ Adobe Illustrator

PHASE 2 OPTIMIZING

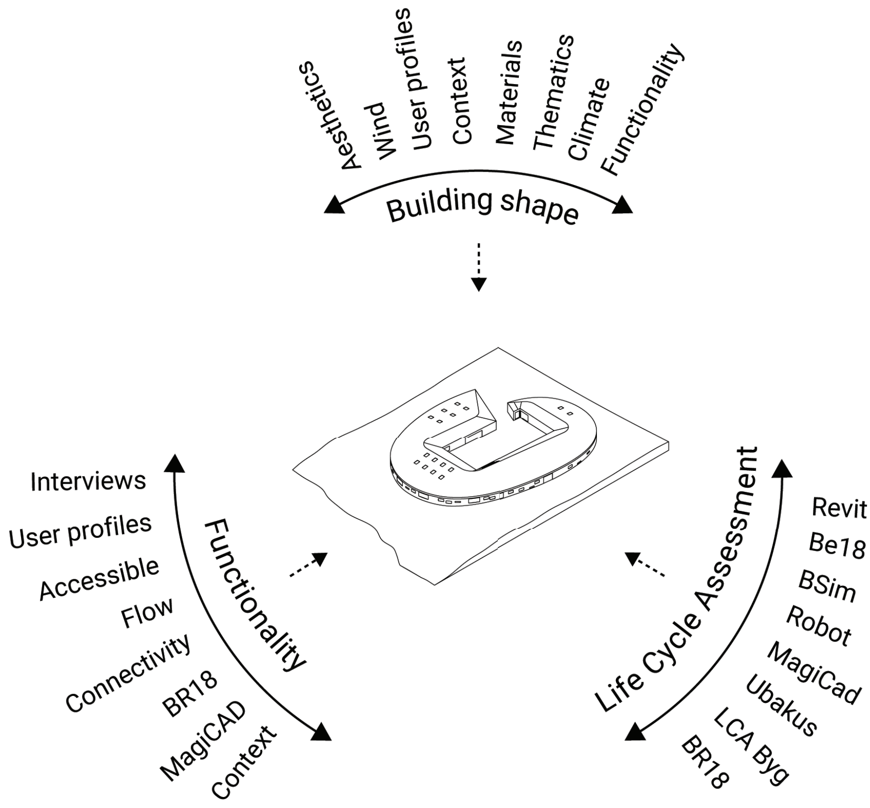
CONTENT
+ Wind simulations
+ Structure studies
+ Daylight simulation
+ Further plan interations
+ Accessibility studies
+ Indoor environment
+ Atmosphere studies

METHODS & TOOLS
+ 3D modelling
+ Rhino
+ Revit
+ LCA Byg
+ Autodesk CFD Motion
+ MagiCAD
+ Autodesk Robot
+ BSim
+ Be18

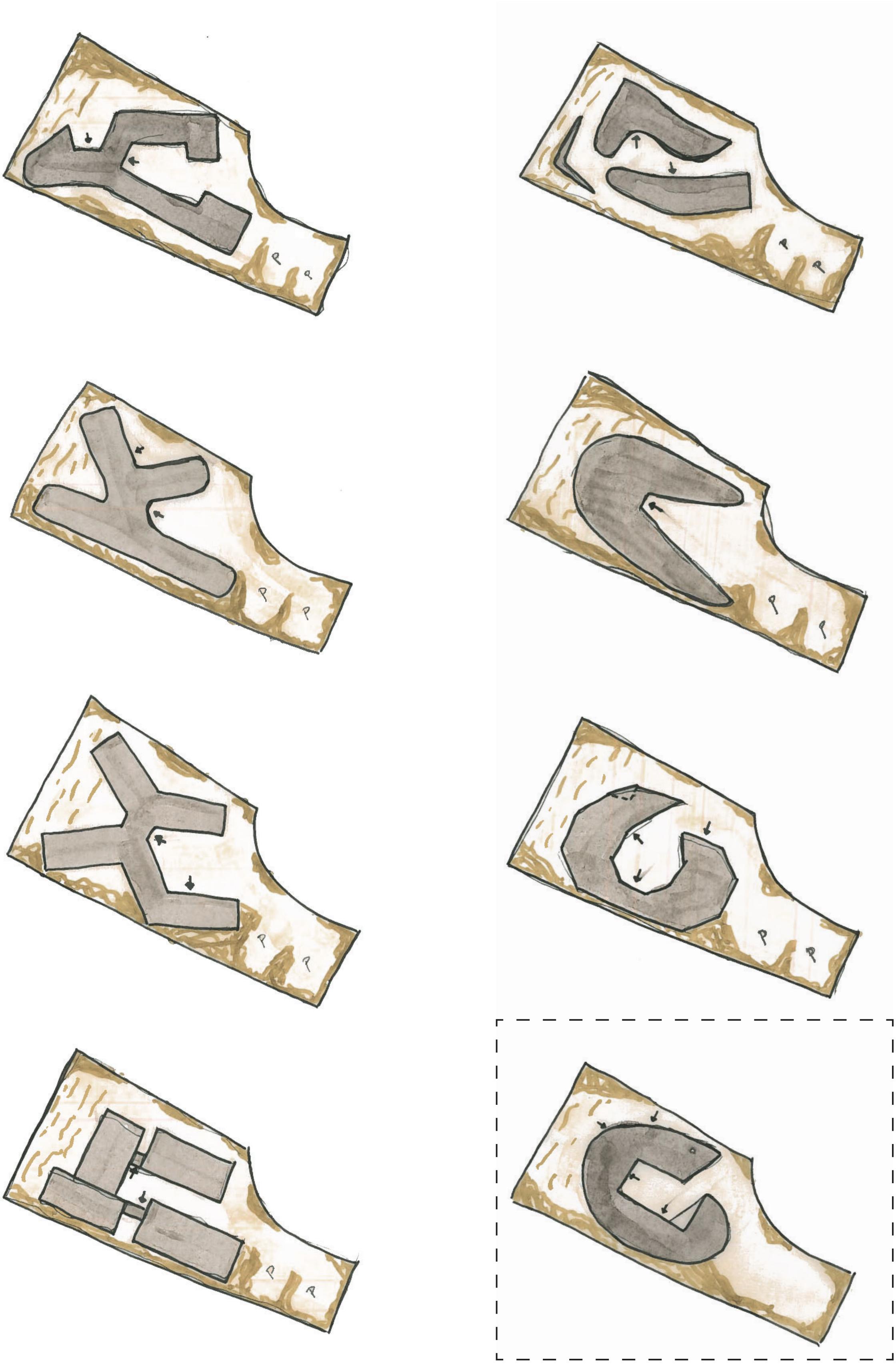
PHASE 3 DETAILING

CONTENT
+ Detailing of plans
+ Detailing of materials
+ Window detailing
+ Visualizations
+
+
+

METHODS & TOOLS
+ 3D modelling
+ Rhino
+ Revit
+ Adobe Indesign
+ Adobe Illustrator
+ Adobe Photoshop
+ BSim
+ Be18
+ Enscape

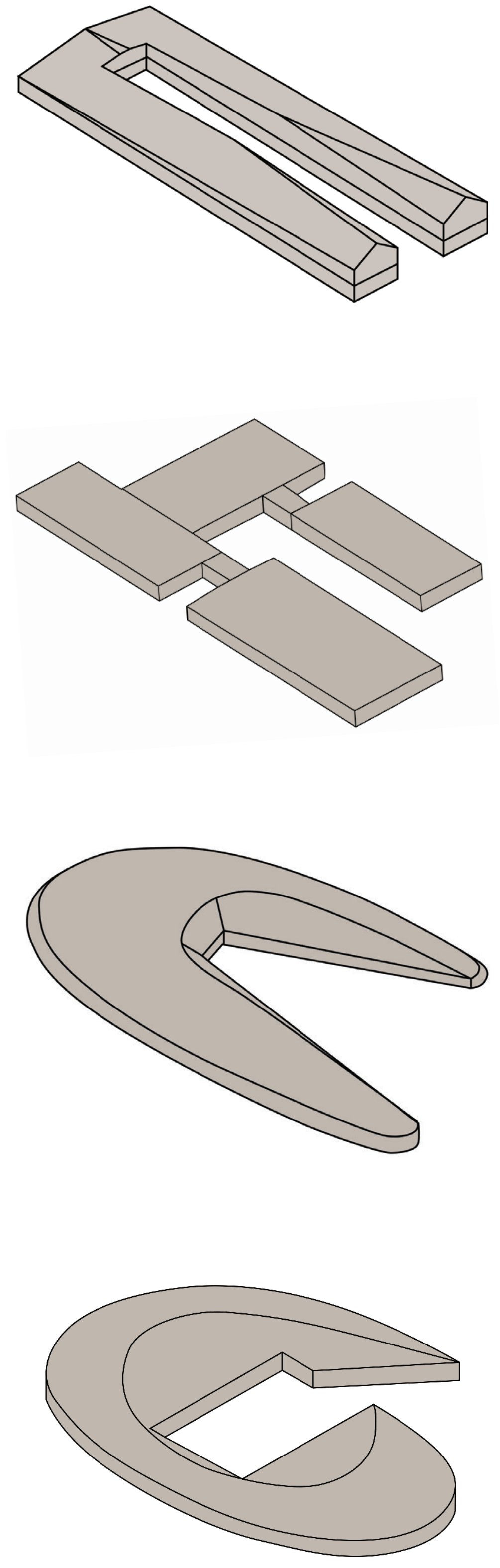


Ill.93: Design process approach



Ill.94: 2D form iterations

STUDY OF FORM



Ill.95: 3D form iterations

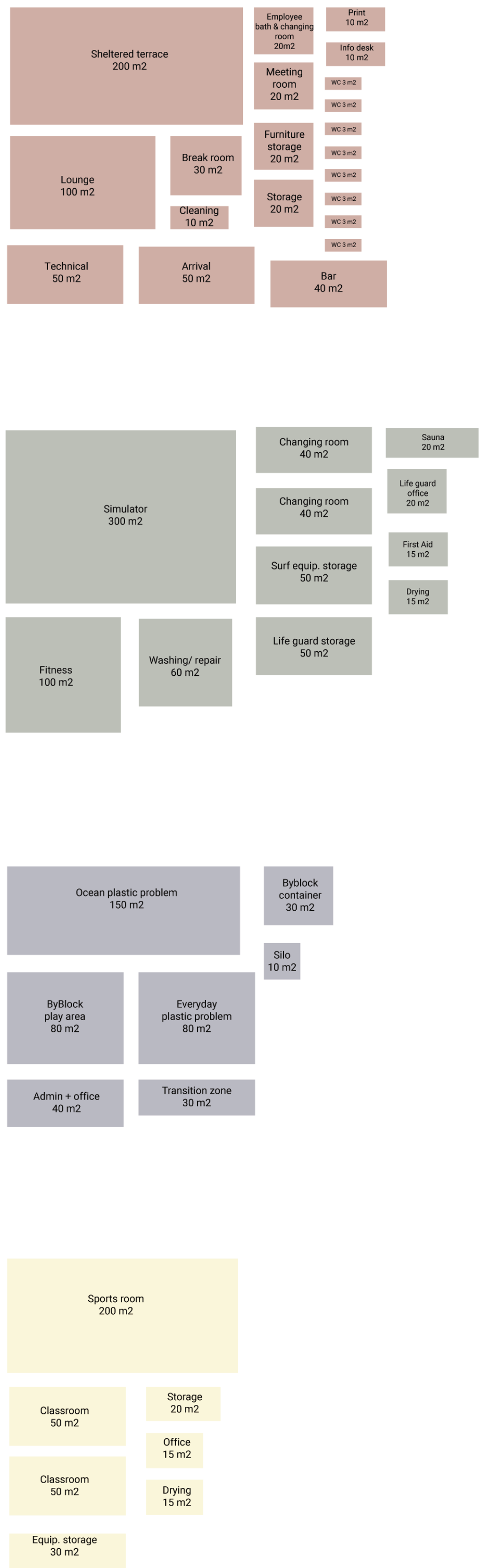
As a kickstart of the design process, multiple shapes and ideas were explored to get a starting point for the discussion of individual interpretations and goals of each group member. Concepts based on contextual tradition, theme, and identity were compared with more modernistic expressions.

A wish for a clear separation between the four main functional groups brought designs reaching out into the landscape with longer and slimmer building parts, raising the total façade area, which then again could be expected to raise the total heat loss of the structure.

A site visit to the given area and context brought a personal experience of the strong winds and harsh environment, in which the building would be placed. A wish for a shielded area or courtyard, then lead the design to a more compact form, with greater focus on the possible community activities happening within this space.

A general consensus formed throughout the process to keep exploring the designs, which incorporated some sort of fluidity or organic look. This way a new interpretation of the naturally moving landscape of the dunes could be explored within the building design.

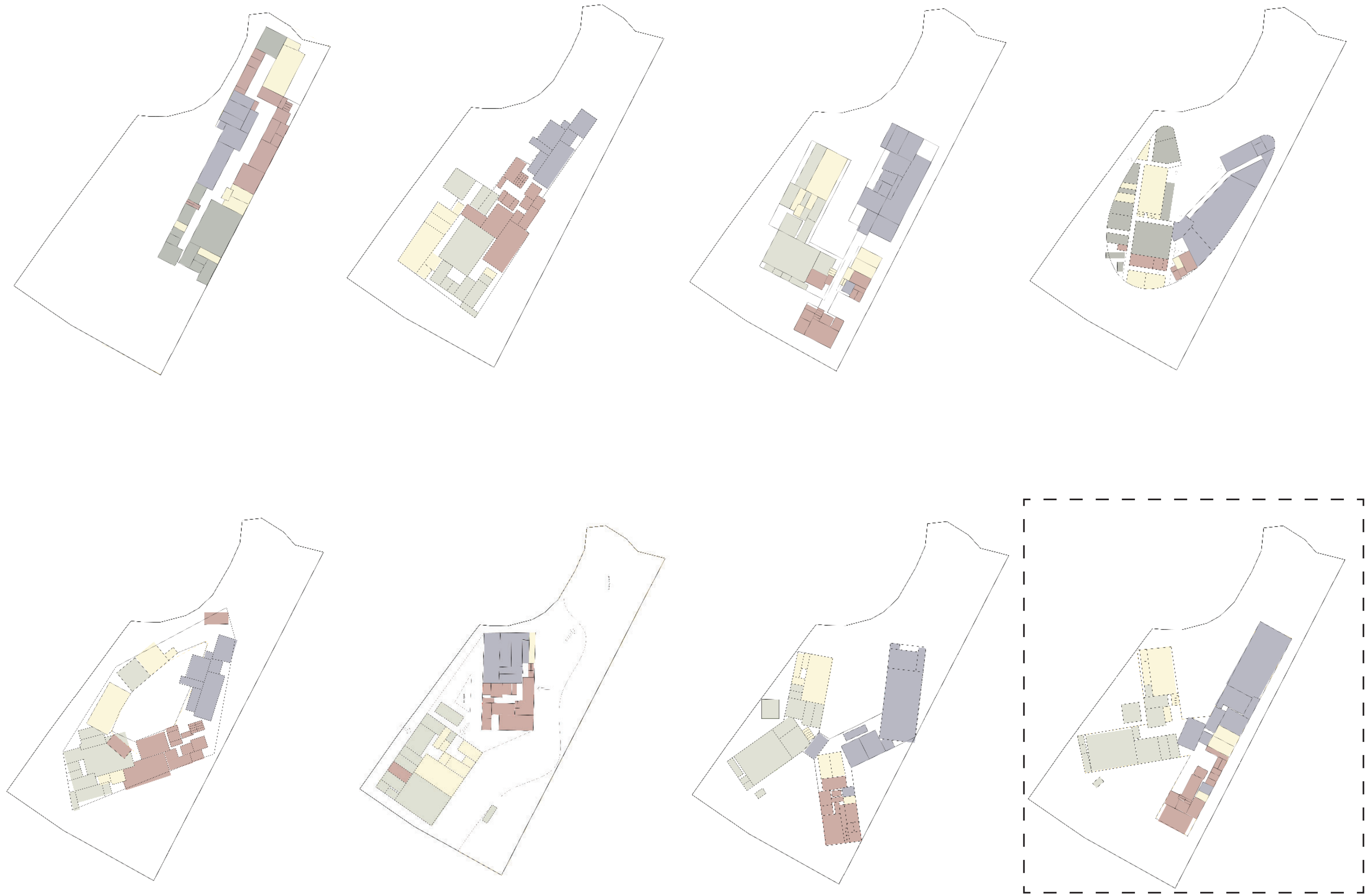
STUDY OF FUNCTION



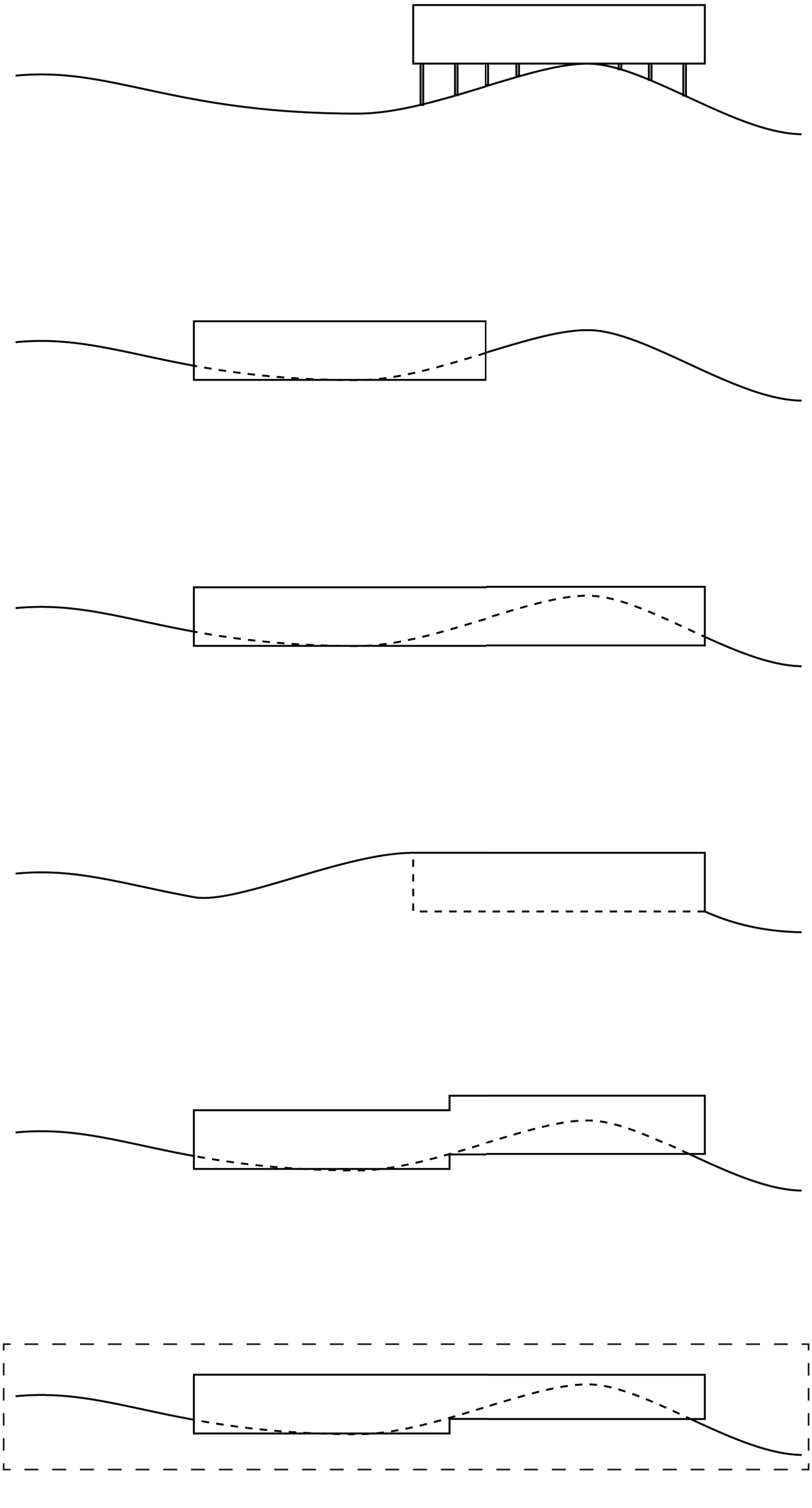
Ill.96: Functions

Based upon preliminary discussions of themes and goals towards the making of this thesis, a decision upon some kind of community and informational space was decided on. Together with interviews with local zealots and residents, it was made clear to us, that no international icon was wanted – instead, a building which could both support the local community and boost the tourism-pull of the area seemed a possible merger of all desires.
To best support a realistic scale perception, while sketching different concepts and shapes, four main user groups were created and estimates of functions and sizes were decided on. The four groups were functions related to the surf-school for beginners, the surf-facilities for the advanced, the exhibition of climate change and plastic waste, which is a very visual problem for the surfers, and last but not least, functions connected to supporting the growth and spirit of the local community.

Through multiple iterations, some focusing only on relations between rooms, some with outer building shape in mind, a general consensus formed upon the placement of the exhibition functions (blue) towards the city, the community functions (red) towards the dunes on the left, and general surfing functions (green) towards the beach to the north, and the surf-school functions towards the parking areas and road.



Ill.97: Function based plan iterations



Ill.98: Buildings' interaction with landscape

IN TOUCH WITH THE LANDSCAPE

ON TOP OF

Creating a building on top of pillars that make as low as possible impacts on nature.

IN THE BOTTOM OF

Creating a building that's lay on the ground and therefore follows the landscape.

THROUGH

Creating a building that cuts through the nature destroying the dunes.

AS PART OF

Building into the sides of the dunes makes a building that becomes a part of nature.

FOLLOWING CONTOUR

Here the building is grationel reducing the hight and therefore showing how the landscape and dunes are changing.

CONTRASTING CONTOUR

Here the building uses lines to and show how the landscape changes here the strength lines continues.

Given the location of the site being right on the edge of dune and beach, the context of the landscape has played a large role in the making of the design. At the same time of prioritizing the nature, the inclusion of the context within the city have therefore been purposefully downgraded.

On the stretch of land which engulfs the site, the terrain varies in height by up to two meters. Different opportunities to either work with or against these curvatures, therefore arises. To minimise the visual impact of a large structure of approximately 3000 square meters within a dune and beach landscape, a possibility could be to tuck in the building at the bottom of the site and through the dunes, like seen on many other coastal buildings. To minimize the environmental impact, a possibility could also be to raise the full structure up on top of pillars, leaving the wild landscape to be beneath the structure. A possibility to mimic the rise and fall of the landscape could also be done by dividing the building in different parts, rising or lowering these parts along the curvature of the site, thereby playing with different levels or room height within the building.

To best respect the landscape and adapt to the future possibilities of movement in the dunes surrounding the building, a decision was made to build upon pillars, as well as work with differentiating levels. Furthermore, this also supports the different needs for lower or higher ceiling height for different functions.
Last but not least, a continuous roofline was chosen to emphasize the meeting point of roof and façade, showcasing a strict contrast to the diverse landscape.

WIND AS A DESIGN GENERATER

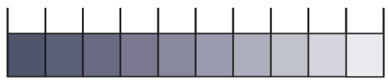
GENERIC STUDIES

Not only the context, but also the microclimatic situation of the site plays a big part in the design process. Situated on the west coast of Denmark includes being exposed to high wind speeds and large amounts of salt, sand and water in the air. To best incorporate these factors in the design, multiple dynamic wind studies have been conducted by the use of the program Autodesk CFD motion module.

All analyses have been performed with an estimate of wind across the site, directly from West by 20 m/s. The plane of analysis has been set at 1,8 meters to ensure the best comfort for the largest amount of people.

Preliminary studies of a generic building of 38 meters in length and 10 meters in width have been used, and heights of 3,5 meters, 5 meters and 7,5 meters have been investigated to simulate a building of either 1 floor, 1,5 floors or 2 floors. Furthermore, different iterations of detailing have been investigated to optimize certain outside areas even more – these includes slopes on facades and roofs, fillet of corners of the building plan and the use of overhang.

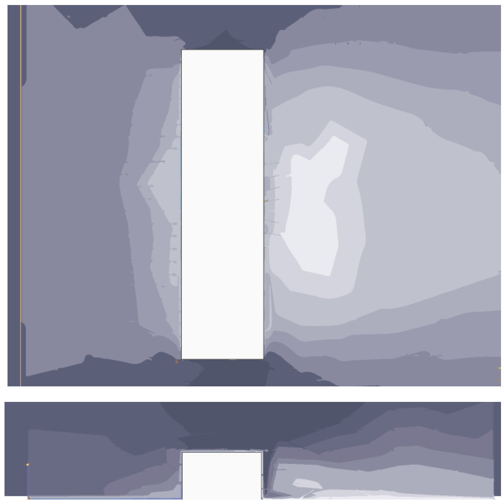
As expected, a greater building heigh supports a greater area of lee, alongside the roof shapes, which lead the wind upwards instead of downwards.



Velocity Magnitude (m/s)

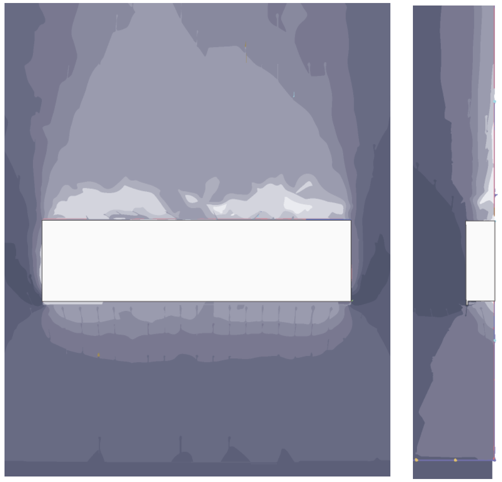
3,5m height

5m height



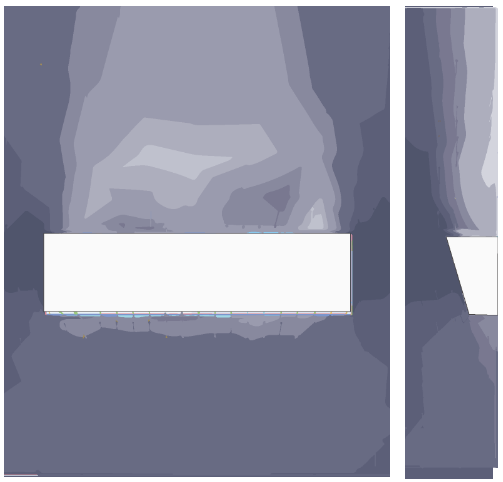
7,5m height

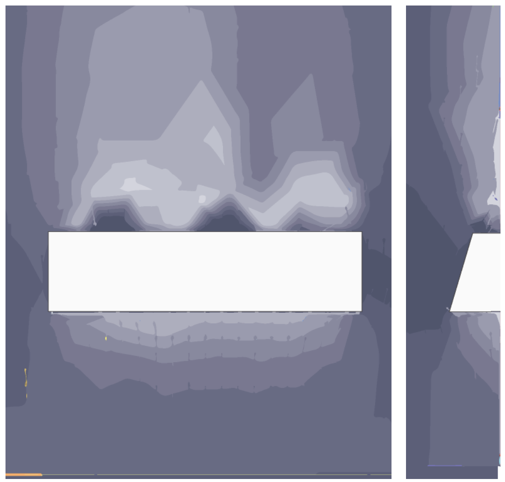
Ill.99: General wind studies

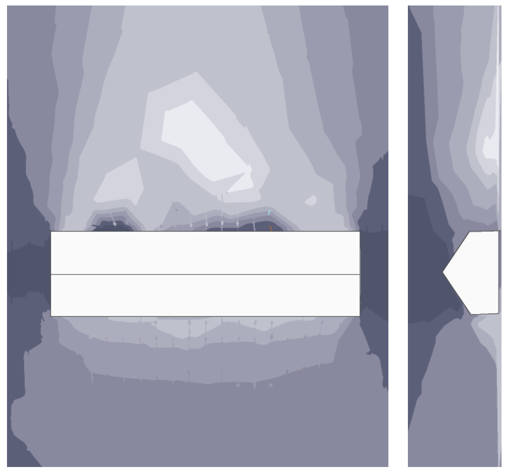

3,5m height. 0,5m overhang on wind-ward side


3,5m height. 30degree slope of wind-side wall


3,5m height. 2m fillet of wall-corners


3,5m height. 15 degree angle on roof (right)

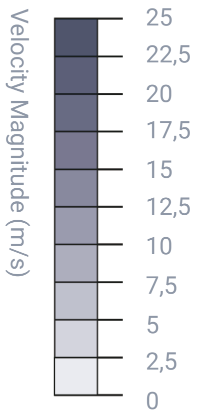

3,5m height. 15 degree angle on roof (left)


3,5m height. Gable roof of 30 degrees

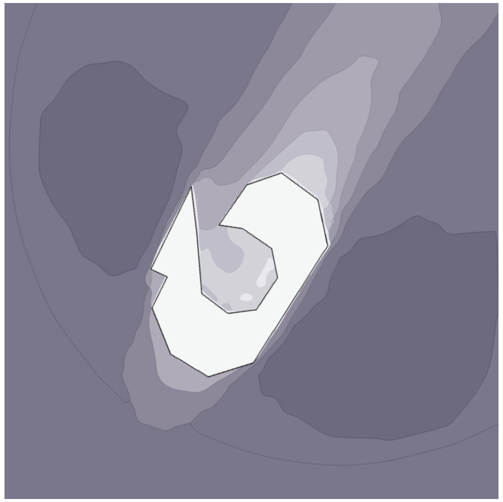
CONCEPT STUDIES

Continuously throughout the process, different concepts have been analysed through the CFD tool, also used as a way to evaluate and compare chosen designs. As the design concept moved towards organic shapes, the formation and properties of typical dune formations proved to create great areas of lee, inspiring the following plan designs and roof shapes, and providing a new twist to the traditional gable roof of the coastal cities.

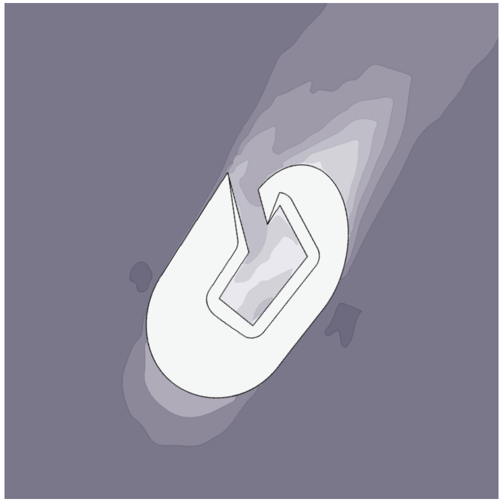
Within the later iterations of the elliptic building form, specific details such as size and façade rotations within the courtyard was explored to further optimize the comfort of the outdoor spaces.



Ill.100: Concept wind studies

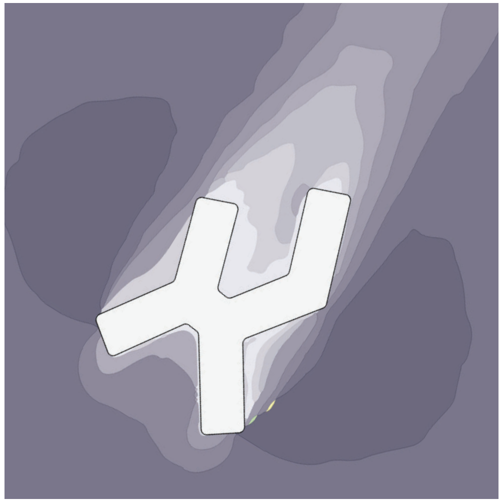


Concept 4 - 1st iteration

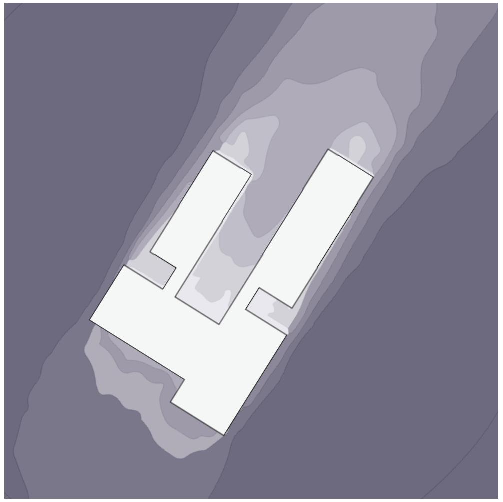


Concept 4 - 2nd iteration

Concept 4 - 3rd iteration

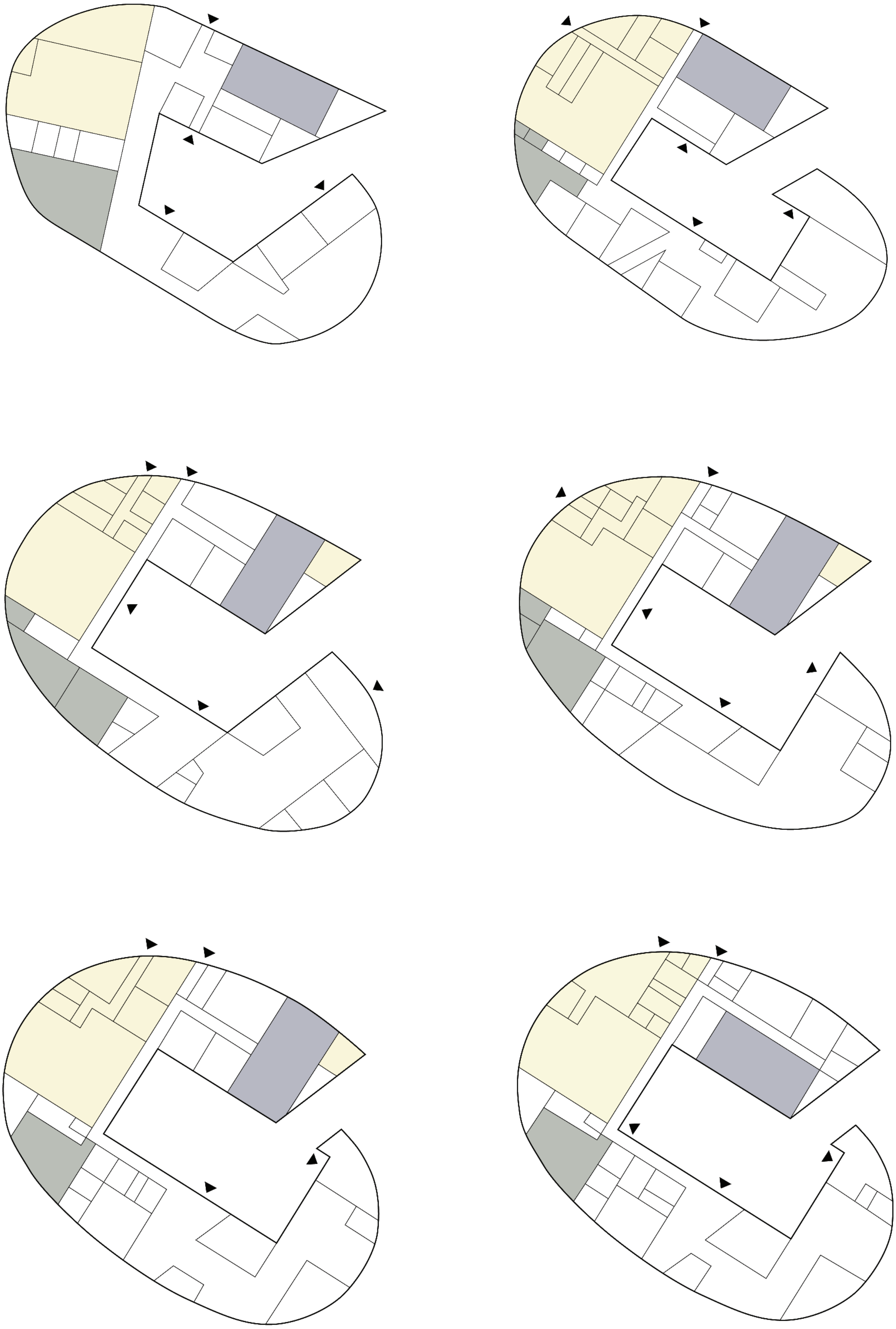


Concept 1



Concept 2

Concept 3



Wet zone

Activity space

Office and lounge

Ill.101: Floorplan concepts

FLOORPLAN DEVELOPMENT

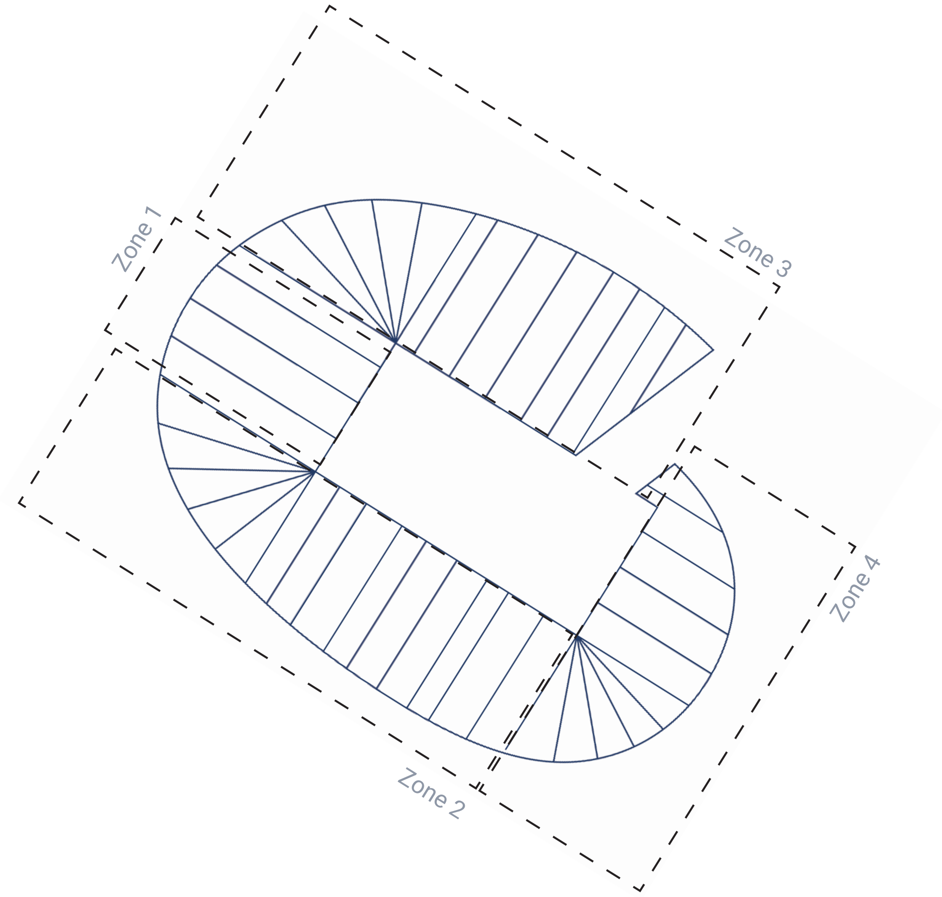
Based upon the set placements of the user group-functions mentioned in the study of function, a further detailing of room relations, height requirements and formations were developed. Especially the areas of the Activity room, the wet-zone functions, the office and the lounge presented alternating iterations.

By placing the activity room along the outer façade, a quick access could be reached along with a very great visibility out to the area of any activity happening, inviting more to join. By rotating the room 90-degree, daylight from both north and south would be possible, alongside a view from courtyard to context through the space. However, in the end, the possibility to add further functionality to the space, made it clear that the space had to be better linked to the inner façade of the courtyard to best allow for a flexible use in correlation to events happening out there.

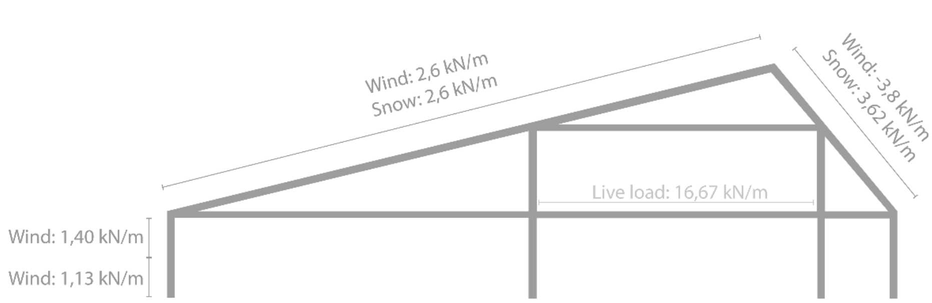
With regards to the wet-zone, a wish for the surf simulator to be placed closest to the beach, made sure that the placement of this function was restricted to the north-west of the building. Furthermore, the great depth of the machine itself, meant that no other rooms should be placed between this and the courtyard, to avoid an even larger building depth than necessary. However, the placement of supporting functions such as changing rooms and storage proved able to be solved through different concepts. Different places of storage, and different ways of adding a separate wet-zone area or hallway, were explored, to keep excess water and sand out of the main building, when surfers bring back equipment and such from the beach and sea.

Last, but not least, the placement of office and lounge functions also changed during the design development. When the intention of only one floor level were kept, the lounge and office were placed close together to add the possibility of the lounge being used also as a break room for the people renting one of the flexible workstations in the building. Later on, when the construction of the roof proved to create excess space for a smaller second floor, both office and lounge were considered to be placed here. By placing the lounge on the second floor, a better privacy from the tourist of the surf-functions and plastic-exhibition would be possible. However, due to the changing room height of the second floor, and the limited possibilities of views through roof windows, the functionality of the space was better suited for office space. Thereby, the lounge functions were placed on the ground floor, receiving great connection and views to the beautiful landscape.

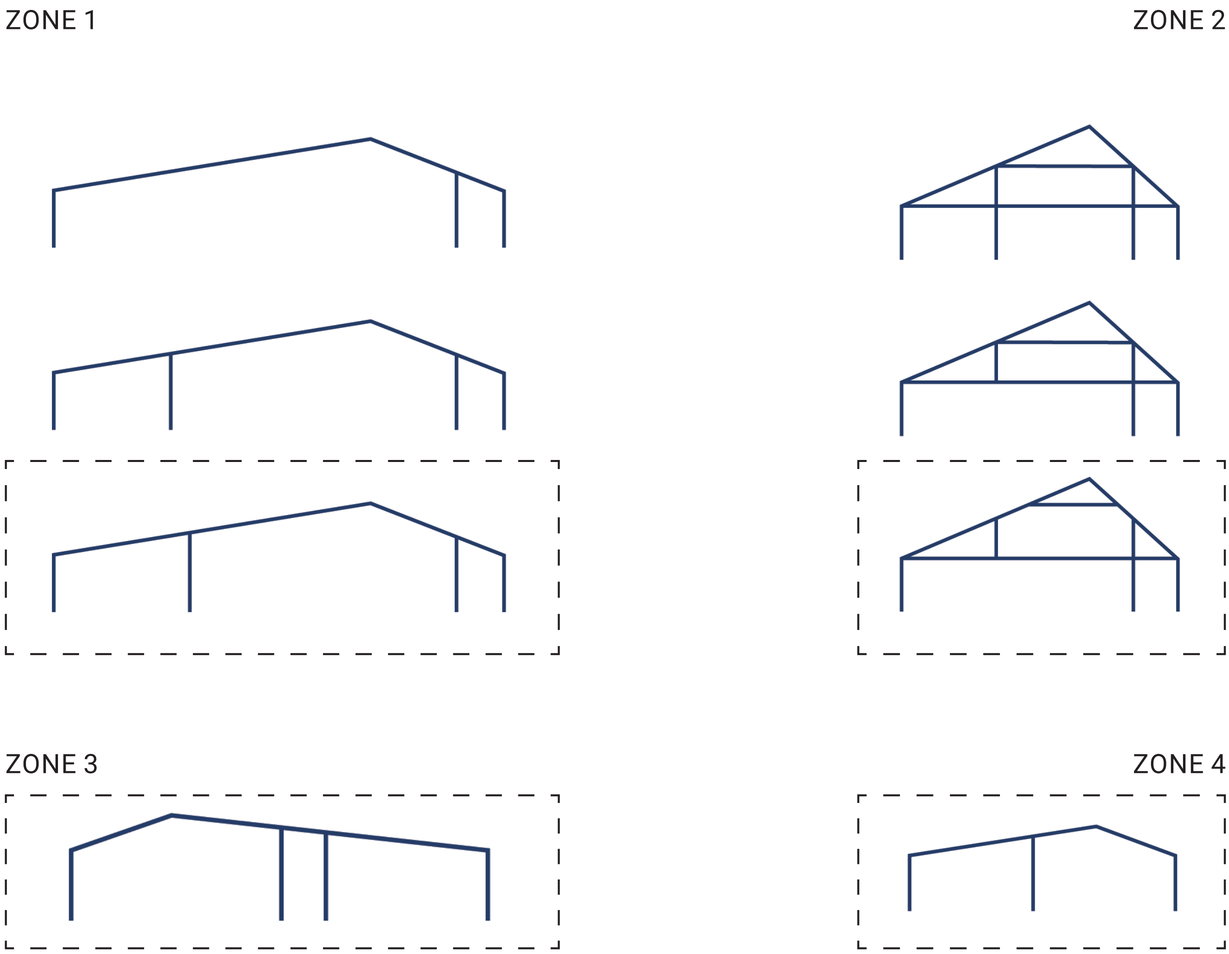
STRUCTURAL DEVELOPMENT



Ill.102: Zones of structures



Ill.103: Applied loads



Ill.104: Structure development

Simultaneously with the floor plan development, structural dispositions were tested to verify that the proposed plan would comply with the structural elements no larger than 200x200mm with regard to verification of ULS and SLS. This to allow the load bearing structure to be integrated into the outer walls and act as part of the interior partitions and curtain walls. The building was divided into four zones that would need similar structures and one frame of each zone were tested (ill.99).

To eliminate multiple, unnecessary iterations and calculations, estimates of the worst-case scenarios of external loads were applied to all iteration, thus, some iterations would be exposed to higher forces than the case would be in reality. The external loads are applied in a load combination with dominating wind- and variable snow loads for ULS and characteristic loads for SLS, while assuming the direction of the wind is due west creating the highest pressure on the building (app. 2)(ill. 100).

Each zone structure was investigated based on functional needs, less obstruction in the rooms and minimising material use. For instance, in zone 1 covering the wet zone large spans are needed to make room for the surf simulator. First iteration tested a full span which did not comply with either ULS or SLS verification of the structural elements. The second iteration added a detached column to support the roof structure, though it needed to span less to comply with SLS resulting in the third iteration as final result.

For zone 2, revolving around the only place in the building with two floors, it was important to eliminate any detached loadbearing elements on the ground floor to ensure functionality in the lounge. This resulted in a complex solution in which the roof structure should eliminate stress through the loadbearing structure to the foundation. Simultaneously, the roof structure should provide enough room on the first floor to make it usable for the office. Multiple iterations resulted in a structure complying to these elements.

For zone 3 and 4, a structure in the building envelope and interior wall showed to be preferable to withstand the loads of the building and exterior forces (ill. 101).

LIFE CYCLE ASSESMENTS

Alongside optimization of indoor climate and load bearing structures, a continuous study of material choices and their environmental impact were performed, as levels of detail and focus shifted through the building design.

Looking into construction types, a beam and column formation was chosen to best support the large spans needed. Fiberglass, steel and wood were investigated for the structural system based upon a conceptual section and calculated wind, snow and live loads (app. 2). Wood performed the best regarding the global warming potential, although needing the biggest amount of material due to its low strength. As an alternative to wood, and to best convey the story of the building, fiberglass proved to be a better solution than steel, with equally as good strength capacities, needing half det depth in column size, than the choice of wood would require.

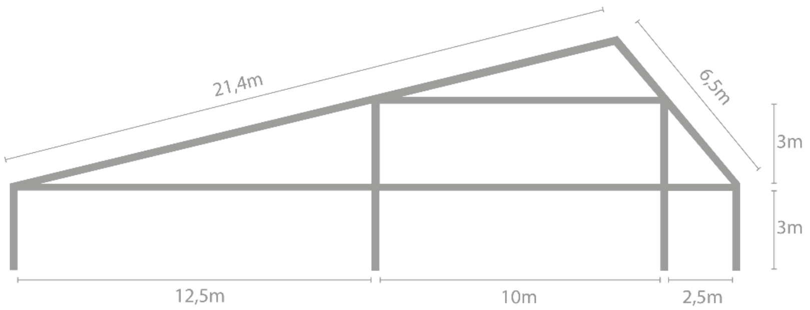
Compared to a loadbearing structure, depending on certain strength-wise stabilities and properties, a product used for cladding on facades only need a long lasting durability to wear and tear. By this notion, the environmental impact of both new and recycled fiberglass is investigated and compared with the properties of wooden cladding - a traditional and sustainable cladding option. It is estimated that 70% of the fiberglass raw-material used for cladding panels (A1-A3) could be derived from decommissioned wing turbine blades. Furthermore it is estimated that the durability and lifetime of wooden cladding will be halved in the given environment, adding the need for one replacement of the cladding during the 50 year span of the LCA analysis. Comparing the use of new fiberglass and the common lifespan of wood, the results inform us that the performance of wood, under these circumstances, is approximately 3,5 times better. However, the results of a comparison of the recycled fiberglass and the downgraded wood, shows a result very close to each other, concluding that the use of fiberglass could be a great replacement in this given environment, when considering an even longer lifespan than 50 years.

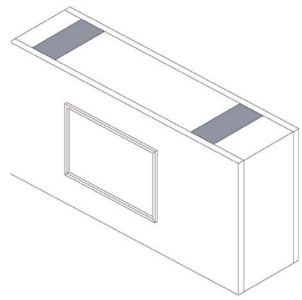
Using the same notion of protecting the outside of the building by the use of a highly durable material, a study of different windowsill materials has also been investigated. While wood clearly outperforms the common uses of plastic (PVC) and aluminium, Fiberglass is shown to be the best choice when including the downgraded lifespan of wood in the calculations.

Last but not least, an investigation of the use of fiberglass granulate as insulation, is also done. Estimating a composition of glass wool insulation with 50% raw material (A1-A3) from recycled wind turbine blades, this insulative material slightly outperforms both paper wool and wood fibre insulation. This slight win for fiberglass is guessed to be caused by the slightly better thermal performance which glass wool provides, also providing the need for a thinner wall construction.

MATERIAL PROPERTIES

STRUCTURE

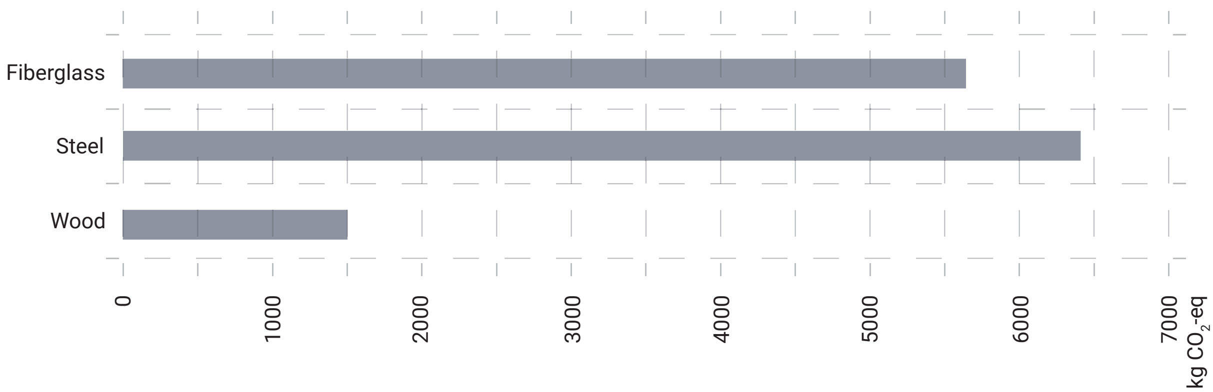




CONSTRUCTION

Material	Type	Profiles	Amounts (m^3)	Density (kg/m^3)	Tensile strength (MPa)	Compressive strength (MPa)	GWP (kg CO_2-eq)
Fiberglass	-	Square pipes: 240x240(x16) 200x200(x12)	0,76	1400	235	235	5,7x10^3
Steel	S450	H-beams: H300 H200 H280	0,81	7800	230	235	6,4x10^3
Wood	GL32h	Gluelam beams: 200x200 200x500 200x400	6,00	450	32	32	1,5x10^3

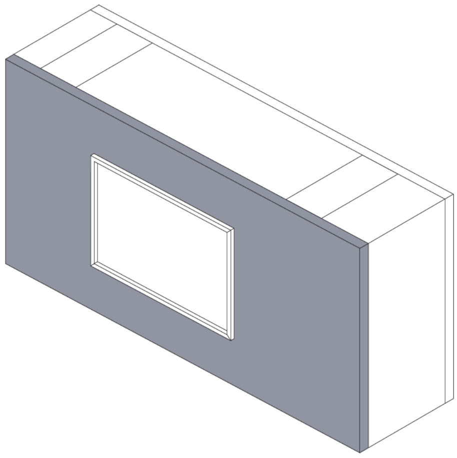
GLOBAL WARMING POTENTIAL



Ill.105: Structure comparison

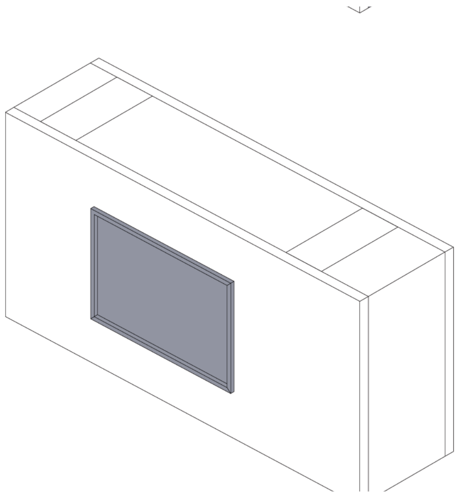
FACADES

Material	GWP (kg CO_2-eq)
Fiberglass (New)	43,65
Fiberglass (70% recycled)	22,83
Wood (Standard durability)	9,99
Wood (50% durability)	22,70



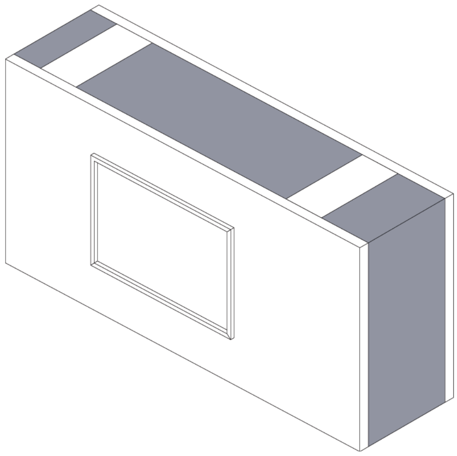
WINDOWS

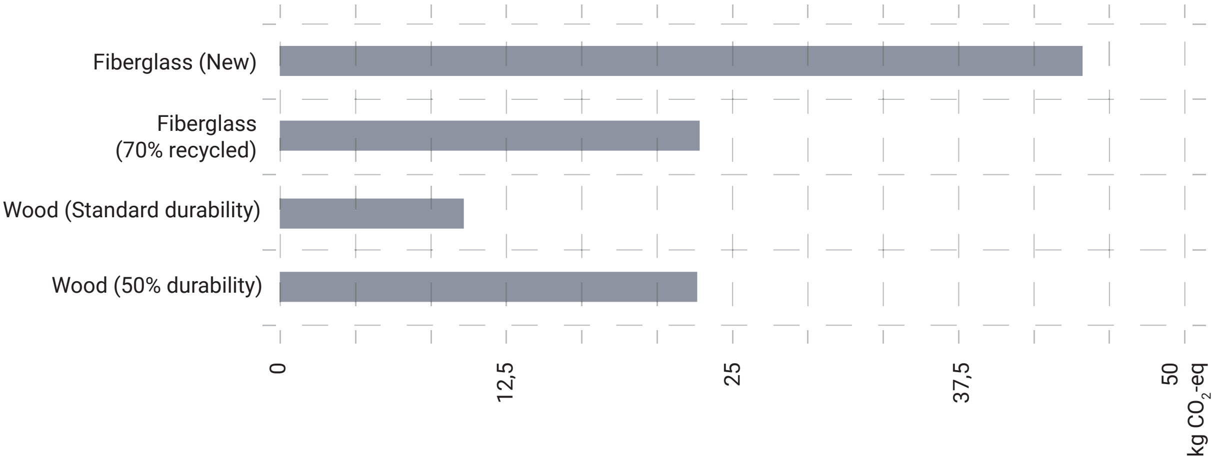
Material	U-value (W/m^2*K)	GWP (kg CO_2-eq)
Aluminium	1,30	3,50
Plastic (PVC)	0,17	2,76
Fiberglass	0,25	1,68
Wood (Standard durability)	0,13	1,03
Wood (50% durability)	0,13	1,73



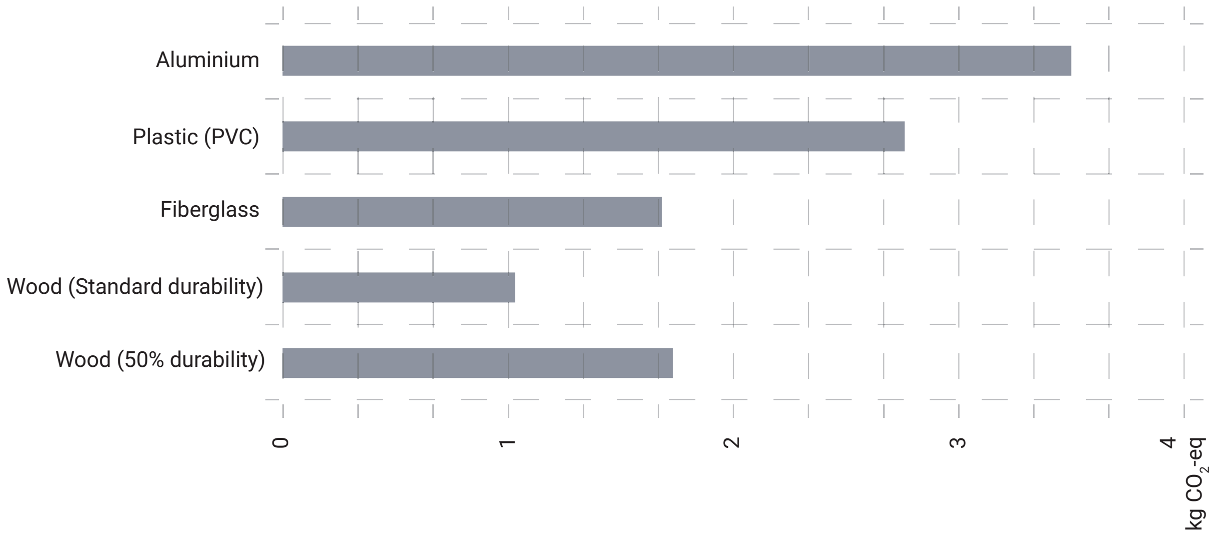
INSULATION

Material	Thermal coefficient (Lambda)	Wall thickness (mm)	GWP (kg CO_2-eq)
Glasswool	0,32	430	15,15
Fiberglass (50% recycled)	0,35	460	8,93
Woodfiber	0,39	500	10,92
Paperwool	0,40	510	10,01

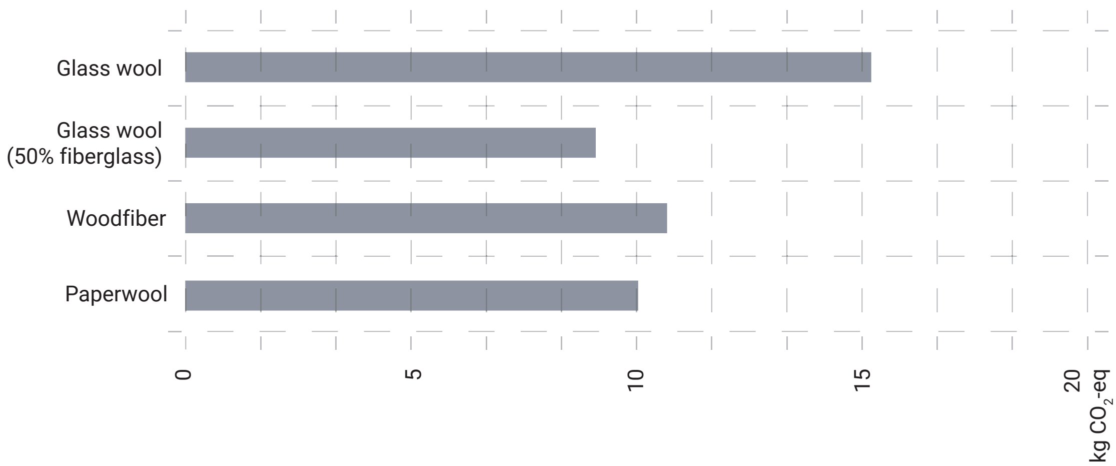




Ill.106: Facade comparison



Ill.107: Window comparison

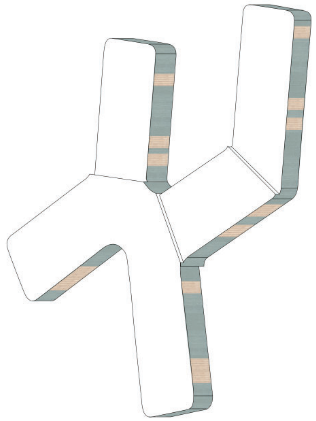


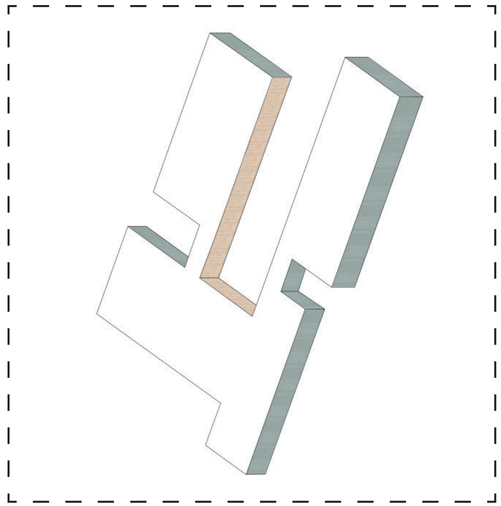
Ill.108: Insulation comparisom

Fiberglass and wood facade

Concept 1 - mixed materials

Concept 2 - separet materials





Ill.109: Exterior amotsphere studies

Brick facade

Concrete facade

Wood facade

EXTERIOR ATMOSPHERE

As informed upon through the LCA-studies, the use of wood has the best environmental properties with the lowest global warming potential, and a great aesthetical feel. However, in a coastal context like Nørre Vorupør, the expected durability of a natural porous material like this must be adapted, and thereby lowered significantly along with a greater need for care and replacements.

In the nearby context of the city, other materials such as concrete and brick is also present and have been investigated. Lastly, as a contrast to these well-known materials a façade of glass-fibre panels from the Danish company of Fiberline Composites, have also been considered to represent the reusability of glass-fibre from wind turbine blades, and the placement of a plastic information centre within the building.

In correlation to the natural landscape of green, yellow, and brown shades of sand and grasses, the materiality of wood stands out with its warmth and texture, along with the surprising blue-greenish colour match and stripey look of the glass-fibre panels. However, with the mentioned challenges of durability of wood, a dural-concept has been chosen to exploit the best properties of both materials – the durability of glass-fibre makes for a great protecting fit on the outer facades and roof, whereas the warmth and cosiness of the wood is favourable within the sheltered courtyard facades.

Concrete, glassfiber and plaster

Concrete and glassfiber

Wood and glassfiber

Wood, glassfiber and plaster

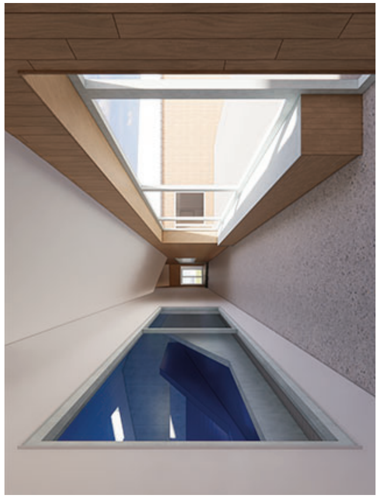
INTERIOR ATMOSPHERE

To continue with the thematic choice of materials, different combinations have been investigated interior-wise. Two rooms with different characteristics have been chosen for this purpose.

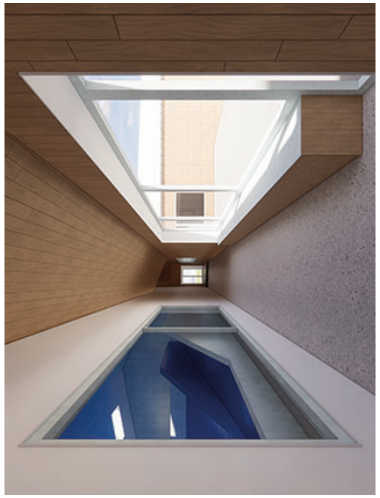
A section of the exhibition area is investigated with a wish for the materials to support a flexible use of the space. By further adding stone chips to the finish of the concrete floors, it is possible to yet again enhance the contextual references by reaching a great terrazzo-like look, mimicking the small stones imbedded in the sand on the beaches as seen in on page 54.

To uphold a feeling of cohesion throughout the whole building, this concrete floor will be continuous throughout the building, with the exception of waterproof tiles in the wet-zone and a wooden finish in the lounge and office to add a bit of cosiness to these social areas. To add further hints to the themes of the building, the windowsills toward the context will also be made of glass-fibre to add the illusion of the facades and roofs being pulled inwards. At the windows of the courtyard, the same concept will be copied, by the wooden facades turning into the windowsills and then again on the inside turning into integrated seating areas, creating cosy break points along the course of the building.

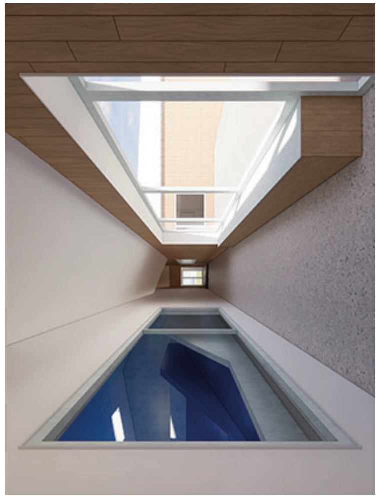
Ill.110: Interior amotsphere studies



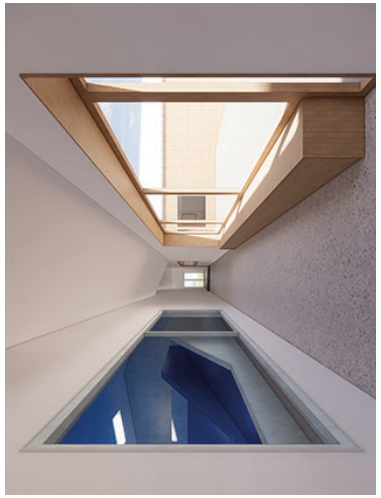
Concrete , wood, glasfiber and plaster



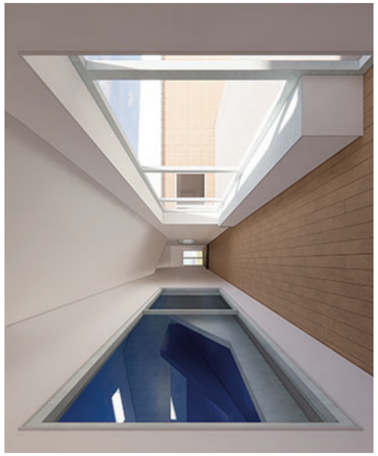
Concrete , wood, glasfiber and plaster



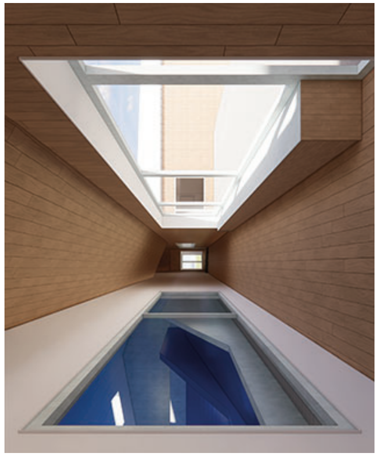
Concrete , wood, glasfiber and plaster



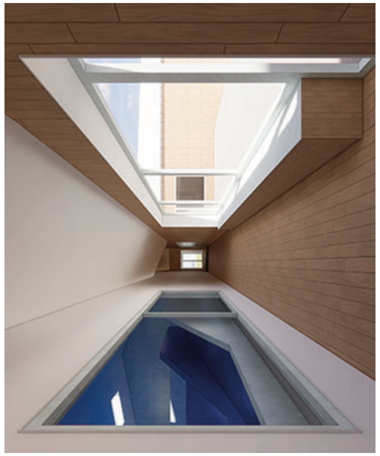
Concrete , wood, glasfiber and plaster



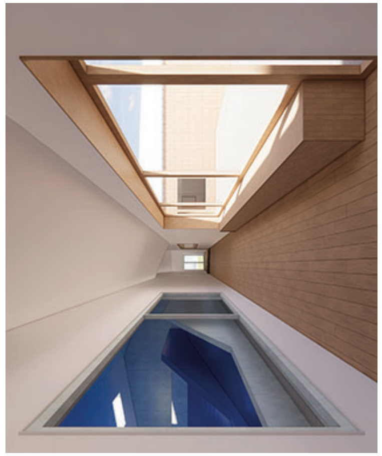
Wood, glassfiber and plaster



Wood, glassfiber and plaster



Wood, glassfiber and plaster



Wood, glassfiber and plaster

WINDOW STUDIES

CONCEPT 1

Vertical windows in strict pairs of two:
1000x2000 mm

CONCEPT 2

Rectangular windows with specific height-placements of bottom sill:
4000x2000 mm
1000x2000 mm
1000x1500 mm

CONCEPT 3

Square windows in differating placements:
2000x2000 mm
1500x1500 mm
500x500 mm

CONCEPT 4

Horisontal windows in differating height-placements:
4000x2000 mm
2000x1000 mm
2000x500 mm

WINDOW PLACEMENT

To best emphasize the duality of the exterior material choices a duality of window settings is also chosen. Within the courtyard, large horisontal window panels are used to support the calm vibe and the great flow in-, and out of the building. To contrast this look, different concepts for the exterior glass-fibre facades have been investigated.

By the use of vertical window pairs reaching both floor and ceiling, a strict and traditional feeling is reached. However, since the façades of the building are expected to align with the landscape, which might change due to the movability of the dunes, this would mean that some windows might be partly covered by sand in the future. Instead, a more dynamic window placement, lifted from the level of the landscape, will be better adapted to future changes and could possibly be integrated as cosy seating nooks.

Other possibilities investigated include a dynamic mix of vertical windows, which aesthetically enhance the height of the exterior façade, or a mix of square windows, providing a clear concept of placement. Last but not least, a dynamic placement of smaller horisontal windows provide great panoramic views of the context from inside the building and help enhance the circular movement of the building shape.

Ill.111: Window placement concepts

STUDY 1

Adjusting window height

300 lux in 50% of daylight hours

Window to floor ratio

STUDY 2

Adjusting window placement

300 lux in 50% of daylight hours

Window to floor ratio

STUDY 3

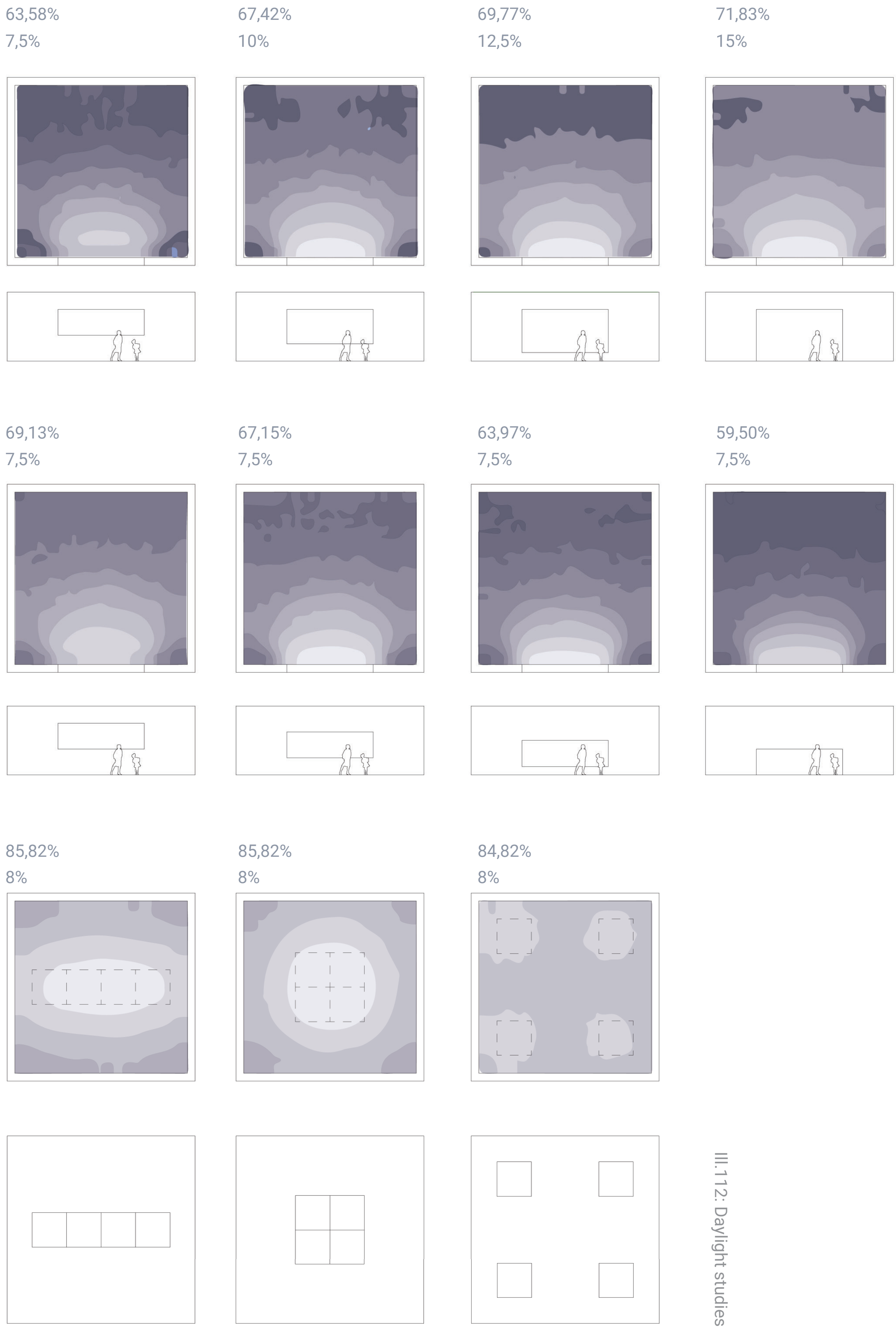
Adjusting skylight placement

300 lux in 50% of daylight hours

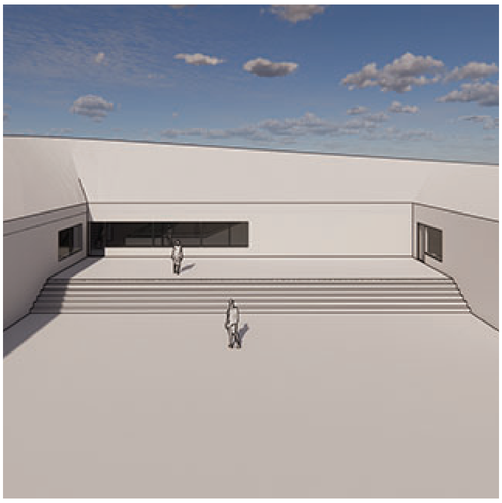
Window to floor ratio

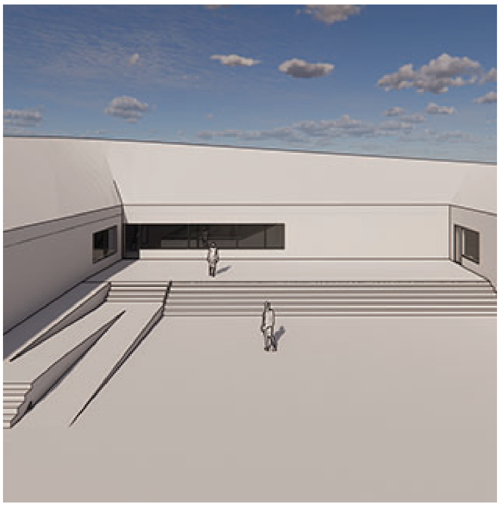
DAYLIGHT

To create the right atmosphere the impact on different windows is tested on a 100m^2 room, here it is investigated which impact the lower boundary of the window has and how to place the rooftop windows. It can be concluded that removing the lower 0,5 m of the window gives 2% lesser hours that fulfil 300 lux in 50% of the daylight hours and removes 16,6% of the window area. Therefore, this is seen as an optimal chose to avoid the windows gets covered, as the sand dunes can change over time. In general, the bottom of the window is the less important part to gain daylight into the room, therefore it could be utilizing better to integrate it as a seating area in the design. In placing rooftop windows, the best result is to centre the windows in the centre of the room but the different is minimal(EN/DS 17037).

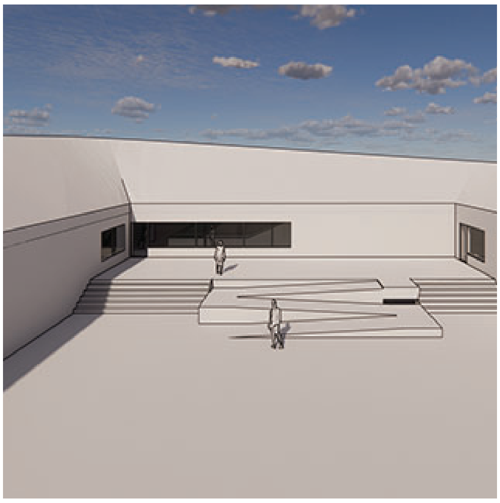


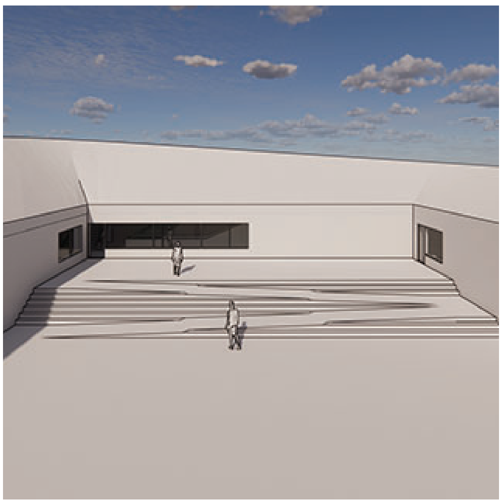
Ill. 112: Daylight studies

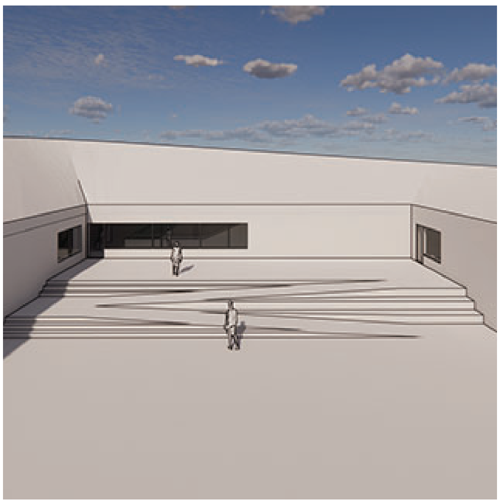

Normal stairs


Stairs, with a ramp on the left side


Ramp split in three

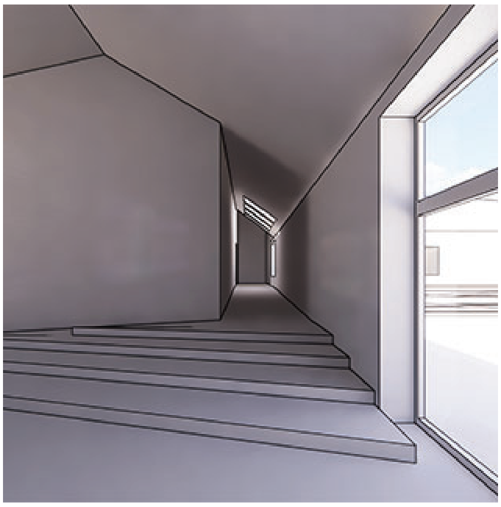

Centeralised ramp combined eith stairs


Split ramp with integrated stairs


Split ramp with integrated stairs and seating

ACCESSIBILITY

Stairs with integrated seating



Ramp turning a corner with stairs at the end

One continous ramp

Ill. 113: Accessability studies

To support the notion of social sustainability within the building, flexibility and accessibility are of great importance. With a site, which varies in height by up to two meters, regulation of terrain has only been a possibility along the north façade, due to the length of this stretch. The placement of only offices on the level 2, eliminates the need for either ramps or elevators, but the heigh gap of 1 meter between level 0 and level 1, still requires a direct entrance opportunity to all exterior doors, meaning a need for ramps for both interior and exterior use.

According to the regulations of BR18, a rise of 1 meter requires a ramp of 20 meters including a flat break point after a rise of 60 centimetres. To reach this length different possibilities of ramps and stairs have been investigated, and an exterior solution including both have been reached. This solution provides a great break in the large courtyard, both adding access to a raised terrace and adding stairs for a seated break outdoors. Interior-wise, different solutions have also been investigated, but due to only the narrow spaces of the hallways usable for this purpose, stairs in general have been completely replaced by the long ramps, creating a soft transition from level 0 to level 1 all through the building.

VENTILATION


No mechanical ventilation

Throughout the project development, the ventilation has mainly been used to inform upon the pressure losses needed to calculate the operational energy results of Be18, again used to inform upon the LCA calculations. To obtain a realistic estimate of these values, a ventilation plan has been composed in MagiCAD (App 4) as an example of the layout needed to support the ventilation of the whole building. Ducts sizes and placements have been tested through different iterations, within a simplified set-up, not analysing the effect of certain choices of devices or comfortable throwing lengths and wind speeds. An estimate of windspeeds between of 4-8 m/s is set, and SystemairCAD is used to supply a suitable aggregate, informing upon the space needed within each technical room.

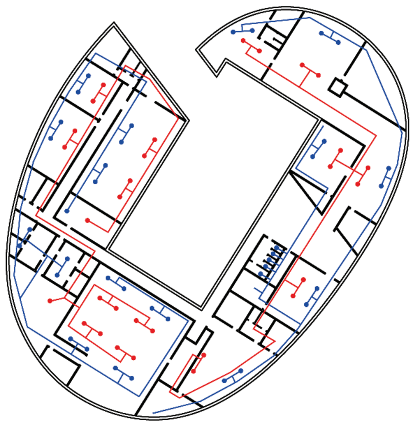

Visible mechanical ventilation

The needed ventilation requirements of every room have been calculated to comply with the biggest need for the dimension of the ventilation system, with regards to the requirements of the BR18 regulations, a maximum of 20 percent dissatisfaction, and a maximum CO_2 level of 1000 ppm (DS/EN 16798-1:2019).

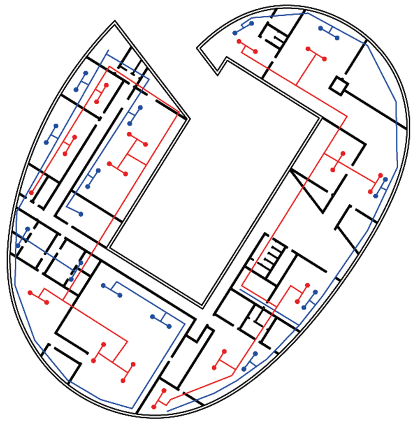

Hidden mechanical ventilation

As the ventilation need require large ducts in some places, it was furthermore investigated how these would impact the atmosphere of the rooms, if left visible. It quickly became clear, that the large dimensions of the ducts had a negative impact on the atmosphere intended. Therefore, the lowered ceiling was chosen within most areas, here showcased in the exhibition space (ill. 114).

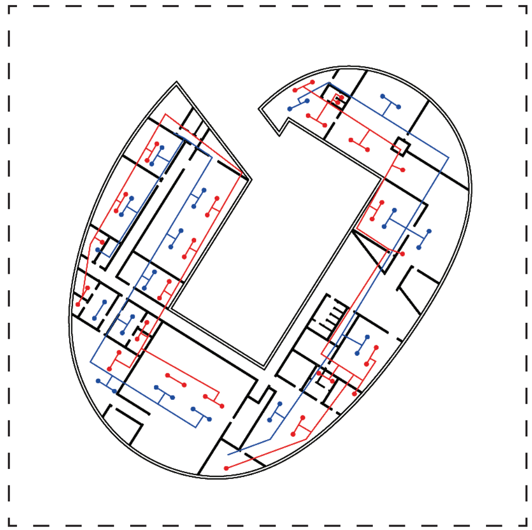
Ill.114: Mechanical ventilation studies



Ventilation concept 1



Ventilation concept 2



Ventilation concept 3

Exhaust air

Supply air

08 EPILOGUE

Conclusion
Refletion
References
Illustrations

Ill.115: View to site from the beach

CONCLUSION

At present in the architectural world, most projects gaining recognition and praise often relate to the new tendencies of pragmatism. Indeed, these projects deserve the honor even though there are major flaws with the approach of ignoring contextual qualities, history and local traditions. With Hawstok, the qualities of pragmatism attempts to merge with the mindset of regionalism embracing the unique characteristics of a given place, culminating in architectural design of the new Danish contextualism.

The design proposal for the centre aims to facilitate a modern, conveying, and yet relatable base for the dissemination centre of the plastic-problem and the given surfing facilities while providing the locals distinct spaces they are able to use throughout all seasons, as it belongs purely to them. Both the locals as well as the visitors will thereby, be able to comprehend the building shape mimicking the nabouring dunes, which it tucks itself into, along with its message of the possibilities of plastic waste, throught its own example of how to reuse a local resource of decommissioned fiberglass wind turbine blades within the buildings structure.

The interplay with the surrounding landscape, and the high regards to the micro climatic situation of the site, thus contributes to the design manifesting itself as a new take on the classical and traditional Danish four-lane farmhouse of the west coast area of Denmark.

REFLECTION

The Integrated Design Process, setting the baseline of methodology of this thesis, is an approach that builds upon continuous iterative analyses utilizing the interdisciplinary play between architecture and engineering. By such a notion, a reflection of the project development of this thesis also touches upon certain areas linked to both fields of work. In correlation to the main themes of the project, these are: Recycled plastic as a building material, wind as a design generator, and the use of LCA in practice and as a method.

USE OF RECYCLED PLASTIC

As soon as the notion of using plastic waste within the construction of the building came to light, the next question, which arose were: to what extent? To support a strong sense of theme and to explore fully what and how to incorporate existing recycled and upcycled plastic waste into the building, a total integration of the plastic in all layers of construction, insulation and wall-faces was considered. With the finished design mostly incorporating the plastic in the hidden structure, except for the exterior façade panels, and heavily supported by wooden non-loadbearing structures, it might seem that the strong theme and storytelling of a plastic waste building has faded as a compromise to other requirements. The concern of the atmospheric experience of the plastic building, as being somewhat of the experience of being trapped in a plastic bag - as is the cause of death of much marine life - however, brought a halt in the plastic enthusiasm. The concern of the cold tactile readability and lack of familiarity of the material, further led to the inclusion of more details made in wood and concrete into the structure, minimizing the amount of plastic, however strong a storytelling the building would have made on its own if fully embraced.

WIND AS A DESIGN GENERATOR

The exhilarating inspiration and many possibilities of the dune shapes of the context, became somewhat stuck in the functionalistic approach of function before form, based in the given restrictions of size and subject. The many possibilities of how to relate architecture to a context that is constantly changing, such as dunes are, thereby could have reached further architectural qualities through a further development of the organic shapes and structures inspired by nature's own parameters of design, within the analyzes of the wind and the movements of the sand.

Further wind studies of the final building shape could also have been used to challenge the need for mechanical ventilation, by exploiting the areas of lee, created by the roof structure, to enhance the use of natural ventilation. This notion could just as well as the goal for a comfortable climate within the courtyard, have been used as a design driver, throughout the project development, to support the use of integrated design, and strengthen the theme of wind as a design generator.

USE OF RECYCLED PLASTIC

Last but not least, a main theme of this project has also been the use of the Life Cycle Assessment (LCA) method throughout the design development. A satisfying result of the environmental impact of the building was reached, but still leaves room for reflection - especially considering the alternative use of fiberglass in this project. As seen on page 105, a 14% increase in the result was able to be reached by including an estimate of recycling materials - respectively 50% of the A1-3 phase of the insulation and 70% of the A1-3 phase of the fiberglass cladding. In this case, as in all cases revolving recycling a material, it is however worth considering, not only if this estimate is fair, but also if the processing of the decommissioned wind turbine blades, demands such a great amount of work - and thereby environmental impact - to fit the new use of the material, that it might just cancel out the savings of the recycling itself.

Another way of lowering the impact of the building could have been to work with the current trend of a full structure of wood, and only keep the fiberglass cladding. By doing so, a lower Global Warming Potential (GWP) could be expected. However, within a Danish context it is also worth noticing that the bulk of wood needed for the structure of this design, would most likely not be possible to be obtained from Danish sawmills, due to the low supply of lumber being produced in Denmark compared to the actual demand. Importation from other Nordic countries, such as Norway, would then be the only option, eventually also leading to a higher emission with regards to the long distance of transport of the heavy wood.

With the design as is now, it is furthermore worth noticing that the biggest share of impact is to be found in the C3 phase by 46% - this phase setting the boundary for waste processing with regards to reuse, recovery or recycling. To the best of our knowledge, we have found this to be caused by the great amount of construction wood used in the structure of the building to support the load-bearing fiberglass components. The potential for reuse or recycling of this material, then provides a great deal of work needed to carefully demolish and process the wood before it can be ready for its next life cycle. To lower this amount of work, and thereby hopefully lower the environmental impact needed to separate and process the wood, a design for disassembly mindset could be considered, due to it being based upon the exact notion of greater possibilities for reuse at the end-of-life stage of a certain material. If not the prepping of new material for reuse, would be the option, then the use of the prepped material itself could be - meaning that an initial use of already recycled wood in the supporting structure also could be an option to lower the GWP of the building, along with also emphasizing the storytelling of the building itself, as an example of how to use recycled materials in new constructions.

By the consideration of these reflections, or the actual studies of each, the integration of an iterative and integrated design process could continue on and add yet another layer of optimization to the design development. The use of the LCA method has therefore in this case proven well worthy of the work, by providing a new layer of knowledge, in both the field of architecture and engineering, through different phases of the project, merging very well with the guidelines of IDP, taught to us at Aalborg University during the last 5 years of studies at Architecture and Design.

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09 APPENDIX

Life Cycle Assessments
Structure
Building energy frame
Ventilation
Daylight

APPENDIX 01: LIFE CYCLE ASSESSMENTS

ANALYSIS DETAILS - AMOUNTS

Beskrivelse	Navn	Indtastet mængde		Beregnet mængde		Vægt	
Bygningsdel	Fiberline søjler					1090,60	kg
Konstruktion	Søjle H200	0,64	m³			894,60	kg
Byggevare	Glasfiber-forstærket plast, polyester (30% fiberandel)	1400,00	kg/m³	894,60	kg	894,60	kg
Konstruktion	Søjle H240	0,14	m³			196,00	kg
Byggevare	Glasfiber-forstærket plast, polyester (30% fiberandel)	1400,00	kg/m³	196,00	kg	196,00	kg
Bygningsdel	Stål søjle					6318,00	kg
Konstruktion	Bjælker/søjler, stål HEB 300	0,15	m³			1170,00	kg
Byggevare	Stålprofil	7800,00	kg/m³	1170,00	kg	1170,00	kg
Konstruktion	Bjælker/søjler, stål HEB 280	0,28	m³			2184,00	kg
Byggevare	Stålprofil	7800,00	kg/m³	2184,00	kg	2184,00	kg
Konstruktion	Bjælker/søjler, stål HEB 200	0,38	m³			2964,00	kg
Byggevare	Stålprofil	7800,00	kg/m³	2964,00	kg	2964,00	kg
Bygningsdel	Træ					2558,50	kg
Konstruktion	Bjælker, konstruktionstræ 200/200	0,72	m³			309,60	kg
Byggevare	Limtræ, nåletræ	430,00	kg/m³	0,60	m³	309,60	kg
Konstruktion	Bjælker, konstruktionstræ 200/200	1,00	m³			430,00	kg
Byggevare	Limtræ, nåletræ	430,00	kg/m³	0,83	m³	430,00	kg
Konstruktion	Bjælker, konstruktionstræ 200/200	4,23	m³			1818,90	kg
Byggevare	Limtræ, nåletræ	430,00	kg/m³	3,53	m³	1818,90	kg

ANALYSIS DETAILS - RESULTS

Beskrivelse	Navn	Total	Total	Total	Total	Total	Total
		Udskiftninger	GWP	GWP	GWP	GWP	GWP
			a1_3	c3	c4	d	sum
			kg CO2 eq.	kg CO2 eq.	kg CO2 eq.	kg CO2 eq.	kg CO2 eq.
Bygningsdel	Fiberline søjler		4069,12	1737,95	0,00	-804,70	5807,06
Bygningsdel	Stål søjle		6282,90	0,00	4,31	-2482,97	6287,21
Bygningsdel	Træ		-2933,08	4490,91	0,00	-1123,74	1557,82

PRESENTATION DETAILS - RESULTS

Beskrivelse	Navn	Total	Total	Total	Total	Total	Total
		Udskiftninger	GWP	GWP	GWP	GWP	GWP
			a1_3	c3	c4	d	sum
			kg CO2-eq.	kg CO2-eq.	kg CO2-eq.	kg CO2-eq.	kg CO2-eq.
Sum	Bygning		1,41E+05	4,05E+05	1,05E+04	-1,39E+05	8,75E+05
Sum	Drift		0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,23E+05
Driftforbrug el	El (Fremskrivning 2020-2040)		0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,07E+04
Driftforbrug varme	El (Fremskrivning 2020-2040)		0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,92E+05
Bygningsdel	Etagedæk		-8,35E+03	1,48E+04	1,23E+02	-2,23E+03	8,29E+03
Bygningsdel	Pæle fundament		1,77E+04	3,01E+02	2,73E+00	-2,64E+03	1,98E+04
Bygningsdel	Indervægge		1,74E+04	1,06E+04	8,05E+02	-2,83E+03	3,14E+04
Bygningsdel	Fiberline konstruktion		1,03E+04	4,41E+03	0,00E+00	-2,04E+03	1,62E+04
Bygningsdel	Tag fiberglas		-4,71E+04	2,14E+05	2,61E+03	-5,67E+04	2,05E+05
Bygningsdel	Terrændæk		1,55E+05	8,56E+04	5,61E+03	-3,88E+04	2,71E+05
Bygningsdel	Døre		-2,49E+03	5,13E+03	7,48E+00	-6,07E+02	3,98E+03
Bygningsdel	Glasfacader i gårdrum		3,78E+03	2,81E+02	3,03E+01	-1,30E+02	4,50E+03
Bygningsdel	Ovenlys		1,13E+04	7,55E+02	1,05E+01	-1,48E+04	2,53E+04
Bygningsdel	Vinduer		5,90E+03	1,27E+03	7,84E+02	-1,16E+03	1,35E+04
Bygningsdel	Ydervæg fiberglas		-9,10E+03	4,26E+04	3,17E+02	-1,13E+04	3,90E+04
Bygningsdel	Ydervæg træ		-1,34E+04	2,55E+04	1,76E+02	-5,88E+03	1,44E+04

PRESENTATION DETAILS - AMOUNTS

Beskrivelse	Navn	Total	Total	Total	Total
		Udskiftninger	GWP	GWP	GWP
			a1_3	a5	b4
			kg CO_2-eq.	kg CO_2-eq.	kg CO_2-eq.
Sum	Bygning		1,41E+05	5,53E+04	4,02E+04
Sum	Drift		0,00E+00	0,00E+00	0,00E+00
Driftforbrug el	El (Fremskrivning 2020-2040)		0,00E+00	0,00E+00	0,00E+00
Driftforbrug varme	El (Fremskrivning 2020-2040)		0,00E+00	0,00E+00	0,00E+00
Sum	Bygningsdel		1,41E+05	5,53E+04	4,02E+04
Gruppe	Dæk		-8,35E+03	4,95E+02	1,20E+03
Undergruppe	Etagedæk		-8,35E+03	4,95E+02	1,20E+03
Bygningsdel	Etagedæk		-8,35E+03	4,95E+02	1,20E+03
Konstruktion	Dæk, uden fiberline, mineraluld		-6,22E+03	2,40E+02	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	2,18E+02	2,18E+01	0,00E+00
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-1,83E+03	0,00E+00	0,00E+00
Byggevare	Krydsfinérplade	0	-5,39E+03	2,18E+02	0,00E+00
Byggevare	Mineraluld, alm. (Klon)	0	7,75E+02	0,00E+00	0,00E+00
Konstruktion	Gulv, trægulv		-3,64E+03	9,37E+01	0,00E+00
Byggevare	Træ, fyrretræ (12% fugt / 10,7% H2O)	0	-3,64E+03	9,37E+01	0,00E+00
Konstruktion	Loft, gipsplader		1,51E+03	1,62E+02	1,20E+03
Byggevare	Gipskartonplade 13 mm, hulplade	0	1,11E+03	1,22E+02	0,00E+00
Byggevare	Overflade, Facademaling, akryl maling	3	3,27E+02	3,29E+01	9,87E+02
Byggevare	Overflade, Facademaling, grunder, dispersion	3	6,98E+01	7,09E+00	2,13E+02
Gruppe	Fundamenter		1,77E+04	1,80E+03	0,00E+00
Gruppe	Pælefundering		1,77E+04	1,80E+03	0,00E+00
Bygningsdel	Pæle fundament		1,77E+04	1,80E+03	0,00E+00
Konstruktion	Rammet betonpæl, 250/250/10000		1,77E+04	1,80E+03	0,00E+00
Byggevare	Armeringsnet	0	2,73E+03	2,74E+02	0,00E+00
Byggevare	Beton C50/60, fabriksbeton og betonelementer	0	1,50E+04	1,53E+03	0,00E+00
Gruppe	Indervægge		1,74E+04	2,64E+03	0,00E+00

	Total	Total	Total	Total
	GWP	GWP	GWP	GWP
	c3	c4	d	sum
	kg CO_2-eq.	kg CO_2-eq.	kg CO_2-eq.	kg CO_2-eq.
	4,05E+05	1,05E+04	-1,39E+05	8,75E+05
	0,00E+00	0,00E+00	0,00E+00	2,23E+05
	0,00E+00	0,00E+00	0,00E+00	3,07E+04
	0,00E+00	0,00E+00	0,00E+00	1,92E+05
	4,05E+05	1,05E+04	-1,39E+05	6,52E+05
	1,48E+04	1,23E+02	-2,23E+03	8,29E+03
	1,48E+04	1,23E+02	-2,23E+03	8,29E+03
	1,48E+04	1,23E+02	-2,23E+03	8,29E+03
	1,02E+04	1,55E+01	-1,01E+03	4,28E+03
	0,00E+00	4,17E-02	-1,11E+02	2,39E+02
	2,65E+03	0,00E+00	-6,63E+02	8,23E+02
	7,57E+03	0,00E+00	-2,38E+02	2,40E+03
	2,80E+01	1,55E+01	0,00E+00	8,19E+02
	4,57E+03	0,00E+00	-1,21E+03	1,03E+03
	4,57E+03	0,00E+00	-1,21E+03	1,03E+03
	0,00E+00	1,08E+02	-9,20E+00	2,98E+03
	0,00E+00	1,04E+02	0,00E+00	1,34E+03
	0,00E+00	2,33E+00	-5,85E+00	1,35E+03
	0,00E+00	1,16E+00	-3,36E+00	2,91E+02
	3,01E+02	2,73E+00	-2,64E+03	1,98E+04
	3,01E+02	2,73E+00	-2,64E+03	1,98E+04
	3,01E+02	2,73E+00	-2,64E+03	1,98E+04
	3,01E+02	2,73E+00	-2,64E+03	1,98E+04
	0,00E+00	2,73E+00	-1,57E+03	3,01E+03
	3,01E+02	0,00E+00	-1,07E+03	1,68E+04
	1,06E+04	8,05E+02	-2,83E+03	3,14E+04

Undergruppe	Ikke-bærende indervægge		1,74E+04	2,64E+03	0,00E+00	
Bygningsdel	Indervægge		1,74E+04	2,64E+03	0,00E+00	
Konstruktion	Beklædning, brandgips 15 mm		2,92E+03	3,20E+02	0,00E+00	
Byggevare	Gipskartonplade, brandimprægneret	0	2,92E+03	3,20E+02	0,00E+00	
Konstruktion	Beklædning, brandgips 15 mm (Klon)		2,92E+03	3,20E+02	0,00E+00	
Byggevare	Gipskartonplade, brandimprægneret	0	2,92E+03	3,20E+02	0,00E+00	
Konstruktion	Glasvæg (komplet væg) (Klon)		1,62E+04	1,65E+03	0,00E+00	
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	3,70E+01	3,70E+00	0,00E+00	
Byggevare	Glas 3 mm	0	1,57E+04	1,59E+03	0,00E+00	
Byggevare	Glasfiber-forstærket plast, polyester (30% fiberandel)	0	3,88E+02	5,54E+01	0,00E+00	
Byggevare	Tætningsliste, EPDB, ekstruderet	0	2,60E+01	4,40E+00	0,00E+00	
Konstruktion	Midterdel, træskelet, ikke-bærende, mineraluld (Klon)		-4,63E+03	3,49E+02	0,00E+00	
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	2,80E+02	2,80E+01	0,00E+00	
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-7,12E+03	3,20E+02	0,00E+00	
Byggevare	Mineraluld, alm. (Klon)	0	2,21E+03	0,00E+00	0,00E+00	
Gruppe	Søjler og bjælker		1,03E+04	1,47E+03	0,00E+00	
Undergruppe	Andet (søjler og bjælker)		1,03E+04	1,47E+03	0,00E+00	
Bygningsdel	Fiberline konstruktion		1,03E+04	1,47E+03	0,00E+00	
Konstruktion	Fiberline rektangulært rør 200x200x12		5,44E+03	7,76E+02	0,00E+00	
Byggevare	Glasfiber-forstærket plast, polyester (30% fiberandel)	0	5,44E+03	7,76E+02	0,00E+00	
Konstruktion	Fiberline rektangulært rør 200x200x16		4,89E+03	6,98E+02	0,00E+00	
Byggevare	Glasfiber-forstærket plast, polyester (30% fiberandel)	0	4,89E+03	6,98E+02	0,00E+00	
Gruppe	Tage		-4,71E+04	1,70E+04	1,83E+04	
Undergruppe	Tage		-4,71E+04	1,70E+04	1,83E+04	
Bygningsdel	Tag fiberglas		-4,71E+04	1,70E+04	1,83E+04	
Konstruktion	Loft, gipsplader på trælægter		-2,59E+04	3,55E+03	7,94E+03	
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	9,60E+02	9,60E+01	0,00E+00	
Byggevare	Gipskartonplade 13 mm, hulplade	0	7,37E+03	8,05E+02	0,00E+00	

	1,06E+04	8,05E+02	-2,83E+03	3,14E+04
	1,06E+04	8,05E+02	-2,83E+03	3,14E+04
	0,00E+00	2,84E+02	0,00E+00	3,52E+03
	0,00E+00	2,84E+02	0,00E+00	3,52E+03
	0,00E+00	2,84E+02	0,00E+00	3,52E+03
	0,00E+00	2,84E+02	0,00E+00	3,52E+03
	1,84E+02	1,93E+02	-1,06E+02	1,82E+04
	0,00E+00	7,09E-03	-1,88E+01	4,07E+01
	0,00E+00	1,93E+02	0,00E+00	1,75E+04
	1,66E+02	0,00E+00	-7,67E+01	6,09E+02
	1,80E+01	0,00E+00	-1,06E+01	4,84E+01
	1,04E+04	4,42E+01	-2,72E+03	6,17E+03
	0,00E+00	5,38E-02	-1,43E+02	3,08E+02
	1,03E+04	0,00E+00	-2,58E+03	3,53E+03
	7,96E+01	4,41E+01	0,00E+00	2,33E+03
	4,41E+03	0,00E+00	-2,04E+03	1,62E+04
	4,41E+03	0,00E+00	-2,04E+03	1,62E+04
	4,41E+03	0,00E+00	-2,04E+03	1,62E+04
	2,32E+03	0,00E+00	-1,08E+03	8,54E+03
	2,32E+03	0,00E+00	-1,08E+03	8,54E+03
	2,09E+03	0,00E+00	-9,67E+02	7,68E+03
	2,09E+03	0,00E+00	-9,67E+02	7,68E+03
	2,14E+05	2,61E+03	-5,67E+04	2,05E+05
	2,14E+05	2,61E+03	-5,67E+04	2,05E+05
	2,14E+05	2,61E+03	-5,67E+04	2,05E+05
	6,04E+04	1,04E+03	-1,57E+04	4,70E+04
	0,00E+00	1,84E-01	-4,89E+02	1,06E+03
	0,00E+00	6,89E+02	0,00E+00	8,86E+03

Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-4,17E+04	1,88E+03	0,00E+00
Byggevare	Overflade, Facademaling, akryl maling	3	2,16E+03	2,18E+02	6,53E+03
Byggevare	Overflade, Facademaling, grunder, dispersion	3	4,62E+02	4,69E+01	1,41E+03
Byggevare	Puds, kalk-gips, inde	0	4,77E+03	5,10E+02	0,00E+00
Konstruktion	Midterlag, bjælkespær, ventileret, skrå tage, mineraluld (Klon)		-3,16E+04	6,67E+03	1,03E+04
Byggevare	Dampspærre PE (tykkelse 0,0002 m)	1	1,08E+03	2,58E+02	2,58E+03
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	1,44E+03	1,44E+02	0,00E+00
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-4,20E+04	1,89E+03	0,00E+00
Byggevare	Krydsfinérplade	0	-2,38E+04	9,61E+02	0,00E+00
Byggevare	Mineraluld, alm. (Klon)	0	2,11E+04	2,22E+03	0,00E+00
Byggevare	Mineraluld, løsfyld (Klon)	0	3,89E+03	4,12E+02	0,00E+00
Byggevare	Tagpap, bitumen undermembran	1	6,68E+03	7,75E+02	7,75E+03
Konstruktion	Tag, glasfiber, underkonstruktion i træ		1,04E+04	6,76E+03	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	1,92E+03	1,92E+02	0,00E+00
Byggevare	Glasfiber-forstærket plast, polyester (30% fiberandel) (Klon)	0	2,42E+04	5,86E+03	0,00E+00
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-1,56E+04	7,04E+02	0,00E+00
Gruppe	Terrændæk		1,55E+05	2,46E+04	0,00E+00
Undergruppe	Terrændæk		1,55E+05	2,46E+04	0,00E+00
Bygningsdel	Terrændæk		1,55E+05	2,46E+04	0,00E+00
Konstruktion	Dæk, betonelement, forspændt huldæk 0,22/12,0 m		1,15E+05	1,17E+04	0,00E+00
Byggevare	Armeringsnet	0	1,58E+04	1,58E+03	0,00E+00
Byggevare	Beton C45/55, fabriksbeton og betonelementer	0	9,88E+04	1,01E+04	0,00E+00
Konstruktion	Gulv, beton slidlag (Klon)		5,78E+04	6,25E+03	0,00E+00
Byggevare	Afretningslag, cementbaseret	0	5,78E+04	6,25E+03	0,00E+00
Konstruktion	ISO 140mm, træskelet, ikke-bærende, mineraluld		-1,52E+04	1,93E+03	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	9,33E+02	9,33E+01	0,00E+00

	6,04E+04	0,00E+00	-1,51E+04	2,06E+04
	0,00E+00	1,54E+01	-3,87E+01	8,92E+03
	0,00E+00	7,70E+00	-2,22E+01	1,92E+03
	0,00E+00	3,24E+02	0,00E+00	5,61E+03
	9,67E+04	1,58E+03	-1,85E+04	8,37E+04
	1,50E+03	0,00E+00	-1,48E+03	5,42E+03
	0,00E+00	2,76E-01	-7,33E+02	1,58E+03
	6,09E+04	0,00E+00	-1,52E+04	2,08E+04
	3,34E+04	0,00E+00	-1,05E+03	1,06E+04
	7,59E+02	4,21E+02	0,00E+00	2,45E+04
	1,51E+02	8,39E+01	0,00E+00	4,54E+03
	0,00E+00	1,07E+03	0,00E+00	1,63E+04
	5,71E+04	3,68E-01	-2,26E+04	7,43E+04
	0,00E+00	3,68E-01	-9,78E+02	2,11E+03
	3,44E+04	0,00E+00	-1,59E+04	6,45E+04
	2,27E+04	0,00E+00	-5,67E+03	7,75E+03
	8,56E+04	5,61E+03	-3,88E+04	2,71E+05
	8,56E+04	5,61E+03	-3,88E+04	2,71E+05
	8,56E+04	5,61E+03	-3,88E+04	2,71E+05
	2,08E+03	1,58E+01	-1,65E+04	1,28E+05
	0,00E+00	1,58E+01	-9,08E+03	1,74E+04
	2,08E+03	0,00E+00	-7,39E+03	1,11E+05
	0,00E+00	4,73E+03	0,00E+00	6,88E+04
	0,00E+00	4,73E+03	0,00E+00	6,88E+04
	3,44E+04	1,47E+02	-9,01E+03	2,12E+04
	0,00E+00	1,79E-01	-4,75E+02	1,03E+03

Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-2,35E+04	1,06E+03	0,00E+00
Byggevare	Mineraluld, alm. (Klon)	0	7,35E+03	7,76E+02	0,00E+00
Konstruktion	ISO 200mm, træskelet, ikke-bærende, mineraluld		-2,22E+04	2,72E+03	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	9,33E+02	9,33E+01	0,00E+00
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-3,36E+04	1,51E+03	0,00E+00
Byggevare	Mineraluld, alm. (Klon)	0	1,05E+04	1,11E+03	0,00E+00
Konstruktion	Yderside, fibercementplade		1,98E+04	2,03E+03	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	1,40E+03	1,40E+02	0,00E+00
Byggevare	Fibercementplade	0	1,84E+04	1,89E+03	0,00E+00
Gruppe	Vinduer, døre, glasfacader		1,85E+04	2,68E+03	1,79E+04
Undergruppe	Døre		-2,49E+03	2,65E+02	1,07E+03
Bygningsdel	Døre		-2,49E+03	2,65E+02	1,07E+03
Konstruktion	Dør, indvendig		-3,01E+03	1,58E+02	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	2,10E+02	2,10E+01	0,00E+00
Byggevare	Overflade, Indendørsmaling, emulsions maling, slidstærk	0	5,53E+01	5,56E+00	0,00E+00
Byggevare	Spånplade	0	-2,43E+03	1,10E+02	0,00E+00
Byggevare	Træ, fyrretræ (12% fugt / 10,7% H2O)	0	-8,42E+02	2,17E+01	0,00E+00
Konstruktion	Dør, indvendig, glasdør		5,18E+02	1,07E+02	1,07E+03
Byggevare	3-lags-rude	1	8,34E+02	8,85E+01	8,85E+02
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	1	4,62E+01	4,62E+00	4,62E+01
Byggevare	Overflade, Indendørsmaling, emulsions maling, slidstærk	1	4,92E+00	4,95E-01	4,95E+00
Byggevare	Spånplade	1	-1,81E+02	8,18E+00	8,18E+01
Byggevare	Træ, fyrretræ (12% fugt / 10,7% H2O)	1	-1,86E+02	4,78E+00	4,78E+01
Undergruppe	Glasfacader		3,78E+03	4,10E+02	0,00E+00
Bygningsdel	Glasfacader i gårdrum		3,78E+03	4,10E+02	0,00E+00
Konstruktion	Karm, curtain wall facade, aluminium (Klon)		3,78E+03	4,10E+02	0,00E+00
Byggevare	3-lags-rude	0	3,56E+03	3,78E+02	0,00E+00
Byggevare	Glasfiber-forstærket plast, polyester (30% fiberandel)	0	2,21E+02	3,15E+01	0,00E+00
Undergruppe	Vinduer		1,72E+04	2,00E+03	1,68E+04

	3,41E+04	0,00E+00	-8,53E+03	1,17E+04
	2,65E+02	1,47E+02	0,00E+00	8,54E+03
	4,91E+04	2,10E+02	-1,27E+04	2,99E+04
	0,00E+00	1,79E-01	-4,75E+02	1,03E+03
	4,87E+04	0,00E+00	-1,22E+04	1,66E+04
	3,79E+02	2,10E+02	0,00E+00	1,22E+04
	0,00E+00	5,12E+02	-7,13E+02	2,23E+04
	0,00E+00	2,69E-01	-7,13E+02	1,54E+03
	0,00E+00	5,12E+02	0,00E+00	2,08E+04
	7,44E+03	8,33E+02	-1,67E+04	4,73E+04
	5,13E+03	7,48E+00	-6,07E+02	3,98E+03
	5,13E+03	7,48E+00	-6,07E+02	3,98E+03
	4,59E+03	3,57E-01	-3,95E+02	1,74E+03
	0,00E+00	4,02E-02	-1,07E+02	2,31E+02
	0,00E+00	3,17E-01	-2,28E-01	6,12E+01
	3,53E+03	0,00E+00	-8,16E+00	1,21E+03
	1,06E+03	0,00E+00	-2,80E+02	2,39E+02
	5,40E+02	7,12E+00	-2,12E+02	2,24E+03
	4,38E+01	7,09E+00	-4,06E+01	1,86E+03
	0,00E+00	8,87E-03	-4,71E+01	9,71E+01
	0,00E+00	2,81E-02	-4,06E-02	1,04E+01
	2,63E+02	0,00E+00	-1,22E+00	1,72E+02
	2,33E+02	0,00E+00	-1,23E+02	1,00E+02
	2,81E+02	3,03E+01	-1,30E+02	4,50E+03
	2,81E+02	3,03E+01	-1,30E+02	4,50E+03
	2,81E+02	3,03E+01	-1,30E+02	4,50E+03
	1,87E+02	3,03E+01	-8,67E+01	4,16E+03
	9,43E+01	0,00E+00	-4,37E+01	3,47E+02
	2,03E+03	7,95E+02	-1,60E+04	3,88E+04

Bygningsdel	Ovenlys		1,13E+04	1,21E+03	1,21E+04
Konstruktion	Fladtagsvindue, plast (komplet vindue)		1,13E+04	1,21E+03	1,21E+04
Byggevare	Fladtagsvindue, plast (komplet vindue)	1	1,13E+04	1,21E+03	1,21E+04
Bygningsdel	Vinduer		5,90E+03	7,95E+02	4,72E+03
Konstruktion	Karm, vinduer, fiberglas		1,45E+03	3,23E+02	0,00E+00
Byggevare	EPDM-tætning til aluminiumsprofil	0	7,65E+02	2,26E+02	0,00E+00
Byggevare	Glasfiber-forstærket plast, polyester (30% fiberandel)	0	6,84E+02	9,75E+01	0,00E+00
Konstruktion	Rude, 3-lags energirude		4,45E+03	4,72E+02	4,72E+03
Byggevare	3-lags-rude	1	4,45E+03	4,72E+02	4,72E+03
Gruppe	Ydervægge		-2,25E+04	4,60E+03	2,85E+03
Undergruppe	Ydervægge		-2,25E+04	4,60E+03	2,85E+03
Bygningsdel	Ydervæg fiberglas		-9,10E+03	3,38E+03	1,84E+03
Konstruktion	Facade, glasfiber, underkonstruktion i træ		3,12E+03	1,64E+03	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	4,44E+02	4,44E+01	0,00E+00
Byggevare	Gipskartonplade 13 mm, imprægneret	0	6,99E+02	7,64E+01	0,00E+00
Byggevare	Glasfiber-forstærket plast, polyester (30% fiberandel) (Klon)	0	5,59E+03	1,36E+03	0,00E+00
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-3,62E+03	1,63E+02	0,00E+00
Konstruktion	ISO 140mm, træskelet, ikke-bærende, mineraluld		-3,63E+03	4,59E+02	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	2,22E+02	2,22E+01	0,00E+00
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-5,60E+03	2,52E+02	0,00E+00
Byggevare	Mineraluld, alm. (Klon)	0	1,75E+03	1,85E+02	0,00E+00
Konstruktion	ISO 140mm, træskelet, ikke-bærende, mineraluld		-3,63E+03	4,59E+02	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	2,22E+02	2,22E+01	0,00E+00
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-5,60E+03	2,52E+02	0,00E+00
Byggevare	Mineraluld, alm. (Klon)	0	1,75E+03	1,85E+02	0,00E+00
Konstruktion	ISO 45mm, træskelet, ikke-bærende, mineraluld		-1,11E+03	1,54E+02	0,00E+00
Byggevare	Dampspærre PE (tykkelse 0,0002 m)	0	1,25E+01	2,98E+00	0,00E+00

	7,55E+02	1,05E+01	-1,48E+04	2,53E+04
	7,55E+02	1,05E+01	-1,48E+04	2,53E+04
	7,55E+02	1,05E+01	-1,48E+04	2,53E+04
	1,27E+03	7,84E+02	-1,16E+03	1,35E+04
	1,04E+03	7,47E+02	-9,42E+02	3,56E+03
	7,47E+02	7,47E+02	-8,07E+02	2,48E+03
	2,92E+02	0,00E+00	-1,35E+02	1,07E+03
	2,34E+02	3,78E+01	-2,16E+02	9,91E+03
	2,34E+02	3,78E+01	-2,16E+02	9,91E+03
	6,80E+04	4,93E+02	-1,72E+04	5,35E+04
	6,80E+04	4,93E+02	-1,72E+04	5,35E+04
	4,26E+04	3,17E+02	-1,13E+04	3,90E+04
	1,32E+04	6,48E+01	-5,23E+03	1,80E+04
	0,00E+00	8,52E-02	-2,26E+02	4,89E+02
	0,00E+00	6,47E+01	0,00E+00	8,40E+02
	7,96E+03	0,00E+00	-3,69E+03	1,49E+04
	5,25E+03	0,00E+00	-1,31E+03	1,79E+03
	8,18E+03	3,50E+01	-2,14E+03	5,05E+03
	0,00E+00	4,26E-02	-1,13E+02	2,44E+02
	8,12E+03	0,00E+00	-2,03E+03	2,77E+03
	6,31E+01	3,49E+01	0,00E+00	2,03E+03
	8,18E+03	3,50E+01	-2,14E+03	5,05E+03
	0,00E+00	4,26E-02	-1,13E+02	2,44E+02
	8,12E+03	0,00E+00	-2,03E+03	2,77E+03
	6,31E+01	3,49E+01	0,00E+00	2,03E+03
	2,65E+03	1,13E+01	-7,18E+02	1,70E+03
	1,74E+01	0,00E+00	-8,57E+00	3,28E+01

Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	1,11E+02	1,11E+01	0,00E+00
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-1,80E+03	8,10E+01	0,00E+00
Byggevare	Mineraluld, alm. (Klon)	0	5,62E+02	5,94E+01	0,00E+00
Konstruktion	ISO 45mm, træskelet, ikke-bærende, mineraluld		-1,13E+03	1,51E+02	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	1,11E+02	1,11E+01	0,00E+00
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-1,80E+03	8,10E+01	0,00E+00
Byggevare	Mineraluld, alm. (Klon)	0	5,62E+02	5,94E+01	0,00E+00
Konstruktion	Vægside, krydsfiner / gipsplade		-2,71E+03	5,17E+02	1,84E+03
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	2,22E+02	2,22E+01	0,00E+00
Byggevare	Gipskartonplade 13 mm, hulplade	0	8,52E+02	9,32E+01	0,00E+00
Byggevare	Krydsfinérplade	0	-5,50E+03	2,22E+02	0,00E+00
Byggevare	Overflade, Facademaling, akryl maling	3	5,00E+02	5,04E+01	1,51E+03
Byggevare	Overflade, Facademaling, grunder, dispersion	3	1,07E+02	1,09E+01	3,26E+02
Byggevare	Puds, kalk-gips, inde	0	1,10E+03	1,18E+02	0,00E+00
Bygningsdel	Ydervæg træ		-1,34E+04	1,22E+03	1,02E+03
Konstruktion	ISO 140mm, træskelet, ikke-bærende, mineraluld		-2,01E+03	2,54E+02	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	1,23E+02	1,23E+01	0,00E+00
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-3,10E+03	1,40E+02	0,00E+00
Byggevare	Mineraluld, alm. (Klon)	0	9,69E+02	1,02E+02	0,00E+00
Konstruktion	ISO 140mm, træskelet, ikke-bærende, mineraluld		-2,01E+03	2,54E+02	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	1,23E+02	1,23E+01	0,00E+00
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-3,10E+03	1,40E+02	0,00E+00
Byggevare	Mineraluld, alm. (Klon)	0	9,69E+02	1,02E+02	0,00E+00
Konstruktion	ISO 45mm, træskelet, ikke-bærende, mineraluld		-6,17E+02	8,56E+01	0,00E+00
Byggevare	Dampspærre PE (tykkelse 0,0002 m)	0	6,91E+00	1,65E+00	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	6,15E+01	6,15E+00	0,00E+00
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-9,97E+02	4,49E+01	0,00E+00

	0,00E+00	2,13E-02	-5,65E+01	1,22E+02
	2,61E+03	0,00E+00	-6,52E+02	8,91E+02
	2,03E+01	1,12E+01	0,00E+00	6,53E+02
	2,63E+03	1,13E+01	-7,09E+02	1,67E+03
	0,00E+00	2,13E-02	-5,65E+01	1,22E+02
	2,61E+03	0,00E+00	-6,52E+02	8,91E+02
	2,03E+01	1,12E+01	0,00E+00	6,53E+02
	7,72E+03	1,60E+02	-3,70E+02	7,52E+03
	0,00E+00	4,26E-02	-1,13E+02	2,44E+02
	0,00E+00	7,97E+01	0,00E+00	1,02E+03
	7,72E+03	0,00E+00	-2,43E+02	2,45E+03
	0,00E+00	3,56E+00	-8,95E+00	2,06E+03
	0,00E+00	1,78E+00	-5,14E+00	4,45E+02
	0,00E+00	7,50E+01	0,00E+00	1,30E+03
	2,55E+04	1,76E+02	-5,88E+03	1,44E+04
	4,53E+03	1,94E+01	-1,19E+03	2,80E+03
	0,00E+00	2,36E-02	-6,26E+01	1,35E+02
	4,50E+03	0,00E+00	-1,12E+03	1,54E+03
	3,49E+01	1,94E+01	0,00E+00	1,13E+03
	4,53E+03	1,94E+01	-1,19E+03	2,80E+03
	0,00E+00	2,36E-02	-6,26E+01	1,35E+02
	4,50E+03	0,00E+00	-1,12E+03	1,54E+03
	3,49E+01	1,94E+01	0,00E+00	1,13E+03
	1,47E+03	6,23E+00	-3,97E+02	9,41E+02
	9,62E+00	0,00E+00	-4,75E+00	1,82E+01
	0,00E+00	1,18E-02	-3,13E+01	6,77E+01
	1,45E+03	0,00E+00	-3,61E+02	4,94E+02

Byggevare	Mineraluld, alm. (Klon)	0	3,11E+02	3,29E+01	0,00E+00
Konstruktion	ISO 45mm, træskelet, ikke-bærende, mineraluld		-6,24E+02	8,39E+01	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	6,15E+01	6,15E+00	0,00E+00
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-9,97E+02	4,49E+01	0,00E+00
Byggevare	Mineraluld, alm. (Klon)	0	3,11E+02	3,29E+01	0,00E+00
Konstruktion	Vægside, krydsfiner / gipsplade		-1,50E+03	2,86E+02	1,02E+03
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	1,23E+02	1,23E+01	0,00E+00
Byggevare	Gipskartonplade 13 mm, hulplade	0	4,72E+02	5,16E+01	0,00E+00
Byggevare	Krydsfinérplade	0	-3,05E+03	1,23E+02	0,00E+00
Byggevare	Overflade, Facademaling, akryl maling	3	2,77E+02	2,79E+01	8,37E+02
Byggevare	Overflade, Facademaling, grunder, dispersion	3	5,92E+01	6,02E+00	1,80E+02
Byggevare	Puds, kalk-gips, inde	0	6,12E+02	6,53E+01	0,00E+00
Konstruktion	Yderside, bræddebeklædning, nåletræ		-6,66E+03	2,56E+02	0,00E+00
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0	1,85E+02	1,85E+01	0,00E+00
Byggevare	Gipskartonplade 13 mm, imprægneret	0	3,87E+02	4,23E+01	0,00E+00
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0	-4,61E+02	2,08E+01	0,00E+00
Byggevare	Træ, fyrretræ (12% fugt / 10,7% H2O)	0	-6,77E+03	1,75E+02	0,00E+00

	1,12E+01	6,22E+00	0,00E+00	3,62E+02
	1,46E+03	6,23E+00	-3,93E+02	9,23E+02
	0,00E+00	1,18E-02	-3,13E+01	6,77E+01
	1,45E+03	0,00E+00	-3,61E+02	4,94E+02
	1,12E+01	6,22E+00	0,00E+00	3,62E+02
	4,28E+03	8,86E+01	-2,05E+02	4,17E+03
	0,00E+00	2,36E-02	-6,26E+01	1,35E+02
	0,00E+00	4,41E+01	0,00E+00	5,68E+02
	4,28E+03	0,00E+00	-1,35E+02	1,36E+03
	0,00E+00	1,97E+00	-4,96E+00	1,14E+03
	0,00E+00	9,86E-01	-2,85E+00	2,47E+02
	0,00E+00	4,15E+01	0,00E+00	7,18E+02
	9,19E+03	3,59E+01	-2,51E+03	2,82E+03
	0,00E+00	3,54E-02	-9,40E+01	2,03E+02
	0,00E+00	3,58E+01	0,00E+00	4,66E+02
	6,69E+02	0,00E+00	-1,67E+02	2,29E+02
	8,52E+03	0,00E+00	-2,25E+03	1,92E+03

PROCESS DETAILS

Beskrivelse	Navn	Indtastet mængde		Beregnet mængde		Vægt	
Bygningsdel	Vinduer					2,03	kg
Konstruktion	Karm, vinduer, Glasfiber	0,03	m²			0,29	kg
Byggevare	EPDM-tætning til aluminiumsprofil	5,78	m/m²	0,19	m	0,03	kg
Byggevare	Vindueskarm, plast (PVC)	4,20	kg/m²	0,14	kg	0,14	kg
Byggevare	Vinduesramme, plast (PVC)	3,50	kg/m²	0,12	kg	0,12	kg
Konstruktion	Karm, vinduer, aluminium	0,03	m³			0,31	kg
Byggevare	EPDM-tætning til aluminiumsprofil	5,78	m/m³	0,19	m	0,03	kg
Byggevare	Vindueskarm, aluminium	2,76	m/m³	0,09	m	0,13	kg
Byggevare	Vinduesramme, aluminium	2,87	m/m³	0,09	m	0,14	kg
Konstruktion	Karm, vinduer, plast	0,03	m²			0,58	kg
Byggevare	EPDM-tætning til aluminiumsprofil	5,78	m/m²	0,19	m	0,03	kg
Byggevare	Vindueskarm, plast (PVC)	2,87	m/m²	0,09	m	0,27	kg
Byggevare	Vinduesramme, plast (PVC)	2,76	m/m²	0,09	m	0,28	kg
Konstruktion	Karm, vinduer, træ	0,03	m³			0,43	kg
Byggevare	EPDM-tætning til aluminiumsprofil	5,78	m/m³	0,19	m	0,03	kg
Byggevare	Vindueskarm, træ	2,87	m/m³	0,09	m	0,20	kg
Byggevare	Vinduesramme, træ	2,76	m/m³	0,09	m	0,19	kg
Konstruktion	Karm, vinduer, træ, nedsat holdbarhed	0,03	m³			0,43	kg
Byggevare	EPDM-tætning til aluminiumsprofil	5,78	m/m³	0,19	m	0,03	kg
Byggevare	Vindueskarm, træ	2,87	m/m³	0,09	m	0,20	kg
Byggevare	Vinduesramme, træ	2,76	m/m³	0,09	m	0,19	kg
Bygningsdel	Facade					41,96	kg
Konstruktion	Fyrtræ, bræddebeklædning	1,00	m²			12,78	kg
Byggevare	Overflade, træfacade, semi-pigmenteret lasursystem	0,38	kg/m²	0,38	kg	0,38	kg

Byggevare	Træ, fyrretræ (12% fugt / 10,7% H2O)	12,40	kg/m²	0,02	m³	12,40	kg
Konstruktion	Fyrtræ, nedsat holdbarhed	1,00	m²			12,78	kg
Byggevare	Overflade, træfacade, semi-pigmenteret lasursystem	0,38	kg/m²	0,38	kg	0,38	kg
Byggevare	Træ, fyrretræ (12% fugt / 10,7% H2O)	12,40	kg/m²	0,02	m³	12,40	kg
Konstruktion	Glasfiber	1,00	m²			8,20	kg
Byggevare	Glasfiber-forstærket plast, polyester	8,20	kg/m²	8,20	kg	8,20	kg
Konstruktion	Glasfiber genbrug	1,00	m²			8,20	kg
Byggevare	Glasfiber-forstærket plast, polyester (30% fiberandel)	8,20	kg/m²	8,20	kg	8,20	kg
Bygningsdel	Isolering					58,90	kg
Konstruktion	Glasfiber genbrug - Mineraluld klon	0,37	m³			11,10	kg
Byggevare	Mineraluld, alm.	30,00	kg/m³	0,42	m³	11,10	kg
Konstruktion	Mineraluld	0,32	m³			9,60	kg
Byggevare	Mineraluld, alm.	30,00	kg/m³	0,37	m³	9,60	kg
Konstruktion	Papiruld	0,43	m³			17,20	kg
Byggevare	Papiruldsisolering, løsfyld	40,00	kg/m³	0,38	m³	17,20	kg
Konstruktion	Træfiber	0,42	m²			21,00	kg
Byggevare	Træfiberisolering	50,00	kg/m²	0,13	m³	21,00	kg
Bygningsdel	Konstruktion					10082,00	kg
Konstruktion	Bjælker, stål IPE 100	0,81	m³			6318,00	kg
Byggevare	Stålprofil	7800,00	kg/m³	6318,00	kg	6318,00	kg
Konstruktion	Glasfiber	0,76	m³			1064,00	kg
Byggevare	Glasfiber-forstærket plast, polyester (30% fiberandel)	1400,00	kg/m³	1064,00	kg	1064,00	kg
Konstruktion	Midterdel, træskelet, bærende, mineraluld	6,00	m³			2700,00	kg
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	450,00	kg/m³	5,10	m³	2700,00	kg

PROCESS DETAILS

Beskrivelse	Navn	Total	Total	Total	Total	Total	Total
		Udskiftninger	GWP	GWP	GWP	GWP	GWP
			a1_3	c3	c4	d	sum
			kg CO2-eq.	kg CO2-eq.	kg CO2-eq.	kg CO2-eq.	kg CO2-eq.
Bygningsdel	Vinduer		6,08E+00	3,37E+00	5,38E-01	-4,14E+00	1,07E+01
Konstruktion	Karm, vinduer, Glasfiber		1,06E+00	5,13E-01	1,08E-01	-3,04E-01	1,68
Konstruktion	Karm, vinduer, aluminium		3,16E+00	2,27E-01	1,08E-01	-1,97E+00	3,50
Konstruktion	Karm, vinduer, plast (PVC)		1,73E+00	9,18E-01	1,08E-01	-7,34E-01	2,76
Konstruktion	Karm, vinduer, træ		6,18E-02	8,58E-01	1,08E-01	-4,17E-01	1,03
Konstruktion	Karm, vinduer, træ, nedsat holdbarhed	1	6,18E-02	8,58E-01	1,08E-01	-7,17E-01	1,73
Bygningsdel	Facade		7,03E+00	7,13E+01	0,00E+00	-3,11E+01	99,18
Konstruktion	Fyrtræ, bræddebeklædning		-1,67E+01	2,26E+01	0,00E+00	-6,28E+00	9,99
Konstruktion	Fyrtræ, nedsat holdbarhed	1	-1,67E+01	2,26E+01	0,00E+00	-1,28E+01	22,70
Konstruktion	Glasfiber		3,06E+01	1,31E+01	0,00E+00	-6,05E+00	43,65
Konstruktion	Glasfiber 70% genbrug		9,76E+00	1,31E+01	0,00E+00	-6,05E+00	22,83
Bygningsdel	Isolering		-2,57E+01	7,02E+01	3,15E-01	-2,82E+01	45,02
Konstruktion	Glasfiber 50% genbrug		8,46E+00	3,05E-01	1,69E-01	0,00E+00	8,93
Konstruktion	Glasuld		1,47E+01	2,64E-01	1,46E-01	0,00E+00	15,15
Konstruktion	Papiruld		-2,80E+01	3,79E+01	0,00E+00	-1,17E+01	10,01
Konstruktion	Træfiber		-2,08E+01	3,18E+01	0,00E+00	-1,65E+01	10,92
Bygningsdel	Konstruktion		6,98E+03	6,43E+03	4,31E+00	-4,45E+03	13555,14
Konstruktion	Stål		6,28E+03	0,00E+00	4,31E+00	-2,48E+03	6370,51
Konstruktion	Glasfiber		3,97E+03	1,70E+03	0,00E+00	-7,85E+02	5686,42
Konstruktion	Træ		-3,27E+03	4,74E+03	0,00E+00	-1,18E+03	1498,22

All data extracted has been given through the program of LCA Byg by 25/5/2022.

APPENDIX 02: STRUCTURE

LOAD CALCULATIONS

Konstruktionen regnes som konsekvensklasse 2

Egenlasten laves direkte i Autodesk Robot på baggrund af information og data for enkelte konstruktionselementer. Der laves manuelle last kombinationer direkte i Robot.
Følgende vind og snelaster beregnes med udgangs punkt i det værste scenarie ift. dominerende vindlast. Dvs. vind fra VNV.

Dominerende vindlast

$\gamma_{Q1} \cdot K_{F1} \cdot Q_{K1}$ taget fra brudgrænseligningen (andet led)

Først skal basisvindhastigheden beregnes:

$v_b = c_{dir} \cdot c_{sæson} \cdot v_{b,0}$:

hvor:

$v_{b,0} = grundværdien\ regnes\ til\ 27 \cdot \left(\frac{m}{s}\right)$:

$c_{dir} = retningsfaktor$: vind fra vest 1.0

$c_{sæson} = årstidsfaktor$: værste måned 1.0

Basisvinden udregnes til:

$$v_b = 1 \cdot 1 \cdot 27 \left(\frac{m}{s}\right) = v_b = \frac{24\ m}{s}$$

Middelvindhastigheden

$v_m(z) = c_r(z) \cdot c_o(z) \cdot v_b$:

hvor:

$z = er\ højden\ over\ terræn$:

$c_r(z) = ruhedsfaktoren$:

$c_o(z) = orografifaktoren,\ regnes\ til\ 1.0$:

Ruhedsfaktoren bestemmes ud fra følgende formel:

$$c_r(z) = k_r \cdot \ln\left(\frac{z}{z_0}\right) :$$

hvor z_0 : aflæses ud fra terrænkategori 1 (EC1- tabel 4.1) til 0.01

z sættes til 4m, da dette er højden af vind over terræn og 4m er cirka midt på konstrutionen.

k_r : er terrænfaktoren afhængig af ruhedslængden og findes med følgende formel:

$$k_r = 0.19 \left(\frac{z_0}{z_{0,2}}\right)^{0.07} :$$

hvor:

$z_{0,2} = 0.01\ m$:

$$k_r = 0.19 \cdot \left(\frac{0.01\ m}{0.01\ m}\right)^{0.07} = k_r = 0.19$$

dette kan nu indsættes i tabellen for ruhedsfaktoren

$$c_r(z) = 0.19 \cdot \ln\left(\frac{4\ m}{0.01\ m}\right) = c_r(z) = 1.138378264$$

Dette kan nu sættes ind i formlen for middelvindhastigheden:

$$v_m(z) = 1.138378264 \cdot 1 \cdot 27 \left(\frac{m}{s}\right) = v_m(z) = \frac{30.73621313\ m}{s}$$

Vindens turbulens

$$I_v(z) = \frac{\sigma_v}{v_m(z)} = \frac{k_I}{c_o(z) \cdot \ln\left(\frac{z}{z_0}\right)} :$$

hvor:

$k_I = turbulensfaktor\ med\ anbefaletværdi = 1$:

vi benytter os af den sidste af formlerne da vi kender alle værdierne fra forrige udregninger.

$$I_v(z) = \frac{k_I}{c_o(z) \cdot \ln\left(\frac{z}{z_0}\right)}$$

$$I_v(z) = \frac{1}{1 \cdot \ln\left(\frac{4\ m}{0.01\ m}\right)} = I_v(z) = 0.1669041004$$

Peakhastighed

$q_p(z) = [1 + 7 \cdot I_v(z)] \cdot \left(\frac{1}{2}\right) \cdot \rho \cdot v_m^2(z)$

hvor:

$\rho = luftens\ densitet\ 1.25 \cdot \left(\frac{kg}{m^3}\right)$:

og de resterende værdier haves fra forrige udregninger

$q_p(4) = (1 + 7 \cdot 0.1669041004) \cdot \left(\frac{1}{2}\right) \cdot 1.25 \left(\frac{kg}{m^3}\right) \cdot \left(30.73621313 \left(\frac{m}{s}\right)\right)^2 = q_p(4) = \frac{1280.282633\ kg}{m\,s^2}$

Dette kan omskrives til $\frac{1.28\ kN}{m^2}$:

Det udvendige vindtryk

$w_e = q_p(z_e) \cdot c_{pe}$:

hvor:

$c_{pe} = formfaktor$:

Formfaktoren aflæses ved at indele taget i zoner, da vi har et sadel tag.

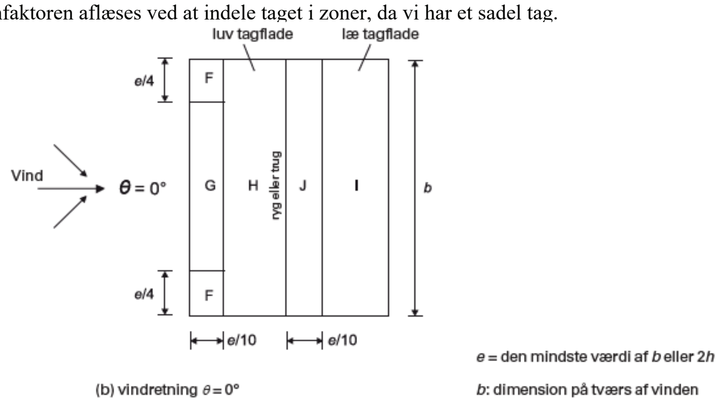


Illustration (EC1, side 109) vejledning over hvordan man inddeler i zoner og ikke denne konkrete situation.

Opslagsværket er EC1 tabel 7.2. Vi vælger $c_{pe,\,10}$ da længdesnittet er over 10 m2

Zone F= 0,2
Zone G= 0,2
Zone H= 0,2
Zone J = -1,0
Zone I = -0,7

F, G og H sammensættes til én zone for simpelthedens skyld:

ZoneFGH: $\frac{(0.2 + 0.2 + 0.2)}{3} = 0.2000000000$

Disse værdier indsættes i vindtrykket, hvorledes der regnes et vindtryk for hver zone.

Zone FGH

$w_e = \frac{1.28\ kN}{m^2} \cdot (0.2) = w_e = \frac{0.256\ kN}{m^2}$

I og J sammensættes til én zone for simpelthedens skyld:

ZoneIJ: $\frac{(-1.0 + -0.7)}{2} = -0.8500000000$

Zone IJ

$w_e = \frac{1.28\ kN}{m^2} \cdot (-0.85) = w_e = -\frac{1.0880\ kN}{m^2}$

Det indvendige vindtryk

$w_i = q_p(z) \cdot c_{pi}$

***NOTE c_{pi} kan sættes til +0.2 og -0.3 hvis det anses ikke nødvendigt at vurdere µ i sitautionen. (EC1. 7.2.9)
Vi benytter +0.2 når c_{pe} er negative og -0.3 når den er positiv.

Zone FGH

$w_i = \frac{1.28\ kN}{m^2} \cdot (-0.3) = w_i = -\frac{0.384\ kN}{m^2}$

Zone IJ

$w_i = \frac{1.28\ kN}{m^2} \cdot (0.2) = w_i = \frac{0.256\ kN}{m^2}$

Det indvendige og udvendige vindtryk kombineres.
Det udregnes med følgende formel:

$w_e - w_{i=} w_{netto}$:

Zone FGH

$\left(\frac{0.256\ kN}{m^2}\right) - \left(-\frac{0.384\ kN}{m^2}\right) = \frac{0.640\ kN}{m^2}$

Zone IJ

$\left(-\frac{1.0880\ kN}{m^2}\right) - \frac{0.256\ kN}{m^2} = -\frac{1.3440\ kN}{m^2}$

Ud fra disse resultater kan det konkluderes at i de tilfælde hvor resultatet er positivt vil der opstå tryk på konstruktionen og i de tilfælde resultatet er negativt vil der opstå sug.

Variende snelast

Snelasten beregnes som værende den variende last, hvorimod vindlasten var den dominerende.

$\gamma_{Q2} \cdot \psi_{0.2} \cdot K_{F1} \cdot Q_{K2}$ det sidste led i brudgrænseligningen.

Snelasten kan udregnes ud fra følgende formel:
$s = \mu_i \cdot C_e \cdot C_t \cdot s_k$:

hvor:
$\mu_I = formfaktor\ 0.8$ **for** *under* 30 *graders hældning* :
$\mu_{II} = formfaktor\ 1.6$ **for** *mellem* 30 − 60 *graders hældning* :
$C_e = eksponeringsfaktor\ sættes\ til\ 0.8$ **for** *vindblæst topografi* :
$C_t = Termiskfaktor\ sættes\ normalt\ til\ 1.0$:
$s_k = Karakterisktisk\ terrænværdi,\ i\ DK\ anvendes\ 1.0 \cdot \left(\frac{kN}{m^2}\right)$:

Disse værdier indsættes i formlen

$s_1 = 0.8 \cdot 0.8 \cdot 1 \cdot 1 \left(\frac{kN}{m^2}\right) = s_1 = \frac{0.64\ kN}{m^2}$
$s_2 = 1.6 \cdot 0.8 \cdot 1 \cdot 1 \left(\frac{kN}{m^2}\right) = s_2 = \frac{1.28\ kN}{m^2}$

Vertikal vindlast

Først skal basisvindhastigheden beregnes:
$v_b = c_{dir} \cdot c_{sæson} \cdot v_{b,0}$:

hvor:
$v_{b,0} = grundværdien\ regnes\ til\ 27 \cdot \left(\frac{m}{s}\right)$ *overalt i DK, med untagelse af randzone* :
$c_{dir} = retningsfaktor$: vind fra vest 1.0
$c_{sæson} = årstidsfaktor$: værste måned 1.0

Basisvinden udregnes til:
$v_b = 1 \cdot 1 \cdot 27 \left(\frac{m}{s}\right) = v_b = \frac{27\ m}{s}$

Middelvindhastigheden
$v_m(z) = c_r(z) \cdot c_o(z) \cdot v_b$:

hvor:
$z = er\ højden\ over\ terræn$:
$c_r(z) = ruhedsfaktoren$:
$c_o(z) = orografifaktoren,\ regnes\ til\ 1.0$:

Ruhedsfaktoren bestemmes ud fra følgende formel:
$c_r(z) = k_r \cdot \ln\left(\frac{z}{z_0}\right)$:

hvor z_0 : aflæses ud fra terrænkategori 1 (EC1- tabel 4.1) til 0.01
z sættes til 3m, da dette er højden af vind over terræn, da dette er toppunktet af væggen/facaden.

k_r : er terrænfaktoren afhængig af ruhedslængden og findes med følgende formel:

$$k_r = 0.19\left(\frac{z_0}{z_{0,2}}\right)^{0.07} :$$

hvor:
$z_{0,2} = 0.01\ m$:

$$k_r = 0.19\left(\frac{0.01\ m}{0.01\ m}\right)^{0.07} = k_r = 0.19$$

dette kan nu indsættes i tabellen for ruhedsfaktoren

$$c_r(z) = 0.19 \cdot \ln\left(\frac{3\ m}{0.01\ m}\right) = c_r(z) = 0.9520207059$$

Dette kan nu sættes ind i formlen for middelvindhastigheden:

$$v_m(z) = 1.083718670 \cdot 1 \cdot 27\left(\frac{m}{s}\right) = v_m(z) = \frac{29.26040409\ m}{s}$$

Vindens turbulens

$$l_v(z) = \frac{\sigma_v}{v_m(z)} = \frac{k_l}{c_o(z) \cdot \ln\left(\frac{z}{z_0}\right)} :$$

hvor:
$k_l = turbulensfaktor\ med\ anbefaletværdi = 1$:

vi benytter os af den sidste af formlerne da vi kender alle værdierne fra forrige udregninger.

$$l_v(z) = \frac{k_l}{c_o(z) \cdot \ln\left(\frac{z}{z_0}\right)}$$

$$l_v(z) = \frac{1}{1 \cdot \ln\left(\frac{3\ m}{0.01\ m}\right)} = l_v(z) = 0.1753222540$$

Peakhastighed ved 4m

$$q_p(z) = [1 + 7 \cdot l_v(z)] \cdot \left(\frac{1}{2}\right) \cdot \rho \cdot v_m^{\ 2}(z)$$

hvor:

$$\rho = luftens\ densitet\ 1.25 \cdot \left(\frac{kg}{m^3}\right) :$$

og de resterende værdier haves fra forrige udregninger

$$q_p(3) = (1 + 7 \cdot 0.1753222540) \cdot \left(\frac{1}{2}\right) \cdot 1.25\left(\frac{kg}{m^3}\right) \cdot \left(29.26040409\left(\frac{m}{s}\right)\right)^2 = q_p(3) = \frac{1191.820224\ kg}{m\,s^2}$$

Dette kan omskrives til $\frac{1.19\ kN}{m^2}$:

Peakhastighed ved 1,5m

$$q_p(z) = [1 + 7 \cdot l_v(z)] \cdot \left(\frac{1}{2}\right) \cdot \rho \cdot v_m^{\ 2}(z)$$

hvor:

$$\rho = luftens\ densitet\ 1.25 \cdot \left(\frac{kg}{m^3}\right) :$$

og de resterende værdier haves fra forrige udregninger

$$q_p(1,5) = (1 + 7 \cdot 0.1995754912) \cdot \left(\frac{1}{2}\right) \cdot 1.25\left(\frac{kg}{m^3}\right) \cdot \left(25.70455906\left(\frac{m}{s}\right)\right)^2 = q_p(1,5) = \frac{989.8594203\ kg}{m\,s^2}$$

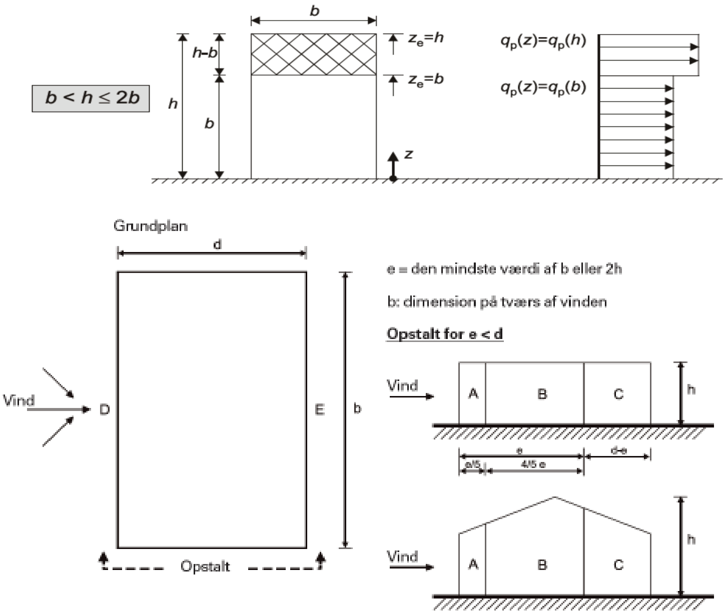
Dette kan omskrives til $\frac{0.98\ kN}{m^2}$:

Det udvendige vindtryk

$w_e = q_p(z_e) \cdot c_{pe}$:

hvor:
$c_{pe} = formfaktor$:

Det vurderes, at der skal udregnes vindtrykket for zone D, hvor formfaktoren aflæses i tabel 7.1 til: $c_{pe} = 0.7$



Vindtrykket for zone A(øvre) og B(nedre):

$$w_{e,A} = \frac{1.19\ kN}{m^2} \cdot 0.7 = w_{e,\ A} = \frac{0.833\ kN}{m^2}$$

$$w_{e,B} = \frac{0.98\ kN}{m^2} \cdot 0.7 = w_{e,\ B} = \frac{0.686\ kN}{m^2}$$

<u>Det indvendige vindtryk</u>

$w_i = q_p(z) \cdot c_{\text{pi}}$

***NOTE c_{pi} kan sættes til +0.2 og -0.3 hvis det anses ikke nødvendigt at vurdere µ i sitautionen. (EC1. 7.2.9)
Vi benytter +0.2 når c_{pe} er negative og -0.3 når den er positiv.

Vindtrykket for zone A(øvre) og B(nedre):

$$w_{i,A} = \frac{1.19\ kN}{m^2} \cdot (-0.3) = w_{i,\ A} = -\frac{0.357\ kN}{m^2}$$

$$w_{i,B} = \frac{0.98\ kN}{m^2} \cdot (-0.3) = w_{i,\ B} = -\frac{0.294\ kN}{m^2}$$

Det indvendige og udvendige vindtryk kombineres.
Det udregnes med følgende formel:

$w_e - w_{i=} w_{netto}$:

$$w_{nettoA} = \frac{0.833\ kN}{m^2} - \left(-\frac{0.357\ kN}{m^2}\right) = w_{nettoA} = \frac{1.190\ kN}{m^2}$$

$$w_{nettoB} = \frac{0.686\ kN}{m^2} - \left(-\frac{0.294\ kN}{m^2}\right) = w_{nettoB} = \frac{0.980\ kN}{m^2}$$

Appendix

ROBOT RESULTS

ZONE 1 - ULS

DS/EN 1993-1:2005/DK NA:2015/A1:2014 - Member Verification (ULS) 1to9

Results | Messages

Member	Section	Material	Lay	Laz	Ratio	Case
2	OK BOX_200x200	Fiberglas	127.58	127.58	0.46	4 Lastkombination, U
1	OK BOX_200x200	Fiberglas	95.85	95.85	0.27	4 Lastkombination, U
3	OK BOX_200x200	Fiberglas	54.15	54.15	0.24	4 Lastkombination, U
7	OK BOX_200x200	Fiberglas	38.92	38.92	0.22	4 Lastkombination, U
8	OK BOX_200x200	Fiberglas	51.54	51.54	0.19	4 Lastkombination, U
4	OK BOX_200x200	Fiberglas	19.52	19.52	0.16	4 Lastkombination, U
5	OK BOX_200x200	Fiberglas	19.52	19.52	0.16	4 Lastkombination, U
9	OK BOX_200x200	Fiberglas	64.10	64.10	0.16	3 Snelast
6	OK BOX_200x200	Fiberglas	35.49	35.49	0.15	4 Lastkombination, U

Calc. Note | Close | Help

Ratio: Analysis | Map

Calculation points
Division: n = 3
Extremes: none
Additional: none

RESULTS - Code - DS/EN 1993-1:2005/DK NA:2015/A1:2014

Auto | BOX_200x200_16 | Section OK | OK | Change

Member: 2
Point / Coordinate: 3 / x = 1.00 L = 9.62 m
Load case: 4 Lastkombination, ULS (1+3)*1.00+2*1.50

Simplified results | Detailed results

FORCES

N,Ed = 36.28 kN	My,Ed = -1.96 kN*m	Mz,Ed = -70.96 kN*m	Vy,Ed = 37.63 kN
Nc,Rd = 2569.31 kN	My,Ed,max = -1.96 kN*m	Mz,Ed,max = -70.96 kN*m	Vy,T,Rd = 805.11 kN
Nb,Rd = 2355.20 kN	My,c,Rd = 177.73 kN*m	Mz,c,Rd = 177.73 kN*m	Vz,Ed = -1.15 kN
	MN,y,Rd = 177.73 kN*m	MN,z,Rd = 177.73 kN*m	Vz,T,Rd = 676.30 kN
	Mb,Rd = 162.92 kN*m		Tt,Ed = 0.18 kN*m
			Class of section = 1

Forces | Detailed

LATERAL BUCKLING

z = 1.00	Mcr = 1605.46 kN*m	Curve,LT - d	XLT = 1.00
Lcr,low=9.62 m	Lam_LT = 0.35	fi,LT = 0.53	XLT,mod = 1.00

BUCKLING y
kyy = 1.00

BUCKLING z
kzz = 1.00

Calc. Note | Parameters | Help

SECTION CHECK
Mz,Ed/MN,z,Rd = 0.40 < 1.00 (6.2.9.1.(2))
Vy,Ed/Vy,T,Rd = 0.05 < 1.00 (6.2.6-7)

MEMBER STABILITY CHECK

N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) + kyz*Mz,Ed,max/(Mz,Rk/gM1) = 0.46 < 1.00 (6.3.3.(4))

ZONE 1 - SLS

DS/EN 1993-1:2005/DK NA:2015/A1:2014 - Member Verification (SLS) 1to9

Results | Messages

Member	Section	Material	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
2	OK BOX_200x200	Fiberglas	0.82	5 Lastkombination, S	0.06	1 Egenlast	-	-	-	-
9	OK BOX_200x200	Fiberglas	0.27	5 Lastkombination, S	0.01	1 Egenlast	-	-	-	-
6	OK BOX_200x200	Fiberglas	0.10	5 Lastkombination, S	0.02	1 Egenlast	-	-	-	-
1	OK BOX_200x200	Fiberglas	0.08	5 Lastkombination, S	0.01	1 Egenlast	-	-	-	-
3	OK BOX_200x200	Fiberglas	-	-	-	-	0.28	5 Lastkombination, S	0.01	5 Lastkombination, S
4	OK BOX_200x200	Fiberglas	-	-	-	-	0.43	3 Snelast	0.00	5 Lastkombination, S
5	OK BOX_200x200	Fiberglas	-	-	-	-	0.34	5 Lastkombination, S	0.00	5 Lastkombination, S
7	OK BOX_200x200	Fiberglas	-	-	-	-	0.56	5 Lastkombination, S	0.00	5 Lastkombination, S
8	OK BOX_200x200	Fiberglas	-	-	-	-	0.42	5 Lastkombination, S	0.00	2 Vindlast

Calc. Note | Close | Help

Ratio: Analysis | Map

Calculation points
Division: n = 3
Extremes: none
Additional: none

RESULTS - Code - DS/EN 1993-1:2005/DK NA:2015/A1:2014

Auto | BOX_200x200_16 | Section OK | OK | Change

Member: 2

Displacements | Detailed results

Member deflection

uy = 40 mm < uy max = L/200.00 = 48 mm		Verified
Governing load case:	5 Lastkombination, SLS (1+2+3)*1.00	
uz = 3 mm < uz max = L/200.00 = 48 mm		Verified
Governing load case:	1 Egenlast	

Member node displacements

Calc. Note | Parameters | Help

ZONE 2 - ULS

DS/EN 1993-1:2005/DK NA:2015/A1:2014 - Member Verification (ULS) 1to16

Results | Messages

Member	Section	Material	Lay	Laz	Ratio	Case
13	BOX_200x20	Fiberglas	102.11	102.11	0.70	5 Lastkombination,
4	BOX_200x20	Fiberglas	14.50	14.50	0.60	5 Lastkombination,
1	BOX_200x20	Fiberglas	24.80	24.80	0.60	5 Lastkombination,
6	BOX_200x20	Fiberglas	76.56	76.56	0.39	5 Lastkombination,
9	BOX_200x20	Fiberglas	29.46	29.46	0.38	5 Lastkombination,
11	BOX_200x20	Fiberglas	19.50	19.50	0.36	5 Lastkombination,
7	BOX_200x20	Fiberglas	44.75	44.75	0.35	5 Lastkombination,
3	BOX_200x20	Fiberglas	29.62	29.62	0.34	5 Lastkombination,
16	BOX_200x20	Fiberglas	39.01	39.01	0.29	5 Lastkombination,
12	BOX_200x20	Fiberglas	33.16	33.16	0.27	5 Lastkombination,
5	BOX_200x20	Fiberglas	68.56	68.56	0.26	5 Lastkombination,
8	BOX_200x20	Fiberglas	29.46	29.46	0.26	5 Lastkombination,
10	BOX_200x20	Fiberglas	19.50	19.50	0.21	5 Lastkombination,
2	BOX_200x20	Fiberglas	50.68	50.68	0.19	5 Lastkombination,
15	BOX_200x20	Fiberglas	39.01	39.01	0.18	5 Lastkombination,
14	BOX_200x20	Fiberglas	70.41	70.41	0.11	5 Lastkombination,

Calc. Note | Close | Help

Ratio: Analysis | Map

Calculation points
Division: n = 3
Extremes: none
Additional: none

RESULTS - Code - DS/EN 1993-1:2005/DK NA:2015/A1:2014

BOX_200x200_16 | Auto | Section OK | OK | Change

Member 13
Point / Coordinate: 3 / x = 1.00 L = 7.70 m
Load case: 5 Lastkombination, ULS (1+3)*1.00+(2+4)*1.50

Simplified results | Detailed results

FORCES
N,Ed = -165.39 kN
Nt,Rd = 2569.31 kN
My,Ed = -2.01 kN*m
My,pl,Rd = 177.73 kN*m
My,c,Rd = 177.73 kN*m
MN,y,Rd = 177.73 kN*m
Mb,Rd = 162.92 kN*m
Mz,Ed = 123.70 kN*m
Mz,pl,Rd = 177.73 kN*m
Mz,c,Rd = 177.73 kN*m
MN,z,Rd = 177.73 kN*m
Vy,Ed = -83.97 kN
Vy,T,Rd = 804.98 kN
Vz,Ed = -1.34 kN
Vz,T,Rd = 676.18 kN
Tt,Ed = -0.20 kN*m
Class of section = 1

LATERAL BUCKLING
z = 1.00
Lcr,low=7.70 m
Mcr = 1996.31 kN*m
Lam_LT = 0.31
Curve,LT - d
fi,LT = 0.50
XLT = 1.00
XLT,mod = 1.00

BUCKLING y

BUCKLING z

SECTION CHECK
Mz,Ed/MN,z,Rd = 0.70 < 1.00 (6.2.9.1.(2))
Vy,Ed/Vy,T,Rd = 0.10 < 1.00 (6.2.6-7)

MEMBER STABILITY CHECK
My,Ed/Mb,Rd = 0.01 < 1.00 (6.3.2.1.(1))

Forces | Detailed | Calc. Note | Parameters | Help

ZONE 2 - SLS

DS/EN 1993-1:2005/DK NA:2015/A1:2014 - Member Verification (SLS) 1to16

Results | Messages

Member	Section	Material	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
13	BOX_200x20	Fiberglas	0.87	6 Lastkombination,	0.06	1 Egenlast	-	-	-	-
6	BOX_200x20	Fiberglas	0.28	6 Lastkombination,	0.03	1 Egenlast	-	-	-	-
5	BOX_200x20	Fiberglas	0.21	6 Lastkombination,	0.04	1 Egenlast	-	-	-	-
3	BOX_200x20	Fiberglas	0.18	6 Lastkombination,	0.00	1 Egenlast	-	-	-	-
1	BOX_200x20	Fiberglas	0.16	6 Lastkombination,	0.03	1 Egenlast	-	-	-	-
14	BOX_200x20	Fiberglas	0.15	4 Nyttelast	0.04	1 Egenlast	-	-	-	-
12	BOX_200x20	Fiberglas	0.12	6 Lastkombination,	0.00	1 Egenlast	-	-	-	-
7	BOX_200x20	Fiberglas	0.09	6 Lastkombination,	0.04	1 Egenlast	-	-	-	-
4	BOX_200x20	Fiberglas	0.09	6 Lastkombination,	0.01	1 Egenlast	-	-	-	-
2	BOX_200x20	Fiberglas	0.07	4 Nyttelast	0.02	1 Egenlast	-	-	-	-
8	BOX_200x20	Fiberglas	-	-	-	-	0.13	6 Lastkombination,	0.02	6 Lastkombination,
9	BOX_200x20	Fiberglas	-	-	-	-	0.78	6 Lastkombination,	0.01	4 Nyttelast
10	BOX_200x20	Fiberglas	-	-	-	-	0.17	6 Lastkombination,	0.02	6 Lastkombination,
11	BOX_200x20	Fiberglas	-	-	-	-	0.19	6 Lastkombination,	0.02	6 Lastkombination,
15	BOX_200x20	Fiberglas	-	-	-	-	0.11	6 Lastkombination,	0.02	6 Lastkombination,
16	BOX_200x20	Fiberglas	-	-	-	-	0.09	6 Lastkombination,	0.01	6 Lastkombination,

Calc. Note | Close | Help

Ratio: Analysis | Map

Calculation points
Division: n = 3
Extremes: none
Additional: none

RESULTS - Code - DS/EN 1993-1:2005/DK NA:2015/A1:2014

BOX_200x200_16 | Auto | Section OK | OK | Change

Member 13

Displacements | Detailed results

Member deflection
uy = 34 mm < uy max = L/200.00 = 38 mm Verified
Governing load case: 6 Lastkombination, SLS (1+2+3+4)*1.00
uz = 2 mm < uz max = L/200.00 = 38 mm Verified
Governing load case: 1 Egenlast

Member node displacements

Calc. Note | Parameters | Help

ZONE 3 - ULS

DS/EN 1993-1:2005/DK NA:2015/A1:2014 - Member Verification (ULS) 1to7

Results | Messages

Member	Section	Material	Lay	Laz	Ratio	Case
2	OK BOX_200x20	Fiberglas	102.64	102.64	0.30	4 Lastkombination,
1	OK BOX_200x20	Fiberglas	52.63	52.63	0.16	4 Lastkombination,
4	OK BOX_200x20	Fiberglas	22.75	22.75	0.16	4 Lastkombination,
3	OK BOX_200x20	Fiberglas	61.32	61.32	0.15	4 Lastkombination,
6	OK BOX_200x20	Fiberglas	45.51	45.51	0.12	3 Snelast
7	OK BOX_200x20	Fiberglas	69.28	69.28	0.12	3 Snelast
5	OK BOX_200x20	Fiberglas	22.75	22.75	0.08	4 Lastkombination,

Calc. Note | Close | Help

Ratio: Analysis | Map

Calculation points
Division: n = 3
Extremes: none
Additional: none

RESULTS - Code - DS/EN 1993-1:2005/DK NA:2015/A1:2014

Auto
BOX_200x200_12

Section OK

Member 2
Point / Coordinate: 1 / x = 0.00 L = 0.00 m
Load case: 4 Lastkombination, ULS (1+3)*1.00+2*1.50

OK | Change

Simplified results | Detailed results

FORCES
N,Ed = 12.64 kN
Nc,Rd = 1968.87 kN
Nb,Rd = 1804.80 kN
My,Ed = -0.57 kN*m
My,Ed,max = -0.57 kN*m
My,c,Rd = 138.99 kN*m
MN,y,Rd = 138.99 kN*m
Mb,Rd = 127.41 kN*m
Mz,Ed = 20.15 kN*m
Mz,Ed,max = 36.57 kN*m
Mz,c,Rd = 138.99 kN*m
MN,z,Rd = 138.99 kN*m
Vy,Ed = 23.27 kN
Vy,T,Rd = 602.21 kN
Vz,Ed = 0.51 kN
Vz,T,Rd = 529.94 kN
Tt,Ed = 0.43 kN*m
Class of section = 1

Forces | Detailed

LATERAL BUCKLING
z = 1.00
Lcr,low=7.89 m
Mcr = 1555.84 kN*m
Lam_LT = 0.31
Curve,LT - d
fi,LT = 0.50
XLT = 1.00
XLT,mod = 1.00

BUCKLING y
kyy = 1.00

BUCKLING z
kzz = 1.00

Calc. Note | Parameters | Help

SECTION CHECK
Mz,Ed/MN,z,Rd = 0.14 < 1.00 (6.2.9.1.(2))
Vy,Ed/Vy,T,Rd = 0.04 < 1.00 (6.2.6-7)

MEMBER STABILITY CHECK
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) + kyz*Mz,Ed,max/(Mz,Rk/gM1) = 0.30 < 1.00 (6.3.3.(4))

ZONE 3 - SLS

DS/EN 1993-1:2005/DK NA:2015/A1:2014 - Member Verification (SLS) 1to7

Results | Messages

Member	Section	Material	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
2	OK BOX_200x20	Fiberglas	0.44	5 Lastkombination,	0.01	1 Egenlast	-	-	-	-
7	OK BOX_200x20	Fiberglas	0.21	2 Vindlast	0.01	1 Egenlast	-	-	-	-
1	OK BOX_200x20	Fiberglas	0.06	3 Snelast	0.01	1 Egenlast	-	-	-	-
3	OK BOX_200x20	Fiberglas	-	-	-	-	0.23	2 Vindlast	0.01	5 Lastkombination,
4	OK BOX_200x20	Fiberglas	-	-	-	-	0.45	2 Vindlast	0.00	5 Lastkombination,
5	OK BOX_200x20	Fiberglas	-	-	-	-	0.17	2 Vindlast	0.00	5 Lastkombination,
6	OK BOX_200x20	Fiberglas	-	-	-	-	0.24	5 Lastkombination,	0.00	3 Snelast

Calc. Note | Close | Help

Ratio: Analysis | Map

Calculation points
Division: n = 3
Extremes: none
Additional: none

RESULTS - Code - DS/EN 1993-1:2005/DK NA:2015/A1:2014

Auto
BOX_200x200_12

Section OK

Member 2

OK | Change

Displacements | Detailed results

Member deflection
uy = 17 mm < uy max = L/200.00 = 39 mm Verified
Governing load case: 5 Lastkombination, SLS (1+2+3)*1.00
uz = 1 mm < uz max = L/200.00 = 39 mm Verified
Governing load case: 1 Egenlast

Member node displacements

Calc. Note | Parameters | Help

ZONE 4 - ULS

DS/EN 1993-1:2005/DK NA:2015/A1:2014 - Member Verification (ULS) 1to9

Results | Messages

Member		Section	Material	Lay	Laz	Ratio	Case
4	OK	BOX_200x20	Fiberglas	68.86	68.86	0.17	4 Lastkombination,
3	OK	BOX_200x20	Fiberglas	71.95	71.95	0.16	3 Snelast
1	OK	BOX_200x20	Fiberglas	22.75	22.75	0.15	4 Lastkombination,
5	OK	BOX_200x20	Fiberglas	105.76	105.76	0.15	2 Vindlast
2	OK	BOX_200x20	Fiberglas	22.75	22.75	0.13	3 Snelast
9	OK	BOX_200x20	Fiberglas	45.55	45.55	0.12	3 Snelast
7	OK	BOX_200x20	Fiberglas	57.15	57.15	0.10	4 Lastkombination,
8	OK	BOX_200x20	Fiberglas	60.31	60.31	0.09	3 Snelast
6	OK	BOX_200x20	Fiberglas	28.78	28.78	0.08	3 Snelast

Calc. Note | Close | Help

Ratio: Analysis | Map

Calculation points
Division: n = 3
Extremes: none
Additional: none

RESULTS - Code - DS/EN 1993-1:2005/DK NA:2015/A1:2014

Auto
BOX_200x200_12

Member 4
Point / Coordinate: 1 / x = 0.00 L = 0.00 m
Load case: 4 Lastkombination, ULS (1+3)*1.00+2*1.50

Section OK

OK | Change | Forces | Detailed | Calc. Note | Parameters | Help

Simplified results | Detailed results

FORCES

N,Ed = 18.52 kN
Nc,Rd = 1968.87 kN
Nb,Rd = 1804.80 kN

My,Ed = -0.79 kN*m
My,Ed,max = -0.79 kN*m
My,c,Rd = 138.99 kN*m
MN,y,Rd = 138.99 kN*m
Mb,Rd = 127.41 kN*m

Mz,Ed = 19.92 kN*m
Mz,Ed,max = 19.92 kN*m
Mz,c,Rd = 138.99 kN*m
MN,z,Rd = 138.99 kN*m

Vy,Ed = 21.05 kN
Vy,T,Rd = 602.39 kN
Vz,Ed = 0.66 kN
Vz,T,Rd = 530.10 kN
Tt,Ed = 0.40 kN*m
Class of section = 1

LATERAL BUCKLING

z = 1.00
Lcr,low=5.30 m

Mcr = 2292.62 kN*m
Lam_LT = 0.26

Curve,LT - d
fi,LT = 0.47

XLT = 1.00
XLT,mod = 1.00

BUCKLING y

kyy = 1.00

BUCKLING z

kzz = 1.00

SECTION CHECK

Mz,Ed/MN,z,Rd = 0.14 < 1.00 (6.2.9.1.(2))
Vy,Ed/Vy,T,Rd = 0.03 < 1.00 (6.2.6-7)

MEMBER STABILITY CHECK

N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) + kyz*Mz,Ed,max/(Mz,Rk/gM1) = 0.17 < 1.00 (6.3.3.(4))

ZONE 4 - SLS

DS/EN 1993-1:2005/DK NA:2015/A1:2014 - Member Verification (SLS) 1to9

Results | Messages

Member		Section	Material	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
5	OK	BOX_200x20	Fiberglas	0.38	2 Vindlast	0.01	1 Egenlast	-	-	-	-
4	OK	BOX_200x20	Fiberglas	0.24	5 Lastkombination,	0.01	1 Egenlast	-	-	-	-
6	OK	BOX_200x20	Fiberglas	0.11	3 Snelast	0.01	1 Egenlast	-	-	-	-
1	OK	BOX_200x20	Fiberglas	-	-	-	-	0.32	2 Vindlast	0.00	5 Lastkombination,
2	OK	BOX_200x20	Fiberglas	-	-	-	-	0.33	3 Snelast	0.00	5 Lastkombination,
3	OK	BOX_200x20	Fiberglas	-	-	-	-	0.06	3 Snelast	0.56	3 Snelast
7	OK	BOX_200x20	Fiberglas	-	-	-	-	0.21	5 Lastkombination,	0.00	2 Vindlast
8	OK	BOX_200x20	Fiberglas	-	-	-	-	0.20	5 Lastkombination,	0.00	3 Snelast
9	OK	BOX_200x20	Fiberglas	-	-	-	-	0.27	5 Lastkombination,	0.00	3 Snelast

Calc. Note | Close | Help

Ratio: Analysis | Map

Calculation points
Division: n = 3
Extremes: none
Additional: none

RESULTS - Code - DS/EN 1993-1:2005/DK NA:2015/A1:2014

Auto
BOX_200x200_12

Member 5

Section OK

OK | Change | Calc. Note | Parameters | Help

Displacements | Detailed results

Member deflection

uy = 16 mm < uy max = L/200.00 = 41 mm Verified
Governing load case: 2 Vindlast
uz = 1 mm < uz max = L/200.00 = 41 mm Verified
Governing load case: 1 Egenlast

Member node displacements

Appendix

APPENDIX 03: BUILDING ENERGY FRAME

KEY NUMBERS

Nøgletal, kWh/m² år

Renoveringsklasse 2

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
70,8	0,0	70,8
Samlet energibehov		29,0

Renoveringsklasse 1

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
53,1	0,0	53,1
Samlet energibehov		29,0

Energiramme BR 2018

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
30,4	0,0	30,4
Samlet energibehov		29,0

Energiramme lavenergi

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
27,0	0,0	27,0
Samlet energibehov		29,0

Bidrag til energibehovet

Varme	24,4
El til bygningsdrift	3,6
Overtemp. i rum	1,3

Netto behov

Rumopvarmning	11,7
Varmt brugsvand	5,3
Køling	0,0

Udvalgte elbehov

Belysning	3,6
Opvarmning af rum	0,0
Opvarmning af vbv	0,0
Varmepumpe	0,0
Ventilatorer	3,6
Pumper	0,0
Køling	0,0
Totalt elforbrug	16,7

Varmetab fra installationer

Rumopvarmning	12,8
Varmt brugsvand	0,0

Ydelse fra særlige kilder

Solvarme	0,0
Varmepumpe	0,0
Solceller	0,0
Vindmøller	0,0

SELECTED INPUT PARAMETERS

the following appendix is part of the output from Be18, but downsized so all information is not presented exaple only part of the rooms and zone in ventilaitipon showed. this is done only to give a example on how the values is used. the following is downs from the Be18 repport

Comment	
The building	
Building type	Detached house
Rotation	32,0 deg
Area of heated floor	2836,0 m²
Area heated basement	0,0 m²
Area existing / other usage	0,0 m²
Heated gross area incl. basement	2836,0 m²
Heat capacity	40,0 Wh/K m²
Normal usage time	45 hours/week
Usage time, start at - end at, time	7 - 24

External walls, roofs and floors					
Building component	Area (m²)	U (W/m²K)	b	Dim.Inside (C)	Dim.Outside (C)
Nord	1298,0	0,09	1,000	20	-12
Syd	0,0	0,09	1,000	20	-12
Øst	0,0	0,09	1,000	20	-12
Vest	0,0	0,09	1,000	20	-12
nord (gård)	0,0	0,09	1,000	20	-12
Syd (gård)	0,0	0,09	1,000	20	-12
Vest (gård)	0,0	0,09	1,000	20	-12
Øst (gård)	0,0	0,09	1,000	20	-12
(tag)	0,0	0,06	1,000		
Nord	760,0	0,06	1,000		
Syd	796,0	0,06	1,000		
Øst	490,0	0,06	1,000		
Vest	585,0	0,06	1,000		
gulv	2740,0	0,10	1,000	30	-12
Ialt	6669,0	-	-	-	-

Foundations etc.					
Building component	l (m)	Loss (W/mK)	b	Dim.Inside (C)	Dim.Outside (C)
Fundament	330,0	0,40	1,000	20	-12
Linjetab vinduer og døre	1068,0	0,06	1,000	20	-12
samling tag og væg	330,0	0,06	1,000	20	-12
ventilations kanaler	88,0	0,40	1,000	20	-12
Ialt	1816,0	-	-	-	-

Windows and outer doors													
Syd	1	S	90,0	33,0	0,84	1,000	0,80	0,61	Syd	0,70			0
Øst	1	Ø	90,0	8,0	0,84	1,000	0,80	0,61	Øst	0,70			0
Vest	1	V	90,0	21,0	0,84	1,000	0,80	0,61	Vest	0,70			0
Nord(gård)	1	N	90,0	30,9	0,84	1,000	0,80	0,61	Nord(gård)	0,70			0
Syd(gård)	1	S	90,0	31,0	0,84	1,000	0,80	0,26	Syd(gård)	0,70			0
Vest(gård)	1	V	90,0	11,5	0,84	1,000	0,80	0,26	Øst(gård)	0,70			0
Øst(gård)	1	Ø	90,0	12,8	0,84	1,000	0,80	0,61	Vest(gård)	0,70			0
-tag-	1		90,0	0,0	0,00	1,000	0,00	0,61		1,00			0
Nord(tag)	1	N	38,0	31,5	0,83	1,000	0,80	0,30		0,70			0
Syd(tag)	1	S	90,0	0,0	1,00	1,000	0,80	0,30		0,70			0
Øst(tag)	1	Ø	90,0	0,0	1,00	1,000	0,80	0,30		0,70			0
Vest(tag)	1	V	38,0	15,4	0,83	1,000	0,80	0,30		0,70			0
Ialt	13	-	-	214,1	-	-	-	-	-	-	-	-	

Ventilation													
Zone	Area (m²)	Fo, -	qm (l/s m²), Winter	n vgv (-)	ti (°C)	El-HC	qn (l/s m²), Winter	qi,n (l/s m²), Winter	SEL (kJ/m³)	qm,s (l/s m²), Summer	qn,s (l/s m²), Summer	qm,n (l/s m²), Night	qn,n (l/s m²), Night
Theoretical classroom	58,0	0,35	3,90	0,87	0,0	No	0,00	0,00	1,8	0,30	4,60	0,00	0,00
Sports Facility	203,0	0,66	9,10	0,87	0,0	No	0,00	0,00	1,8	0,30	2,60	0,00	0,00
Indoor Storage	20,0	0,33	1,90	0,87	0,0	No	0,00	0,00	1,8	0,30	3,20	0,00	0,00
Changing room	39,0	0,50	3,70	0,87	0,0	No	0,00	0,00	1,8	0,30	5,10	0,00	0,00
Kichen	19,0	0,13	1,30	0,87	0,0	No	0,00	0,00	1,5	1,00	1,90	0,00	0,00
Workshop area	87,0	0,08	4,50	0,87	0,0	No	0,00	0,00	1,5	0,30	5,60	0,00	0,00
Changing room	39,0	0,50	3,70	0,87	0,0	No	0,00	0,00	1,8	0,30	5,10	0,00	0,00

Internal heat supply				
surf school	2636	4,0	6,0	0,0

Lighting											
Zone	Area (m²)	General (W/m²)	General (W/m²)	Lighting (lux)	DF (%)	Control (U, M, A, K)	Fo (-)	Work (W/m²)	Other (W/m²)	Stand-by (W/m²)	Night (W/m²)
Changeingroom	40,0	3,0	1,0	300	0,00	A	1,00	0,0	0,0	0,0	0,0
Kichen	19,0	1,0	1,0	300	2,34	A	0,12	1,0	0,0	0,0	0,0
Workshop area	17,6	1,0	1,0	300	5,30	A	0,08	1,0	0,0	0,0	0,0
Workshop area	62,9	1,0	1,0	300	0,64	A	0,08	1,0	0,0	0,0	0,0
theoretical classroom	39,0	1,0	1,0	300	2,30	A	0,20	1,0	0,0	0,0	0,0
Sports facility	203,0	0,0	0,0	600	5,00	A	0,00	0,0	0,0	0,0	0,0
indoor storage	20,0	1,0	1,0	200	0,00	A	0,04	0,0	0,0	0,0	0,0
toilets	37,0	1,0	1,0	300	0,00	A	0,13	0,0	0,0	0,0	0,0
Changeingroom	40,0	3,0	1,0	300	0,00	A	1,00	0,0	0,0	0,0	0,0
surf simulator room	328,0	3,0	1,0	300	3,60	A	1,00	1,0	0,0	0,0	0,0
fitness	100,0	3,0	1,0	300	2,10	A	1,00	0,0	0,0	0,0	0,0
Wetzone	108,0	3,0	1,0	300	1,00	A	1,00	0,0	0,0	0,0	0,0
first aidroom	18,0	3,0	1,0	300	1,00	A	1,00	1,0	0,0	0,0	0,0
shapersbay	52,0	3,0	1,0	300	2,30	A	1,00	1,0	0,0	0,0	0,0
Lounge 1	39,0	1,0	1,0	300	3,45	A	0,12	0,0	0,0	0,0	0,0
Lounge 2	85,0	1,0	1,0	300	1,00	A	0,25	0,0	0,0	0,0	0,0
Funiture storage	24,0	1,0	1,0	300	0,00	A	0,04	0,0	0,0	0,0	0,0
childrens lounge	35,0	1,0	1,0	300	1,67	A	0,25	0,0	0,0	0,0	0,0
toilets	15,0	1,0	1,0	300	0,00	A	0,08	0,0	0,0	0,0	0,0

Heat distribution plant					
Composition and temperature					
Supply pipe temperature	70,0 °C				
Return pipe temperature	40,0 °C				
Type of plant	2-string		Anlægstype		
Pumps					
Pump type	Description	Number	Pnom	Fp	
Heating pipes					
Pipe lengths in supply and return	l (m)	Loss (W/mK)	b	Outdoor comp (J/N)	Unused summer (J/N)
tilslutning	20,0	0,22	1,000	N	N
Fordelingsrør	660,0	0,17	0,000	N	N

Domestic hot water	
Description	Varmt brugsvand
Hot-water consumption, average for the building	100,0 litre/year per m² of floor area
Domestic hot water temp.	55,0 °C

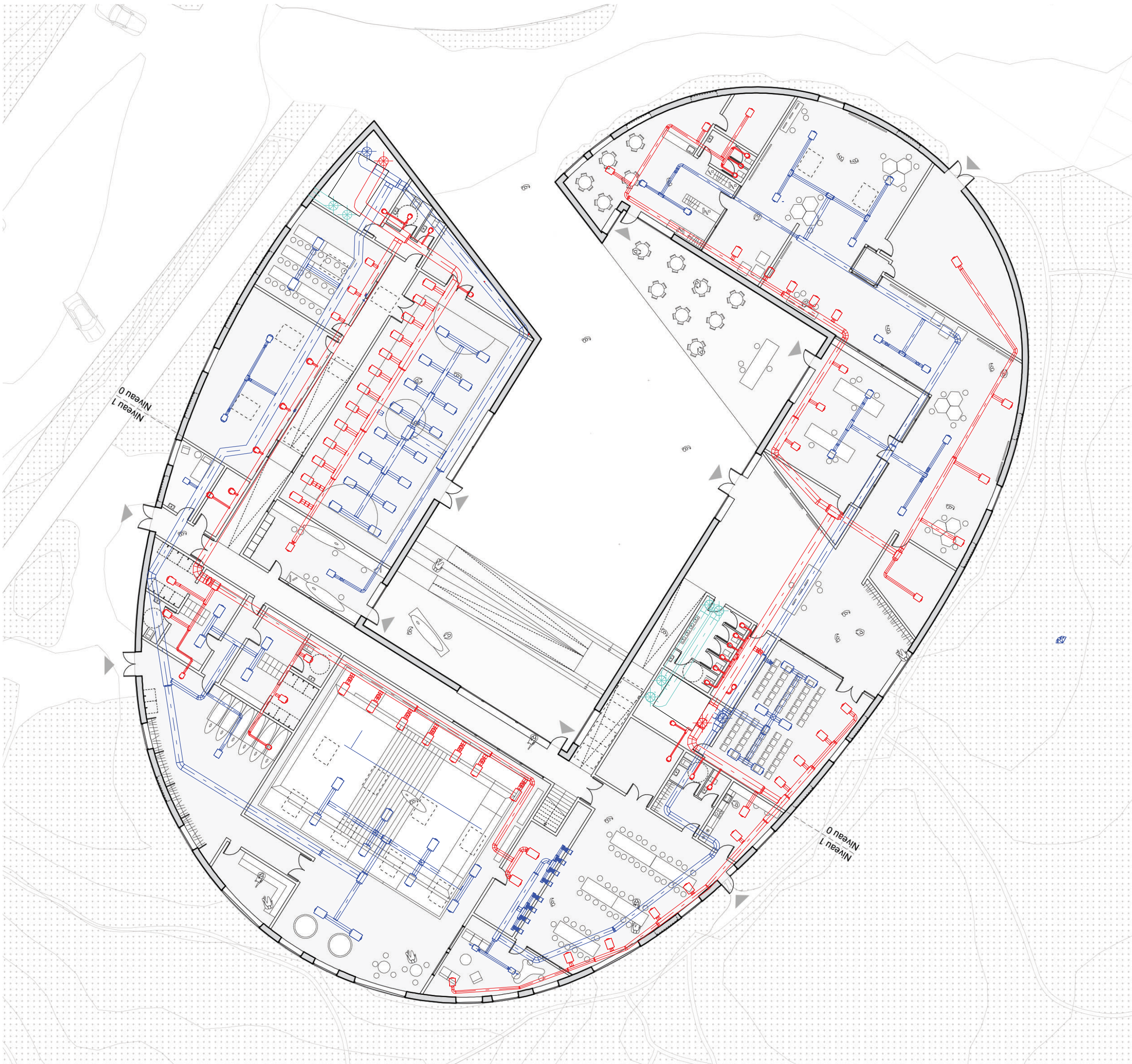
APPENDIX 04: VENTILATION

Ventilation needs	F l o o r area	Ceiling height	Number of people	Activation level
	m^2	m		met
Theoretical classroom	58	3	16	1,2
Sports facility (Physical warn-up)	203	3	32	7,5
Indoor storage	20	3	1	1
Toilets	37	3	1	1,2
Surf facilities				
Changing room - m/w	40	3	16	1,2
Changing room - m/w	40	3	16	1,2
Sauna	20	3	4	1,6
Surf simulator room	328	3	15	7,5
Cleaning room	10			
Fitness	88	3	10	1,6
Wet zone	108	3	1	1,6
First Aid room	18	3	2	1,6
Shaperbay/repair station	52	3	3	1,6
Kichen	19	3	2	1,6
Lounge/event	123	3	60	1,2
Furniture storage	24	3	1	1,0
Childrens lounge	35	3	7	1,2
Toilets	15	3	1	1,2
Cleaning room	13	3	1	1,0
Technical	28	3	1	1,0
Storage	25	3	1	1,0
Office	117	3	12	1,6
Meeting room	10	3	4	1,6
Meeting room	10	3	4	1,6
Print room	18	3	1	1,0
Employee changing room	5	3	1	1,6
Workshop area/production	87	3	32	1,6
Lecture room	86	3	60	1,2
Dissimination of plastic-problem	399	3	60	1,6
Plastic collection point	4	3	0	0,0
Toilets	19	3	1	1,2
Plastic storage	79	3	1	1,0
Arrival + info area	83	3	0	1,6
Kaff' og bar	84	3	10	1,2
Storage	15	3	1	1,0

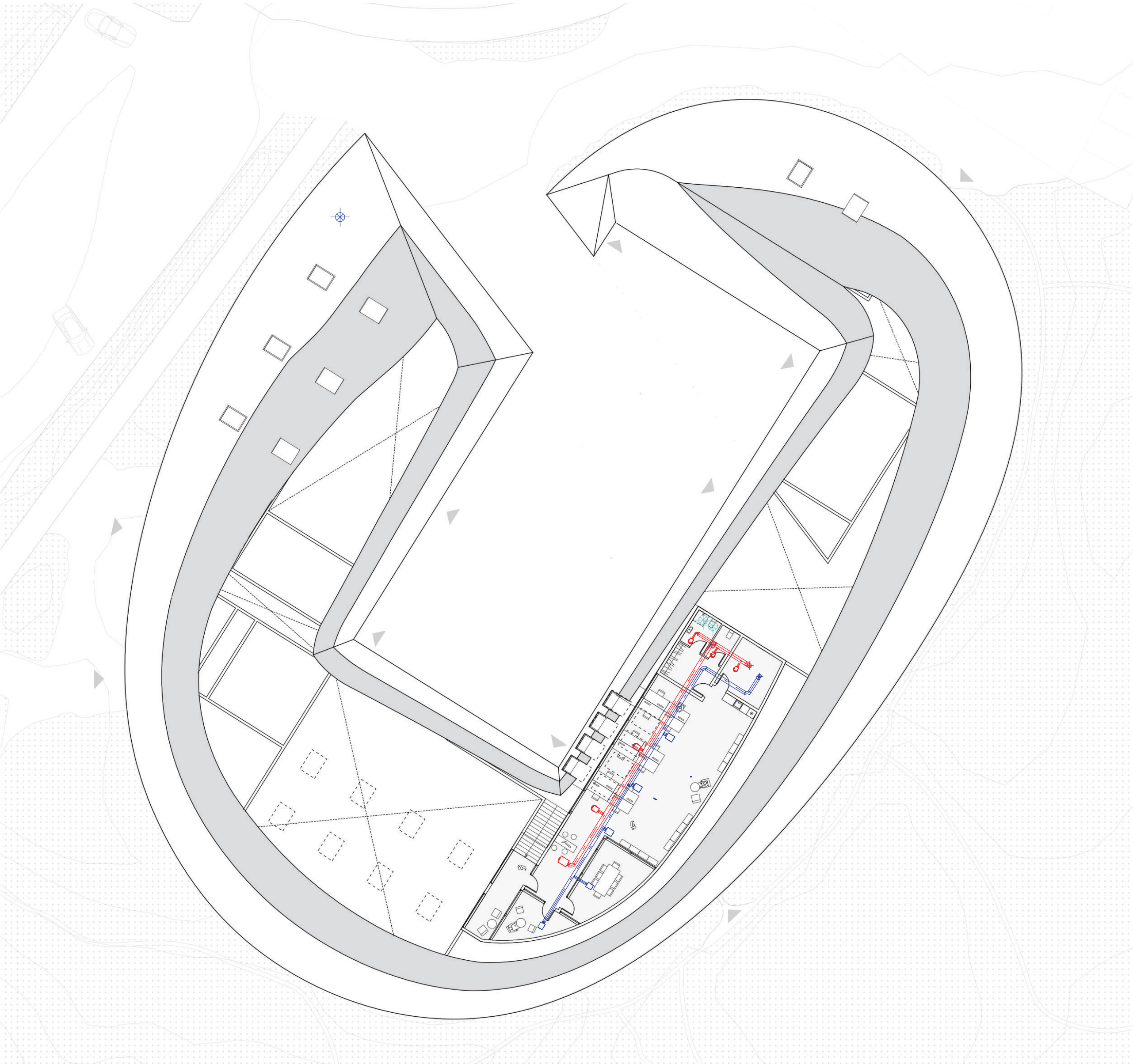
VENTILATION NEEDS

CO2	Minimum amount Be18	Airchange	Biggest air volume	Biggest air volumen pr m^2		
l/s	l/s	h^{-1}	l/s	l/s m^2	m^3/s	m^3/h
146,2	20	3,0	146,2	2,5	0,1462	526,v
1828,0	60,9	10,8	1828,0	9,0	1,8280	6580,645161
7,6	20	1,2	20,0	1,0	0,0200	72
9,1	20	0,6	20,0	0,5	0,0200	72
146,2	20	4,4	146,2	3,7	0,1462	526,4516129
146,2	20	4,4	146,2	3,7	0,1462	526,4516129
48,7	20	2,9	48,7	2,4	0,0487	175,483871
856,9	98,4	3,1	856,9	2,6	0,8569	3084,677419
121,9	26,4	1,7	121,9	1,4	0,1219	438,7096774
12,2	32,4	0,4	32,4	0,3	0,0324	116,64
24,4	20	1,6	24,4	1,4	0,0244	87,74193548
36,6	20	0,8	36,6	0,7	0,0366	131,6129032
24,4	20	1,5	24,4	1,3	0,0244	87,74193548
548,4	36,9	5,4	548,4	4,5	0,5484	1974,193548
7,6	20	1,0	20,0	0,8	0,0200	72
64,0	20	2,2	64,0	1,8	0,0640	230,3225806
9,1	20	1,6	20,0	1,3	0,0200	72
7,6	20	1,8	20,0	1,5	0,0200	72
7,6	20	0,9	20,0	0,7	0,0200	72
7,6	20	1,0	20,0	0,8	0,0200	72
146,2	35,1	1,5	146,2	1,2	0,1462	526,4516129
48,7	20	5,8	48,7	4,9	0,0487	175,483871
48,7	20	5,8	48,7	4,9	0,0487	175,483871
7,6	20	1,3	20,0	1,1	0,0200	72
12,2	20	4,8	20,0	4,0	0,0200	72
390,0	26,1	5,4	390,0	4,5	0,3900	1403,870968
548,4	25,8	7,7	548,4	6,4	0,5484	1974,193548
731,2	119,7	2,2	731,2	1,8	0,7312	2632,258065
0,0	1,2	0,4	1,2	0,3	0,0012	4,32
9,1	20	1,3	20,0	1,1	0,0200	72
7,6	23,7	0,4	23,7	0,3	0,0237	85,32
0,0	24,9	0,4	24,9	0,3	0,0249	89,64
91,4	25,2	1,3	91,4	1,1	0,0914	329,0322581
7,6	20	1,6	20,0	1,3	0,0200	72

VENTILATION PLANS LEVEL 0-1 1:500



- Exhaust air
- Supply air
- Outdoor supply and exhaust
- Aggregate



PRESURE LOSS - FROM MAGICCAD

Process presure loss calculations made to give a more informed design to find the energy usage to inform Be18.

Exhaust Air ducts (surf area)

Total flow:	12364 m³/h
Total pressure:	-125.0 Pa
Including design margin 5.00 %	12982 m³/h
Including design margin 5.00 %	-131.3 Pa
Calculation Input Values	
Air Density:	1.20 kg/m3
Air Dynamic Viscosity:	0.00001813 Pa*s
Min. dp air devices:	20.0 Pa

Supply Air ducts (surf area)

Total flow:	10895 m³/h
Total pressure:	145.1 Pa
Including design margin 5.00 %	11440 m³/h
Including design margin 5.00 %	152.4 Pa
Calculation Input Values	
Air Density:	1.20 kg/m3
Air Dynamic Viscosity:	0.00001813 Pa*s
Min. dp air devices:	20.0 Pa

Exhaust Air ducts (Expo and Commen functions)

Total flow:	10701 m³/h
Total pressure:	-146.4 Pa
Including design margin 5.00 %	11236 m³/h
Including design margin 5.00 %	-153.7 Pa
Calculation Input Values	
Air Density:	1.20 kg/m3
Air Dynamic Viscosity:	0.00001813 Pa*s
Min. dp air devices:	20.0 Pa

Supply Air ducts (Expo and Commen functions)

Total flow:	9209 m³/h
Total pressure:	266.2 Pa
Including design margin 5.00 %	9669 m³/h
Including design margin 5.00 %	279.5 Pa
Calculation Input Values	
Air Density:	1.20 kg/m3
Air Dynamic Viscosity:	0.00001813 Pa*s
Min. dp air devices:	20.0 Pa

SEL VAULE - FROM SYSTEMAIRCAD

Energy data aggregate (Surf area)

Kalkulation af energi

Gennemsnitlig varme genvinding:	87	%
Gennemsnitlig SFPv (rene filtre)	1.42	kW/(m³/s)
Gennemsnitlig SELe (ved dimensionerende filter tryktab)	1.48	kW/(m³/s)
Energi klasse Vinter / Sommer	A+ / A+	

Energy data aggregate (Expo and Commen functions)

Kalkulation af energi

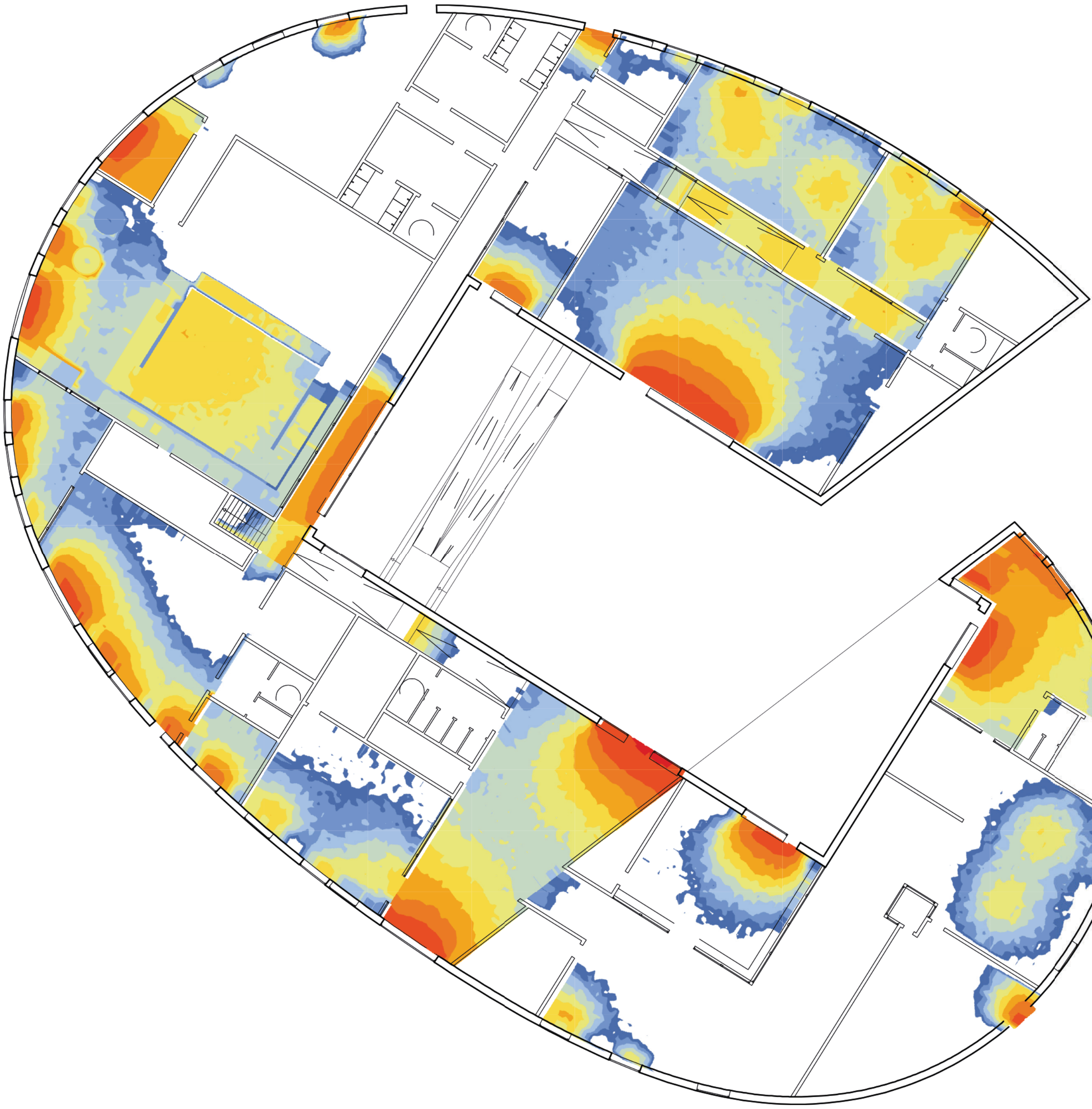
Gennemsnitlig varme genvinding:	87	%
Gennemsnitlig SFPv (rene filtre)	1.52	kW/(m³/s)
Gennemsnitlig SELe (ved dimensionerende filter tryktab)	1.58	kW/(m³/s)
Energi klasse Vinter / Sommer	A+ / A+	

DAYLIGHT

The daylight simulations are made using Climate Studio, which is a plugin to Rhino Curios. The analyse is divided into each room, where the senses are placed 0,5m from the walls. The analyse is made after the building regulations, that's states that 50% of the daylight hours should have over 300 Lux. Lux in 50% of the floor area. Here all under 50% will be coloured white. The analyse is made on all rooms to understand the atmosphere but only part of the rooms have regulations. Materials properties are chosen after the material properties instead of the values from the guidance from building regulations.

The rooms that require the that 50% of the daylight hours should have over 300 Lux in 50% of the floor area, is the lounges and the educational rooms. And the office here is only in the working area that needs it.

LEVEL 0-1



LEVEL 2