Svinkløv Badehotel 2.0

Natural ventilation: re-engineered

Master Thesis

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Abstrakt / Abstract

Dansk

"Svinkløv Badehotel 2.0" er en kandidatafhandling skrevet på Aalborg universitet. Denne opgave er en opfølgning på den brand som hærgede Svinkløv badehotel i efteråret 2016. Opgaven er et forslag til hvordan et nyt Svinkløv badehotel kunne være udformet, men med særlig fokus på naturlig ventilation samt bæredygtighed.

Denne opgave er udarbejdet på bagrund af Problem Baseret Læring samt den Integreret Designproces, som er udarbejdet på Aalborg universitet. Research er lavet på baggrund af pragmatisme og fænomenologi undersøgelser.

Det ikoniske Badehotel som stammer tilbage fra starten af det 20. århundrede har en lang og rig historie. Mange danskere har et tilhørsforhold til det gamle hotel. Enten fordi de har været gæster der eller er kommet der for spise den fantastiske mad eller bare nyde naturen. På denne baggrund forsøger dette forslag at finde frem til de værdier som det gamle hotel havde og viderebringe dem i et nyt og forbedret forslag.
Tilgangen til den naturlige ventilation er blevet et af omdrejnings punkterne for dette projekt, som er et modsvar til den tilgang der bliver brugt i moderne arkitektur, hvor det ofte er mekanisk ventilation som benyttes og derved gør ventilationsstrategien mindre vigtig. Denne kandidat afhandling undersøger et unik ventilationssystem til at ventilere bygningen. Bygningen vil kun være åben for gæster i sommermånederne. .

Denne afhandling repræsentere et forslag til hvordan et nyt hotel kunne se ud, naturlig ventilation, strategi samt bæredygtige simulationsresultater baserede på Bygnings reglementet (BR15). Desuden indeholder afhandlingen design processen bag forslaget samt refleksion og konklusion over det samlede projekt.

English

"Svinkløv Badehotel 2.0" is a master thesis done at the Aalborg University. The goal of the work was to propose a new hotel on the site of Svinkløv Badehotel that burned down in September 2016. Moreover, the goal of this work was to research the natural ventilation strategies in contemporary architecture in the era of sustainable architecture development.

This work was done by using The Problem Based Learning and The Integrated Design methodologies developed at the Aalborg University. The research was done by using literature, on-site excursions as well as an abroad research-excursion.

This iconic Badehotel with a rich history should be rebuilt in the opinion of many Danes and also the building owners. Thanks to this work, the new building is trying to resurrect the good qualities of the old hotel and present it in an upgraded version that can fit the contemporary sustainable architecture of the beginning of 21.th century.
The natural ventilation approach is a result of the global changes in the approach to the architectural design, where the performance of the building is making ventilation strategies least important in the design process. The mechanical ventilation is trying to cover more and more of ventilation problems. This master thesis is proposing quite a unique efficient solution for ventilating the building which will be mainly run during the warm months.

Thus, this work presents a new building proposal, the natural ventilation solutions and the sustainable simulation according to the Danish energy frames from the Danish Building Regulations (BR) 2015 and (BR) 2020. Moreover, this work presents a design process behind this thesis as well as a conclusion and a reflection upon the gathered result of this work.

Foreword

This thesis is created by group 32 on MSc04 of Architecture & Design, Aalborg University. The project is a manifestation of gained knowledge from previous semesters, thus the theme that the project is paying special attention to is Sustainability accompanied by the integrated design process methodology. This report documents the reflection and concept development of the project proposal and its process.

The theme for this report cut was chosen by the students themselves. Hence, this report is rethinking the natural ventilation. This requires all the above mentioned approaches and also new skills and knowledge for the designing of such architecture.

This thesis is supervised by Michael Lauring, Associate Professor at the Department of Architecture, Design and Media Technology, AAU and technical supervisor Claus Topp, Part-time Lecturer, Department of Civil Engineering, AAU.

Reading guide

This thesis's is presenting process of analysing, research and design of the new Svinkløv Badehotel. This work focuses on natural ventilation, it is being used as guideline for the design process and the final result.

First analyses are being presented, followed by the natural ventilation research. The result of those is a short presentation of the new building proposal. Afterwards there is a presentation of the design process that stood behind the design phase.

The final chapter contains conclusion and reflection upon the thesis, followed by the literature and illustration list. The literature is referenced, per Harvard referencing citation style.

Special thanks

Thesis' authors would like to give special thanks to:

their architectural supervisor Michael Lauring and technical supervisor Claus Topp. For guiding through the thesis development

Steen Royberg from Svinkløv Foundation Erf for introducing detailed history of the Svinkløv Badehotel and explaining the impact of the building on local Danish society

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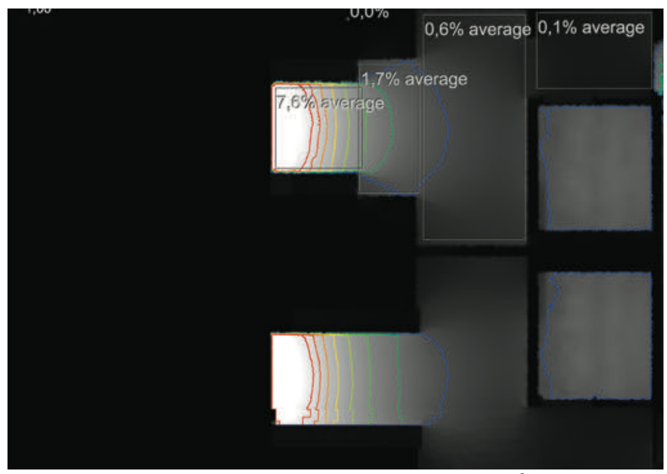


Design process

Introduction

Every good book, has a good story in it. This should not be an exception.

Right ill. 7.1. Beach between the site and the sea.

In September 2016 the iconic Svinkløv Badehotel was burned down. It was a fantastic place, known to almost all society in Denmark. Site owner and Svinkløv Foundation Erf almost already knew that the new Badehotel will need to be built again. It was basically in the national interest.

While preparing to this master thesis in late 2016, its authors, master programme architecture students Jesper Søndergaard and Piotr Zbierajewski from Aalborg University where searching for a site and a theme for their diploma. Svnkløv seemed perfect, since it could be used as an example of a fresh and quick work on the site that lost its previous function.

While researching the topic and history of the old Svnkløv Badehotel, authors became more and more fascinated not only by the history of the site but also an impact that it had on (mostly) Danish society. Generations of families were coming there to escape from everyday life and to enjoy nature and sea. It started to be obvious that no other function will fit on this site than the new Badehotel.

During 1st master degree year at Aalborg University, both authors started to be interested in a sustainable architecture solutions. Their advantages and disadvantages. Quite suprisinly it turned out that from many aspects of this kind of architecture, one in particular seemed to be treated as a problematic one. Ventilation.

More and more buildings are working mainly on mechanical ventilation, providing, formally, with right amount of fresh air. Most of such buildings are having huge issues when something in the ventilation system stops to work. Moreover, such systems are also using energy, have some maintenance cost and a life cycle. In many situations, every other aspect of the sustainable elements were designed in one way or another. But ventilation was the one that was usually left untouched to the very end in an approach “it is going to be solved one way or another”.

This was the moment when authors knew that natural ventilation should be the main technical focus of their master thesis.

Both of those aspects: architectural and technical, met together and gave a result of this. This is a proposal for new Svinkløv Badehotel.

Svinkløv Badehotel 2.0

Jesper Søndergaard and Piotr Zbierajewski

Methodology

Methodology is base upon the way the problem should dealt with.

This project is based on The Integrated Design Process (IDP) described by Mary-Ann Knudstrup *(Ring Hansen and Knudstrup, 2005)*. It is a very complex process, because it consists of five different phases that overlay each other; moreover, the process in not chronological and in addition, consists of numerous loops between each phase of the process (il. 8.1).

The first phase represents a problem formulation: this is the first step in the project, since it contains the problem formulation or the project idea.

The second phase is the analysis phase. It contains the information needed to begin the main work of the project, such as the site analyses (for example, the geography of the site, the weather analyses of the area and so on), the user analyses (who will use this building, what are the demands of the future users, who might be impacted by it as well), or any other analyses relevant in connection to the first phase. Finally, it should investigate the special qualities of the site and the sense of the place (genius loci). Also, this is the phase were the principles for the further project development should be specified. This phase ends up with the design criteria which are being created as a summary of the analysis.

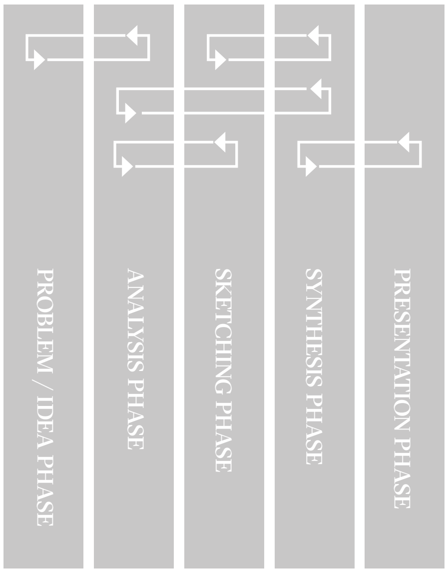
The third phase is a sketching phase, where the professional knowledge between the architecture and the engineering is combined. By using IDP, the demands and wishes for the building should be met. This also applies for any other demand that has emerged in the second phase. This is the phase, where the creative ideas and solutions are produced. The sketching phase is a complex mental process, where the mental visualisations of the building emerge and which are then transferred on to a paper (hand sketches) and a digital form (computer aided design).

The fourth phase is a synthesis phase. This is where the building finds its final form, and where the demands from all the sides are meeting; this is where the final architecture, the engineering and the performance aspects are being created.

The last, the fifth phase, is a presentational phase. It shows the final form of the whole project, underlining its qualities and aims. It should also be a visual representation of the resulted design criteria.

This is a brief representation of a even more complex process which contains an interaction between each of the parameters of the IDP. However, they may vary depending on the specification of the project and many other input and output data throughout the design process.

It is important to note, that IDP is referring to the whole project creation and must not be confused with the number of the phases in the design process.



Ill. 8.1. The 5 phases of the Integrated Design Process.

Motivation

"Building services are essentially a mechanical compensation for the fact a building is bad at what it is designed for: human inhabitation."

"(...) Essentially, the buildings were now on life support – supplemented by air conditioning, central heating, and mechanical ventilation. The machines replaced traditional consideration of the thicknesses of the walls, solar orientation, proximity to windows, and the operability of daylight. Suddenly, a building was not performing anymore; it was reduced to a mere container of space – a big blank box, tube-fed by a whole arsenal of machines. The building services are essentially a mechanical compensation for the fact that a building is bad at what it is designed for: human inhabitation." *(BIG – Bjarke Ingels Group, 2015)*

Based on this quote, this thesis is trying to explore how architects can rethink the way they are approaching the life support solutions in architecture, experimenting with sustainable solutions with the main focus on natural ventilation. The reason is that often architects are focusing more on solutions regarding thermal solutions for the walls or more on the energy production on the site (going more into net-zero energy buildings). When it comes to the ventilation, however, the mechanical systems are being introduced by the default. At the same time, we reached the point where the need for cooling is bigger than the need for heating in our hemisphere *(Passe and Battaglia, 2015)*.

The thesis is not trying to prove that mechanical ventilation is wrong. Instead, it is focusing on the problem with a lot of new solutions which are appearing in a new architecture. They are trying to negate status quo of old solutions instead of searching for the development of those that were before.

As a study case, this thesis is trying to use an opportunity in presenting a concept of a new building instead of old Svinkløv Badehotel, which burned down completely in September 2016. The strong reputation of this place and its importance to the Danish nation have made a big impact on the decision of the location and the architecture topic of this thesis. Moreover, the site owners would like to implement some new solutions for the new building to make it more environment-friendly. It is then the common ground for the natural ventilation solutions. Especially, this area of Denmark is often met with wind extremes.

So, the thesis can also ask a question about the architectural solutions in such areas. What would happen, if the extreme weather situations took the lead in researching solutions we had so far? What if we could reinvent and upgrade the solutions so far? What if we could take the mentioned natural ventilation and try to improve the solutions we know so far? Natural ventilation: reengineered. Or re-architecturized.

Analysis

‘A building should appear to grow easily from its site and be shaped to harmonize with its surroundings if Nature is manifest there’

- Frank Lloyd Wright (Uhlfelder, 2000)

Nordic architecture

Understanding the language of architecture and architectural principles in the region in general, can help in providing a better solution for the context.

Throughout the history, the Nordic architecture has been shaping in a common way. The first golden age came in 20th century. Today the Nordic architecture is standing out again - globally. It is not that typical for the group of countries with old common roots to represent exactly the same values in the design process. The Nordic architects mix innovative thinking with strong architectural roots. Often we see architectural offices spread across those countries, cooperating with each other and having local offices in other countries from the Nordic family. However, this collaboration has a long tradition.
In the beginning of 20th century, when Congrès Internationaux d'Architecture Moderne (CIAM) was created, the Nordic countries were represented there by many famous architects from this region, like Lars Backer, Scen Markelius, Poul Henningsen and Alvar Aalto. The early Nordic modernist architects were visible as a representatives of all Nordic countries, speaking the same language of architecture. The first contemporary description of this architecture was made by Lars Becker in 1927. He said that there was no longer need for "pastiche details, but for practical homes, bright working spaces, show-windows, and illuminating advertising. The new architecture is as international as modern technology, as the materials we use and machines we operate. But there is still room for national identity based on climate, needs and indivisuality" *(Ibler, 2014)*. From the very beginning of modern architecture there was a strong social involvement in the Nordic architecture. It was its distinctive element. This is strongly correlated "with the Nordic tradition for welfare as we know it Today" (*Ibler, 2014*).

Throughout the 20th century, "Nordic Genius Loci" - the old Roman expression for good architectural practice - was created. This "spirit of place" was concluded in the honesty of the material, good relationship with the context and a big respect for the nature. It was also about considerable amounts of light inside the spaces but without overexposured places.
The light has always been in the centre of the Nordic architecture, particularly because of the long dark winters and the light summer months. Many architects played with the natural and artificial light in order to obtain interesting effects, so that the occupants would not feel the lack of the light *(Ibler, 2014)*.

The Nordic architecture is also characterised by taking into consideration the local materials. Norway, Sweden and Finland have vast amounts of forests and the architects from these countries like very much working with wood. It is not the case in Denmark, however, since the forests were grubbed, between the end of 18th and the beginning of 19th century. It is estimated that in 2015 only 14% of the country's area is covered by forests *(Data.worldbank.org, 2017)*.

In the 19th and 20th century the country was under the sign of brick. Bricks have been used in the local architecture and until today it is a very respected material. Since the collaboration between the countries is mentioned, we should also speak about timber, which is treated as a local material in Denmark, but it is often supplied from neighbouring Nordic countries, mostly Norway, that is famous for its quality wood.

Today, the biggest thread to the Nordic architecture is the danger for its being commercialized through different media, television, internet, etc.: "A circus based on economic interests rather than on architecture and human quality" *(Ibler, 2014)*. But this is, in fact, a prediction. The Nordic architecture and the Nordic culture are currently being covered by many magazines and films. In 2016, one of most searched words in Oxford Dictionaries was Danish "hygge" *(Dictionaries, 2017)*. At the same time, more and more Nordic architectural offices are realizing projects abroad, or even on other continents. The influence of Nordic architecture is spreading fast since the abroad-projects are gaining awards outside origin countries *(ArchDaily, 2017)* and because these projects make use of sustainable solutions (for example, the Norwegian wood is the building sectors' high-class export product).

Right ill. 13.1. Gug Kirke in Denmark

Site description

The site is located in Svinkløv, near the city Fjerritslev in the Northern Jytland, Denmark. With a population of 3.700 people, Fjerritslev is a commercial town for the tourists in the old Hannæs area, with plantations, seaside hotels and a summerhouse area with about 1.000 homes and 136 hotel beds.

The area has been plagued by sand drift because of strong storms, but due to the establishment of Svinkløv Klitplantage (dune plantation) the area is today a home for different species of vegetation and a wild life *(Helhedsplan.jammerbugt.dk, 2017)*.

The mentioned above dune plantation is spreading from Svinklovene to Slettestrand *(Denstoredanske.dk, 2017)*. Moreover, there is a St. Olaf's Source which is a holy spring that rises in the hills under the birch scrub near the rest stop on Sletteåvej between Svinkløv and Slettestrand. The source history goes far back in time and the introduction of Christianity was dedicated to Olav the Holy, Norway's national saint *(Svinkløv og Kollerup Plantager, n.d.)*.

A few kilometres down the coast at Thorup beach, the fishers are keeping to an old tradition. They are pulling their fishing vessel up on to the beach with steel wires and winches. The fisheries that are operating here are gentle to the environment and are producing eating fish of the highest imaginable quality.

Today all the boats are owned by the union "Han Herred Havbåd" (Kragh Jespersen, Topperzer and Sandvej, 2008).

Until 2015 the government supplied only electricity to the site. The water supply comes from a well that can provide sufficiently with water one or two households. The heating is being provided by own furnace. In 2015 the site was connected to the sewer *(Royberg, 2017)*.

Right ill. 14.1. Aerial photo.


St. Olaf's Spring
Slettestrand
Hjortdal

ill. 16.1. Aerial photo taken above the site. View towards east.

The nature and the landscape

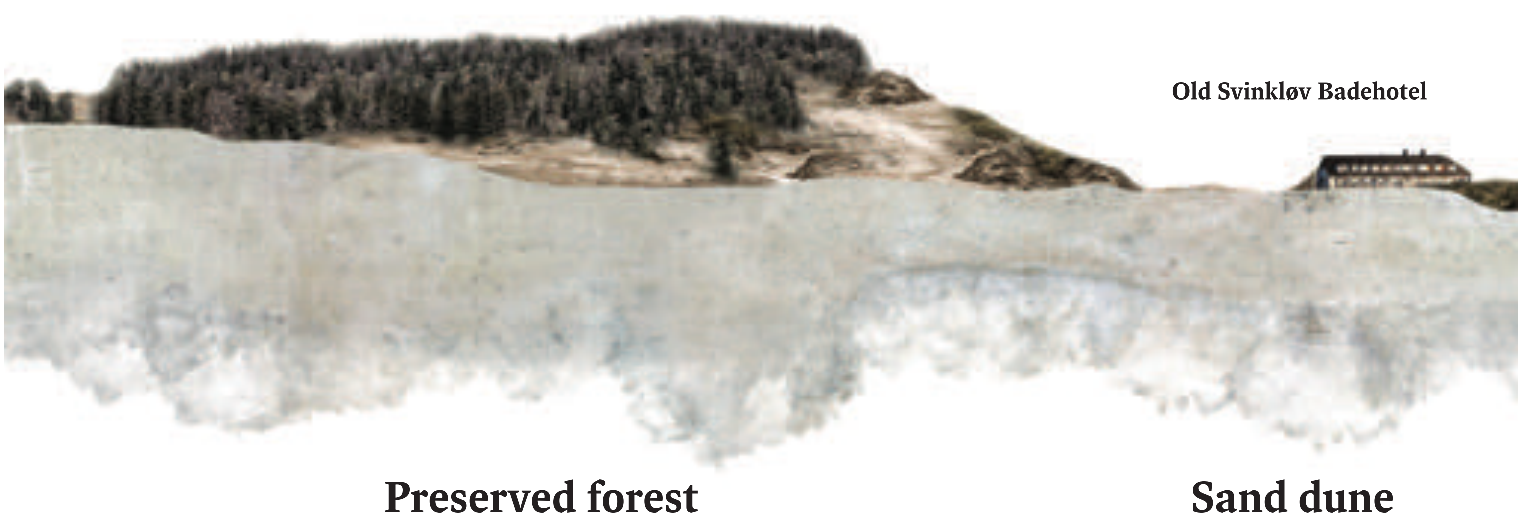
The very first thing that visitors see when coming to this site is a beautiful landscape and the fascinating way in which the terrain meets the sea.

Svinkløv is a Stone Age cliff of chalk spreading at the northern seacoast of Denmark, 7 km north from Fjerritslev. Around 1900 the cliff appeared nude and white because of strong storms. Today it is a home for different species of vegetation. The top of the cliff is named Stenbjerg, which is 52 meters high *(Denstoredanske.dk, 2017)*.

The area of the site is really rich in high grass and large amount of dunes. These dunes are the remains of the last ice age, overlying moraine deposits. There are series of narrow V-shaped valleys at the edges of the cliff that are protected from the drying out on in the sun. This gives a great variety and richness of species, whether these are plants or animals. Currently, this district has the longest cliffs in Denmark *(Kragh Jespersen, Topperzer and Sandvej, 2008)*.

The sand drift in Jammerbugt area was the reason for the state's planting in the years from 1884 to 1910. The old dune vegetation had been worn by humans and grazing animals and the subsequent sand drift was violent and destructive. The planting of French mountain pines put an end to the sand drift, and since then other species came here as well, especially the wind resistant and salt tolerant Sitka spruces. There are still some impressive 35-meter-high specimens of this spruce, which dates back to the 1880s,

ill. 18.1. Section through the site.



but large areas of these trees got reduced in recent years due to bark beetles. Scots pines and firs are still well represented, and beeches, alders and ashes represent deciduous trees with the oak scrubs that characterize the peripheral area facing the flat land below the slope *(Kragh Jespersen, Topperzer and Sandvej, 2008)*.

The dense vegetation is growing along the banks, which pours out of the fast-flowing, clear water. There is one bigger stream that crosses an asphalt road. It changes the character and runs lazily of large meanders through the flat foreland, where the cattle grazes. Woods and meadows are being replaced eventually by dune and sand before the river disappears into the North Sea *(Kragh Jespersen, Topperzer and Sandvej, 2008)*.

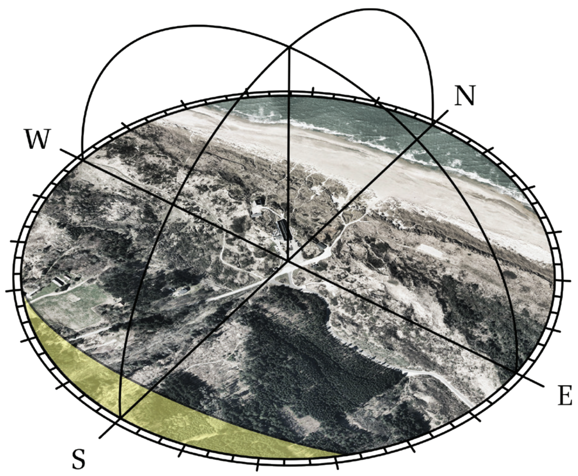
Deer Valley is located to the east of Svinkløv Klitplantage and it is a conservation area (started in 1961). In the west, the plantation borders to a larger conservation area at Grønnestrand (started in 1972) *(Denstoredanske.dk, 2017)*.

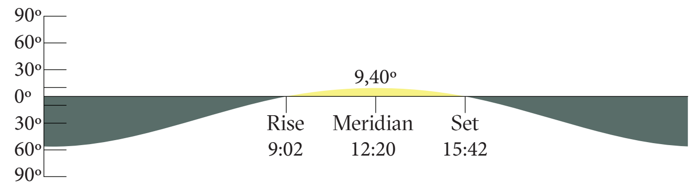
ill.19.1. Dunes at the site.

ill. 19.2. One of the buildings from the complex.

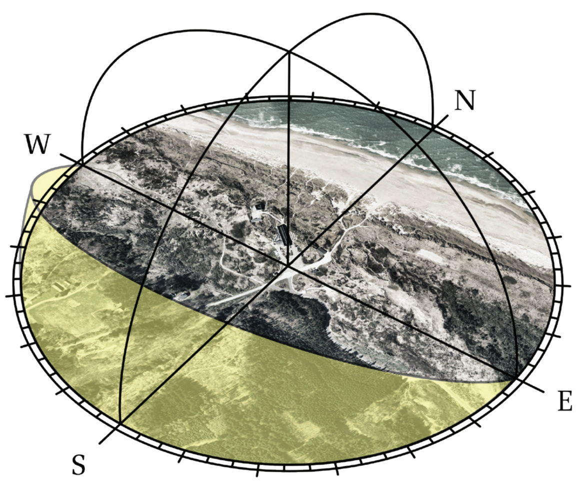
Beach **Skagerrak**

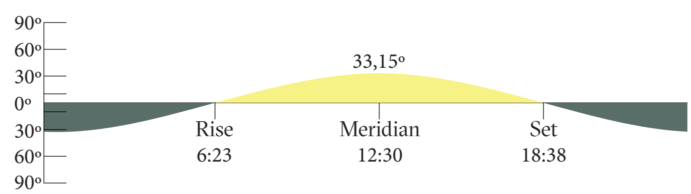
Top ill.20.1. Svinkløv.
Bottom ill. 20.2. Svinkløv.
Right ill. 21.1. Svinkløv.



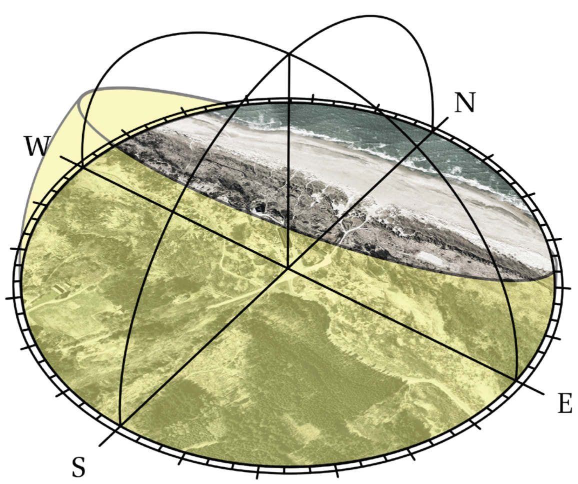


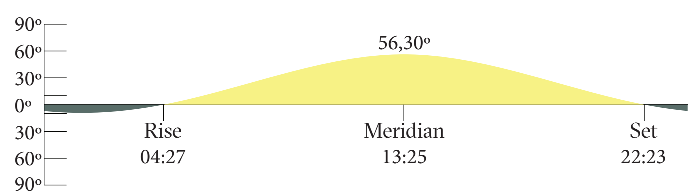
ill. 22.1. Sun path on the site on 21st of December.



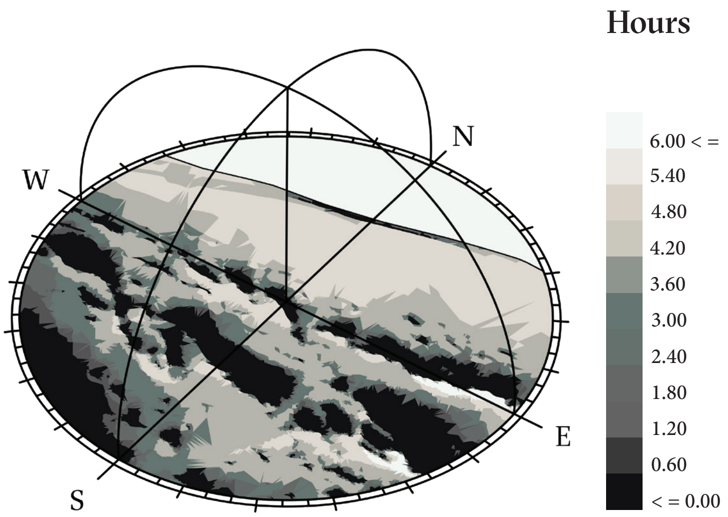


ill. 22.2. Sun path on the site on 21st of March.

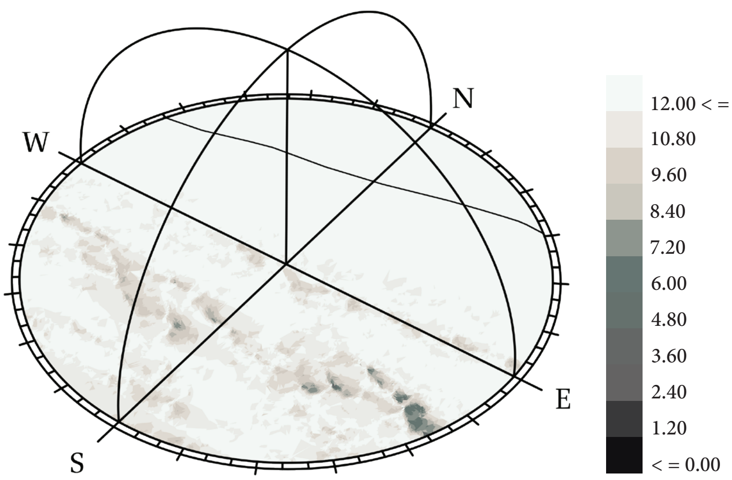




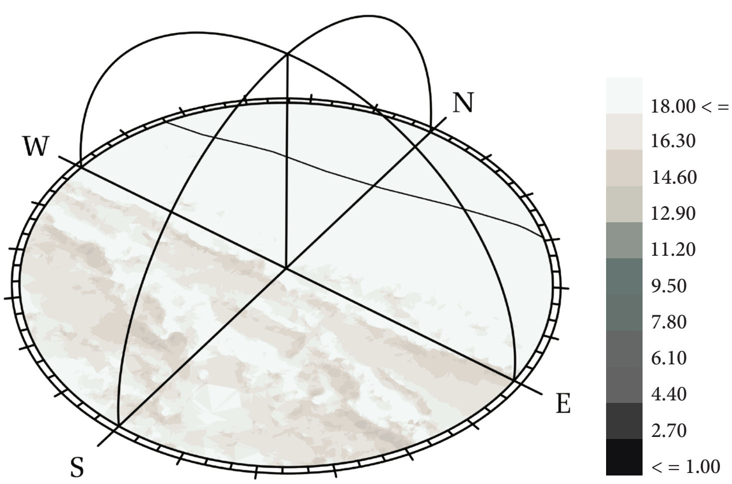
ill. 22.3. Sun path on the site on 21st of June.



ill. 23.1. Sun hours on 21st of December.



ill. 23.2. Sun hours on 21st of March.



ill. 23.3. Sun hours on 21st of June.

Sun study

The simulation of the sun-path showed that even though during the summer, spring and autumn there is a plenty of light, during the winter it is barely there. This resulted in the need for a sun-hours study for the site in order to find out exactly what kind of differences we can see throughout the year. It showed that actually during the winter time the light conditions are not that bad.

Conclusion

The sun studies show that the site has a lot of light throughout the year. This might help with shaping the light conditions inside the building, as well as it could be used for the considerations of using the solar panels in the project. In regards to natural ventilation, the solar energy might be used, especially during winter, in double-facade systems for air preheating.

Wind study

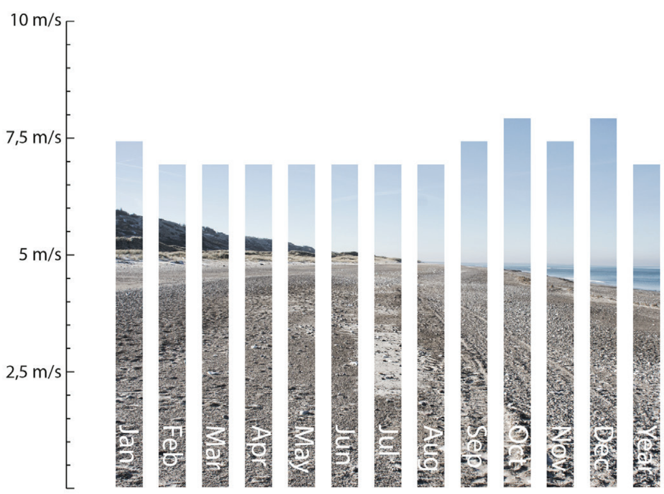
The wind roses show that annually the wind directions are more or less equally distributed throughout the world directions, but the winds from South and from North-West are slightly dominating.

It is also important to notice that the average wind force is around 7,29 m/s (4 - 5°B). However, during the storms, which happen few times a year in this area, the wind speed can rise up to 35 m/s (12°B) (Se kortet: Så voldsomt har stormen Urd ramt Nordjylland, 2017). The data mentioned above is recorded during the storm in December 2016 in Denmark.

The building owners reported that neither the storm in 2016 nor the storm "Bodil" from December 2013 caused any troubles. Due to the strong winds and quite thin walls of the Badehotelet, it often had problems with keeping warm temperatures inside the building during the winter months. Even though there is high grass growing along the coast, once every two years there was usually a need to clean up the hotel from the sand gathered in many places of the building *(Royberg, 2017)*.

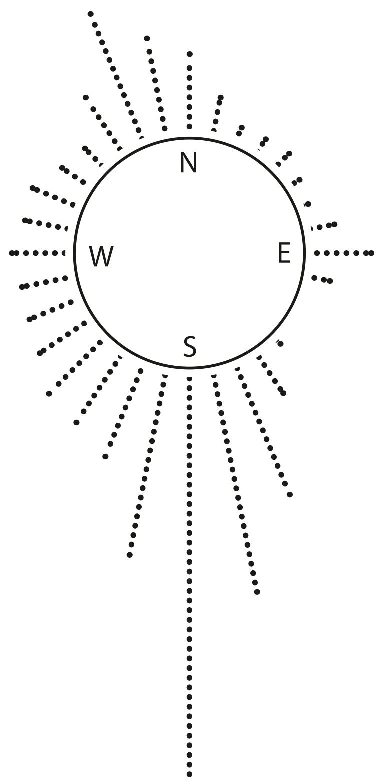
Conclusion

Considering the technical focus of this thesis, which is natural ventilation, this analysis shows that the site is good for using natural ventilation. However, there might be a problem with the drafts due to this type of ventilation in the building because of the weather extremes. This might propose some solutions to steer it in a way that would avoid having drafts or to use heat recovery systems. It is also interesting to consider the mentioned wind directions in accordance with the time of the year when they occur. Moreover, sand drifts might need special attention when using natural ventilation, so that the sand does not get stuck in the system.



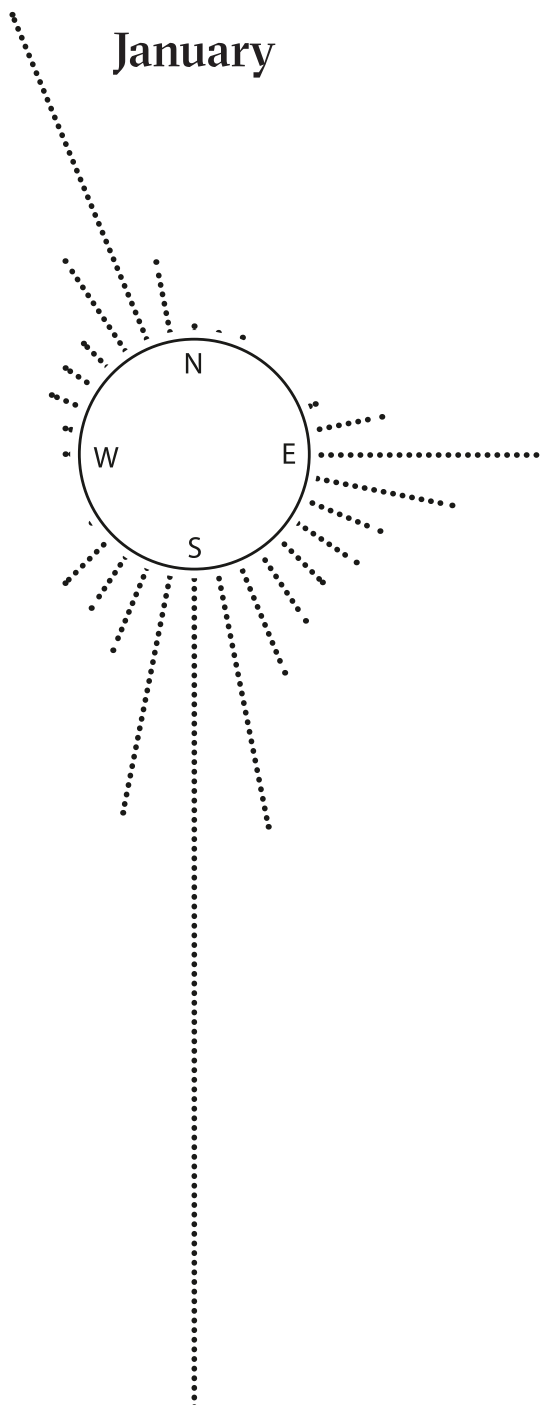
ill. 30.1. Average monthly wind speed in Svinkløv.

Year



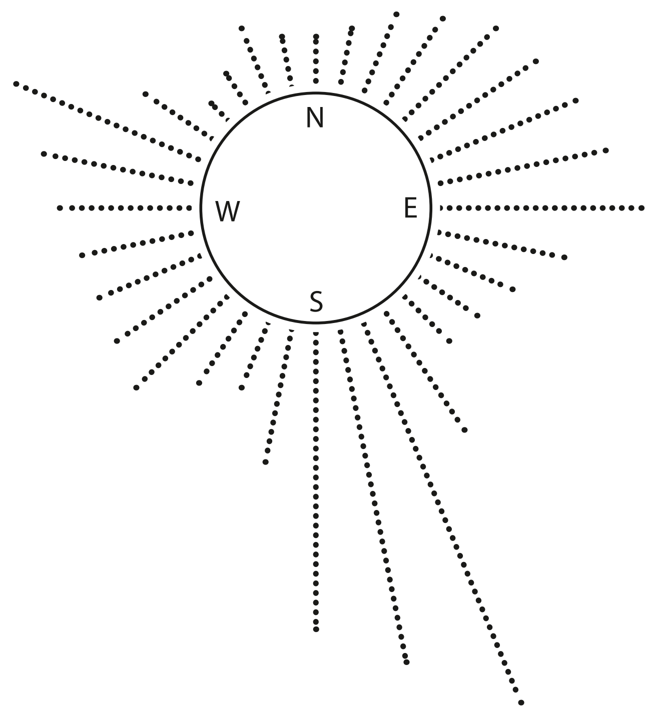
ill. 30.2. Average yearly wind directions in Svinkløv.

January

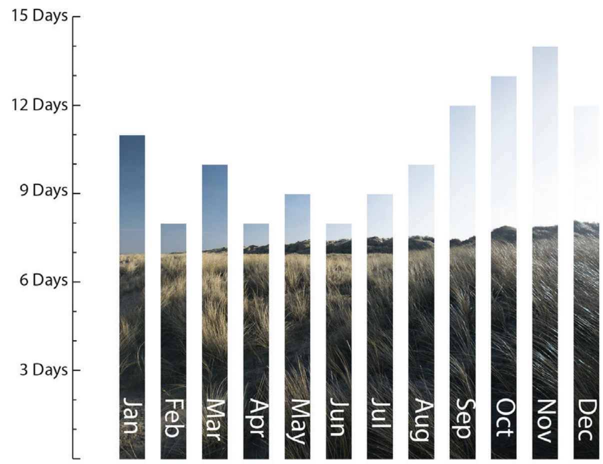


ill. 31.1. Average wind directions in Svinkløv for January. .

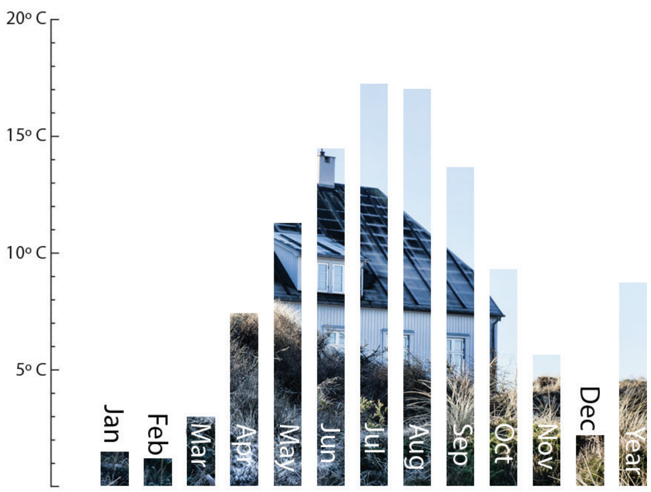
June



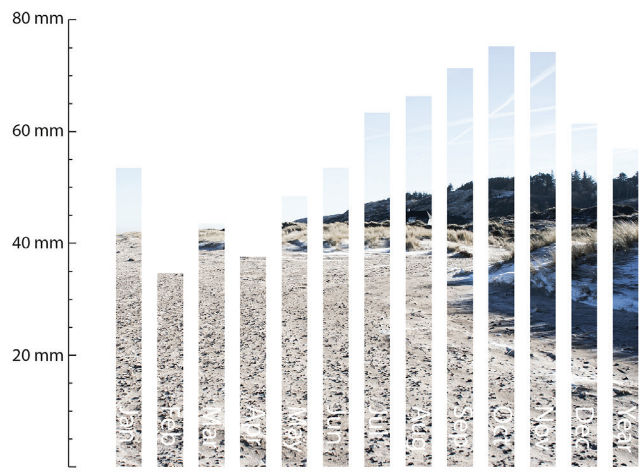
ill. 31.2. Average wind directions in Svinkløv for June.



ill. 26.2 Days of precipitation in Northern Jytland.



ill. 26.1 Monthly average tempertaures in Northern Jytland.



ill. 26.3 Average amount of precipitation in Northern Jytland.

Temperature

The temperature chart shows clearly that there are not too many warm months in Northern Jutland. The highest average temperature is in July. And the coldest month is February. The project chooses to treat months January – April and October – December as "cold" ones (when the average temperatures are below 10°C).

Conclusion

These data will have a tremendous impact on the design process. Mainly due to the use of the natural ventilation which contributes to considerable heat loss in the building. This means that the installation of heat recovery could have a major impact on the energy consumption of the building.

Precipitation

The chart of the average monthly precipitation shows that the highest amount of rain falls in October, and that from June to December it exceeds 60 millimetres. February is the driest month of the year (35 millimetres).

However, November is the month with the highest number of precipitation days, while the lowest amount of precipitation days are in February, April and June.

Conclusion

This analysis shows that there is sufficient precipitation in the area for collecting the drain water to cover the needs of toilet flushing or any other use of grey water..

Sea level

The Sea level can be understood in many aspects. One refers to the pure "0 level" - the value from which we count the height above the sea. Another expresses the data of the tides or the sea level rise caused by the global warming. And there are also extremes, as the highest wave possible in the 100-year prediction.

The data regarding the tides level show that the highest tides may vary from 0.0 to 0.5 meter high, whereas the lowest ones vary in the range of 10 cm high during the day *(Tides: DMI, 2017)*.

At the same time, the highest water level caused by the storms which is being predicted in 20-years forecast is around 160 cm above the sea *(Sea level: DMI, 2017)*.

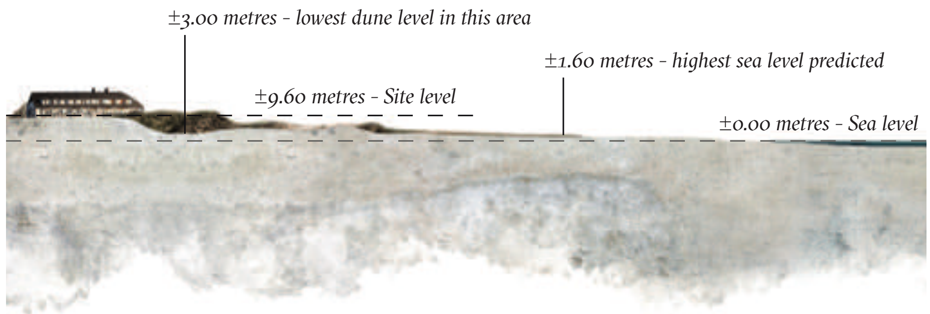
The sea level is catching as the global warming is setting a bigger and bigger mark on the planet. It is being predicted that in the years 2046-2065, the sea level will rise by 0.1 - 0.4 meters and in 2081 – 2100 by 0.2 to 0.7 meters.

This is an average number since this prediction will vary depending on the exact place in Denmark. However, the water levels in Northern Jytland are stable even though the rest of Denmark will be experiencing a rising sea level in the next 100 years. The explanation is that in Northern Jytland the geological land rise is more extensive, compared to other places in the country and it is faster than the sea rise *(Future sea levels, 2017)*. The reason for this difference can be traced back to the Ice Age (when the land got compressed under the weight of the huge amount of ice) and the movement of the tectonic plates *(Ingeniøren, 2017)*. That's why it is possible that the water level at the site will actually drop down until the climate-change-induced rise becomes more significant *(Future sea levels, 2017)*.

All above mentioned will not cause any problems, when it comes to the Svinkløv Badehotel, as it is placed high - around 9,6 meters - above the sea level. For the sake of comparison, it is worth to point out that the lowest dune level in the direct surroundings of the site is about 3.0 meters higher than the sea level. The building owners have also confirmed the lack of problems with the sea *(Royberg, 2017)*.

Conclusion

Considering the height of the terrain at the site, the sea level does not cause any problems at that exact place. Even if the new project chooses the lowest points in the dunes, it will still not create any major problems for the construction, as the site's lowest point is 3.0 meters higher than the sea level.



ill. 27.1 Section through the site.

ill. 27.2 View at the sea, towards north, near the site.

ill. 28.1. One of site restrictions examples - moor and pasture areas.

Site restrictions

The site presents a considerable number of restrictions. Some of them are mainly related to the nature, whereas others refer to the permission for constructing new buildings. The combination of both makes it hard to come up with a possible solution for a new building.

Here is a complete list of the restrictions that fully cover both the site and its surroundings.

Here is a complete list of the restrictions that fully cover both the site and its surroundings

- it represents an area, where no new trees can be planted;
- it is a nature protected area;
- it belongs to the cultural heritage where the landscape is worth preserving;
- it is under a specific geological conserva tion;
- it is classified as a valuable geological area;

- it is located in the middle of a forest reserve;
- it belongs to the program Natura 2000;
- the sand dunes are under protection;
- the beach and the nearby water area are public;
- the pasture and moor are protected nature; *(PlansystemDK, 2017)*

There also exist other restrictions claiming that in the case of the rebuilding of the Svinkløv Badehotel it must be rebuilt as a replica: with the same function, volume, style, colours and details *(Hyttel, 2017)*.

The Danish Planning Act (protection of the coastal landscape) forbids making any new sites in the area of approximate 3 km from the coast. In regards to this site, it is also forbidden to build anything 300 meters from the coast (which would end behind the cliff). However, the same law states clearly that there could be granted an exceptional permission for the construction, if the building will be of national interest *(Auken and Christiansen, 1997)*. This thesis is researching what kind of "national interest" the new building could potentially represent.

Conclusion

Even though there are a lot of different types of restrictions, there are three possible ways to reconstruct the Svinkløv Badehotel. One possible solution is to rebuild a replica of the old hotel; another - is to erect a new building with a new function that will be important for Denmark from the national point of view. The thid option is to make a new local plan.

Badehotels in Denmark

Briefly about one of the most specific hotels in Denmark.

The first Badehotels were built in Denmark in the 1880s. They were placed along the Danish coast usually isolated on a hilltop, well away from the cities. The guests were wealthy and important individuals. The style of the first 'Badehotels' was inspired by the French hotels and the old Viking castles. The common rooms were a typical trademark for the Badehotels. It was also typical for the common to be made from marble and decorated with plush furniture; meanwhile the guest rooms were humble and minimally furnished. The rooms were meant as a place to sleep only. The guests arrived individually or in small groups. It could be parents with an adult child, a young married couple or two elderly widows' in the company of a lone gentleman – that is why the socializing between the guests were extensive and widespread. In addition to bathing, there were playing bocce, tennis and common meals.

The guest didn't have any contact with the locals in the area, but it was normal for the guest to lend a hand when there were some tasks on the hotel *(TV2, 2017)*.

Before and especially after the First World War began, the seaside hotels switched the character – they became popular and the guests started to pour in. Also, people from the middle class started to visit the 'Badehotels'. The process was fully commercialized, so guests no longer participated in any kind of work *(DR 1, 2017)*.

Over 100 'Badehotels' were built during the 1910s across Denmark. This form of holiday was offering something as rare as an informal contact between unmarried women and men; just as it was possible to meet people from a finer family as one self. Actually, this was not without complications, partly due to the fact that the ordinary people now were spending their holidays at the 'Badehotels'; and partly because the inexperienced guests rarely knew the standards of the behavior, which led to a formation of cliques and an outright isolation of the families who did not know the unspoken rules of the hotel.

In the 1940s, after the Second World War, the people had the desire to visit other countries as they had been bound to Denmark too long during the war. This was the beginning of the charter tourism which had a tremendous influence on the 'Badehotels' and many of them closed.

Today people are again finding the 'Badehotels' interesting, because they are the only places, where to they can escape from everyday life and technology *(TV2, 2017)*.

ill. 31.1. Beach at Svinkløv.

Svinkløv Badehotel

Svinkløv Badehotel has a long and interesting history. It was a famous hotel, loved by many Danes, which - unfortunately – burned down in 2016.

ill. 32.1. Photo of the old Svinkløv Badehotel.

The site's history started with the sand drifts in Jammerbugt area, which also was the state's planting area at the end of 19th and at the beginning of 20th century. Due to the greenery expansion, the sand drifts were no longer causing any troubles.

Svinkløv Badehotel was established by Karl Brix Kronborg, a Danish-American. He was fighting for the United States in the First World War, and after the war he returned to Denmark. Upon his return, he got an idea to build a hotel and chose the location by Svinkeløv, which was very close to the sea.

As the site conditions were rather tough, with the dunes and the surrounding nature making the construction even more difficult, Kronborg used a lot of time convincing the government to let him build there. And it would not happen if it had not been for the help from Royal House's architect, Ejnar Packness.

He got inspired by the movement for better building practices with the emphasis on classical ideas of the building proportions, colours, as well as the sizes and the position of the windows and doors, which found its expression in the hotel's construction.

The hotel was built in 1925 with a few rooms and a very small restaurant, but in the course of time the original building turned out to be very small, and it was extended three times. The first extension started in 1933 and in 1934 the building was finished in its present form *(Kragh Jespersen, Topperzer and Hansen, 2010)*.

In the beginning, with the total area of 1.750m2 (450m2 of basement, 700m2 of

Top ill. 35.1. Svinkløv Badehotel.
Bottom ill. 35.2. Svinkløv Badehotel.

'this is the mother of all "Badehotels" in Denmark'

Top ill. 37.1. Svinkløv Badehotel.
Top ill. 37.1.Cuising of Svinkløv Badehotel.
Left ill. 36.1. Svinkløv Badehotel.

ground floor and 600m2 of 1st floor *(Royberg, 2017))* it was not a successful business, as there was no bigger settlement in the area, and the only one road leading to the hotel was primitive and long, meandering between the forest and dunes.

But finally, the hotel became very famous because of its direct connection to the sea, beautiful views and - probably - precisely because it was so far away from any settlement: what made the hotel to sand out as a solitude. It was a good place to spend a holiday *(Kragh Jespersen, Topperzer and Hansen, 2010)*.

The hotel was also unique, because it was one of the last remaining hotels made of wood. Moreover, it was the longest wooden building in Denmark. During the season (from April to October) it was often the place for art exhibitions (which were exhibited in the rooms) and classical concerts *(Svinkløv Badehotel, 2017)*. The guests could also buy some exhibited items as a souvenir. In 2014, the hotel became even more famous because of the Danish TV series "Badehotellet". When the TV producers arrived to the site to make a research on the building, Anders Agger, the main executive producer of the program, said that "this is the mother of all "Badehotels" in Denmark" *(Royberg, 2017)*.

Normally, Badehotel was open each year from Easter to late September. During that period the hotel was full. All rooms were always booked for next three months. Usually the guests were booking ahead of time for the same week next year. The hotel was not cheap to stay at, but it offered great quality in return *(Royberg, 2017)*.
Besides the main hotel, there was also an annex to the hotel – a small building which›

ill. 38.1. Svinkløv Badehotel's annex.

had 9 extra rooms for the guests that had been coming here for many, many years. So this was an optional "extra treat" for regular customers. There was a copy of that annex-building on the cliff – a house in which people, running the Badehotel business, lived. Both buildings were also designed by Packness and both were kept in the same style as the original hotel. Moreover, there was a small pavilion in the southern corner of the site, and it had only one function - to sell ice-creams during the summer *(Royberg, 2017)*.

The hote is currently own by a fountadion called Foundation Svinkløv Erf. And are leasing the hotel out. The corrent oweners is a yng cupple where the man have ben the head cheff of svinkløv for meany years. The overtook the hotel in the end of 2015.

The Fire

In the night of 26th of September 2016, the hotel burned down. Fortunately, no people were hurt (including 48 accommodated guests) *(nyheder.tv2.dk, 2017)*. During the first week after the fire, there were 700 announcements in media about the accident. Not only because it was a known place, but also because it was an icon for all "Badehotels" in Denmark *(Royberg, 2017)*.

The next steps

The board of Svinkløv Badehotel, Foundation Svinkløv Erf, consisting of five people, decided that the place was too important for the Danes, and that it should be rebuilt.

Actually, there was one architect among the members of the Board, and almost immediately the owners started to hold meetings with different architecture offices in order to discuss the possibilities of reviving the building.

They contacted eight offices in the beginning, later the number was reduced to four and finally they chose one architecture office for realizing the project.

Initially, the owners informed the media that the new Badehotel hotel would be ready in 2018 *(Royberg, 2017)*, but due to the long procedure of getting the money from the insurance company *(Royberg, 2017)*, this date was corrected to 2019 *(Skaftved and Skaftved, 2017)*.

Getting to know the soul of the place

After the Svinkløv Badehotel burnt down, and before starting any discussions with ›

+1

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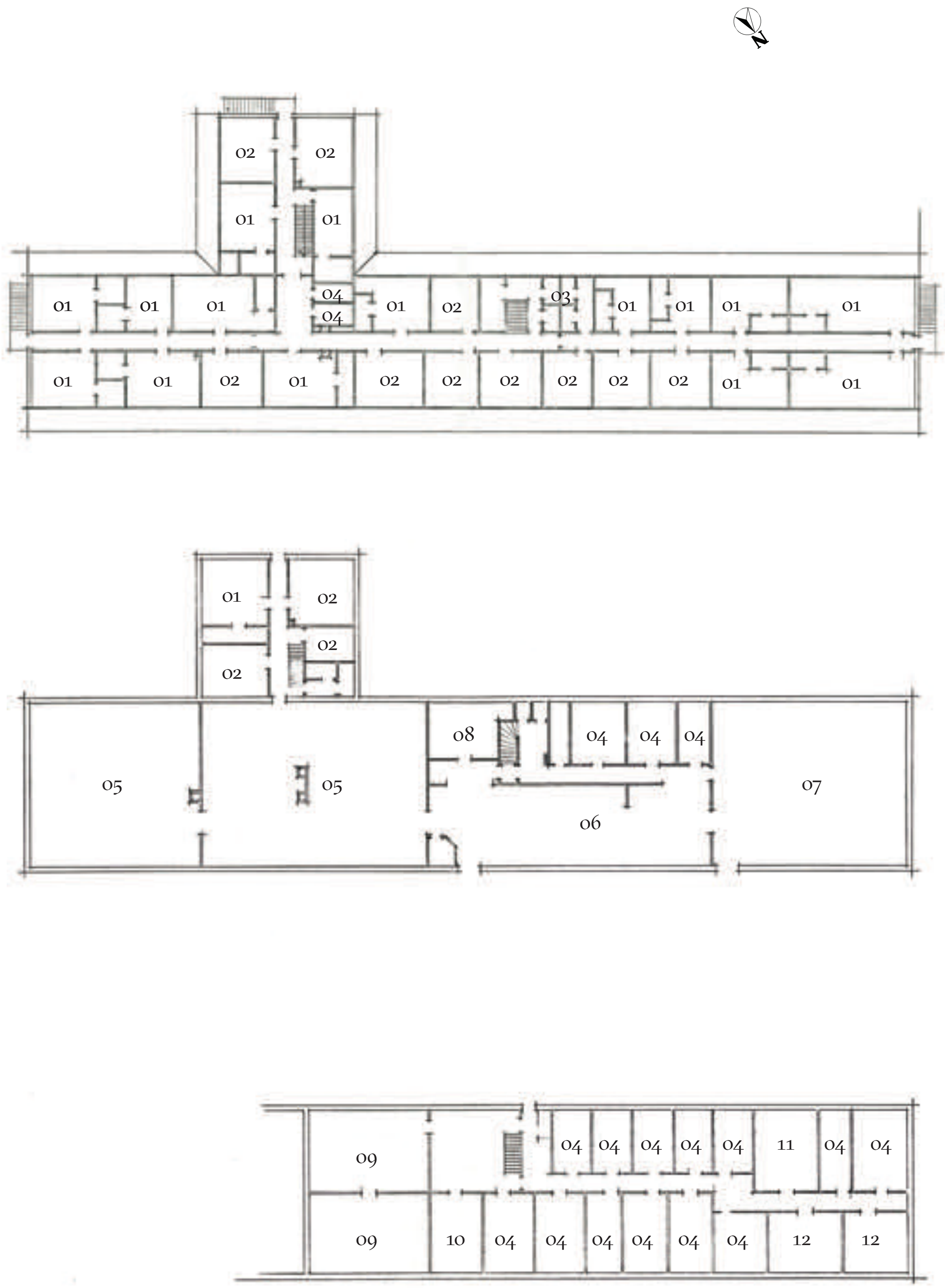
01 Room with toilet
02 Room without toilet
03 Toilet
04 Storage
05 Living room
06 Foyer
07 Restaurant
08 Arrange
09 Kitchen
10 Bakery
11 Technical room
12 Laundry room

-1



ill. 39.1. Floor plans of old Svinkløv Badehotel.

ill. 41.1. **Badehotel burned down during the night between 25th and 26th of September 2016.** *(nyheder.tv2.dk, 2017)*

the architects about a new one, the owners wanted to understand the DNA of the place and its soul. They wanted to understand the very reason for, why people were coming there generation after generation, and why it was always fully booked. The analysis took many months *(Royberg, 2017)*, and the Foundation (hvem er det?) made quite a remarkable discovery.

First of all, what the guest liked was the building's fantastic position in the nature: the building looked nice but not fancy; they also liked the hotel's amazing cuisine. The rooms were tiny, and there was neither TV, nor Internet there, but the guests never complained about the lack of these functions, on the contrary. They spent more time on the ground floor instead, where the dining- and the living rooms were. When coming down to these rooms, one could sense a special atmosphere there: a younger couple playing chess; an elderly couple - reading books. After getting used to each other's company, people would fall into chatting with each other.

When interviewed, a stuff member told that many couples were coming here for more than 20 years. In the dining room, the guests were totally focused on the food. A possible conversation between the two could sound like this:

- Dear, how does it taste?
- Lovely.

But when coming back to the common room, “Yellow room”, they were suddenly surrounded by many other people and had a great time together talking, laughing, and enjoying a cup of tea or coffee.

That was the very DNA of the place. When the guests were coming year after year, they started to treat each other as a family. Suddenly, people could ask each other how the kids were getting on, where they went for a holiday and so on. The place gave a special feeling of togetherness, the sense of belonging to one big family.

The staff also tried to treat the guests like they were a part of a family *(Royberg, 2017)*. “When you see a modern hotel, of course you get the service, but everybody is trained like dogs. The guests can have requests during the day and the staff can take care of you individually at Badehotel” *(Royberg, 2017)*.

As far as the food is concerned, Svinkløv Badehotel was famous across the country. The kitchen Chef at the hotel had the title of Denmark's best. Very often, people from local summerhouses and even from places up to 40 km away, came there just for lunch or dinner, but Badehotel's own guests had always the first priority. Frequently one could see visitors as far as from Aalborg coming there just to have some food and enjoy the view of the sea and the shore *(Royberg, 2017)*.

There is a current tendency in Denmark to find such kind of escape from everyday life. Even part of the board members of Svinkløv Badehotel spent their time there because of these qualities. This is the soul of the place *(Royberg, 2017)*.

Not everything was perfect

Besides all the positive properties of the hotel pointed out by the guests, there were also some negative sides. For example, not every room had its own bathroom or even a toilet. The guests had to choose: either a room with a sea-view but without a bathroom; or the room with a bathroom but without a sea-view.
In many cases the guest had to make use of a common bathroom in the corridor. Also the building owners complained about the fact that they had too little space for gathering herbs or any local ingredients.

Moreover, the building was producing a lot of food waste without any special storage. The building used too much water. The solar panels that covered small area of the roof did not work for after 11 years, as the salt had damaged the installations. The metal elements in the envelope of the building were always covered in rust, they had not been galvanized. Also, the poor solutions for the thin exterior walls made it almost impossible to warm up the place effectively in the winter: not only because of the temperatures but also because of very strong winds *(Royberg, 2017)*.

Conclusion

The history of the location focuses on the story about the hotel that doesn't longer exist. For many Danes it was an extraordinary place, where they could escape from everyday life: from struggling, running, performing round the clock, seven days a week.

It is interesting to note, that the things that we normally associate with discomfort - tiny rooms, no internet, no TV – were loved by the hotel guests. They spent their time with their friends or families, with no stress and rush; they enjoyed delicious food and great views of the sea and the shore.

'(...) DNA of the place and its soul (...) The very reason why people were coming there for many generations (...)'

ill. 43.1. Svinkløv during the winter.

Solitude hotels case studies

Solitude can have many meanings. It can mean absolute solitude. One person. Nothing else. But it might also mean an emotional solitude...

ill. 44.1. Svinkløv nature gives perfect opportunity for escaping from every day life.

Architecture is a great way of influencing people's perception of space and their feelings. The next four buildings represent quite similar ideas realised across the world: each of them approaches the matter of solitude but in their own way. Some approaches are more focused on the individuals, while others take a more social approach to the matter. Through the examples this thesis is show many different solutions and how they can be used depending on the building styel and enverment.

It is important to run away from the reality once in a while in order to 'reboot the brain'. Which helps to regain focus and sharpen one's problem-solving skills *(Gordon, 2017)*.

ill. 46.1. (Anon, n.d.).

The Oval
Tadao Ando

Designed by Tadao Ando in 1995 the annex is a part of Benesse House Museum complex on the island of Naoshima, Japan. The main function of the buildings is to let the people explore art, nature, architecture and their own thoughts. This building, in a shape of oval (40×20m), includes four double guest rooms, two suites and an in-house café. Central courtyard consists of a large pool (20×10m) (*ArchEyes, 2017*).
Each room has 30m2 and can provide space from one person up to three people in total *(Benesse Art Site Naoshima, 2017)*.

ill. 46.2. (Anon, 2017).

Juvet Landscape Hotel
Jensen & Skodvin

This is the first landscape hotel in Europe located in Valldal, Norway. Designed by Jensen & Skodvin, built in 2008 it was the first phase of the larger complex. The building is trying to experience breath-taking sceneries in the wild nature. But instead of constructing one big building, this hotel has the rooms which are spread throughout the terrain as small individual houses.
One or two walls in each unit are transparent giving the guests the possibility to focus on and enjoy the view. At the same time, the houses are designed in a way so that they do not face each other: privacy was a very important issue in this project. The buildings have very thin walls, without any insulation, as the house is mainly used in summer. Each room is different in the laoyout because of the terrain . This project is meant as a statement, showing that not only the sustainability, but also the conservation of the topography are important in the architecture *(Jsano, 2017)*.

ill. 47.1. (Anon, 2015).

Awasi Patagonia Hotel
Felipe Assadi
and Francisca Pulido

Felipe Assadi and Francisca Pulido have designed this hotel complex in National Park of Torres del Paine, Chile. It consists of 14 villas and a main lodge. It gives the guests not only the possibility to have their own private place to sleep, but also an opportunity to go out and explore the surroundings at their own pace: visiting the places they want, when they want it. Moreover, there is also a common space where the guests can meet, relax and spend time. There are magnificent views from each building showing the nature and wild animals living in the National Park *(Patagonia, 2017)*.

ill. 46.1. (Anon, 2017).

Alcácer do Sal Residences
Aires Mateus

This is a project by Aires Mateus which is designed for elderly people in Portugal. The main goal for the architect was to explore the issue of the borders between the individual and the community space in this kind of buildings and to give both the privacy and the social mingling to the users. Each room stands out as a separate living unit with their own private terraces. There are common spaces in the building, where people can escape from their privacy and socialise with other inhabitants of the project. The building is naturally rising from the terrain, respecting the topography *(Arcspace.com, 2017)*.

Left ill. 48.1. Svinkløv Badehotel's annex.

Users

There is a high pressure from the history of the site to recreate the Badehotel in some way, but it will not be possible if the users' needs are not identified. It is important to keep the best qualities of the old building and try to implement them in the new one in order to get the best result.

Svinkløv Badehotel was a landmark on the local tourist map. It was visited by many people. Some of them were staying at the hotel, while others just came to eat the delicious food that was served there. Due to the fact that the hotel was burnt down, the hotel-owners decided that the new hotel should be improved with the elements that were lacking in the old building - not only in the eyes of the guests but also in their own *(Royberg, 2017)*.

It was important to think about the future of the hotel. What should it contain, what should be changed, what should be improved. The hotel managers and the staff were asked to prepare a list of changes that - in their opinion - should be implemented in the new version "2.0" of the building.

So, the foundation "Svinkløv Erf" proposed a number of changes. They decided that each room should have a bathroom, but still the rooms should stay small, so that the guests would not be tempted to go back to their rooms and stay there. The Foundation wanted to preserve the soul of this place – which was attributed to the hotel visitors' extensive use of common rooms. The new Svinkløv Badehotel wished to hire the same chef that cooked there before - he wished to have more space in the kitchen for younger people that could help him in cooking and raise another generation of good chefs. Moreover, the building owners would like to produce - in the low seasons - chutneys, pickled vegetables and fruits, and to make chocolate for sale and serving in the restaurant.

The couple leasing Svinkløv would also like to do more gardening, to grow herbs, pick mushrooms and plants in the area. Moreover, they wanted to get more fresh fish from the nearby sea, especially from Thorupstrand. In the future, the building should also be furnished with more furniture from the Danish designers. It is also important for the building owners to bring the nature into the hotel. Currently, the Board would like to make the hotel in wood again. Of course, the basement must be constructed in concrete. It is not that common to build wooden buildings in Denmark. The owners are well aware of this fact that will make the construction costs much higher.

One of the keystones for the new building should be the environment. The newly rebuilt Badehotel should be as sustainable as possible. The foundation would also like to avoid the problems which they had with thin non-insulated exterior walls and the heat loss.

When it comes to the water, Badehotel will still use the well which is already on the site, but the owners would like to considerably reduce the amount of water used in the building. It should be heated by using geo-thermal solutions. Own green-energy production should be implemented again, but with more efficient solutions. The owners would also like to optimise and minimize the energy use. All the problems in connection with the use of the materials that did not work well with the weather and the sea conditions (like the rust on the metal) should be prevented from happening in the future *(Royberg, 2017)*.

Detailed room program

This room program was created on user demands and analyses of contemporary hotels. It consists of (for at undgå contain 2 gange) detailed data including names, areas, functional demands and indoor climate requirements.

It was important to create groups of functions which contain specific programs. On

ENTRY

	Function	Size	Functional demands	Indoor climate
Entrance				
	Reception	100-125 m²	The reception must include space for information, hall, shop. Must be close to the parking.	
	Cloakroom	20 m²		
	Storage	2-3 m²	For paper and other things	
	Toilet	4 m²		

ROOMS

Guestrooms				
	Double	15-18 m²	30 rooms. Only think as a place to sleep and for shorts stays drying the day.	
	Single	10-12 m²	5 rooms. Only think as a place to sleep and for shorts stays drying the day	

LIVING ROOMS

Living rooms				
	Cocktail bar	150-200 m²		
	Lounge	150-200 m²		
	Fireplace area	150-200 m²		
	Toilets	20-30 m²		

EMLOYEE AREA

Office				
	Secretarial office	8-10 m²		
	Manager office	8-10 m²		
	Accounts office	8-10 m²		
	Housekeeping offices	8-10 m²		
Break				
	Common room	60-80 m²	Including Canteen and kitchen	
	Changing room	25-35 m²	Unisex with 2-3 separate rooms with showers	
	Bedroom	10 m²	2-3 rooms for personal (night sift)	

top of it, analyses have been done to better understand the needs of the users. Moreover, it created a foundation for discussing user-needs and solving possible future problems of the functional program of the hotel.

The biggest group of rooms are common rooms (630 m2) and the guest rooms which should comprise around 600 m2. They are followed by the kitchen and the dining area combined together to 424 m2. The rest of the functions are grouped into much smaller zones not exceeding 150 m2. This means that the majority of the functions (excluding the outdoor area) are focused on the guest area only. The detailed data might slightly change in the design process. The outdoor area will vary most, since it depends predominantly on the solution for need of the parking space.

The sheet is a base for the scheme showing connections and relations between the rooms. It should represent also the priority of setting up right the building and its zones.

DINING

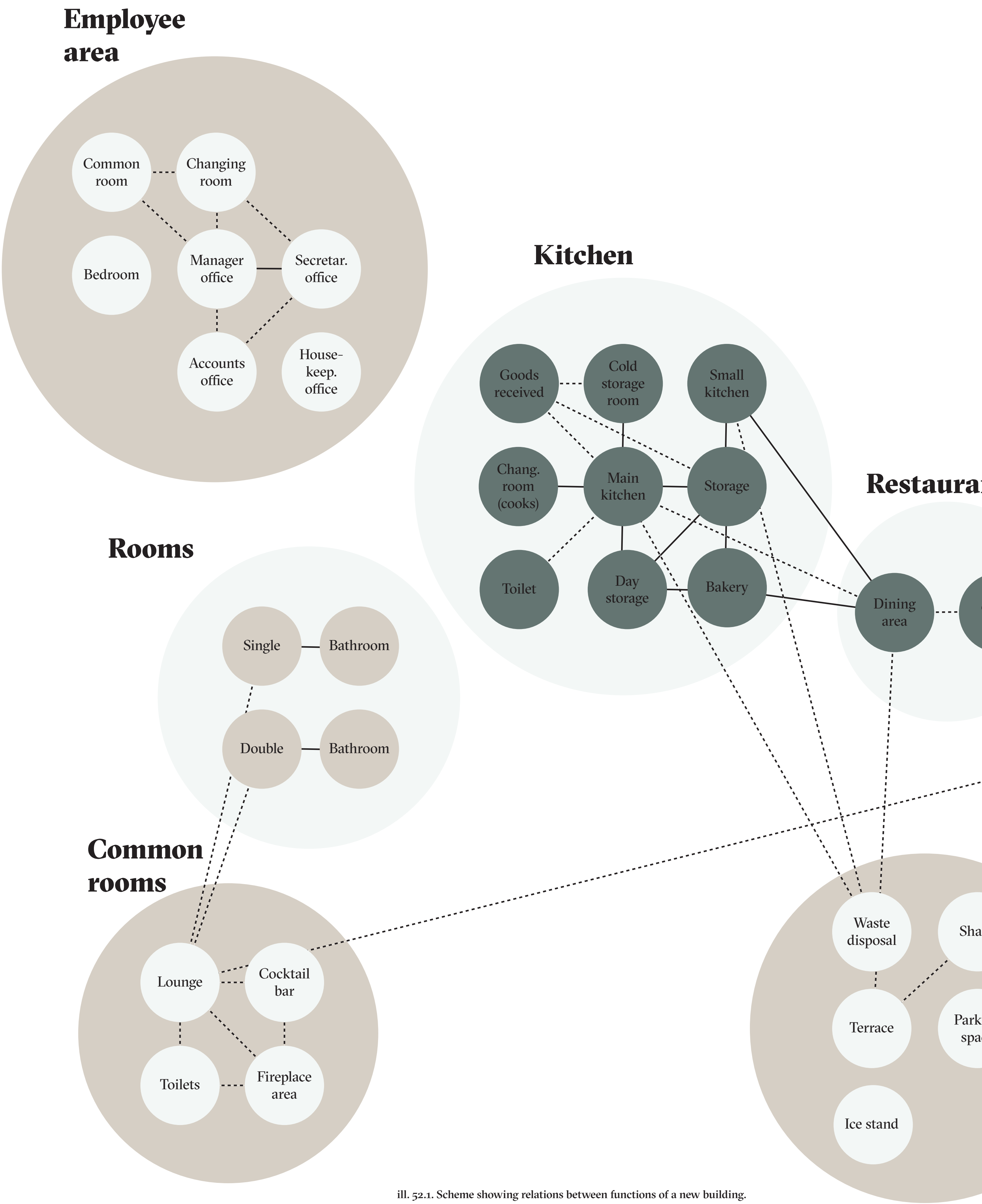
	Function	Size	Functional demands	Indoor climate
Restaurant				
	Dining area	100-150 m²	View over the sea	
	Toilet	15-20 m²		
Kitchen				
	Main kitchen	75-120 m²	6-7 cooks. The kitchen must include space for dishwasher, preparation and servery	
	Cold storage room	10-15 m²	For fruits, meat and etcetera	
	Toilet	4 m²	With shower	
	Day storage	10-20 m²		
	Goods received	10 m²	Direct access from the food truck	
	Changing room (for cooking purposes only)			
	Small kitchen	8-15 m²	1-2 cooks. For preparation and pickling	
	Storage	20-30 m²	For pickle product, jam and dry mushrooms	
	Bakery	8-10 m²		
	Storage	20-30 m²	For foodstuff and cooler for cakes	

VARIOUS

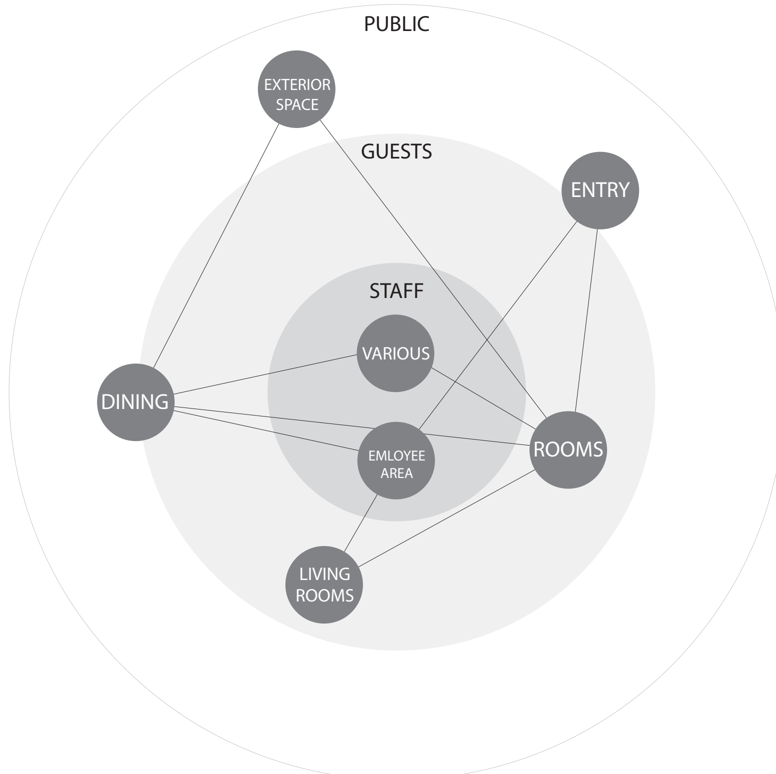
Housekeeping				
	Laundry/ironing room	15-20 m²	For washing machines and flat iron's	
	Storage	10-15 m²	For clean laundry	
	Utility room	2-4 m²	3-6 rooms depending on layout. Max 20m from farthest room	
Technical				
	Technical room	50-80 m²		

EXTERIOR SPACE

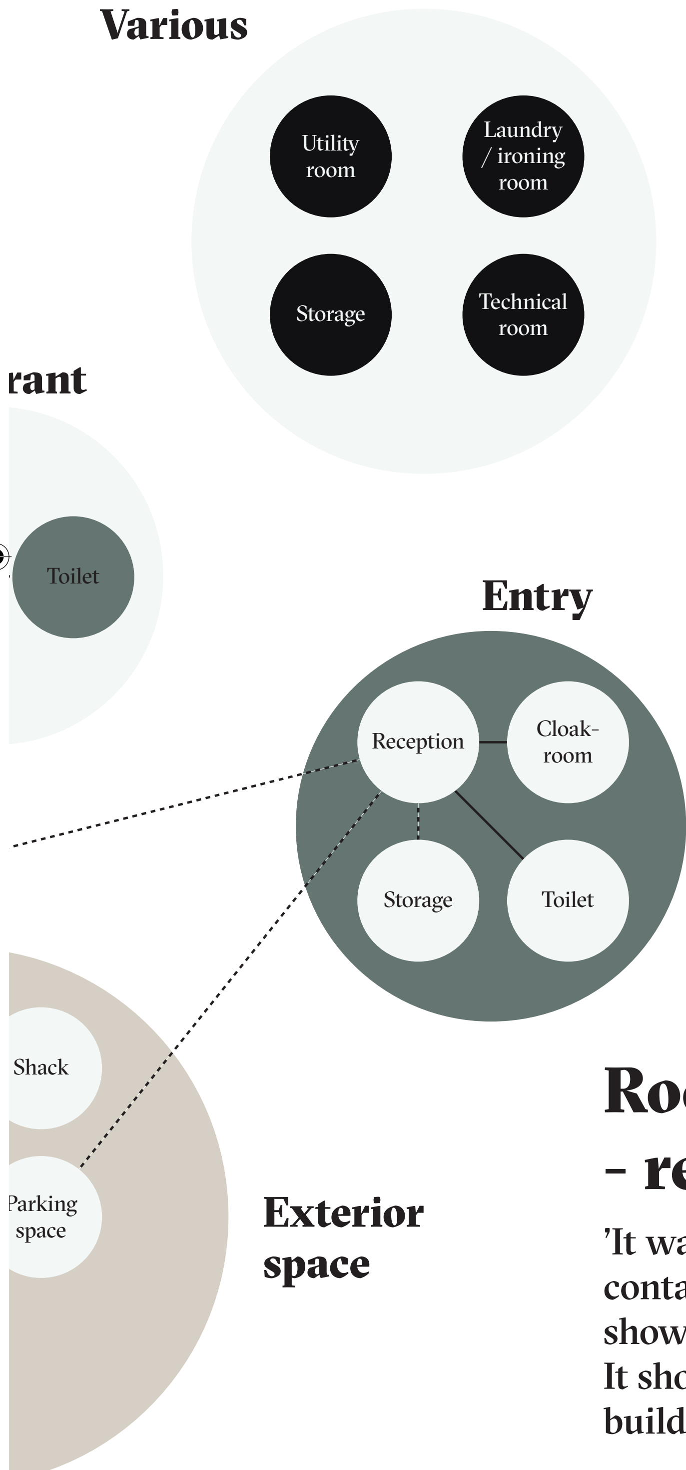
Outside				
	Terrace	100-150 m²	Close to the kitchen or the restaurant	
	Shack	10-15m²		
	Waste disposal	10-15m²	Hidden in the landscape	
	Parking space	2-2500 m²	90-110 parking spaces	
	Ice stand	20-30 m²	For the public	



ill. 52.1. Scheme showing relations between functions of a new building.



ill. 53.2. Scheme showing relation between main categories of rooms according to the privacy.



Room program - relation scheme

’It was important to create groups of functions which contain specific programs (...) a base for the scheme showing connections and relations between the rooms. It should represent also priority of setting up right the building and its zones.’

"What is now called 'green architecture' is an opportunistic caricature of a much deeper consideration of the issues related to sustainability that architecture has been engaged with for many years. It was one of the first professions that was deeply concerned with these issues and that had an intellectual response to them." – Rem Koolhas

(Monitor, 2017).

Sustainability

Nowadays, the focus on sustainable design is increasing. The primary reason for this is the progressing climate change and the global warming. The building sector has a huge impact on the global warming effect - it is actually responsible for 40% of global energy consumption and nearly the same share of CO2 emissions. The change in the people's mentally towards a more sustainable, rational way of living can help reduce the impact on the climate. Denmark is trying to reduce the numbers mentioned above by creating and using new solutions for refurbished housing, offices and public institutions across the country. This is caused by the building regulations in Denmark which are becoming more and strict. The same restrictions are pushing towards the reduction of the energy consumption in buildings by 50-80% *(Energy Efficiency solutions and profiles in Denmark | State of Green, 2017)*. Moreover, there are growing concerns regarding our waste management, as the waste is also destroying our ecosystems. In addition, bad design of places can affect our effectiveness at work, the way we relax and feel in spaces. It can have a great impact on human health, which can lead to even more poor choices of using and distributing the goods in the ecosystem.

The building regulations

Denmark has already one of the strictest laws in European Union regarding sustainability in building regulations – Building Regulations 2015 (BR15). In 2020, a new regulation will see the light of day – Building Regulations 2020 (BR20), which will introduce even more restricted laws *(Aggerholm, 2011)*. These regulations are creating more and more problems of coming full circle, when it comes to the sustainable solutions' reasons and effects. As mentioned in "Motivation", many of the building regulations created a loop, because of more strict rules for energy reduction in some areas, more mechanical systems started to be used as a solution. Nevertheless, the energy demand and CO2 pollution stayed almost the same at the end *(Passe and Battaglia, 2015)*. However, sometimes it happens that these are not the regulations that are not good enough, but the way in which they are executed is bad. For example, there is no rule in Denmark regarding the obligation of using mechanical ventilation, but this is, actually, the easiest solution for developers to provide the occupants with good air quality in the rooms.

The materials

Sustainability also means the usage of nature-, indoor- and climate-friendly materials for the construction and finishing of the buildings. As far as the building materials are concerned, they can also have a big impact on the indoor air quality and the air pollution in the rooms. Sometimes occupants complain of the odors, and sometimes people can even get sick with building-related illnesses. Besides the popular biological contaminants like humidification systems or water-damaged building materials, it is often just the building materials which are under the stress and other conditions, for example, cooling and warming, can also pollute the air through production of gases *(Fundamentals of Indoor Air Quality in Buildings | Indoor Air Quality (IAQ) | US EPA, 2017)*. Moreover, poor choices of materials can create, for instance, an overheating effect on a building during the summer.

The daylight

Another element which is important for the indoor quality is daylight. There must be a good amount of it helping with the economy and the ecology, since it is reducing the energy consumption and CO2 levels. Moreover, it effectively stimulates human's visual and circadian systems. Finally, it helps the occupants to focus on a task, perceive the space well and simulate the feeling of the environment *(Kunkel et al., 2015)*. One of the ways of working with the daylight is to use Daylight Factor (DF). Many of the energy certifications require the use of at least some DF values in the projects. For example, for the BREEAM certification, the usual minimum daylight factor for the majority of functions should be 2% in 80% of all rooms in the building. However, the mostly recommended level is around 4% *(Breeam.com, 2017)*. In BR15, the recommended daylight factor is also 2% *(BR15 §6.5.2 (Bygningsreglement 2015 (BR15), 2015))*. The calculations for the daylight factor are based on an overcast sky, which means that a higher daylight factor can be expected.

The thermal comfort

There also exists a thermal comfort, as a part of the indoor climate quality. In Denmark it is regulated by BR15. It states that the occupants of the building must feel comfortable inside the rooms where they reside, and they should have a healthy indoor climate where they reside. The thermal indoor climate is determined by the temperature of the air and the surfaces. According to the same document, there should be no more than 100 hours a year when the indoor temperature exceeds 27°C , and no more than 25 hours per year, when the temperature exceeds 28°C *(BR15 §6.2.1 (Bygningsreglement 2015 (BR15), 2015))*.

The water usage

The United Nations has estimated that before year 2030, the water consumption will rise by 30 percent globally. It means that the impact of the increasing demand will be more and more visible on political agendas in upcoming years *(Quality, 2017)*. At the same time, there aren't any solutions in the building industry to actually re-use the grey water for toilet flushing, the landscape or crop irrigations *(Greywateraction.org, 2017)*. It is, actually, better to use the rain water instead, which is usually less contaminated. It is especially useful in rainy regions.

The Nordic Way

During the United Nations Conference on Sustainable Development, Rio+20 in 2012, the Nordic Council of Ministers presented a perspective of the Nordic Way towards the green economy with the main focus on holistic sustainable solutions. It emphasises mostly the sustainable consumption and the production as well as ecosystems and biodiversity. As for the building sector, the most important here is the area of clean technology and innovation, as well as the clean sustainable solutions. This actually suits very well in the area of Nordic countries and their approach to architecture in the last few decades, because the Nordic architecture is trying to use the holistic sustainable approach in most of new designs, since the nations from these countries are more enlightened in this matter *(Norden.org, 2017)*.

Conclusion

All mentioned elements create together sustainable guidelines for the project. Each of them taken separately, is very important, however, the Nordic experience shows that the best way is to use the holistic approach to sustainability in the project. This fits very well the focus on the natural ventilation in this thesis.

'Building sector has (...) 40% of global energy consumption'

The ventilation

The good air quality in the indoor climate insures good condisitions for users to live in the spaces. It also prevents from having health problems caused by the air pollution. BR15 states that every building must be ventilated and that the systems designed to do so must provide a satisfactory air quality *(BR15 §6.3.1.1 (Bygningsreglement 2015 (BR15), 2015))*. It means that the occupants should always have an access to the fresh air. For centuries, the main way to provide the fresh air in the buildings has been the use of natural ventilation. However, in the last decades, the tendency has been to make an increasing use of mechanical ventilation solutions. More about it will be said on the next pages of this thesis.

The social sustainability

According to Western Australian Council of Social Service, "Social sustainability occurs when the formal and informal processes; systems; structures; and relationships actively support the capacity of current and future generations to create healthy and liveable communities. Socially sustainable communities are equitable, diverse, connected and democratic and provide a good quality of life" *(Freestone, Butler-Bowdon and Randolph, 2006)*. It means that the new project should assist in creating such social environment. It appears that Svinkløv Badehotel was exceptionally good at it; therefore this quality should be retained in the new hotel proposal.

Natural ventilation

"I studied in London in 1968. Our school had a separate department of tropical architecture. Of course, it was totally unfashionable, partly because nobody wanted to think about colonialism, but basically what you learned there was that, OK, the sun is here, so you should create natural ventilation here – an unbelievable amount of really sound principles that have been completely abandoned, so now everything is air conditioned with big machines. – Rem Koolhas *(Michael, 2017)*

As mentioned in the introduction, this thesis focuses on natural ventilation which – unfortunately – is becoming an abandoned solution in the current architecture. In Denmark, the mechanical ventilation has become the default way of dealing with ventilation and to insure a flow of fresh air to the rooms.

In some cases, the natural ventilation is called an "ancient" solution. At the same time, the world can see an opposite example - a new Apple Campus 2 building which is going to be opened in 1st half of 2017. Users (Apple Inc.) and the architect (Norman Foster) have placed a considerable focus on natural ventilation solutions - almost the whole building is making use of them *(Fox, 2017)*.

This implies that there is actually a misconception regarding the natural ventilation across the world. In Demark, where the sustainability is beginning to be a basic foundation for the architectural design, somehow the natural ventilation is being ignored.

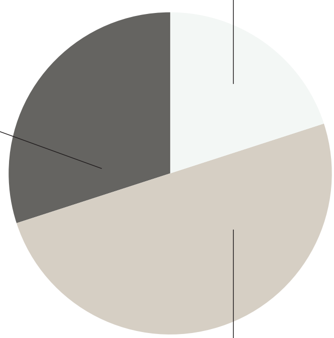
But there exist an even bigger – global – problem. Due to the global warming, there is a increasing number of hot regions in the world, where the mechanical ventilation would be the common sense response to the problem. However, the mechanical ventilation (or cooling) uses a lot of energy. Many people cannot afford to pay such high costs in their homes. And those who can, might experience a power-supply failure, when the weather conditions become extreme. The temperature situation is predicted to become worse according to the forecast of the Fifth Assessment Report on climate change published in April 2014. What is interesting, this problem has already touched millions of people in the USA *(Passe and Battaglia, 2015)*.

But why is the natural ventilation so important?

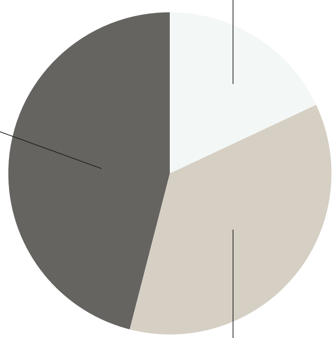
Besides the previously mentioned aspects, the air is one of the basic elements of human life. It is quite strange, that even though everybody acknowledges this obvious fact, there is barely anyone, who knows the reasons, why we need constant air exchanges in the buildings. People often think, we need to ventilate the spaces to get more oxygen inside. This is, however, a false assumption, as only in tightly sealed places the oxygen will run out at some point. Normally, the air contains plenty of it. The main reason for ventilating the rooms is to remove odour particles and Volatile Organic Compounds (VOCs), CO2 levels, as well as humidity. These are the most problematic indoor air quality disturbances for occupants. As far as humidity is concerned, it is often the cause ›

Right ill. 57.1. Portcullis House in London, England. Finished in 2001 it is being used as an office building. It's characteristic chimneys are being used as exhaustion for stack ventilation.

ill. 58.1. Survey results regarding the satisfaction of the occupants in naturally ventilated buildings.



ill. 58.2. Survey results regarding the satisfaction of the occupants in artificially ventilated spaces.



of such problems as fungus and mould on the walls. In many cases, people assume that these troubles are caused only by some problems with the insulation in external layers of the walls. Often they don't realise that the users must also be responsible for these problems, as humans' exhalation has an air humidity of 90%. Moreover, we need to ventilate rooms in order to get rid of too much CO_2 pollution, which can make occupants drowsy *(Passe and Battaglia, 2015)*.

Since each human breath contains carbon dioxide gas in the concentration of between 38,000 and 56,000 ppm (depending on the level of the physical activity), this is a very important issue (Bugarski and Noll, 2014). For even a better perspective, it is important to mention that a healthy indoor environment should contain no more than 600-1000 ppm (Satish et al., 2012). However, according to the Danish Standards, the indoor air quality can be only 500 ppm above the outside average air pollution *(Input-parametre til indeklimaet ved design og bestemmelse af bygningers energimæssige ydeevne vedrørende indendørs luftkvalitet, termisk miljø, belysning og akustik, 2007)*.

Last but not least, the ventilation is used for regulating the heat and cooling in the rooms.

The research done by Sribanurekha, Wijerathne, Wijepala and Jayasinghe in 2011, showed that people feel more comfortable in naturally ventilated spaces than in mechanical ventilated spaces (ill. 58.1 and ill. 58.2) *(Sribanurekha et al., 2011)*.

The advantages of using the natural ventilation

By the default, the natural ventilation is starting with big advantage over mechanical ventilation, which is no energy to supply fresh air to the building.

When designed right, this type of solution can be used in every typical functional need of the building. Thanks to this, not only the users can save money on the energy required by the building, but also on the duct works during the construction. It also reduces the need for an extra space to install all needed elements for mechanical solutions. natural ventilation can also cooling down the building fabric over night by removing heat from the thermal mass and providing additional energy capacity for the daytime *(Passe and Battaglia, 2015)*.

The types of ventilation and their influence on the design

The mechanical and natural solutions differ a lot in the approach to the building design. In a simple description, the mechanical ventilation will need special vertical and horizontal shafts going through the building. It means that, for example, we will need to leave some space in the room's height in order to provide it with the ventilation from the upper ceiling. The same goes with the vertical ducts: there is a need for a special technical room which is a home for the mechanic installations that are forcing the air to go through these ducts. Besides, there should be an inlet and an outlet for the system.

However, there is also a concern regarding the controlling the system. This means that the system must be scheduled and controlled which can become a major concern, when it comes to this solution. For example, a night-time ventilation may be only possible at night hours, when the air outside has finally cooled down enough to allow a breeze to pass through the building. The only problem is that the users are not there at that time. This means that the mechanical system needs to use way more complex control strategies to work properly in the building. It needs to use a lot of detectors which are getting the data regarding VOCs. The problem is that the system is starting to be even more complex, if suddenly people will not work according to how the system was programmed. "Control strategies are directly related to human behaviour and are probably best executed by smart control systems that still need to give occupants individual influence as well, because current research shows that occupants are far more tolerant to thermal conditions in naturally ventilated spaces and in spaces over which they have individual control" *(Passe and Battaglia, 2015)*.

Moreover, there is also a concern regarding the mentioned individual control of the air quality. In some cases, during the mechanical ventilation, the system does not provide an option to open the windows manually. This means that the user needs to use the programmed air quality. In other cases, the mechanical ventilation system is not connected to the windows, so the users can operate the air quality manually. But then, when opening the window, the natural ventilation occurs. The question is then, does the mechanical ventilation work just for its own purpose and uses the unnecessary amount of energy?

When it comes to the natural ventilation, there is a bit of similarity in the scheme approach. It needs an inlet and an outlet for the air, but the rest can vary depending on the function. For example, for the cross-ventilation, there would be a need for a window or a door on one side of the room, and the other opening on the other side of it. Both need a connection to the outside air. If this would be a more complicated and larger space, for example, in a big public building, there would also be a need for shafts, but not necessarily in mechanical pipes. The inlet and outlet do not use any technical rooms in this case. The only problem is the way of steering the air in the right way. "Natural ventilation and daylight are complex, uncertain, and dynamic phenomena, design experience takes time to accumulate, and mechanization is often chosen because of lack of basic design experience and guidelines" *(Passe and Battaglia, 2015)*.

Energy costs, heat recovery and emissions

The building sector is well aware of the fact that a large portion of the building energy consumption is used to condition the indoor environment of buildings. Whether it is by heating or cooling outdoor air or just by providing fresh air to the needed spaces. In 2009 US residential building used 39% of primary energy to condition the indoor environment. Between 1970 and 2005 the energy spending in the USA increased from $83 billion to $1 trillion. When adding the inflation, this was an increase by 250% *(Passe and Battaglia, 2015)*. This is extremely important and urgent for the economy, community, humans and our world to conserve the energy and reduce CO_2 emissions in order to reduce or even stop at some point human impact on the global climate change.

One of the challenges in the regions of the world with winter season is a heat recovery. During the process of ventilation, the fresh air brings also along the cold air from outside into the warm zones of the building, and the heat from the building is being ventilated outside of the unit. This is where heat recovery comes to help.

BR15 states that the heat recovery efficiency in mechanical ventilation cannot be lower than 80% *(BR15 §8.3 (Bygningsreglement 2015 (BR15), 2015))*. Let's take into consideration one of the typical examples of this type of airflow solution, a house which has 140 m2. The current natural gas price is around 8 DKK per m3 and the electricity prices are around 2 DKK per kWh. The annual savings from the mechanical heat recovery of such a house in Denmark should achieve the cost of approx. 3.600 DKK *(Lindab villaventilation, 2017)*. The heat recovery unit (without the rest of mechanical ventilation cost) is priced between 35.000 and 80.000 DKK (depending on the efficiency and how advance it is) *(Sode and Jensen, 2017)*. If one of the more advanced and more sustainable options of heat recovery system is chosen for the price of 70.000 DKK, it would mean that it will take 20 years till savings from the mechanical heat recovery would cover its own cost. It is important to underline that this is just a cost of the system installation. It is not including maintenance (filter exchange, system checks, small repairs and man hours of work). It is important to underline that the mechanical ventilation systems have the cycle of around 20 years. This means that after 20 years of covering the costs (again, not including the maintenance) of this type of ventilation, there would be a need for a replacement of the whole system. The saving of heat to the heat recovery system also saves CO_2 emissions. When taking into consideration that each year 900 kg of CO_2 would be saved, it means that after 20 years this would reach level of 18 tons.

However, this is the savings point of view. Looking from the pure sustainable point of view and the basic costs, this is not the way to present the mechanical system. The mentioned heat recovery solution uses 385 kWh a year *(Ventilationsanlæg med varmegenvinding, 2017)*, equal to 1,05 kWh a day. That is still a lot seen from the energy consumption standards, having in mind that this is just 140 m2 house. For the sake of comparison, washing machines use approx. 150 kWh a year (with 220 cycles at 60° C and the full chamber) *(Bosch washing machine product card, n.d.)* A standard fridge for a small family uses nowadays around 260 kWh a year (when it is switched on throughout the whole year) *(Miele Fridge product card, n.d.)*.

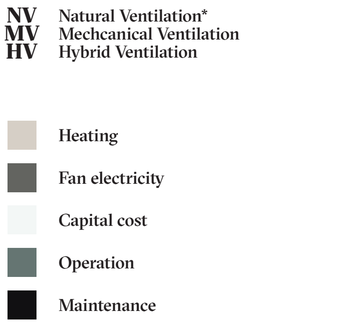
The Fraunhofer Institute for Buildings Physics in Stuttgart has performed detailed energy calculations of an office building with an area of almost 3.000 m2 equipped with either natural, mechanical or mixed mode ventilation. The building performance was investigated in three different locations in Europe: Copenhagen, London and Munich *(Windowmaster.com, 2016)*.

The results showed the primary energy consumption for the three ventilation principles: natural ventilation, mechanical ventilation and hybrid solutions. The results also showed that the natural ventilation uses 9-11 kWh/m2/year and the mixed mode ventilation - 7.0- 8.5 kWh/m2/year. The mixed mode ventilation enables the energy savings of 20-25% compared with the natural ventilation and 60-70% compared with the mechanical ventilation (which uses 4-5 kWh/m2/year) *(Windowmaster.com, 2016)*. However, the natural ventilation did not include any heat recovery system, so the hybrid solution might have more power consumption than a natural air flow strategy.

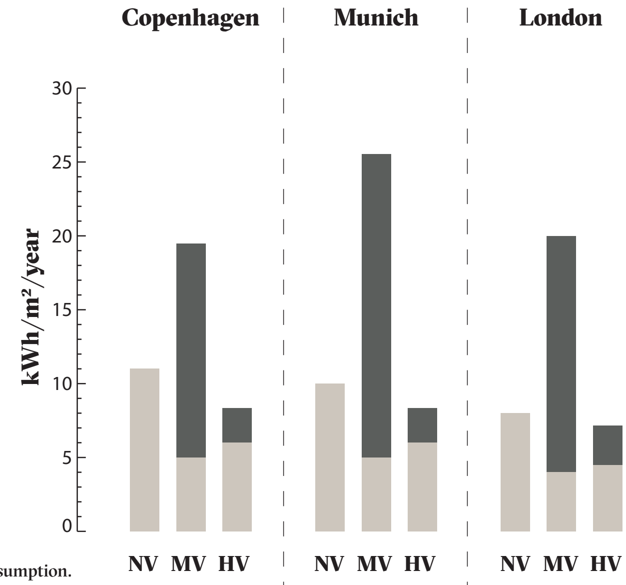
According to the Fraunhofer Institute for Buildings, during 20-year period of time, CO_2 emissions from electricity and heat would be emitted much less by the natural ventilation and hybrid systems when compared to the mechanical ventilation. When it comes to the life cycle cost (LCC) over the same period of time, the natural ventilation system (without heat recovery!) would be 5 times cheaper than the mechanical system (ill. 61.3).

Why is natural ventilation so rarely used nowadays?

As mentioned in the beginning of this introduction, mechanical solutions are simply easier to implement and easier to design even with a small amount of experience. Not diminishing the importance of this serious matter, it is funny that in many cases, the natural ventilation is being called “ancient” in a negative way. At the same time, we can still enjoy old medieval buildings which have been using such solutions for centuries. We still open the windows in the buildings which are supporting the mechanical ventilation. People often don’t give enough credit to natural ventilation, even though they like to open windows during the summer to get in warm air from the outside; or maybe to cool the room down during the winter; or just to get a fresh breeze of air. The problem

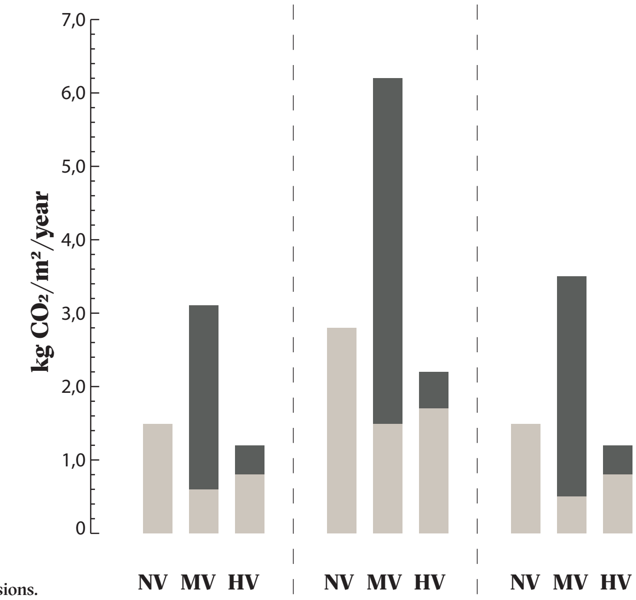


**Natural ventilation results are presented with the solution that does not use heat recovery system.*

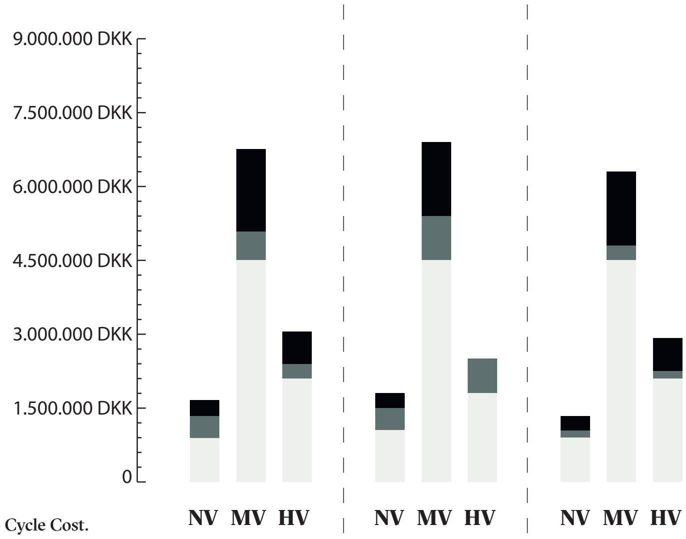


ill. 61.1. Energy consumption.

is that during the years this approach started to be taken for granted in architecture and engineering professions as well as by the users *(Passe and Battaglia, 2015)*.



ill. 61.2. CO_2 emissions.



ill. 61.3. Life Cycle Cost.

ill. 62.1. Portcullis House in london and its characterisitc chimneys and air inlets in facade.

Natural ventilation expression case studies

Using the natural ventilation in the design process can create specific design conditions which might lead to specific expression of the building.

Nowadays, the buildings are created in a way in which the HVAC systems are more or less adjusted to the design (beside the need for technical rooms). When ventilated naturally, the buildings need to be designed from the very beginning in such a way, in which the air ventilation can provide not only the right amount of fresh air to the building, but also can sustain the overall air flow. When the mechanical systems are used, it is possible just to push the air in all directions. In natural ventilation, this kind of movement can be implemented only by the pressure difference or basically by the natural forces of the flow. This air movement also needs a three-dimensional flow-path that leads the fresh air in and the stale air out of the building. The design of this flow path depends on space connectivity dominated either by vertical or horizontal connection or both. Moreover, this airflow should connect areas of the building that promise the creation of largest possible pressure gradient *(Passe and Battaglia, 2015)*.

#1 The UCL School of Slavonic and East European Studies (SSEES)

Unfortunately sometimes the buildings are not working as they should even if the users are using them right.

ill. 64.1. The building is using chimneys as an outlet for the exchanged air.

This building located in London was designed by Short and Associates. After the end of the construction period in 2005, it has won a lot of awards between years 2006 and 2008. According to the architects it is a first passive downdraught cooled building in the city centre in the world. The reason for this was to maintain the comfort within the urban heat island. The building is using both – natural (hybrid) ventilation all year with passive cooling through the summer peak temperature months by engaging the downdraught cooling via a central light well *(Shortandassociates.co.uk, 2017)*.

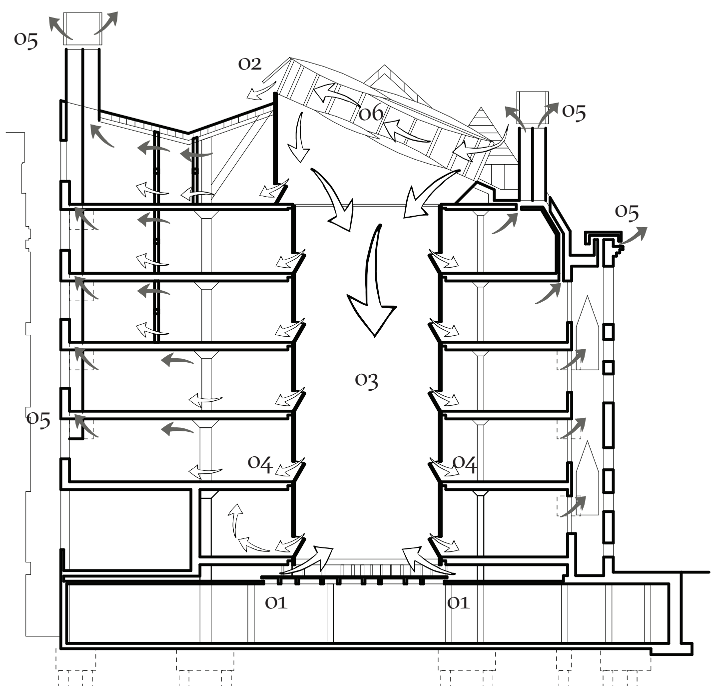
For natural ventilation there is used a system which takes the fresh air from the inlets in the ground floor of the building, next to the entrances. In some areas the air is preheated during the winter thanks to the double façade system. Then it is transported to the rooms and exhausted outside through the chimneys. During the summer fresh air flows from the atrium across the floorplates to the exterior exhausts.

Authors claim also that the acoustic solutions were treated properly so the narrow section ducts within partitions allowed air to pass across enclosed spaces *(Shortandassociates.co.uk, 2017)*.

Users are satisfied with the building but they are complaining about the natural ventilation solutions. When asked about the problems, they tend to say that first of all they are having problems with the temperature control. During the winter, the temperature is warm, which is great. But during the summer it is way hotter in the building than outside of it. One of the biggest annoyances is the lack of possibility to manually open windows because the system is hybrid. It means that ventilation is natural, but the windows are being opened or close by the detectors which are gathering data about VOCs. Moreover, flow of the air from the light well look like it was meeting the obstacles, radiators, which are covering almost whole area of the opening that lets air inside. Users of last floor have this advantage that they can open manually windows in the façade, which they do very often. During the winter some of the rooms on the top floors are actually too cold because too much heat is lost in quite big process of air exchange. There were also some problems with drafts in the first years of running the building, but eventually they were fixed and problem does not occur any more.

One of the problems with the natural ventilation inlets in this building is that they are located next to the entrance. This is also ›

ill. 65.1. Front facade of the school. In the groundfloor there are visible inlets for the air.



ill. 65.2. Cross section of the building.

Cross Section

01 Intake dampers at lightwell base open
02 Intake dampers at lightwell head open
03 Lightwell fills with air at ambient temperature
04 Air enters floors at low level via bottom hung windows
05 Air exits at breathing parapet and via stacks
06 Void between inner and outer ETFE layers vented

the place where the people are smoking. That's why cigarettes' smoke was easy to smell in the office rooms of the building. The solution of the building was to put as many signs as possible with the information about prohibition of smoking in this area. But still, after people started to gather in front of the building, the smoke often still goes to the ventilation shafts. Staff described the problem as the lack of knowledge among the students what those inlets are used for. Those signs in front of the building didn't help with spreading information about the natural ventilation in this building.

Left ill. 66.1. Light well which is also used for natural ventilation downdraught flow of the air.

Top-Right ill. 67.1. Double facade system. This stack is gathering exchanged are and getting it out on the roof top.

Bottom-Right ill. 67.2. Unfortunately position of the air inlets makes it easy for a smoke from cigarretes and cars to go into the building.


No smoking

#2 BedZED

The icon of contemporary natural ventilation housings with hear recovery system.

In 2002, the company ZEDfactory (run by Bill Dunster Architects) designed an environmentally-friendly housing development in Wallington, a south suburb of London. At the moment, it is the biggest eco-village in the United Kingdom. It consists of 82 properties, community facilities and a visitor centre *(Hertfordshire.gov.uk, 2017)*.

The Beddington Zero Energy Development (BedZED) is sustainable in many aspects. It provides a great amount of light to the apartments as well as to quite big gardens. There is quite a big production of solar energy from the PV panels. The building complex also collects rainwater for re-use as grey water, but what gives the place a quite exceptional character is the natural ventilation which uses colourful wind cowls for inlet and outlet of the air.

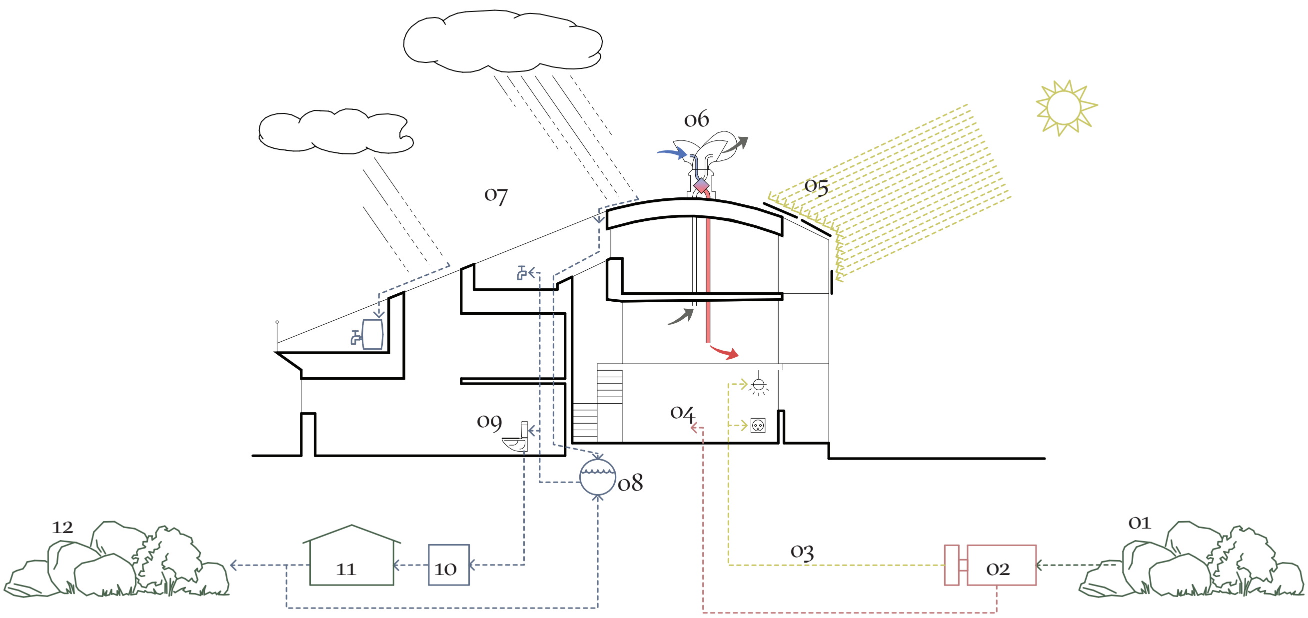
The wind cowls are a very special type of chimneys (ill. 69.1). They catch the fresh air and preheat it through the air exchange filter, which is already heated by the warm air exiting the system. The fresh air is led to the rooms through the ducts. The same wind cowl system gathers the polluted warm air and takes it through different ducts system and the air exchange filters. Then, it is exhausted by a big opening which is always on the opposite side of the air catchers. The reason for this process can be explained by fluid physics: when there is a positive pressure on the inlet side, there will be a negative pressure on the other side of the wind cowl. The top part of the system is loose and can rotate around a vertical axis, according to the wind direction.

There is also a heat recovery system implemented in the wind cowls. This makes the consumption of the energy needed for heating the rooms much lower. An engineering company Arup developed a harnessing system for this project that captures a low velocity wind. It is also the first set-up that introduced the heat recovery system using the wind power, with both a positive and a negative wind pressure used to deliver supply air and extract vitiated air *(Twinn, 2006)*.

ill. 68.1. The building is using chimneys as an outlet for the exchanged air.

Right ill. 69.1. The building is using chimneys as an outlet for the exchanged air.

ill. 70.1. Cross section scheme showing sustainable solutions in the BedZED.



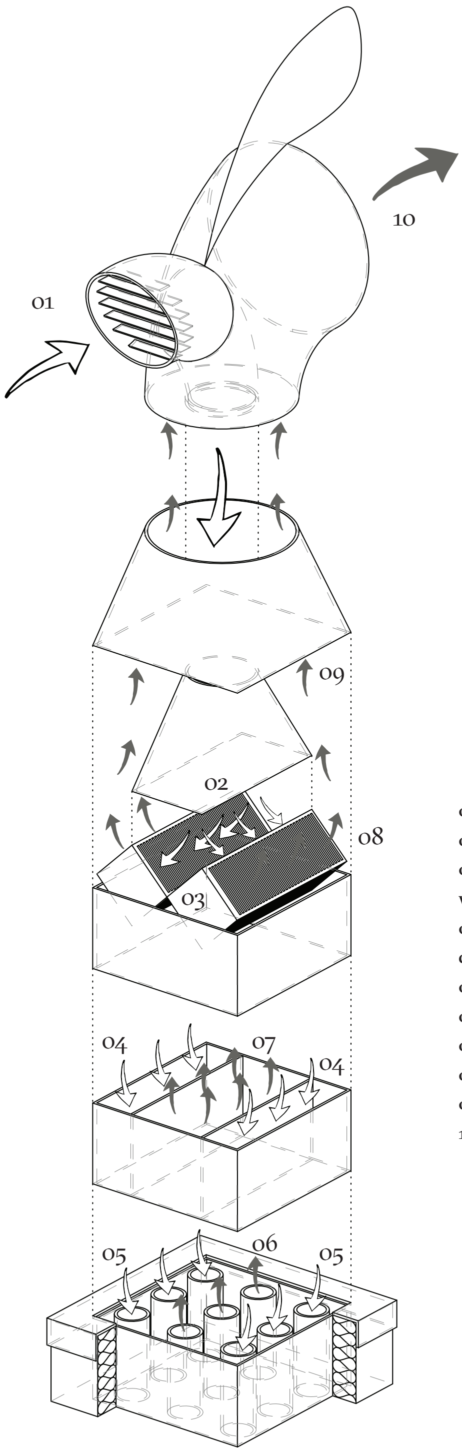
Cross Section

01 Wood chips gathered for use
02 Creating power from the wood chips
03 Generated electrical energy is used in the building
04 Generated heat is being used in the building
05 Energy from solar panels is also used in the building
06 Wind driven ventilation with heat recovery
07 Rainwater collection
08 Rainwater store
09 Low flush WC
10 Septic tank
11 Foul water treatment
12 Use of clean waste for growing the greenery

ill. 70.2. One of the roads in the housing complex.

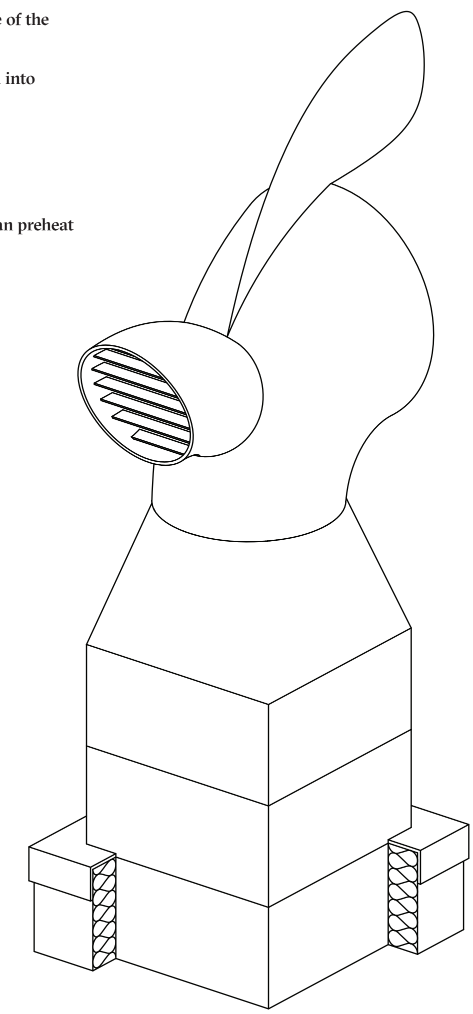
Wind cowls

As mentioned before, one of the most characteristic elements of the housing complex are wind cowls. They are quite big but also very efficient. Users claim that natural ventilation works perfect and they are really happy with it. One of the most important elements of this solution is heat recovery. Fresh cool air goes through the inlet, pre-heats in the air exchange filter, goes to the ducts, and then, when exhausted, it goes back using different ducts, heats the filter and then goes to outlet.



ill. 71.1. Scheme showing how the wind cowls work.

01 Fresh, cool air is going through the inlet
02 Fresh air meets the air exchange filter
03 Cool air is being warmed since the filter is warmer because of the warm air coming out from the building
04 Preheated air goes through last zone before being separated into ducts
05 Air is being distributed through the ducts
06 Exchanged air is going through the ducts
07 All the air from exchange meet in common zone
08 Warm exchanged air is warming the filter so the cold air can preheat
09 Exchanged air is going around isolated fresh air
10 Air goes through outlet



ill. 71.2. Assembled wind cowl.

#3 Bang & Olufsen Headquarters

When the airflow goes in between the slabs.

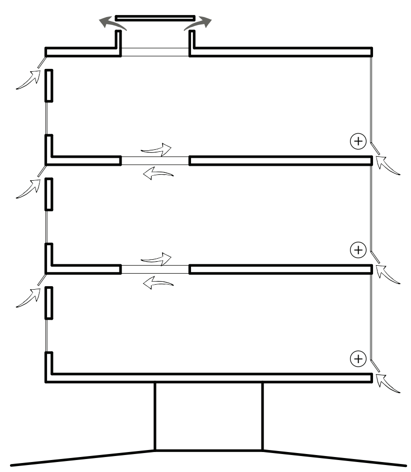
Bang & Olufsen Headquarters in Struer, Denmark was built in 1997. It was designed by KHR Architects. Soon after the construction was complete, the building became known as "The farm". This name was inspired by the fact, that solitary farmhouses were a typical sight in this area at that time. Moreover, the building is located just in the nature – in the area for growing crops and breeding animals - the main goal of the architects was to create a dialogue between the technology and the nature *(BeoWorld, 2006)*.

This 12 meters high building has three floors. Each of them consists of a large open office area, directors' offices and the basic infrastructure like toilets, staircases and elevators. The North facade is fully covered with glass, whereas the rest of the building has a regular window system. The main idea behind the construction was to keep it as simple as possible and to use as few technical mechanisms as possible *(BeoWorld, 2006)*.

Compared to other buildings that were mentioned, this one makes use of hybrid ventilation. When it is possible, B&O Headquarters ventilates with the help of natural airflow. When the natural pressure from the wind and convection is not enough, it is being supported mechanically with air fans. Some days in summer, when there is no wind, the mechanical ventilation helps also to provide with the air flow *(Marsh and Lauring, 2003)*.

The building is ventilated according to the principle of displacement. It means that lighter, cooler air is brought into low level inlets. The air passes over ribbed heating pipes. It means that it can be preheated during winter. Then the heat and the pollution are being pushed upwards, where the air is sucked out or expelled into the attic. Moreover, the central staircase is being used as an air exhaust as well *(Marsh and Lauring, 2003)*. The building has two main vents which drive the polluted air outside the building. In addition, those vents have large axial air fans that help with the air exchange if, as mentioned, the natural ventilation is not enough. However, when the natural air pressure is sufficient, they remain stationary. They can also turn on if the concentration of CO_2 is too high. Moreover, the air fans are sometimes used during warm nights for cooling down the air. There is a need for this, when the building has accumulated too much warmth during the day, and when it is radiating it during the night. Due to the mentioned above, the mechanical cooling is avoided during summer, since the temperature during the day is reduced *(BeoWorld, 2006)*.

It is an interesting fact that Aalborg University has been involved in a number of target programs at the B&O building. The building has also been a "participant" in many Danish energy research studies and a number of international research projects" *(BeoWorld, 2006)*.



Cross Section

Top ill. 72.1. Cross section of the B&O Headquarters.

Right ill. 73.1. B&O Headquarters.

#4 Home for life

When the architects and engineers design a building and the user is using in completely diffferent way than it was planned.

This building was designed by AART Architects. It was built in 2009 in Lystrup, Denmark. The main idea behind the design was to create a new CO2-neutral one-family house that would provide a great indoor climate with sustainable solutions *(Home for life. Model home 2020, n.d.)*.

However, this example shows a building, where the natural ventilation was the last priority among all sustainable solutions. Although the fresh air is provided to the building, the natural ventilation occurs only during warm months. When it comes to winter, the building uses the mechanical ventilation for heat recovery to reduce the energy needed to warm the building up. Moreover, the ventilation is controlled by an indoor sensor that ensures that the house is not ventilated more than necessary *(Home for life. Model home 2020, n.d.)*. When the natural ventilation is used, the airflow occurs mainly by cross-ventilation and the thermal buoyancy, where the air is being warmed and goes to the higher parts of the volume. Next, it goes to the closest outlet (above the living rooms or the bedrooms). In this case, the big windows above the main hall of the house work like big stack ventilation which gathers all the pollution from the ground floor.

ill. 74.1. Home for life, front facade.

Furthermore, this building also has solutions like solar panels, solar heating (on the roof) and other sustainable solutions. The goal was that after 30 years, the surplus energy will become equivalent with the amount of the energy used in producing the materials from which the house is built *(Home for life. Model home 2020, n.d.)*.

Unfortunately, what the designers and the engineers did not foresee was that the inhabitants did not use the building according to the sustainable strategy. They started to roll down the window shades in the hours where the sun should be in the building to heat it up. They also ventilated the building by opening the windows, when the mechanical

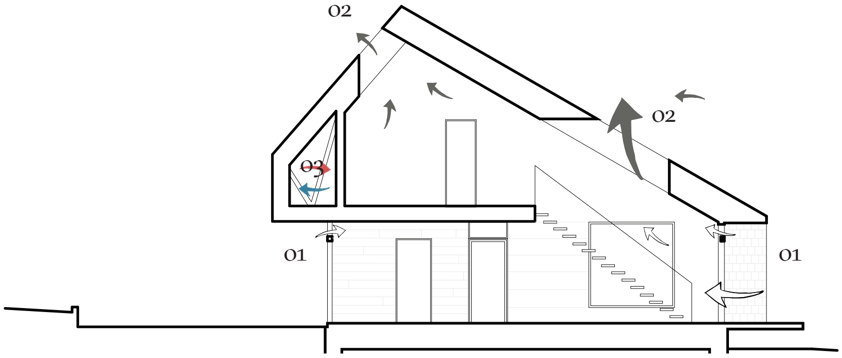
ill. 75.1. Home for life.

Cross Section

01 Inlets in the ground floor through opening windows

02 Outlet of the air in the roof windows

03 Heat recovery system (hybrid solution)



ill. 75.2. Cross section showing natural ventilation in the building.

ventilation was operating. When it comes to the natural ventilation, the users opened often other windows than prescribed by the design, mainly due to the complexity of the window placement strategy. Currently, the "30 years" strategy of the building paying back the construction costs is no longer valid. It is estimated that with the current use the building would repay itself in 40-50 years at the earliest *(Kirkegaard Bejder, 2016)*.

Among many different problems when using the building, it is crucial to underline the problem of not letting the users control the building by themselves. This is one more clear example, when only data and numbers regarding the artificial control of the building do not live up to the real-life indoor climate experience.

Analysis summary

Gathered information are crucial for proper understanding of the site context which ensures that proposal will correspond it.

The analysis contains basic research studies of the site relevant for the project development. The gathered information serves as guidelines and restrictions in the design process, emphasising the qualities and the potentials of the site.

The nature and the landscape are being represented by the big areas of the dunes and the cliffs along the coast. Beside the tall grass growing in the site's surroundings, there are forests spreading on the cliff's top. Due to the site restrictions regarding new greenery, there can't be planted any new plants in this area. The mentioned dunes could be used for shaping the building or using their quality for similar purposes. Of course, one of the biggest tourist attraction is how close the sea from the site is. The old Badehotel was designed in such a way, so that the people sitting in the dining room could enjoy beautiful views of nature and the sea.

The sun studies showed great qualities of the site. Throughout the year there is a lot of light coming to the site. This will help shaping the access to the natural light for the building. It might also suggest some more detailed solutions, like placing the solar panels for reducing the energy demand for the building. This could also suggest thinking about going into area of near net-zero energy building. As the site is also quite big, there is still space to suggest different energy or heat collector's solutions.

The wind studies are proving that there is a lot of wind on the site with many extremes throughout the year. The directions of the wind and its strength can help to shape the building and implement such solutions as, for example, the natural ventilation. It might also be a challenge to make it in a way that it can avoid drafts.

The sea level studies showed that the site is safe from the sea water, even in the conditions of big storms, but the salty environment was causing troubles with some elements of the old building, like solar panels and metal which were not prepared for such habitat.

The site's history is mostly about the old Svinkløv Badehotel. This building was a very famous place, where people could escape from an everyday life and from the technology. The tiny rooms and cosiness made this place special. The restrictions, however, are forcing to rebuild a replica of this hotel. The new design can show what would happen, if the building went through the process of changing the local plan (which would mean delaying the process of the construction). The conclusion was that this Badehotel had great importance for the Danish nation and its resurrection is demanded, not only by the site owners, but also by the guests who still remember and miss the place.

The users want to bring back the very soul of the old hotel. At the same time, the new building should be sustainable and fit into the nature and its context. The famous cuisine should also return to the place. Moreover, the users would like to produce even more home-made food at the Badehotel. The owners of the site would also like to invite the nature into the building. There is also a wich for Danish design furniture in the interior. The amount of the restrictions is underlining the need for respecting the nature and the landscape in this area. The old hotel was a landmark and the reason for visiting this coast of Denmark and the new building must do the same.

The quick case studies of the solitude hotels show a great potential for a new Badehotel. These buildings have some things in common, even with the old hotel. It means that there exist universal solutions which might be helpful in creating a new building.

The new Badehotel should follow the Danish sustainable approach to the design and also express the spirit of the Nordic architecture.

It should follow the Building Regulations, be honest in the materials, provide good daylight, give pleasant thermal comfort and avoid too much of water waste.

The thesis has chosen the natural ventilation as the main technical focus. As a sustainable solution for providing the airflow, this method is currently more and more abandoned mostly because of the complexity of its use, but it does not mean that it is no longer used. There exist some places in the world which are using this solution. Unfortunately, the users are not always happy with the natural ventilation, if the freedom of its use is not given to them. The analysis of this airflow type showed that hybrid solutions (the natural ventilation with an electronic control over windows' opening mechanisms) are not the best way to deal with it. The mechanical ventilation is easy to design; however, the energy consumption and the system maintenance mean that this solution is not sustainable at all.
The biggest problem with the natural ventilation is the heat recovery (whereas the mechanical ventilation has the best efficiency). However, it does not mean, that it is impossible to design. Many different solutions for dealing with the natural airflow show that there are many ways it can be designed and how it can affect expression of the building.

The summarized, accumulated knowledge helps to set priorities and determine the design criteria for the proposed project. The gathered information is crucial for a proper understanding of the site context which ensures that the proposal will correspond to it.

Problem

How can a design of a modern "Badehotel" preserve the core values of the old Badehotels"?
How can the new hotel and its design bring back the soul of the old Svinkløv Badehotel?
How can the architecture and the landscape become connected in a way so that they complement each other?

Project's vision

The vision of the project is to design a new Svinløv Badehotel version 2.0: with a clearly visible soul; where people can escape to from an everyday busy life; where people can take a break from the technology and experience the nature, meet new people, make new friends.

The building should integrate the old "Badehotel's" qualities. It means that the rooms must be comfortable, but still small, urging the guests to abandon their privacy and gather in the main living rooms instead. The quality of the space should encourage and facilitate socializing.

The place should also be in condition to provide the guests with the best food possible. Moreover, people should have a possibility of enjoying delicious food and beautiful views of nature at the same time.

The building should use sustainable solutions with the main focus on natural ventilation. The new "Badehotel" will try to comply with the "Building Regulations 2015" and even the "Building Regulations 2020", if is possible.

The design criteria are the explicit goals that the project must achieve in order to get a proper design. This is the result and the conclusion of the analysis phase of the project. These restrictions help to narrow down the range of possible solutions and decisions. Thus, by following them (the design criteria i stedet for them) the project is able to specify the paths and the foundations for the proposal.

Design Criteria

The building must be integrated with the surrounding nature. It should not be an alien object.

Aesthetics

1. TThe emphasis on the nature. It should respect the terrain and complement the nature.

2. The strong visual connection between the building and the nature. It should underline the qualities of the surroundings by showing it to the guests through some openings and other solutions.

3. The architecture should represent the values of Nordic architecture. The building should use materials which will stay faithful to their properties and function.

4. The building should create a contemporary representation of "Badehotels". It should show the possibilities for creation of a new generation of "Badehotels".

Function

1. The parking lot should be integrated in such a way so that it does not stand out in the nature. It must not be a parking square as it was before. It should not disturb the view of the surroundings.

2. The rooms should be comfortable but very small. They should provide just the right amount of space for using a bathroom and sleeping, but should not give too much luxury, so the guests would have to go to the common rooms and socialize with others.

3. The building should respect the requests of the user. The demands of the users should be fulfilled.

4. The building should not exceed 1.800-2.500m2. The building should not impact the terrain too much and it shouldn't create too big Floor Area Ratio (FAR).

5. The building should integrate the guests. The program of the building should help the guests to socialize together and meet new people.

6. The building should embrace the feeling of solitude. It should be a place where people can really relax and forget about everyday life problems.

7. The building should remain as a seasonable place. The program for guests will operate during warm months only. During off –season, only some staff might be there temporarily to prepare the hotel for the coming season.

Technology

1. Each guest-room, living- room and the common area must have a clear sea view. The guests should have a possibility to enjoy the view, even if the weather is rough.

2. The natural ventilation as the main solution for airflow. The mechanical ventilation must not be implemented in the building.

3. Should the mechanical ventilation support occur, it must not be controlled by computer systems. In cases, when there is a need for the mechanical ventilation in specific rooms, it must not be operated by the detectors.

4. The natural ventilation should be as simple as possible for the guests to use. The visitors and the staff should not have any problems in understanding how to use and operate the natural ventilation.

5. The natural ventilation should not use any hybrid solutions. There should be no electrical and mechanic system operating at the same time, when the natural ventilation is working (for example, the windows can be opened only manually).

6. The building should represent good indoor qualities. The overheating, drafts, odors and other annoyances should not occur in the building.

7. The building should use thermal mass to help with the natural ventilation. There should be no sudden temperature changes in the building.

8. The building should focus on the ease of use for both guests and staff. Any solutions or functional aspects of the building should be easy to understand and use by the people.

9. Every room should have a daylight factor of minimum 3%. The building should not use regulation minimum numbers to provide better daylight qualities but to provide with at least very comfortable amount of it.

Presenta-
tion

‘Our opportunity, as designers, is to learn how to handle the complexity, rather than shy away from it, and to realize that the big art of design is to make complicated things simple.’

(Tim Parsey)

Svinkløv Badehotel 2.0

This is a proposal for the new chapter in the history of the site. A history of Svinkløv Badehotel 2.0.

Right ill. 84.1. Visualisation of the new Badehotel. View towards the sea (north).

After many analyses, knowing the history of the old Svinkløv Badehotel, whole design process, the time came for presenting proposal of the building which could fill the gap after old hotel. This project is not trying to prove that it the best possible solution. But it is focusing strongly on the legacy of the old building and proposing quite sustainable solutions that might have big impact for the idea of creating new generation of the 'Badehotels' in Denmark.

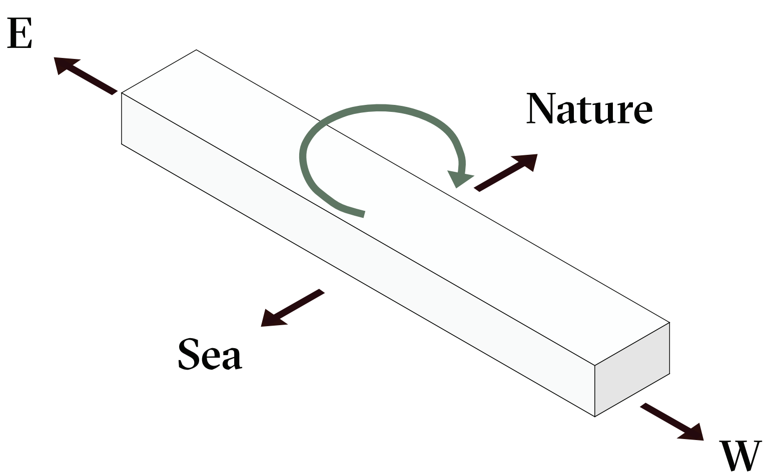
Idea of quite long, 85m long building standing out in the Svinkløv dunes sounds a bit odd. However, the dominating nature till the very horizon are making in reality like this building was nothing comparing to the mother nature surrounding it. Wooden cladding is making an effect like it was holding heavier roof. The roof whose 1 meter overhang is trying to dominant the building is making an effect like it was the main accent in this architecture expression. Which is not that far from the truth since it is truly one of the most important reasons this building has such form.

But let's try to go back and look at how the previous hotel was positioned, how it worked and how it had an impact on the idea of placing the functions in a new, but also in the same time similar way.

Original Svinkløv Badehotel was a long building oriented from southern-east towards northern-west. Guest rooms where located on both sides of the corridor that was placed in the main axis of the building. This resulted with some rooms having amazing view towards sea, and other having beautiful view towards nature and the trees on the cliff. This was not a perfect situation since ›

Top ill. 87.1. Svinkløv Badehotel.
Bottom ill. 87.2. Example detail of the facade.

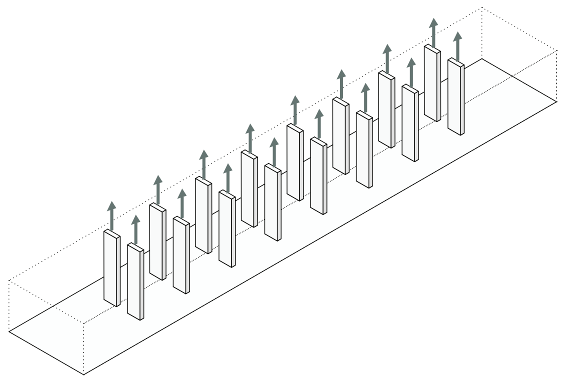
The Concept



Top ill. 88.1.

The rotation

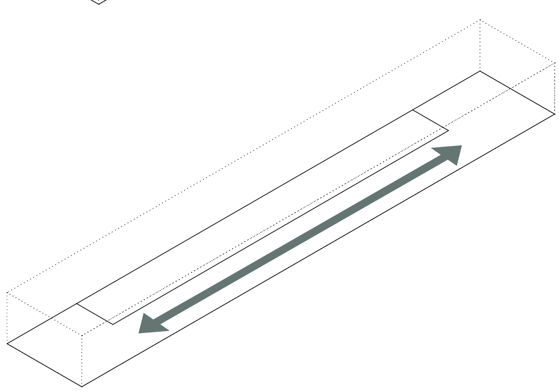
Comparing to the old hotel which had two different groups of rooms, one towards the nature and one towards the sea, this project decided to rotate the building towards the north and give exactly the same quality of view for every guest room in the hotel.



Top ill. 88.2.

Ventilation

Vertical shafts have been introduced to provide air exchange in the building as well as piping for the bathrooms.



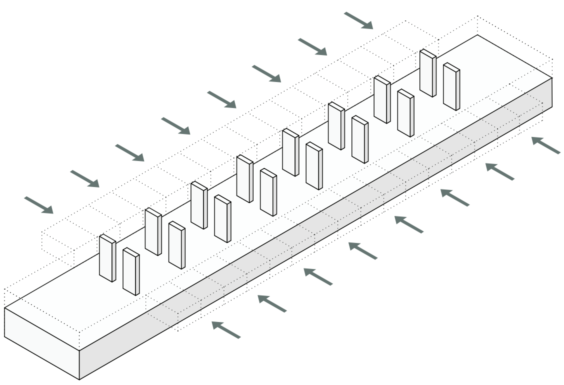
Top ill. 88.3.

Common rooms corridor

The old hotel used common rooms to connect the whole building in the ground floors. This concept has been brought back. Each of the rooms has been connected to the shafts to provide natural ventilation.

cliff side didn't offer anything more (beside the fact, that this side of the building had bathrooms as a part of the rooms, which were lacking in the rooms with the view towards the sea).

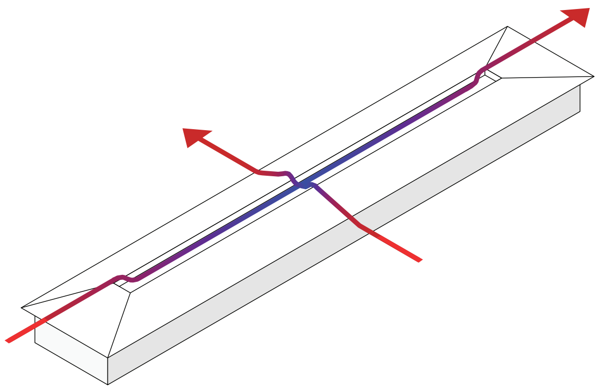
That's why proposal has rotated the building to stand exactly on the axis north-south (ill. 88.1). Thanks to this all the rooms on both sides of the hotel will have the same quality of view. Partly towards the nature, partly towards the sea. That was, however, only part of the bigger plan. After researching natural ventilation solutions, this design needed ventilation ducts (which also help to distribute needed piping throughout the building). Those were placed in equal distances from each other on both sides of the main axis (ill. 88.2). On the ground floor, main functions have been distributed along long common room corridor that joins building from south to north (ill. 88.3). On both endings of the building there are large glassed 'cubes'. On the south, there is an



Top ill. 89.1.

Guest rooms

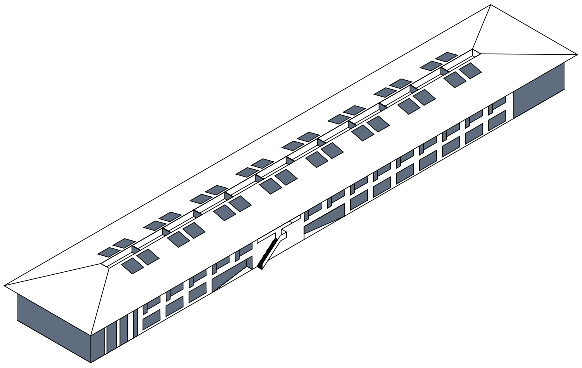
Guest rooms have been placed on the first floor according to the strategy of having same view qualities from them. They were also attached to the building in a way that they could directly connect to the shafts.



Top ill. 89.2.

The roof

New roof uses the strategy of creating a negative pressure on the top of the roof (lower pressure than the one on the facades). This makes natural ventilation outlet very efficient.



Top ill. 89.3.

Openings

Openings have been designed to fit the functions of the rooms. Façade windows are working as cross and stack ventilation airflow. Roof windows are being used not only for ventilating the bathrooms but also for providing natural light in the bathroom, as well as additional light to the bedrooms thanks to the glazing between them and the bathrooms.

orangery. It is being used as an unheated area during the winter. In the opposite, northern part of the building there is another 'cube' containing dining area. All the room were designed to have connection to the shafts. On the first floor, as mentioned before, guest rooms were placed in a way, that each bathroom has the same access to the ducts (ill. 89.1). On top there is a roof which was shaped to created always negative pressure on the top of the roof (lower than on the facades) (ill. 89.3). The reason for doing so was to ensure that the polluted air will be always sucked out of the building. Lastly, openings were created in a way to deliver not only big amount of light to the inside of the building but also to help with natural ventilation (ill. 89.3).

When it comes to the outside area of the building, it uses not only the concept of the old hotel terraces but also almost the same placement (ill. 91.1). Thus, there is a morning terrace north-east from the building.

Its function is mostly to take the morning coffee out of the building and just enjoy drinking it in the morning sun if the weather will allow it. North-west from the building there is a sunset terrace. It has been used so far for gathering (socializing) together and watching the sunset. This project would like to continue this tradition.

As far as the outside area is concerned, the old parking space on the eastern part of the plot has been moved to the southern corner of it. The reason for doing so was to prevent hotel's guests to have the view from the apartment towards the cars. It was important that they could have the view towards the nature instead.

ill. 91.1. Master plan.

Right ill. 92.2. Visualisation of the new Badehotel. View from the beach towards east.

ill. 94.1. 3D panoramic visualisation of the guest room.
View from the window area towards entrance.

Guest rooms

Guests. Are a key element for the hotel to exist. They need to have space there, where they can sleep but also where they can escape as to the solitude if tired of socializ-ing.

“Badehotels” were designed in a way so the people could escape from everyday life, being far from technology. It does not mean that the guests should not be able to relax in a cosy, and nice place. Svinkløv Badehotel 2.0 is presenting carefully designed guest rooms that offer a mix between luxury and solitude. It was important to create space, where people can rest but also a frame for experi-encing the nature. When entering the guest room, the guests have a big wardrobe for their clothes on one side and entrance to the bathroom on the other. Since the building is made from Construction Laminated Timber

(CLT), which is exposed to provide the interiors with warm colors. The only one element of the guest room which has different finishing is the mentioned bathroom which is constructed of white concrete. Moreover, this room has big skylight on top which is mounted in a way that it is impossible to see the window frame. When looking up, the guests can see only the sky. No matter if it is sunny or rainy. This combination give two different experiences between those two areas. In addition, between the bedroom and bathroom there is a full glazing opening at the ceiling. This transparent opening gives a lot of additional natural light to the room.

All the guest rooms are the same. Because of the ducts throughout the building, every second of them is mirrored through the long axis of the ducts. However, that does not apply to the windows. Big vertical opening gives an option to open a door and look out to the nature as well as just to ventilate the room. However as long as ventilation is concerned, small window above the window doors is absolutely enough to get the right amount of fresh air inside the room.

Moreover, the window was designed in a way that it creates a niche for seating in it or laying while having the face always oriented towards the sea. This gives additional experience of enjoying both nature and the sea.

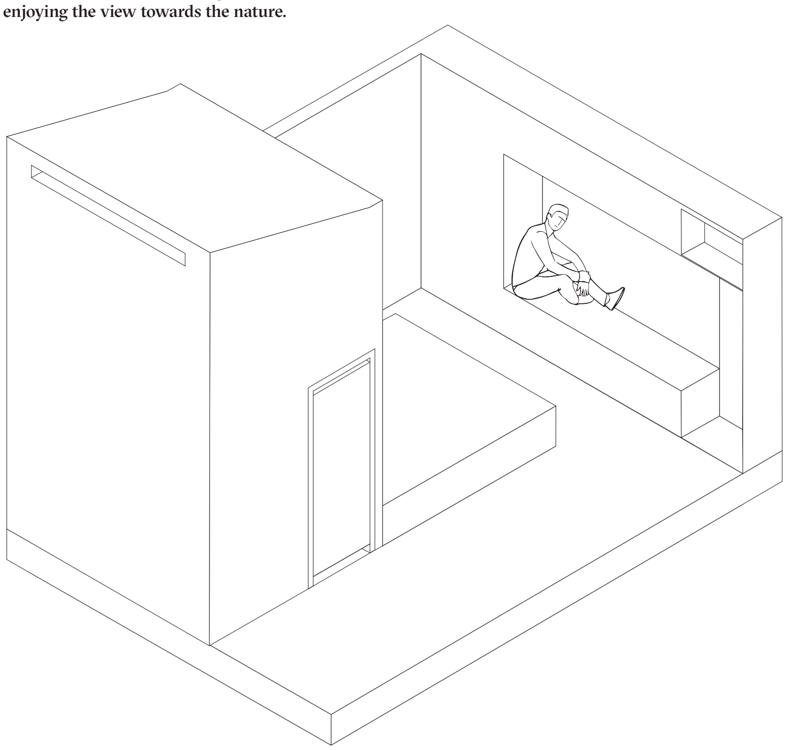
In details, the room also consist of Danish designed furniture and big photo or painting frames to expose artwork. This was a tradition in the old Badehotel.

*i*ll. 96.1. 3D visualisation of the guest room. Two main materials are CLT finishings of the walls and white concrete which is representing the bathroom area. Concrete helps with keeping the temperature right thanks to its great thermal mass properties.

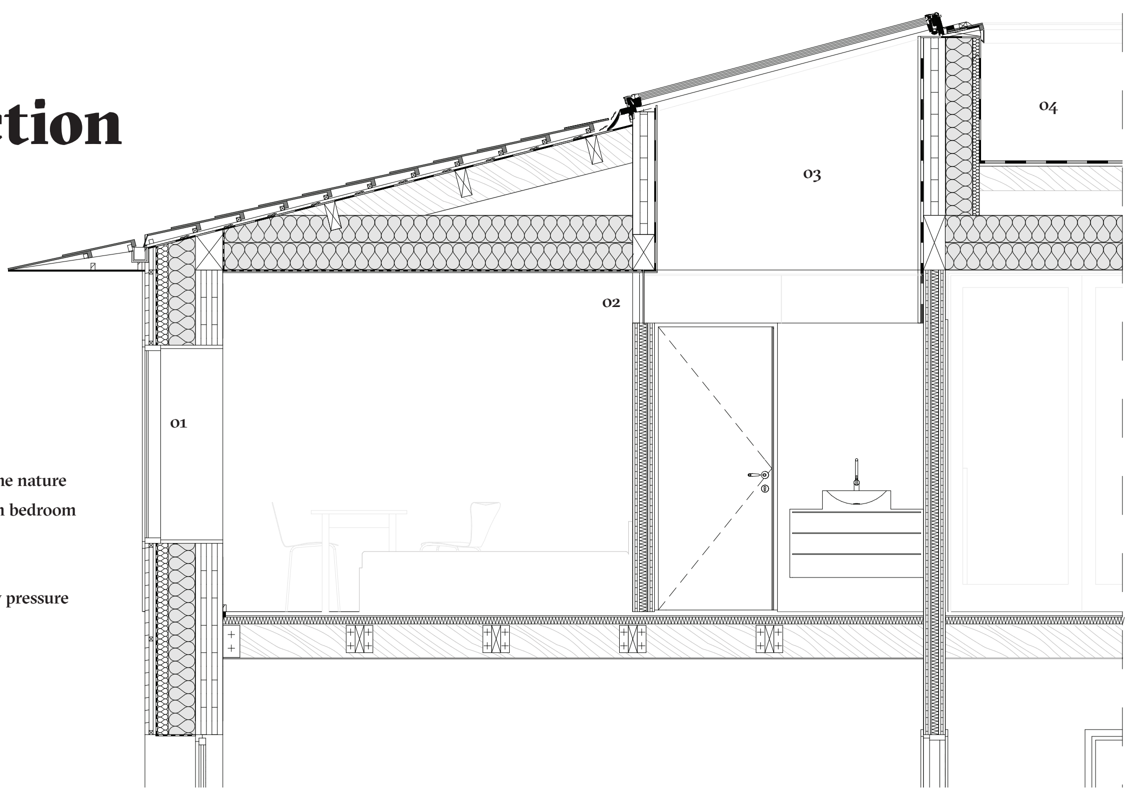
*i*ll. 97.1. 3D visualisation of the guest room. Close-up view to the window during rainy weather.

ill. 98.1. 3D visualisation of the guest room. View towards the window.

ill. 100.1. Illustration showing use of a window as place for enjoying the view towards the nature.



Cross Section

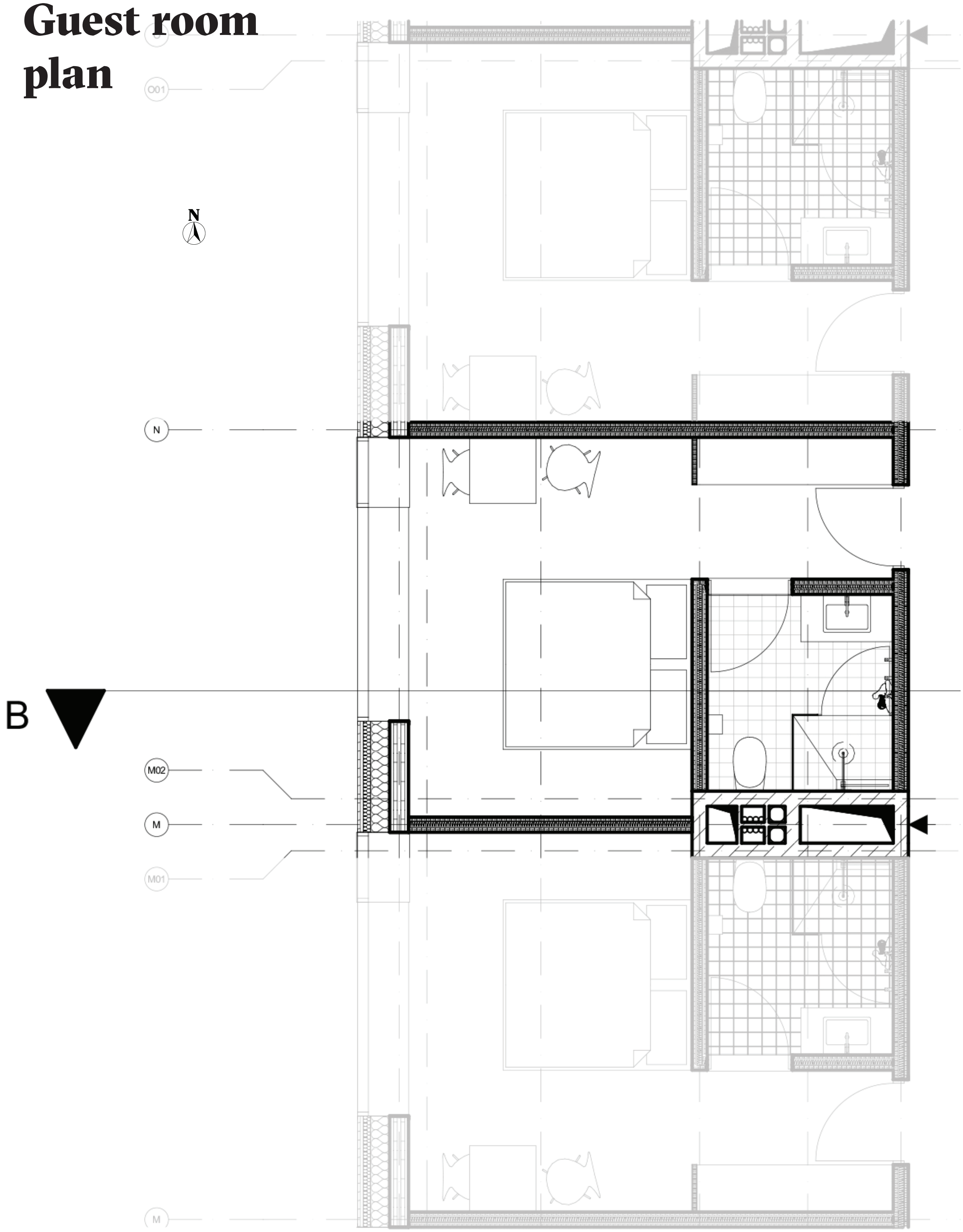


01 Window with the view towards the nature
02 Upper glazing in the wall between bedroom and bathroom
03 Light well
04 Niche on the roof that creates low pressure

ill. 100.1. Cross section through the guest room. Not in scale.

ill. 101.1. Guest room plan. Not in scale.

Guest room plan



*i*ll. 102.1. 3D visualisation of the bathroom in the guest room. Two main materials are CLT finishings of the walls and white concrete which is representing the bathroom area. Concrete helps with keeping the temperature right thanks to its great thermal mass properties. View towards the entrance to the bathroom.

ill. 103.1. 3D visualisation of the bathroom in the guest room.
View from the entrance.

Common rooms

Common rooms in the old hotel were creating place for socializing, meeting new people, opening towards others. It seemed that bringing back those spaces would be a great idea.

Below ill. 104.1. Common room area - corridor.

The very first question regarding old hotel was if the new common rooms should be just simple rooms, or should they combine together like a corridor-like space like in the old hotel. Since there was a need for connecting the southern and northern poles of the project, it has beed decided that this space should be a merged corridor-common room.

To keep people together from too high amount of people walking by every 5 minutes, it has beed decided that in the rhythm of shafts, there should be placed some niches. This created semi-closed but still public spaceswith a very comfortable couches (ill. 104.1.). They have great view towards the nature and since the ventilation shafts are close, it is easy to keep there fresh air by opening even small amount of the window in the ground floor.

The rhythm of such niches repeat between northern and southern end of the project. However near the orangery, there is a niches that extends between both western and eastern facade (105.1). This place has also a function of a bar,

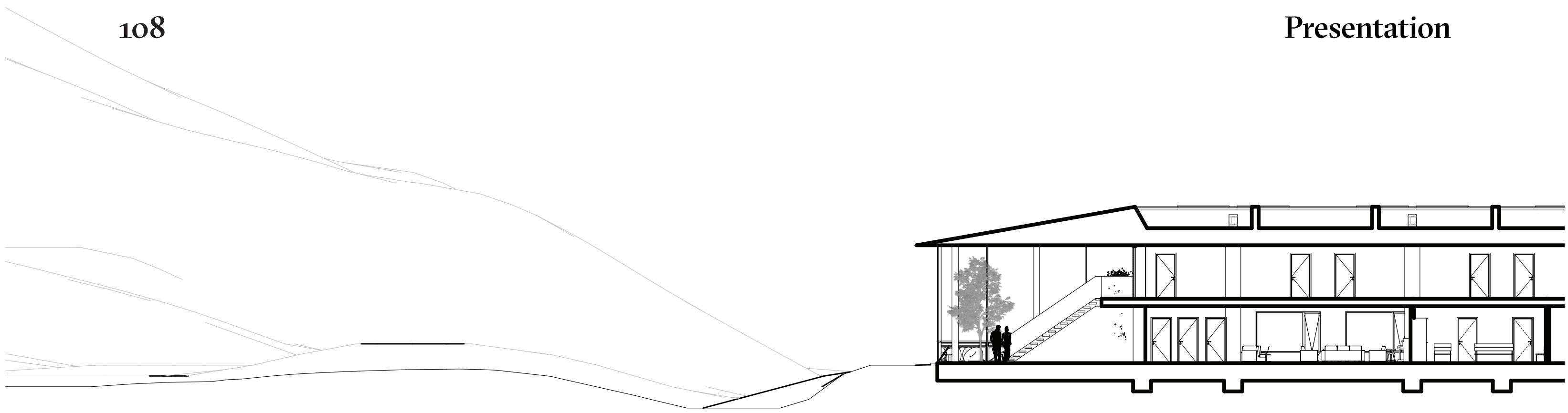
Top ill. 105.1. Common room area - lounge.

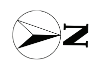
Right ill. 107.1. 3d visualisation of the dining area.

Dining area was always one of the most important parts of the Svinkløv Badehotel. There were few reasons behind it. One was the nationwide famous cuisine. Another reason was amazing view towards outside nature and the sea. Those qualities has been brought back in this new reincarnation of the old hotel. Because of the orientation of the building towards the north, the guests can now enjoy large, panoramic view towards the nature and especially the sea. No obstruction of the view and the nature that is trying to actually get inside the dining room, makes a beautiful transition between indoor and outdoor areas.

Dining area

Northern part of the building is occupied by the dining area.





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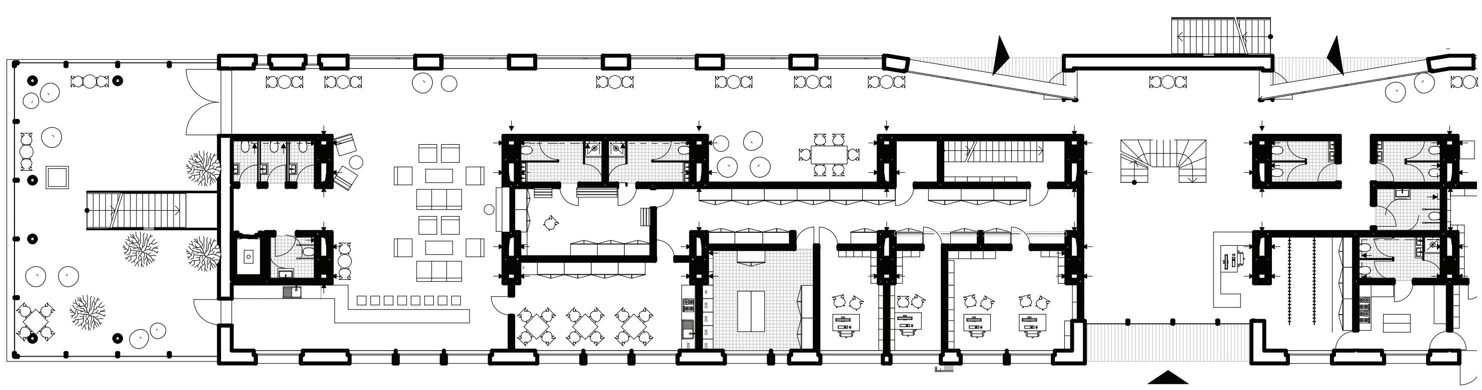
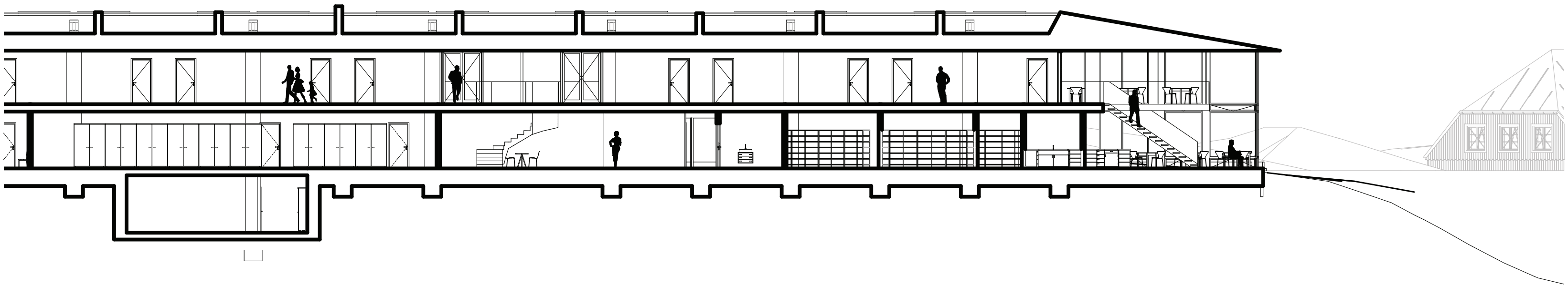
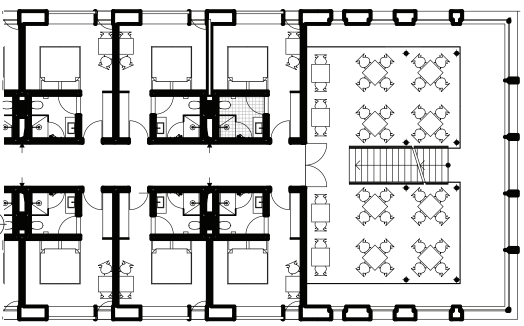


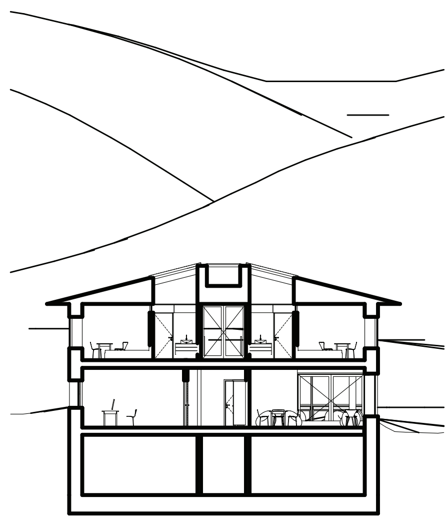
Long Section

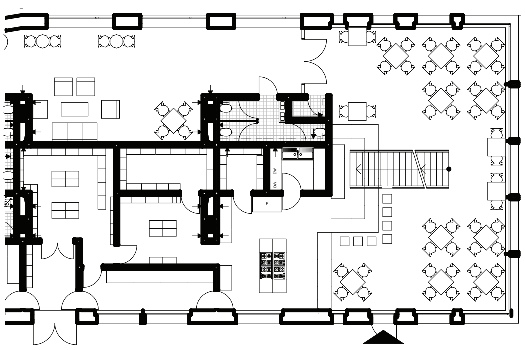


Right ill. 109.1. Sections of the new hotel.



Cross Section





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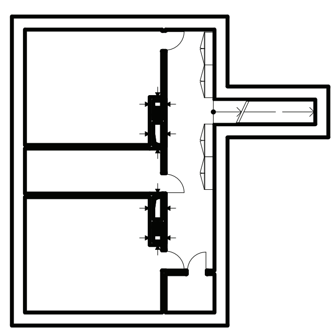
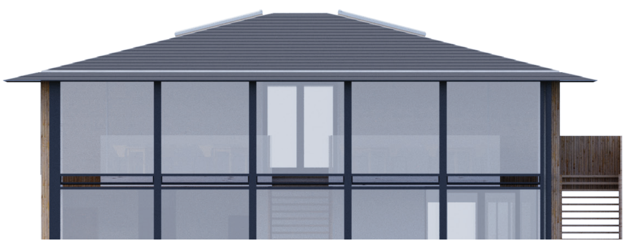


Facades

ill. 110.1. Facade east of the new building.

ill. 110.2. Facade west of the new building.

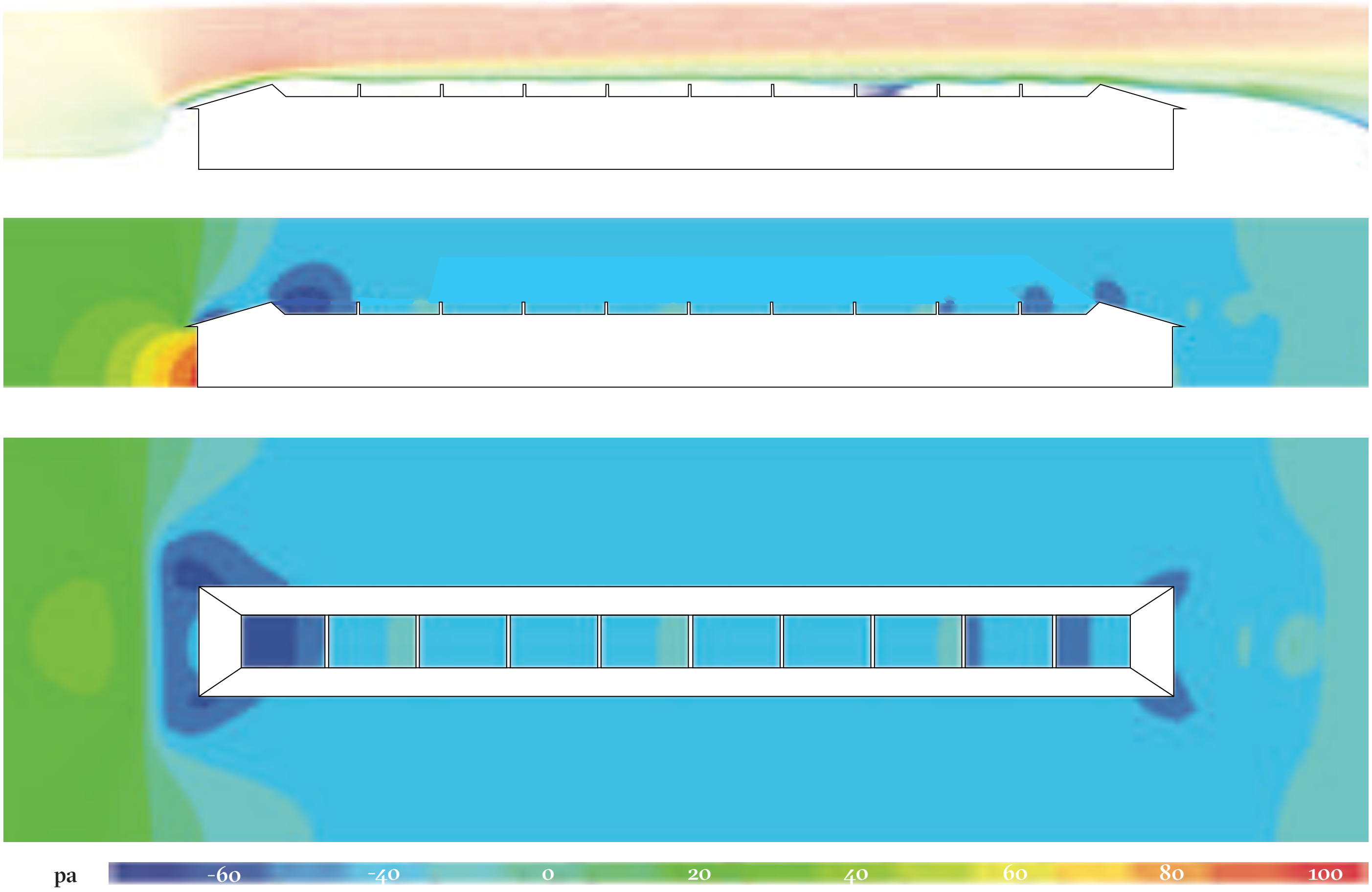
ill. 110.3. Facade south of the new building.



ill. 110.4. Facade north of the new building.

Natural ventilation: re-architecturized

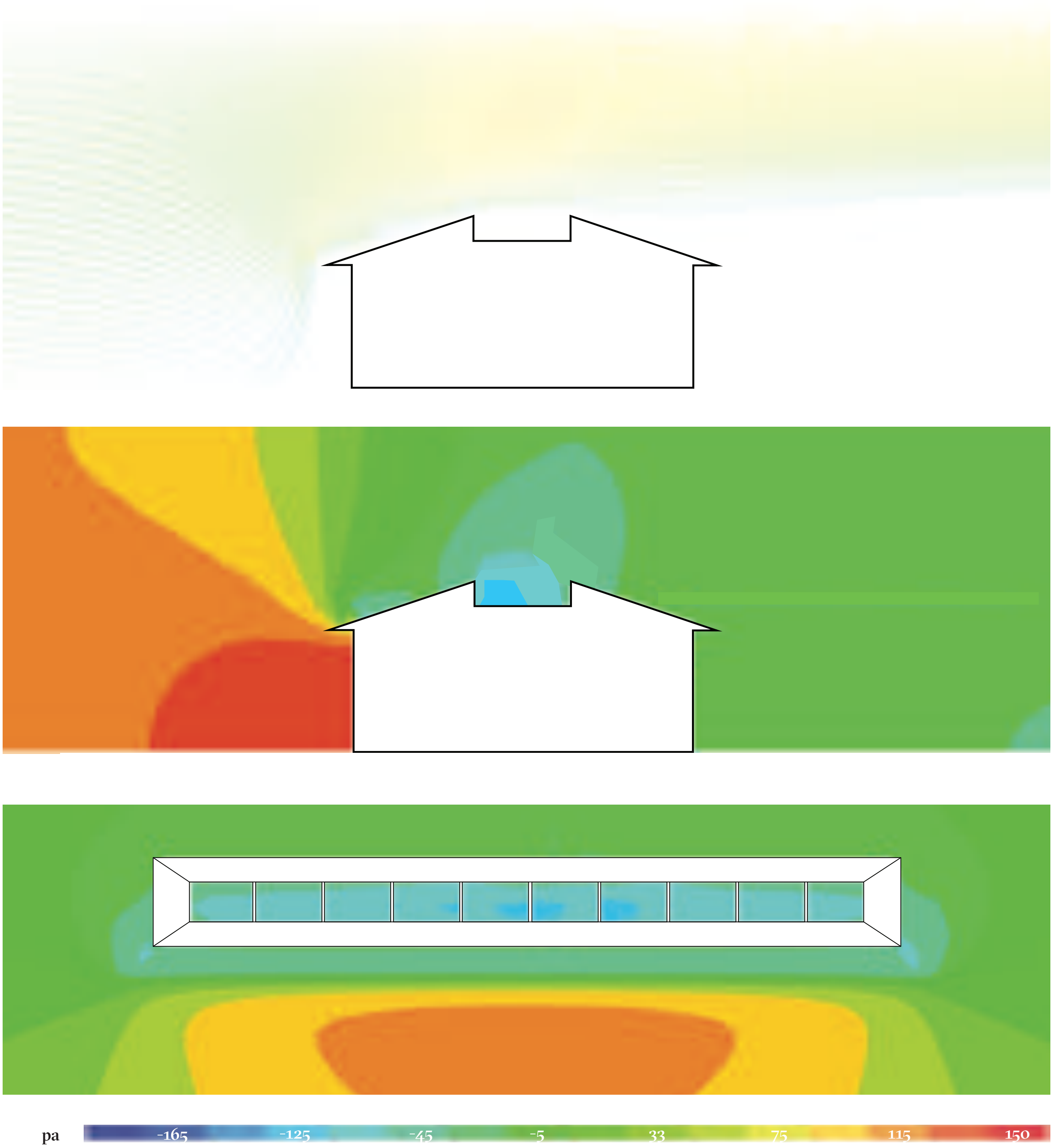
Below ill. 112.1. Principles of the natural process in the evelope of the building. Simulation of the airflow along the building.



The main technical focus of this thesis was natural ventilation. Thanks to the CFD software (Autodesk Flow for preliminary simulations and RhinoCFD for more advance airflow studies) this thesis could develop aerodynamic properties of the roof to create a roof, where on the top there is always lowest pressure in the building surroundings. What does it mean is that no matter from which direction wind will blow, the air will be always exhausted through the roof, without any need for having chimneys (ill. 112.1. and 113.1.).

The way it works is that whenever the wind blows from the side of the building, air hit the façade below the overhang, creating local turbulences. Those turbulences work on the air below the overhang creating more or less equally distributed airflow on the façade. However, on the roof top this is creating an effect when the airflow is keeping more to the roof. Since this is forcing to create even more positive pressure on the slope side of the roof, in its niche there is a negative pressure being created (ill. 113.1.). This principle works very well when the wind blows from the eastern or western side of the building. Whenever wind blows along the building, the situation changes a bit. Since the gap now is very long, negative pressure is not that extremely different from the one on the facades, since there is no vertical barrier behind which a negative pressure could emerge. Therefore, extra walls have been added on the rooftop (ill. 112.1.) to help improve low pressure on the roof top. Even though it is not as efficient as when the wind is blowing from the sides, it also is efficient enough to make the polluted air exhaustion outside the building through the shafts.

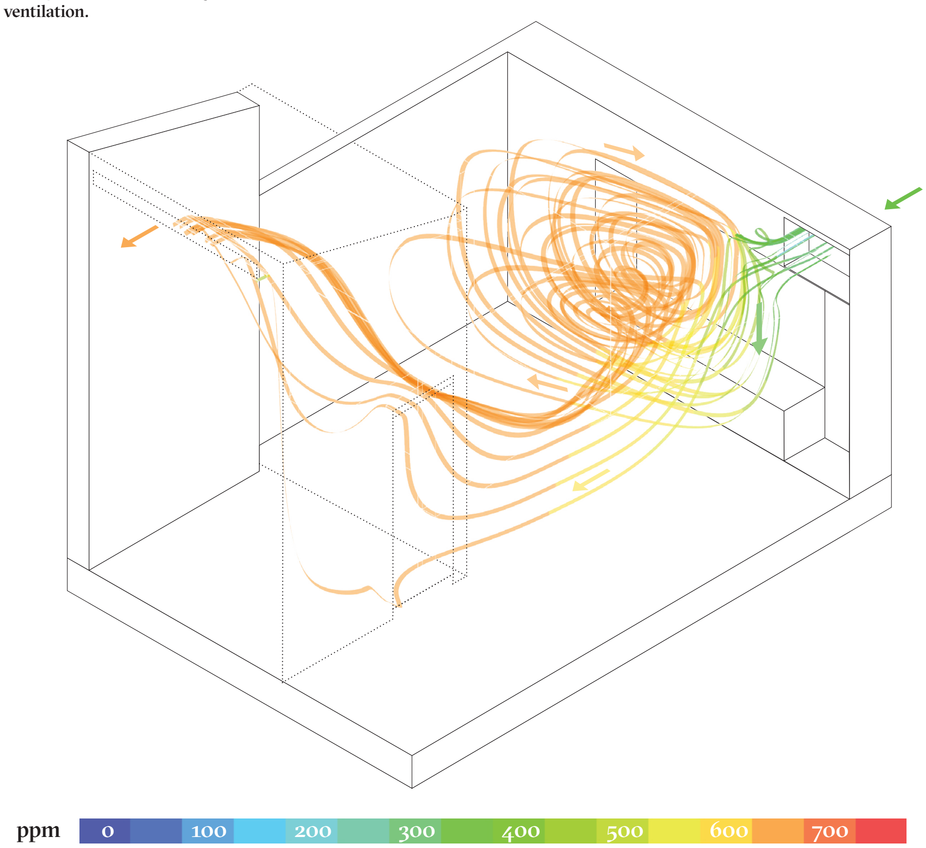
Below ill. 112.1. Principles of the natural process in the evelope of the building. Simulation of the airflow across the building.

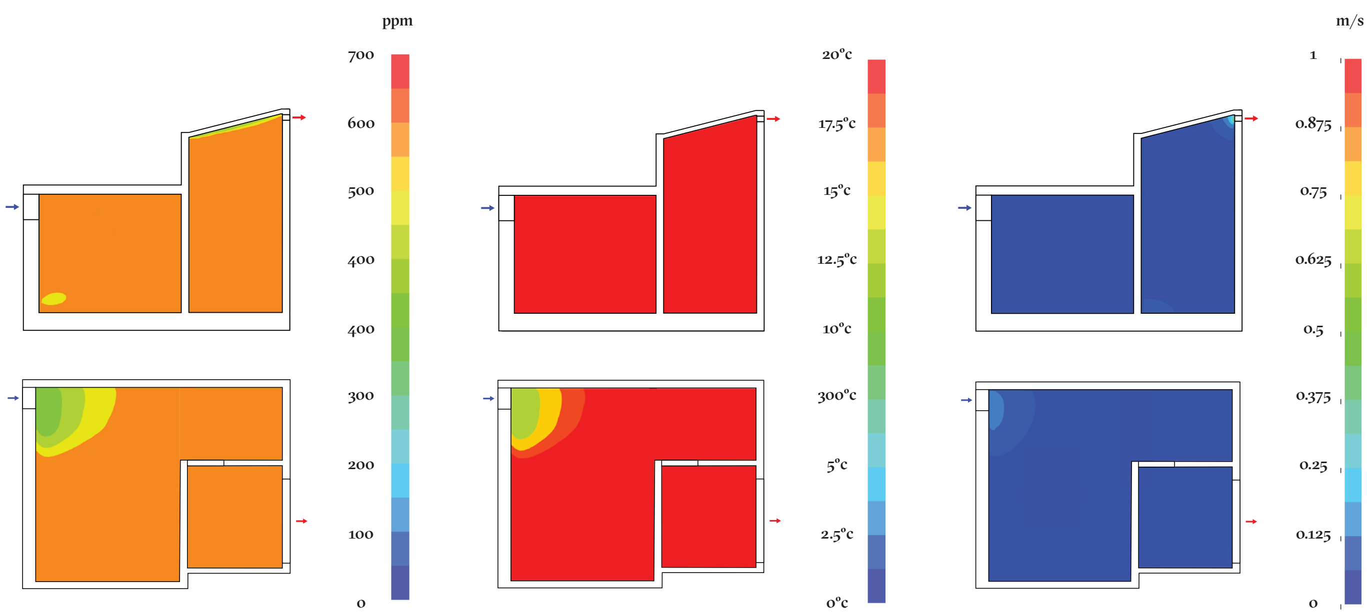


Natural ventilation strategy

0 sec.

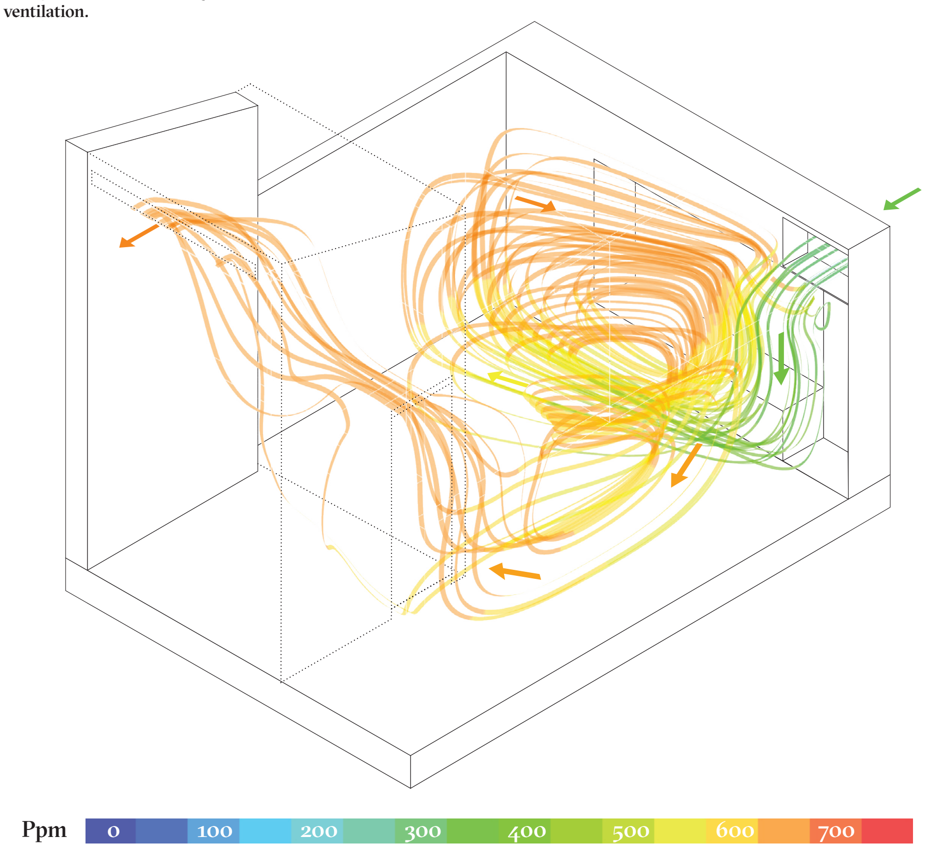
ill. 114.1 Ventilation of the guest room after 20 seconds of ventilation.

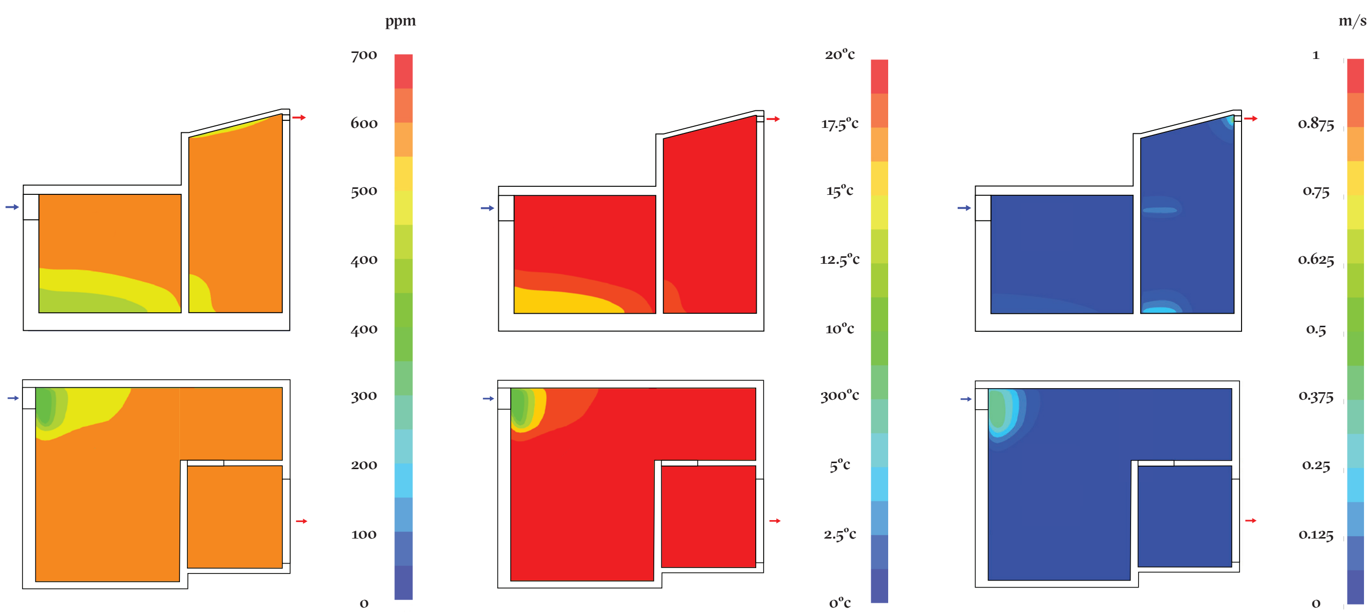




20 sec.

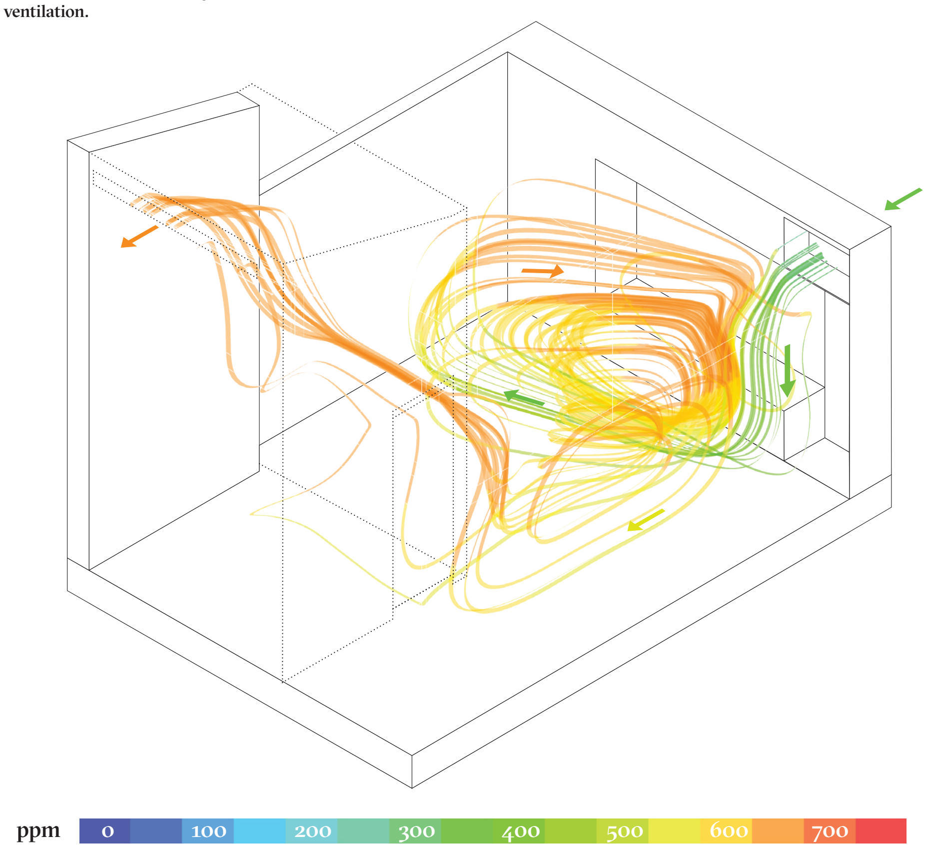
ill. 115.1 Ventilation of the guest room after 20 seconds of ventilation.

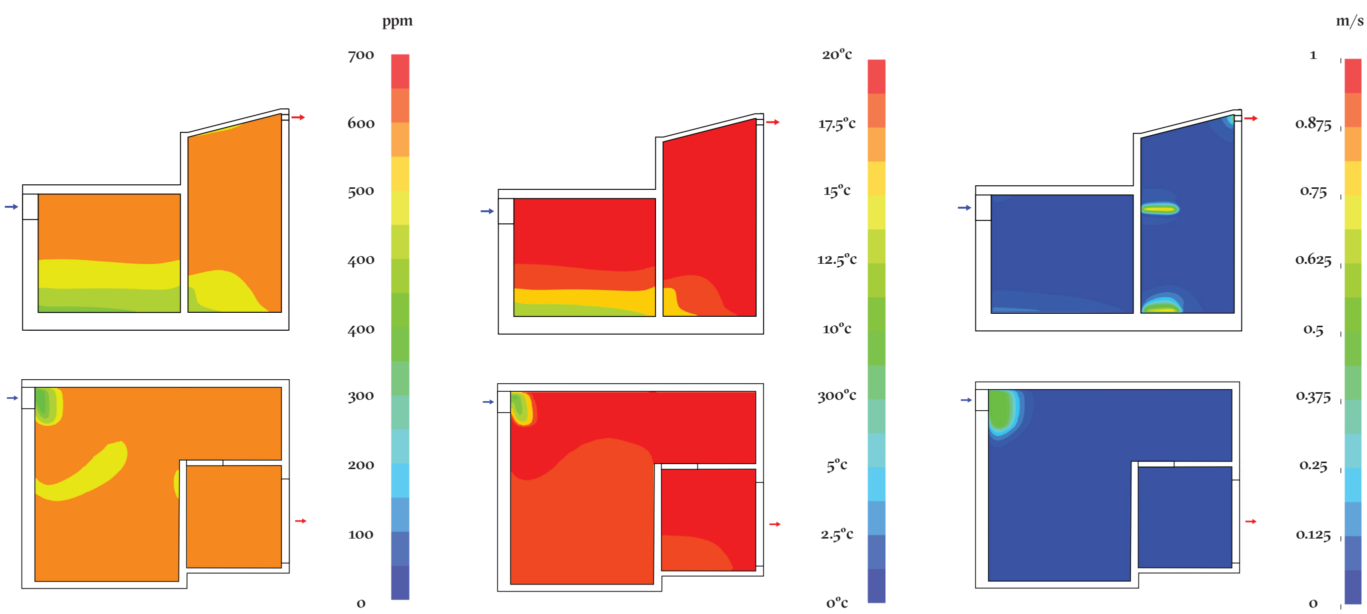




40 sec.

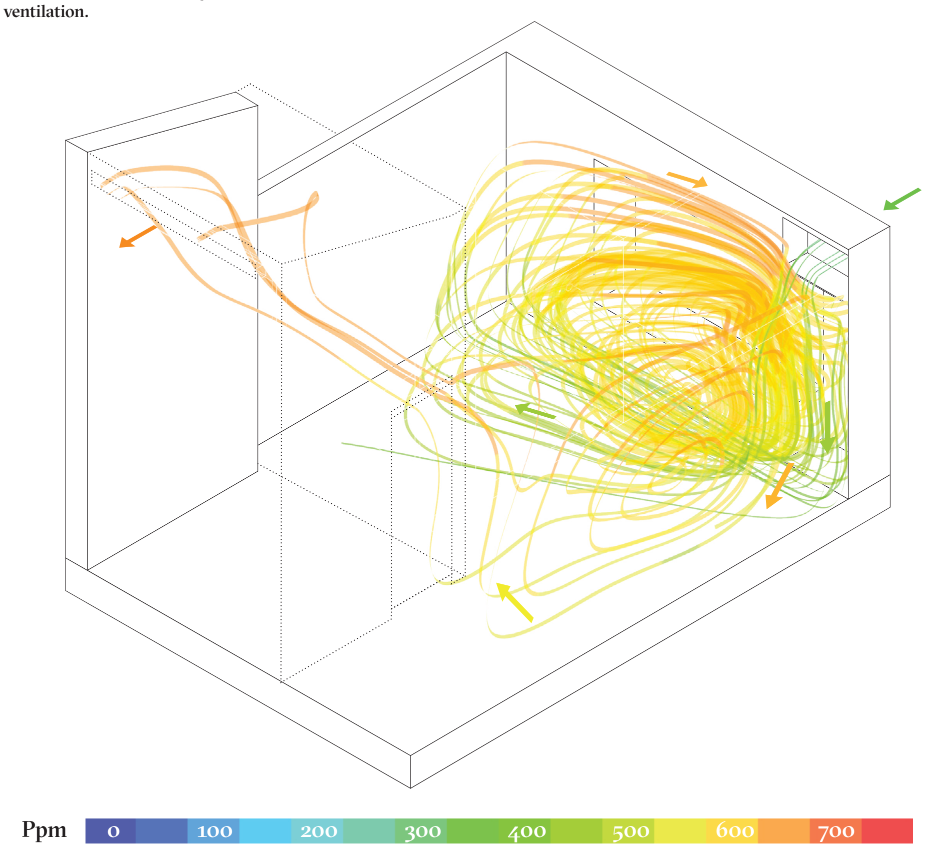
ill. 116.1 Ventilation of the guest room after 20 seconds of ventilation.

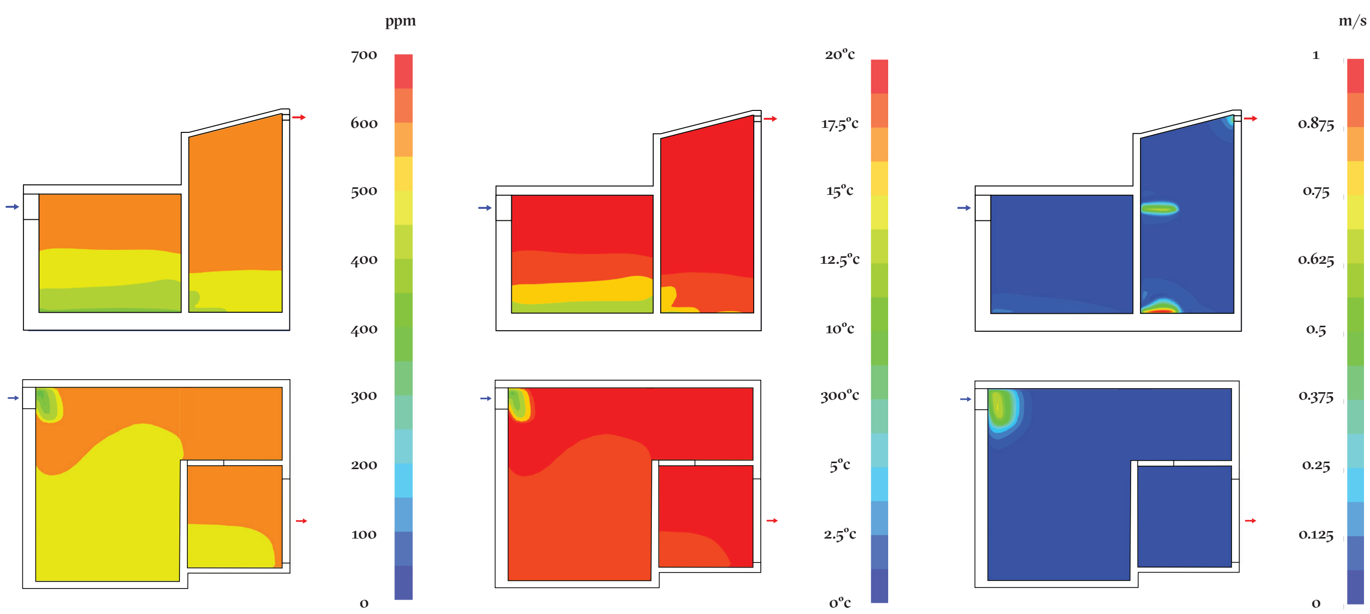




1 min.

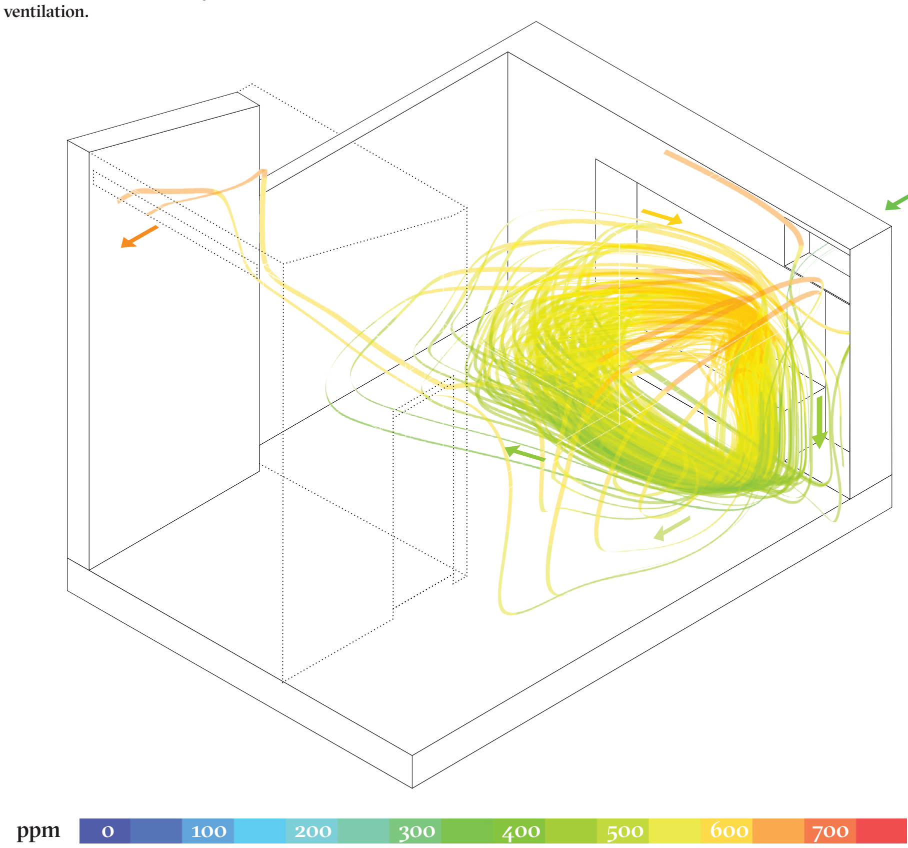
ill. 117.1 Ventilation of the guest room after 20 seconds of ventilation.

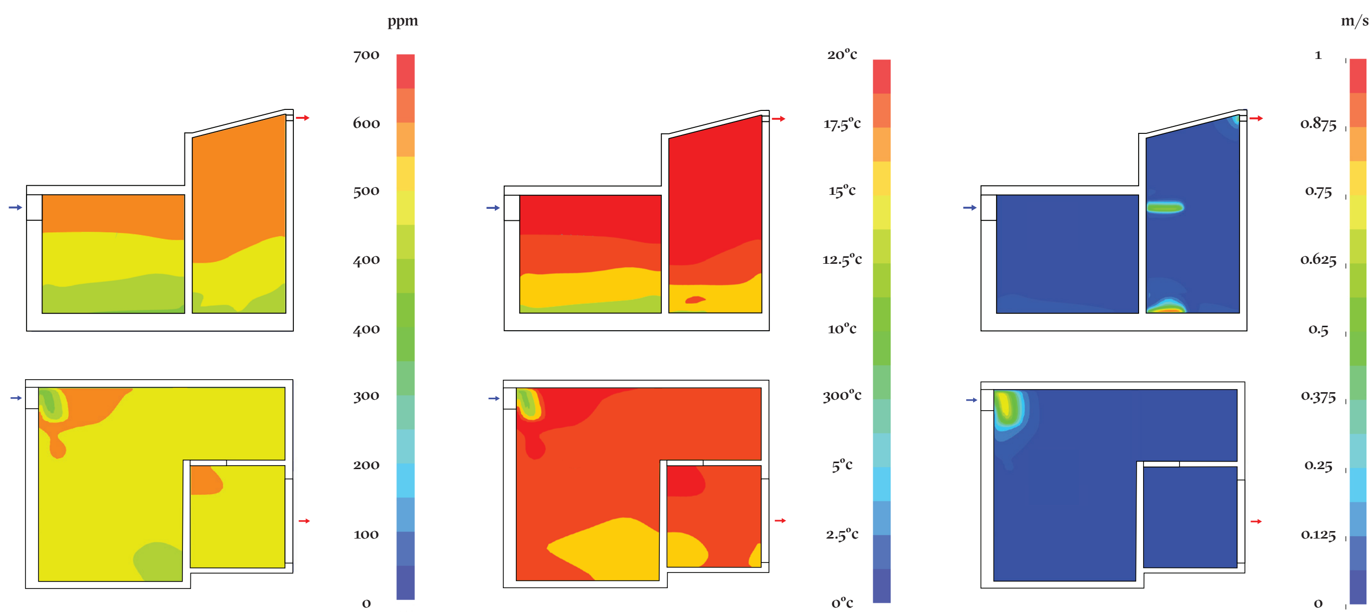




1min. & 20 sec.

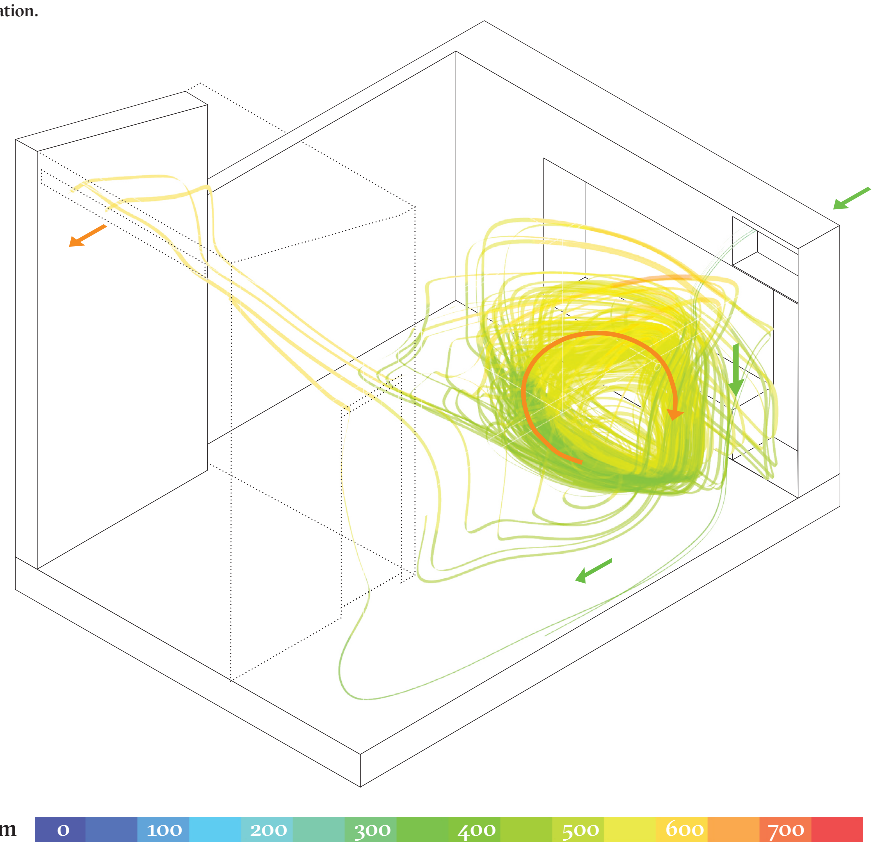
ill. 118.1 Ventilation of the guest room after 20 seconds of ventilation.

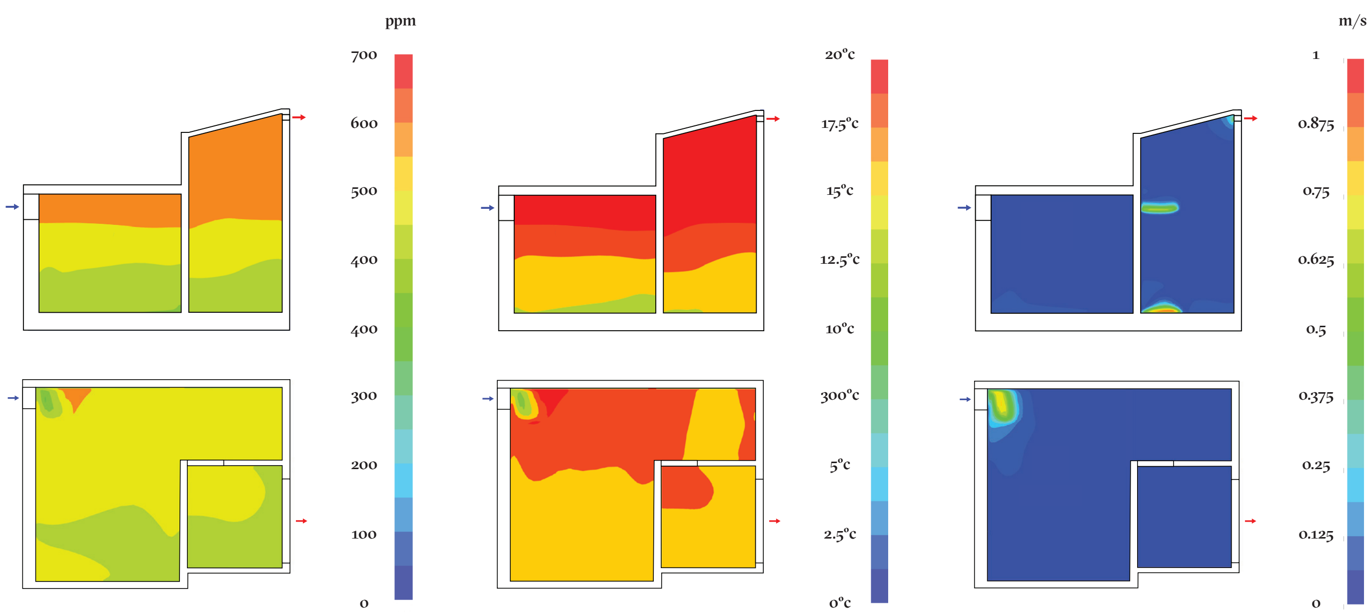




1min. & 40 sec.

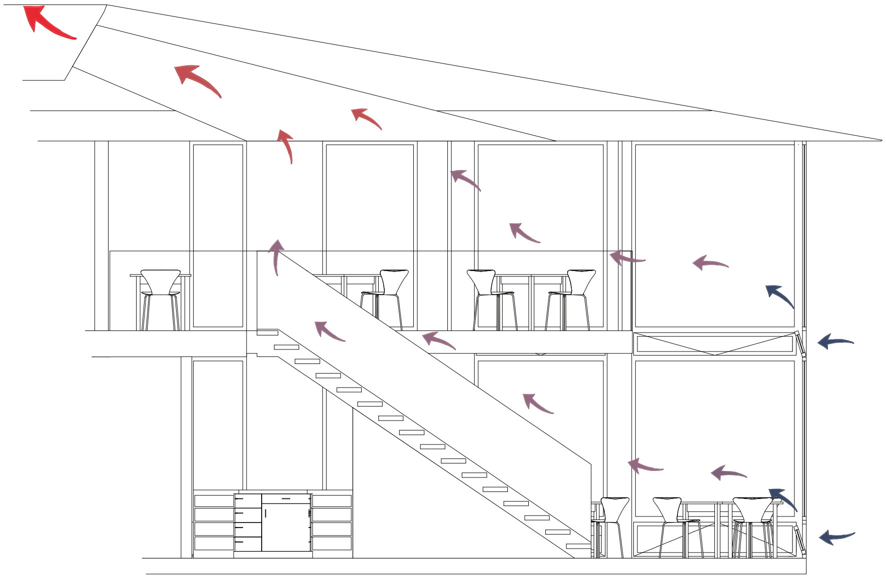
ill. 119.1 Ventilation of the guest room after 20 seconds of ventilation.





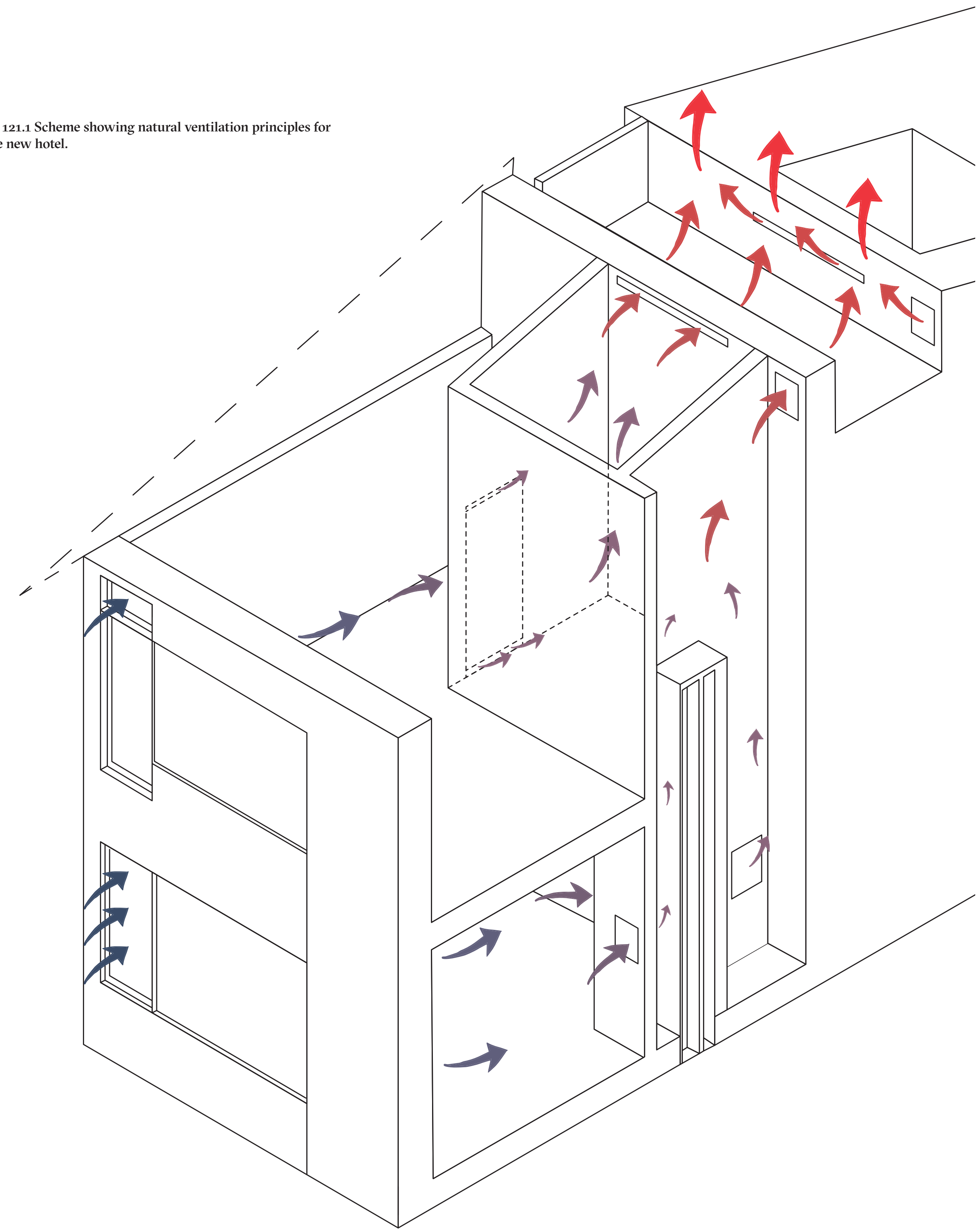
ill. 120.1 3d visualisation of the interior furniture in the guest rooms.

As far as the roof is consered, there are big light wells above the bathrooms. They have to meanings. One is with providing the room with a good light. Another is helping with the natural ventilation and stack effect.



ill. 120.2 Scheme showing natural ventilation principles for the new hotel in the dining area.

ill. 121.1 Scheme showing natural ventilation principles for the new hotel.

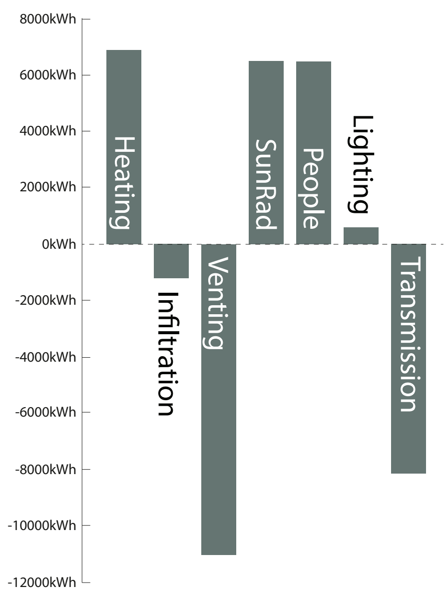


Performance

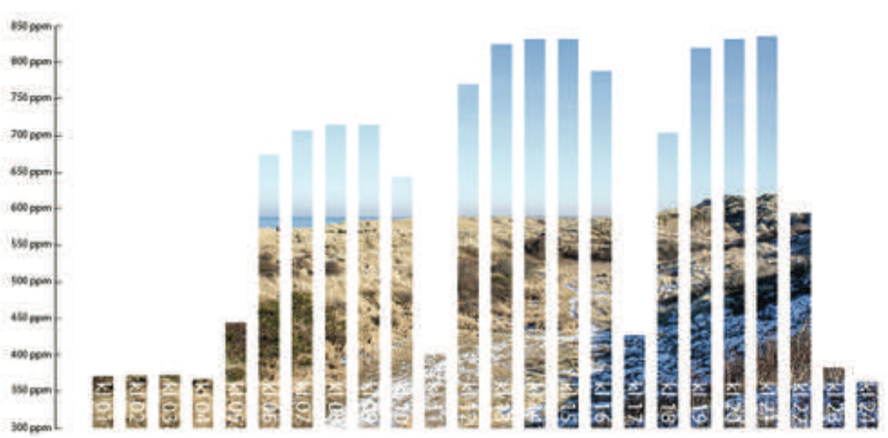
The building performance has been tested in BSim and Be15 software. First one is a Danish software used to analyse indoor environment quality. Second is used to check energy frame according to BR15 and BR2020.

For BSim simulation the two most problematic rooms of the building has been tested. First one is the dining room in the northern part of the building. The reason for choosing this zone was that it had big amount of glazing and large heat production from the people load. The dining room schedule was set up to serve for three hours three times a day with people coming in and coming out of this zone (since people has option to choose hour of heating the meal as well as it is being used for the guests who are coming to the hotel just to eat food) (ill. 122.2).

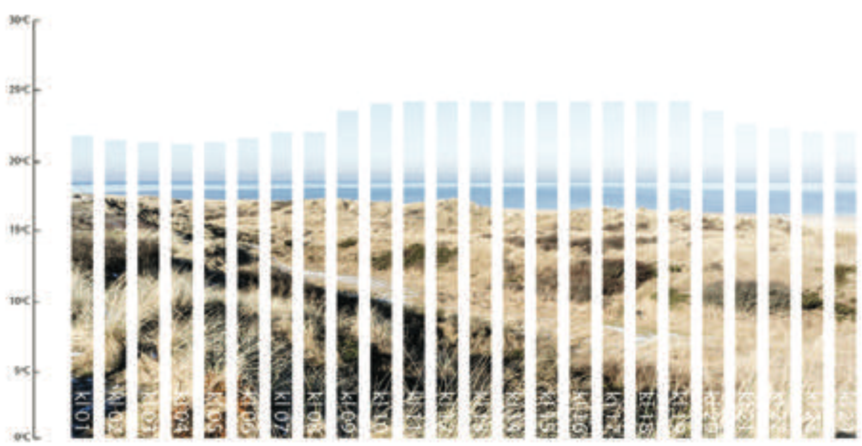
ill. 122.1. Scheme showing natural ventilation principles for the new hotel in the dining area.



ill. 122.2. Scheme showing natural ventilation principles for the new hotel in the dining area.



ill. 123.1. Scheme showing natural ventilation principles for the new hotel in the dining area.

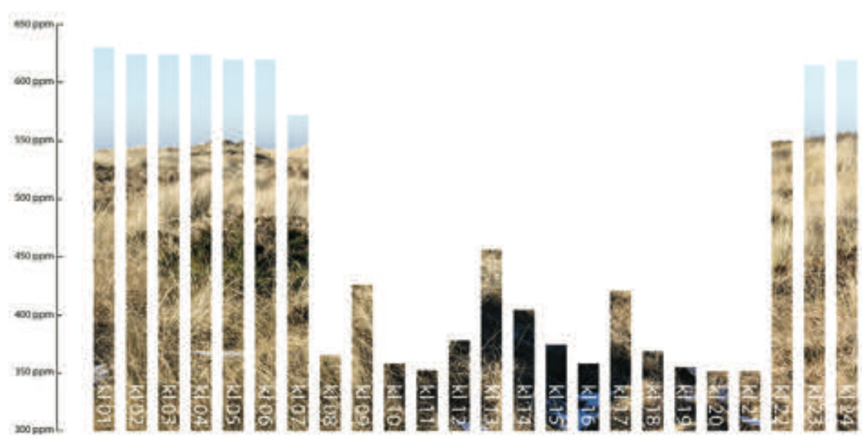


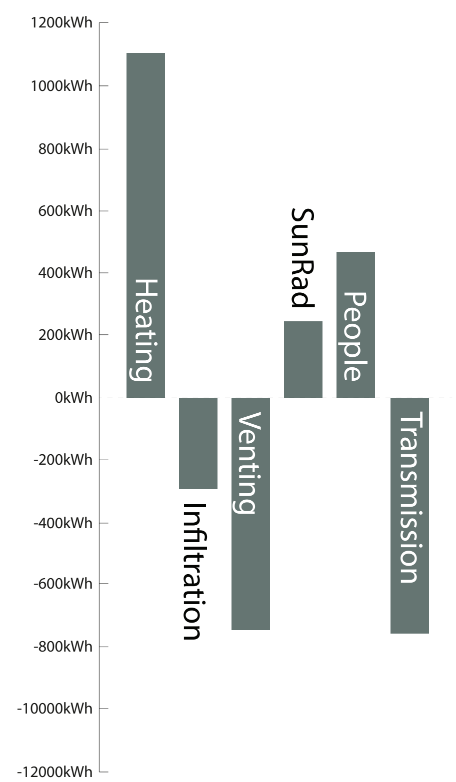
Another simulation was made on the guest room since this is the most important room for the guests. Simulation analyzed usage by two people (ill. 123.2).

Be15 simulation has been tested in two variations. First one was setup for original usage of the building – during the season only (from Easter till the end of September). Here two cases have been tested. One tried to use building without renewable energy production (ill. XYZ), second used solar panels on the roof top (ill. XYZ).

Second variation researched possible extension of the hotel use to the full year. Here also two cases have been studied (with and without the solar panels) (ill. XYZ and ill. XYZ).

ill. 123.2. Scheme showing natural ventilation principles for the new hotel in the dining area.





Heat pump
The hotel is heated by a ground source heat pump system. This type of heat pumps are using pipes in the ground to gather the solar energy stored in the ground. The position of the pipes can be seen on (ill.xx). Because the soil consist of mainly sand, a 25% enlargement of the system is needed. To run the heat pump electricity is needed and to combine the heat pump with solar cells is a great option.

Solar energy strategy

As far as solar panels are concerned, their efficiency has been based on estimations (of upcoming solar panels from Tesla company *(Looper, 2017)*. Their efficiency is being predicted on the level of 22%. There were few aspects of choosing Tesla's solution over standard panels.

Firstly, the company has freshly presented new product - Tesla Roof *(Tesla.com, 2017)*. Their revolutionary technology join both, solar panels with the traditional and modern tiling roofs. From ground level their roofs look normal. The only one way to see the solar cells is to see the panels when standing perpendicular to their surface.

Secondly, Tesla has also very efficient battery system for storing the energy *(Tesla.com, 2017)*. The project is strongly suggesting to use the whole roof surface for the solar panels. That means 1000m2. At one point this area looks big. Yes, there would be overproduction of energy, however there are two reasons why this strategy should be implemented in the new hotel. This energy could be sold to the grid. This could easily make the building reach not only net-zero energy level but make it a PlusEnergy building.

Thirdly, as mentioned, Tesla has a system of batteries that can store the energy. Since the Svinkløv Badehotel 2.0 would be (like old hotel) far from big cities, electricity failure is possible. Having stored energy would help to avoid situations when the building has no connection to the electricity.
Fourth aspect is connected to much bigger picture – the hotel could help with switching to electric cars (thus helping with switching to sustainable car solutions) by installing Tesla supercharger points for the guests.

At the end using whole the ecosystem from Tesla could help reduce energy costs, help being more independent on energy, reduce the costs of running the building and help the global movement of switching to the sustainable solutions.

Key numbers, kWh/m²

Energy frame BR 2015

Wihtout supplement	Supplement for special conditions	Total energy frame
30.5	0,0	30,5
Total energy requirement	¨	3,6

Energy frame BR 2020

Wihtout supplement	Supplement for special conditions	Total energy frame
30.5	0,0	20
Total energy requirement		-2,3

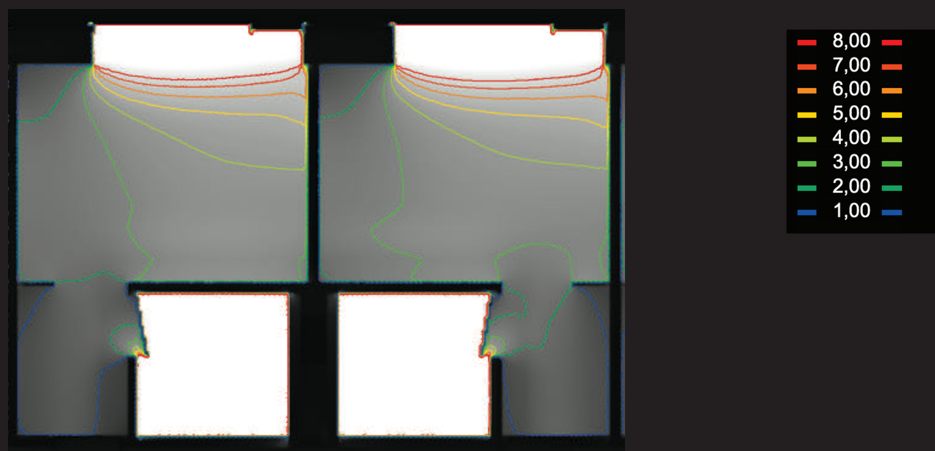
Contribution to energy requirement	
	0.0
Heat	-1.6
El. for operation of the building	7.5
Excessive in rooms	

Selected electricity requirements	
	1.6
Lighting	0.0
Heating of rooms	0.3
Heating of domestic hot water	8.0
Heat pump	0.2
Ventilators	0.0
Pumps	0.0
Cooling	37.8

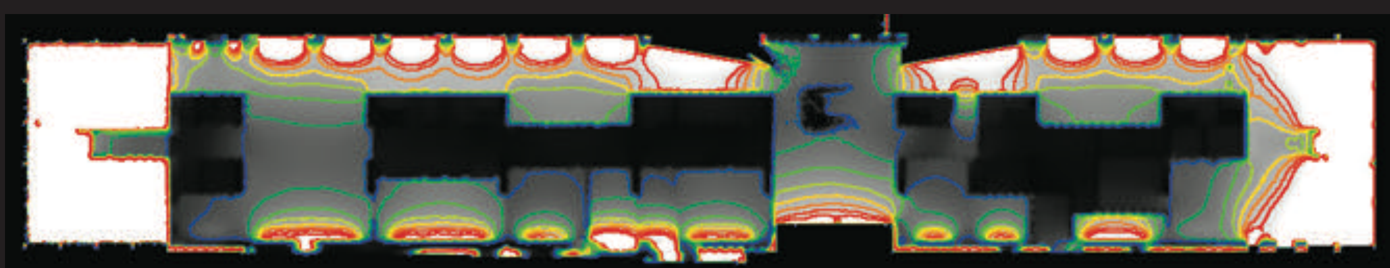
Net requirements	
Room heating	0.0
Domestic hot water	-1.6
Cooling	7.5

Heat loss from installations	
Room heatin	0.0
Domestic hot water	0.2

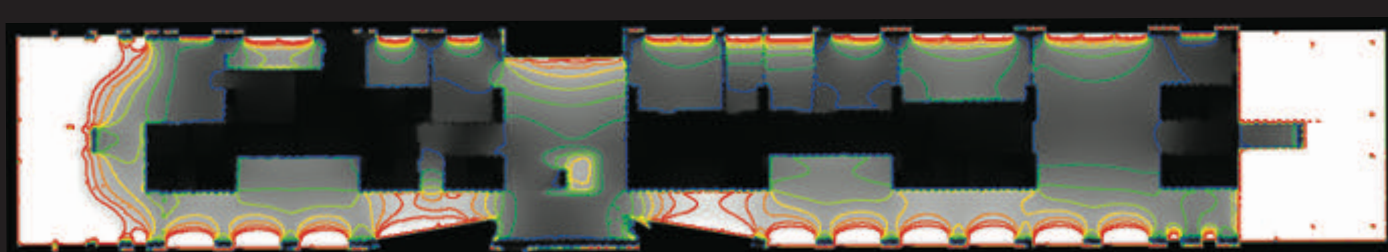
Output from special sources	
Solar heating	27.2
Solar cells	113.8
Wind mills	0.0



ill. 125.1 Daylight factor results for the guest rooms.



ill. 125.2 Daylight factor results for the ground floor.



ill. 126.2 Daylight factor results for the ground floor.

Program: updated

ENTRY

	Function	Size	Functional demands	Change comparing to original program
Entrance				
	Reception	63 m²	The reception include space for information, hall, shop. Must be close to the parking.	63 %
	Cloakroom	20 m²		100 %
	Storage	2-3 m²	For paper and other things	100 %
	Toilet	5.8 m²		145 %

ROOMS

Guestrooms				
	Double	21 m²	30 rooms.	115 %

COMMONROOMS

Living rooms				
	Hallway	217 m²		109 %
	Lounge / bar	87 m²		57 %
	Orangery	120 m²	Only accessible when the weather allows it.	80 %
	Toilets	21 m²		100 %

EMLOYEE AREA

Office				
	Manager office / Secretarial office	25 m²		125 %
	Accounts office	13 m²		130 %
	Housekeeping offices	13 m²		130 %
Break				
	Common room	32 m²	Including small kitchen	53 %
	Changing room	34 m²	Unisex with 2 separate rooms with showers	100 %
	Bedroom	16 m²	room for 2 personal (night sift)	100 %

DINING

	Function	Size	Functional demands	Change comparing to original program
Restaurant				
	Dining area	175 m²	View over the sea and nature	115 %
	Toilet	24 m²		120 %
Kitchen				
	Main kitchen	41 m²	6-7 cooks. The kitchen include space for dishwasher, preparation and servery	55 %
	Cold storage room	9 m²	For fruits, meat and etcetera	90 %
	Toilet	7 m²	With shower	175 %
	Day storage	12 m²		100 %
	Goods received	7 m²	Direct access from the food truck	70 %
	Changing room (for cooking purposes only)	1,5 m²		
	Small kitchen	12 m²	1-2 cooks. For preparation and pickling	100 %
	Storage	4 m²	For pickle product, jam and dry mush-rooms	22 %
	Bakery	11 m²		110 %
	Storage	18 m²	For foodstuff and cooler for cakes	90 %

VARIOUS

Housekeeping				
	Laundry/ironing room	22 m²	For washing machines and flat iron's	112 %
	Storage	10 m²	For clean laundry	100 %
	Utility room	4 m²		100 %
Technical				
	Technical room	70 m²	Ground source heat pump system and battery	100 %

ill. 129.1. 3D visualisation of the guest room.

Design process

‘Design
is not
just what it looks
like and
feels like.

Design is how it
works’

- Steve Jobs (Walker, 2017)

Phase #1
Theme research

The choice of the site came just after the fire of the Svinkløv Badehotel. The reason for doing so was connected with an opportunity to work with a very fresh example of building that stopped to exist. However, the very first concept was about the sea and the shore research facility at the site of the old hotel. The goal was to present a concept, in which a new function replaces the old one, giving a new value to the site and hopefully to the Danes and the science society. Soon after the beginning of the work on the thesis, its au-

ill. 132.1. Stormy weather at the Svinkløv beach. Fish boats on the land in the background.

thors decided to start with an analysis of the site. During the excursions, a phenomenological approach was used through observations of the site and the context. Further investigations of the site have been done by using both qualitative and quantitative analysis on the history of place, mappings and the studies of the mentioned site, the nature, the climate and the users.

While doing so, the history of Svinkløv Badehotel showed that this was an important place for the Danish society. The interviews with the hotel's board representatives showed that the site owners cared not only about the reviving this place, but also wanted to improve the things that did not work in the previous hotel, including a focus on a sustainability of the building (Royberg, 2017). This showed that the owners paid more attention to the importance of the place itself than to economics.

The next step was to visit the potential users of the firstly proposed the Sea and the shore research facility. One of the key moments of this phase was the visit to the Nordsøcentret Nordsøen Forskerpark in Hirsthals, Denmark, where a representative of its board was interviewed. It turned out during the interview that the choice of the new function for Svinkløv was missing. Beside the biggest ocean research facility in this region of Europe, which is the mentioned in Forskerpark, there is also a smaller one in Hanstholm. Hirsthals is approximately 60 km from the site, and Hanstholm is approximately 45 km from the site. There is no need for a new facility of the sea and the shore research in the area between these two cities. Moreover, there is nothing specific from this function point of view in the area of Svinkløv, both on the land and at the sea *(Laursen, 2017)*.

At the same time, more and more research was done on the old hotel. Finally, a decision was made to abandon the sea and the shore research facility topic. The importance of the Svinkløv Badehotel created the need to try to bring back the hotel, but under the specific case study – what if the site owners would like to wait a few years with the rebuilding of the hotel, so they could try to get the new local plan for creating a new building? As the site would stay the same, there was no need to change the analysis. In fact, these data have been only enriched. This was the time when the idea of presenting a new hotel emerged: the idea of Svinkløv Badehotel 2.0.

Phase #2
Volume studies

This phase researched the relation between the building forms, their volumes and the site. This process was based on the previous analyses of the site and its surroundings. These considerations were giving different possible solutions for the site. The phase was very important for the whole design process, since it concluded with the volume strategy that met few of the design criteria.

Concept A (ill.134.01) proposed to keep the envelope tight, but with a space for giving some expression to the building. The guest rooms were positioned on the top of the building with a view towards the north and south. The living rooms, the common rooms and the kitchen were located in the lower part of the building giving a view towards the sea. Unfortunately, some of the rooms would need to be undergrounded.

Concept B (ill.134.02) used a technical-only approach for the complex. It used natural ventilation consideration regarding venting the guest rooms. The right scale of the courtyard system would give an opportunity to make ventilation without risking the drafts in the rooms during a windy weather. The rooms would use a niche for this purpose. The cons of this idea were related to the views from different functions. This concept was against the design criteria regarding the need for a view towards the nature and underlying it. Instead, it produced a lot of obstacles and a confusion regarding the common rooms and how to make people go there.

Concept C (ill.134.03) was a much simplified composition with one courtyard. Unfortunately, it would mean that still many functions would be disconnected from the experience of the nature.

Concept D (ill.134.04) was the first one to use what thesis' authors call the "smart envelope" approach. Since majority of the functions are being used only during a summer season, some of those functions have been spread loose on the site. In this case, these were the guest rooms. Unfortunately, this reduces the opportunity for people to socialize with each other.

Concept E (ill.134.05) tried to put the all the functions on the northern edge of the plot, so the majority of the rooms would have the view towards the sea. Unfortunately, the amount of area needed for the building would not fit on this boundary. It would also create an extremely long building (more than 140m long).

Concept F (ill.134.06) is a small iteration, where all the guest rooms were placed on top of the building.

Concept G (ill.134.07.) proposed a building with the same footprint as the old Badehotel. As the old hotel used a basement for over 1/3 of the functions, in the new building it would need three stories to be built in the new hotel. Moreover, the new hotel would be pretty cramped with the position of the new functions.

Concept H (ill.134.08.) was trying to combine two concepts together – one regarding the view from the dining room and the common rooms towards the sea, while giving the view from the rooms towards the west and east with the same amount of view access towards the nature and the sea (the position of this part would be north-south). The problem was that it created quite a big envelope and the building that started to take a lot of space on the site.

Concept I (ill.134.09.) proposed a more simple approach. Again – to give an equal view to everybody in the guests' rooms (the position of the building north-south), and then to put the common room at the very north of the building, so the people could have a panoramic view towards the sea and nature on the west, north and east, while placing all the other functions slowly towards the south.

Concept J (ill.134.10.) was proposing idea behind having big rood over all the functions. Unfortunately the amount of different area would not fit inside the building envelope when the site shape and size would be taken into consideration.

Concept K (ill.134.11.) was a sketch iteration of Concept A.

Concept L (ill.134.12.) was a sketch iteration of Concept D investigating spaced betwen each ot he units in relation also to the larger, central part of the hotel.


Ill.134.01. Concept A.


Ill.134.02. Concept B.


Ill.134.03. Concept C.

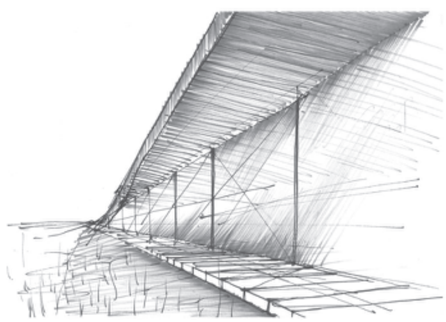

Ill.134.04. Concept D.

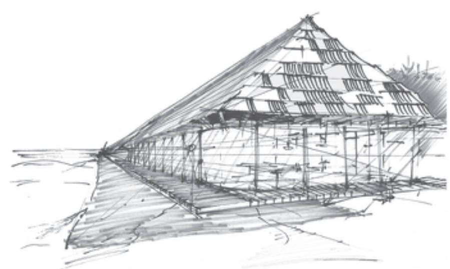

Ill.134.05. Concept E.

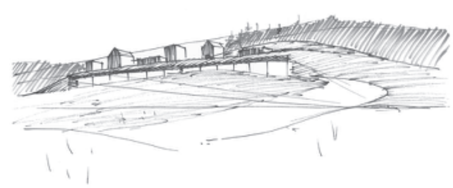

Ill.134.06. Concept F.

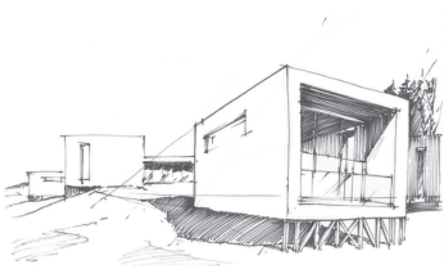

Ill.134.07. Concept G.


Ill.134.08. Concept H.

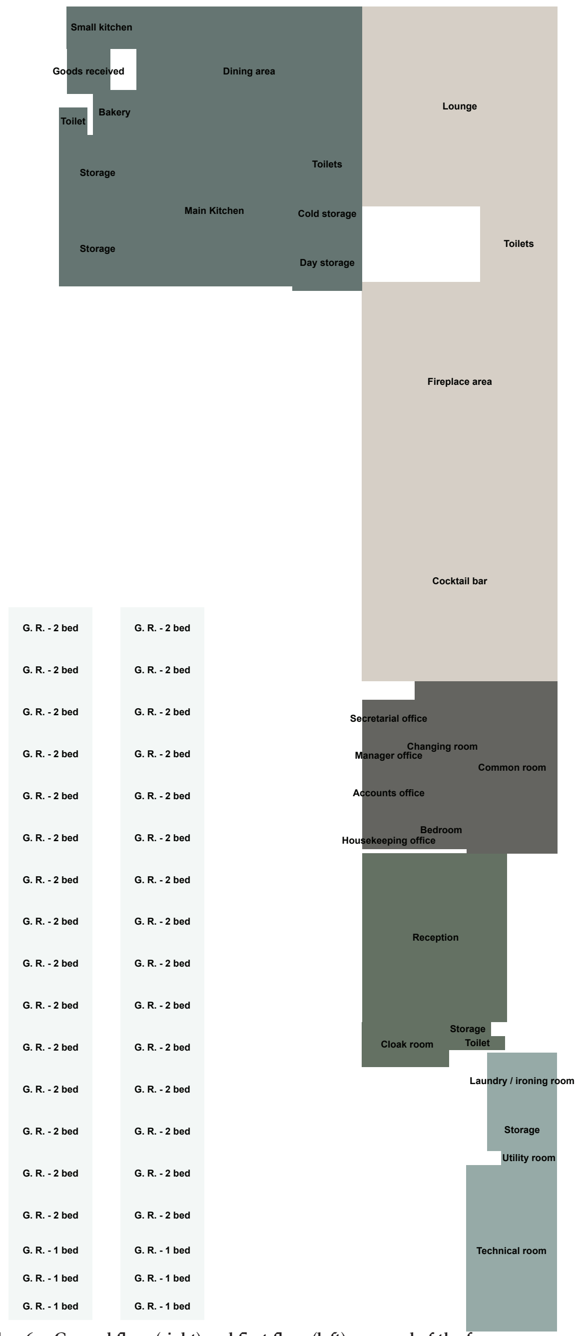

Ill.134.09. Concept I.


Ill.134.10. Concept J.

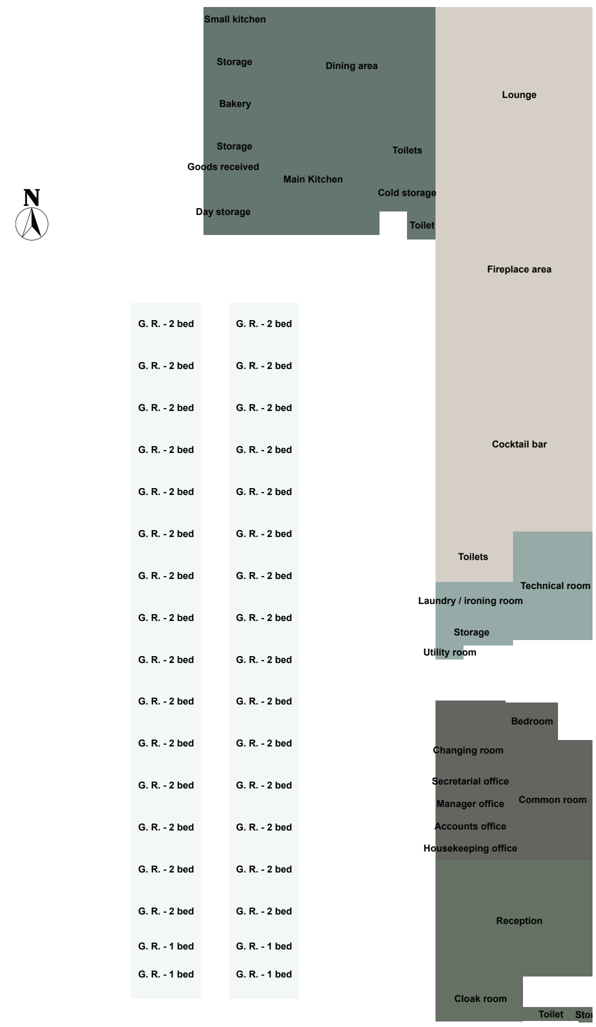

Ill.134.11 Concept K.


Ill.134.12. Concept L.

Phase #3 *Further volume development*



ill. 136.1. Ground floor (right) and first floor (left) proposal of the functional program using maximum area predicted for the building. Scale 1:500.



ill. 136.2. Ground floor (right) and first floor (left) proposal of the functional program using minimum area predicted for the building. Scale 1:500

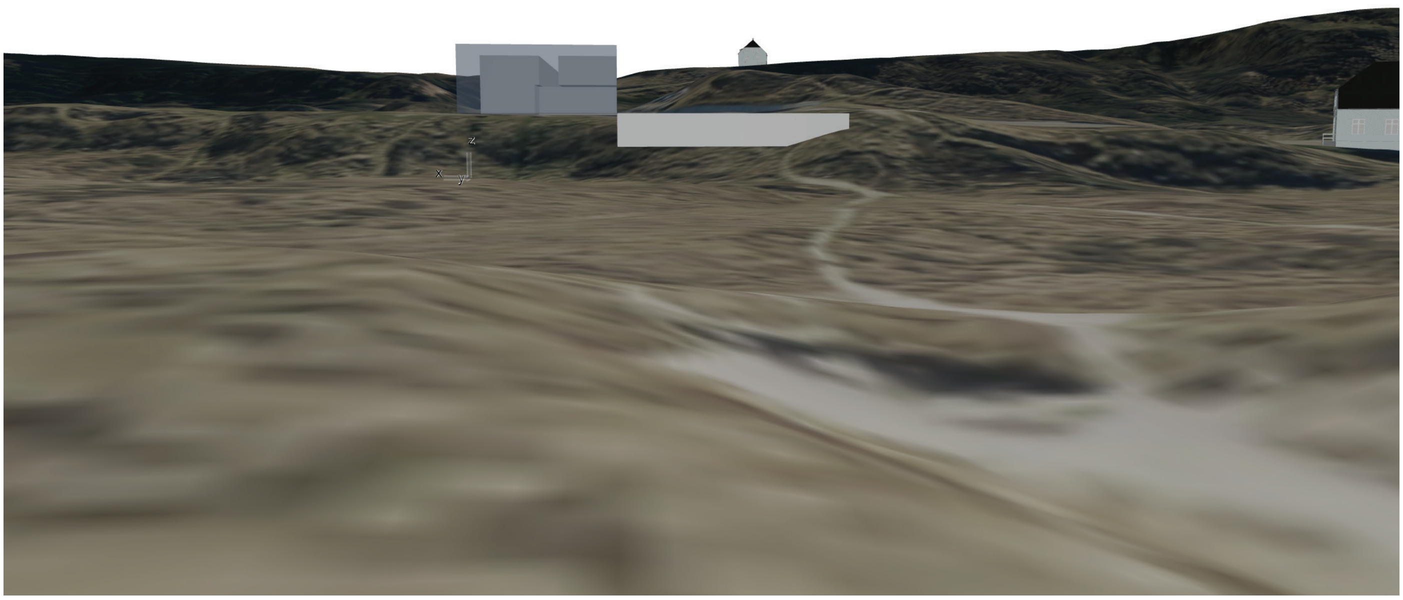
Working with the volume

Concept G was taken into a further investigation. The building would be made along a north-south direction. During the design development, the design criteria were taken fully into consideration. As the common rooms were very important for creating the social spaces in the hotel, at this point they were moved towards the north to have the best view from the hotel (towards the sea). The idea of this space was to create a panoramic view towards the west, north and east, so that the nature and the sea could be complemented. However, during the investigation of the spaces, it turned out that the dining area would be placed deep in the building. The problem was that in the previous hotel, like mentioned before, the restaurant was very famous for its amazing cuisine, and also for the view from the dining room *(Kragh Jespersen, Topperzer and Sandvej, 2008)*. The change of the position of the dining room would be a bad idea for the concept, as the previous location of it was loved so much both by the hotel's users and the guests. This is when the idea appeared to move the kitchen next to the common room on the north (ill. 136.1). However, it would be lower and closer to the nature. People coming to the restaurant from Svinkløv would use the access from the sea side; however, the hotel's guests would have a direct connection from the common room by using the stairs or a ramp going lower to the dining area. The reception area was placed in the southern part of the building. In the old hotel there were 25 rooms placed on the first floor and 4 on the main floor. The concept predicted two versions of this solution.

ill. 137.1. Aerial view of the building volume.

- Staff area
- Reception area
- Dining / kitchen area
- Various
- Common rooms
- Guest rooms

ill. 137.2. View from the beach towards the building volume.



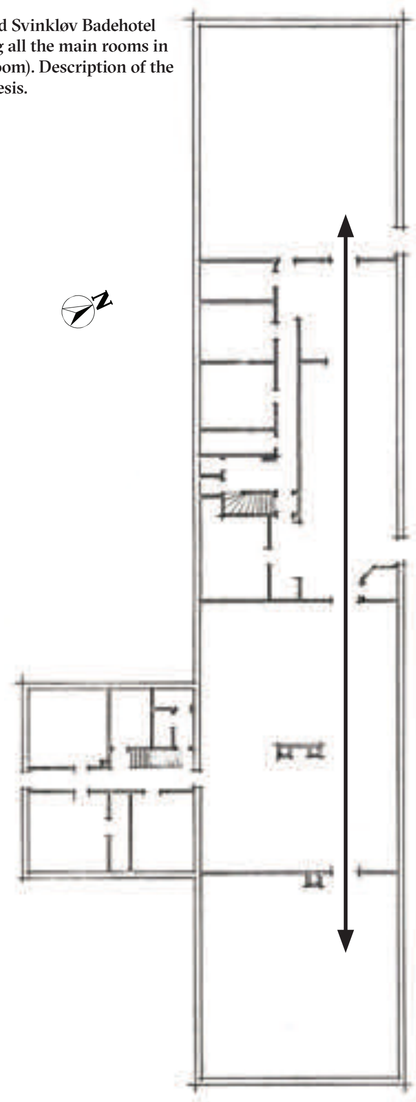
One - using the maximum floor area from the analysis (1.904 m2); and another - using the minimum space needed (1590m2) (ill. 136.2). This was the first time there was a program area analysis done regarding the ratio between the possible variations of the building. However, there was an idea to keep to the worst case scenario - the biggest program - since the building can always be done smaller.

Although this concept was creating a very interesting façade expression when looking at the building from the north, it added confusion to the project. Firstly, the hierarchy of the functions was not clear anymore. Secondly, since the building was already occupying some space, it was quite disturbing for the volume to spread in the terrain, when there still was a big long dominant volume standing next to the dining area. It was also problematic to solve the light access to the kitchen and its supporting rooms not to mention the goods delivery. It could be solved, of course, by lowering the terrain and adding a road on the side of the hotel. Unfortunately, this would affect the surrounding terrain too much. This made the concept to change the focus of the area distribution throughout the building: how to solve the need to have really good views from the common rooms and the dining area without the element of a competition between those two?

This is where the review of the analysis of the previous hotel's qualities came handy. Since the best view in the old hotel was in the dining room, the concept started to focus on this matter. So, the decision was made to make the dining area have the best view possible in the hotel: a panorama towards the west, north and east. This meant that the room and supporting areas (like the kitchen, the bakery and the storage) should be placed in the northern pole of the building. Since this place would be used for dining and enjoying the view, there was an idea to put the big common room in the opposition to the place of eating – in the very southern part of the building. Thus, the guests and the staff could enjoy the sunlight from the south and also have a view towards the nature, even if it would be rainy and very windy. This also made the building very simple in its form. A pure, long cuboid volume in the terrain (ill. 138.1). Since the previous idea of having the guests' rooms with the similar view quality on the first floor was working so far, there was a decision made to keep them there untouched at this point.

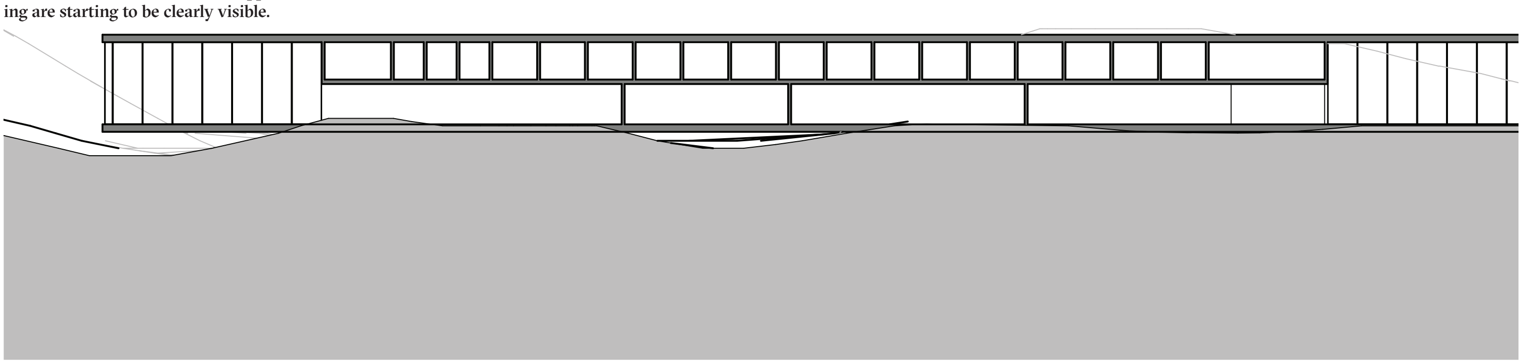
Later the idea of the reception being in the heart of the building was also taken back from the old hotel (ill. 138.3). Moreover, the project has been inspired by the layout of the common rooms in the old hotel - the common rooms were on the main floor and all the connections were made through them. That is why the new proposal is trying to recreate this idea (ill. 138.2). The solution gave the project a more solid expression and started to reuse the good qualities of the old hotel, according to the design criteria. Still, at this point, it was too early to predict if there would be no major changes in the volume, since the project would need to switch to a more detailed design with planning the connections between the functions. For example, it was a question if the project could handle to solve all the kitchen supporting rooms like the bakery, the small kitchen and others, where the design criteria set the ›

ill. 138.1. Ground floor plan of the old Svinkløv Badehotel showing common rooms connecting all the main rooms in the groundfloor (including dining room). Description of the rooms in the Analysis part of the thesis.



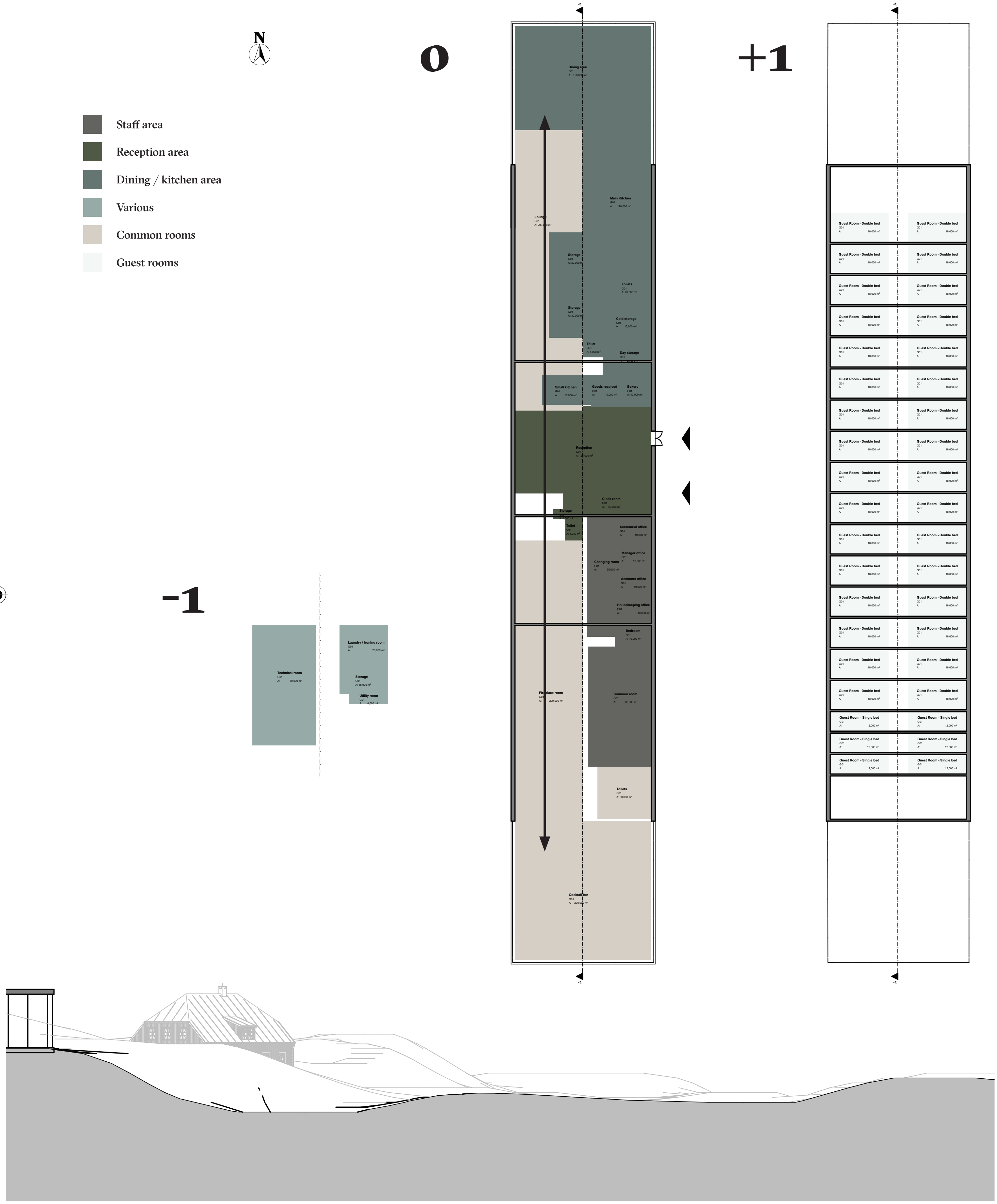
Cross Section

ill. 138.2. Cross section through the building showing cuboid form starting to develop. Two stories high dining area and common room on the opposite ends of the building are starting to be clearly visible.

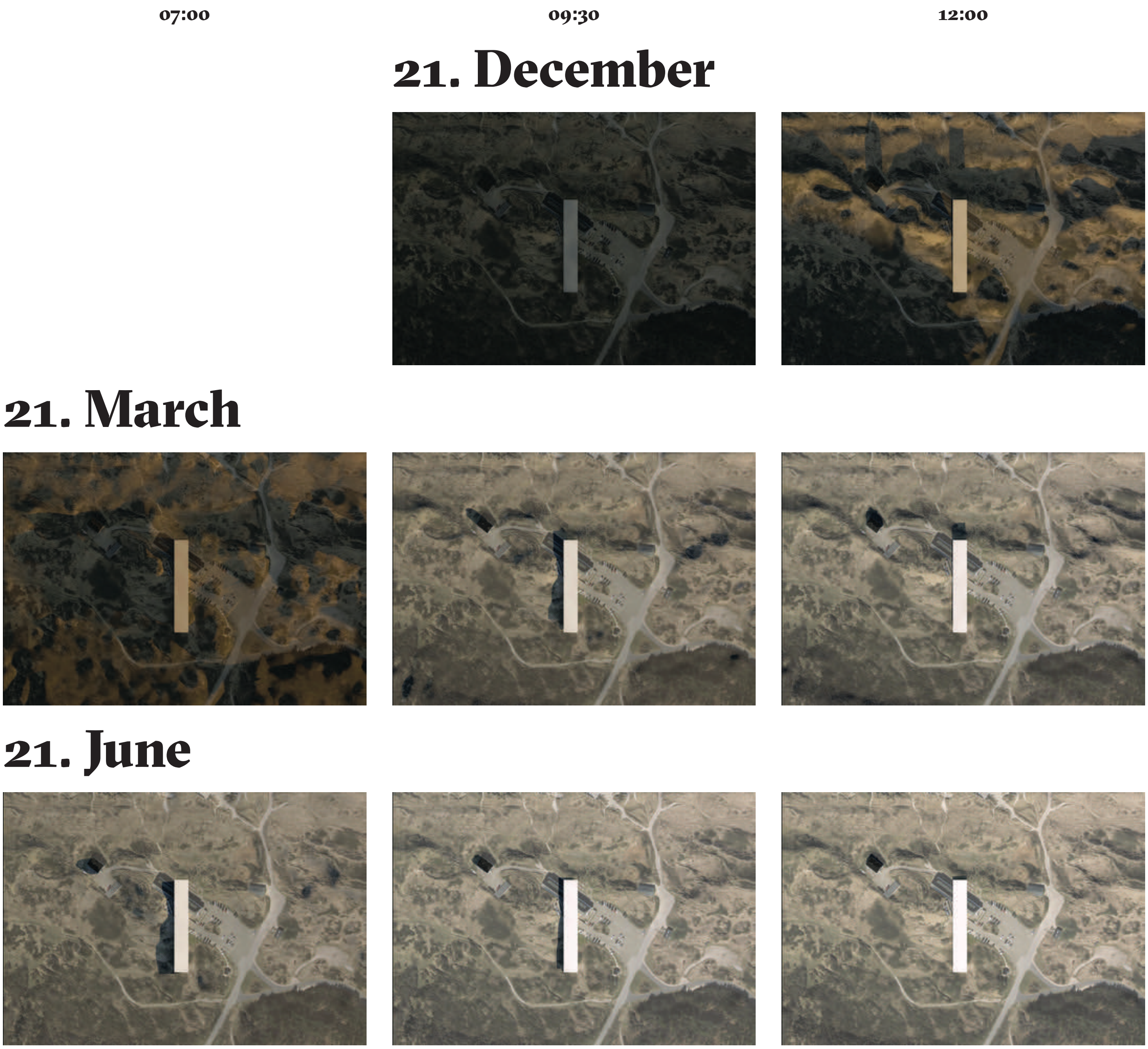


Phase #3: Further volume development

ill. 138.3. Plans of the concept development.



ill. 140.1. Sun studies of the developed volume.

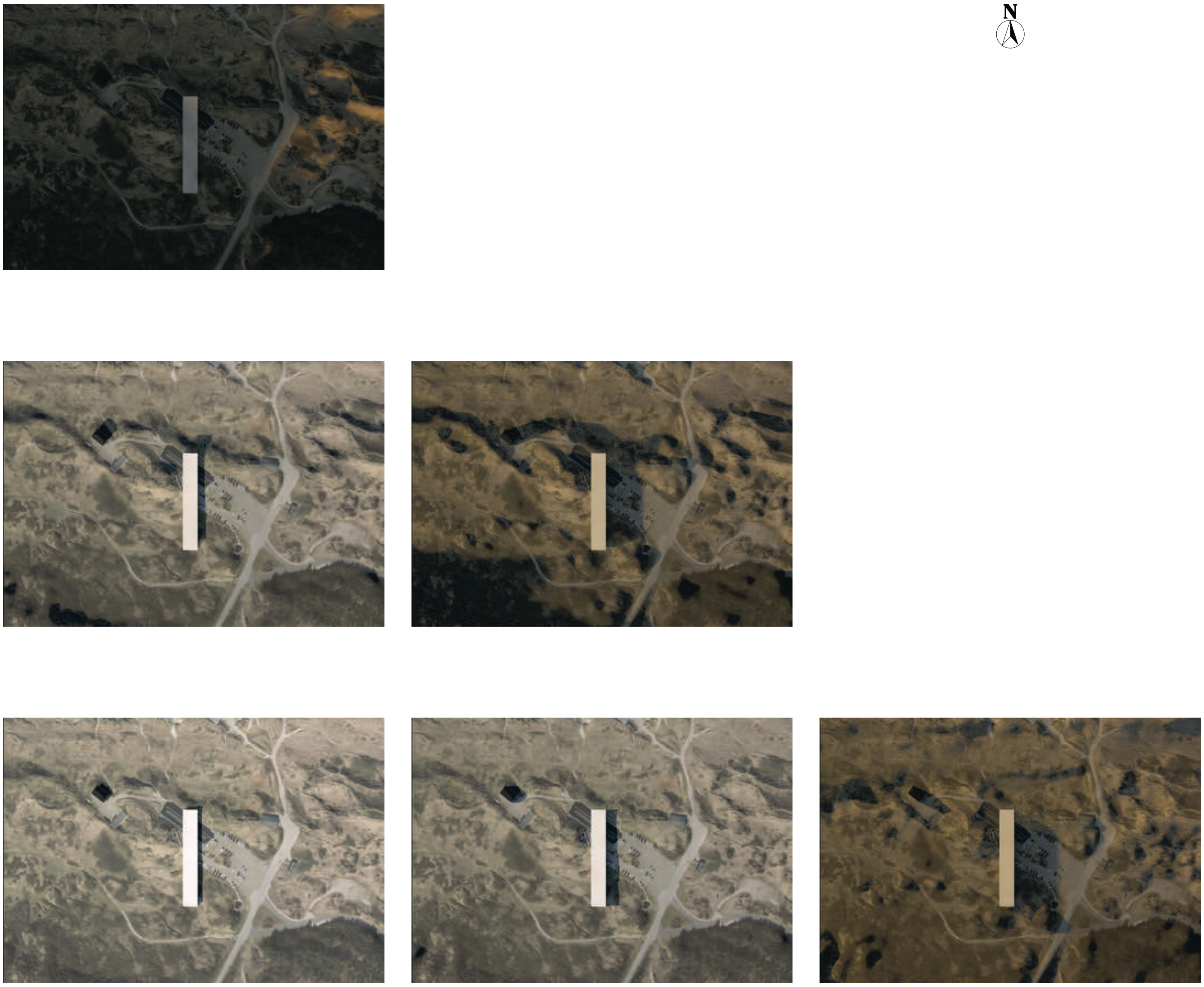


daylight factor at the level of at least 3%. A similar case would need to be solved in the staff area. When it comes to the guest rooms on the first floor, at this time their number was still 36 (in total). However, a lack of the detailed plans, walls, staircases were generating questions if their number could even fit into the current building footprint. Also the technical aspects started to emerge regarding the handling of the unheated and heated area during the winter time. At this point there were three clear heated zone-blocks. The reception, the staff area and the part of kitchen area (especially the small kitchen which is meant to be used during the winter to prepare chocolate, chutney and jams for the season).

The sun studies

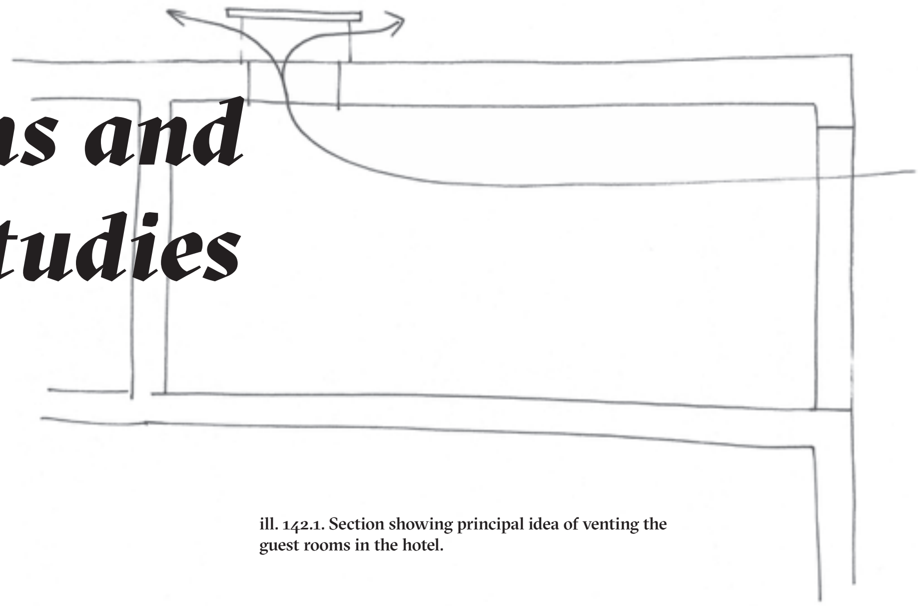
At this point, the last thing to do before proceeding to another phase, was to check the sunlight simulation regarding the casting the shadows on the terrain and receiving a sunlight. The test had been done on 21st of December and 21st of months from March to June. The reason for such analysis was to check the day with a smallest amount of the sun during a year for the purpose of winter use of the building (when the staff is preparing the food and the hotel for the summer season). Regarding the hotel's guest, an analysis from March to June had been done, since the hotel used to run from the Easter till the end of September. The main goals were to check the light for breakfast, lunch and dinner times; and the outdoor area was checked too. At this point, the idea of having morning and afternoon terraces came to life. In the old

14:30 **17:00** **19:30**

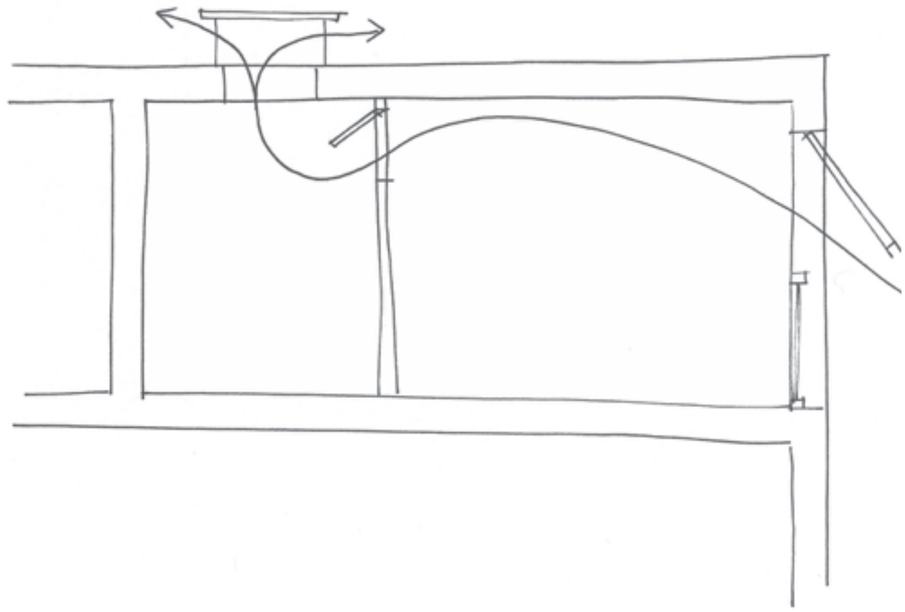


hotel, it was very popular to gather together outside and enjoy watching the sun set. This idea could be also used later on in the development of the design. The simulation showed exactly the same data as the preliminary sun studies in the Analysis chapter. Even though in the above shown simulation the last study of light on 21st of June ends at 19:00, there is still plenty of time before the sunset which starts around 22:23.

Phase #4
Initial plans and technical studies



ill. 142.1. Section showing principal idea of venting the guest rooms in the hotel.



Natural ventilation ideas

The next phase used the gathered data so far: mainly the volume, the orientation of the building and the distribution of the functions in the building. Since the idea behind the guest rooms was pretty fixed (regarding their position in the building), the next step was to solve it and actually check how much space the guests rooms will need. This was important, since the rooms need more space, they will affect the ground floor's rooms. The thesis is trying to research natural ventilation as a foundation for this building. Each room should be ventilated using this solution. There were few aspects that needed to be taken into consideration. For example, like mentioned in the design criteria, the system should be easy to use for even inexperienced users. At the same time, the building should keep its volume tight and envelopes small regarding the sustainability. As the site is very windy throughout the year, there should be no problem with exhausting the air from the building through the pressure difference around the building's envelopes. It sounded easy, but much harder to execute.

As mentioned before, the site is windy. In this case, the hotel could use the wind blowing towards the façade by letting the air inside, go through the guest room and exhaust by the opening in the roof (ill. 142.1). In case of the guest room, it could use a skylight inside the room. Since the room is pretty small, it should not be placed above the bed. Placing an opening above the sleeping area would only cover a small part of the room (for example, 2 meters) between the inlet and the outlet. However, each of the room will contain a bathroom as well. This is the place which generates a big amount of heat and moisture twice or even more times during the day. Moreover, the bathroom should be ventilated more when the shower is used.

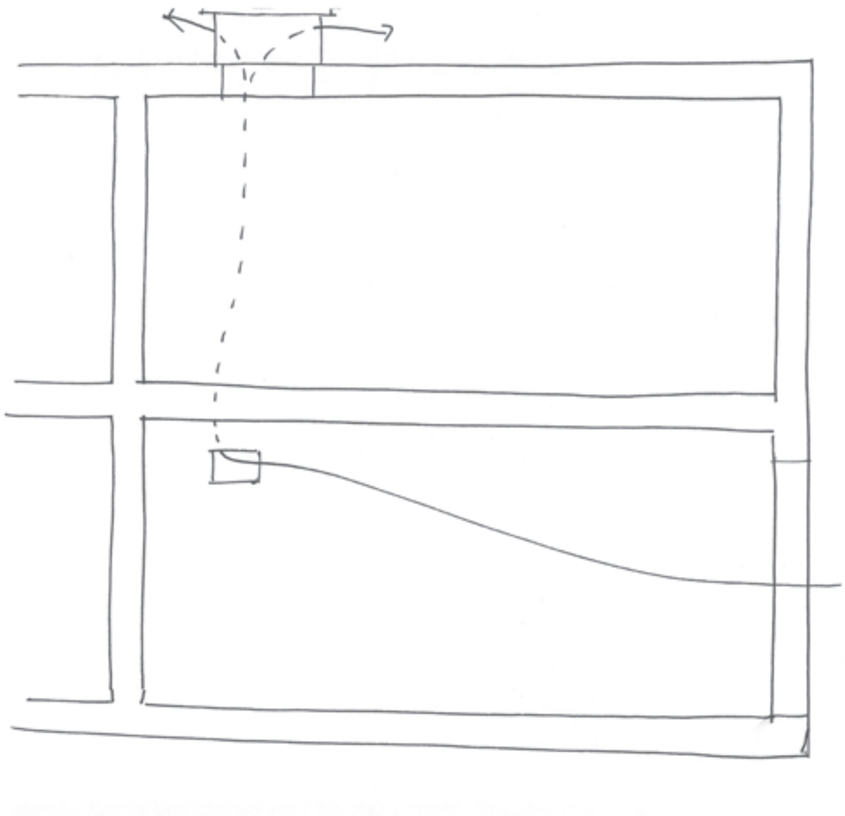
Fresh air could go into the room, getting through it to the bathroom and then be exhausted with the heat and moisture from the building by a skylight or another opening in the roof. As people usually take a shower before going to sleep in the evening or in the morning, they can improve ventilation of their guest room while using the bathroom. For example, during the evening they could take a shower and ventilate effectively the room before going to sleep.

However, there are three main problems with implementing this solution.

First of all - the inlet. There are two extreme situations that can appear. One is when the wind is too strong, and there is no way to open the window. In this case, such a window should have its own small system that allows getting fresh air inside through the frame. Another example is when the wind is blowing from a different side of the building, so actually there is suction on this site of the building. How to force then the air to go inside the room?

The second problem of using this solution is the outlet. How to make the air go through the bathroom? What if the wind is blowing in the direction of the outlet? How to be sure that the air always will go out through that opening and will not create a reverse system, when the air from the bathroom (with all the moisture) is being led to the room and then exhausted through the façade. There is a risk that some of the moisture will stay in the room and will penetrate the furniture, walls and roof.

The third problem with such a solution is in the use of the bathroom. If there are two peo-



ill. 142.2. Section through two floors. Illustration shows the idea behind venting the ground floor.

ple in the guest room – one sitting in the bed area, and another one using the bathroom, then how to avoid having uncomfortable situations coming from using the toilet? It is not only the sound, but also the smell that can affect the bedroom area when the opening between those two rooms is not shut.

These problems will be solved in the further development of the project. However, as for now, two first ones are the most crucial for the natural ventilation to work. So, basically how to force the air always go the way, as it is intended? This is the goal at the current point: which is always to have the exhaustion of the air through the roof.

But so far, the ventilation problem is all about the guest rooms, which are placed on the first floor. What about the ground floor then? Well, it turned out that by creating an underpressure on top of the roof there is forcing the air to leave the building that way, it can be used for ventilating the other rooms in the building as well. For example, the air coming through, for instance, the windows of the manager's office, could also be forced to leave the building through the shaft that will already contain ducts for the bathrooms upstairs (ill. 142.2). After all, there will be a lot of the guest rooms in the building that will need a lot of ventilation shafts.

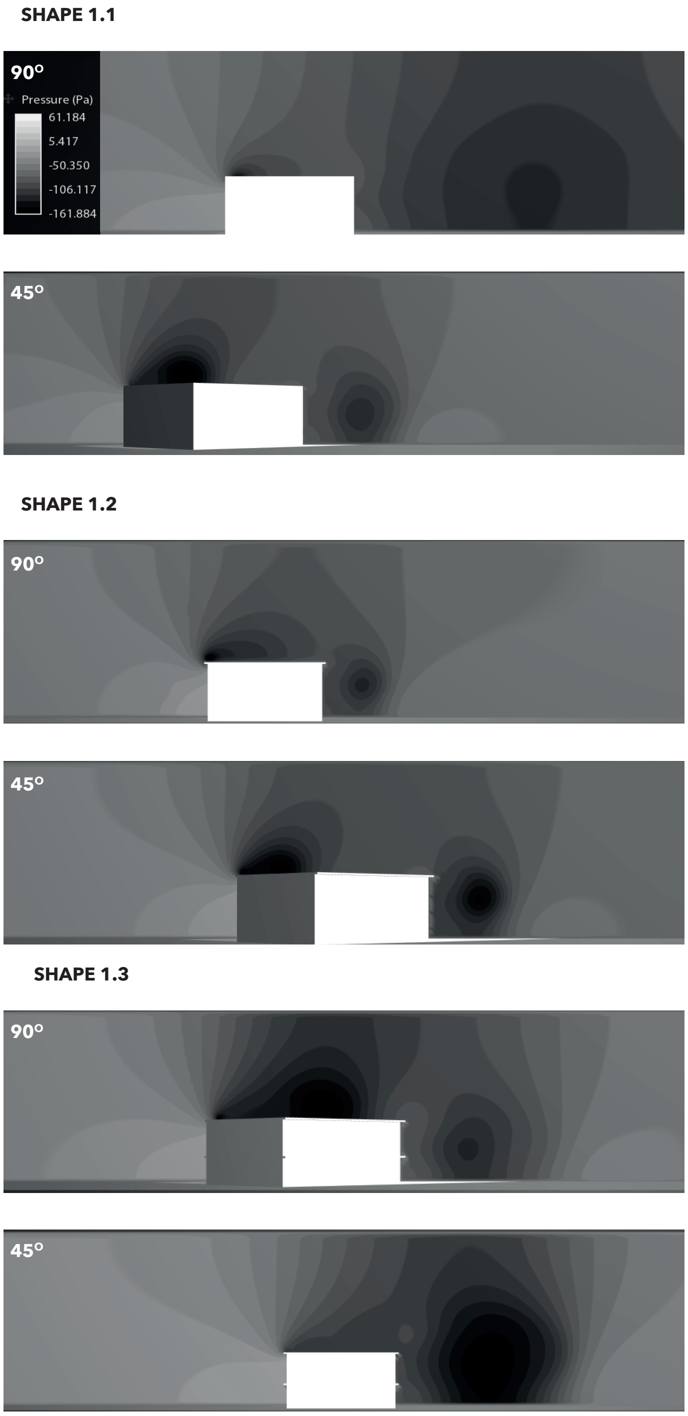
So, it can be concluded that the above described results in a need of creating a solution merging the cross ventilation and the stack ventilation.

The air pressure around the building

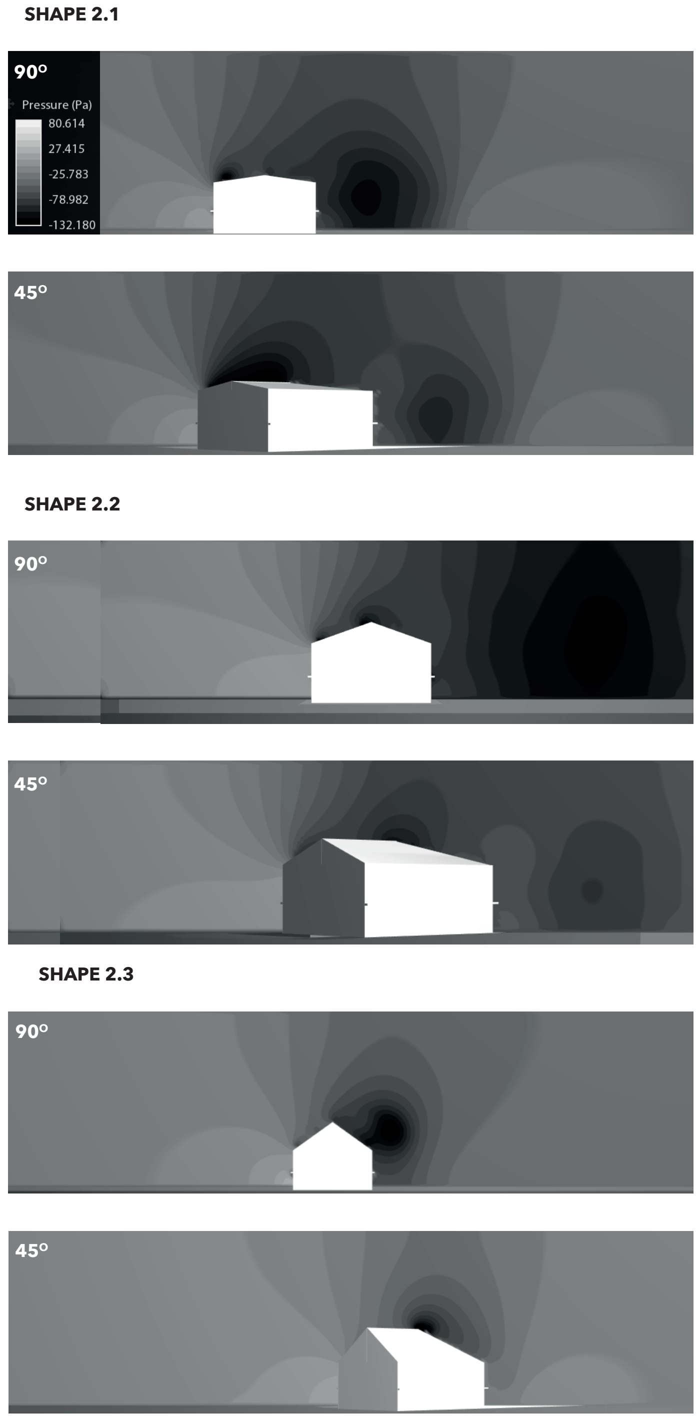
At this point, there was a need to check, if it is possible at all to force the air to leave the building through the roof.

It would have been easier, if it have been about the buoyancy effect. However, in this case, the issue was to force the air moving through the roof with the use of the mentioned strategy.

Thanks to the natural ventilation analyses in this thesis, there has appeared an idea to use the pressure difference. Just the strategy to have the air going from higher pressure (inside the building) towards the negative pressure was not enough. This solution will always require having a strongly negative pressure on the roof. In some cases, it could ›



ill. 144.1. CFD roof simulation. Shapes 1.x.

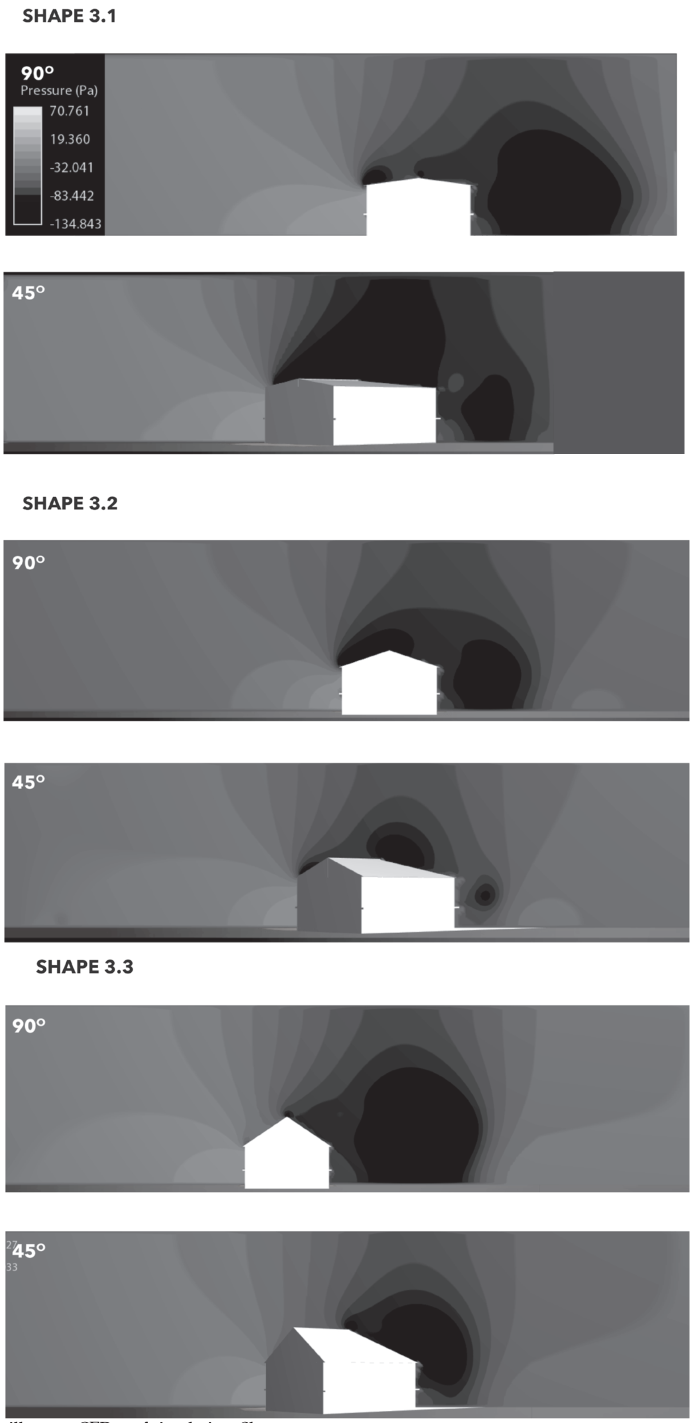


ill. 144.2. CFD roof simulation. Shapes 2.x.

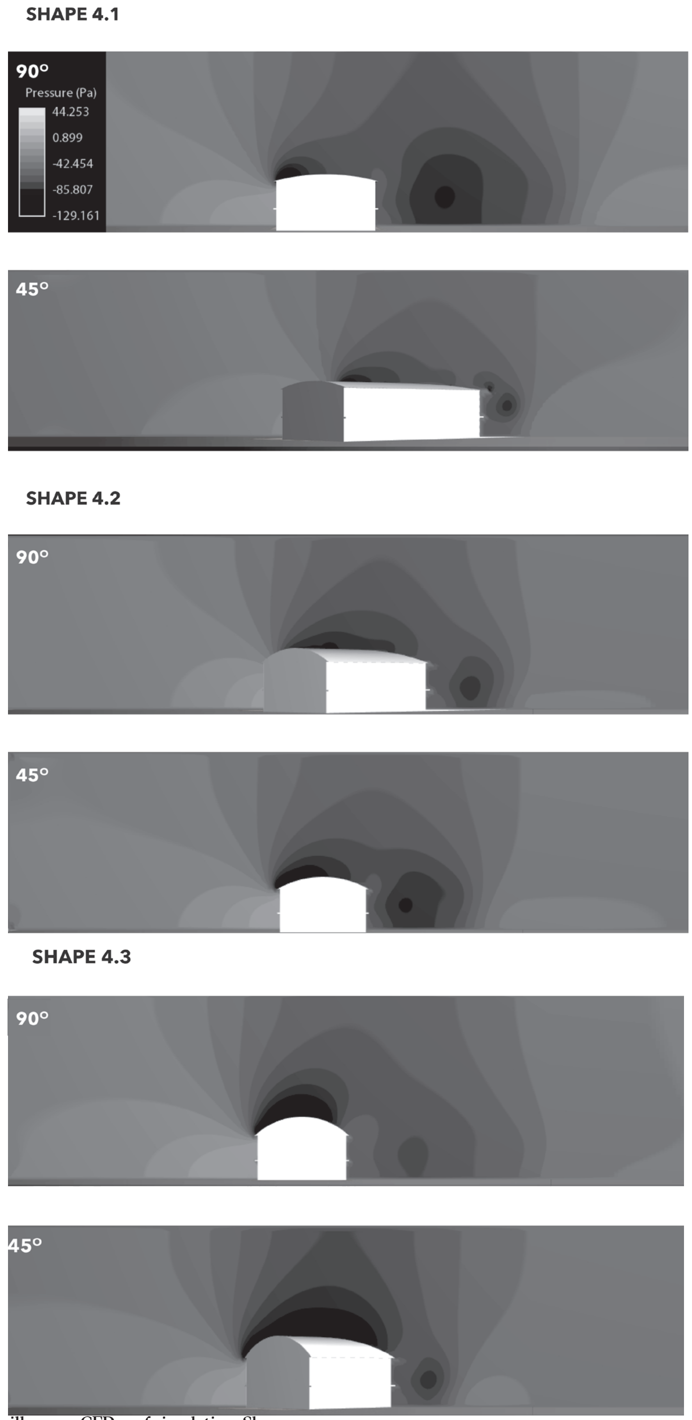
then force the air going out of the building, but in some cases it could make an inverted effect. At this very moment the thesis' authors wanted to avoid going into wind cowls solution to keep the building clean outside from too many elements sticking out from the roof.

After this, the first CFD (Computational Fluid Dynamics) test was done to make a research on how the pressure around the building differ depending on the shape of the roof, wind direction and many other factors.

First of all, simple cuboid volume was taken into consideration (shape 1.1). When applying a wind from a side of the building, the pressure difference was lazily surrounding the building. However, adding small overhangs (shape 1.2) made the negative pressure to keep more into the roof. Unfortunately, the negative pressure division on the roof was not equal and it would change depending on the wind force. It was interesting to see that adding extra overhangs on the height of the slab between the floors created an effect with the negative pressure covered the whole roof. The problem was that in this case the pressure was not negative enough to create a huge difference and make the air always go out from the building. (Shapes 2.1) tested the two-sided roof but without the overhangs on it. It turned out that this created even more negative pressure, but on the other side of the building, which was still not the result this analyses was looking for. Shapes 3.1 tested the same principle but with overhangs on the roof. As in shapes from 1. series, this resulted in a negative pressure appearing near the



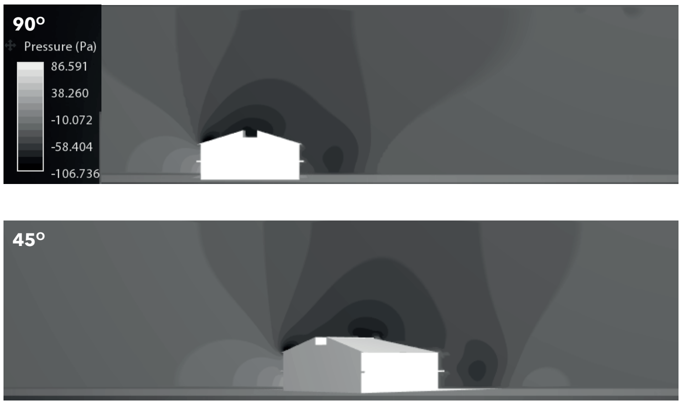
ill. 145.1. CFD roof simulation. Shapes 3.x.



ill. 145.2. CFD roof simulation. Shapes 4.x.

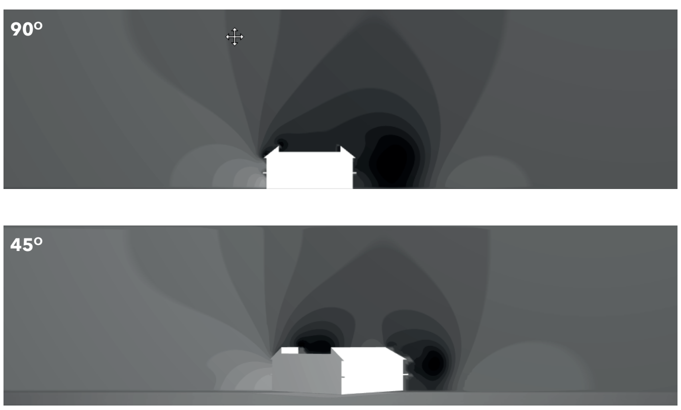
building. However, when the slope was too high, this pressure moved to the side of the building instead. Unfortunately, a smaller angle of the roof didn't create stable negative pressure situations. Depending on the direction of the wind it would change completely. Shapes 4. tested different variations of the height of the curved roof. Shape 4.3 gave good results, however the pressure difference was still not strong enough. It was interesting, however, to see how this shape made the building better in distributing the air flow around it, making the pressure difference ›

SHAPE 5.1



SHAPE 5.2

SHAPE 5.3



ill. 146.1. CFD roof simulation. Shapes 5.x.

small and not that aggressive. This proved that the round buildings handle better air flow around the building.

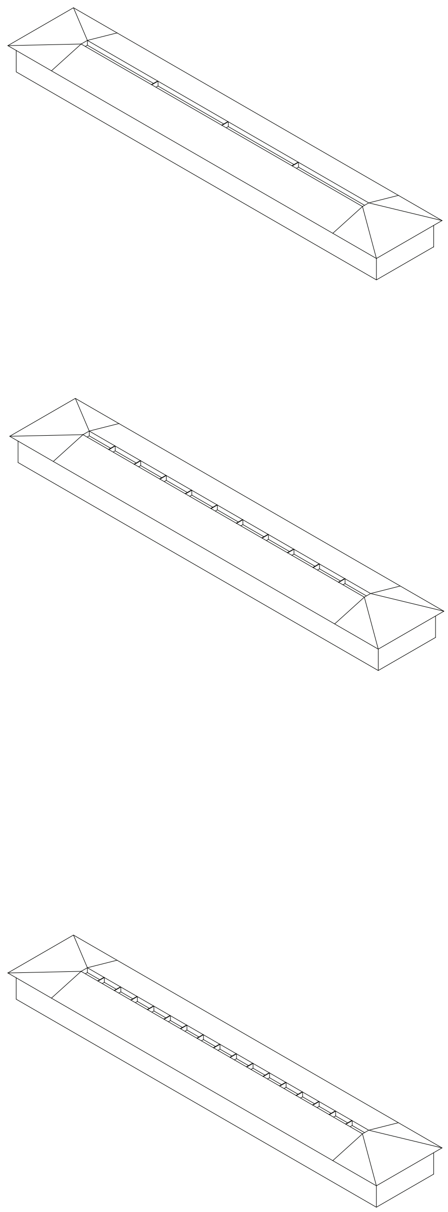
So far, these analyses of the shapes of the roof made it clear that this shapes won't create an optimal solution.

This is when the idea of creating a gap in the roof came (shape 5.x). A simulation showed that as long as the wind is not blowing along the building, there will always be a negative pressure at the very base of the gap. Still, the wind blowing from the south or from the north would make a problem. After analysing how the gap is responsible for creating the negative pressure there, it started to be clear, that in the mentioned direction of the wind there should also be some kind of an obstacle on the way of the air flow. This is where the additional walls in the gap were added to ensure that there will be also a negative pressure or equal to the facades in those gaps, when the wind will blow from those directions. Further, the investigations tried to figure out how many of these elements there were needed depending on the roof slope (ill.147.1).

Planning the guest rooms

The position of the rooms was already known – according to the north-south axis, they should be positioned perpendicular to it.

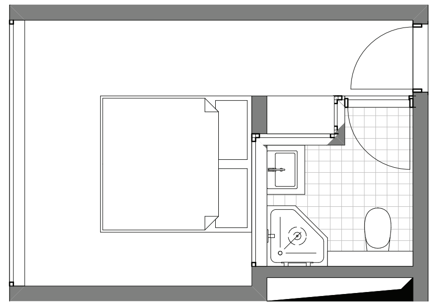
Once the basic idea for the natural ventilation was proved to be working in the theory, it was time to use the before mentioned strategy for ventilating the guest rooms. At



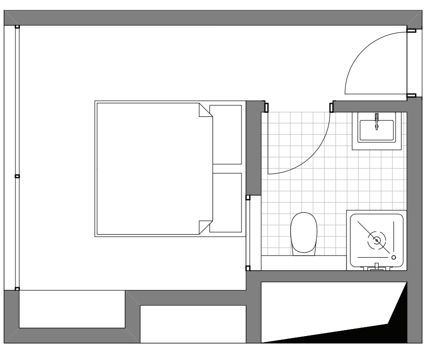
ill. 147.1. Creating and testing additional small wall division of the roof for creating negative pressure in the gaps when the wind is blowing along the building.

this point, it was clear that the bathroom should be next to the exhaustion system, for example, skylight.
Moreover, since the bathroom needs a plumbing system going to the sewer, it felt natural to use the shaft system to gather the sewer pipes on one side of the plumbing, and to place on the other side - the air ducts for the air exhaustion from the ground floor

As far as the bathroom is concerned, there was an idea of making the whole roof of it open (using a fixed skylight), with the



ill. 148.1. Guest room configuration 1.

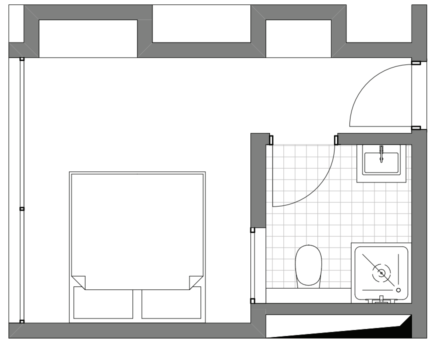


ill. 148.2. Guest room configuration 2.

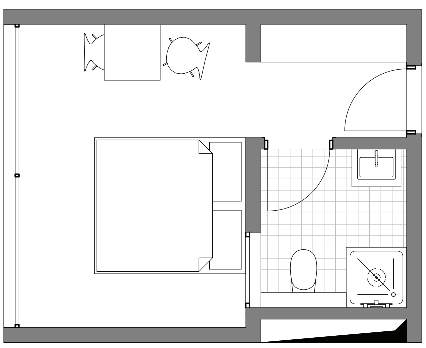
window frame being hidden. As there will be a need for an extra window between the sleeping area and the bathroom, the decision was made to actually make the top glazing all around the bathroom. That could provide more light, for example, to the corridor.

The bathroom, however, is not a main part of the guest room. The resting (sleeping) area needed to be solved as well. It all started with a very simple shape of the room and the bathroom, giving just enough space to make a simple corridor access to the resting area (ill. 148.1). The wardrobe was situated in a way, so that it shared a wall with the bathroom. However, this made the top window between the sleeping area and the bathroom going in a snake shape. This wardrobe approach also took space from the already small bathroom. It is important to mention that at this point the only furniture planned in the room was a bed and wardrobes.

Another concept (ill. 148.2) proposed having



ill. 149.1. Guest room configuration 3.



ill. 149.2. Guest room configuration 4.

the wardrobe system on the bed-side of the room, alternating with a mirrored another guest room. This, however, was creating the problem of accessibility to the furniture and called automatically for a need of a wall in the façade.

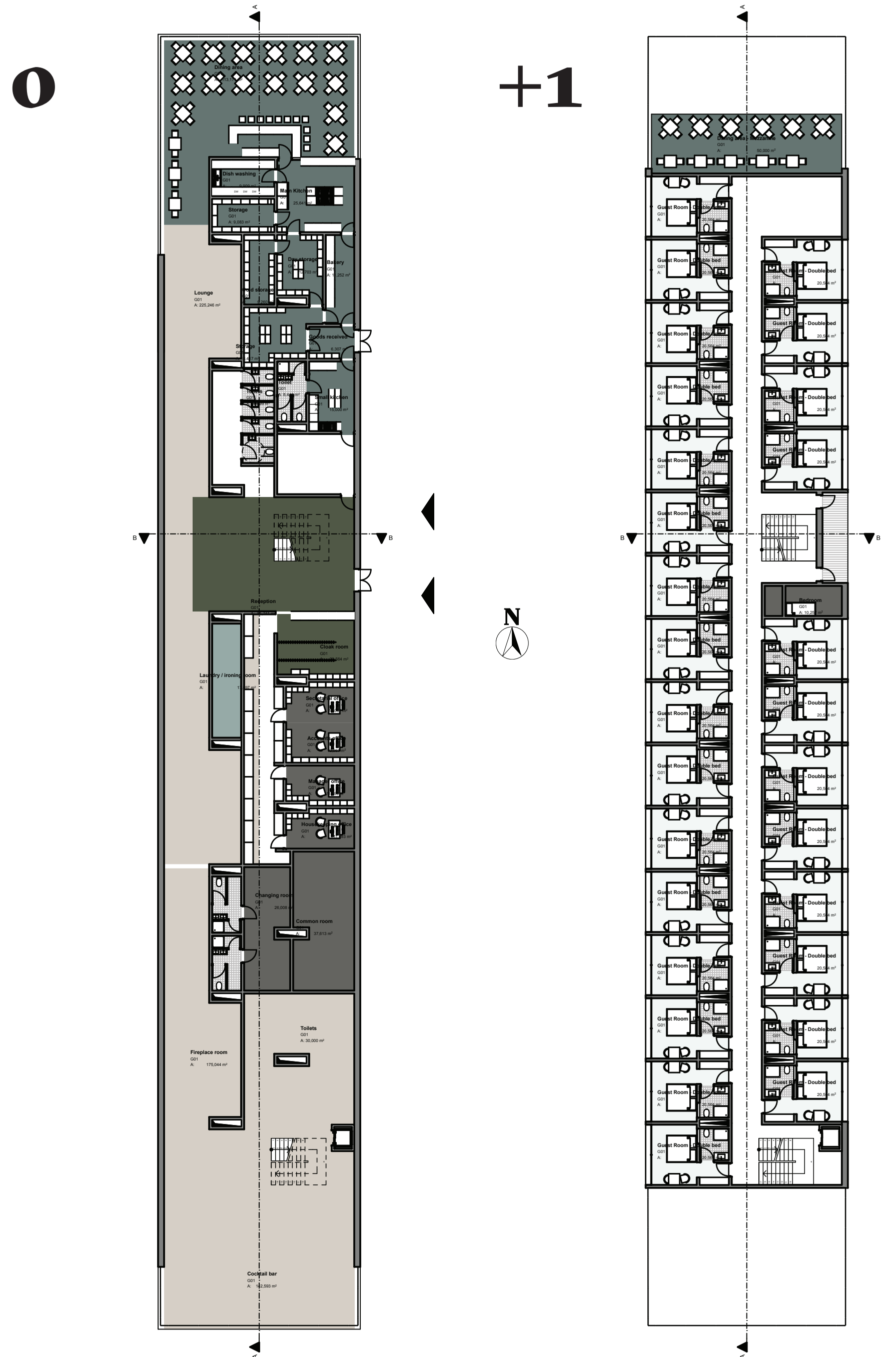
Another iteration of this idea (ill. 149.1) was to put more wardrobes to the room. Still, alternating with another guest room. Unfortunately, this made some problems, if the bed had to be spited up in two single beds.

As the need for having a solitude place in the hotel emerged, the new proposal for the room program was to have a place for chairs and a table. After taking into consideration the previous proposals, and this new need, a new concept emerged (ill. 149.2). It created a slightly bigger room area. However, taking into consideration the need for a space for the wardrobes before, two last concepts also used bigger area than the first one. Since the wardrobe was now situated in the entrance › zone, with no alteration with another room, there was no more problem with altering the bed configuration. Moreover, it gave a space to place a small table and two chairs in the niche that suddenly appeared in the room. This seemed to solve all mentioned before problems at the same time. However, the design of the guest rooms started to dictate how the building would be shaped regarding its program.

The guest rooms, shafts and their effect on the ground floor plan

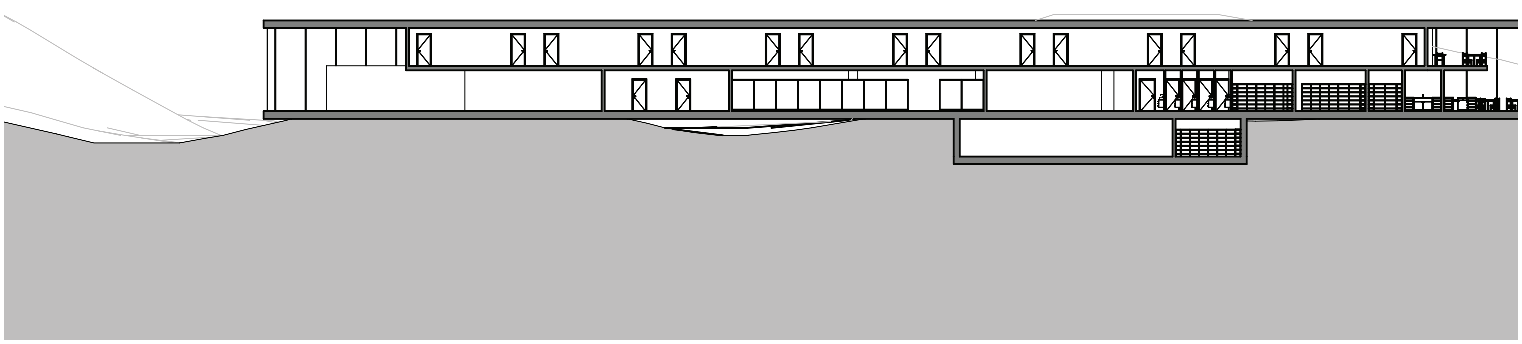
The next step was to work with the ground floor plan. Since the shafts were created on the first floor in specific places, it also affected the ground floor plan. This is also when more detailed plans started to emerge (ill. 150.01). It forced to plan the rooms carefully. The planning started with finding a solution for the dining area, the kitchen and its surrounding functions. The decision was made to add a mezzanine there, on the first floor - which would be later accessible from the ground floor. This would add – possibility – an enjoyable view towards the nature from another perspective. The entrance area was the next to solve. It is the first zone, which the guests are entering. There was an idea to put three stairs in the building. One - near the southern common room, the second - in the entrance area (which would be wider than the other) and the third – in the dining area. For making the building shorter, all the technical rooms were placed in the basement.
Unfortunately, the building still stayed quite wide. This was due to the guests' rooms on the first floor. When it comes to mentioning the length of the building, there were considerations to placing a part of them on the ground floor, however, this would break ›

ill. 150.1. Plans of the concept development.



Cross Section

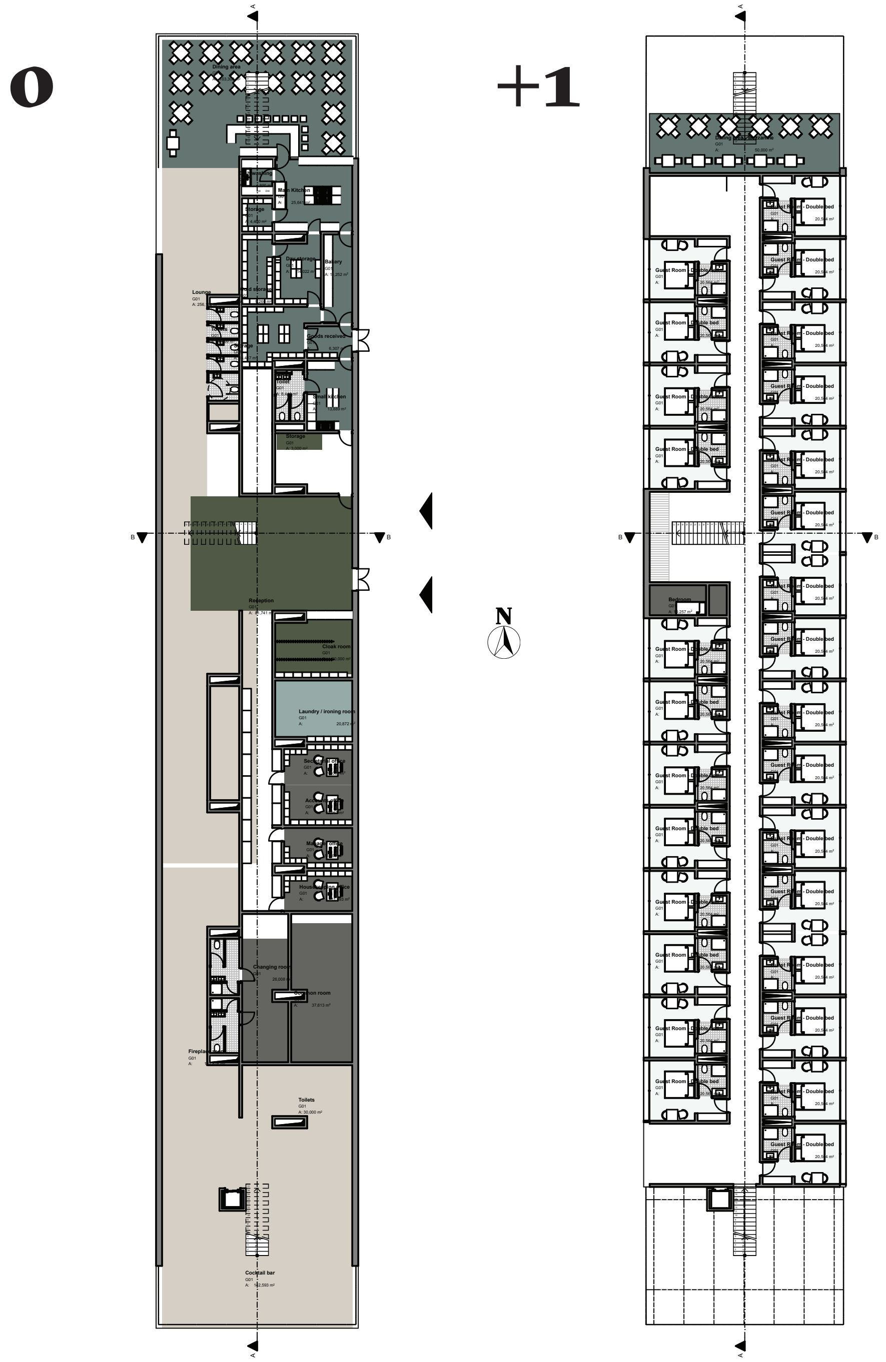
ill. 150.2. Cross section through the building showing cuboid form starting to develop. Two stories high dining area and common room on the opposite ends of the building are starting to be clearly visible.



the design criteria regarding having the same quality of view from each guest room. Still, some of the solutions from this development were not good. For example, the accessibility to the first floor was unacceptable. And some rooms surrounding the kitchen started to be too big, like, for example, the dish washing area. Even though there was a basement planned, there was still no plan regarding the position of the staircase to it. To keep everything tight regarding the heating strategy and the energy demands, the decision was made to keep it close to the heated area of the building. There has been an idea to make two staircases to the basement. One - from the kitchen area (for an extra storage space) and another - for the staff area. However, the stairs would take up too much space on the ground floor, and it would lead towards quite small rooms.

This required a further investigation of the project (ill. 151.3). The rooms on the first floor were flipped around the long axis of the building. This decision was made due to the investigation if the staircases should use the common "corridor" side of the common rooms on the ground floor. This would mean that the hotel would still have a smaller amount of the rooms than the old hotel, because of the space needed to provide the vertical communication. This would lead to a strange situation, where people on the first floor, having the dining area next to them, would need to go downstairs, through the common area and then go to dining area using the stairs again for getting to the ❯

ill. 150.3. Plans of the concept development.



Staff area

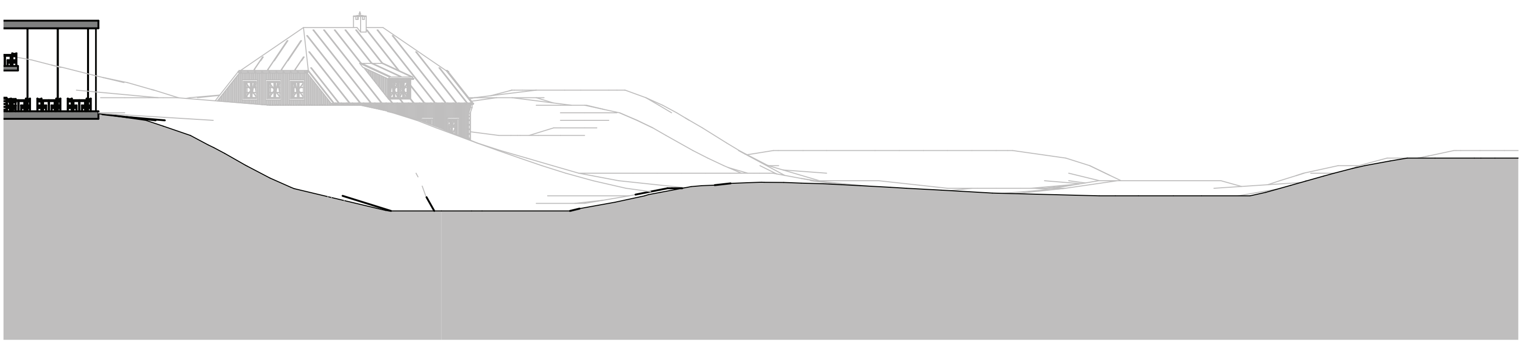
Reception area

Dining / kitchen area

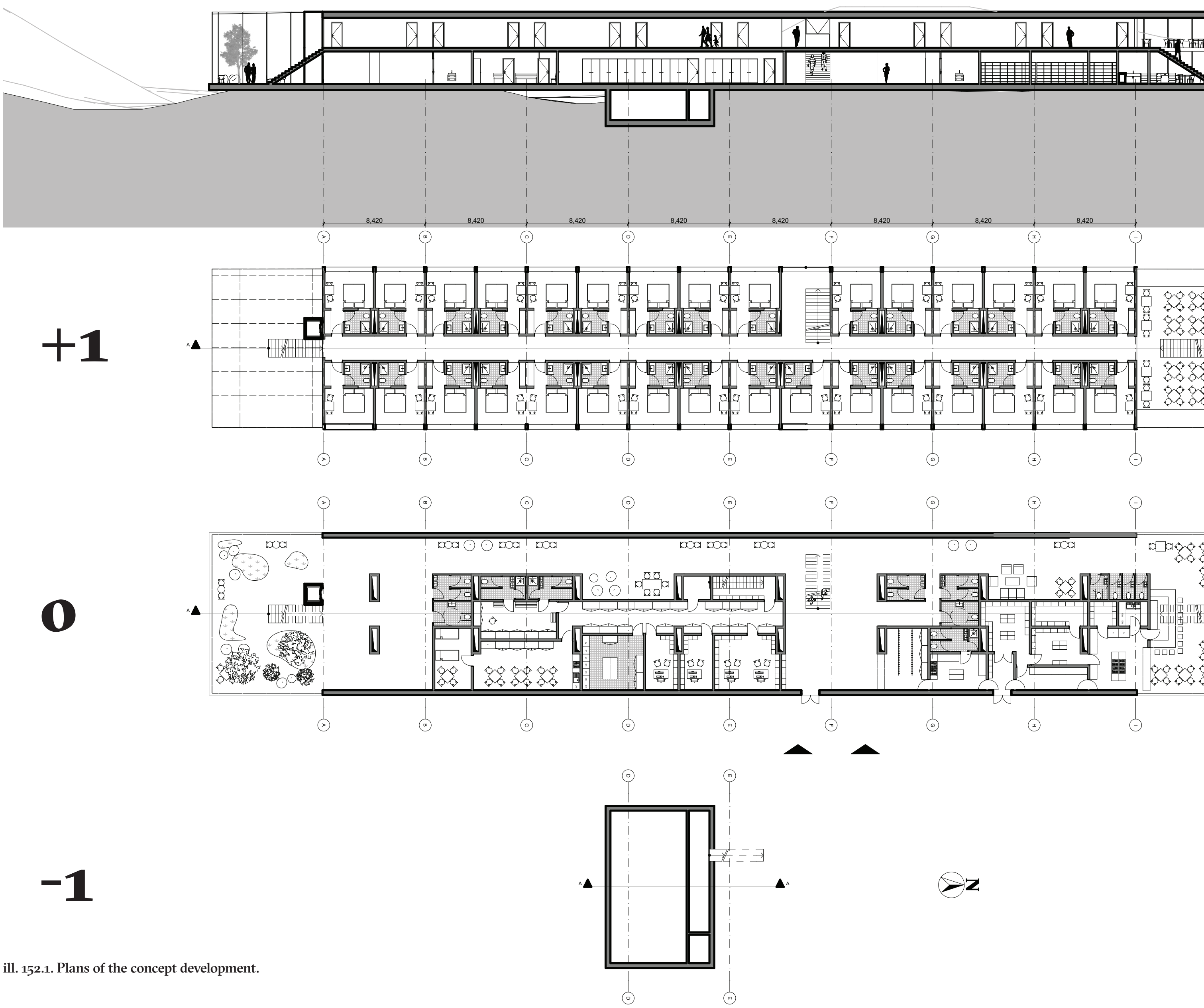
Various

Common rooms

Guest rooms



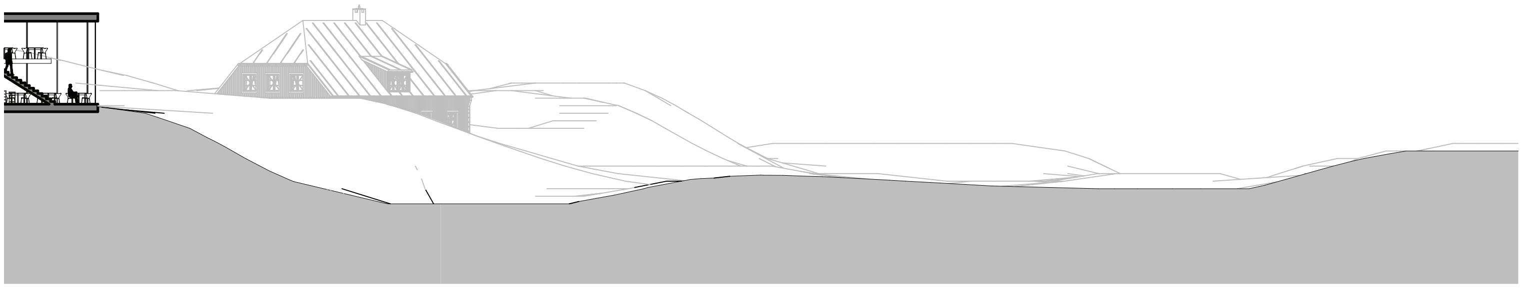
Cross Section

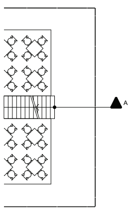


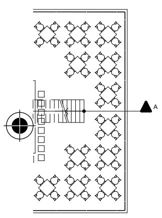
ill. 152.1. Plans of the concept development.

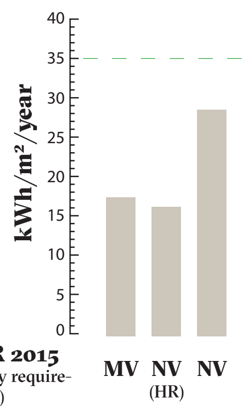
mezzanine. To make it simpler, the decision was made to put the staircases on the main long building axis in both ends. This could provide two extra guest rooms and also give the access from the first floor, through the mezzanine, to the dining room, eliminating the problem of having too many staircases. Flipping the guest rooms also moved the position of the shafts. However, this change did not affect much the position and the shape of the rooms. Still the shafts ware not parallel, but alternating along the main axis.

A further development of the project tried to optimise the space even more. However, because of trying to fit as many of the guest rooms as possible, while having an optimal amount and the position of the shafts, the distribution of the rooms changed. Now the shafts have been position parallel to each other in the main building axis (ill. 152.1). This created their more stable pattern also regarding the future structural system of the building. This is when the first niches where created in the common spaces to give a place where people can sit, read books or just talk while having a beautiful view towards the nature without having any obstacles on the path between the dining area and the southern common room. The basement was moved to the staff area. Also the toilets in the dining area and the entrance area started to look more solved. Unfortunately, the dining area was still not optimised enough regarding the position of the stairs and the space between them and the tables for dining. At the same time, the idea of having some kind of a green house in the southern common room appeared. As far as this area is concerned, the elevator has been placed there as well. At this point, there was still no strategy regarding the landing. Basically, the southern area

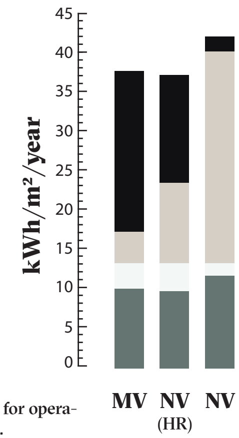




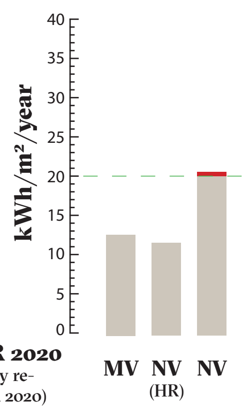




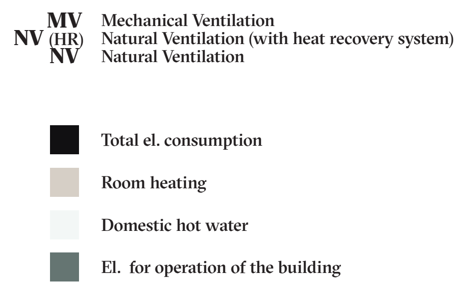
Energy frame BR 2015
ill. 153.1. Total energy requirement (as for BR 2015)



ill. 153.3. Electricity for operation of the building.



Energy frame BR 2020
ill. 153.2. Total energy requirement (as for BR 2020)



needed more work to be done for developing further solutions for it.

It turned out quite surprisingly, that the preliminary program regarding the rooms' area was in most cases overestimated. On the contrary, the guest rooms actually became a bit larger than the program predicted.

A preliminary performance of the building

The preliminary studies of the building performance tried to investigate different natural ventilation strategies for the summer season only (from March to late September). After setting the early input data for the new Badehotel's envelope, the openings, other needed information and the simulation results were analysed.

Although, according to BR 2015, all the output numbers were below the total energy requirement (ill. 153.1), in case of BR 2020, the natural ventilation solution was not reaching the new upcoming energy frame (ill. 153.2). The more detailed data (ill. 153.3) showed that the total energy consumption was the highest for this type of ventilation mainly because of the need for heating the building and pure heat lose. This is where the natural ventilation with heat recovery performed much better. It was quite interesting to see that even though the mechanical ventilation solution obviously needed less heating in the building, the energy consumption was almost as big as the one with the natural ventilation. It can be concluded that this simulation showed, that it would be necessary to combine more input data, as well as the integrated design, in order to optimize the natural method of ventilating the building.

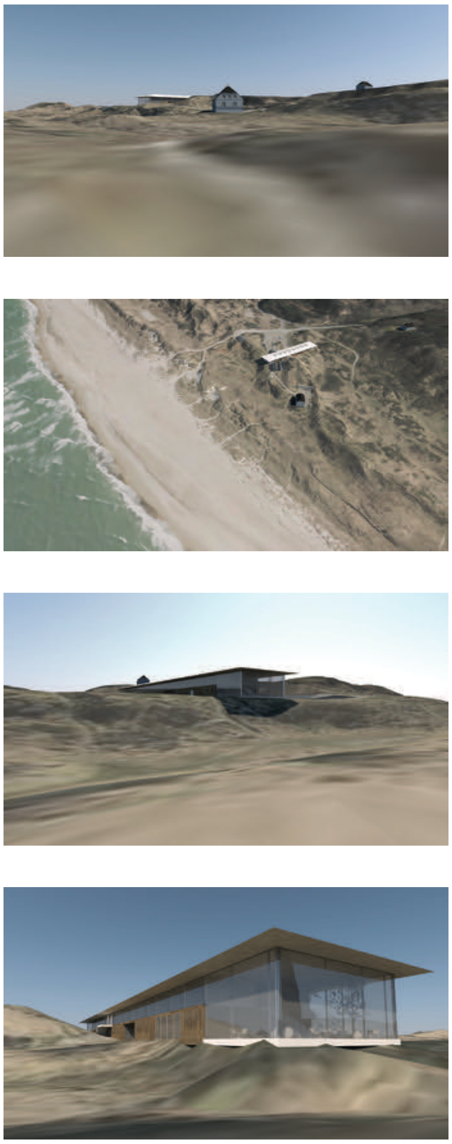
Phase #5
Further project development

ill. 154.1. Svinkløv dunes. Characteristic view of dense vegetation of the tall wild grass.

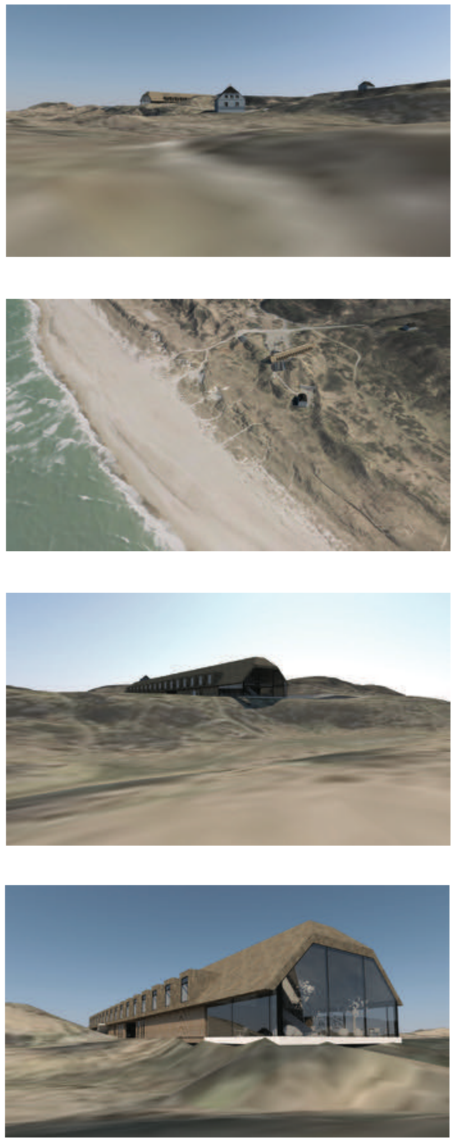
The plans and sections were developing quite well at this point. The strategy of dealing with the roof was set as well as the guest rooms' plans. However, it all required a more integrated investigation which also would start to solve the problem of the building's facades.

Working with the building's envelope

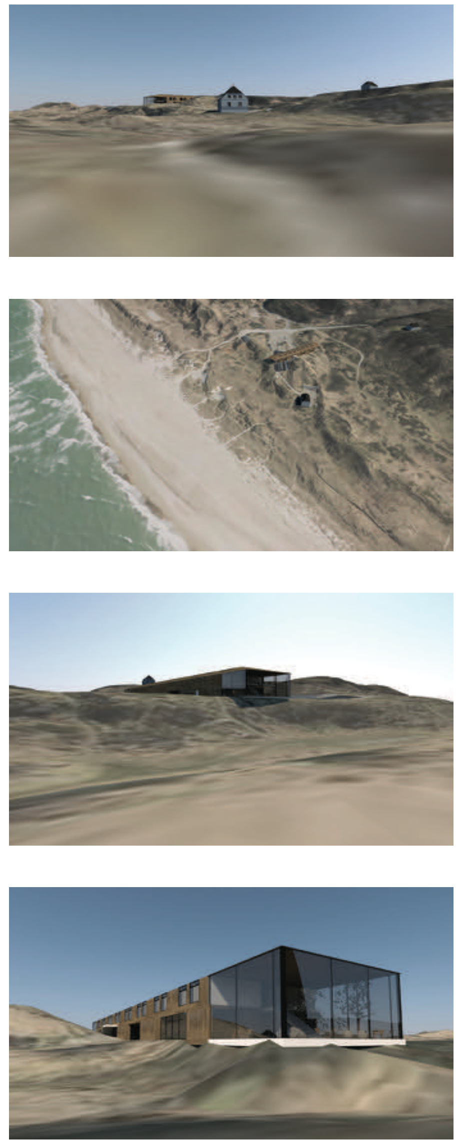
Here the facades, the roof and the window openings in the guest rooms where investigated at the same time to get the most optimised output data. The previous CFD simulations showed in some cases, that it was possible to achieve a working pressure difference between the roof top and the facades, but the aesthetics should also take part in the design process.
The base form of the building was a case taken from shape 5.1 from the mentioned CFD simulation. This has been interpreted with variant A (ill. 154.1). The low profiled roof with a gap in the top of it showed good



Ill. 156.1. Variant A of the envelope.



Ill. 156.2. Variant B of the envelope.

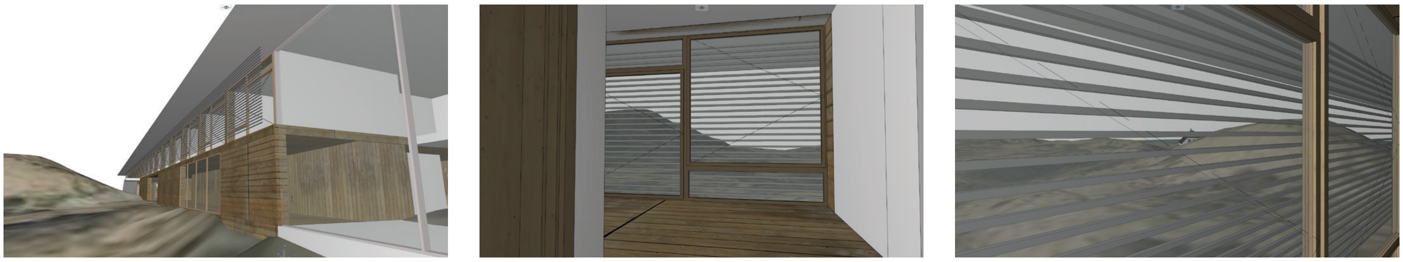


Ill. 156.3. Variant C of the envelope.

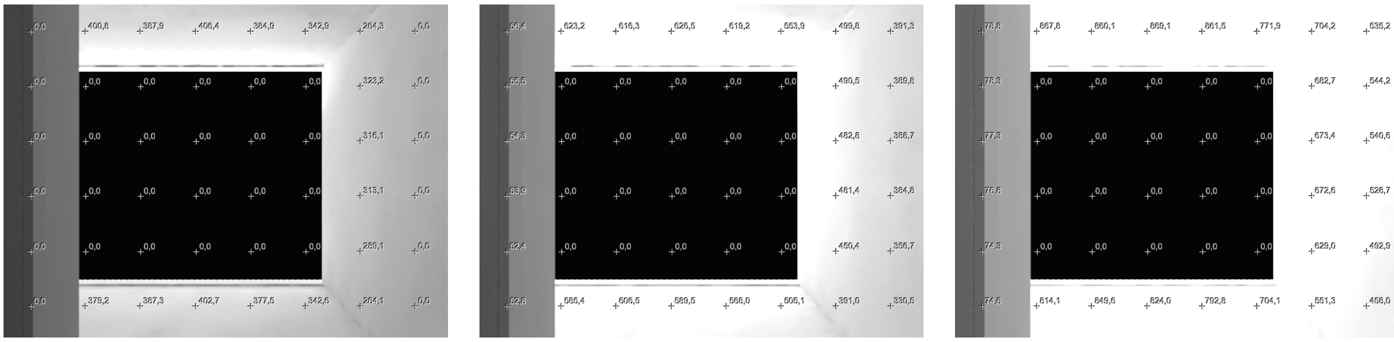
results of the airflow around it. It used overhang of 2 meters, which was making the CFD result worse than if there was a way smaller one. At this point, the building used the concept of having wood materials around the ground floor's milder part. And on the first floor, the wood flooring will symbolise that the first floor was placed on top of a box. In order to enhance the thermal mass on this floor, the concrete walls were used. As for the openings, this concept was trying to introduce big glazed windows that would give the guests a view from the guest rooms towards the nature without any obstacles.

There were three main problems with this concept of the façade. Firstly, it introduced the architecture language more common for the contemporary office architecture in the cities than for solitude architecture in the nature, far from any city. Secondly, this gave a huge problem regarding overheating with (ill.156.1) hours of it throughout the year. Finally, even though there was a great view towards the nature, it also gave, basically, no privacy for the guests.

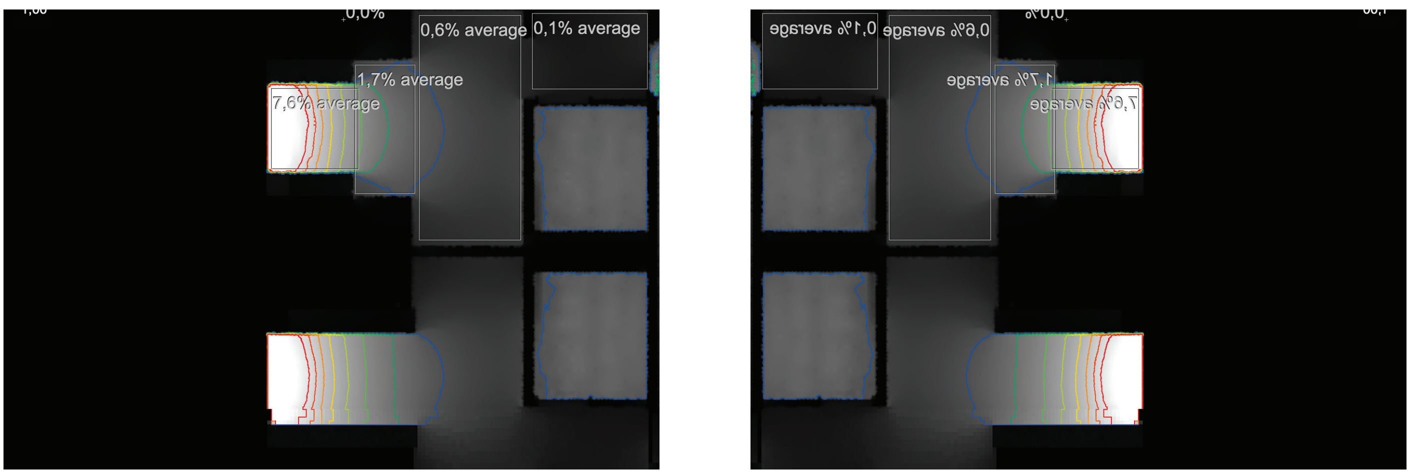
This is when the first test of the lamellas in front of the windows was introduced (ill. 157.1). Even with a simple wooden lamella cladding of 20×20 mm and a gap of 50 mm in between, gave quite good results of the illumination in the main part of the guest room. However, at the same time, the small corridor between the entrance to the room and the bed had way lower results (obviously, because of the distance from the façade). At the same time, they were not critical. The reason for this was that the light well from the bathroom proved to work well.



ill. 157.1. External cladding covering concept.



ill. 157.2. Illumination simulation.



ill. 157.3. Daylight factor studies.

Finally, there was the problem of huge overheating in the dining area and in the southern common room. The northern glass box received over 760 hours over 27 Cº even when the venting will be implemented. This was caused not only by large area of windows, but also because of the human heat. For the calculations, it was counted that the glass area must be reduced on the west and eastern facade. This is where variant B (ill. 157.2) was presented. It was inspired by the roof of the old Badehotel. Even though this gave more shading to the building, it reduced dramatically daylight factors in the guest rooms (ill. 157.3).

Moreover, this will mean that the bathrooms would have a deep light well which does not provide much light.

In addition, the problem was that with this slope of the roof, even when having a gap on the top of it, the airflow would be not very effective regarding the negative pressure. Thus, variant C was created (ill. 156.3). This was a step back to the very simplified shape 5.1 of the roof, without (temporary) any overhang. This was trying to create a solution for the window openings that would provide enough light inside the guest rooms. Since the openings should be big enough to provide large amount of light into the room and should also give a clear view towards the nature, the privacy problem was still not solved. This is where the idea of rising the bottom part of the windows came. At the same time, the luminance simulations were done showing that the overexposure of the room had fallen from Variant A, but was still high enough to provide good indoor light (ill. 165.06).

ill. 158.1. Preliminary early rendering of the guest room with use of VR technology.

The mood double-check

To better understand the moods and possible experience in the building, Virtual Reality tools have been implemented into the design process (ill. 158.1). By using Google card-board goggles it was easier to understand what users would see and experience at exact places in the building.

Solving the guest room window expression

The Virtual Reality helped with creating the right experience for the guest room users. The windows were modelled in a way, so the guests always would have a bigger vertical opening (doors) on the site of the room facing the sea. Moreover, the windows were created as niche windows, so the people could lay there and chill out, while enjoying a view towards the sea (ill. 158.1). As the experience of the nature from such windows was fitting the project very well, it has been decided to include this solution into the design process. The daylight factors have also shown good results regarding the amount of the light in the rooms.

The impact of the guest rooms' window expression on the façade optimisation

The chosen window solution for the guest rooms' windows made an important impact on the façade optimisation. Since the mentioned dining area had a problem with the overheating, there was a need for reducing the amount of glazing around the volume or to put some sun shadings. After having tested different solutions in the mentioned variants A, B and C, it was decided to try a different approach, by adding full walls into the envelope of the dining area - this is when

ill. 159.1. Illumination simulation in the guest room.

ill. 159.2. Materials on roof and facde

the concept of having the vertical elements emerged. This move, however, did not fit the rest of the façade, especially the first floor. As the result, the guest rooms' windows have been added an extra window above the window doors. After the CFD simulation, it turned out that this top window would be more than enough for ventilating the rooms. Moreover, it could help with the air exchange, since this window could have an option of a little gap-opening, avoiding drafts in a case of strong wind blowing towards that specific façade. This also created more vertical elements scattered throughout the building elevations.

The choice of the materials

During the design process, the proposal of using wood was coming back to the desk very often. After the rejection of variant A, the materials were no longer connected strictly to the concept of the "material volumes" (it was stated in the variant, that the wooden box was surrounded by light concrete blocks and glass). Since the old Badehotel was the longest wooden building in Denmark, and Svinkløv Foundation Erf wanted to rebuild the old Badehotel using wood and sustainable solutions, it became clear that wood should be used as the main material for the building. There were two structural strategies planned for the building. The first one considered a balloon frame construction. The second was using a plate construction with Cross Laminated Timber (CLT). The second proposal had, however, three crucial advantages. The first one was that CLT thermal mass was bigger than the one in the balloon frame construction and would help providing heat capacity when ventilating the building. The second one was the ease of mounting the elements together which would speed up the work at the construction site. The third advantage was the material's finish that could be used as a final touch in the interiors. The biggest disadvantage of this structural system is that the building plans would not be open, which means if the owners would like to remove some walls, it might be problematic, as most them are structural.

The shafts have been designed to be made from white concrete. This material is local, since it is being mined and burned in Aalborg, which is 40 km from Svinkløv. An important property of the concrete is that it has a big thermal mass that would have two outputs: it would help warm up the air after ventilating the hotel's rooms; and, at the same time, this would help to slightly heat the air going through the ducts. That would increase the stack effect for the rooms on the ground floor.

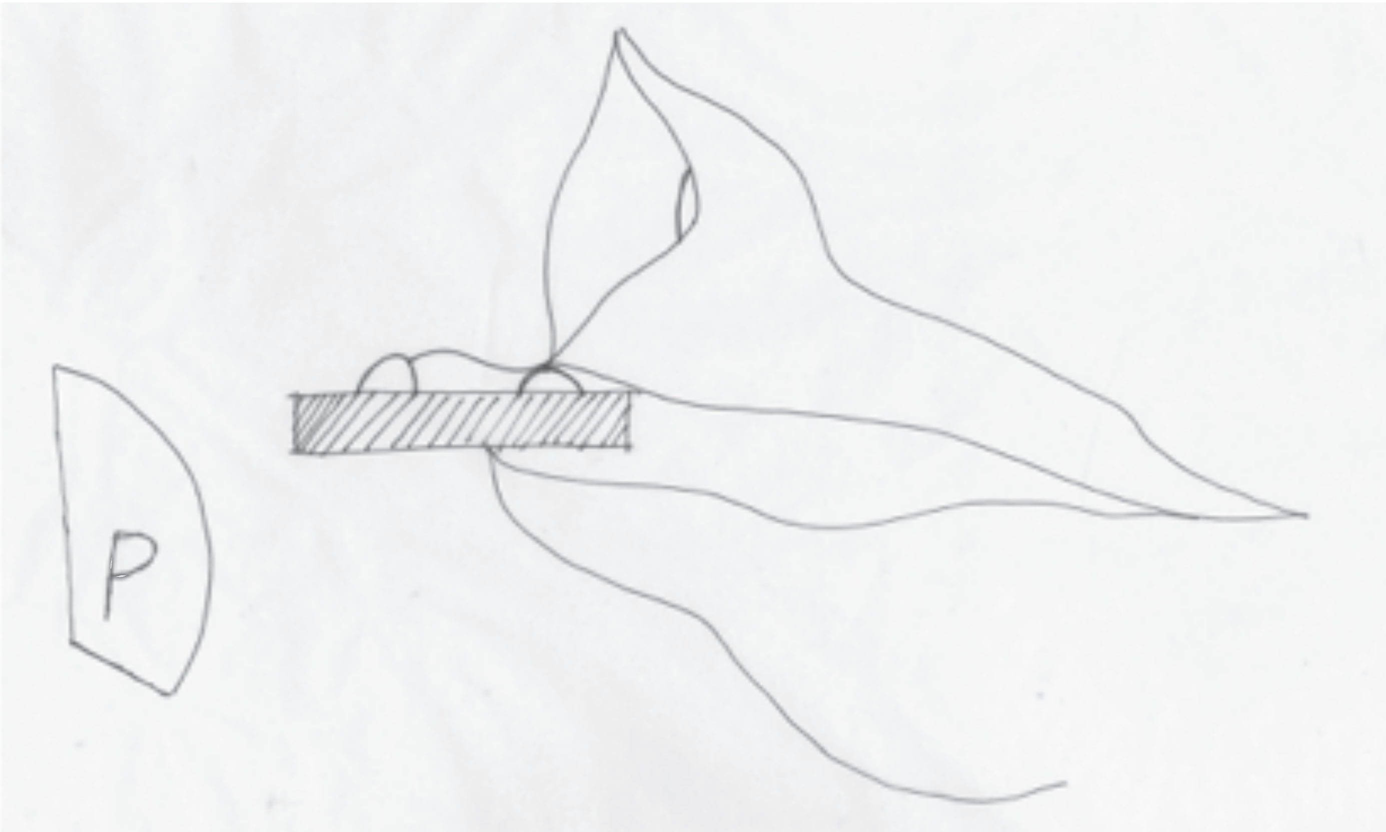
The program update

During the development of the project, the program has been changed as a better understanding of the users' needs and a possible use of the building was gained. For example, the proposed fireplace area has been hard to implement, because of the lack of reasonable exhaustion solution as well as estimation that the guests would use the one outside more often the fireplace in the building. Instead, a lounge area (connected with a bar function) has been proposed (also from the old preliminary program). Another big change in the southern area of the building was the change from a common room in the big glassed area to an orangery. The reason was that this part of the building would not make much sense during the off-season and also for the sake of lowering the envelope of the building. As a result, this makes the overall energy-use of the building effective due to the amount of overheating and the heat loss that this part would provide.

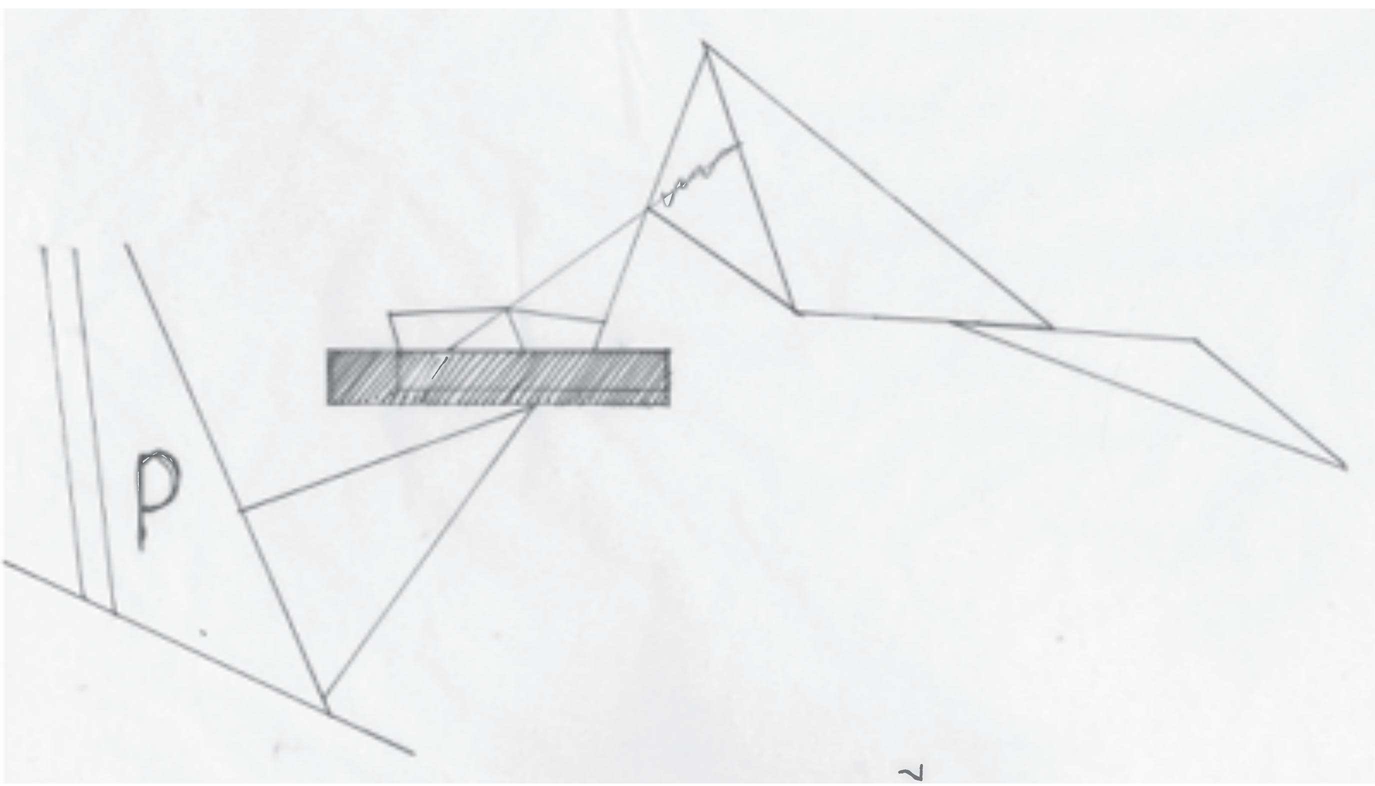
The outdoor area

It was clear after the analyses, that the site was special because of the surrounding nature. It was clear that the outdoor area shout be kept to a minimum, so the guests would not have to go far from the hotel to experience the nature.
The main idea behind the outdoor area was to analyse the good qualities of the previous one that supported the old Svinkløv Badehotel. There were two main areas around the building: one in front of the north-east façade, where there were tables and the guests could drink coffee while sitting outside the hotel. Another area was in front of the short northern-west façade, where the people gathered usually in the evening to enjoy the sunset. Both areas have inspired this project. Thus, the aim was not only to recreate them but also to place new terraces ("a breakfast terrace" and "a sunset terrace") at almost the same place as a continuation of their functional tradition (ill. 160.1).

There was a decision made to place the parking lot in the southern corner of the site. The reason for this was to avoid having the view from the guest rooms directly to this function.



ill. 160.1.



ill. 160.2.

Key numbers, kWh/m²

Energy frame BR 2015

Wihtout supplement	Supplement for special conditions	Total energy frame
35.0	0,0	35.0

Total energy requirement 16.1

Energy frame BR 2020

Wihtout supplement	Supplement for special conditions	Total energy frame
20	0,0	20

Total energy requirement 11.6

Contribution to energy requirement		Net requirements	
Heat	0.0	Room heating	23.1
El. for operation of the building	6,4	Domestic hot water	13.1
Excessive in rooms	0.0	Cooling	0.0

Selected electricity requirements		Heat loss from installations	
		Room heatin	0.0
Lighting	0.0	Domestic hot water	0.0
Heating of rooms	0.0		
Heating of domestic hot water	0.0	**Output from special sources**	
Heat pump	6.4	Solar heating	0.0
Ventilators	0.0	Heat pump	23.1
Pumps	0.0	Solar cells	0.0
Cooling	0.0	Wind mills	0.0
Total el. consumption	37.1		

ill. 162.1. Natural ventilation with heat recovery.

Key numbers, kWh/m²

Energy frame BR 2015

Wihtout supplement	Supplement for special conditions	Total energy frame
35.0	0,0	35.0

Total energy requirement 17,3

Energy frame BR 2020

Wihtout supplement	Supplement for special conditions	Total energy frame
20	0,0	20

Total energy requirement 12,5

Contribution to energy requirement		Net requirements	
Heat	0.0	Room heating	17.0
El. for operation of the building	6,9	Domestic hot water	13.1
Excessive in rooms	0.0	Cooling	0.0

Selected electricity requirements		Heat loss from installations	
		Room heatin	0.0
Lighting	0.0	Domestic hot water	0.0
Heating of rooms	0.0		
Heating of domestic hot water	0.0	**Output from special sources**	
Heat pump	4.8	Solar heating	0.0
Ventilators	2.1	Heat pump	17.0
Pumps	0.0	Solar cells	0.0
Cooling	0.0	Wind mills	0.0
Total el. consumption	37.6		

ill. 162.2. Mechanical ventilation.

Key numbers, kWh/m²

Energy frame BR 2015

Wihtout supplement	Supplement for special conditions	Total energy frame
35.0	0,0	35.0

Total energy requirement 28,4

Energy frame BR 2020

Wihtout supplement	Supplement for special conditions	Total energy frame
20	0,0	20

Total energy requirement 20,4

Contribution to energy requirement		**Net requirements**	
Heat	0.0	Room heating	40.2
El. for operation of the building	11.4	Domestic hot water	13.1
Excessive in rooms	0.0	Cooling	0.0

Selected electricity requirements		**Heat loss from installations**	
		Room heatin	0.0
Lighting	0.0	Domestic hot water	0.0
Heating of rooms	0.0		
Heating of domestic hot water	0.0	**Output from special sources**	
Heat pump	10.9	Solar heating	0.0
Ventilators	0.0	Heat pump	40.2
Pumps	0.0	Solar cells	0.0
Cooling	0.0	Wind mills	0.0
Total el. consumption	42.0		

ill. 163.1 Natural ventilation with heat recovery.

Epilogue

'No. I don't think the Empire had Wookiees in mind when they designed it, Chewie'

– Han Solo to Chewbacca about the Tydirium imperial shuttle they're flying (Star Wars)

Conclusion

The text is waiting for project development.

This thesis was written responding to two needs: creating a new Svinkløv Badehotel; and creating a building that will try to prove that there is still a place for the natural ventilation in the emerging need for sustainable architecture.

Svinkløv Badehotel 2.0 is trying to bring back the good qualities of the old hotel. The ones that created the soul and the DNA of the place. This proposal offers both the solitude and social spaces to integrate with other people. The good views towards the nature and the sea and the lack of appliances like television, is setting up the escapist mood from the everyday city life. Even the bathrooms in the guest rooms have large skylight above that brings the sky into the room as a further concept of the outside world close to the guests. Long corridors with the common rooms in the building are being used for integrating the people while still having great views of the nature. The concept of sitting in the window niches in the common areas is taken from the first floor. This makes the building easier to understand for the users. The big northern largely glassed volume of dining area is giving a very special, clear view of the sea. Since the old hotel's cuisine was nationally known, the kitchen chefs would also have beautiful nature views. Omformuleret, men lyder mystisk.

Foreslå: The old hotel's cuisine was nationally known, and the building was constructed in such a way, that even kitchen chefs had beautiful nature views out of the kitchen windows.

The concept of the view towards the Southern part of the building works like an orangery and a common room for warm months. During winters, it is used as a greenhouse.

The building is prepared to serve during warm months (from Easter till the end of September), and during the off-season the building will be getting ready for the next one. Taking this into consideration, the building outperforms the mechanical ventilation solutions by using a natural ventilation strategy. By doing so - the proposed building - functioning during the season, is safe within the BR15 energy frame. When it comes to BR2020, this building is incredibly slightly below the energy frame. In both cases, the building will not use any renewable energy sources for the energy production.

The building is prepared, however, for extending its use to a full year. However, the minimum energy frame required by both BR15 and BR2020 would not be met: in particular, with BR15 being slightly off, and BR2020 being far from the demands, if, in that case, there would not be energy production from renewable sources. However, the project proposes to use the roof for installing solar cells roof tiling and to store the produced energy by using batteries in the basement. In that case, Svinkløv Badehotel 2.0 would produce few times more energy, than it needs throughout the whole year.

Thus, this project suggests quite a unique roof design, allowing to constantly maintain a negative pressure in the roof top niches (always lower than the pressure on the facades). This makes possible, at any time, to ventilate the building efficiently. During the colder months, this ventilation should be more than enough, even with a little window gap opened for ventilating. In the guest rooms, the natural ventilation uses a mixed effect between a cross and stack ventilation. Taking hot showers improves the ventilation even more: hot moist air is using then the thermal buoyancy effect and leaves the bathroom rapidly through an opening next to the light well skylight window. On the ground floor, the natural ventilation functions applying the same principle, however, the polluted air is being gathered and exhausted through the shafts scattered throughout the building. Since the roof design ensures a negative pressure during the whole year - regardless of a wind direction - there is no chance for a backward effect.

As mentioned in the motivational part of this thesis, it was never intended to prove that the mechanical ventilation is bad. According to the results, there is only a small difference for a summer hotel, but for the hotel, which is open year-round, is mechanical ventilation superior. Of course, it would be ideal to join both the ventilation strategies to get the best performance and the lowest energy demand for a building. Taking the LCA into account, the mechanical ventilation systems need to be fully replaced after 25 years of use. This is making the system cost high, when considering more than one life-cycle of mechanical ventilation solution. The natural ventilation is using more energy than the mechanical ventilation, when taking the electricity for the fans into account. Even with the heat recovery system, the overall savings are small, when the LCA of mechanical ventilation is taken into consideration.

As mentioned in the analysis chapter, Svinkløv Badehotel was called "a mother of all 'Badehotels' in Denmark". Svinkløv Badehotel 2.0 is a mother for the future generation of new 'Badehotels', and, possibly, a hope for the further development of the new generation of the natural ventilation strategies.

Reflection

The text is waiting for project development.

This thesis was not about the Svinkløv Badehotel from the very beginning. As mentioned in the design process' Phase #1, it was intended at the beginning to be a building with the function of sea and shore research facility. However, while investigating the history of the site more and more, it turned out that Badehotel is the function that is being missed at the site and a need of bringing this building back is very important for local people. This is how the whole story of new proposal begun. However common ground for both themes was the natural ventilation.

Thus, two important output results have been presented.

One is possible future typology of a new generation of the 'Badehotels'. The approach of placing the guest rooms in a way that everybody has the same quality of view seems fair. It also follows Danish approach of equality in society. Maybe all the new 'Badehotels' would also have large dining area, always positioned in the direction of the sea.

Second output is the natural ventilation strategy. Even though, as mentioned before, this thesis proposes quite unique roof using traditional, very well-known fluid physics strategies, the output of creating always negative pressure part of the roof seems to be new. This could be taken to the further development in many ways. Beside optimising the roof even more, the next step could be to introduce completely new approach to the heat recovery system that does not use any mechanical system. The subtitle "natural ventilation: re-engineered" was not trying to literally re-engineer this airflow solution. However, heat recovery system research should then take this into literal considerations. If we, as engineers, can take typical building physics and connect it to creativity, maybe we could achieve new solutions. It would be interesting to develop this project further with mentioned aspects. One of the examples could be to research new non-mechanical heat recovery systems and trying to make a whole year building with almost no renewable energy sources and still reaching BR2020.

As far as renewables are concerned, the project proposes in a loose way to use new Tesla roof solutions with Tesla commercial batteries. This seems quite right for a site with such amount of sun hours throughout the year. However, this could be taken into next level. For example, the parking lot could have Tesla charging stations to provide the energy to the electric cars. While making so, the new Svinkløv Badehotel would join the forces of movement on switching from fossil fuel cars into electric cars.

However, this project is not flawless. There are areas that should be taken more into consideration. Southern orangery area, for example, is a result of building development. However, even though this thesis is showing a lot of different interesting experiences that the hotel's guest might experience (different ones for bedrooms, bathrooms, common rooms, dining areas, and so on), there was very little work done on the experience of such orangery. The same goes for the staff area. Reception is the first thing that the hotel guest see when entering the building. However, again, there was little work done to show expression of this area and experience of the space when entering it. Moreover, there should be more development of the outdoor area, since there are already few considerations about the, for example, access paths for the hotel guests, restaurant guests (who are not registered in the hotel) or the access area for the delivery truck. Also, façades should join the design process during much earlier stages. That could provide with even better façade expressions. Also, there was very little work done regarding the experience when arriving to the site.

This thesis is trying to propose new typology of new generation of the 'Badehotels', however this could be taken more into consideration by presenting some of possible different outputs, even if just overall.

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Illustrations

All illustrations and photos not listed below were made by the thesis' authors.

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Appendix

U-values

The formulary is for u-values

$$U = \frac{1}{R_{se} + \frac{\iota_1}{\lambda_1} + \frac{\iota_2}{\lambda_2} + \cdots + \frac{\iota_n}{\lambda_n} + R_{si}}$$

λ : Thermal conductivity coefficient
ι : Martial thickness

External wall

Martial	$\iota\ [m]$	$\lambda\ [W/mK]$
CLT element	0.2	0,12
RockWoll	0.28	0.036

R_{se} : External transition value 0.04 $[m^2K/W]$
R_{si} : Internal transition value 0.13 $[m^2K/W]$

$$U = \frac{1}{0.04\ [m^2K/W] + \frac{0.2[m]}{0.12\ [W/mK]} + \frac{0.28[m]}{0.036\ [W/mK]} + 0.13\ [m^2K/W]} = \mathbf{0.104[W/m^2K]}$$

Ground deck

Martial	$\iota\ [m]$	$\lambda\ [W/mK]$
Reinforces concert	0.1	0,2
Polystyrene	0.3	0.039

R_{se} : External transition value 0.04 $[m^2K/W]$
R_{si} : Internal transition value 0.17 $[m^2K/W]$

$$U = \frac{1}{0.04\ [m^2K/W] + \frac{0.1[m]}{0.2\ [W/mK]} + \frac{0.3[m]}{0.039\ [W/mK]} + 0.17\ [m^2K/W]} = \mathbf{0.114[W/m^2K]}$$

Ground deck

Martial	$\iota\ [m]$	$\lambda\ [W/mK]$
RockWool	0.4	0.036
Wood beam	180x80 [mm]	0.12

R_{se} : External transition value 0.04 $[m^2K/W]$
R_{si} : Internal transition value 0.1 $[m^2K/W]$

In the roof construction, the insulation is between and on top of the truss meaning that the insulation layer is an inhomogeneous layer.

$$U = U' + \Delta U$$

Where

$$\frac{1}{U'} = R_{si} + R_{se} + \sum R_h + \sum \frac{d}{\lambda'}$$

R_h: Thermal resistance of homogeneous layer

$$\lambda' = \frac{A_a \lambda_a + A_b \lambda_b + \cdots}{A_a + A_b + \cdots}$$

A_a: Area of inhomogeneous martial [m^2]
λ_a: Matrial thermal conductivity coefficient $[W/mK]$

$$\lambda' = \frac{0.014[\mathrm{m2}] \cdot 0.12\ [W/mK] + 0.018[\mathrm{m2}] \cdot 0.036\ [W/mK]}{0.014[\mathrm{m2}] + 0.018[\mathrm{m2}]} = 0.0728\ [W/mK]$$

Now the U' can be calculated.

$$\frac{1}{U'} = 0.1\ [m^2K/W] + 0.04\ [m^2K/W] + \sum \frac{0.4[m]}{0.036\ \left[\frac{W}{mK}\right]} + \sum \frac{0.4\ [m]}{0.0728\ \left[\frac{W}{mK}\right]} = 0.069[W/m^2K]$$

Now ΔU is calculated.

$$\Delta U = \Delta U_g$$

ΔU_g: Correction for air gabs in the insolation.

$$\Delta U_g = \Delta U'' \left(\frac{R_i}{R_t}\right)^2$$

R_i : Thermal conductivity of the insolation = 0.036 $[m^2K/W]$
R_t : Thermal conductivity of the construction = 0.12 $[m^2K/W]$
$\Delta U''$: Correction for air gabs. From DS 418 table A.1 = 0.01 $[m^2K/W]$

$$\Delta U_g = 0.01\ [m^2K/W] \left(\frac{0.036\ [m^2K/W]}{0.12\ [m^2K/W]}\right)^2 = 0.009\ [W/m^2K]$$

Now the u-value can be calculated.

$$U = 0.069[W/m^2K] + 0.009\ [W/m^2K] = \mathbf{0.078\ [W/m^2K]}$$

Energy consumption

The calculation of the energy consummation is based on a formula from (Petersen and Gram-Hassen, 2005).

Energy consummation = 340 $[kWh]$ + area · 11$[kWh]$ + pers. · 350 $[kWh]$

= 340 $[kWh]$ + 1920 [m^2] · 11$[kWh]$ + 80 pers. · 350 $[kWh]$ = **49460** $[\boldsymbol{kWh}]$

Dimensioning of solar cells.

$C \cdot D \cdot E =$ energy use

C : Installed power $[kWh/m^2]$
D : Evaluation of the system factor
E : Solar radiation intensity $[kWh/m^2]$

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

A : Total area of modules [m^2]
B : Module efficiency [%]

To calculate the area of solar cells, the equation is modified.

$$A = \frac{49460\ [kWh] \cdot 100}{B \cdot D \cdot E}$$

$$A = \frac{49460\ [kWh] \cdot 100}{22[\%] \cdot 0.8 \cdot 999[kWh/m^2]} = 282[m^2]$$

The energy requirement for building serves according to Be15.

The total electrical requirement for building serves = 19239$[kWh]$ pr. year

$$A = \frac{19239\ [kWh] \cdot 100}{22[\%] \cdot 0.8 \cdot 999[kWh/m^2]} = 109[m^2]$$

Total area $= 109[m^2] + 282[m^2] = \mathbf{391}[\boldsymbol{m^2}]$

Dimensioning of ventilation

Frist the calculation is done for the CO^2 and is defined as.

$$C_i = \frac{q}{n \cdot V} + C_e$$

C_i : indoor co^2 prolusion = 850 [ppm]
C_e : outdoor co^2 prolusion = 350 [ppm]
q : co^2 load [m^3/h]
n : air changes rate [h^{-1}]
V : volume = 47,9[m^3]

Frist q is calculated by

$$q = \frac{4}{100} \cdot 2persons \frac{10[l/min.] \cdot 60[min.]}{1000[l]} = 0.048[m^3/h]$$

Now the air changes rate can be calculated.

$$n = V \frac{q}{C_i - C_e}$$

$$n = 47.95[m^3] \frac{0.048 \left[\frac{m^3}{h}\right]}{850 \text{ [ppm]} - 350 \text{ [ppm]}} = \mathbf{0.046[h^{-1}]}$$

The olf is define by

$$Q_c = \frac{G_c}{C_{c,1} \cdot C_{c,0}} \cdot \frac{1}{\varepsilon_v}$$

Q_c : luftskifet [l/s]
G_c : Sensory load =2 [persons] · 1 [olf]
$C_{c,1}$: Desired air quality = 1.4 [dp] category B (table A.5)
$C_{c,0}$: outdoor air quality = 0.1 [dp]
ε_v : ventilation efficiency = 1

$$Q_c = \frac{2\ [olf]}{1.4\ [olf] \cdot 0.1[olf]} \cdot \frac{1}{1} = 12.62 \left[\frac{l}{s}\right] \cong 0.946[h^{-1}]$$