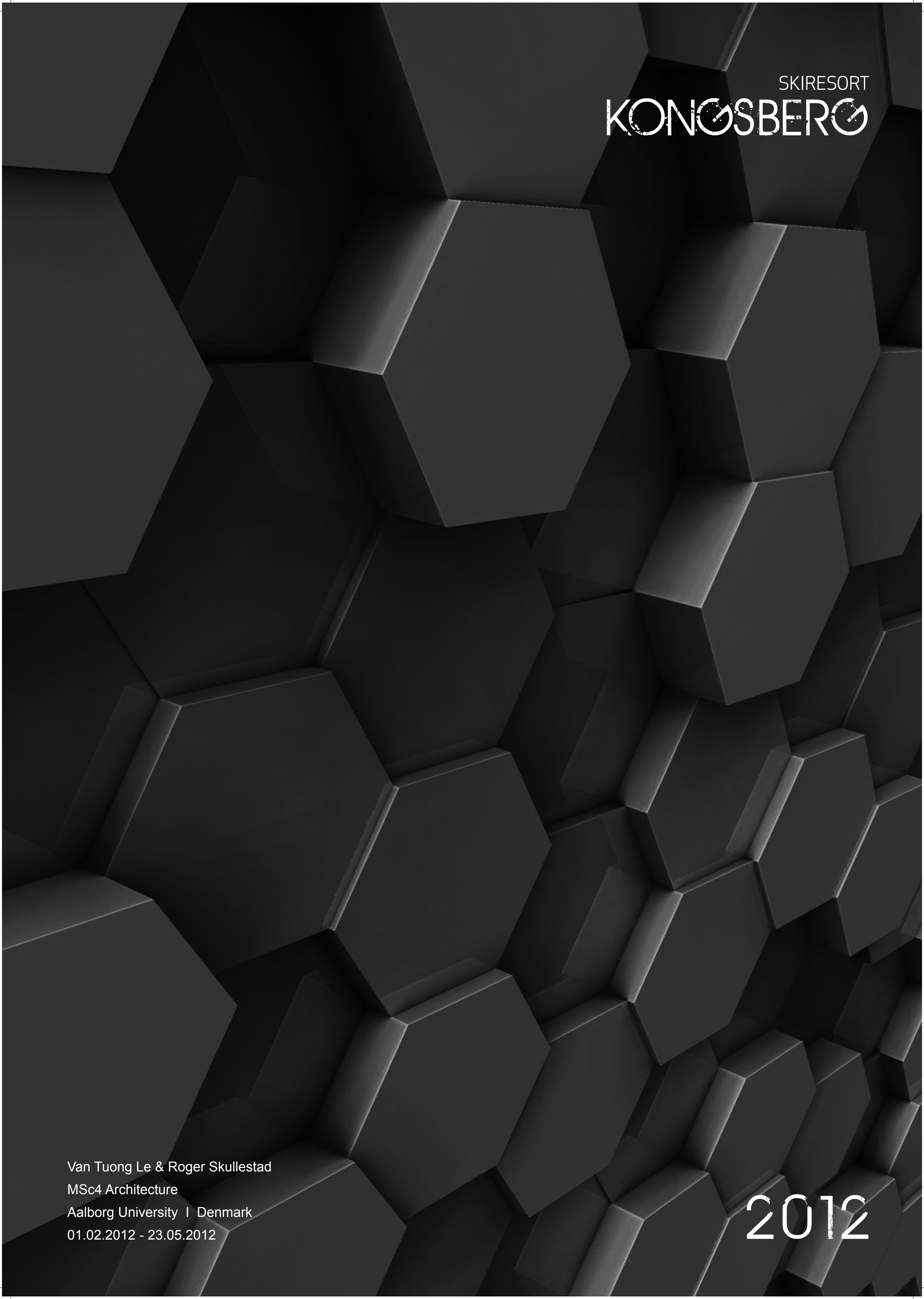
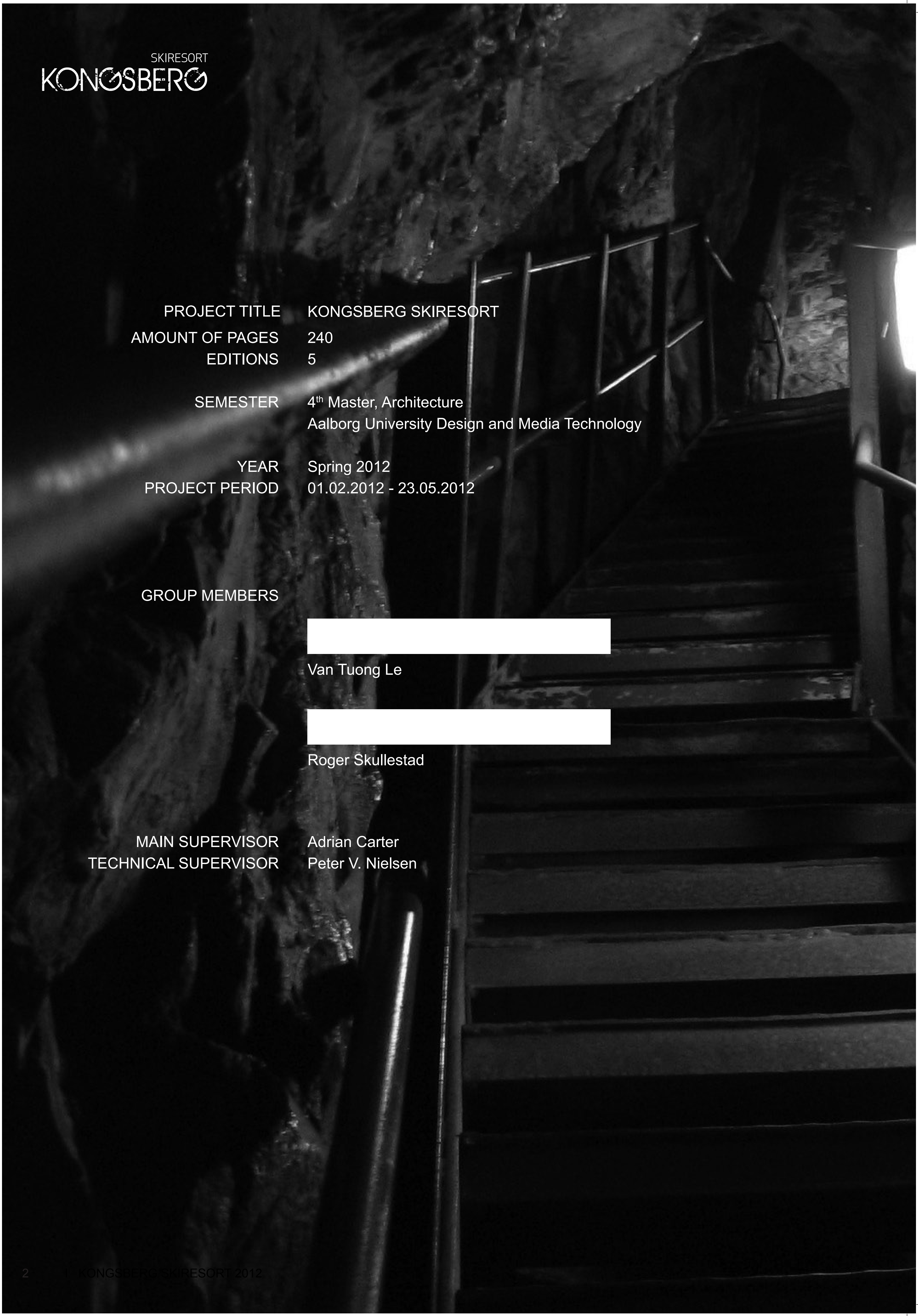


SKIRESORT

KONGSBERG

Van Tuong Le & Roger Skullestad
MSc4 Architecture
Aalborg University I Denmark
01.02.2012 - 23.05.2012

2012



SKIRESORT KONGSBERG

PROJECT TITLE	KONGSBERG SKIRESORT
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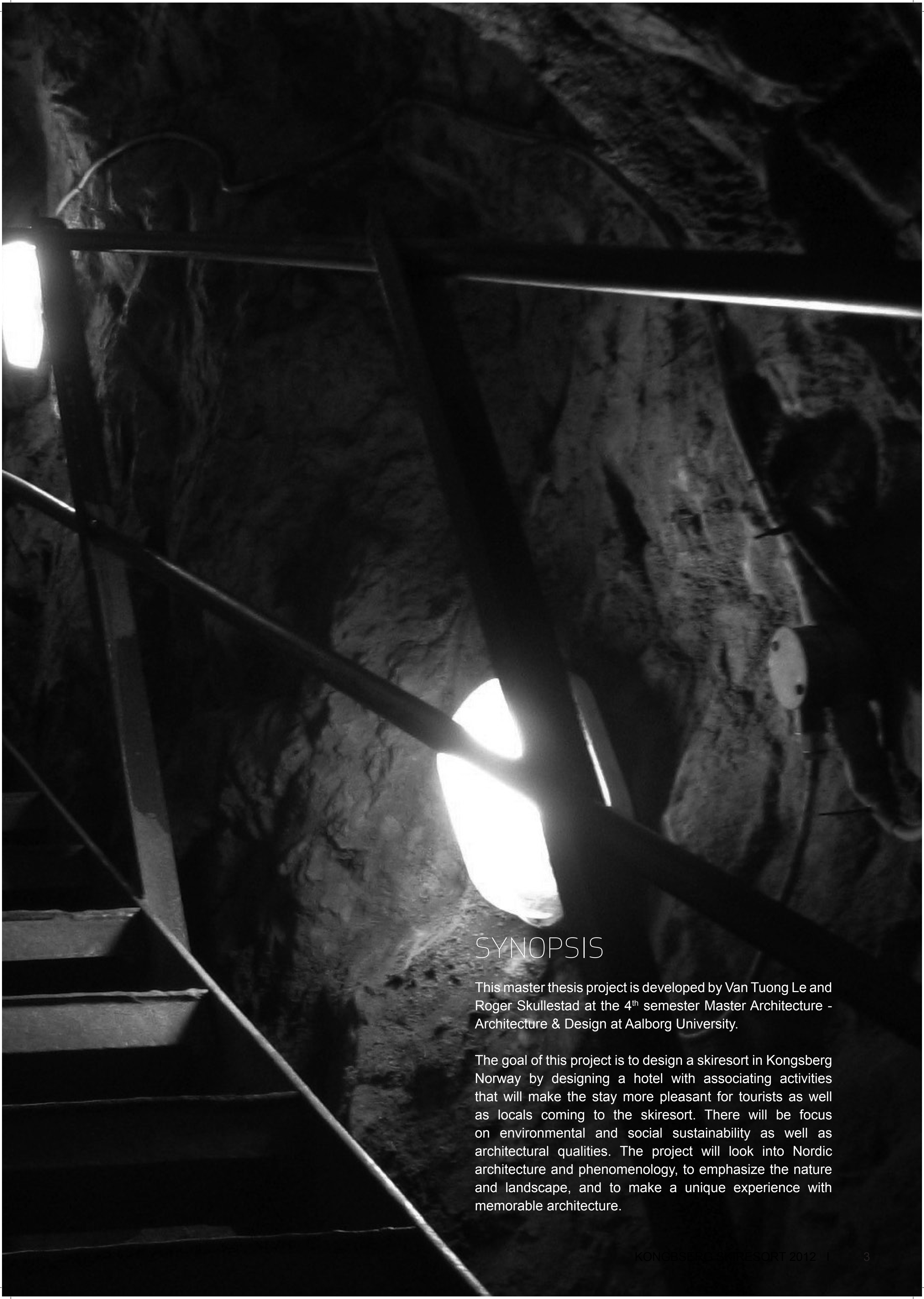

SYNOPSIS

This master thesis project is developed by Van Tuong Le and Roger Skullestad at the 4th semester Master Architecture - Architecture & Design at Aalborg University.

The goal of this project is to design a skiresort in Kongsberg Norway by designing a hotel with associating activities that will make the stay more pleasant for tourists as well as locals coming to the skiresort. There will be focus on environmental and social sustainability as well as architectural qualities. The project will look into Nordic architecture and phenomenology, to emphasize the nature and landscape, and to make a unique experience with memorable architecture.

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ill. 001

INTRODUCTION

When the winter holidays approaching, thousands of families begin to pack their gear for the annual ski holiday. For some it would be the first time, but for most it is almost a tradition. One very important criterion is to find a place where children can ski safely, while mom and dad rushes down the big hill with nearby accommodations that allow afterskiing and other fun activities to make the stay attractive. With this scenario as a starting point, an ideal location for a skiresort has been chosen.

Kongsberg skicenter (Norway) is a known holiday place for thousands of families that yearly comes to ski and snowboarding. The skicenter offers a place for beginners, but also challenging slopes for more experienced drivers. Kongsberg alpine center is located close to Kongsberg city center and 1 hours' drive from Oslo. They have about 150,000 day-visitors a year and 2-3000 visitors in a weekend day.

The current skicenter has no activities or functions that allows the users to use the center after closing time at 21 o'clock, and the only offer for accommodation available for tourists coming to ski are 3 hotels down in the city, about 3km from the alpine center. From there they must get transport either by own car, bus or taxi to reach the alpine center. This is a problem for many families when looking for a skitrip holiday.

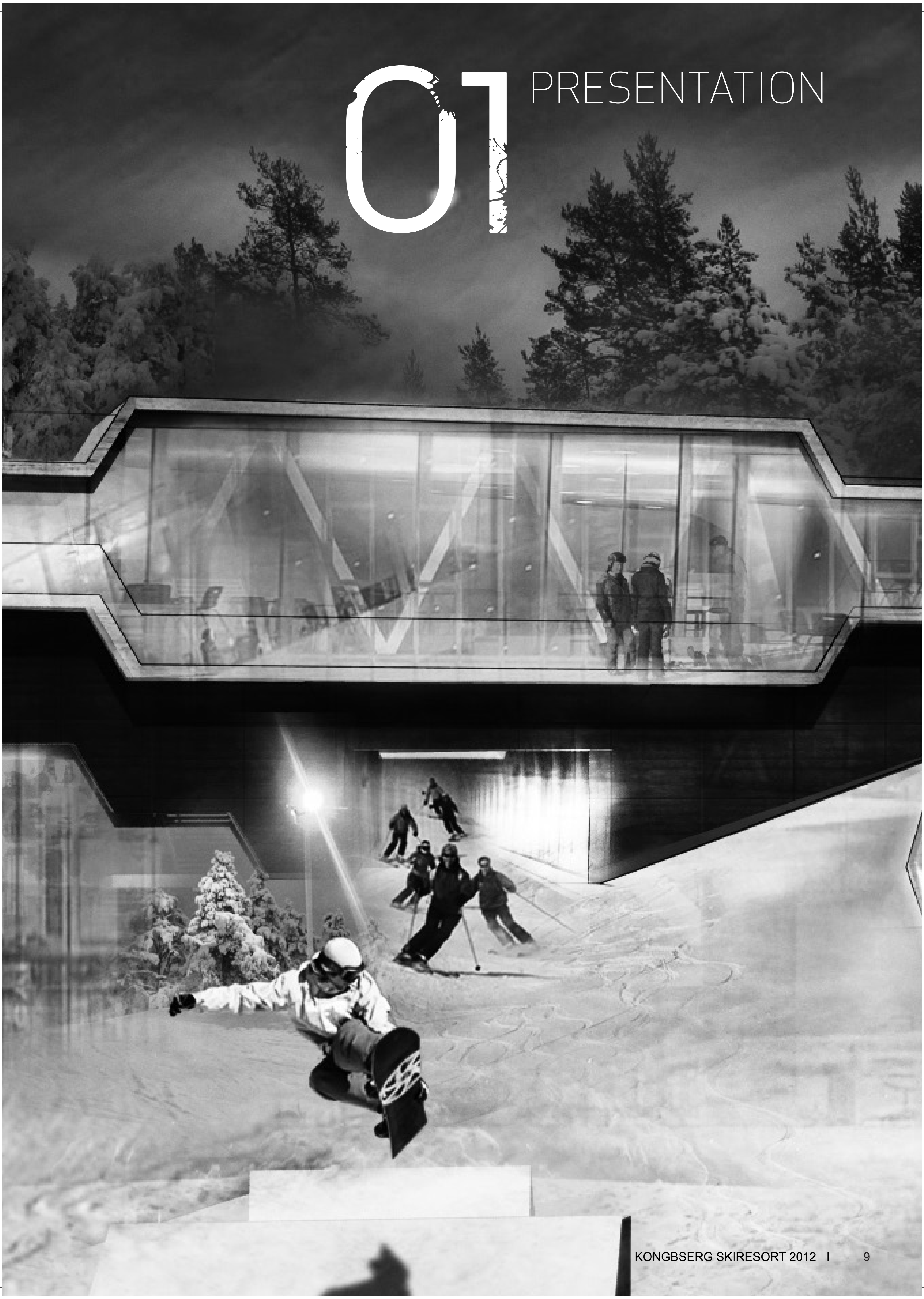
This raises issues of how to design a skiresort on a sensitive site and context, to make it more attractive to come to Kongsberg skicenter? An overall plan for the site will be designed and particular attention is paid to the phenomenology, Nordic architecture and sustainability aspects. Not only for the building, but also for the usage and functions of the skiresort. There has for several years been talking about making a hotel up by the alpine center, and there has been made a local plan [Appendix 1] for the future which includes space for a hotel. The area for the hotel is located just east of the slopes and is on a ridge with good view west to the alpine slopes and southeast to the city center. The area allowed for an hotel is of approximately 18,140m² where the ground floor is allowed to use 50% of this space.

INITIAL PROBLEM FORMULATION

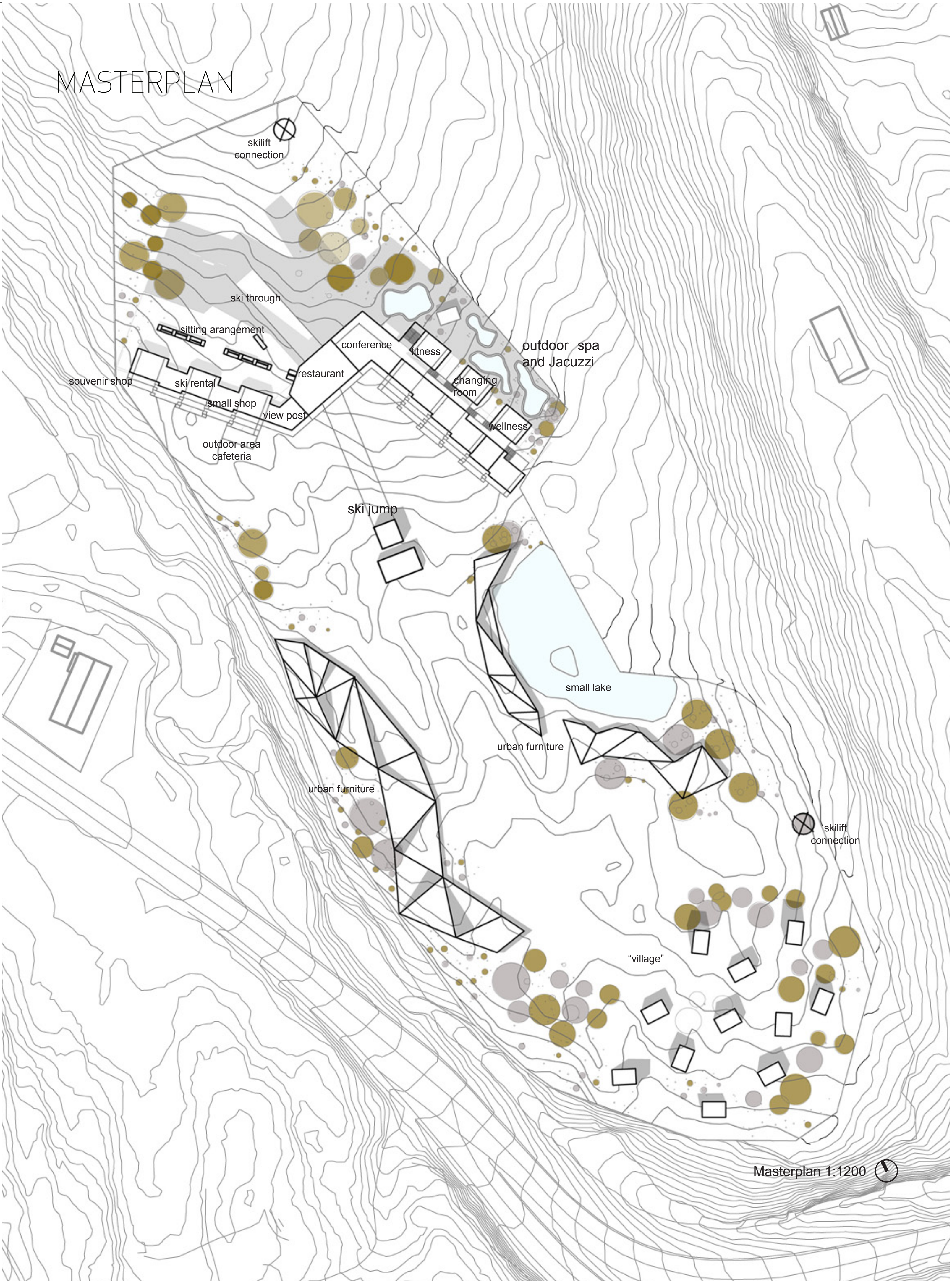
How do we design a sustainable skiresort on a sensitive context with attractive functions and activities all year around, which possesses great phenomenological and Nordic architectural qualities, and is a new landmark for the city of Kongsberg?

ill. 002

01 PRESENTATION



MASTERPLAN

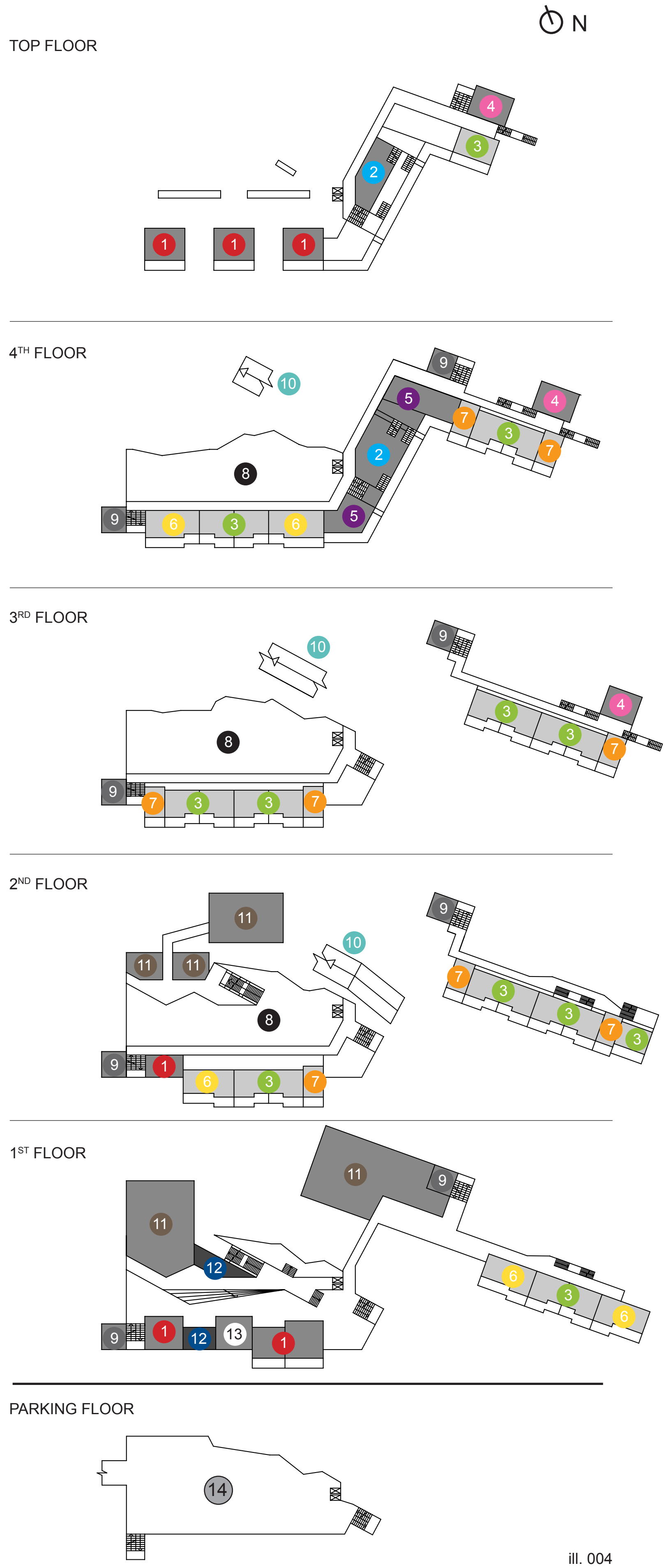


Masterplan 1:1200

ill. 003

FUNCTIONS DIAGRAM

SHOPS / RENTOUT / CAFE	1
RESTAURANT	2
DOUBLE ROOM	3
WELLNESS / SPA / FITNESS	4
RESTAURANT / CONFERENCE	5
PENTHOUSE	6
SINGLE ROOM	7
OPEN ATRIUM	8
TECHNICAL	9
SKI THROUGH SLOPE	10
CAVE FUNCTIONS (cinema, pool, hall)	11
RECEPTION / OFFICE / ADMIN	12
PUBLIC TOILETS	13
PARKING	14



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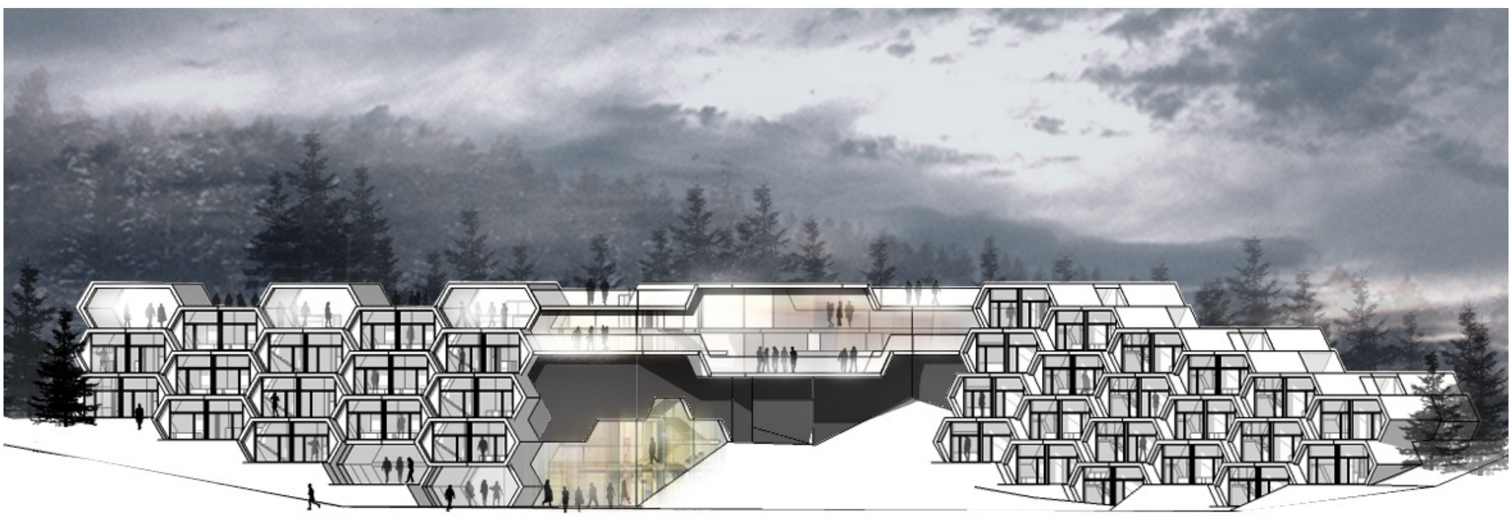
FACADE NORTH

1:500

ill. 006

FACADE SOUTH

1:500



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FACADE EAST

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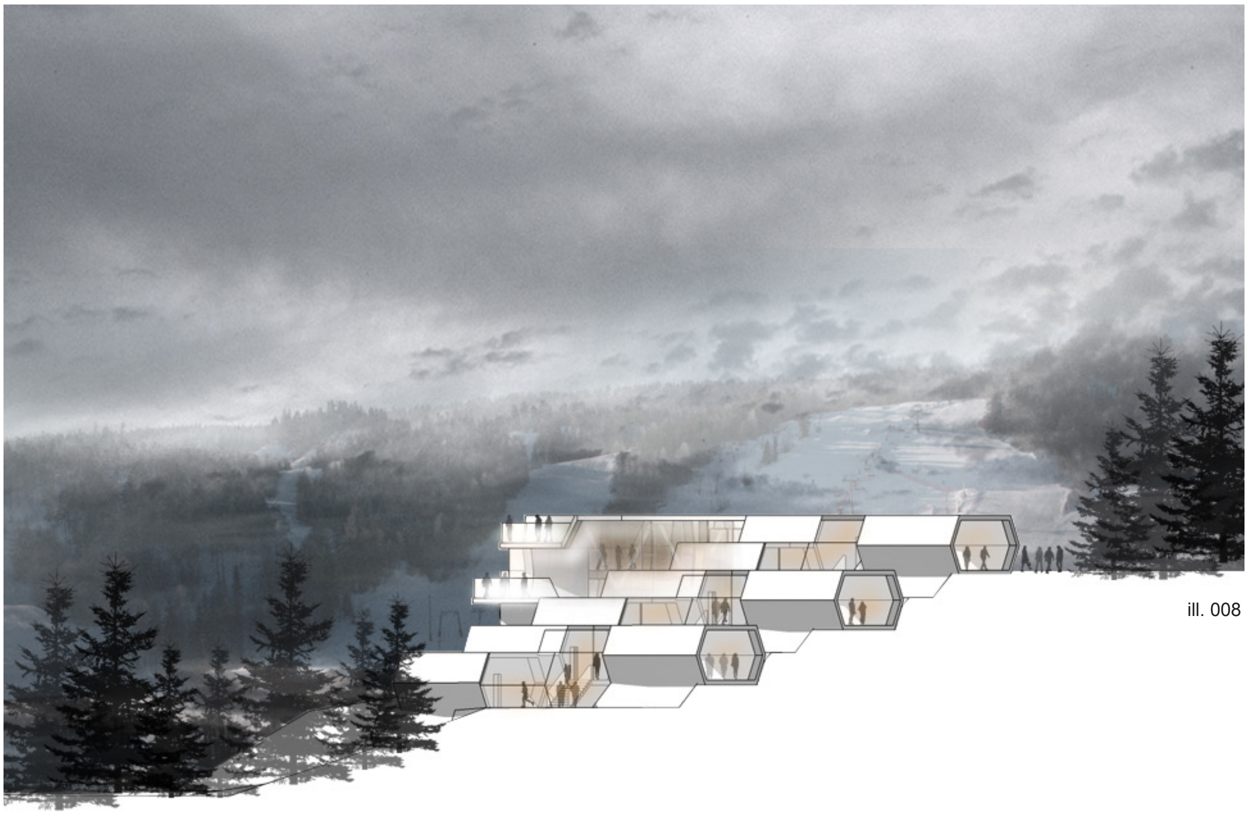

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FACADE WEST

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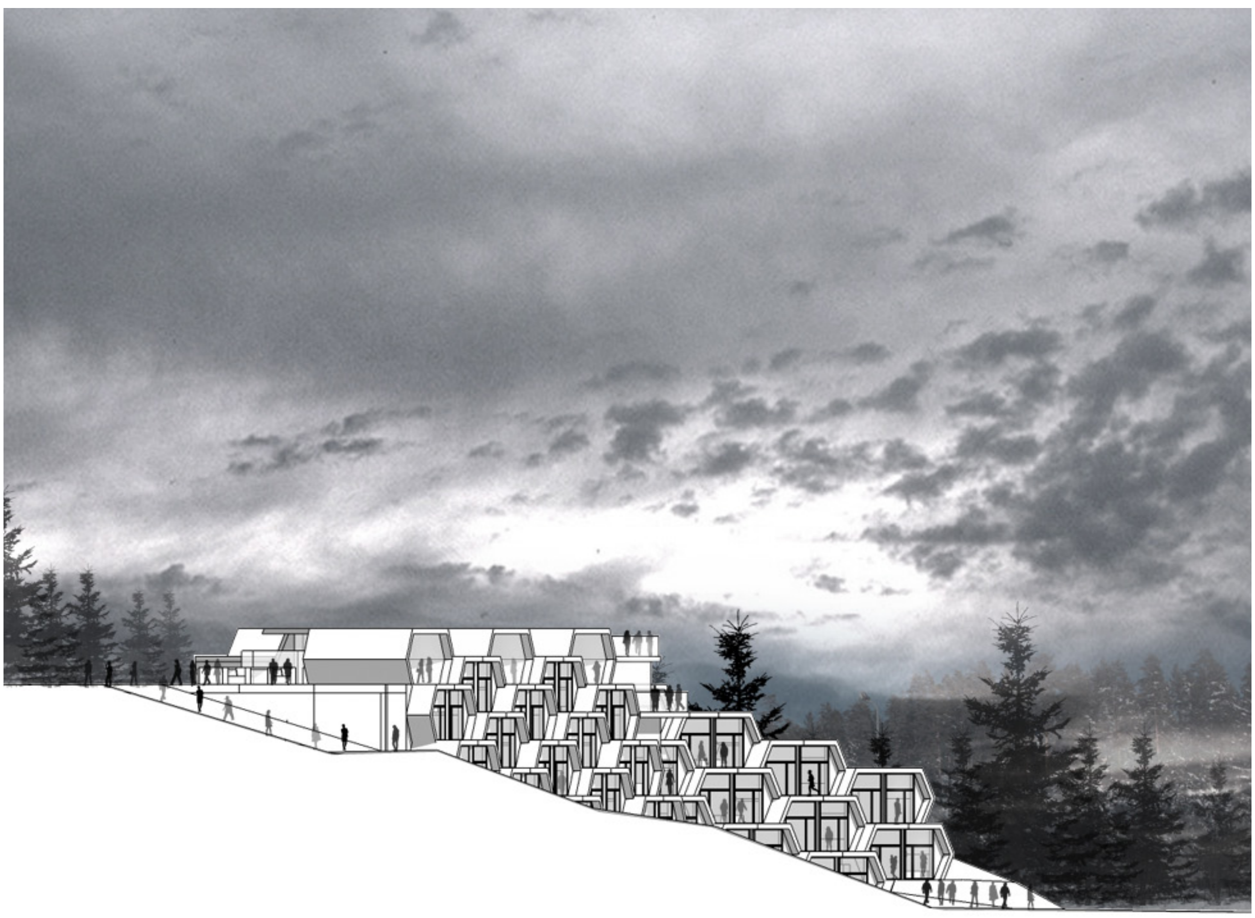

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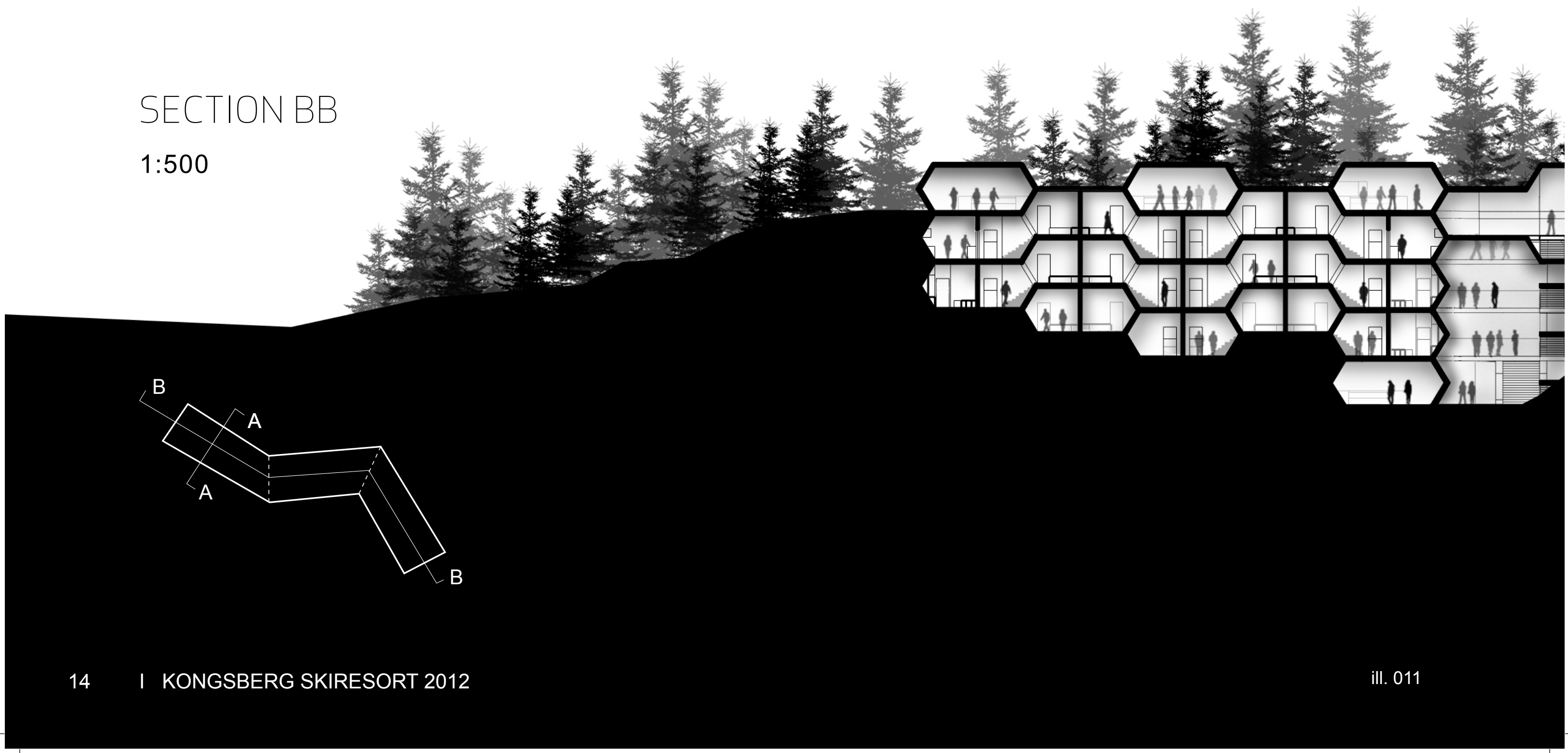
SECTION BB

1:500



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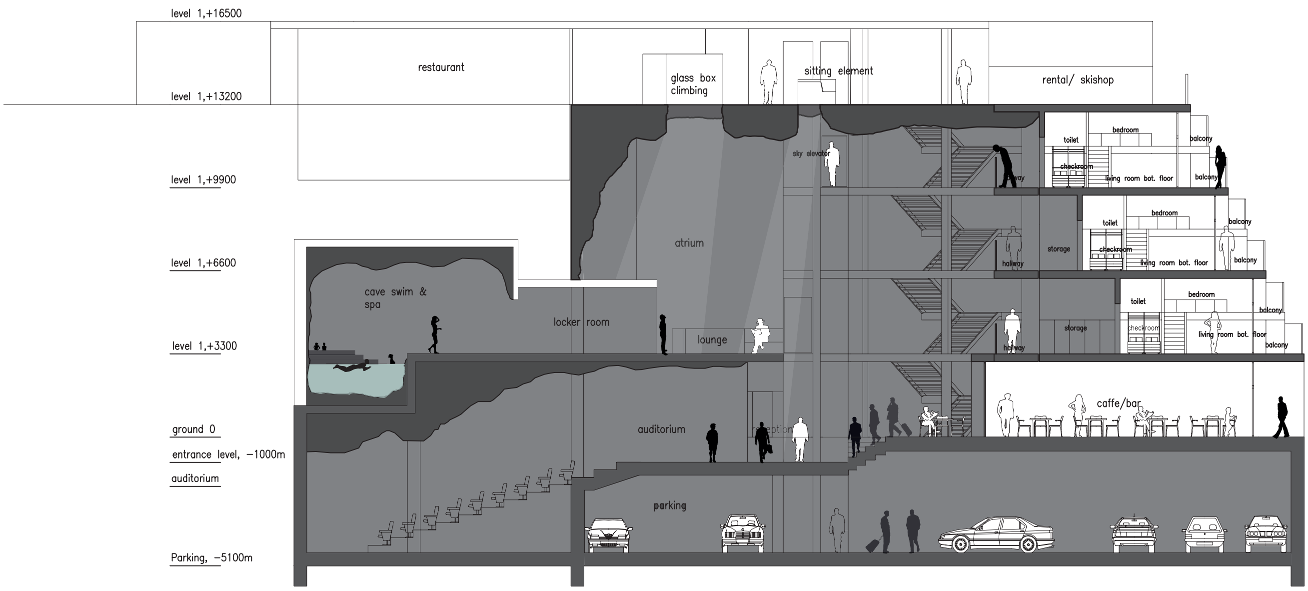
SECTION AA

1:300



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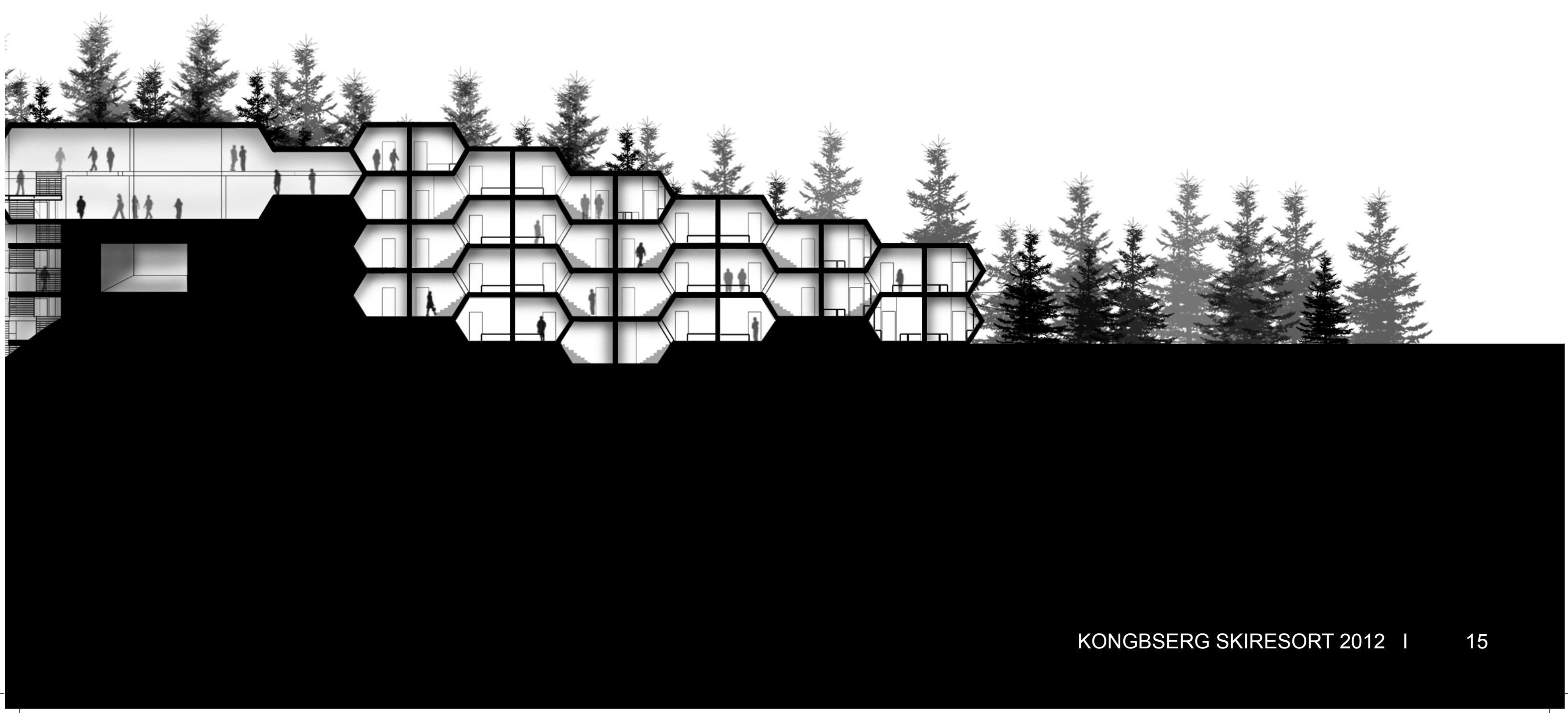


“The landscape brought the activities, the activities brought Kongsberg Skicenter - combining these, a resort arise. A resort with enchanting cave functions, consisting of unique and sensual experiences that works as the new fulcrum. A fulcrum that unites the existing adjacent functions in “Funkelia” to become the new - Kongsberg Skiresort.

ill. 005


1
WINTER VIEW
FROM VILLAGE

ill. 012

2 VIEW FACADE

Full privacy - but still as one unit! All hotel rooms has their own private balcony with a spectacular panoramic view towards the extraordinary and dramatic Norwegian context.

ill. 013

3 WINTER VIEW ROOFTOP

On top of the roof, the ski shop and ski rental is to be found. When buying or renting ski, the direct access leads to the ski lifts connection and to the current skicenter. A ski-through under the restaurant connects to the “village” at the lower part of the site.

ill. 014

4 VIEW ATRIUM 1

The centre of the building is the cave atrium, with only small light streaks penetrating the dark room. A reception, a small cafeteria, sky elevators and a 14m tall climbing wall of pure rock for those whom seeks “enlightenment”. Small narrow path makes the visitors explore and discover the many underground cave functions that the resort offers.

A big stair invites the visitors to experience the hidden cave functions behind the mountain wall. A lounge area on the first floor, provides the visitors to have an overview to enjoy the intimate cave atmosphere.

ill. 015


5 VIEW
ATRIUM 2

Kongsberg Skiresort contains activities inside, over and under the building. One of the many exiting cave activities that Kongsberg Skiresort offers, is an underground cave for unforgettable arrangements and events in a cosy and intimate environment.

ill. 016

6 VIEW RENT OUT ROOM

Another exiting activity is the cave cinema that in its deep location isolates the guests from all the sunlight and noise from outside. The cave cinema makes it all about the most important thing in a cinema – The movie. This room has potential for every kind of video or movie presentation that needs silence and darkness to get the full movie experience.

ill. 017


7
VIEW
CAVE CINEMA

To really dig in to the core of the mountain, and thereby also the history, a large cave swim gives the visitor the free opportunity to discover the huge room themselves. It is not an ordinary swim, but an exiting, mystery and authentic swim that reveals the mountains bare walls, which hides old histories back from the 16-century.

ill. 018

8 VIEW
CAVE SWIM

During summer, when the snow is gone, the snow-white skiresort turns into a beautiful green public space that allows for different summer activities. Swimming and sun bathing by the lake, running and biking in the mountains, is all summer activities that introduce the visitors to the forgotten part underneath – The beautiful green Norwegian nature.

ill. 019


SUMMER VIEW
FROM VILLAGE

To please the visitors the most, Kongsberg Skiresort offers the luxury penthouse. With the 43 square meters big hotel room, there is plenty of space to feel free and enjoy a luxurious and relaxing holiday. The extra square meters provides extra room for enjoyment.

ill. 020


10 VIEW
PENTHOUSE

The double room is appropriate for the couple that prefer cosiness rather than luxury. It contain all the necessary facilities with an open room solution and an extraordinary view towards the beautiful landscape.

ill. 021

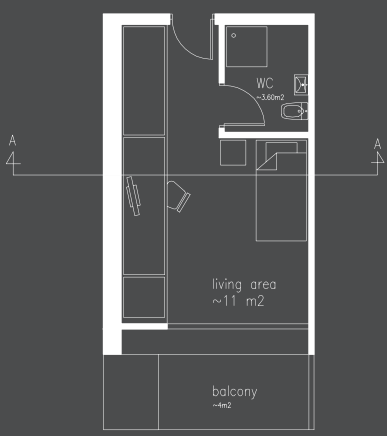
11 VIEW DOUBLE ROOM

ill. 022

12 VIEW SINGLE ROOM

The single room is the smallest room, perfect suitable for one person that doesn’t prefer spending all day in the room. Though it is a small room, the view is still as great as the other rooms.

SINGLE ROOM ~ 18m^2
1:150



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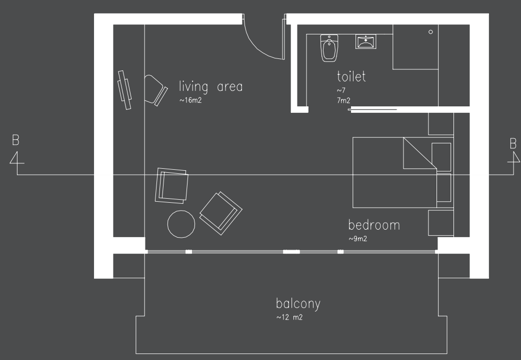
DOUBLE ROOM I ~ 24m^2
1:150



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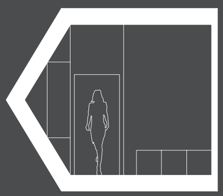
Section single room A-A
1:150



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Section double room I B-B
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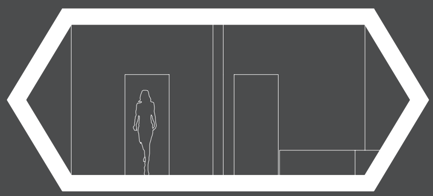

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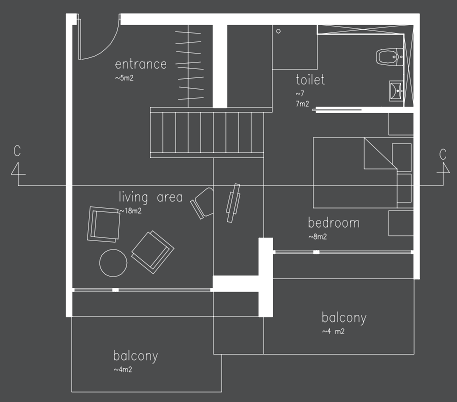
FINAL PLANS & SECTIONS 1:150

DOUBLE ROOM II ~ 28m²
1:150



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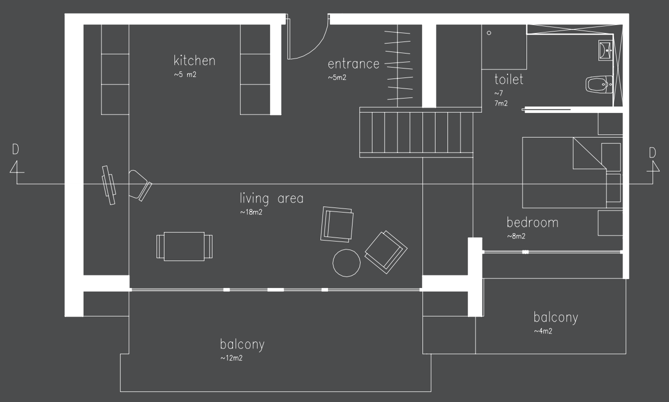
DOUBLE ROOM III ~ 36m²
1:150



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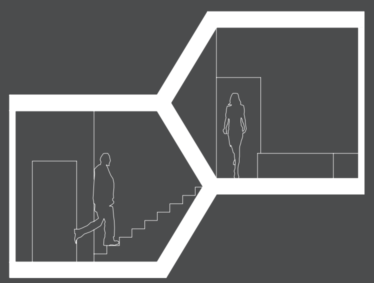
Section double room II C-C
1:150



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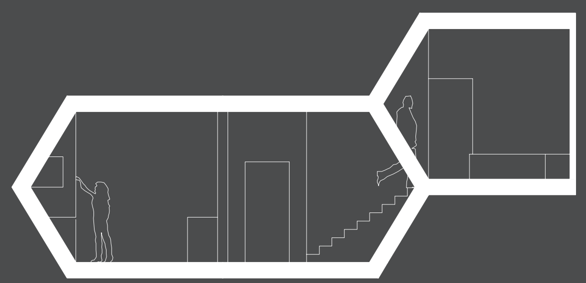
Section double room III D-D
1:150



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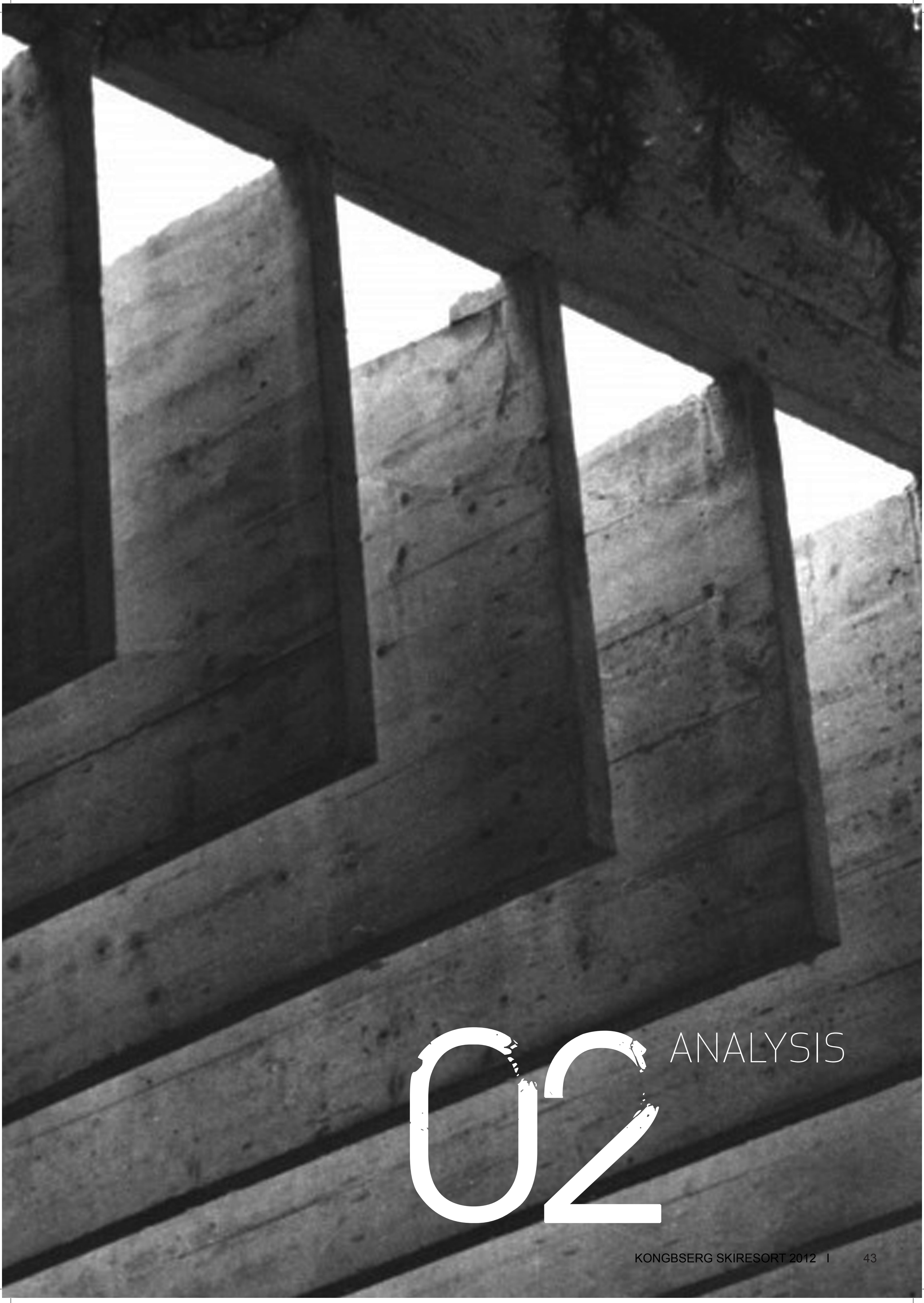


02 ANALYSIS

METHODOLOGY

THE INTEGRATED DESIGN PROCESS

The purpose of this project is to include aesthetical functional as well as technical aspects [Bundegaard, 1961] organized according to the Integrated Design Process [Knudstrup, 2004]. Even though this project is presented linearly, the process is iterative, which means that the phases occurs in loops to always ensure to work simultaneously with all aspects through the design process.

KEVIN LYNCH

In order to get an understanding of the context, an analysis has been made based on a visit to the site. Kevin Lynch's method for analyzing a city was used to achieve an objective understanding of the site, based on his book "The image of the city" [Lynch, 1991]. The approach has been partly empirical, here focusing on pathways, zones, nodes and landmarks etc. through observations of the site and registrations to examine how urban architecture visually and sensory can be experienced as an "experienced phenomenon".

GORDON CULLEN

The Serial Vision by Cullen is a phenomenological urban architecture analysis, based on a given route and all spaces and transitions from an urban space to the next will be registered [Cullen, 1971]. The registrations will be supported by short texts and series of pictures, which almost represents a film sequence with contrast and variety of visual experiences highlighted.

In addition to this, our own phenomenological experiences of the site will be found in the beginning of these chapters, in order to bring our own understand and observation of the urban qualities.

STEEN EILER RASMUSSEN

Steen Eiler Rasmussens theory behind the book "Om at opleve arkitekturen" is introduced in order to achieve a tool to analyze the site phenomenologically. Here focusing on how humans respond to architecture and design, through sensing the context as the architectural cityscape of enhanced or contrasting shapes, materials, rhythms, colors and lighting [Rasmussen, 1957].

ANALYSIS

A detailed site analysis will be made; registration, mapping, observations, wind, sun, shadows and the site's contexts based on the theories and techniques by Kevin Lynch [Lynch, 1991]. The phenomenological approach based on Rasmussen and Cullen will be introduced to experience and sensing the site on a more subjective level.

SKETCHING

The sketching phase is based on the program with the purpose to identify a concept for the project. This will be done through hand sketches, models, 3d models, Excel schemes linked to principles of construction, energy consumption and indoor environment. This is done in iterative loops according to the integrated process [Knudstrup, 2004]

SYNTHESIS

In this phase the aspects of functionally, technicality and aesthetic qualities will be combined. Energy consumption, indoor environment and construction will also in this phase be evaluated and optimized in order to decide the final building form.

PRESENTATION

The presentation of the final design will in this phase be presented in form a report, models, visualizations, renderings to clarify the goals and achievements for this project.

MONTH AVERAGE- SPREADSHEET

This spreadsheet was used to calculate monthly and yearly energy consumption for a building, both for heating and cooling. The input is construction details regarding walls, roof, floor and windows as well as the ventilation rate for summer and winter, and the internal heat loads hourly. This was used for early calculations as the number of inputs was limited.

24 HOUR - SPREADSHEET

This spreadsheet was used to calculate the monthly indoor temperatures in a room. The results are displayed as monthly average along with the temperature variation. The calculations can be based on outdoor temperature ventilated into the building, or on heated/cooled air. The input is room details regarding walls, roof, ceiling and windows, as well as the internal heat loads hourly. This was used for early calculations as the number of inputs was limited.

SIMIEN

Simien is used to simulate the indoor climate for each room, and to dimension the heating and ventilation systems. It is also used to calculate and minimise the energy consumption of the building. The program calculates and evaluates based on TEK10 building regulations and NS3700 low energy / passive house standard. The program allows for a large number of input and output, and thus can be a powerfull and accurate tool if right values are entered. Simien is replacing both BSIM and BE10 as it has the functionalities of both programs.

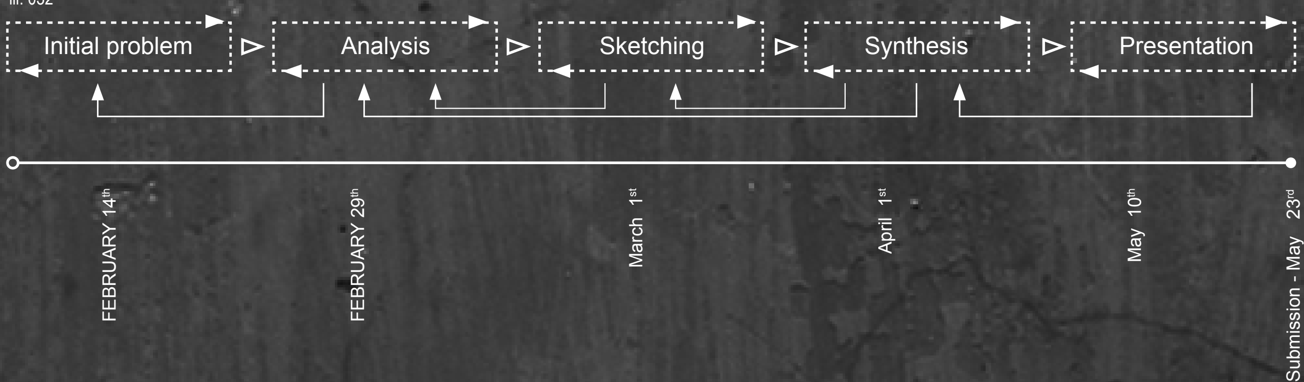
ECOTECT (Radiance)

Simple volume models of the building were made in Sketchup and imported in to Ecotect. Here Radiance was used to estimate the amount of daylight coming into the rooms.

OTHER TOOLS

3D Studio Max, Autocad, Adobe, Sketchup etc.

ill. 032



NORDIC ARCHITECTURE

In order to have an understanding about the Nordic Architecture and phenomenology, it is important to have references of architects that has dealt with and worked with this field. In this chapter different architects and their definitions of what Nordic architecture and phenomenology is will be presented.

When building in Norway, there are different conditions to be aware of, because it differs from most other places in the world. Norway is captured in a huge and diverse landscape space, a nature characterised by four clear seasons staged by the daylight changes, from light and warm summer nights to the cold and dark winter. "Our culture has always been linked to this image of nature" [Fehn, 2010]. These conditions are used as design parameters in many projects and have a great impact on an overall Nordic aesthetics architectural expression. The expression has often been inspired of other big architects in the south, but always with a local interpretation and usage of light and local building materials [www.dti.dk, 2009].
Nordic architecture is about order and harmony, and the architect's task is to create a piece of "paradise", where the mind can find the peace that the troubled world can't otherwise provide [Lund, 2008,p12]. It is important to reflect upon this approach, because buildings and plans together should symbolize the society and culture of its context. "A city without a vision of what the city should be, is inappropriate. A building without commenting on the beauty and "the good life" is uninteresting" [Lund, 2008, p12]. "In his opinion, even behind the simplest house lies a series of choices that cannot be done without the existence of a set of values. Whether you choose one or the other solution depends on the cultural environment you are in" [Lund, 2008, p12].

"The use of a given material should never happen by choice or calculation, but only through intuition and desire," he told Per Olaf Fjeld, the author of "The Thought of Construction".

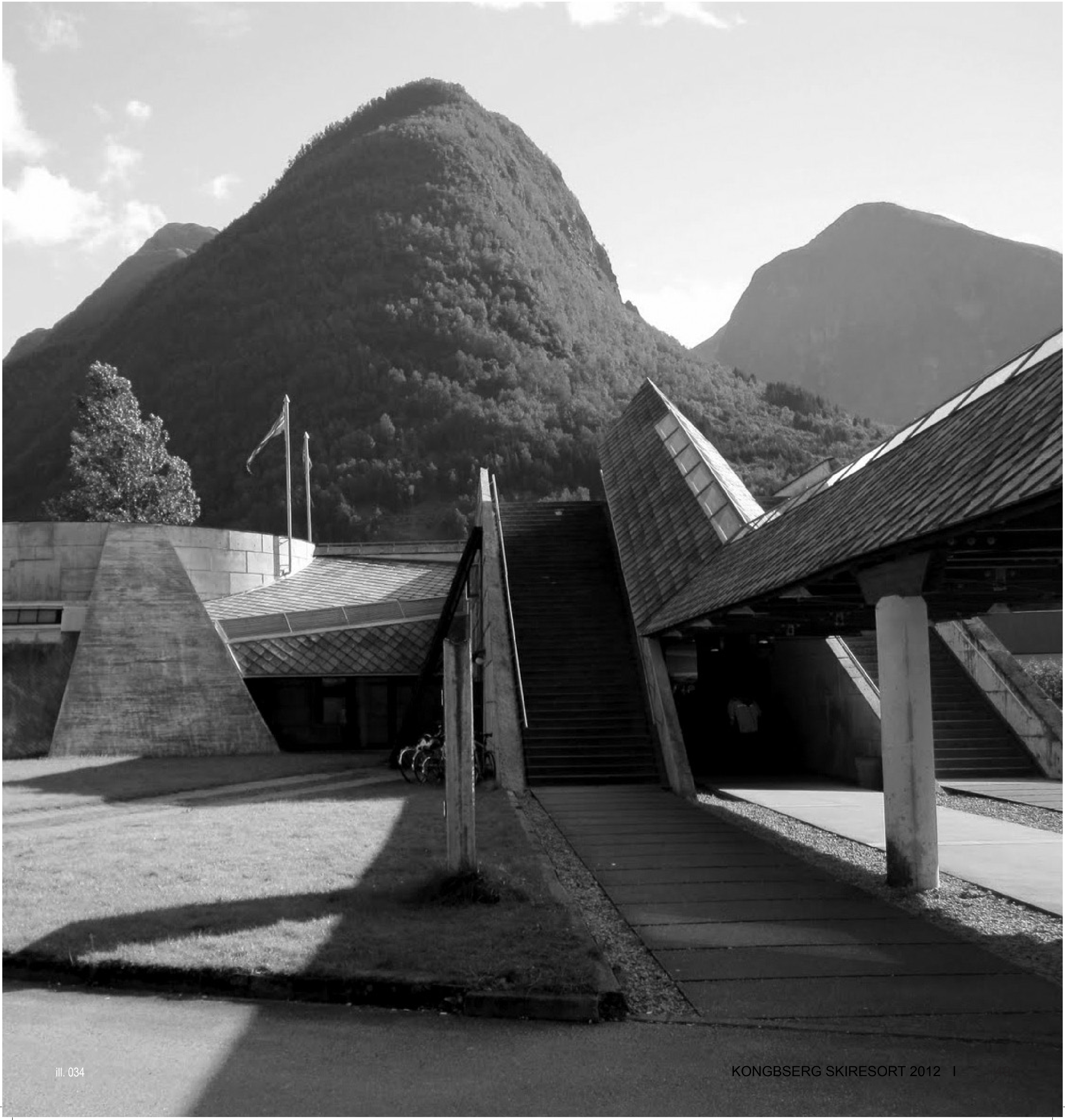
[www.nytimes.com, 2009]

ill. 033

Since the beginning of the 20th century Nordic architecture has found and developed into its own style and characteristic. Compared to the built environment in other places in Europe, the Nordic tradition is based upon a social and cultural character. “With Nordic architecture we try to avoid the spectacular and strive for a more thorough and harmonious expression” [Lund, 2008, p18]. The interplay between social engagement and professional quality awareness is probably the most important aspects in the Nordic tradition. The political and cultural history makes it natural to see a connection between form and content - between ideology and society. The political and cultural understanding prevents us from seeing the architecture solely as a surface. We need to ask what the surface cover and demand it to be meaningful. “Architecture is as much about ethics as an aesthetics” [Lund, 2008, p21]. This is supported by Sverre Fehn, whom has spent a lifetime ingeniously reconciling the urban modernism with focus on construction techniques and natural materials, and with his love of the Norwegian landscape. “When I build on a site in nature that is totally unspoiled, it is a fight, an attack by our culture on nature. In this confrontation, I strive to make a building that will make people more aware of the beauty of the setting, and when looking at the building in the setting, a hope for a new consciousness to see the beauty there, as well” [www.nytimes.com, 2009]. In his opinion, the use of a given material should never happen by choice or calculation, but only through intuition and desire [www.nytimes.com, 2009]. His philosophy was reflected in the Nordic Pavilion at the 1962 Venice Biennale. A concrete structure built around trees, with openings in the roof to admit natural light, and another famous building is the Glacier Museum (1991) at the mouth of the Fjaerland Fjord in Norway, which Mr. Fehn conceived as a rock lying against the surrounding mountains [www.nytimes.com, 2009]. These projects have been presented in this chapter, because its qualities and values will be extracted and used in our project.

“I always thought I was running away from traditional Norwegian architecture, but I soon realized that I was operating within its context,”

[www.nytimes.com, 2009]



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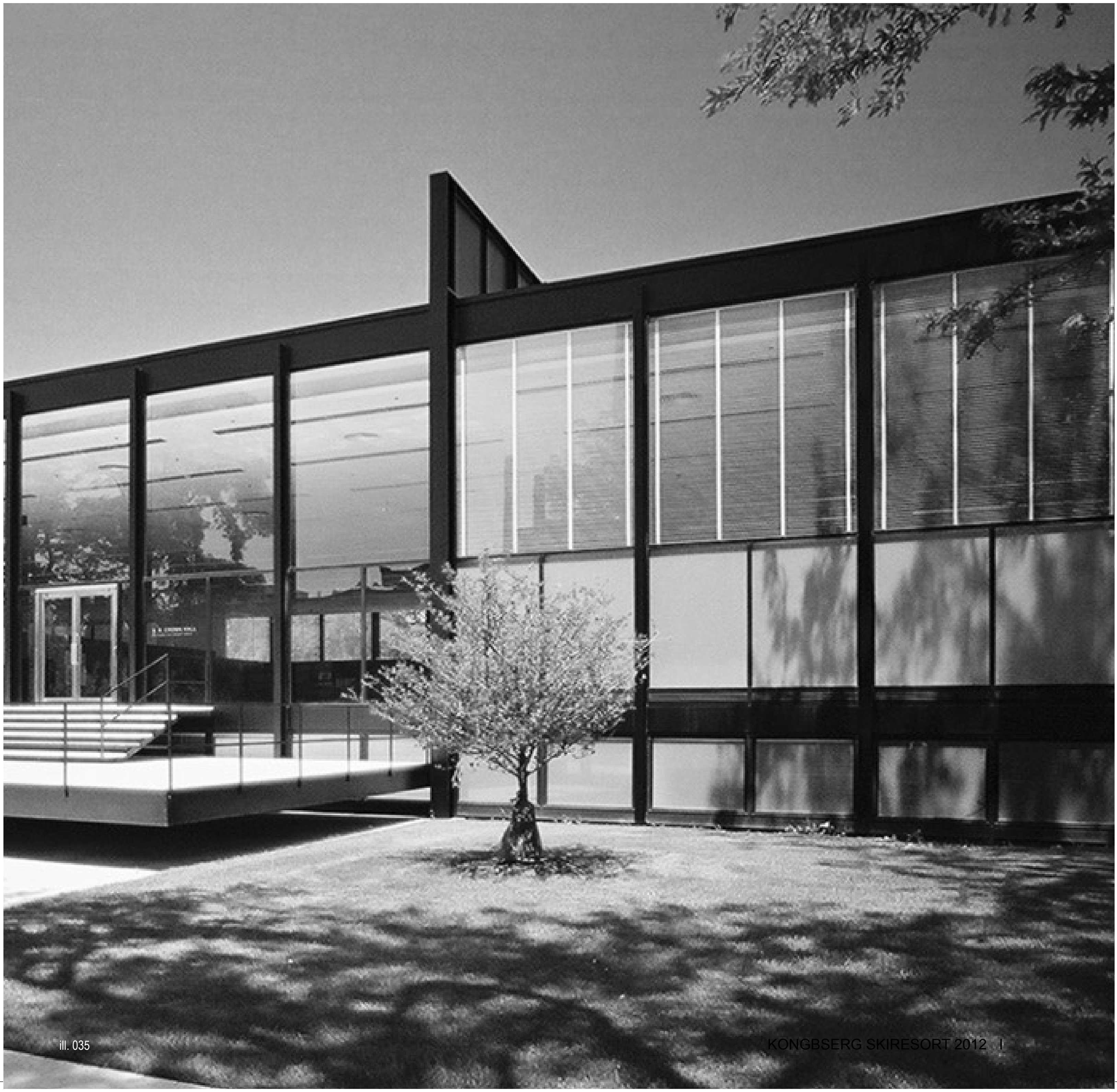
PHENOMENOLOGY

The Phenomenology in architecture can be described as; the environment is defined as “the place”, and the things which occur there “take place”. The place is not so simple as the locality, but the consist of concrete things, which have material substance, shape, texture and color which together coalesce to form the environment’s character or atmosphere” [wikipedia.org, 2012].

Christian Norberg Schulz, who was an important figure of the phenomenological approach to architecture, had a big influence in Nordic architecture with his theories. His big rolemodel Mies Van Der Rohe, was a guideline for his work. Mies Van der Rohe was seeking for the “divine”, by removing all the redundant to reach the “almost nothing” [Lund, 2008, p281]. With the statement Schulz began to seek for the meaning in architecture. He engaged in a phenomenological analysis of both natural places and urban built environments, arguing that there are varying ways that humans can create built environments that connect to natural place and therefore provide existential meaning to humans [Meagher, 2008, p150]. He believes, however, that modern architecture greatly suffers from, what he defines as “loss of place”. He was strongly opposed to the idea of modern buildings that exist in a “nowhere”, which doesn’t relate to the landscape and not to a coherent, urban whole [Meagher, 2008, p151] He emphasizes the importance of understanding the specific nature of the building context in order to let the users identify themselves with the place [Meagher, 2008, p 151]. A good example of this “rootedness” in architecture is the domiciles at Randersvej, Aarhus. The majority of the project is designed by Arkitema Architects, which are not relating to each other or to its context.

“Architecture starts when you carefully put
two bricks together. There it begins”.

[searchquotes.com, 2012]



ill. 035

“In order to design buildings with a sensuous connection to life, one must think in a way that goes far beyond form and construction.”

[archspace, 2012]

ill. 036

Another important architect to mention is Peter Zumthor. Even though he is not a Nordic architect, he always emphasises the sensory aspects of the architectural experience. To him, the physicality of the materials can “involve an individual with the world, evoking experiences and texturing horizons of place through memory” [wikipedia, 2012]. “When I think about architecture, images come into my mind. There was a time when I experienced architecture without talking about it. Sometimes I can almost feel a particular door handle in my hand, a piece of metal shaped like the back of a spoon” [Zumthor, 1988, p9]. The touch, smell and perhaps even taste of the materials is according to him very obsessing. Another reason why he is presented is that this quotation describes some of those values, which we want to bring into our project. One of his famous work “Thermal Vals”, which is a self-willed thermal spa set into the mountain slope, will be used as a strong reference throughout our project.

CONCLUSION

Relating to Nordic architecture and phenomenology, the approaches of this project are defined as:

Nordic approach
Simple and clear functional distribution
Honest and authentic regarding material choices and construction.

Phenomenology
Give the site something specific and unique, that emphasizes and strengthens the visitor’s sensual experience of the place, the building shape and choice of materials.

“The development that meets the needs of the present without compromising the ability of future generations to meet their need.”

[The Brundtland report, p54]

SUSTAINABILITY

Sustainability is an important topic nowadays with much focus on lowering the world's energy consumption to help saving the environment. The decreasing amount of resources as well as the wellbeing of the environment is the driving forces behind sustainable architecture.

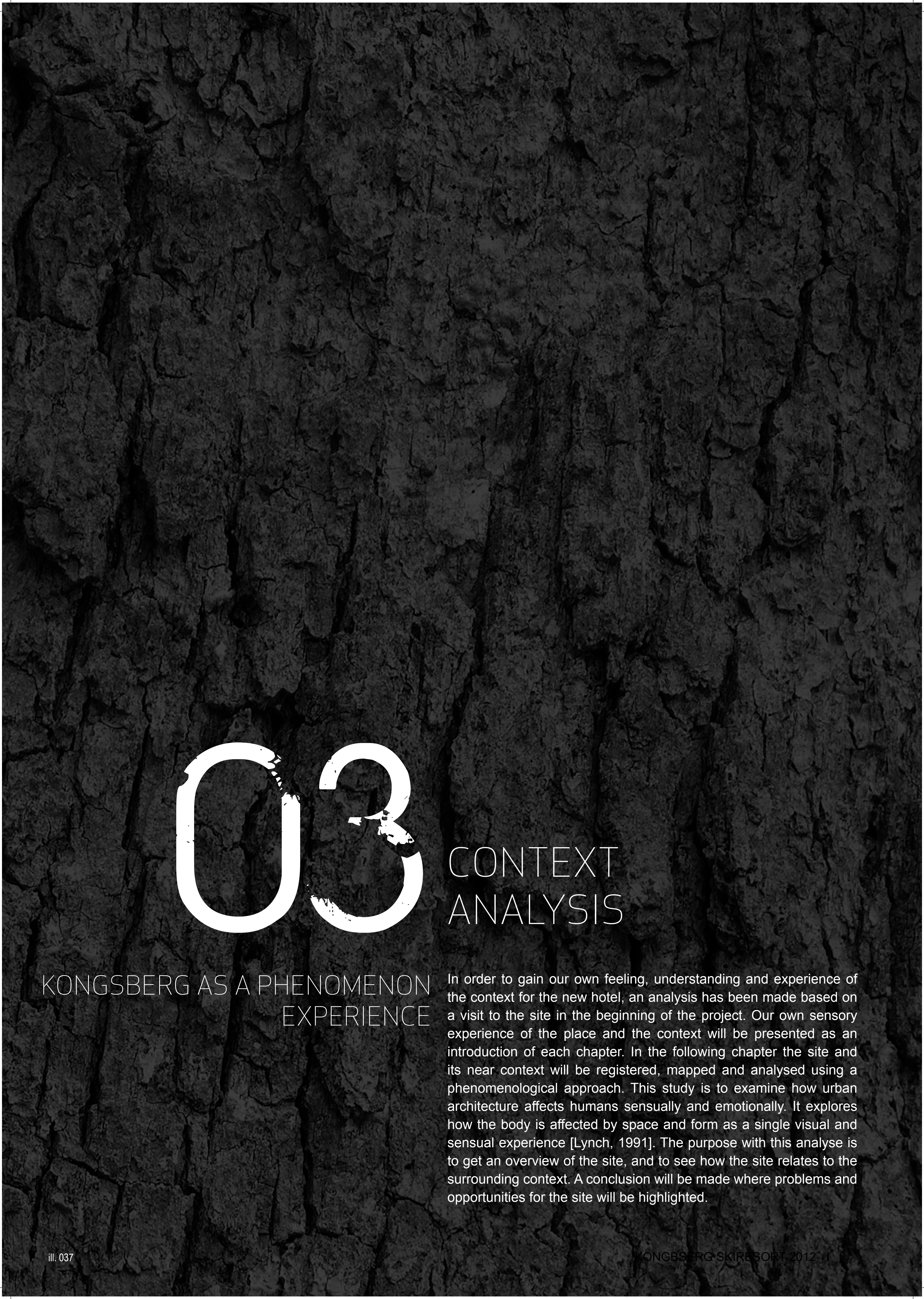
Environmental sustainability means to build in a way that minimizes the footprint on the environment. This can be done by using natural local materials which lower the production and transportation load on the environment, as well as building with good materials and insulation that helps lower the energy consumption. Orientation, design and solutions play a big role in this part and will be looked at during the different project phases.

Social sustainability means to build in a way that works well for the people. This means that we meet the needs of people of all ages and backgrounds, as well as handicapped - and that there are activities that make people want to come to and use the place. In the project there will be focus on making places that meets the requirements and needs of the people, and that keep them entertained in a functional way.

Economical sustainability means to build a place that can run in a profitable way, as well as minimizing the building and running costs. For the project this will be though of, but not covered in detail. There will be paid attention to logical building cost and to make functions and activities that can attract people at all seasons. The main aspect of this will be to ensure there are enough activities to get people to the hotel also during summer when the alpine slopes can't be used for skiing [Lauring, 2011].

CONCLUSION

The goal will as such be to make a hotel with low energy consumption that use renewable energy resources to lower the environmental footprint. It will also be important to make Kongsberg skiresort a place that attracts people of all ages and backgrounds and gives them a reason to stay all seasons.
It will be important to dimension the hotel neither too small or too big, and to provide activities in the area during summer that can attract people. There should also be focused on inviting companies to use the hotel as a place for meetings, workshops and educational purposes as well as a place to hold parties, concerts and other activities that can bring people to the hotel also in off peak seasons.



03 CONTEXT ANALYSIS

KONGSBERG AS A PHENOMENON EXPERIENCE

In order to gain our own feeling, understanding and experience of the context for the new hotel, an analysis has been made based on a visit to the site in the beginning of the project. Our own sensory experience of the place and the context will be presented as an introduction of each chapter. In the following chapter the site and its near context will be registered, mapped and analysed using a phenomenological approach. This study is to examine how urban architecture affects humans sensually and emotionally. It explores how the body is affected by space and form as a single visual and sensual experience [Lynch, 1991]. The purpose with this analyse is to get an overview of the site, and to see how the site relates to the surrounding context. A conclusion will be made where problems and opportunities for the site will be highlighted.

ill. 037

CITY OF KONGSBERG

▸ When we arrived to Kongsberg and stepped out of the car, the first thing that was memorable, was the cracking sound of the crystal clear snowflake under our feet. There were minus 19 degrees and no wind at all. We were surrounded by wood houses that were popping out of the snowlandscape that has covered every single thing as far as the eye can see. Yellow, warm street lamps was lighting up the skicenter on the top of the hill. Fresh cold air brought a feeling of being in a summerhouse neighborhood in Denmark, just surrounded with huge and diverse landscape.

FACTS

Kongsberg (meaning Kings Mountain) was founded in 1624 by Christian IV which was the Danish king. The year before there was discovered silver in the mountain. This resulted in the start mining of silver, making Kongsberg the oldest industrial city in Norway. The mining industry lasted from 1623 to 1958, and 1350 tons of pure silver were taken out.

After the mining industry stopped, other industry took over. Kongsberg weapon factory was founded in 1814 during an economic crisis during the mining time. Originally they manufactured hand weapons for the Norwegian defence troops. The company got economic problems during the 1980s and was shut down in 1987. However parts of the company was split into pieces and carried on through the new companies “Kongsberg Gruppen” and “Kongsberg Defence & Aerospace”. Today the defence operations go on through “Kongsberg Defence Systems”.

Other large industries in Kongsberg today are FMC Technologies and Kongsberg Automotive. Kongsberg has production within many fields like high technology weaponry, car parts, maritime, aviation, and oil and gas industry [wiki_kong, 2012].

ill. 038 - Kongsberg houses

ill. 039 - Kongsberg brigde

Kongsberg lies about 45 minutes drive southwest of Oslo and has good connection by train and bus. It is a small city surrounded by mountains and forest. It reached 25,000 inhabitants in 2011 and is rising with about 500 people each year. [ssb, 2012] The city is divided by the river 'Nummedalslågen', with the old city part located west of the river, while the eastern part is newer and holds a more modern look. Industry is one of the things Kongsberg is well renowned for, but it is also well known for its natural areas with mountains and forest. Kongsberg is covering a large area of 792 km² and it is well connected with the capital in form of transport with busses going both ways every hour all year around. All trains from Oslo going to the southwest is also stopping at Kongsberg station.

Temporary or Permanent industry work, university with unique studies like optics, visiting the mines and the museums, hiking or skiing in the mountains or viewing the small city divided by the river with falls going through the city core, and the yearly jazz festival - are some of the things that bring people to Kongsberg [wiki_kongsberg, 2012].

ill. 041 - Kongsberg city

ill. 040- Kongsberg map

▸ Kongsberg city and the skicenter are separated by a big river, which is the most noteworthy element in the city. Houses with large prints of the city's industrial character, which appears very anonymous as a townscape. No architectural "pieces" stands out in contrast to the white snow and the big mountains in the horizon. When walking between the buildings, we observed that there was a great mixed use of local materials like stone, concrete, wood and bricks. The visual and sensual impressions of the city were not remarkable and most people where seeking indoor because of the very bitterly cold weather and "poor outdoor living areas." From most of the city the lit slopes of the skicenter can be seen up in the mountainside, and it's the first view that welcome visitors coming from Oslo as they drive down the hill towards Kongsberg town.

THE BUILDING SITE

First day at Kongsberg Skicenter; to have a better understanding of the center and experience the site, we decided to go skiing and explorer the place by our self. Hence, to experience the center from the users point of view and gain a better understanding of its atmosphere, the place and the functions distribution of the area.
The skicenter is located approx. 250 m above sea level and 10 minutes' drive from the city center. When driving up you have a beautiful panoramic view of the city, with wood pitched-roof houses popping up through the white snow landscape. Even though it is high up in the mountain, the wind is still very calm and the whole setting is surrounded by masses of "pine trees", which makes the place very natural and peaceful.

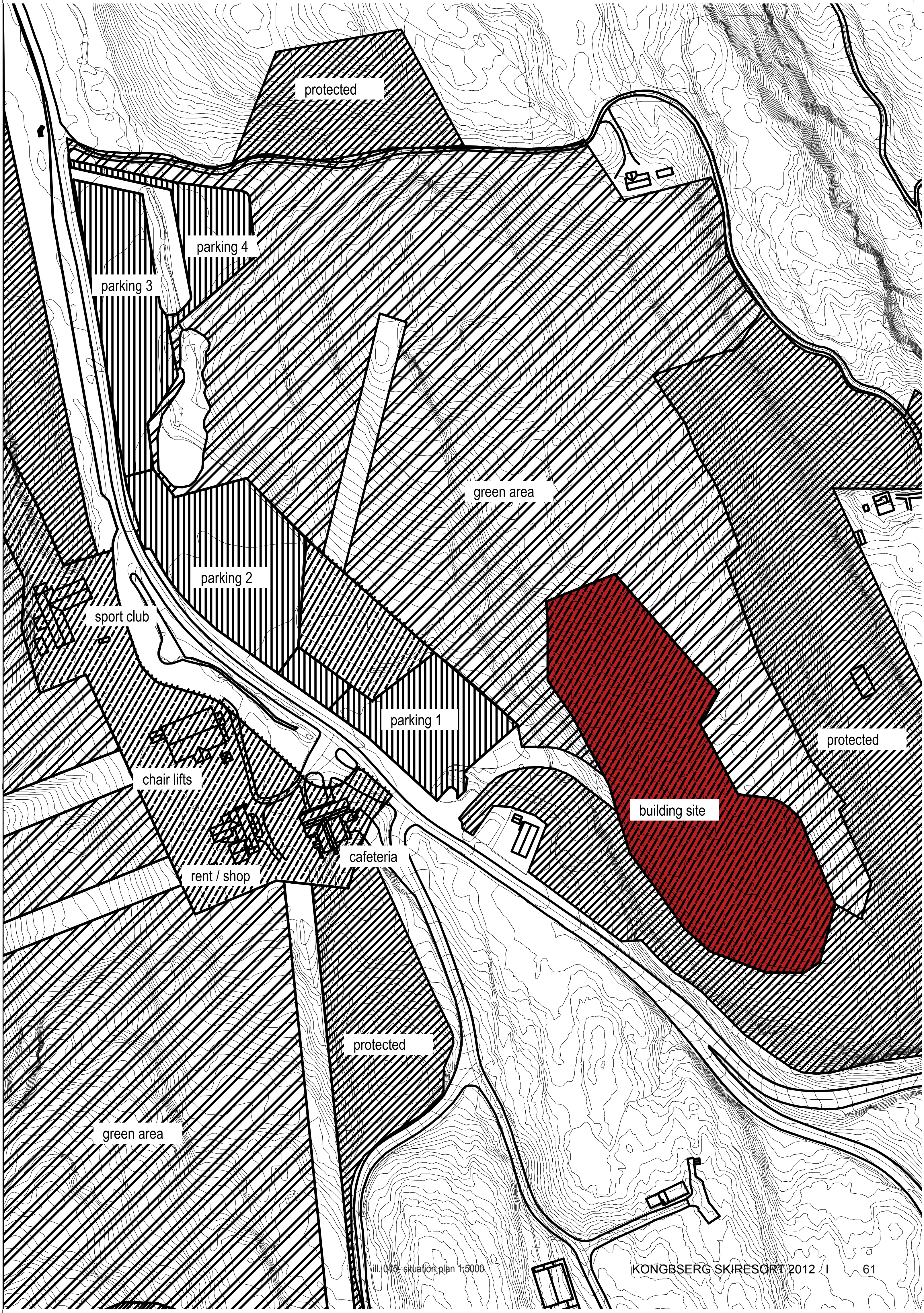
Kongsberg alpine center was opened in December 1965 with a 1.5km long skilift and an accompanying ski slope. Today there are a total of 10km with groomed trails, a chairlift and four surface lifts. The height difference top to bottom is 330m. The lift capacity is 7500 people per hour. In 2009 the alpine center had revenues of nearly 34.8 million Norwegian kr [Historie, 2012].

FACTS
The building site is located on a hill-top east of the alpine center. It has great view east to the slopes and south to the city. The site is about 18140 m² and the shape follows the ridge, which is crowded by pine trees. The whole area is called 'Funkelia' and is located 3 km west of the city center. There is a new localplan (appendix 1) made in 2010 of the site and surrounding area with limits and requirements. The plan is called 360R and includes new parking's, new slopes and new activities like a pond for swimming and a water jump. The site can be used for hotel, catering, business, leisure houses, cabins or rental and there is allowed to make underground parking. The maximum allowed built area on the site is 50% which means about 9070 m².

ill. 042 - View towards Kongsberg city

ill. 043 - Kongsberg skicenter

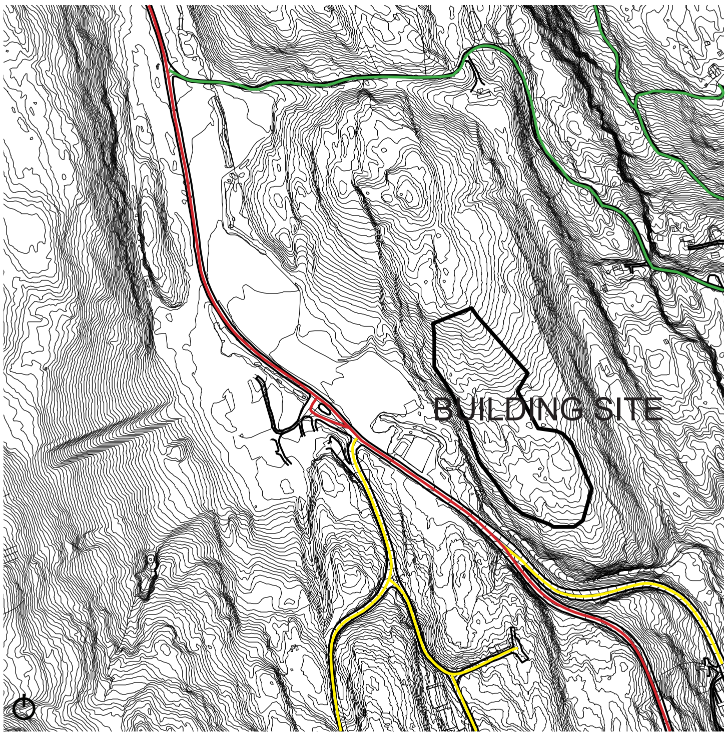
ill. 044 - Building site



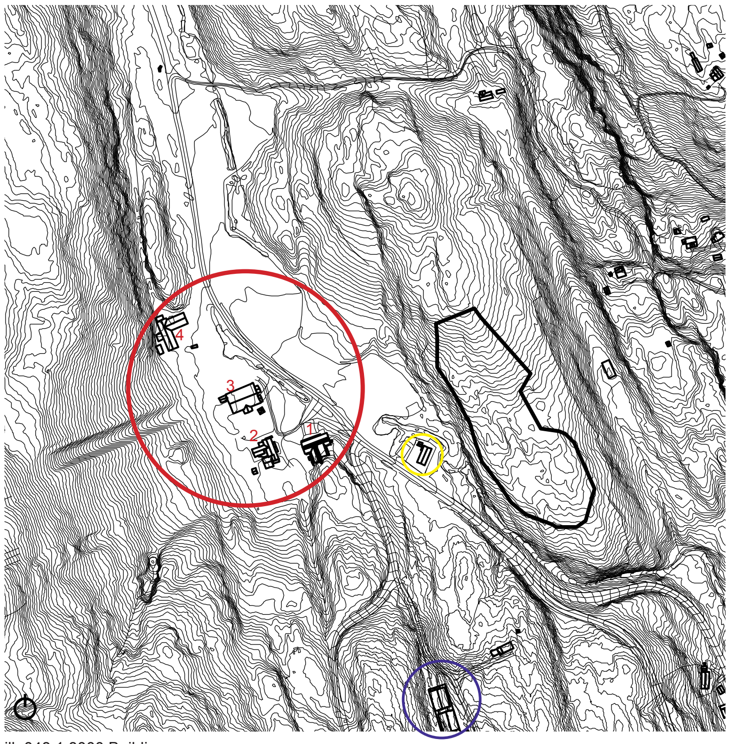
ill. 045- situation plan 1:5000

MAPPING AND REGISTRATION

When arriving to the place, the curiosity level raised up a couple of “knots”. A very inspiring and calm environment with skislopes that ends far up in the mountain. Young, old and even 6-7 year old kids are rushing full speed down the hills, which ends up at a central point in front of 3 buildings. The atmosphere is absolutely at its best. People are laughing, chatting, practicing, barbecuing, chatting and most important - enjoying the whole setting.



ill. 047 -1:8000 Roads



ill. 048 1:8000 Buildings

STREETS AND PATHS

The map shows the flow in the area surrounding the site. The paths have been divided into three types; main and secondary roads, and walking path. The main access to the site is from the main road from the current parking lot. The secondary path (west) is leading up to an apartment area that is rentable. The secondary road (east) is an old road leading to the skicenter, which is not used today. The rural walking path is surrounded by untouched nature and is a natural way to reach the area if you come walking from the city by foot or bike. It passes by ‘Kronene i Håvet’, a historic site with engravings on the cliff side.

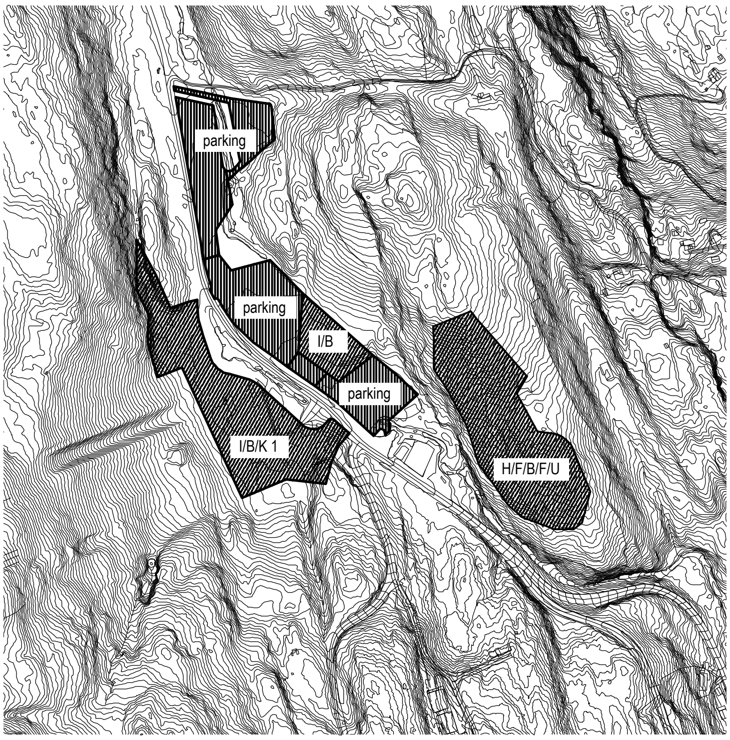
- main road
- secondary road
- rural walking path

BUILDINGS IN THE AREA

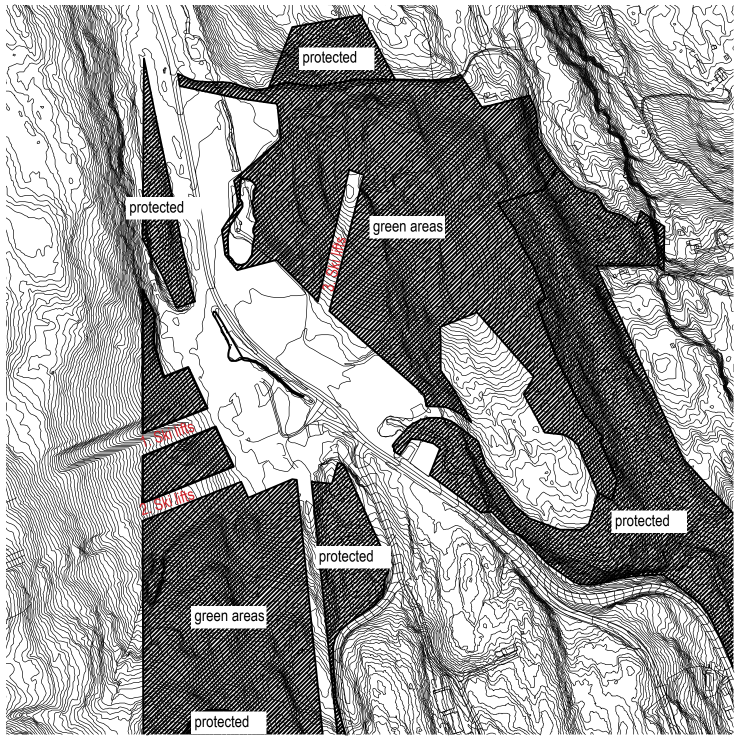
As seen in the map, there are only a few houses in the area. The Skicenter consist of 4 buildings. 1. Cafeteria building where part of the bottom floor there is a small storage for shoes and bags. The cafeteria is found on all three levels. 2. Ski rental, ticket office, ski shop and ski workshop on 2nd floor. Outside the building there are two T-lifts. 3. Chair lift building. 4 Sports club.
The average height of these building is 10 m. A small kindergarten and apartments that are for rent is also to find in the area.

- Kongsberg Skicenter
- Kindergarten
- Apartments

ill. 046 - Slopes



ill. 049 - 1:8000 Zones



ill. 050 - 1:8000 Protected areas

ZONES

To get an overview of what can be built in the area, this map has been divided into different zones.

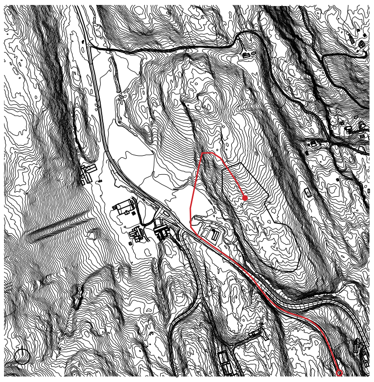
I/B/K;	sport, catering and office
H/F/B/F/U;	hotel, business, catering, leisure and buildings for rent.
I/B;	sport and catering

PROTECTED AREAS

There are many green and protected spaces in the area. It is not allowed to build anything or alter the protected areas. The green areas are ideal for outdoor spaces. There are 3 lifts in the area.

1. chair lift
2. T-lift
3. lift to the children’s skislope

SERIAL VISION



ill. 020 - 1:16000 Route A

ROUTE A

FROM CITY TO SITE

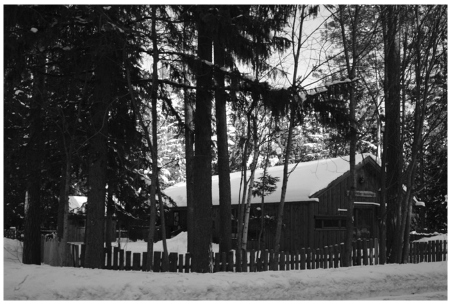
“To capture the moments” - a Serial Vision has been made to document and give the optimal impression of the place.

When we started to climb up to the site, the view towards the skicenter and slopes were remarkable. The sunshine was reflected by the snow and slopes that seems to be naturally integrated and a part of the mountains. We couldn’t feel the wind, only the fresh air that the area provided us. A perfect view to enjoy from a hotel room!

When driving from the city to the skicenter the observers are provided with a great panoramic view towards the city center. This is a new road, which works as the main access route to the skicenter.

ill. 051 - View

A small kindergarten surrounded by pines trees. The building has a tradition Norwegian style and the material is red pine wood. The perimeters of the kindergarten are outlined with a wooden fence that matches the context well.



ill. 052 - Kindergarten

When arriving to the center a pine tree seems to work as a central point with a kind of roundabout that divides the place in two. Parking places on the right and ski slopes and facilities on the left.

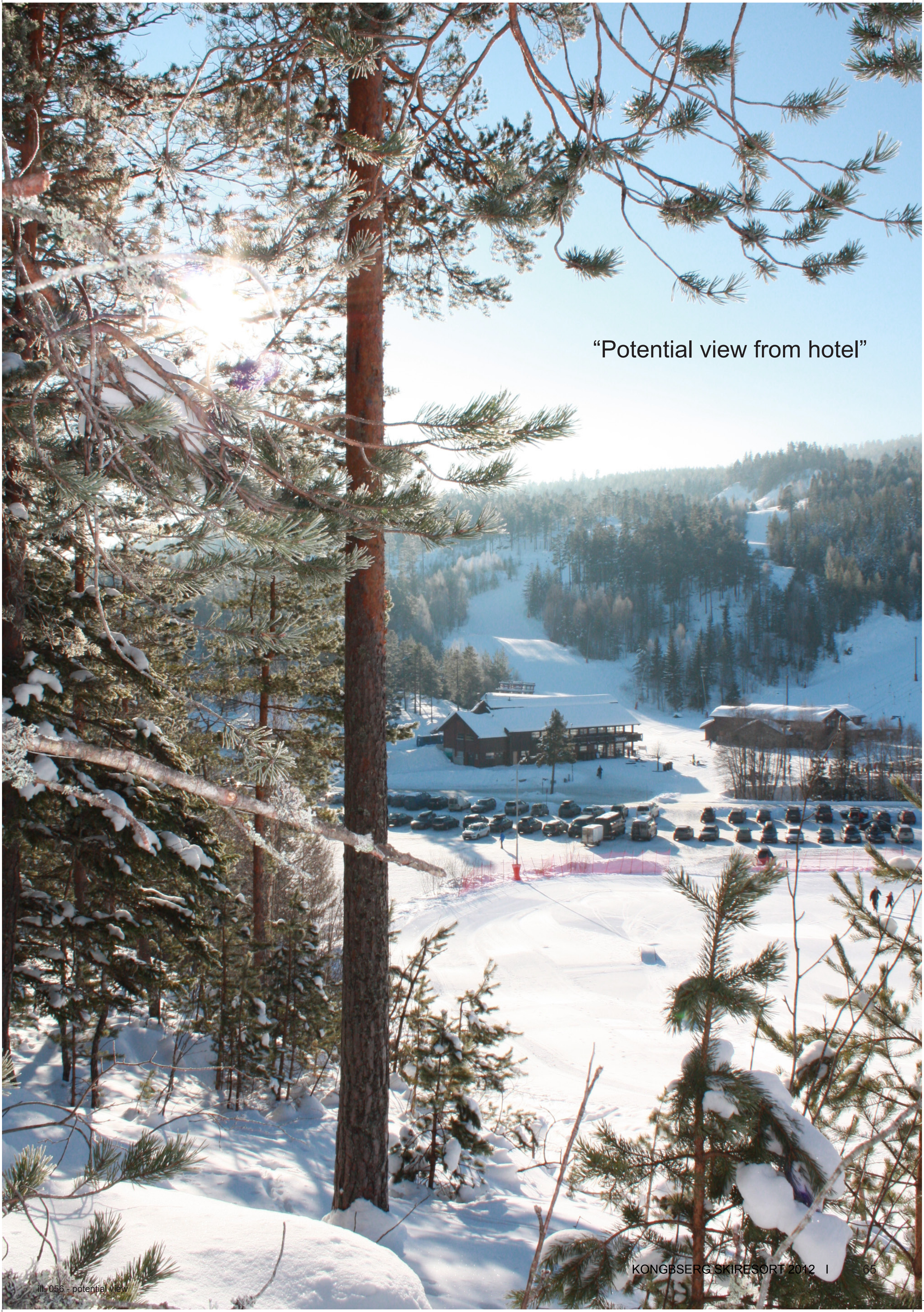
ill. 053 - Entrance route

When the car was parked, the observers were met with a beautiful view to the slopes. 3 red dark buildings seemed to provide a framework for a central point.

ill. 054 - Parking

On the right hand you find the children’s hill, which almost borders up to our site on the right side.

ill. 055 - Children’s slope



“Potential view from hotel”

ill. 056 - potential view

When we walked towards the top of the site it appears to us that this "feeling" about the place of "pure nature" shouldn't by any means be reduced or destroyed. "Our hotel should work as a frame and capture these magnificent views towards the skicenter and the city, and this beautiful and peaceful feeling of being one with the nature should be preserved"!

[See Appendix 2] for further descriptions

In connection with parking lot 1, on a hill top dominated by pine trees, is our site for the hotel. The ridge tilts gently down to the southeast (right side on the picture)

ill. 057 - site

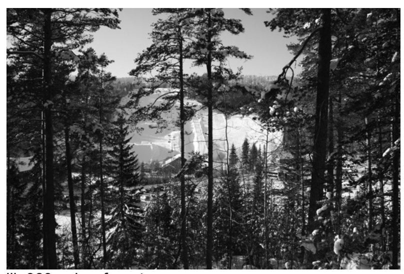
When walking a couple of meters up, a panoramic view of the skicenter and slopes are provided.

ill. 058 - View from children's slope

Pine trees that cast shadows on the site. Potential for natural shades in the summer time.

ill. 059 - shadows

A couple of meters before reaching the top, you are provided with a very attractive view to the center and the slopes.



ill. 060 - view from top

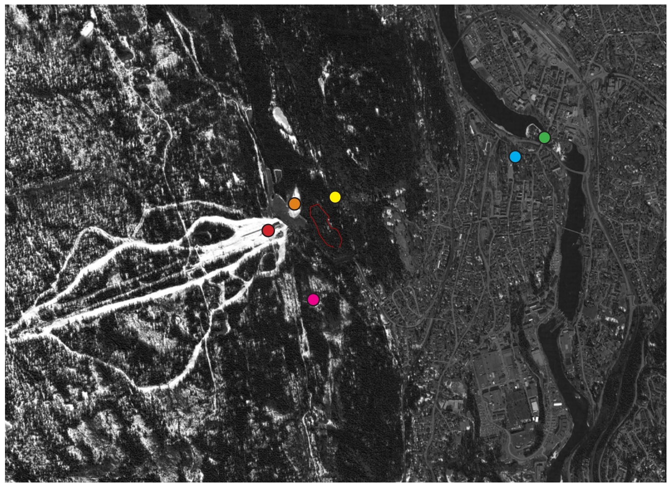
From the top of our site there is approx. 270 degrees view around the area. A potential for panoramic view to the whole city to the east-southeast and the skislopes to the west.

ill. 061 - view from site towards city

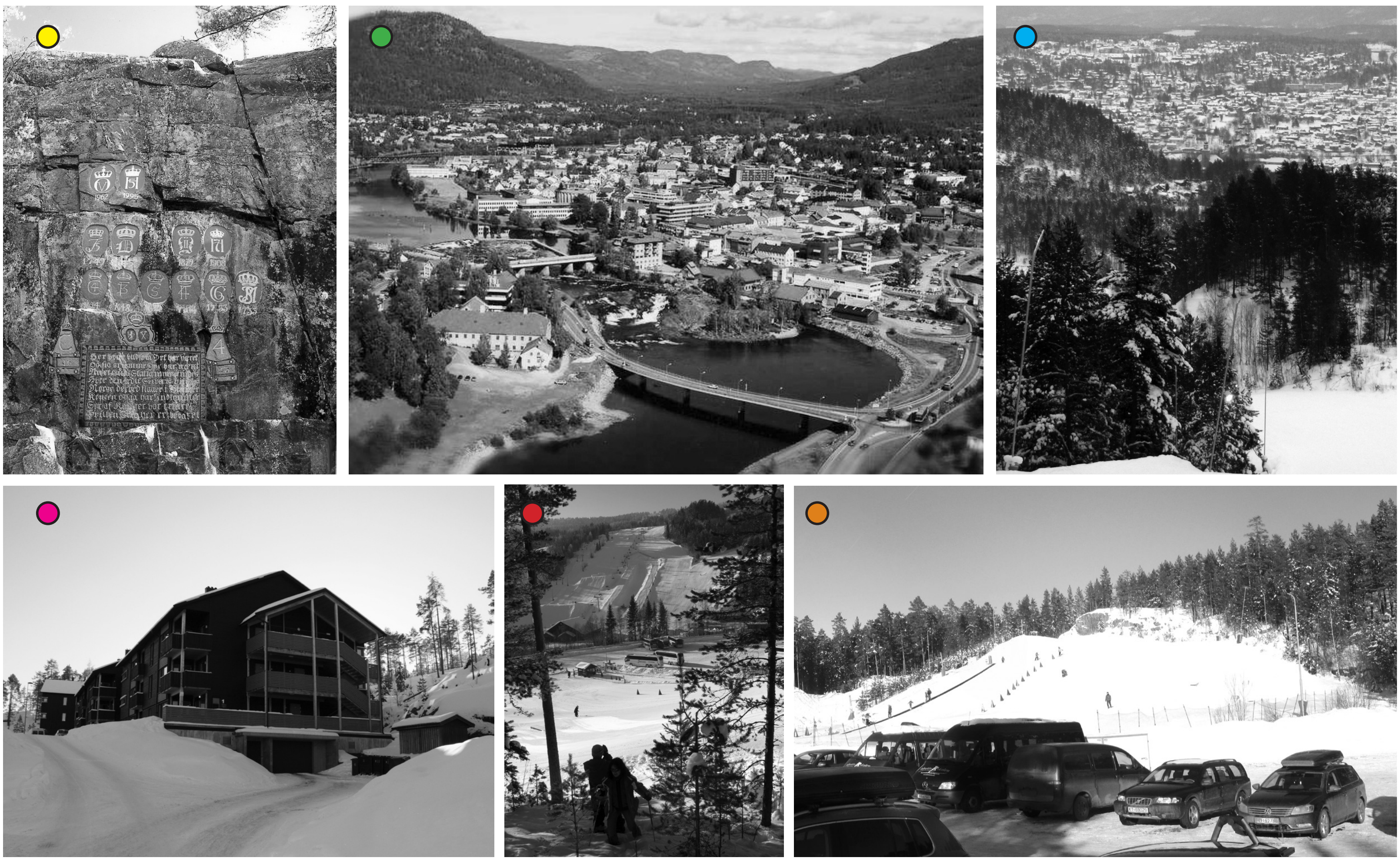
ill. 062 - Inspiration

NODES AND LANDMARKS

The ridge of the building site consist of panoramic views towards nodes and landmarks. To the north you look toward the peak of the ridge our site resides on. Northeast you find 'kronene I håvet' a historical site where you can find royal carvings in the Cliffside showing when royalties has visited Kongsberg. From the east to southeast it overlooks Kongsberg city and the church. To the southwest are the apartments that you can buy and to the west you overlook the main alpine slopes. Northwest of the site, and going down from the same hill is the children's slope. The ridge itself orients (from top to bottom) in south-southeast direction.



ill. 063 - google maps



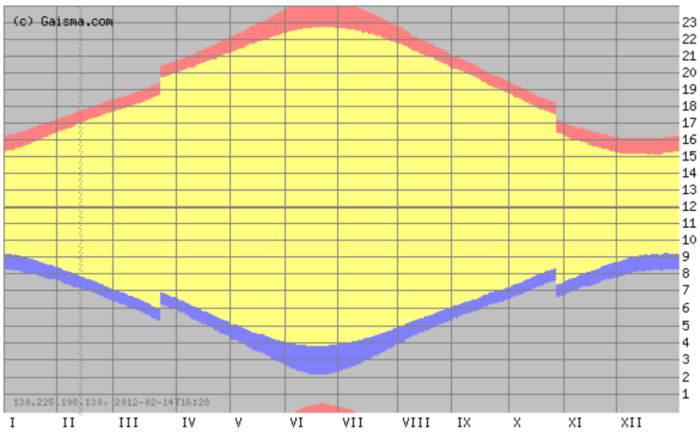
ill. 064 - collage

MICROCLIMATE

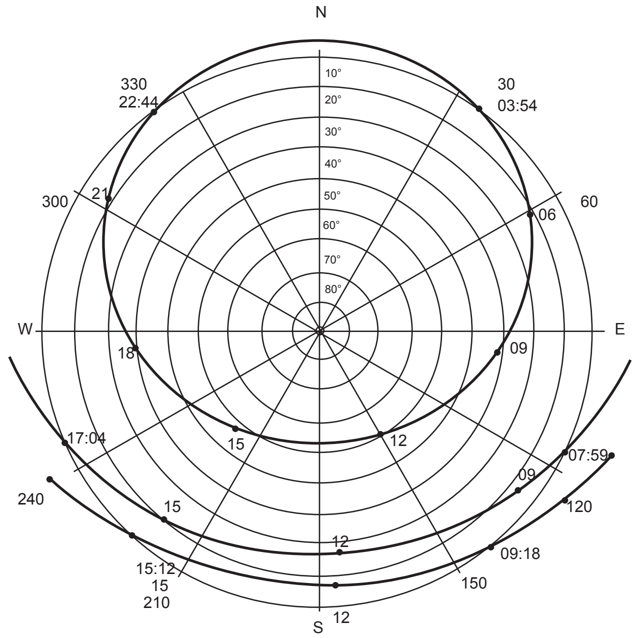
Since our building site is on a mountain hill, it's important to study the parameters that could have an influence on our design. Orientation, sun and shadow are important for building orientation and design, while wind and temperature is important for design according to the indoor climate.

SUN

The sun data is taken from Oslo, 45 minutes drive from Kongsberg. At 21st of December the sun is up from 09:18 to 15:12, peaking 8 degrees on the sky, while at 21st of June it's up from 03:54 to 22:44 peaking 53 degrees on the sky.



ill. 065 - gaisma



ill. 066 - Sun paths

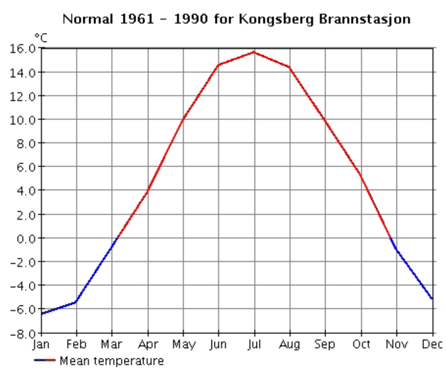
TEMPERATURE

Monthly and yearly mean temperatures in Kongsberg from 1911 to 2012

Weather-Station	Operate from	Operate to	Altitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
II / III	Jan 1911	Sep 1979	171 m	-6.6	-5.5	-0.9	3.7	9.9	14.8	15.8	14.4	9.8	5.2	-1.3	-5.1	**4.5**
IV	Oct 1979	Sep 2002	168 m	-6.5	-5.5	-1.0	3.7	9.8	14.3	15.6	14.3	9.8	5.2	-1.0	-5.2	**4.5**
Firestation	Feb 2003		170 m	-6.5	-5.5	-1.0	3.7	9.8	14.3	15.6	14.3	9.8	5.2	-1.3	-5.2	**4.5**

ill. 067 - Sharki

There are used different weather stations for different years, but they are all in Kongsberg, all on approximately the same altitude and they give almost the same results in all months. The data shows that Kongsberg have 6 months with plus degrees and 6 months with minus. The yearly average temperature in Kongsberg is 4.5 °C [sharki, 2012].



ill. 068- Temp

CONCLUSION

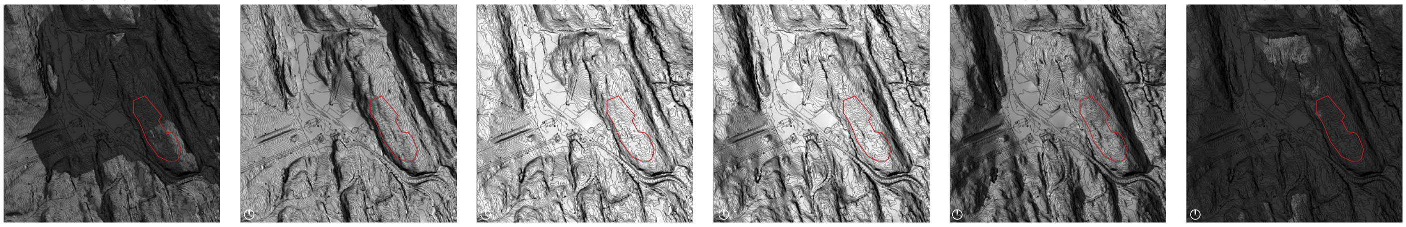
The site holds a great view to the city in the east and the slopes in the west, and is in close proximity of the children's slope and 'Kronene i Håvet'. The site has an open view to the southeast and south giving it plenty of sunlight and heat. During mid-summer the site has about 17 hours of sunlight while it mid-winter only got 4 hours. The mean temperature over a year is only 4.5 °C, varying from -6.5 °C in January to 15.6 °C in July. During mid-summer the sun peaks at 53 °, while it peaks at 8 ° at mid-winter. There is not much wind in Kongsberg where the mean yearly wind speed is only 2 m/s and the max windspeed reach about 20 m/s. The dominant wind direction is from north-northeast.

SHADOW

An understanding of the changing shadow areas during the year is sought to gain a better knowledge about the outdoor spaces and daylight intake in relation to the aspects of sustainability. This shadow analysis is done without considerations to all the pines trees that are dominating the site, which means that the mountain to the northeast and west is the only main obstacles for the sun when it's above the horizon. A further investigation will be made according to shading from the trees and how they can be integrated in shading strategies.

JUNE

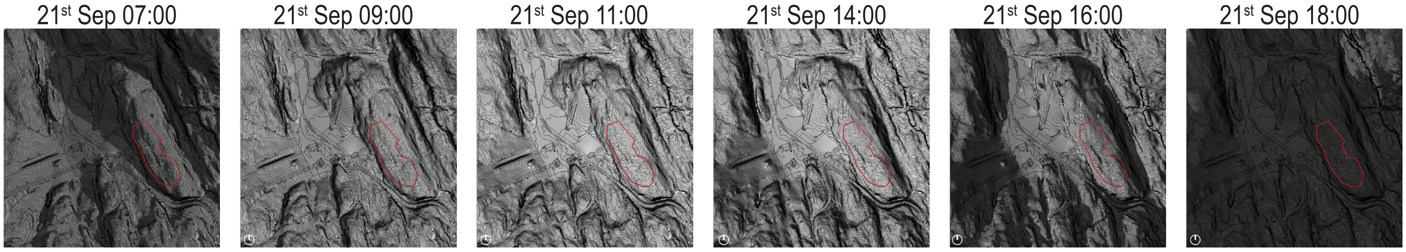
21st Jun 04:00 | 21st Jun 07:00 | 21st Jun 10:00 | 21st Jun 15:00 | 21st Jun 18:00 | 21st Jun 21:00



21st of June the sun comes up at 3:54 and goes down at 22:44, the site is covered with sun from a little past 4:00 to a little before 21:00. This give almost 17 hours of sun to the site in June.

SEPTEMBER

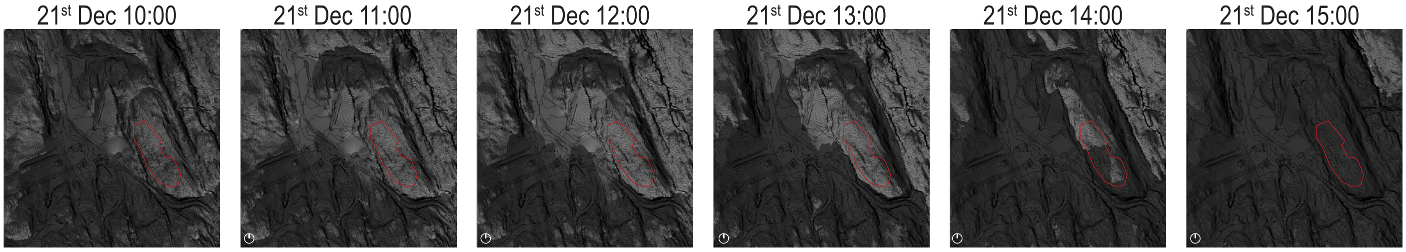
21st Sep 07:00 | 21st Sep 09:00 | 21st Sep 11:00 | 21st Sep 14:00 | 21st Sep 16:00 | 21st Sep 18:00



21st of September the sun comes up at 06:09 and goes down at 18:18, the site is covered with sun from a little past 06:00 to a little past 17:00 giving about 11 hours of sun to the site in September.

DECEMBER

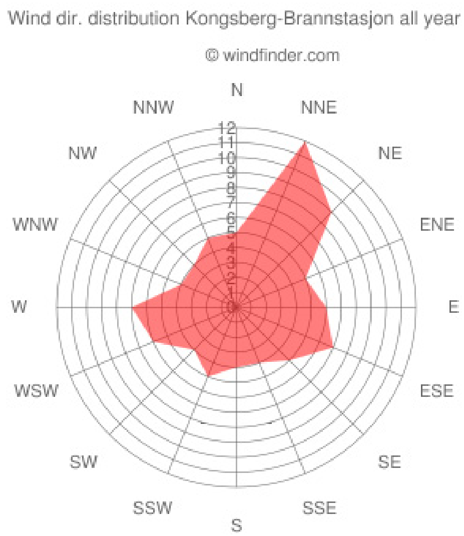
21st Dec 10:00 | 21st Dec 11:00 | 21st Dec 12:00 | 21st Dec 13:00 | 21st Dec 14:00 | 21st Dec 15:00



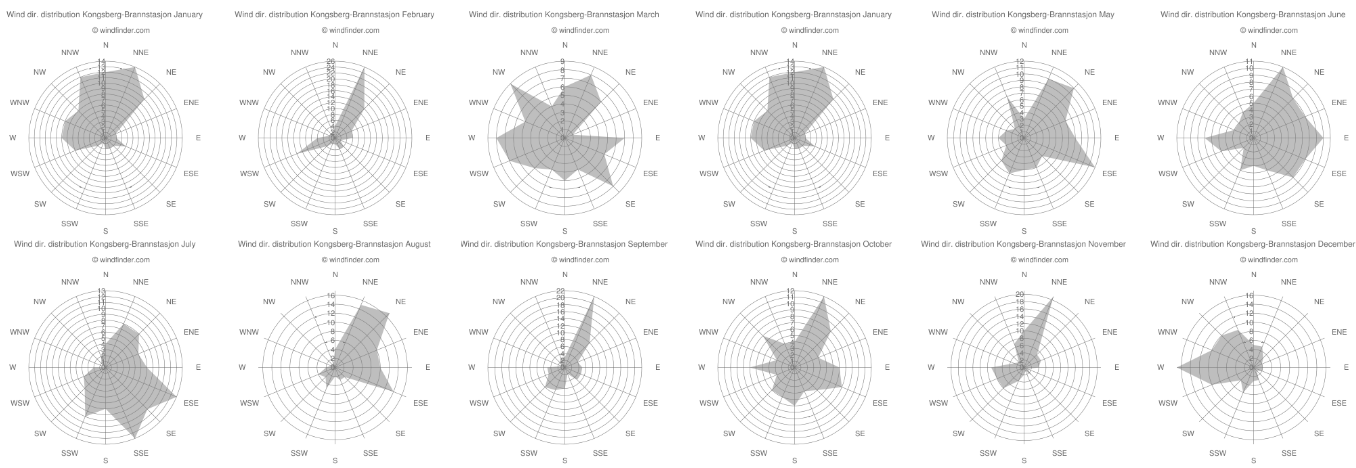
21st of December the sun comes up at 09:18 and goes down at 15:12, the site is covered with sun from about 09:30 to just past 13:30 giving about 4 hours of sun to the site in December.

WIND

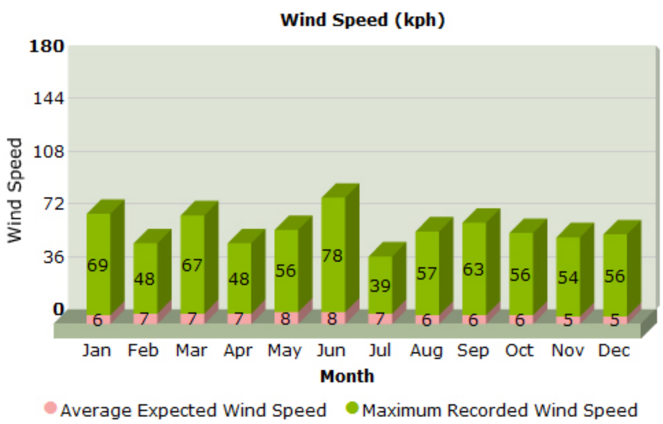
Even though the project site is located on a mountain top, the place is very calm when it comes to wind. Most of the wind comes from north-northeast, and the average windspeed is no more than 2 m/s. while the maximum wind speed hits about 20 m/s. The wind distribution from month to month differs, but is generally well represented in the yearly average chart. The firestation where these readings are done is located only 1.2km east of the project site and should represent quite well the wind conditions at the site. [windfinder, 2012].



ill. 069 - Windrose



ill. 070 - windroses



ill. 071 - avergage wind speed

Årets måned	Jan 01	Feb 02	Mar 03	Apr 04	Mai 05	Jun 06	Jul 07	Aug 08	Sep 09	Okt 10	Nov 11	Des 12	sum 1-12
Dominerende vindretning													
Vind-sannsynlighet > = 4 Beaufort (%)	1	0	2	2	0	0	0	0	0	0	0	1	**0**
Gjennomsnitt Vindhastighet (Knots)	3	4	4	4	5	5	4	4	4	4	4	3	**4**
Gjennomsnittlig lufttemp. (°C)	-3	-5	2	9	11	16	18	16	12	6	0	-6	**6**
Velg måned (Hjelp)	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug	Sep	Okt	Nov	Des	År

ill. 072 - Wind speed

TARGET GROUPS

Due the skiresort's children friendly slopes and atmosphere, the main focus is upon families with 2-4 children, and young couples. To ensure a lively atmosphere at the skiresort throughout the day and after the skicenter closes at 21 o'clock, the aim is to incorporate functions and activities that attracts, pleasures and entertains the usersgroups. The aim of the project is to create an environment of unique phenomenological architectural experiences in term of enjoyment, pleasure and relaxation. The intention is to create a place where you can have a memorable stay and experience the skiresort's many facilities and the surrounding nature of Kongsberg. A skiresort that also have activities to attract the users in the summer time. Based on this, a brainstorm [Appendix 3] of the activities and facilities has been made in order to set up a room program for this project.

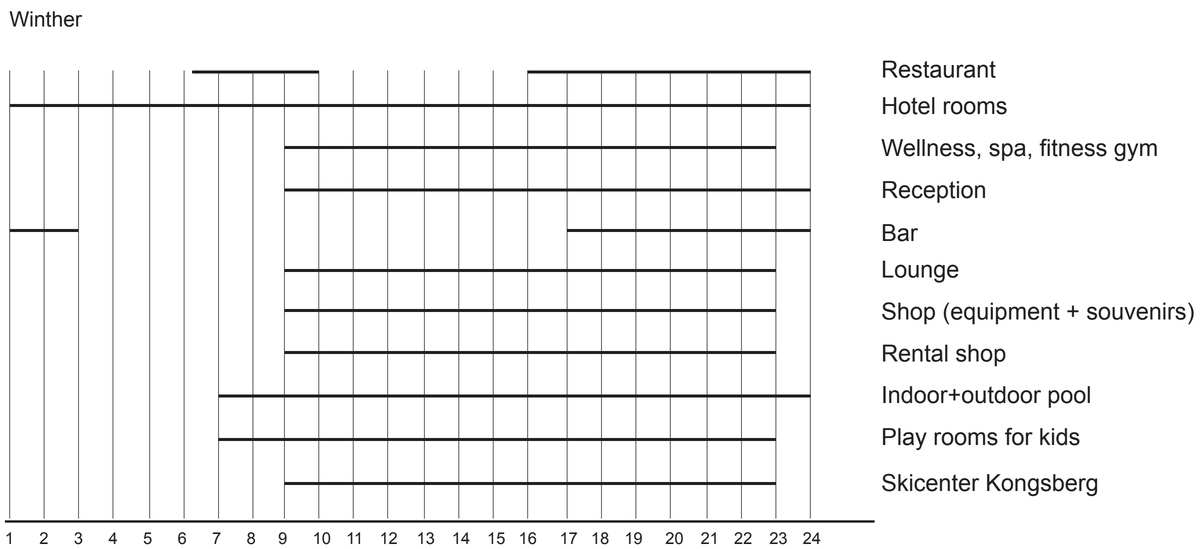


Diagram showing when different functions and activities are active during the day.

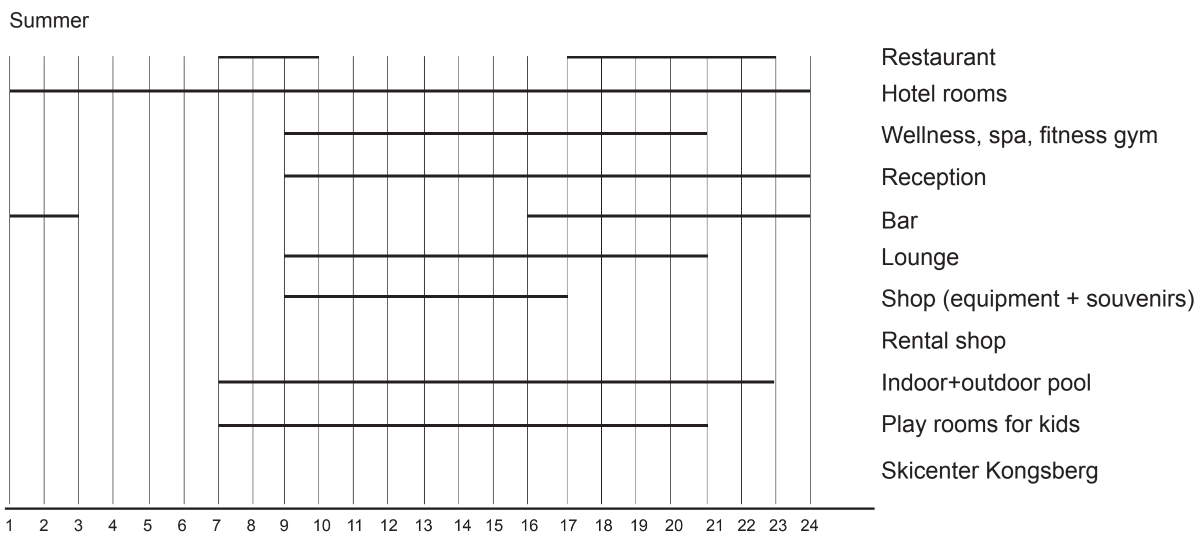


Diagram showing when different functions and activities are active during the day.

ill. 073-074- Activities

ROOM PROGRAM

Minimum requirements for hotel are based on the investigations and analysis seen on [See Appendix 4].

	Area [m²]	Height [m]	Orientation	Occupancy time	Ventilation	Heating	View	Daylight
Hotel rooms	27.8	2.5	SE	20-10	x	x	x	x
Entrance area incl. lifts	240	2.5	N,W	8-24	x	x		x
Reception, WC, luggage etc.	60	2.5	N,W	8-24	x	x		x
Administration	45	2.5		8-16	x	x		x
Restaurant	165	2.5	SE,W	8-22	x	x	x	x
Coffee bar	90	2.5	SE,W	8-20	x	x	x	x
Bar 1	135	2.5	SE, W	18-24	x	x	x	x
Bar 2	75	2.5		18-24	x	x		
Lounge	75	2.5	W	15-24	x	x	x	x
Toilets guest area	60	2.3	C	8-24	x	x		
Conference/lecture rooms	165	2.5		8-16	x	x	(x)	x
Private bed and living rooms	60	2.5			x	x	x	x
Kitchen	570	2.5		7-22	x	x		x
Shop (equipment + souvenirs)	135	2.5	N	9-21	x	x		x
Workshops, maintainance	120	2.5		9-16	x	x		(x)
Laundry, linen store	45	2.5	C	9-20	x	x		
Staff WC, dining & changing rooms	150	2.5		8-24	x	x		x
Personnel rooms, account, supervision, caretaker	45	2.5		24-8	x	x		x
Circulation areas, service lifts	120	2.5		8-24	x	x		
Wellness/Spa		2.5	SE,W	9-20	x	x	x	x
Fitness gym		2.5	SE,W	9-20	x	x		x
Rental shop		2.5	N	9-21	x	x		x
Indoor pool		2.5	SE,W	9-24	x	x	x	x
Outdoor pool		2.5	SE,W	9-24			x	x
Jacuzzi		2.5	SE,W	9-24	x	x	x	x
Playroom for kids		2.5		9-20	x	x		x
Cabin	45	2.5	SE,W	20-10	x	x	x	x

ill. 075 - Room program

These are the minimum requirements for the rooms and they are based on Neufert. The numbers are based on a hotel with 150 rooms. It is expected to have a total cabin and hotel room capacity of about 300 people, and when all those rooms are treated as part of the hotel it ends up being 150 double rooms.

TECHNICAL REQUIREMENTS

In this chapter we will look at what technical requirements we have for the project. Since the project location is in Norway we will use TEK10 as a base for our calculations. TEK10 covers the building requirements in Norway, but it lacks any requirements or guidelines for building low energy or passive houses. Since we aim to make a low energy hotel we will thus look into a report by Sintef that goes in depth of what such requirements could be for Norway. The numbers provided by Sintef are only meant as a guide, and are not final requirements. The reason Norway can't use the regular standards for low energy buildings is the low temperatures which makes it impossible to meet the same requirements as in warmer climates. When evaluating the building towards low energy standards, the NS3700 will be used as it contains requirements for low energy housing. NS3700 itseis not available for free to the public, but its requirements is an integrated part of Simien.

TEK10

TEK10 covers the technical building regulations in Norway and will be used as the base for the calculations for indoor climate and energy. This chapter will sum up the parts of the regulations that will be considered in the project, covering TEK10's chapters about Environment and Health, and Energy. This will later be used when using spreadsheets, Simien and BSIM.

ENVIRONMENT AND HEALTH

General requirements for ventilation

- One person produce 15-20 liter CO_2 per hour
- Outdoor air is usually 400-450 ppm CO_2
- Indoor air should not exceed more than outdoor + 500. (900-950 ppm)
- Air intake should be low with a consistent air velocity over the intake grate for good result, preferably no more than 1-1.5 m/s.

[byggregler-13-1, 2012]

Ventilation in living units

Extraction volume for special rooms in buildings.

Room	Basic ventilation	MAX fan speed
Kitchen	36 m³/h	108 m³/h
Bath	54 m³/h	108 m³/h
Toilet	36 m³/h	36 m³/h
Laundry	36 m³/h	72 m³/h

[See Appendix 5] for more details on this table.

ill. 076 - Volumes

Ventilation in public buildings

Dimension numbers for ventilation

Building type	m² pr. person
Assembly halls without fixed seats	0.6 m²
Standing room	0.3 m²
Dining places with chairs and tables	1.4 m²
Offices	15 m²
Sales premises	2.0 m²
Schools and Kindergartens	2.0 m²

ill. 077 - Ventilation

Minimum exhaust volume for hygiene- and special rooms. (public buildings)

Room	Exhaust Volume
Bath/Shower	54 m³/h pr. shower
Toilet	36 m³/h pr. toilet/urinal
Elevator shaft	30 m³/h pr. m² elevator shaft
Basement	2.5 m³/h pr. m² gross area
Garage for long term parking	3 m³/h pr. m² gross area
Garage for short term parking	6 m³/h pr. m² gross area

[See Appendix 5] for more details on these tables [byggregler-13-3, 2012].

ill. 078 - Exhaust

Thermal indoor climate

Recommended values for operational temperature (collected effect of air temperature and thermal exposure)

Activity group	Easy work	Medium work	Hard work
Temperature °C	19-26	16-26	10-26

[See Appendix 5]

ill. 079 - Climate

LIGHT

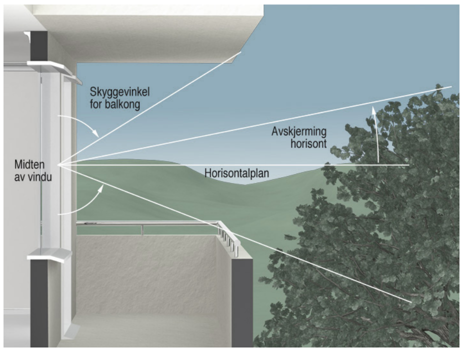
- The building should have satisfactory access to light without causing heating problems.

- Rooms for long term stay like living room, kitchen, sleeping room and working room in living units should have satisfactory access to light. For buildings for public use and working, all working rooms and public rooms should be considered rooms for long term stay.

- Requirements for daylight can be verified either by calculations that confirms an average daylight factor in the room of minimum 2%, or by having the room's daylight surface at a minimum of 10% of the user area. By using the average daylight factor one will achieve a good base for satisfying access on daylight in all room types, independent on room size.

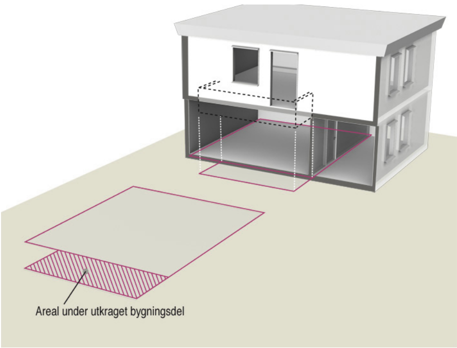
  A simple control of the daylight area can be carried out according to Swedish standard:

  If sufficient daylight is verified by the 10% rule, the use area is calculated according to NS 3940, area and volume estimates of buildings. The daylight surface is the collected unscreened glass area that brings daylight into the room. In addition to the user area one has to take into calculation the area of any balconies or other cantilevered building elements that lies above the room outside the window facade. If the shielding make up more than 20° in height measured from the middle of the window height, the glass area must increase. In these situations the 10% rule is not a good estimate for the daylight level [byggregler-13-12, 2012].



ill. 080 - Screening

Screening of daylight because of terrain & other buildings.



ill. 081 - Cantilevered

Area of cantilevered building elements must be added to the user area of underlying rooms when using the 10% rule.

ENERGY

The building mass accounts for about 40% of inland energy usage in Norway. This makes the building industry an important part of reducing the country's total environmental impact from energy usage. The following rules will contribute to ensure new buildings have a low energy need and environmental friendly energy supply, [See Appendix 6] [byggregler-14, 2012].

ENERGY FRAMES

Total net energy need for buildings should not exceed the limits of the table [byggregler-14-4, 2012]:

Energy frames

Building Cathegory	Total net energy needs (kWh/m² heated BRA pr. year)
Hotel	220

[See Appendix 7] for more info

ill. 082 - Energy Frames

MINIMUM REQUIREMENTS

Following minimum requirements should be met [byggregler-14-5, 2012]:

Minimum requirements

U-value outer wall [W/(m² K)]	U-value roof W/(m² K)]	U-value floor on ground and to-wards the open W/(m² K)]	U-value windows and doors, including frame/sash W/(m² K)]	Leakage numbers at 50 Pa preassure difference (airchange pr. hour) W/(m² K)]
≤ 0.22	≤ 0.18	≤ 0.18	≤ 1.6	≤ 3.0

[See Appendix 7] for more info

ill. 083- Minimum requirements

BUILDINGS WITH LOG WALLS

For buildings with log walls there are some set requirements [byggregler-14-6, 2012]:

Buildings with log walls

Building Cathe-gory	Dimention Outer Wall	U-value roof [W/(m² K)]	U-value floor on ground and towards the open [W/(m² K)]	U-value window and door including frame/sash [W/(m² K)]
Residential Building and recreational resi-dential with one living unit and heated BRA more than 150 m²	≥ 8" notching	≤ 0.13	≤ 0.15	≤ 1.4
Recreational residential with one living unit and heated BRA less than 150 m²	≥ 6" notching	≤ 0.18	≤ 0.18	≤ 1.6

ill. 084 - Log walls

ENERGY SUPPLY

- Buildings of more than 500 m² heated BRA should have a minimum of 60% of net heat need covered by other energy supply than direct electricity or fossil fuels at end user.

- Buildings up to 500 m² heated BRA should have a minimum of 40% of net heat need covered by other energy supply than direct electricity or fossil fuels at end user.

The above mentioned requirements do not apply if it can be documented that natural conditions makes it practically impossible to meet the requirements. For residential buildings the requirements also do not apply if net heat need is calculated to be less than 15,000 kWh/year or if the requirement leads to additional costs of the residential building's life cycle [byggregler-14-7, 2012].

LOW ENERGY

Norwegian Standard (NS 3700) covers info about passive houses and low energy houses in Norway [sintef, 2012]. As there are no set requirements yet for low energy in larger buildings in Norway, a report from Sintef will be used as reference. Because Kongsberg has a yearly mean temperature lower than 6.3 °C there will be used special values based on this. The report stress that all values given are temporary guidelines and should be evaluated later when there is more info and data available on designing after these conditions. The reason for the difference based on temperature is that the cold climate makes it impossible or very hard to meet the same requirements as for warmer climates, while still meeting the requirements for indoor climate. Today, 25-30% of buildings in Norway is located at areas with a yearly mean temperature of less than 6.3 °C. Since Kongsberg is one of those this report will only look at values that cover this situation.

It is expected to be better materials and insulation in years to come, and for cold environments it is important to take these into use to minimize heat loss in buildings. It is expected to be windows with U values towards 0.5 W/m²K, heat recovery values η towards 95 % and new highly effective insulation solutions with λ values towards 0.02 W/mK which should be taken into consideration when aiming for passive house or low energy housing solutions in such cold climate.
For this chapter only the values for hotels will be looked at.

TABLES

Minimum recommended average airvolume for the whole building [sintef, 2012].

Mean Airflow When Used	Mean Airflow When Not Used
6 m³/hm²	1 m³/hm²

The numbers is averages for a whole building, and the report stress that the dimensional airflow in separate rooms can be significantly higher.

Heat gains from lighting, equipment and people, as well as average total internal heat gains (mean value over day and year)

Lighting	Equipment	People	Internal heat (mean)
5 W/m²	1 W/m²	2 W/m²	6.0 W/m²

No net heatgain should be calculated from hot water.

Maximum yearly heating need

Yearly Heating Need
50 kWh/m²year

These are net values (room heating and ventilation heating).

Maximal cooling need

Energy Need Cooling (net)
15 kWh/m²year

Net values for room cooling and ventilation cooling.

ill. 085 - Tables

Maximum allowed heat loss number

Heat Loss Number, H”
0.85 W/(m²K)

Maximum allowed CO_2 emission

CO2 emissions m”
55 kg/(m²year)

These values are based on the total delivered energy for the building, both for heat need and electricity.

Minimum requirements for building parts, components and leakage value

Feature	Value
U-value external wall	≤ 0.18 W/(m²K)
U-value floor	≤ 0.15 W/(m²K)
U-value roof	≤ 0.13 W/(m²K)
U-value window	≤ 1.2 W/(m²K)
U-value door	≤ 1.2 W/(m²K)
Normalised coldbridge value Ψ”	≤ 0.05W/(m²K)
Heat Recovery Efficiency, ηT	≥ 70 %
SFP-factor ventilation system	≤ 2.0W/(m³/s)
Leakage number at 50 Pa, $n50$	≤ 1.5 h^{-1}

The window value refers to the average value over all the buildings windows and window areas.

[See Appendix 8] for numbers behind these tables.

GEOTHERMAL HEATING

How it works

Geothermal energy can be taken out from the ground by pumping up hot water from depths where the earth's core heats it up. In Denmark its normal to do this at depths between 1.5 and 3 km. At 2.5 km depth the water holds 73°C, and the deeper one goes the warmer the water gets. The water goes up to 100 meter depth by itself, and from there it is pumped up to the surface. Because the water pumped up contains much salt it cannot be used in normal hot water circuits, so when used for district hotwater it will be used to heat up fresh water in a twinned system which will then get a temperature of 70°C. During such a process the underground water lowers its temperature, and when it reaches 17°C it is returned to the ground through a different hole. This ensures that the pressure in the water reservoir in the ground remains the same [geotermisk, 2007] [ens, 2012].

Advantages and Disadvantages

The process itself of transmitting the geothermal heat from the underground water to the fresh water does not give any emission directly to the environment, but there is some initial energy need to pump the water. The ratio of the energy saved from the pumped water, til the energy used to pump it is 1:12, so it saves off almost 92% of the energy use and transmission for heating the water.

The installation cost of a plant to run this is high, while the running cost is only 20% compared to the similar plant run on fossil fuels. This means however that there must be invested more money in the beginning, while the saving comes over time.

An important aspect of the usage of geothermal heat is that the process cools down the water in the depths if too much water is circulated in a given timeframe. This means that such a plant needs to be dimensioned right to avoid cooling of the hot reservoir. It is also important to do tests of the ground beforehand and see if the site is suitable for such a plant. [ens, 2012] [conserve, 2012].

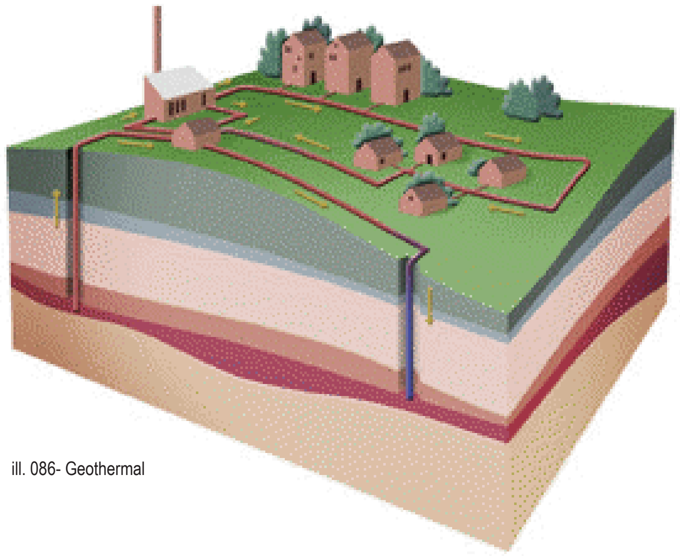
Technology

Another aspect is the technology and equipment involved in the process of drilling to make such a plant. This is a field Norway excels in from tunnel making and subsea oil drilling. NCE Systems Engineering in Kongsberg is these days working on how to use geo thermal energy also for production of electric power. Industries in Kongsberg has good expertise in this field both technical and industrial, which is very valuable in the new field of using geothermal resources for making energy. The awareness of geothermal energy is rising and it's the right time to invest in it. Norway has a unique chance to be world leading in this technology based on the existing competence from petroleum operations, and Kongsberg is among the leading actors ion this field. They hope that this can be a new commercial success like the subsea drilling for oil has become [devotek, 2012].

Conclusion (How to use it)

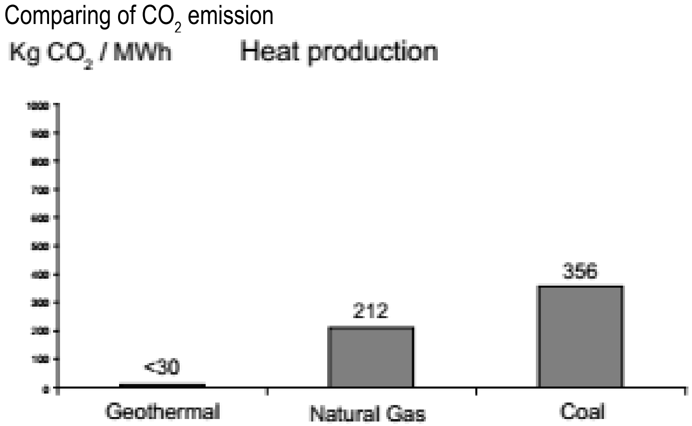
In this project geothermal energy will be used to heat hot water, buildings, Jacuzzis, ventilation air, and also for melting snow on roofs/paths where preferred. This counts for all of Kongsberg Skiresort including the holiday apartments, ski rental and cafeteria building as well as the new hotel and cabins. In the future it may also be possible to use the geothermal energy for electrical power, but this is something the industry is still currently researching. The geothermal heating will save 92% of electricity used for heating and will be implemented in the Simien simulations.

Examle of a geothermal energy facility



ill. 086- Geothermal

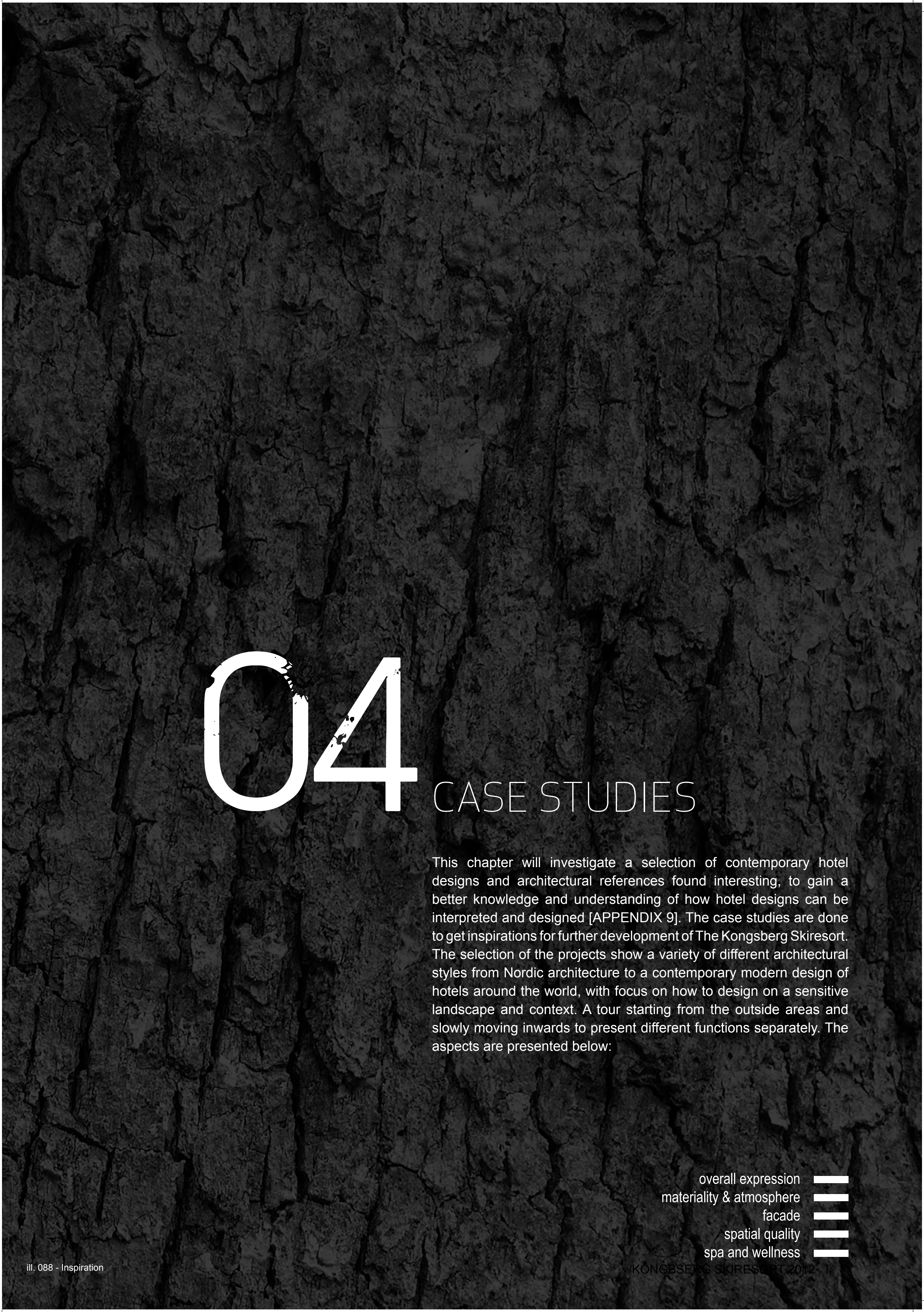
Comparing of CO_2 emission



ill. 087 - CO_2 emission

CONCLUSION

TEK10 will be used as the requirements that have to be met, while Sintef's report and NS3700 will be used as a guideline for what we could aim to reach as a low energy building. The values in the tables will be used as reference when calculating the hotels energy consumption and indoor climate. TEK10 says that the total energy need for a hotel should be maximum 220 kWh/m² heated BRA pr. year, while Sintef says a maximum of 50 kWh/m² (for heating) is a good estimate for a low energy building, This is the number to aim for. Geothermal heat will be used for heating of hot water, room heating as well as heating of paths and roof if needed. When evaluating low energy standards in Simien, NS3700 will be used.



04 CASE STUDIES

This chapter will investigate a selection of contemporary hotel designs and architectural references found interesting, to gain a better knowledge and understanding of how hotel designs can be interpreted and designed [APPENDIX 9]. The case studies are done to get inspirations for further development of The Kongsberg Skiresort. The selection of the projects show a variety of different architectural styles from Nordic architecture to a contemporary modern design of hotels around the world, with focus on how to design on a sensitive landscape and context. A tour starting from the outside areas and slowly moving inwards to present different functions separately. The aspects are presented below:

- overall expression
- materiality & atmosphere
- facade
- spatial quality
- spa and wellness

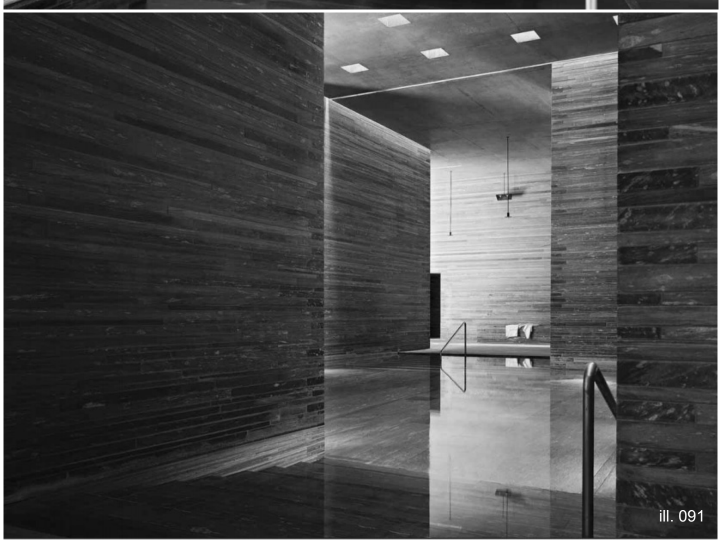
ill. 088 - Inspiration

THERME VALS

Architect: Peter Zumthor
Location: Vals, Austria
Size : 7,300 m²

ill. 089

ill. 090



ill. 091

The perception and use of the term phenomenology by Peter Zumthor in his work are interesting to look at to gain a better understanding of how it can be interpreted and used in real life. His world-wide known Theme Vals has been chosen as a strong reference in this project due to its design, values, material usage, context and sensory experience that the work provides.

Zumthor was born in Basel (1943) and studied industrial design and architecture at Kunstgewerbeschule in his native city starting in 1963 [wikipedia/zumthor, 2012]. During his time as a student, he gained a great understanding of construction and the qualities of different rustic building materials, which enables him to incorporate into modernist construction and detailing. His buildings explore the tactile and sensory qualities of space and materials while retaining a minimalist feel.

Therme Vals Spa was built between 1993 and 1996, and was designed as a form of cave or quarry like structure half buried in the hill side. When observing from the nearby hotel one sees the grass roof with the bath rooms below. The concept of the building is that it slowly reveals itself, resembling the foundations of an archaeological site. The exterior is built with masonry and interior with quarried Valser quarzite slabs. The roof reveals the nature of the construction, because it doesn't join. It has a 8 cm gap and is covered by glass preventing water ingress. This makes the roof appear heavy, but in the meantime also gives the effect of a floating roof top. There are 60,000 1m long sections of stone forming the cladding og the walls [Therme-vals, 2012]. When observing the wall cladding it seems like its random, but they are regular ordered. Even though the cladding stones are of three different heights, the total of the three is always 15cm, which allows for a variety in the arrangement.

In many ways one could refer this building to our project. Even though it doesn't appear to have a strong unique building identity when observing from a distance, it still have lots of qualities and values that can be discuss and used as inspiration and reference for our sketching phase. This project has a very strong usage of materiality and texturing, which gives the project a sensory experience of optimal integration with its context.

“The physicality of materials can
involve an individual with the world,
evoking experiences and texturing
horizons of place through memory”.
[wikipedia/zumthor, 2012]

ill. 092

SKI RESORT LAPLAND

Architect: Bjarne Ingels, Jacob Lange
Location: Levi, Finland
Size : 56,000 m²


ill. 093


ill. 094


ill. 095


ill. 096

BIG (Bjarne Ingels) is a young architectural office, who has footprinted Denmark with their unique interpretation of innovative building design and showed new ways of approaching conventional tasks. This project is interesting because it is a skiresort that has been designed on a mountain ridge of Levi, Finland. The task with this design was to make a building that is well integrated with the landscape on a mountain top.

The ski village is an extension of the existing cluster buildings. The concept is to have four buildings that wrap around the central square to form a public pocket sheltered from the wind, yet open and inviting to the surrounding landscape. “The views from the summit are contrasted by the intimate atmosphere of the spaces between the buildings” [Ingels, 2012]. The undulating curves of the roofs create a continuity of the natural landscape that also functions as ski slopes.

This is brought into the project to discuss whether this design differs from the Nordic architecture theory or if it’s just another innovative way of interpretation to how new modern Nordic architecture could be? This project possesses a fascinating strong identity, with interesting functions, activities, spatial relations between indoor and outdoor spaces, which will be extracted and discuss throughout our design process. There is however a lack of materiality of texture and phenomenological experience, which gives the project a touch of temporality and superficiality.

The simplicity of the concept diagrams and building identity will in this project be used as a reference and inspiration in the sketching phase.

ill. 097

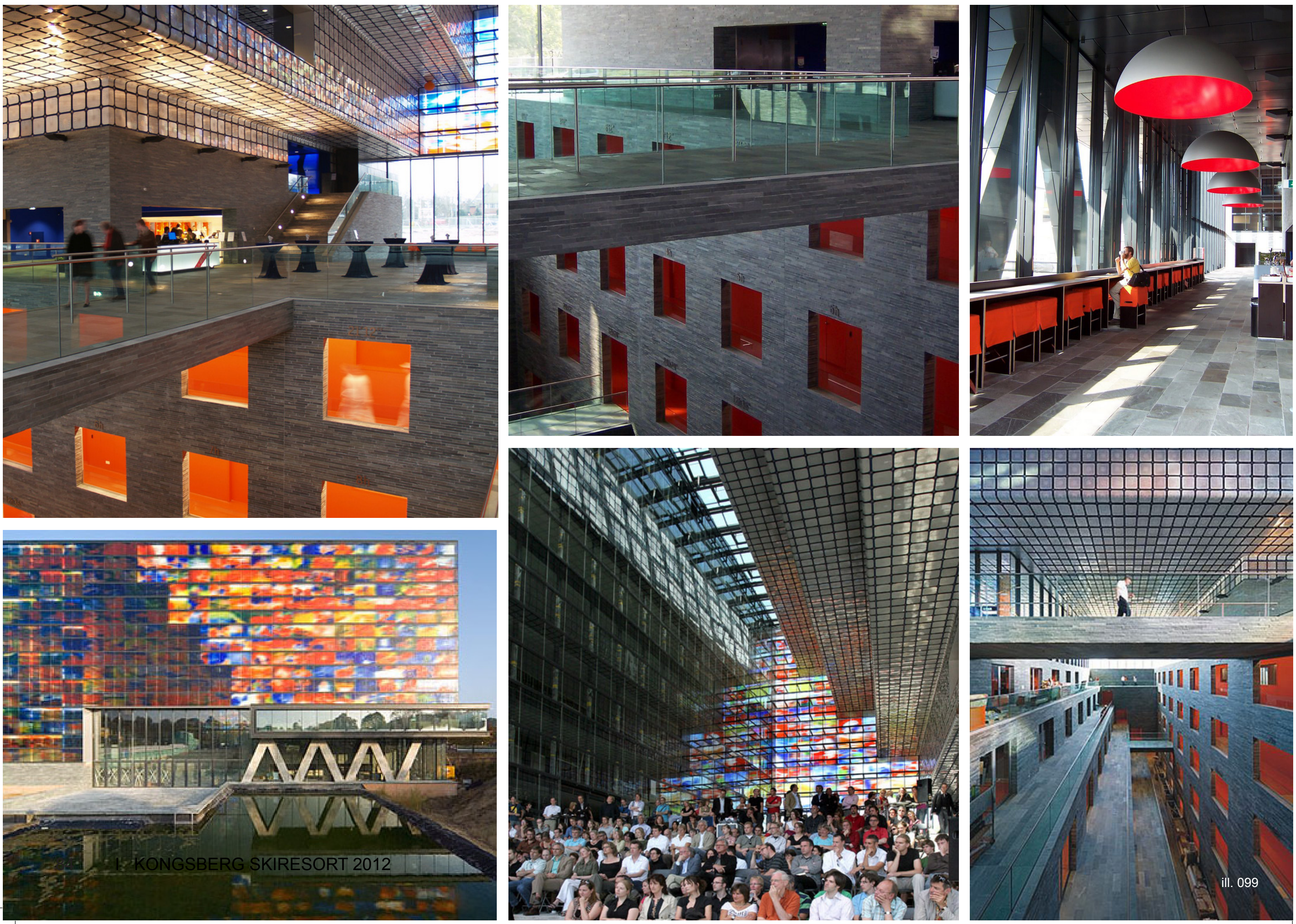
“Our design seeks to create a new hybrid integrating distinct identities such as village and resort, shelter and openness, cozy intimacy and natural majesty, unique character and careful continuity or simply - architecture and landscape”
[Ingels, 2012]

ill. 098

INSTITUTE FOR SOUND AND VISION

Architect: Neutelings & Riedijk
Location: Amsterdam, Netherland
Size: 2,000 m^2

The Netherlands Institute for Sound and Vision is one of the largest audio-visual archives in Europe [greenroofs, 2012] The institute preserves a major part of the Dutch audio and visual heritage and the collection totals over 700,000 hours of television, radio, music and film. The building was designed by the architects Willem-Jan Neutelings and Michiel Riedijk, and has a very eye catching play in the facade. The facade is abstract images from historic film and TV fragments from the history of Netherland. The building measures 54x54 square meters and is 26 meters high. The pond is very impressive because it has 6 different levels with a cascade of lighted waterfalls. The first level also includes three fountains. Although the pond seems to be purely aesthetic, its primary function is to serve as a fire extinguishing reservoir for the Institutes' archives. All archives are distributed in long and straight paths leading into small squared coloured boxes deep into the ground, which creates this atmosphere of mining.



ill. 099

DESIGN CRITERIA

To sum up of the analysis design criteria has been elaborated and listed below. The criteria concerns the architectural considerations, which will end up with a vision and final problem formulation.

- Involve and integrate the landscape
- Arouse visitors curiosity
- Inspired and responding by city history
- A unique sensory experience
- Emphasize the beautiful and dramatic nature
- Provide a transition from open nature to underground
- Dig some functions into the ground
- Create an underground cave/clift atmosphere
- Inspired by mining
- Reuse part of the excavated material for shaping landscape and for facade material
- Interact with the users of the skicenter
- Village area (only the outline of the village will be emphasized due to the timelimit of the project.)
- "Story of the mining days" with the village in the bottom of the building site and mine up in the hills

VISION

The hotel will be a new fulcrum and unite the functions and activities in “Funkelia” completing the skiresort of Kongsberg.

The sustainable hotel will prove that great focus on the sustainability, indoor environment and low energy usage, will not compromise architectural quality. The choice of natural and lasting materials will be highly prioritized as a reference of the material usage in the area.

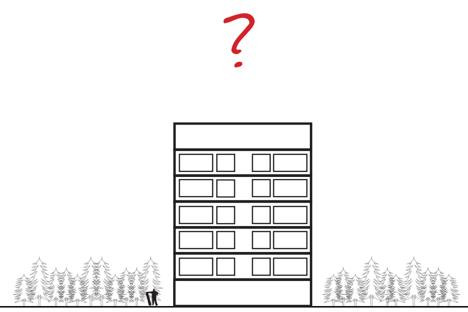
The skiresort should possess great phenomenological and Nordic architecture qualities, which will become the new landmark of the city and a new attractive base for yearly events in Kongsberg.

The hotel will meet the accommodation needs of visitors using the different activities Funkelia has to offer.

ill. 100

PROBLEM FORMULATION

How to involve and integrate the sensitive landscape surrounded by untouched nature, when building a hotel and designing an area for skiers and snowboarders, which by its shape imitates and reflects the activities found in the area? A Hotel inspired by the many mines located in the Kongsberg city, Norway.



ill. 101

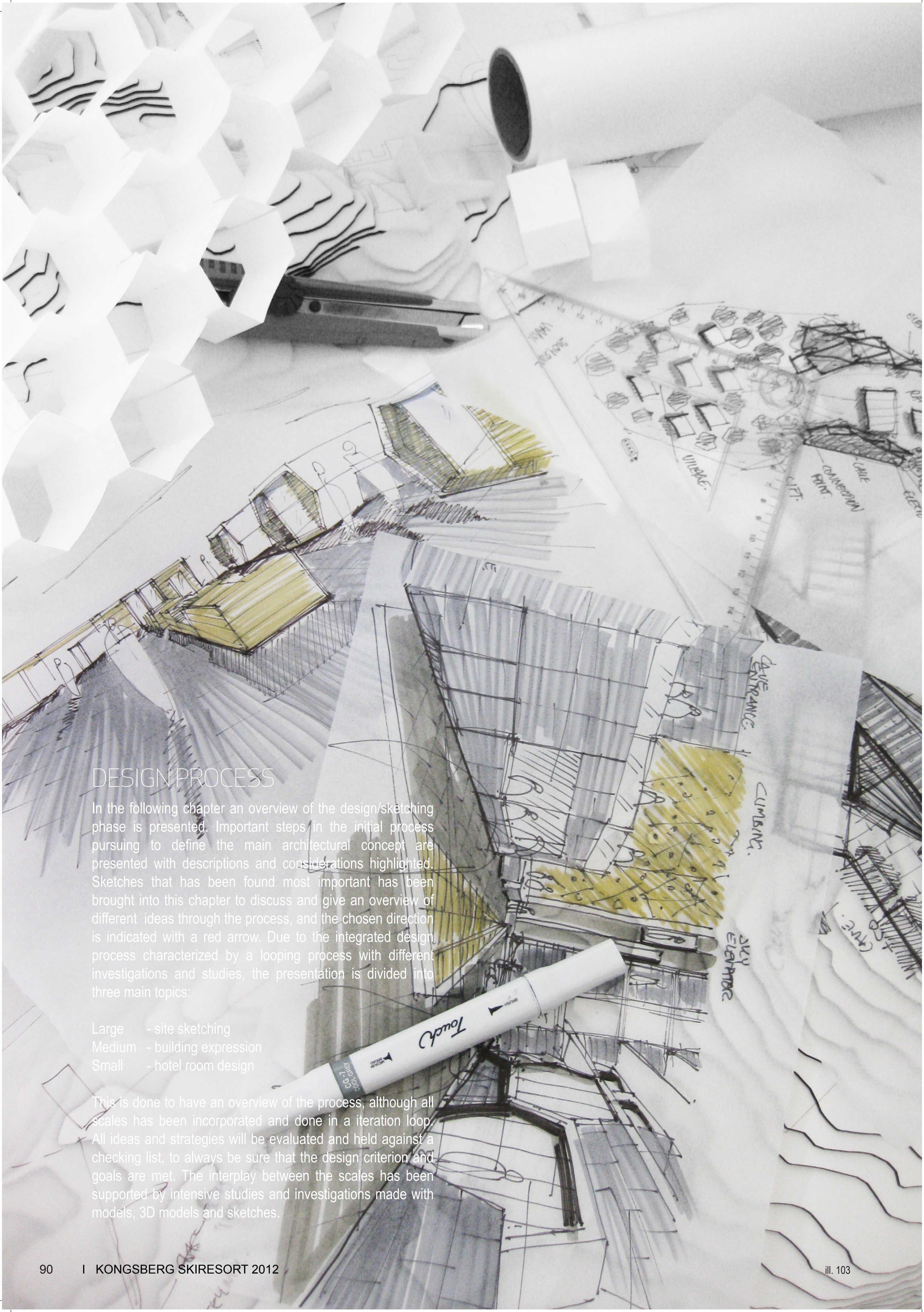
Hotel that responds to the history and identity of Kongsberg ▸ Mines

Hotel that responds to the activities of the users ▸ Skiing and snowboarding


1 room
stairs
sitting place
RESTAURANT

05 SKETCHING PHASE

ill. 102



DESIGN PROCESS

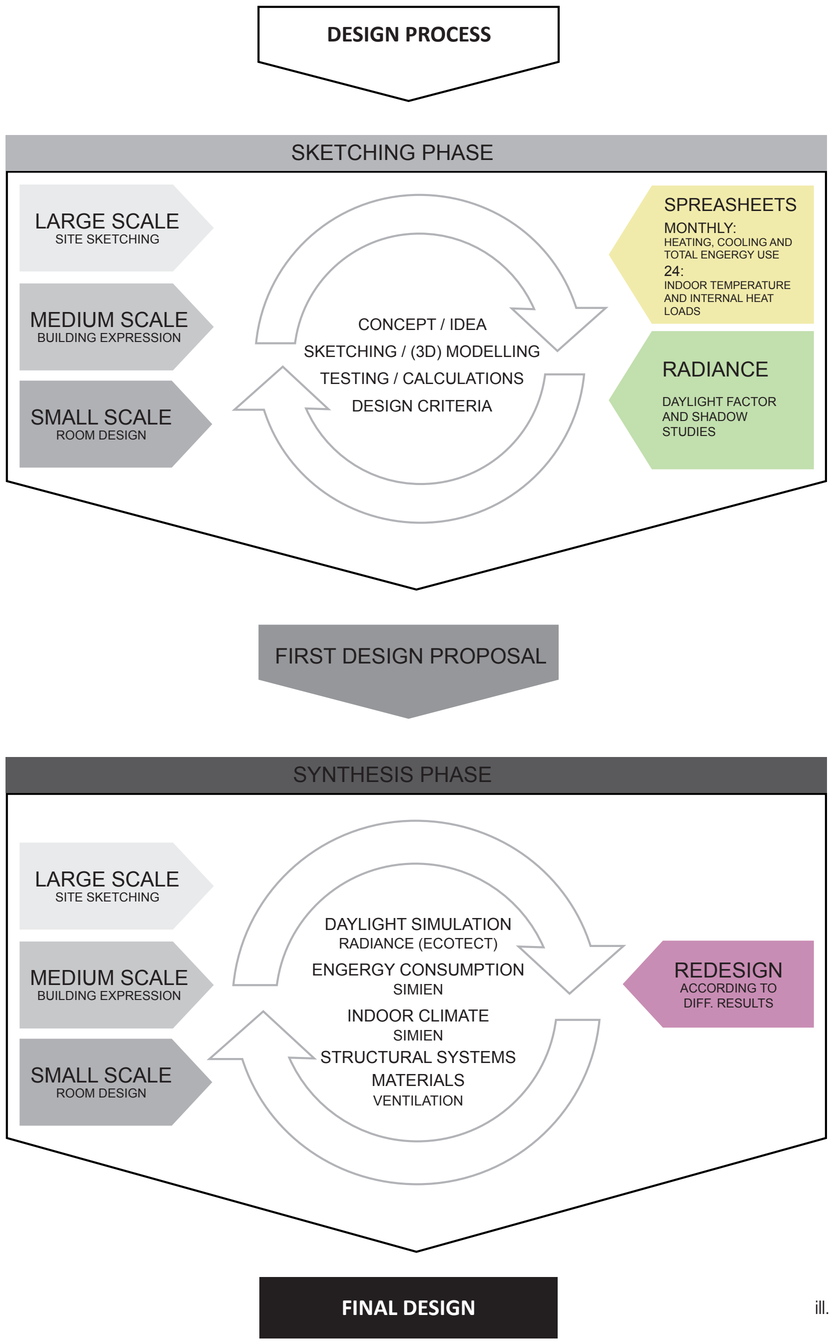
In the following chapter an overview of the design/sketching phase is presented. Important steps in the initial process pursuing to define the main architectural concept are presented with descriptions and considerations highlighted. Sketches that has been found most important has been brought into this chapter to discuss and give an overview of different ideas through the process, and the chosen direction is indicated with a red arrow. Due to the integrated design process characterized by a looping process with different investigations and studies, the presentation is divided into three main topics:

Large - site sketching
Medium - building expression
Small - hotel room design

This is done to have an overview of the process, although all scales has been incorporated and done in a iteration loop. All ideas and strategies will be evaluated and held against a checking list, to always be sure that the design criterion and goals are met. The interplay between the scales has been supported by intensive studies and investigations made with models, 3D models and sketches.

ill. 103

PROCESS DIAGRAM



ill. 104

CONCEPT DEVELOPMENT

After gathering information regarding the contextual aspects, the actual upstart of the design is initiated. To deduce the knowlegde of the context analysis, first considerations in the design process is how to use the contextual understanding and situate the building, and designing a hotel that integrates with the landscape and its context.

DESIGN BRIEF

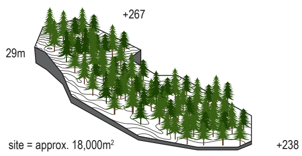
The overall design criterion is a hotel at the current Kongsberg skicenter, which unites the surrounding functions to become a new Kongsberg Skiresort with the size of approximately 6,500m² and 11 cabins. The functions are going to relate to the present activities of the skicenter and should connect to the intended new ski lifts. The design of the hotel should respond to the history of the city, becomming a new icon and offer greater possibilities for accomidations to stay at the area when the current skicenter close down at 9 pm (ill. 073-074- Activities p.72).

By own experiences, when skiing and snowboarding down the slopes at the ski center, there were no natural stops for the users to have a moment to enjoy the beautiful surrounding of the nature and different views towards the city. These parameters will be considered in the concept development.

Due to the site's dramatic nature and sensitive landscape, a study has been carried out to investigate how a hotel can be placed on the building site. The focus has been whether not to have a dominant building mass, which opposes the idea of having a contemporary design, that doesn't relate to the landscape and to a coherent urban whole [Meagher, 2008, p151].

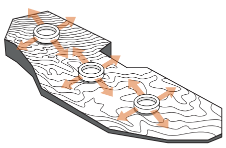
Our vision is to emphasize the landscape when designing the hotel, with attractive activities and functions that defines the site as the new fulcrum. The hotel and its functions unite the adjacent skicenter - becoming a new skiresort. This leads to an analysis of the site and the potential activities on the area.

THE BUILDING SITE



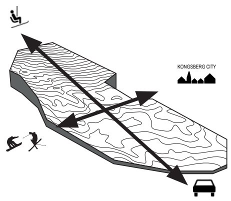
ill. 105

The building site is 18,000 m² and situated on a slope. The area is dominated by pine trees and untouched nature. It slopes from +267 to +238 which is 29m in height difference.



ill. 106

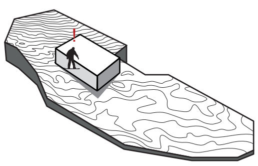
The hotel can be placed anywhere on the site, without downgrading the opportunity to have great view qualities, because the whole site holds good views in all directions.



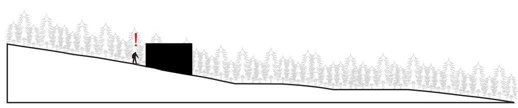
ill. 107

There are 4 important main views and connection points that will be considered in the further design process.

1. view to the ski center and slopes.
2. Connection point to T- and chairlifts
3. View towards the city
4. Entrance point.

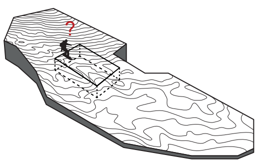


ill. 108

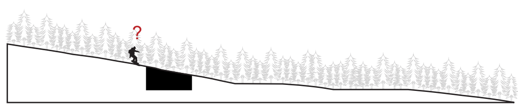


ill. 110

The site topography has a very good inclination for skiers and snowboarders, but when placing a volume on the site it stops the natural flow when rushing down the slope. The volume appears dominating and not as an integrated part of the landscape.



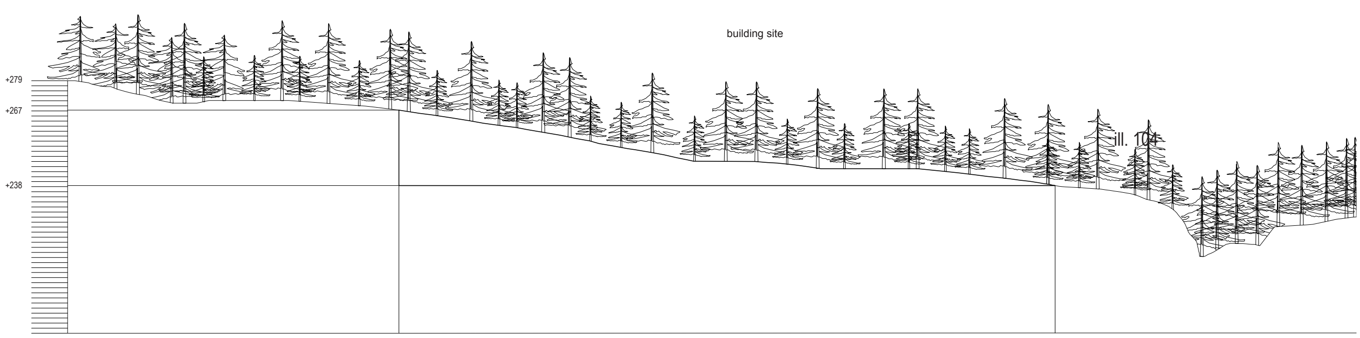
ill. 109



ill. 111

By hiding the hotel underground the skiers and snowboarders will have an undisturbed rush down the slope, but it doesn't allow for any natural stops during the route that enforces one's experience of being in the nature and enjoying the beautiful settings and views that the slope is able to provide. The hotel appears unknown and the users may not be able to perceive that there is a hotel on the site.

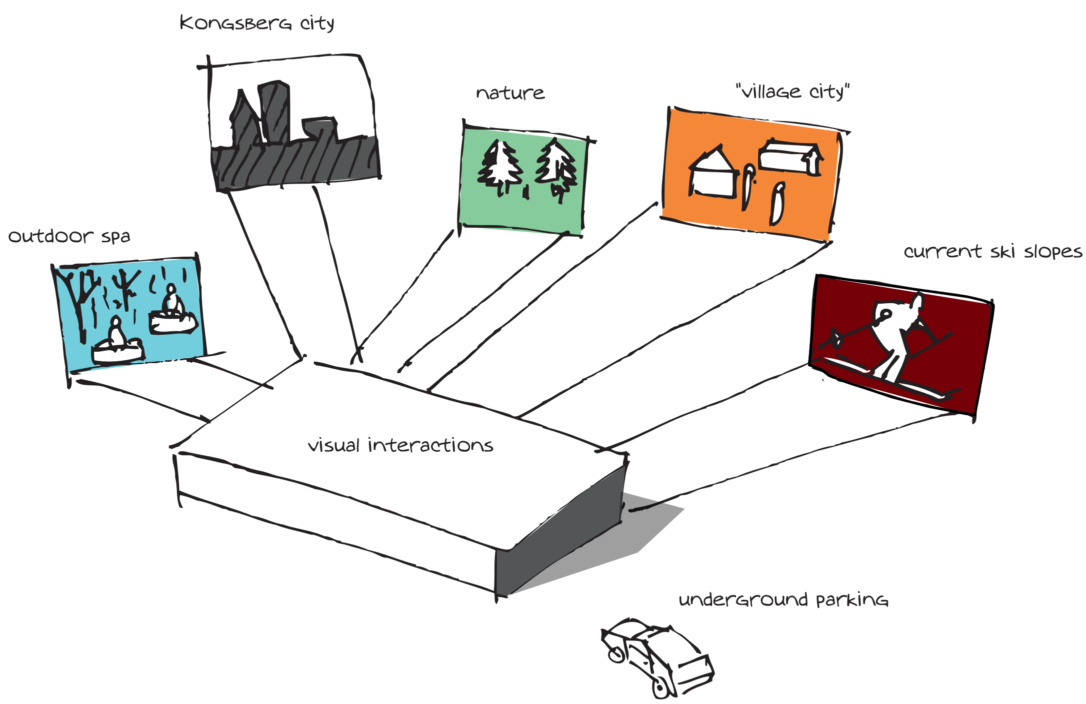
SECTION THROUGH AREA



ill. 112

ACTIVITY PLAN

The previous analysis shows a building site of approximately 18,000m², with a big domination of untouched nature and pinetress, it's important to incorporate activities that relate to this aspect and integrates with the context. To keep the area activated and more attractive, a brainstorm has been carried out to see how the area can be programmed (ill. 113).




Barbecuing and sun Bathing in nature

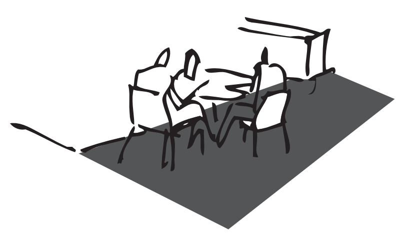

fitness facilities

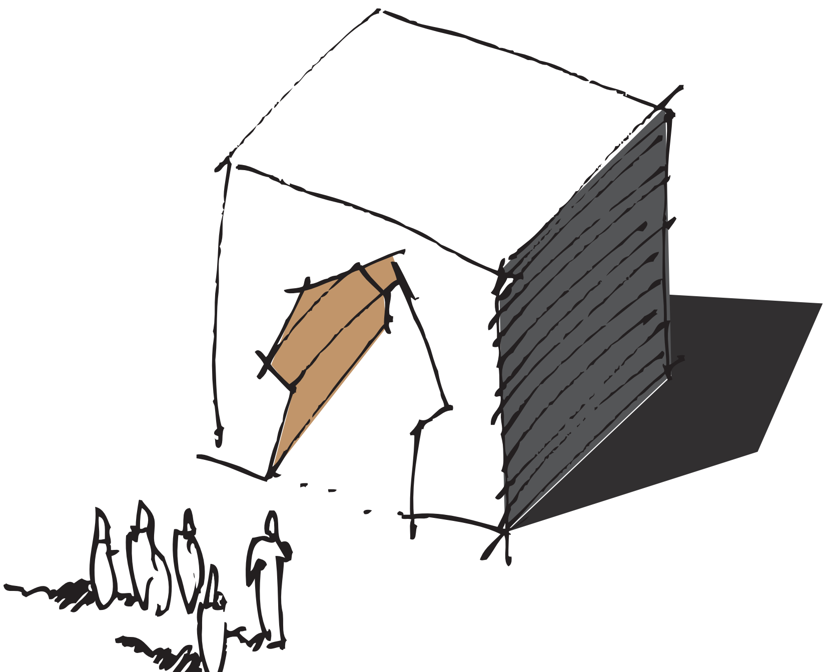

Skiing and snowboarding facilities


famlily kind activities


experiencing the nature

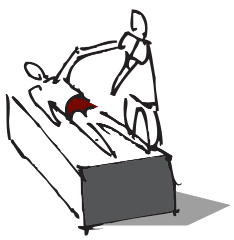

pleasent acommidations


cafeteria / restaurant

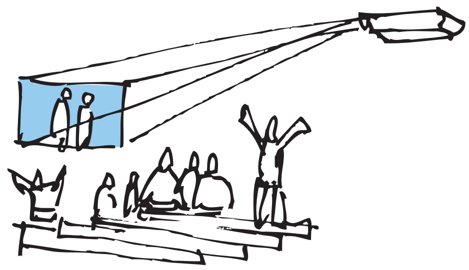


walking in "natural" cave

sitting/lounge area



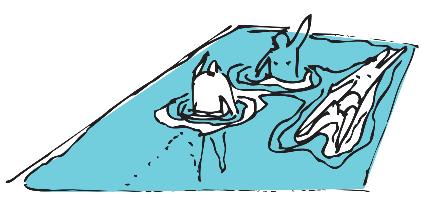
wellness/massages/spa



cave cinema

climbing on "natural" rock wall

sauna



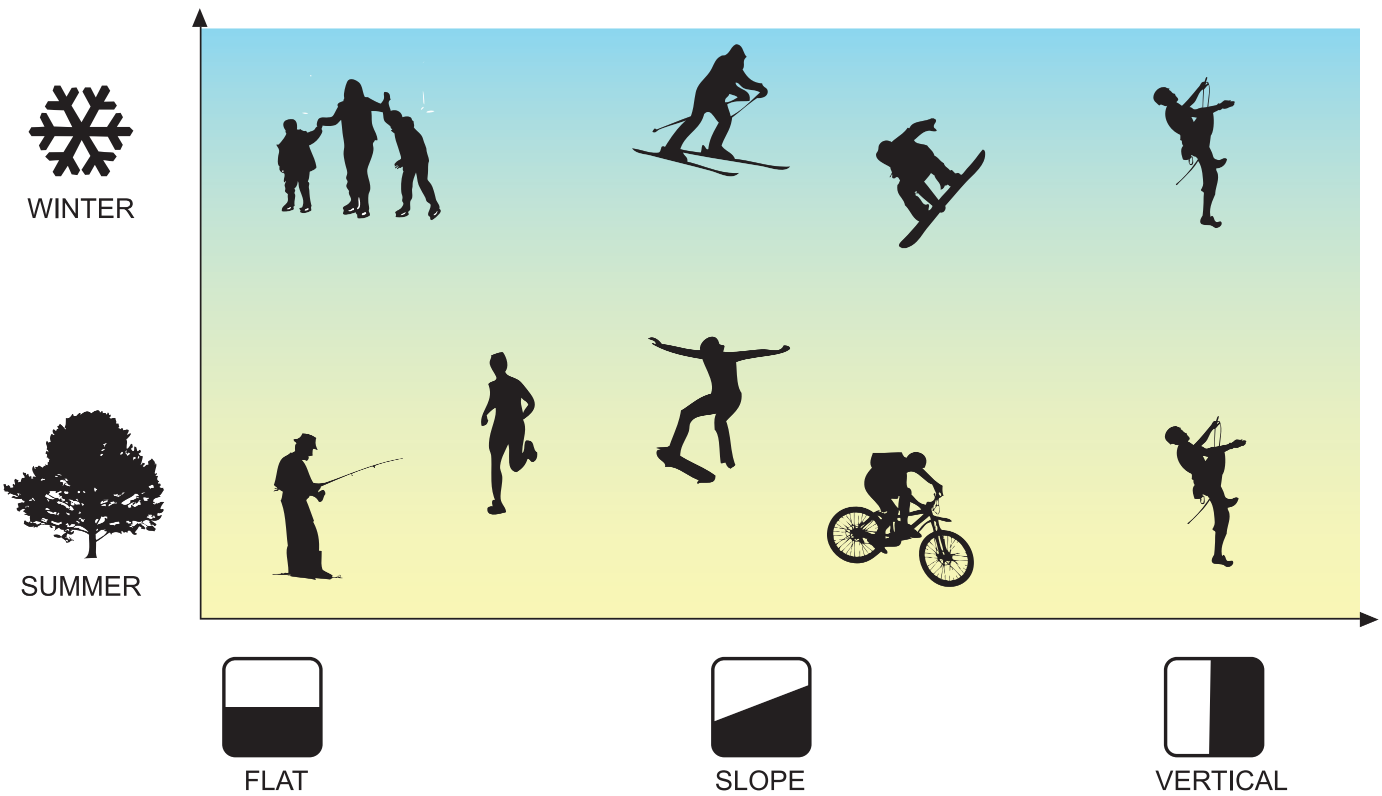
out door swimmingpool / cave swim

ill. 114

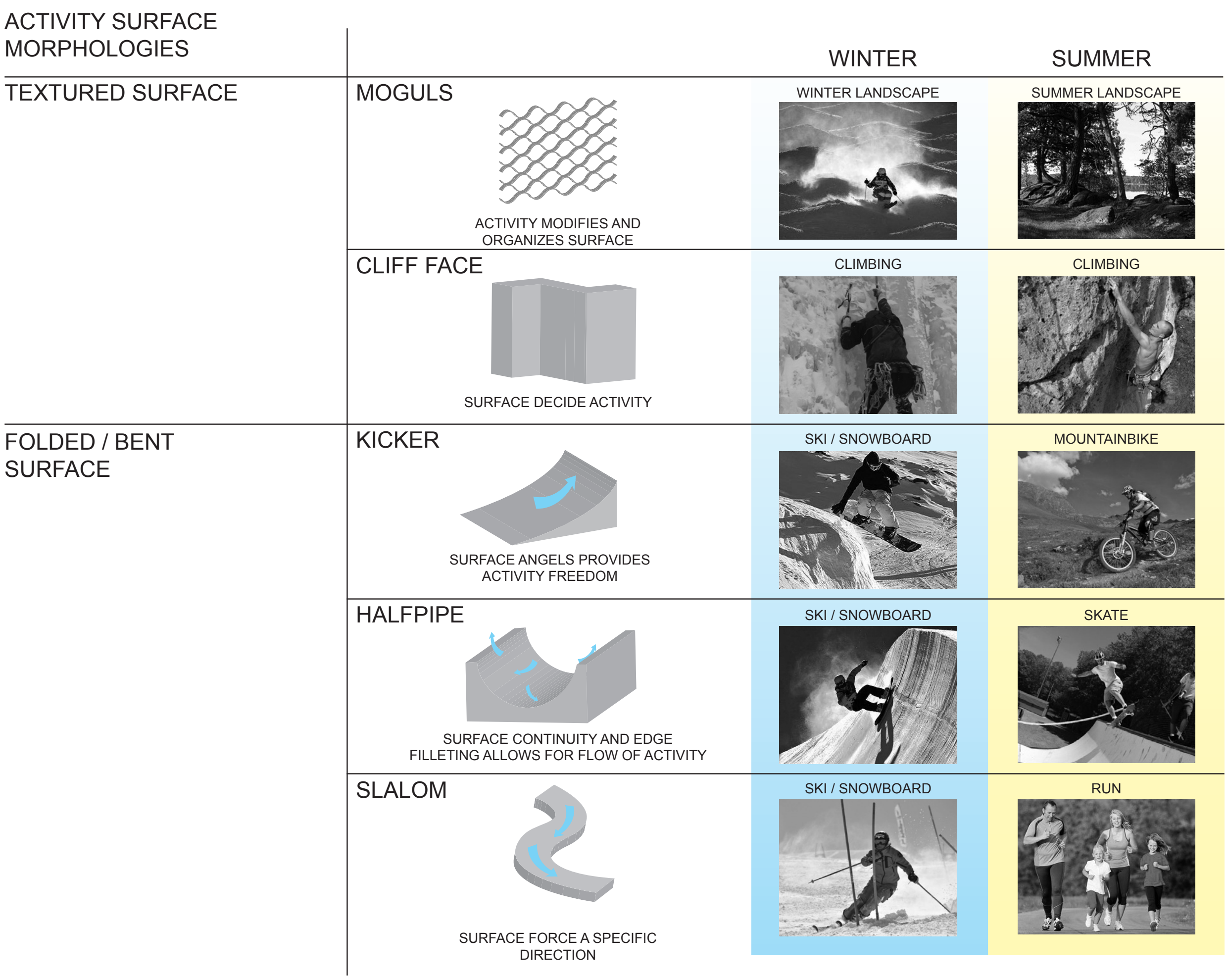
EXPERIENCING THE HOTEL FACILITIES

One of the main focuses within the activity brainstorm for the prospective future hotel was to elaborate the important aspects of how the users experience and explore the mine qualities and the different activities the hotel has to offer. Both the possibility of spatial movement from “cave” to open spaces and its connections to public functions are striving to be enhanced. In order to attract the visitors, the hotel offers a vast range of possibilities of different ways to “seek new exploration” with small narrow paths leading to cave functions, and materiallity that respons the to sites identity. This is thought to incoprporate many types of activity, rest and experience situations together with a pleasent stay at the hotel rooms, which provides the best views towards the ski slopes and its surounding landscape. The illustrations ill. 115 and 116 shows different activities held up against eachother, to ensure different interest of activities in high season and during summer.

ACTIVITIES CREATED
BY SURFACE



ill. 115

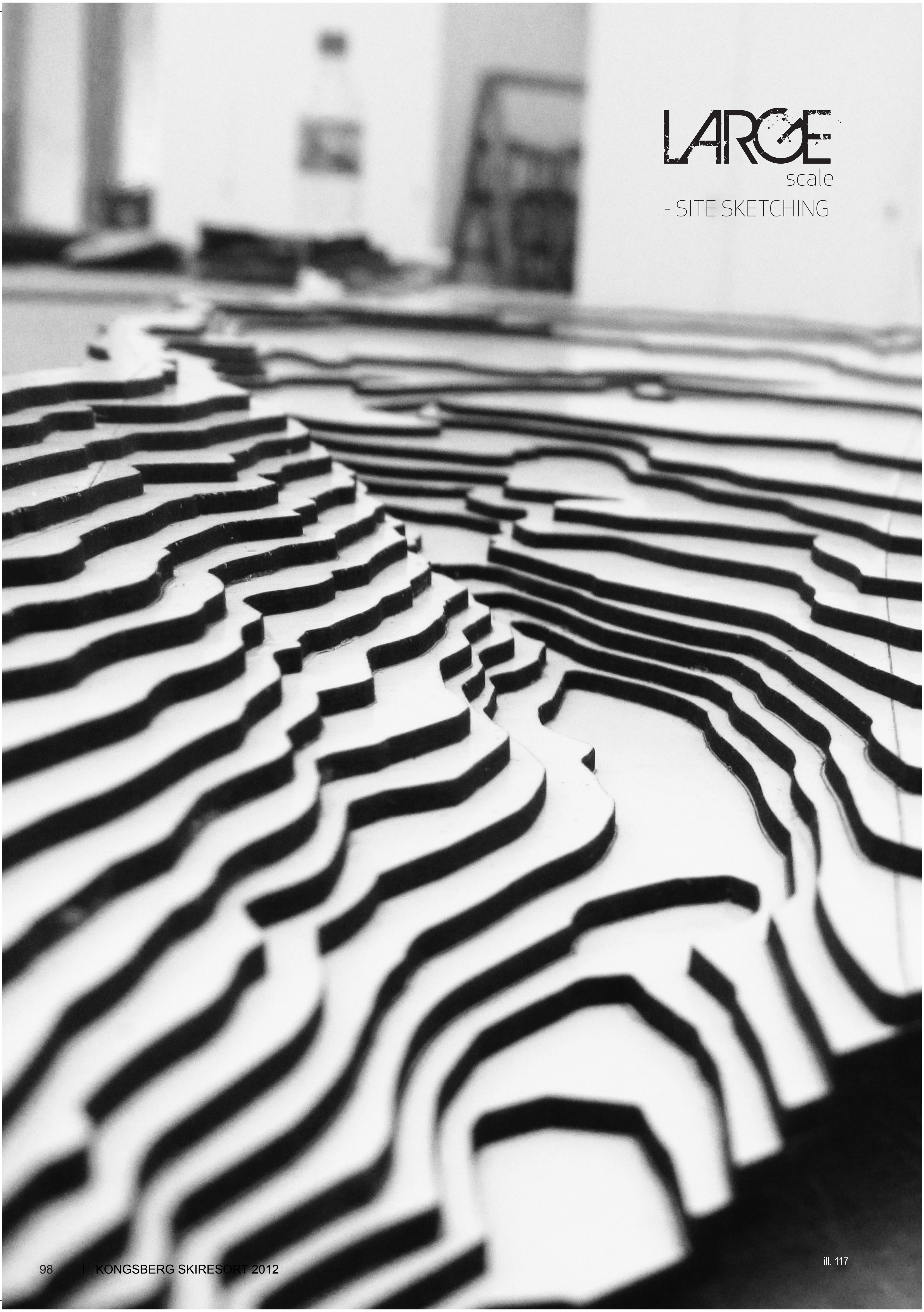


ill. 116

CONCLUSION

The diagrams shows different activities intended to take place within the new hotel. Winter activities are held up against summer activities to ensure the hotel to function for both seasons. The activities created by different surfaces and morphologies will be used as an inspiration for concept development.

LARGE
scale
- SITE SKETCHING

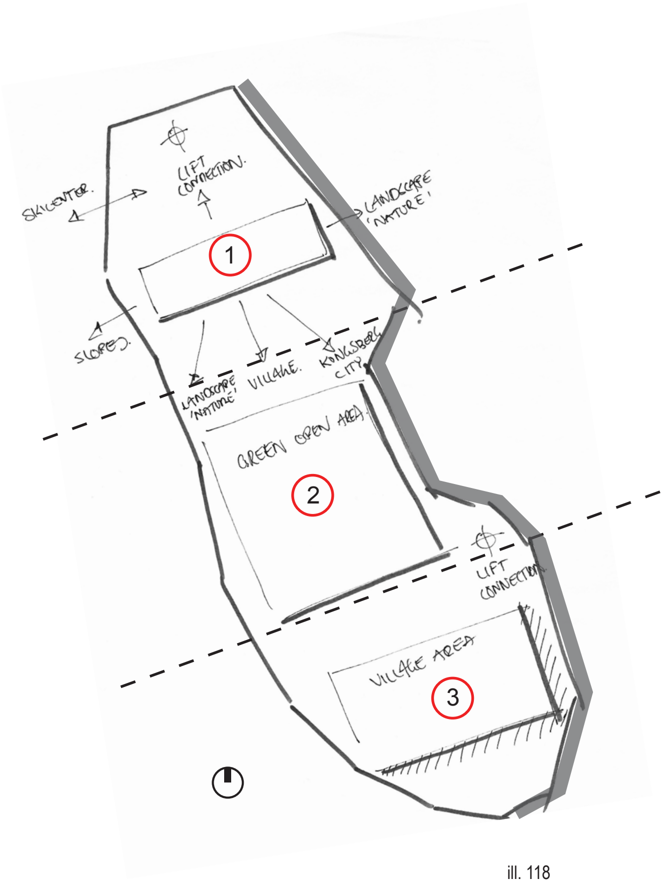


ill. 117

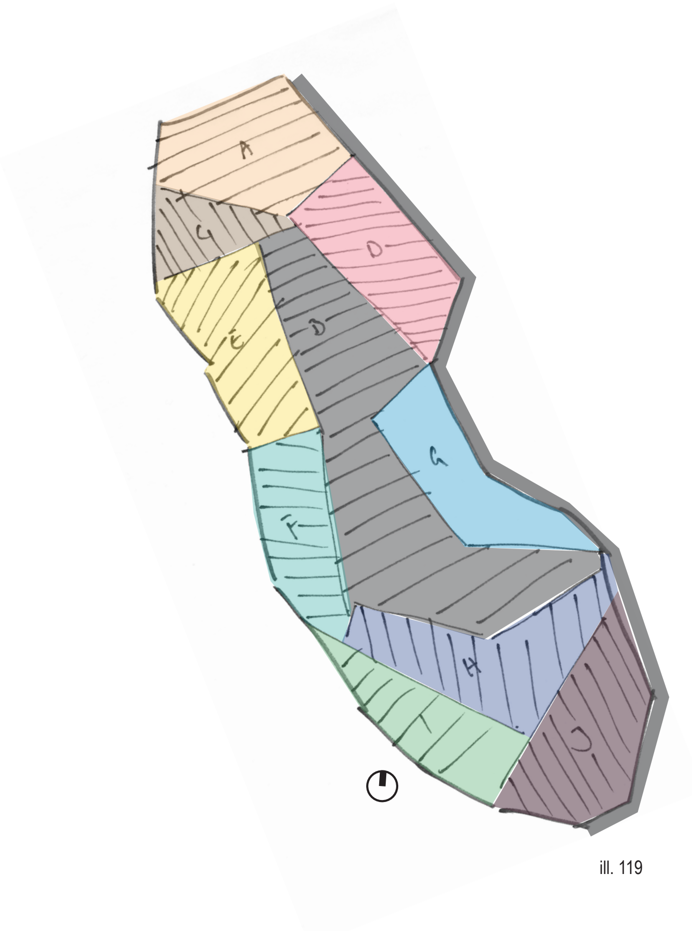
INITIAL IDEAS FOR MASTERPLAN

With focus on previous analysis of the site and future prospective activities, initial ideas for the masterplan can be sketched ill. 118. Strong visual interactions from the hotel to the current skicenter, skislopes, nature, city and village are highly prioritized. The hotel should not be a boundary for physical or visual connections for activities and views towards south. Due to the inclination of the site, it is desired to make hotel rooms that integrates and steps down towards south for both daylight intake and panoramic views towards aforementioned visual connection points. To respond to the history of the city a cave/mine atmosphere is also highly prioritized in terms of giving the visitors a strong sensual and unique experience when exploring the different functions that the hotel has to offer. To meet this idea an underground atrium with small cave entrances and paths leading to "natural" cave functions is to be considered.

With the initial idea of the site, different zones can be created to have an overall plan for the building site. The site is divided into various zones, with activities that responds to the nearby outdoor space.



ill. 118



ill. 119

The site is divided into 3 main activity zones.
1. Hotel with close connection to the lift
2. Green open area - central point of site
3. Village area with close connection to nature

The site is divided into function zones.
a. Lift conncetion
b. Skiarea - connection route to south
c. Atrium
d. Wellness zone
e. Ramps
f. Nature
g. Lake
h. Central point of village
I. Nature
J. Village

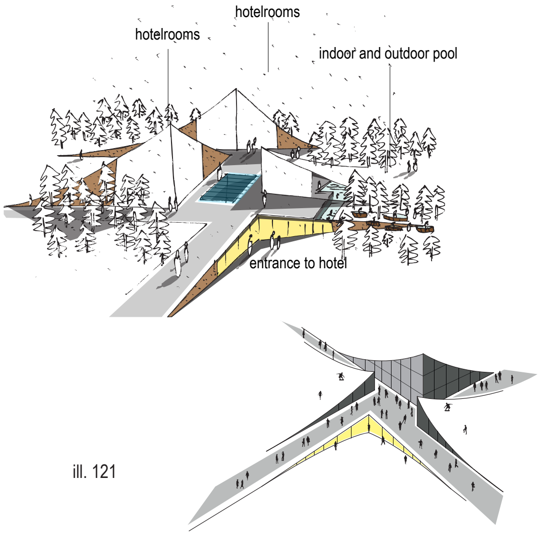
MEDIUM
scale

- BUILDING EXPRESSION

Based on the previous investigations different concepts can be elaborated. A selection of concepts will in this chapter be shown and rated from 1-5 pluses, based on architectural and technical considerations of each concept. Full description of each concept will be found in the appendix 10-13.

ill. 120

CONCEPT 1 - "THE CUT"



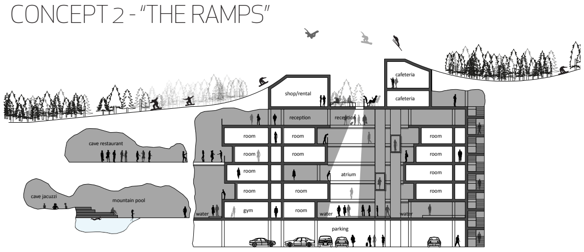
ill. 121

"The Cut" is a concept that emphasize the four main visual connections of the area. Four cuts are made on the site which defines narrow "clift paths" leading to a central open plaza. The plaza is surrounded by three building masses consisting of the hotel functions, with hotel rooms on top floor for daylight intake. One volume is pushed down becoming the entrance to an underground hotel function. The roof becomes skating ramps and outdoor living facilities such as outdoor pool and spa. [APPENDIX 10]

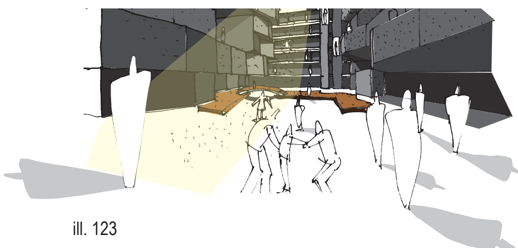
Architectural considerations
outdoor spaces +++
expression +++
dominant ++++
integration ++++

Technical considerations
structural +++
sun (heating) ++
daylight ++

CONCEPT 2 - "THE RAMPS"



ill. 122



ill. 123

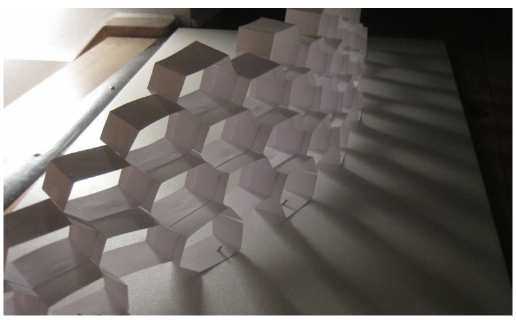
"The Ramps" is a concept of putting a layout of a hotel underground, representing the mines found in the area, which responds to the history of Kongsberg city. To emphasize the landscape, a ramp is created above the hotel. The volumes underneath imitates a layout of a mine shaft. In winter time the ramps invite for jumps as a natural part of a skiresort and the landscape, meanwhile the hotel brings an atmospheric experience of the mine history of the city. Ice skating and a cave atmosphere is found within the hotel, while outside you find a small village of cabins for larger families that wish to have their own private space. All this combined with the essence of being at a skiresort - skiing, relaxation, Jacuzzi in a cave, with hot tubs deep down in the "mine" - a unique experience for all senses! [APPENDIX 11]

Architectural considerations
outdoor spaces +++
expression +
dominant +
integration ++++

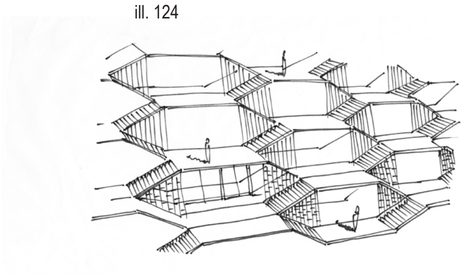
Technical considerations
structural + +

sun (heating) +
daylight

CONCEPT 3 - "MOGULS"



ill. 124



ill. 125

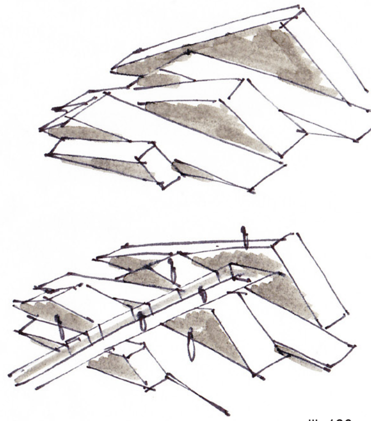
"THE MOGULS" is a concept based on ski activities that modifies and defines the landscape - Moguls. Moguls are a series of bumps on a trail formed when skiers push the snow into mounds or piles.

By imitating the mogul structure, the building will fade into the surroundings and be a part of the whole skiresort context in a natural way. These moguls differ both in shape and size, which also will be done in the building, to meet every rooms needs. An inspiration of the "Rokko housing" by Tadao Ando. [APPENDIX 12]

Architectural considerations
outdoor spaces ++++
expression ++++
dominant +++
integration +++++

Technical considerations
structural ++++
sun (heating) +++++
daylight +++++

CONCEPT 4 - "THE ROCKS"



ill. 126

"The rocks" is a concept that emphasize the pattern of natural rocks. The same shapes are mirrored to create volumes underneath for programming different functions. A straight cut between the volumes creating a skithrough, with hotel rooms lifted at various points allowing daylight intake.

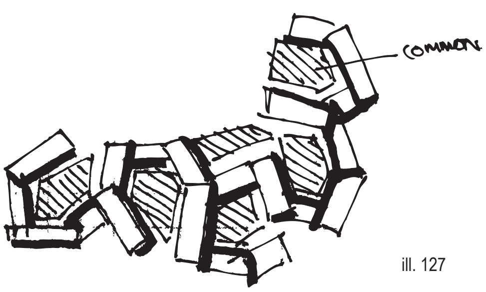
Architectural considerations

outdoor spaces	+++	
expression	++	
dominant		+++++
integration	++	

Technical considerations

structural		++++
sun (heating)	++++	
daylight	+++	

CONCEPT 5 - "SNOWFLAKES"



ill. 127

"Snowflakes" are volumes placed in a fragmented grid creating different common spaces in-between. The rectangular volumes differs in height creating a hierarchy of functions around an open public space. Depending on the orientation of the common spaces, it allows for programming interesting open public and private outdoor spaces.

Architectural considerations

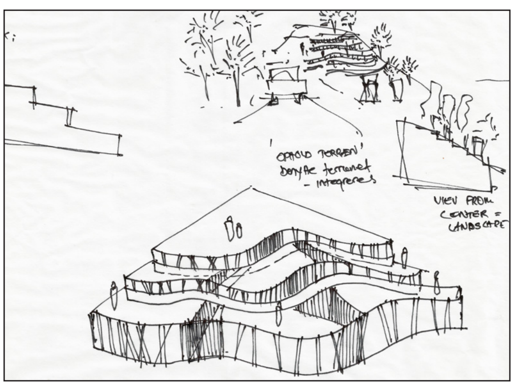
outdoor spaces	++++	
expression	++++	
dominant		++++
integration	++	

Technical considerations

structural		++++
sun (heating)	++++	
daylight	++++	

CONCEPT 6 - "TOPOGRAPHY"

ill. 128



ill. 129

"Topography" is a concept that imitates and emphasizes the landscape for a hotel design by turning the topography into the masterplan. Every 3rd topoline is raised, becoming the facade of the hotel rooms which follows the natural curvature of the hilly terrain proving large outdoor terraces with panoramic views towards the nature and the city. The lifted volumes creates a space underneath becoming the "cave" atrium with small narrow underground entrances. When the hotel is observed from a distance it seems like a hotel that is naturaly integrated with the landscape - topography as architecture.

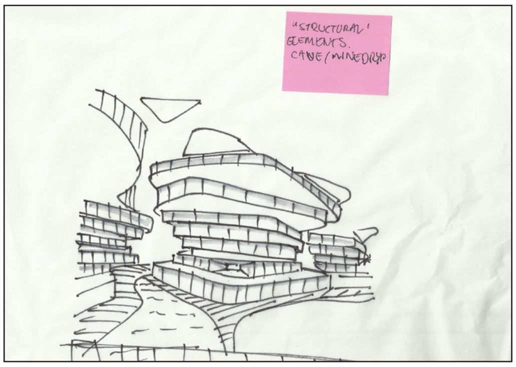
Architectural considerations

outdoor spaces	++++	
expression	+++++	
dominant		+
integration	+++++	

Technical considerations

structural		++++
sun (heating)	+++++	
daylight	+++++	

CONCEPT 7 - "MINEDRIP"



ill. 130

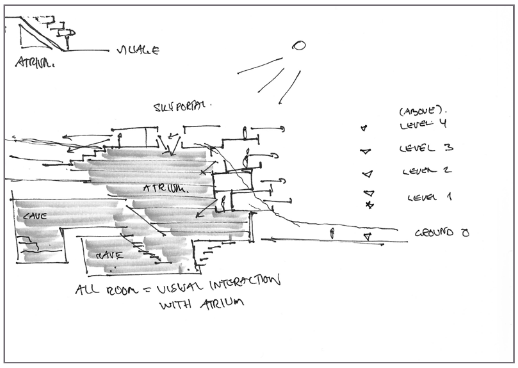
"Minedrip" is an inspiration of the "Sendai Mediatheque" by Toyoto Ito. Four eroded pillars with hotel functions facing an underground cave atrium with water running at the ground floor. Bridge connections between the pillars, with volumes that are twisted according to desired visual interactions. Small openings in the roof and in the pillars are leading light into the atrium.

Architectural considerations		
outdoor spaces		
expression	++++	
dominant		+++++
integration	+	

Technical considerations		
structural		+++++
sun (heating)	+	
daylight	+	

CONCEPT 8 - "THE CLIFT"

ill. 131



ill. 132

"The Clift" is a concept that imitates the inclination of the terrain. A volume mass orientated in different directions to make visual connections and for daylight intake. The horizontal slabs allows the users to ski on them, which leads to an open outdoor central point. An uplighted atrium refers to a mine which is hidden behind a "clift" with hotel functions. The atrium functions as a central point of the hotel with activities that visual connects with the open space. When moving deeper into the "clift", various "natural" caves are found with different functions like cave swim, cave spa, cave cinema etc. [APPENDIX 13]

Architectural considerations		
outdoor spaces	++	
expression	+++	
dominant		++++
integration	++++	

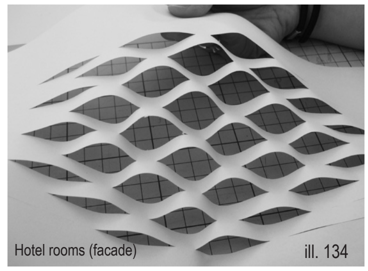
Technical considerations		
structural		++++
sun (heating)	+++++	
daylight	+++++	

CONCLUSION

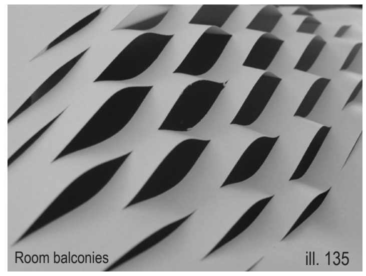
The concepts "Moguls" and "The Clift" were chosen for further development based on the established criteria and rated points. Both ideas has potential in terms of dealing with an underground cave atrium and has great possibilities for daylight intake.

CONCEPT DESCRIPTION

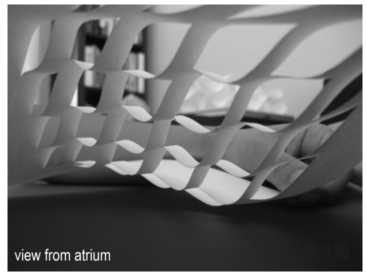
ill. 133



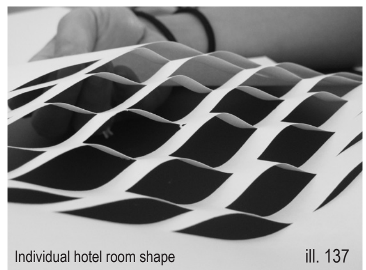
Hotel rooms (facade) ill. 134



Room balconies ill. 135



view from atrium ill. 136



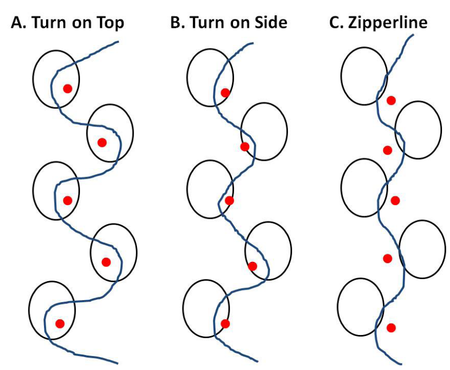
Individual hotel room shape ill. 137

“MOGULS”

The first criterion is to respect the environment and its surroundings and to have a hotel design that integrates with its context. Since it is a skiresort with many outdoor activities, it is obvious for the group to have a concept where the activities modifies and shapes the building. The design has to embrace the beautiful untouched nature and frame the spectacular views from the site. Through research, it turned out that the term concept “Moguls” fits perfectly to this project. The wish was to let the activities modify and shape the hotel, which makes Moguls a big inspiration to both concept and form.

Moguls are a series of bumps on a trail formed when skiers push the snow into mounds or piles. This happens naturally when skiers use the slope. They can also be constructed on a slope for freestyle skiing competitions or practice runs. Once formed, a naturally occurring mogul tends to grow as skiers follow similar paths around it. Since skiing tends to be a series of linked turns (ill. xxx), moguls form together and create a bumpy field. At most ski resorts certain trails are groomed infrequently or left completely ungroomed to allow moguls to develop.
By imitating the mogul structure, the building will fade into the surroundings and be a part of the whole ski resort context in a natural way. These moguls differ both in shape and size, which also will be done in the building, to meet every rooms needs.

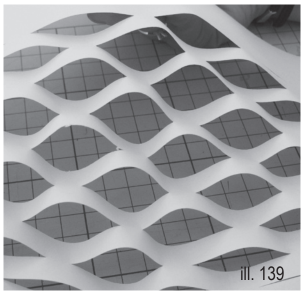
The concept is based on the landscape that step downwards. Hotel rooms are placed to follows this movement for daylight intake and close interaction with the surrounding nature. The shape takes its inspiration from the moguls, which has been analyzed and used to create individual hotel rooms, the structural grid and overall design form.



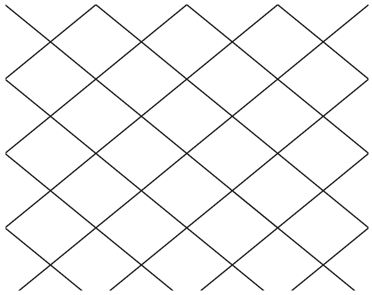
MOGUL MESH

With the concept of using the moguls as a principle for hotel rooms and as a structural element, this chapter shows an analysis of the transition from inspiration to a mogul mesh.

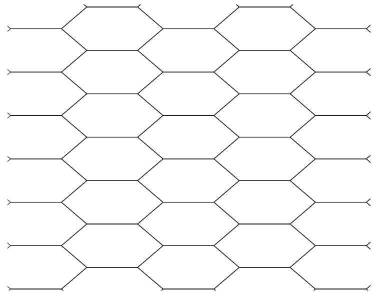
Natural moguls



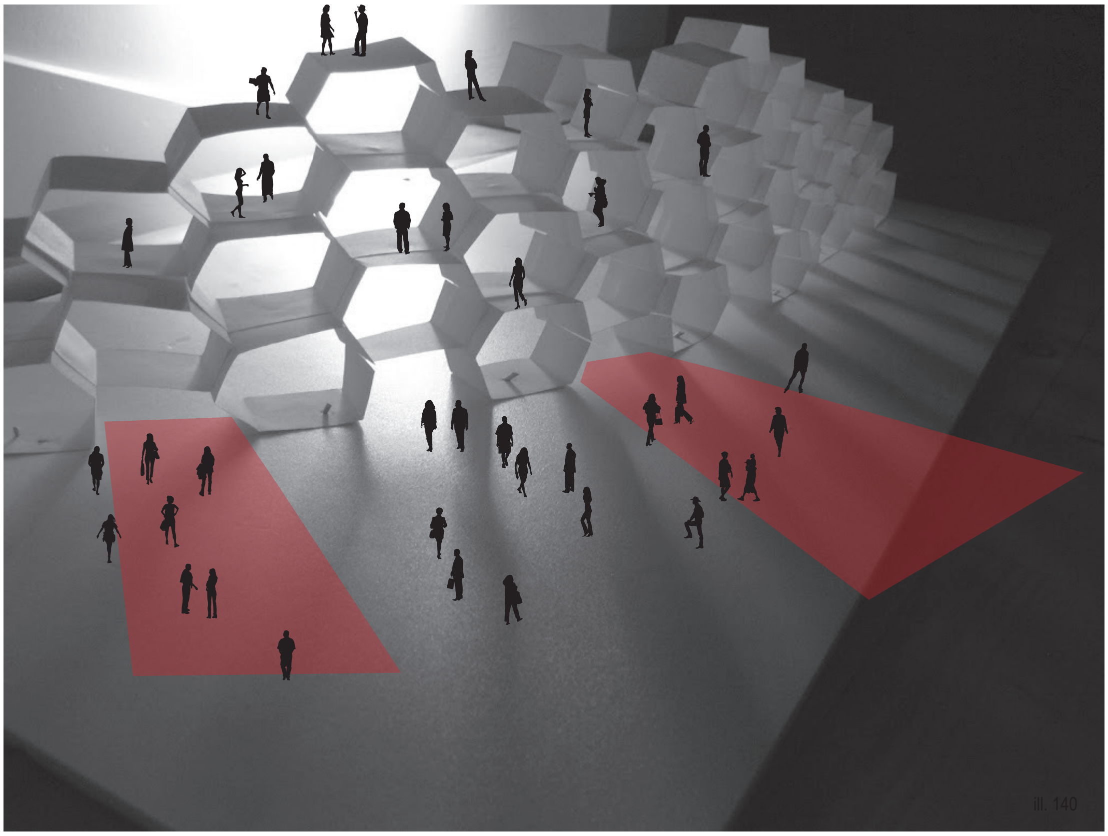
Reinterpretation of the moguls

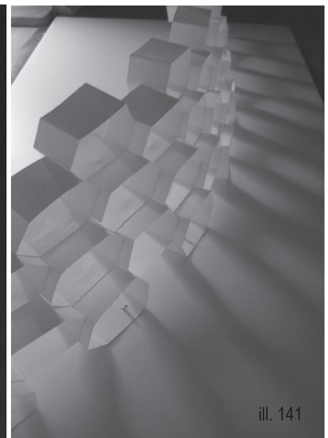


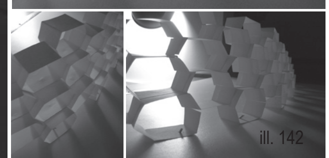
Moguls mesh simplified

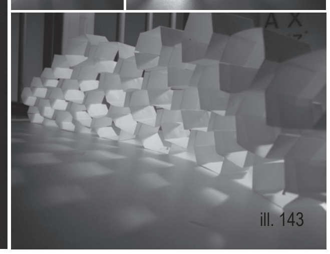


Modified mesh into hexagons which allows for programming of room space, and structural properties









Concept model 1:100

CONCLUSION

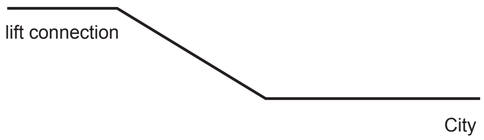
The hexagon mesh has great possibilities of linking and combining its own shape, and has an enormous potential of expansion to become a structural element of the hotel. The image of the natural mogul landscape was analyzed and re-interpreted, modified and adjusted into a hexagon element that will be used as a structural part of the hotel. This idea will further be developed in the next chapter.

"THE CLIFT"

Integration with the landscape, a design that responds to the history of the city, and a daylight intake for the hotel rooms which are according to the established design criteria, are all aspects that needs to be fulfilled. "The Clift" concept was chosen to enhance these aspects and to further develop the initial masterplan. This concept has a great potential of making a coherence with both the integration with the landscape, and creating a cave atrium in response to the history. This chapter deals with how this concept can be incorporated into the project, which is illustrated in the diagrams below.

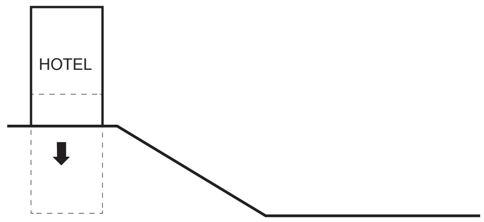
SITE STRATEGY

ill. 144



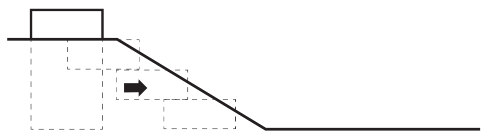
The terrain proposes to have functions that exploit the height to gain panoramic views towards the city, and functions that follows the sloped landscape for daylight intake.

ill. 145

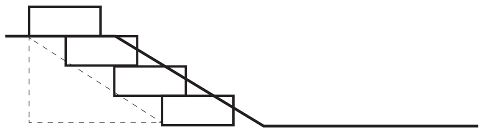


To emphasize the landscape and imitate a "cave/mine" layout the hotel is pushed underground, which allows the nature and the view not to be dominated by a massive building mass.

ill. 146

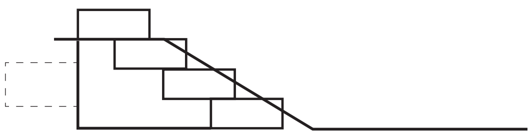


For daylight intake and integration with the terrain the functions are pushed out to the edge.



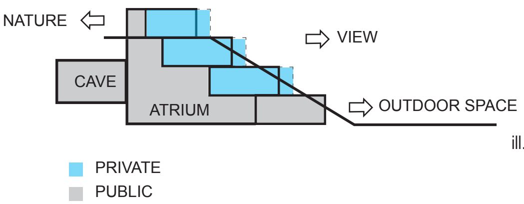
ill. 147

This opens up for an atrium space under the pushed functions with a straight wall cut that refers to the way of cutting into a mountain rock wall.



ill. 148

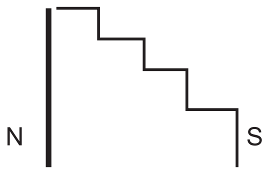
When moving and exploring further into the atrium, ones will discover “natural” cave functions.



ill. 149

The potential volumes are differentiated into public and private function with visual connections with the context.

CONCLUSION



Bioclimatic conception

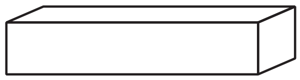
ill. 150

The strategy for the site is to make an adaption between the bioclimatic aspects and the sloping terrain.

FORM STRATEGY

Following diagrams show a process of how the initial form is designed and how both “Moguls” and “The Clift” is implemented and combined.

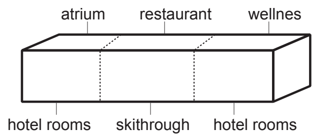
HOTEL



ill. 151

Starting from an ordinary massive box.

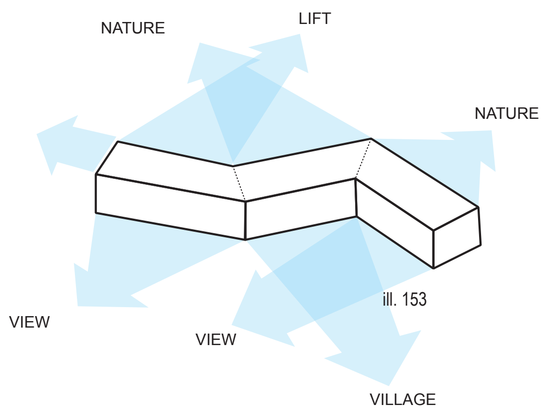
DIVISION



ill. 152

The box is divided into main activities that responds to the surrounding environment.

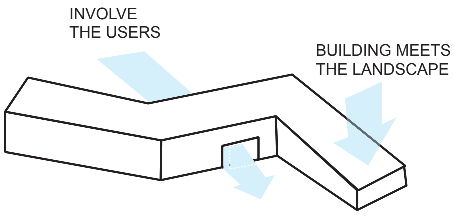
VISUAL INTEGRATION ON SITE



ill. 153

By orientating the building parts it visually connects and take full advantage of the location and offer panoramic views towards the city, current skicenter, village and the beautiful surrounding.

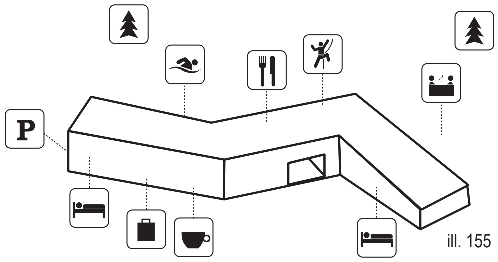
MEETING THE LANDSCAPE



ill. 154

To connect the lift and the village area a skithrough is created. This is done to emphasize the idea of not having a hotel that block the activity, but invite it into the hotel and involve the users.

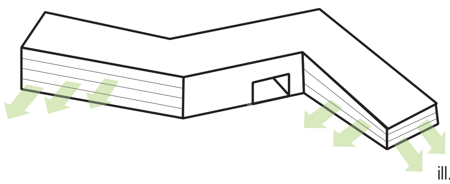
FUNCTIONS



ill. 155

Each function is placed for the full enjoyment of the area's properties.

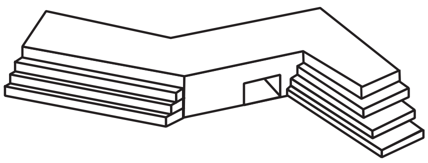
IMITATION



ill. 156

To imitate the site, the building is divided in levels and pushed out to follow the sloping landscape.

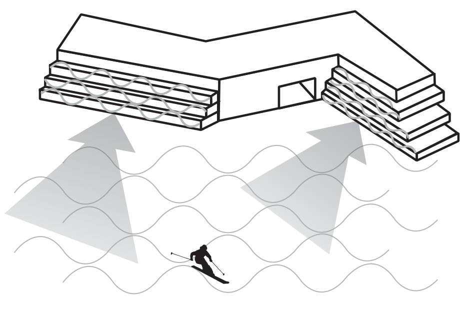
INTEGRATION



ill. 157

The main shape is found, but to integrate/imitate the landscape further, we let the activities modify and shape the facade.

SKI MOGULS

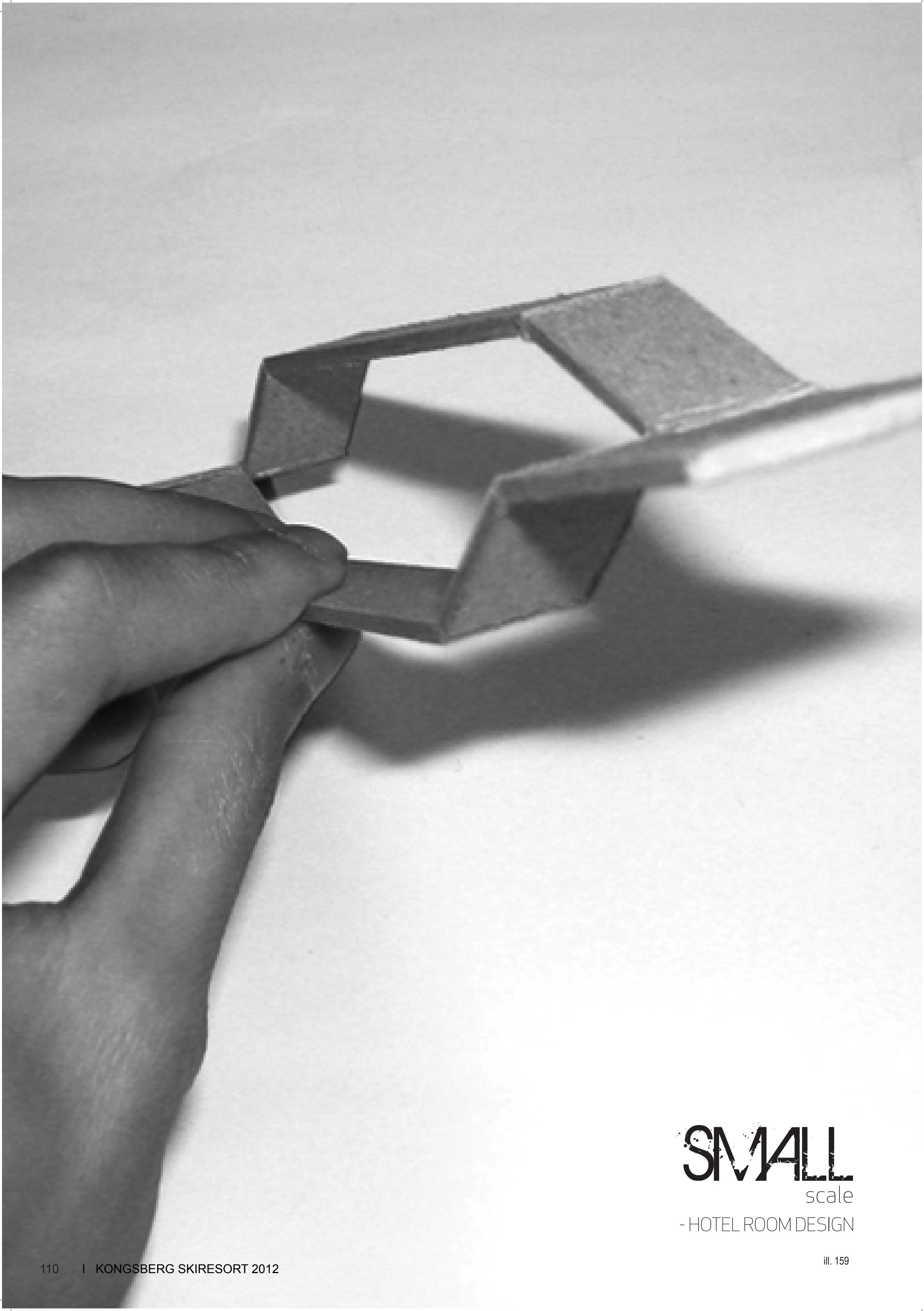


ill. 158

The main activity found at the skiresort is skiing and snowboarding, and to refer to this the moguls are implemented as being the structural element/facade of the hotel.

CONCLUSION

By combining both concepts, an initial shape is found. This leads to further development of the hotel functions such as atrium, caves, restaurant, hotel rooms etc. The potential of combining and expanding the moguls mesh will be the guideline for the design of the hotel room and overall hotel expression.



SMALL
scale

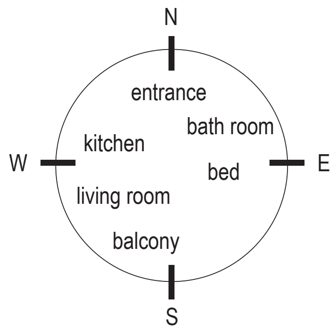
- HOTEL ROOM DESIGN

ill. 159

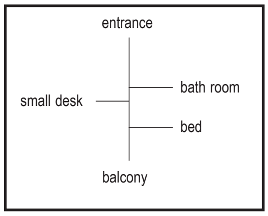
INITIAL FLOORPLAN SKETCHING

Due to our concept of having hexagon shaped moguls as frames for the hotel rooms, it is essential to have floor plans that are optimized according to waste space that might occur when not building traditional boxes. A room analysis [APPENDIX 14] has been made with focus on fulfilling different needs stated in the room program (p.73) but also according to organizations of the functions and daylight (ill. 160). In this chapter different layouts is elaborated with focus on fulfilling previous stated aspects.

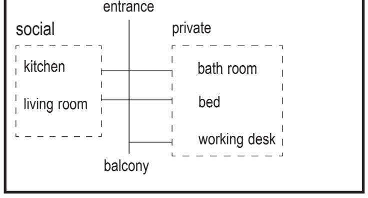
The aim of the project is to create an environment of unique phenomenological architectural experiences in terms of enjoyment, pleasure and relaxation, which have been important aspects while sketching the plans. The vision for the layout is to emphasize the possibilities of giving the users framed panoramic views towards the beautiful surrounding context, daylight intake and close interaction with nature regarding open outdoor spaces. Due to the skiresort's attractive and lively atmosphere, the main focus is upon young couples (p.72), which means that the goal is to have as most double rooms. Besides the double rooms, singles and penthouse rooms will also be elaborated. A mogul combination allows a hotel room to be designed also in two or more levels, which attracts the idea of making rooms that give users the opportunity of "climbing" further up to enjoy more of the beautiful view to the surrounding context. The room distribution as seen on (ill. 162) clarifies a separation of social and private zones. The quality of having a hotel room spanning over two levels with moguls as concept, is that it allows for a "natural" separation of a social and private zone without actually detaching the shape. The natural ventilation is also improved as the height difference is larger. Another aspects is the spatial quality that the mogul creates. A larger and more open atmosphere, which gives the users the feeling of going up to the "loft" (inspired by small huts with lofts beds) for relaxation and sleep. Another scenario is for instance that one person can go early to bed and the other can stay down in the living area without disturbing one and another. From a constructional point of view, the rooms and its grid structure defines a play in the facade with private and semi private balconies.



ill 160. Orientation according to daylight



ill. 161 flow diagram single room



ill. 162 double & penthouse rooms

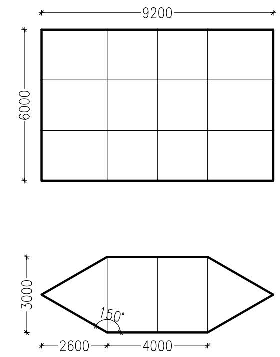
SMALL SCALE

- HOTEL ROOM DESIGN

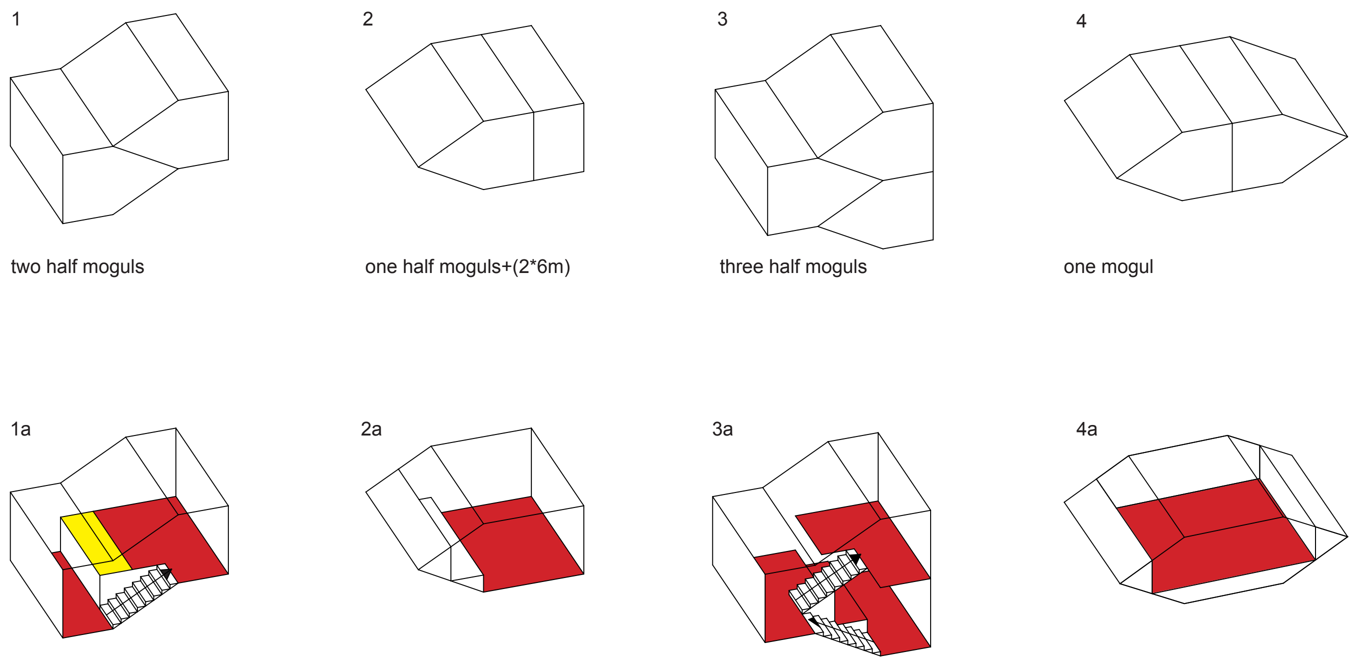
INITIAL HOTEL ROOM SKETCHING

Based on the analysis of the mogul mesh, this chapter deals with design of different types and layouts of the hotel rooms. The focus will be on spatial qualities of the various room proposals, structural grid with area calculations, basic daylight analysis and calculations of the energy use, and lastly room comfort through spreadsheets calculations.

As aforementioned the Mogul concept allows great flexibility to various ways to combine and develop the hotel rooms. Without looking into the details of connection between the rooms this analysis will focus on how rooms could be formed and the qualities of the different forms. An angle of 150 degrees and the initial mogul dimensions (ill. 164) are used in all models.



ill. 164 initial mogul dimensions 1:300



ill. 165-168

DESCRIPTION

MODEL 1
In this design two half moguls are combined creating a room in two storeys with entrance at the bottom part and an extended top floor over the diagonal part to gain more usable floor space. The “yellow area” in model 1a is still usable for functions like bedspace even though it‘s not included in the total floor area because of the ceiling height.
Usable floor area approx. 30 m²

MODEL 2
A half mogul +(2*6m) is suitable for a single hotel room. The room is on one level with a floor area of 24 m². The triangular space can be furnished with integrated elements such as table space for storage.

MODEL 3
A three storey hotel room with entrance at the bottom, living space in the middle and sleeping space on the top floor. A potential layout for a luxury/penthouse room with a floor area of 44 m².

MODEL 4
This model utilize a whole mogul on one storey and have the possibilities of having integrated elements in both ends. The usable floor area is 24 m² and potential of being a single hotel room.

QUALITIES

Room 1a
This model has a clear separation of two spaces, which allows zoning of different functions. An example could be that the public zone could be placed at the bottom floor with living area and entrance, while having private functions such as bed and bathroom on the top floor. This layout gives the users a two storey hotel room, with a floor area of 30 m², which has potential of being a penthouse for two people with big open panorama views on both levels.

Room 2a
This model is particularly suitable for singles and handicapped, because the layout is on one floor. The extra 2*6m is to omit a width of 2m which is too narrow and useless for any furniture. This model also has a big window facade for panoramic views and potential for a simple arrangement of the functions.

Room 3a
This layout divides the functions in three storeys, giving more privacy and clear separation of each level. The need for two staircases in such a small room is wasting much space, and it’s not suitable for a potential hotel room layout.

Room 4a
This mogul layout is also handicap friendly, because it is on one level. The triangular spaces on both ends, which will not be included in the total floor area, is still a useful space for integrated elements. The room has potential to have big panoramic views and is suitable for a double hotel room.

CONCLUSION

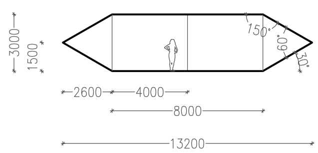
When considering a standard and traditional hotel room, these layouts can be found to be too big and to waste too many square meters. With right dimensions, angle and combinations it however has the potential of creating interesting spatial hotel rooms that emphasizes the movement and zoning in different storeys. The mogul shape is flexible and easily combined to grow and expand in sizes and levels. In combinations with other moguls, each function create its own identity and form language and are also able to differ in depths to make a play in the facade. With adjustments and modifications, model 1, 2 and 4 can be considered to be the most suitable shapes for hotel rooms, while model 3 could hold other functions such as café, shop, staircase etc.
It turns out that even though there are triangular spaces at both ends of a room it’s not necessarily wasted space, because these can be design to have integrated elements. To optimize these moguls, further development and analysis needs to be done. It is desired to make a grid system that can analyze the dimensions, angles and depths of different moguls, and create a combination that will work as a structural element of the hotel.

GRID SYSTEMS

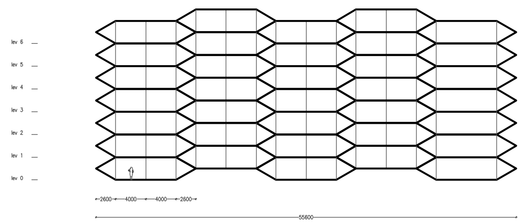
The study on grid systems deals with different strategies of how to optimize the dimensions, angles and combinations of the mogul. This analysis has been made to find approaches that reduce the wasted space and floor area that appears when several mogul modules are combined [APPENDIX 13]. Moguls will in this chapter be incorporated in a grid system to control the previously stated aspects that needs to be optimized.

From previous site study (p. 112), it shows that there are possibilities to dig down an atrium of max. 21m before the landscape flattens out. This implies that the hotel can from ground and down have a maximum of 6 storeys which is the limit used in the grid analysis. Diagrams below show various systems focussing on minimizing wasted space, and different system combinations.

system A: 2.6-4-4-2.6 angle 30 degrees

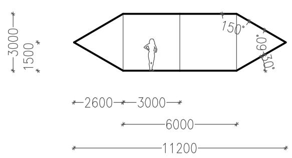


ill. 169

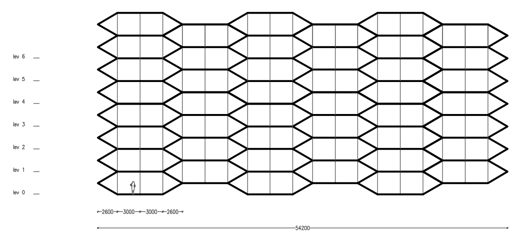


ill. 172

system B: 2,6-3-3-2,6 angle 30 degrees

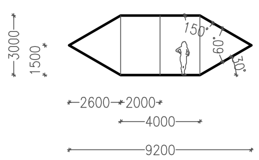


ill. 170

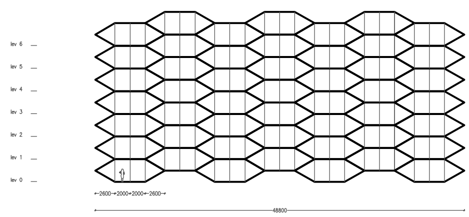


ill. 173

system C: 2,6-2-2-2,6 angle 30 degrees



ill. 171



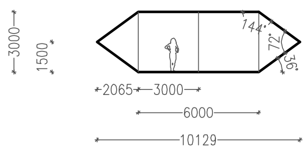
ill. 174

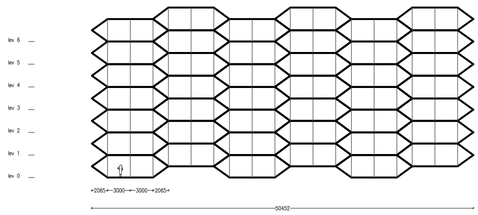
THE WIDTH

With a ground floor of 8m in width in system A, it would have a too large area when utilizing a whole mogul as a hotel room, but in the meantime great width for a half mogul (4m in width). When expanding in the x-coordinate, it takes much space in width, compared to the amount of rooms created. In system B and C, the width has been made smaller, but when considering to use a half mogul in connections with others, system C with only 2m will not be optimal for any kind of arrangement for furniture. When using a half mogul System B with its 3m, will be considered suitable and useful for a hotel room. By narrowing the width of the moguls the whole grid becomes tighter, and allows more moguls to be expanded over a less total width.

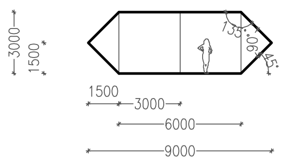
By playing with the width of the moguls, system B has been chosen for further development due to its potential of being split in half and still have enough floor area for a hotel room. When connecting the moguls in a grid system, it defines a solution that has the potential of being a structural element as well as giving an expressive facade.

system E: 2-3-3-2 angle 36 degrees

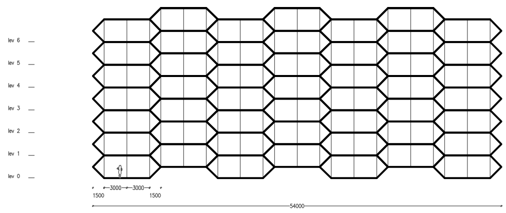




system D: 1,5-3-3-1,5 angle 45 degrees

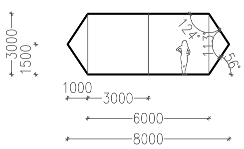


ill. 175

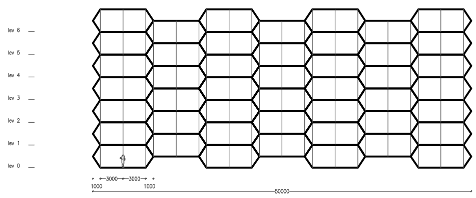


ill. 176

system F: 1-3-3-1 angle 56 degrees



ill. 177



ill. 178

THE ANGLE

In the beginning the idea was to use the angled edge as a stair connection when combined with another mogul. according to Neufert, 36 degrees is the steepest angle one should have for indoor stairs. This angle has been tried out to see what qualities it give to the space. Even though it would be optimal to have stairs along the angled edge, it still creates 2m of triangle space, which is considered to be a waste of space (system E). By increasing the angle and decreasing the width under the triangle, it creates a space that is still useful (system F), because it allows to have integrated furniture in the triangular spaces.

CONCLUSION

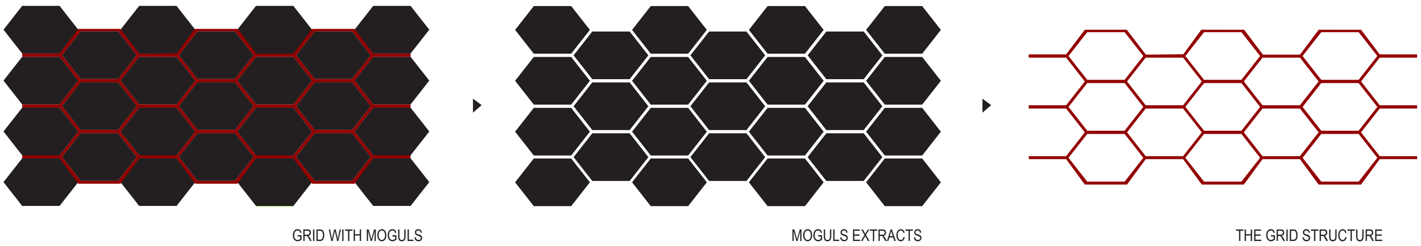
From this analysis suitable and optimized systems has been found. By using an angle of 36 degrees it allows the angled edge to have an integrated a stair connection when combining with another mogul. In the meantime a width of 2m is used, which is considered to be wasted space and not an optimal solution for hotel room modules.
System B and F will be considered as the most optimal solutions for being the frame of a hotel room, because of its possibilities to be split into a half mogul and still have enough space in width to be used. Reducing the triangular space to 1m resulted in an angle of 56 degrees, which turned out to be an ideal solution for a mogul. The triangular spaces will still be considered as a transition zone between two moguls. By reducing the width and increasing the angle it allows more amount of moguls to be expanded along the x-axis, and it also creates a tighter structure because the moguls are now closer to each other.

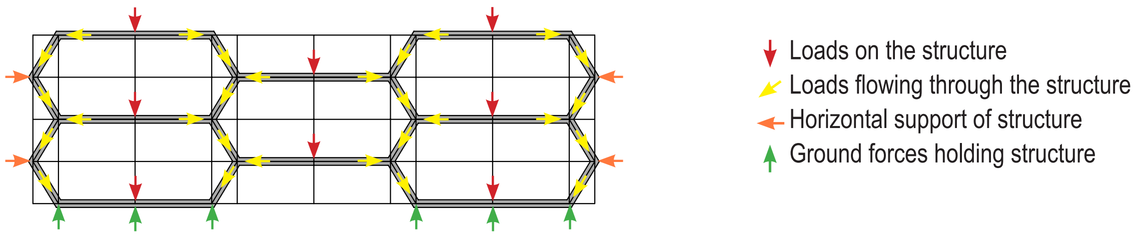
> “Because the honeycomb structure has the ability to transfer forces, the structure ensures the good distribution of stress and avoids the local stress concentration. Even when some tubes are broken from others, the whole structure can still bear the load, which embodies high ductility.”
>
> - Zhang, 2007

ill. 179

STRUCTURAL CONSIDERATIONS

With an overall grid system, it is important to look at the structure from a technical point of view. Considerations of how the grid can be use as a structural element and how forces are distributed, will be elaborated in this chapter. Thus said, only a basic analysis be presented, since the project is focusing on the sustainability calculations. The grid will be extracted and analyzed (ill. XXX).





DISTRIBUTION OF FORCES

ill. 180

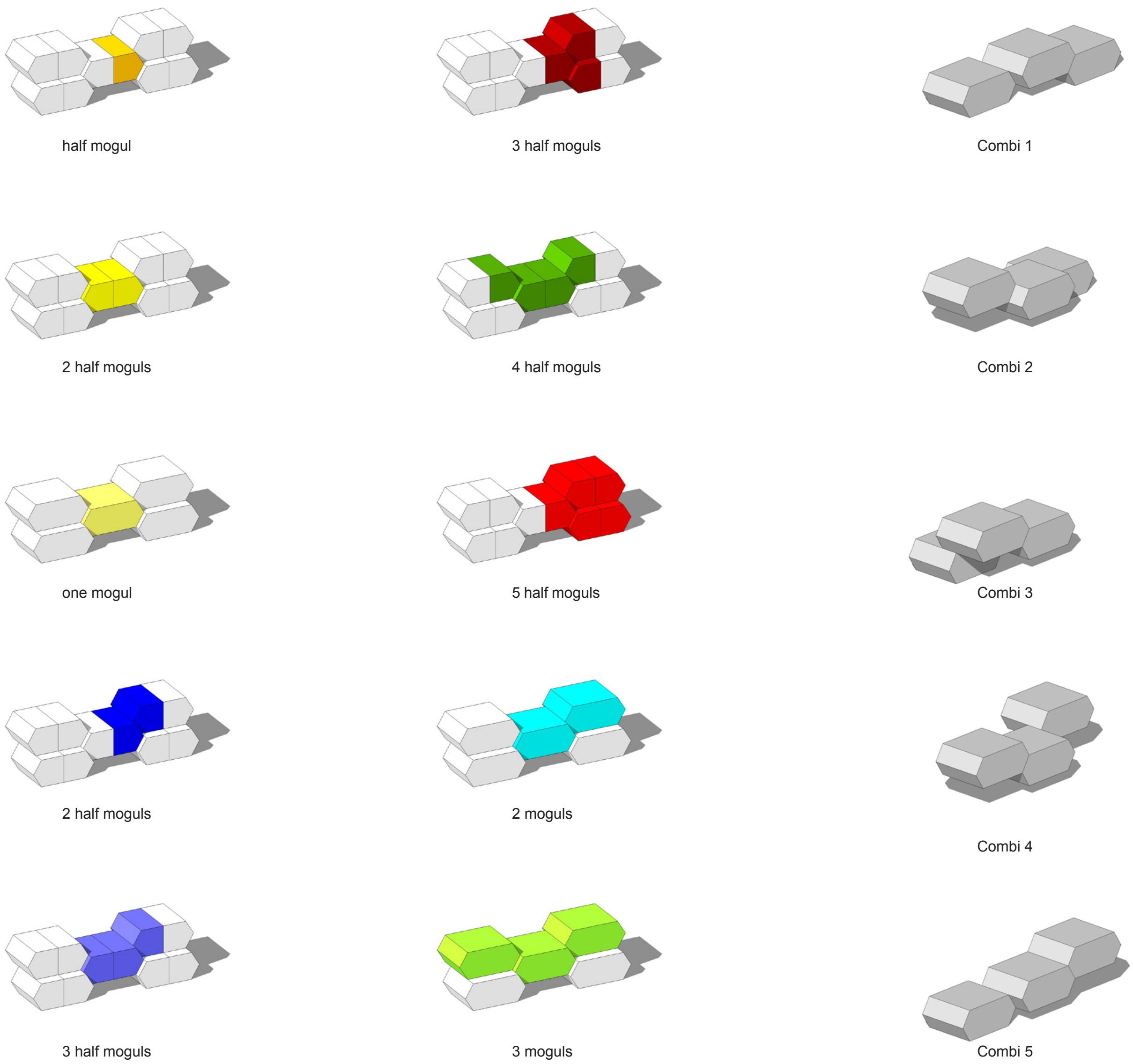
CONCLUSION

When using this mogul grid as a structural construction it's important to understand how forces are distributed within the grid. As the mogul grid turns out to be very similar to a hexagon structure, a honeycomb structure has been used as an inspiration for further development of the grid. A regular hexagon has all sides the same length, and all internal angles are 120 degrees and fits together beautifully. Even though our mogul shape doesn't have the same sizes and are stretch, the structure still maintains high tensile strength [APPENDIX 15]. This result arises due to the honeycomb structure's unusual tendency to become very thin and gain great flexibility. "The more junctions, the greater strength and ability to shift weight to different parts of the structure" [APPENDIX 15]. When exposing the mogul shape to external weight, this load will be distributed in three sizes and sustain forces along the grid.

"Because the honeycomb structure has the ability to transfer forces, the structure ensures the good distribution of stress and avoids the local stress concentration" [Zhang].
The grid provides great flexibilities of how moguls can be combined and systemized according to the desired facade expression. Honeycomb constructions are also extremely economic to built, because of less wasted materials [youtube, 2012]. To gain more knowledge about the distributed forces, a more technical analysis is needed. "Robot" will be an ideal program to use but as aforementioned, this project will not deal with this part, as we will be focusing on energy consumption, ventilation, indoor climate and CO_2 calculations. How moguls can be arranged in the grid structure will be further development in the "combination studies" chapter.

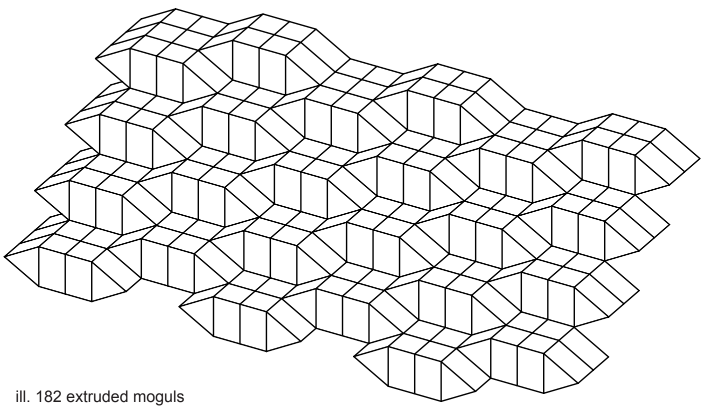
COMBINATION STUDIES

With an initial grid system various combination strategies can be elaborated. A mogul can be combined with others to gain greater volumes for functions that needs more space such as cafeteria, restaurant etc. This chapter shows studies of how these combinations can be made.



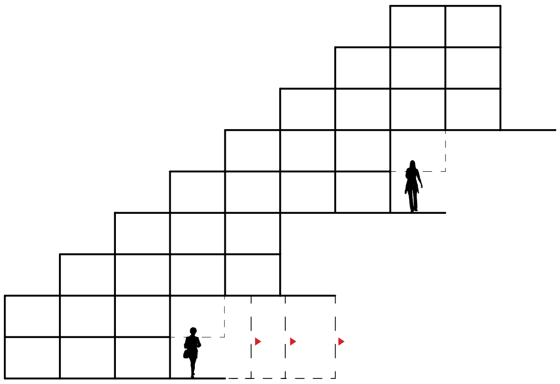
ill. 181

By extruding in depth and letting the moguls step downwards it creates an interesting interplay in the structure. It also make spaces between each mogule, which has the potential of being outdoor areas and balconies. When connecting the moguls by its angled edge, the structure will be pushed down resulting in a half storey structure, which can be troubling when entering the moguls from the back.

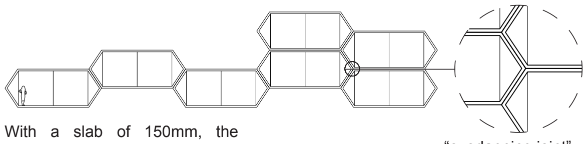


ill. 182 extruded moguls

When looking at a section of the grid, it only allows for full height hallways at every second mogul storey, which is caused by the half steps of the structure. This is not an optimal way for the users to enter the different moguls, and a solution for this will be found in the synthesis phase. The flexibility of the moguls also allows rooms to be extended in depth to create larger volumes.

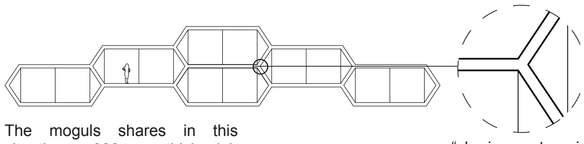


ill. 183 grid section



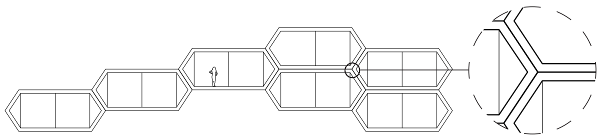
With a slab of 150mm, the moguls can overlap eachother when combining to create a 300mm slab for insulation.

“overlapping joint” with 150mm slab



The moguls shares in this situation a 300 mm thick slab to minimize material and cold bridges.

“sharing centerpoint”



300mm thick slab is considered in this situation for each moguls, because of its possibilities to be shifted in position when being combined with another. 300mm is used to be sure that this thickness is kept in cases where the edges of the moguls doesn’t interacts with eachother. When met the slab will be 600mm, which is considered too be overuse of material.

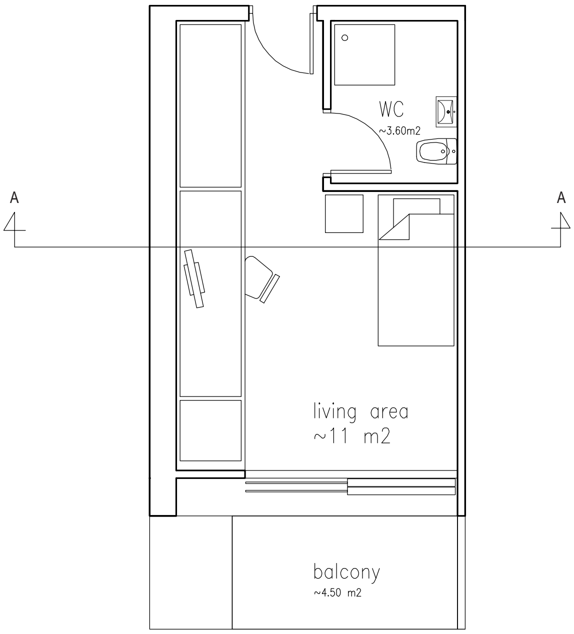
“overlapping joint with 300mm slab”

ill. 184

CONCLUSION

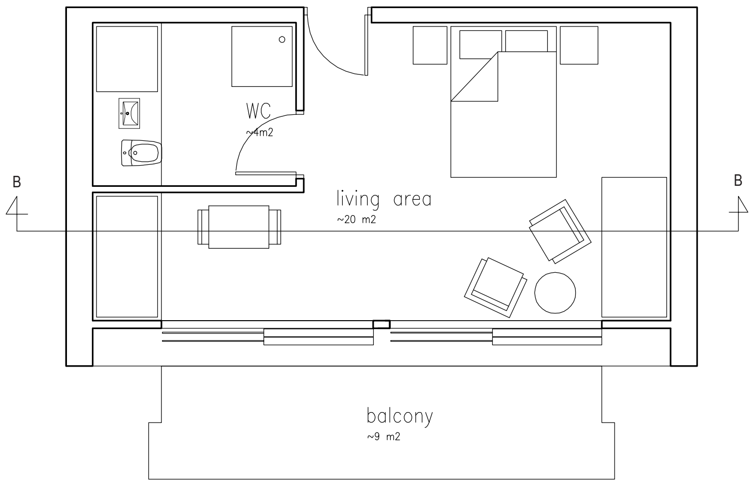
The combinations are many, and by dividing a mogul in half which can be suitable for a single room, it allows many different possibilities of combinations depending on the desired overall building expression. When moguls are extruded in a certain grid system, it creates an interesting interplay between the volumes. It also creates outdoor spaces which has potential of being balconies for each mogul function. The interplay between the moguls also cause a half stepping structure, which could be problematic further on when hallways and entrance to the moguls has to be designed. A solution of how the joint can be done is shown in [appendix 26]

SINGLE ROOM ~ $18m^2$
1:150

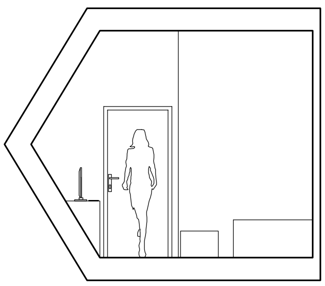


ill. 185

DOUBLE ROOM I ~ $24m^2$
1:150

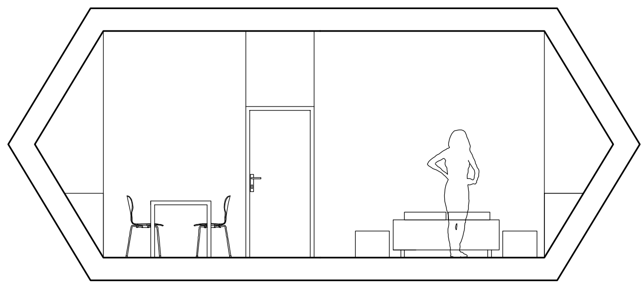


ill. 186



ill. 187

Section single room A-A
1:150



ill. 188

Section double room I B-B
1:150

FIRST PLAN PROPOSALS

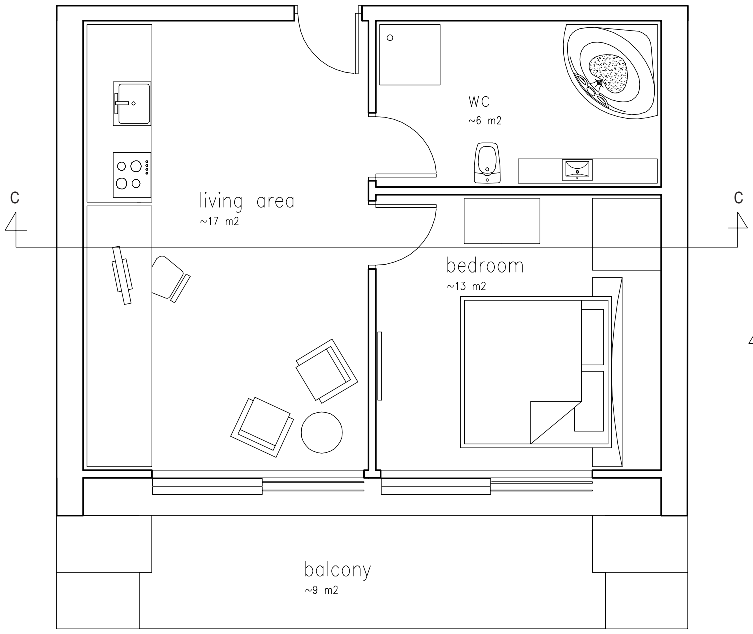
SINGLE ROOM

For single rooms it was essential to use a half mogul, due to the simple requirements and space that a single person needs when staying in a hotel. This plan has been made minimalistic to optimize the usable space and aim for $18m^2$ as stated in the room program (p.73). When entering the single room ones will have direct orientation towards an outdoor balcony and the beautiful view provided by the open facade. The bathroom is placed on the side to share water pipe shafts with other moguls when they are connected. A simple working desk, TV and bed are provided for the guest, and the angled space are used for integrated furniture like closets, tables etc. This layout fulfils the goal of approximately ~$18m^2$ for single hotel rooms.

DOUBLE ROOM I

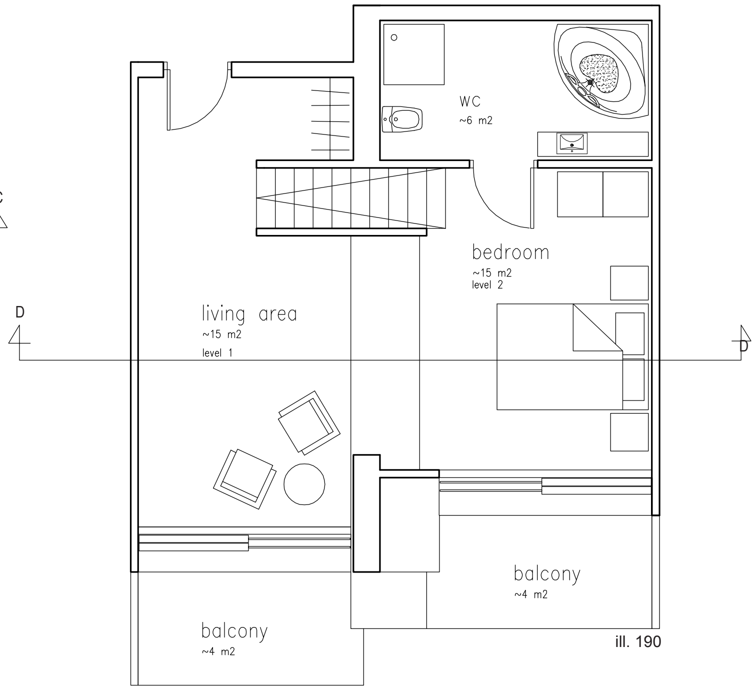
As double rooms are the primary hotel room, it was important to make a room design that emphasize the needs for two individuals. This version consist of one big living space, and allows the idea of having possibilities to use the rooms both as double and twin rooms, meaning that there should be space for separating the bed. When entering, an open living space consisting a bed, sitting area and small eating arrangement is provided. All functions with direct orientation towards the big open facade with panoramic views and $9m^2$ of outdoor balcony. This layout fulfills the goal of approximately ~$24m^2$ for a double hotel room.

DOUBLE ROOM II ~ $36m^2$
1:150

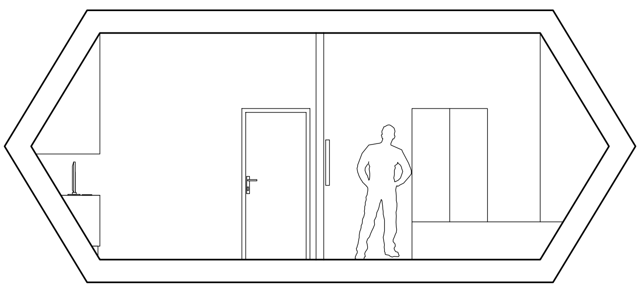


ill. 189

DOUBLE ROOM III ~ $36m^2$
1:150

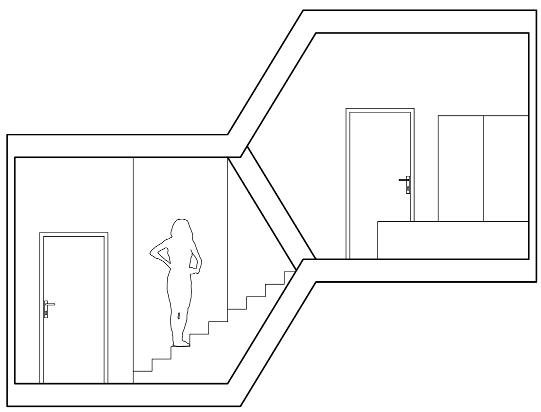


ill. 190



ill. 191

Section double room II C-C
1:150



ill. 192

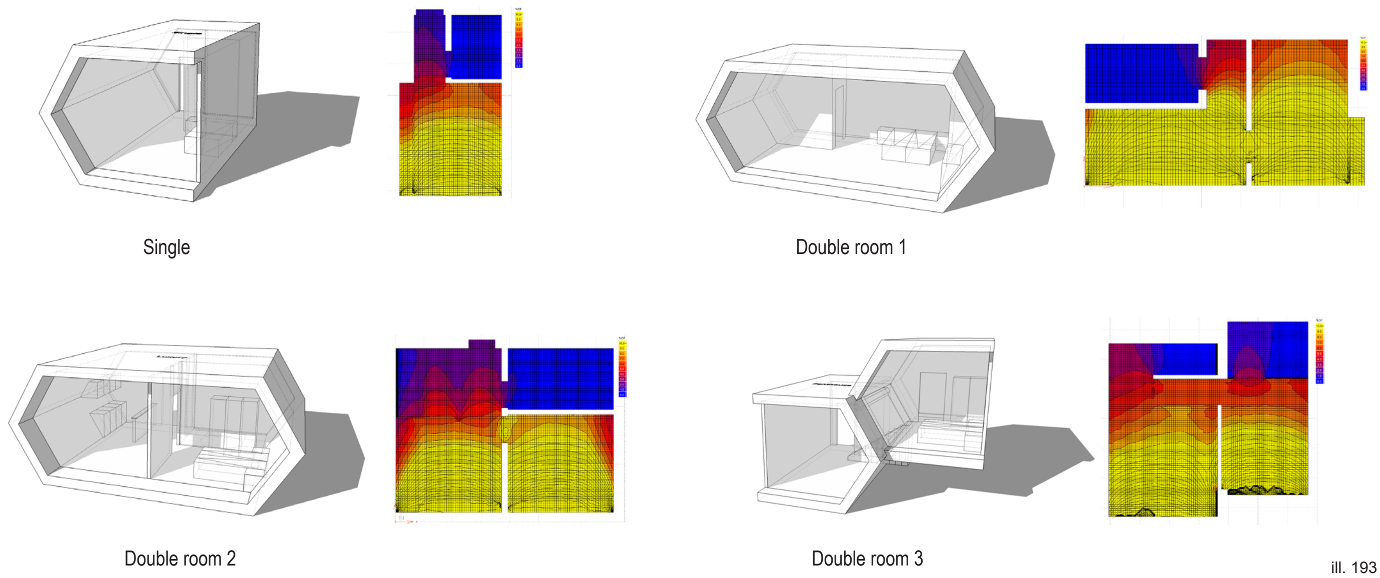
Section double room III D-D
1:150

DOUBLE ROOM II
In contrary to the double room I, this room deals with the idea of having a clear separation of social and private zone. This is done to enabling two people to have the opportunity to do things separately, without being on top of eachothers. When entering, a direct orientation towards the views is provided and the room is separated into two zones. An open living space with a small kitchen and a closed core consisting toilet facilities and bedroom. An outdoor balcony that can be entering from both living- and bedroom. In contrary to double room I, this layout requires more space, due to the small kitchen and larger bathroom with Jacuzzi facilities. 36m² is too big according to the room program, but considered as a suitable size for a luxury double hotel room.

DOUBLE ROOM III
This layout emphasize the idea of combining two half moguls. This hotel room is designed in two levels, which clarifies a strong separation of social and private rooms. With living area in the bottom, bedroom on the top floor, and the middle part used as a transition space. An opening in the middle part maintains a visual connection between the volumes and emphasize the essence of not detaching the mogul shape. When entering, a view towards a big open facade is still kept, and a stair leading up to the top floor, which expresses the idea of making the users “crawl” up to their nest to sleep and gain a even better view over the landscape. In this case one balcony is situated on each level providing the opportunity for stepping outside from both the living room and bedroom. Double room III in two levels is also kept at 36m².

DAYLIGHT ANALYSIS OF INITIAL MOGULS

The initial mogul design will be analyzed in Ecotect with Radiance to estimate the daylight factor inside each room. The requirement is 2%DF in primary rooms (living room, bed room and kitchen). While there is also a wish for 5%DF in parts of those rooms, to ensure good working light. All the analysis will be done for 21st of December with overcast sky to display the worst case scenario. The 4 rooms has been modeled up in Sketchup with the entire south facade open to analyze the maximum light possible into the rooms.



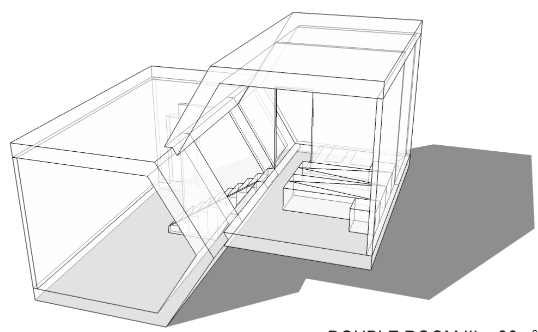
ill. 193

CONCLUSION

As seen in the diagrams (ill. 193) all rooms get plenty of daylight, with the notation that rooms big glass facade is facing south to emphasize the beautiful view towards the landscape. Double room 1 gets the highest DF as it is not as deep as the other rooms. All the primary rooms has 2%DF and most of them has 5% also in part of the rooms. The analysis shows that with an open facade there is plenty of daylight coming in even in mid winter, which means there may be overheating issues in summer time. To solve these issues different facade strategies will be looked at in the next chapter.

FACADE STUDIES

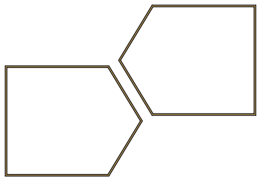
To emphasize the panoramic framed views, the studies on facades is done with the idea of having as big an openings as possible towards the landscape. The previous analysis showed much light penetrating the rooms, as a result of the whole south facade being open to allow for great views. Therefore a facade study has been elaborated with focus on which influences the designs have on the daylight inside the room and the overall expression. The layout of “double room III are used in this analysis, which also represent the others rooms due to the same shape. Each facade design will be analyzed through Ecotect with Radiance to find the daylight factor. The aim is for the primary rooms to have 2%DF while parts of it should also have 5%DF for work lighting. The bathroom and entrance area will not be considered as part of the room that need daylight.

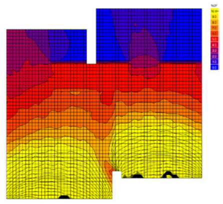


DOUBLE ROOM III ~ $36m^2$

ill. 194

Design 1





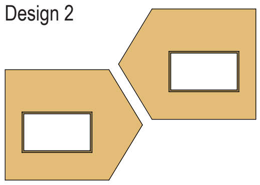
Window area: 2 x 9.2 m²
94% of facade area.
51% of floor area.

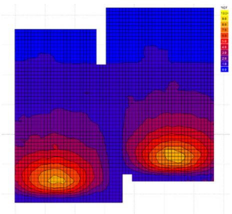
Daylight factor:
2%: 100% of the room
5%: 100% of the room

Reaching +40% close to windows

DESIGN 1
This design utilizes the maximum area of the facade for daylight intake, view towards the surrounding context and to have a design that emphasizes the mogul shape. The mogul shape is kept with a minimalistic window frame with glass that covers up 94% of the facade. As seen on the daylight test (DESIGN 1) 2% of daylight light factor reaches the whole room in winter time, and there may be a problem in summer time according to overheating. Shading strategies is needed for this design solution.

Design 2





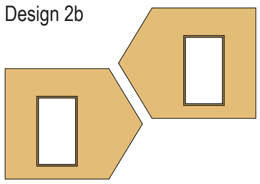
Window area: 2 x 1.8 m²
18% of facade area.
10% of floor area.

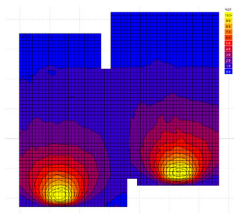
Daylight factor:
2%: 75% of the room
5%: 25% of the room

Reaching 9% close to windows

Design 2
This design is the minimum window area according to the 10% rule [TEK10], with small horizontal windows covering 18% of the facade. Only 75% of the primary rooms will have a daylight factor of 2%, which is not meeting the TEK10 requirement. As seen on (DESIGN 2) the daylight doesn't penetrate deep enough into the room, which is tried to be solved in design 2b.

Design 2b





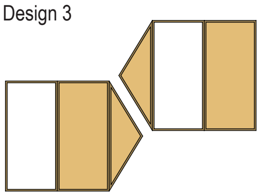
Window area: 2 x 1.8 m²
18% of facade area.
10% of floor area.

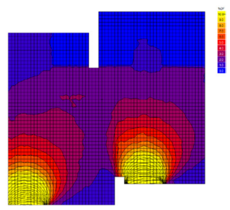
Daylight factor:
2%: 80% of the room
5%: 20% of the room

Reaching 12% close to windows

Design 2b
By rotating the windows 90 degrees, the amount of area covered by 2%DF gets a little larger. The light goes a little deeper into the room, but the width the light covers is reduced, which leads to a smaller area covered by 5%DF. The maximum %DF in the room is raised a little. Although this design is a bit better than Design 2, it is still not good enough to fulfill the goal of 2%DF in the whole room.

Design 3





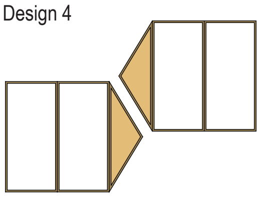
Window area: 2 x 3.8 m²
39% of facade area.
21% of floor area.

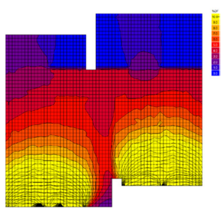
Daylight factor:
2%: 100% of the room TRUE??
5%: 30% of the room

Reaching +20% close to windows

DESIGN 3
By covering up the triangle and half off the square, 39% of the facade remains glass. All primary rooms get covered with a DL factor of 2%, which is considered a good result. By using vertical lines in the facade it still emphasizes the mogul shape, which is a strategy that will be considered for further development.

Design 4





Window area: 2 x 7.6 m²
77% of facade area.
42% of floor area.

Daylight factor:
2%: 100% of the room
5%: 80% of the room

Reaching +20% close to windows

ill. 195

DESIGN 4
In this design only the triangle parts are covered up, which means that 77% of the facade are glass. The DF of 2% reaches all the primary rooms, and 5%DF covers 80% of these rooms. These are optimal results according to light need it in the room. With the triangle covered up it visually expresses the composition of the edge when the moguls are combined, which is also an idea for further development.

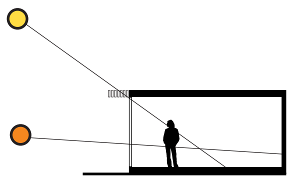
CONCLUSION

Design 1, 3 and 4 all gives a sufficient amount of daylight into the rooms. Design 1 and 4 floods the room with daylight, and would need blinds to avoid too much light into the room at sunny summer days. These two designs is also likely to give a higher heat loss since the glass cover most of the south facade, and may get overheating during summer if overhang/blinds are not used effectively. Design 3 does not depend as much on overhang and blinds to work, but as a tradeoff it also do not give 5%DF in more than 30% of the room. In further development there will be looked at Design 3 and 4, and how they can be improved by adding overhang as a passive solar protector, and blinds as active solar protectors. In the synthesis phase Simien will be used to evaluate the indoor climate. Overhangs and blinds will be adjusted in this phase to ensure a good indoor climate, and glass with good u-values will be chosen to lower heat loss.

SHADING STRATEGIES

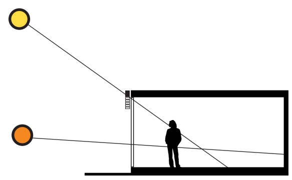
The issues of too much light penetrating the rooms and causing overheating problems, will be studied in this chapter. An overview of different strategies on how shaders can be used to avoid these problems, will be displayed and discussed.

Summer sun 21st of June, 53 degrees (apex) at 13:20
Winter 21st of December, 8 degrees (apex) at 12:15



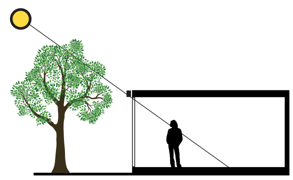
Extended overhangs

wood panels placed along the roof, which will block the sunlight from penetrating the room.



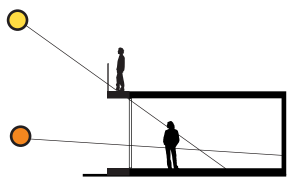
Blinds on the facade

Blinds on the facade will block the sunlight and keep it from heating up the room. By using exterior blinds it stops the sunlight before it hits the room, which avoids the overheating issue.



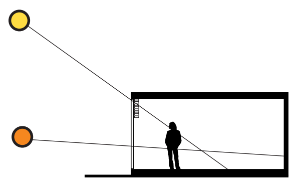
Plants cover - summer

Trees to filtrate the sunlight.



Facade pushed back

To emphasize the mogul shape, the facade is pushed back using the roof as shading strategy, while the upper floor can use the slab as outdoor balcony.



Blinds inside the room

Blinds inside the rooms the sunlight, but the heat is already inside the room and can cause overheating.

plants cover - winter

Tree sorts that do not have any leaves in winter time to let sun heating the room

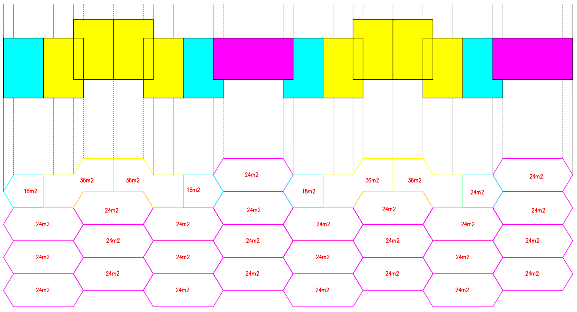
ill. 196

CONCLUSION

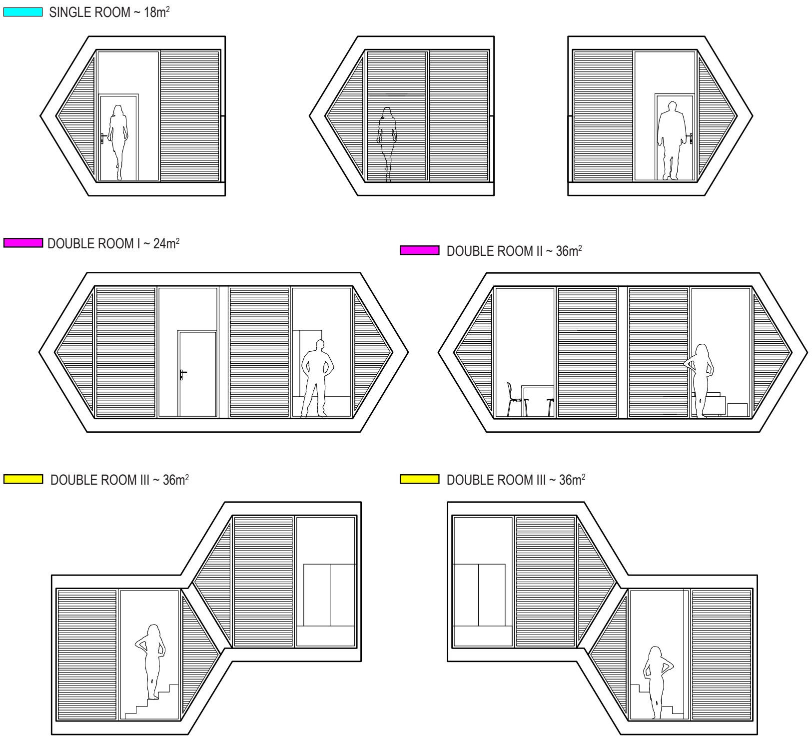
Different types of shaders can be used, each with different qualities. The one found most interesting is the to push in the facade creating a roof slab, which can be used as shaders to prevent overheating during summer, and at the same time be used as balcony for the upper floor. By using this strategy the visual expression of the mogul shape will be kept. Further analysis will be done in synthesis to figure out if external blinds are need it, due to it energy consumption in the hotel room has to be calculated.

INITIAL FACADE EXPRESSION

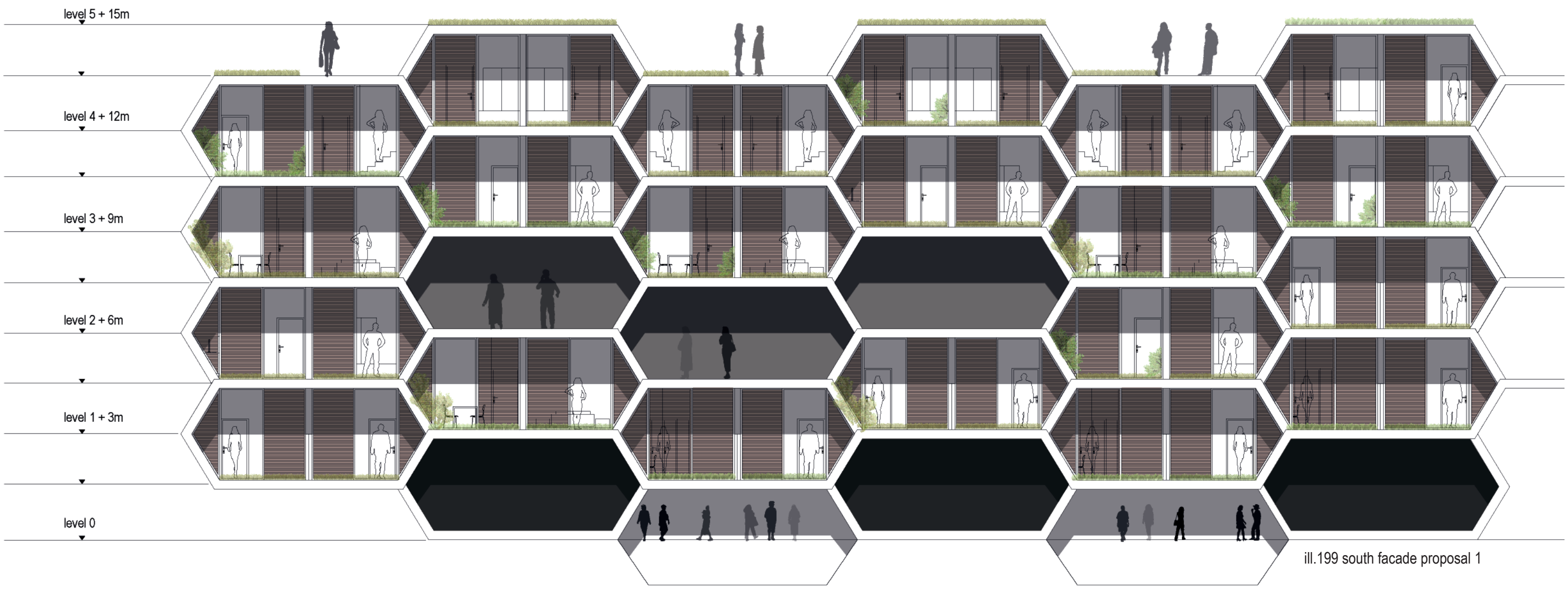
Due to the chosen strategies an initial facade design has been made. Design 3 (facade studies page XXX) is a suggestion of having half of the squared facade covered up with glass, with the other half treated as slidable wood panels in this proposal. This is done to the solve the issue of overheating in the summer, and reducing the amount of light penetrating the hotel room. The design has two slidable wooden panels, which covers up the whole facade when closed.



ill. 197 Grid combination



ill. 198



ill.199 south facade proposal 1

CONCLUSION

A facade proposal based on the grid system with most double rooms and slidable wooden panels seems to give the facade a warm and lively expression. The sliding wooden panels represents the individual users in each moguls, due to the options of having the panels open or closed telling when users are in the room or not. The wooden panels brings an interesting play in the facade supported by the structure of the moguls. The facade and combination strategies will further be development in the synthesis phase.

MATERIALITY

As the project wants to respond to and emphasize the history of the city, the material choices are also desired to reflect on this. The idea is to create a transition from warm wood on the outside that slowly becomes rock, as found in the caves inside the atrium. A choice that has been made to immediately set ones context and make the observer relate and make a stronger coherence with the surrounding context. Other aspects are sustainability and indoor climate, which also has big influence on the material choices.

As the mogul grid allows a light weight construction and flexibilities of organizing the different functions, wood has been considered to be the material choice for the structural grid while concrete/stone is used as the interior part in the atrium. When looking at the materials used in Norway, wood and concrete are the common material used as structural building materials [bygningsmaterialer, 2012]. This chapter will look at these materials with a comparison of pros and cons to elaborate on which should be most suitable for this project.

WOOD

+ Environmental friendly and renewable resource [Christie Gross, 2012]
+ Easy for change in design by moving, replacing or removing walls [Christie Gross, 2012]
+ Slimmer building material allowing for 2 - 10% more living space [wood hybrid, 2012]
+ Wooden structures are cheaper to build than concrete buildings (1-8%) [Jen Davis, 2011]
- Lower limit in number of stories that can be built (about 7 stories) [midrise, 2009]
+ Good energy conservation and thermal properties [wood hybrid, 2012]
+ Shorter building time on site with pre fabricated elements [wood hybrid, 2012]
+ Less foundation loads [wood hybrid, 2012]
- Prone to termite attack

CONCRETE

- Non renewable resource [Christie Gross, 2012]
- More difficult to remodel after its built [Jen Davis, 2011]
- Thicker construction than wood, taking up more of the living space
- More expensive to build than wooden structures
+ Higher limit in number of stories that can be built.
+ Good thermal storage
- Transport more heat through the structure
- Longer building time than wood
- More foundation loads
+ Resist termite infestation [Christie Gross, 2012]

WOOD CONSTRUCTION

ill. 200

CONCRETE CONSTRUCTION

ill. 201

CONCLUSION

Use of renewable and environmental friendly building materials is an important aspect of the project, and as such Wood is the natural choice. It also lowers the cost of the building and creates a slimmer construction meaning more usable space inside the structure. The wood also breaths and allows for a good indoor climate with good energy conservation and thermal properties. There will however be used concrete/stone materials for the inner parts of the hotel, and for parts with heavy loads. The cave part of the hotel will use stone materials to go along with the natural rock environment, and to create a “cave” atmosphere. Wood will be used in the mogul shapes housing the hotel rooms as wood is a natural building material out towards the surrounding nature. The back wall of the moguls facing the cave atrium will have a stone wall creating the transition of going from the natural forest environment into the rocky cave. The foundation of the bottom mogul will also use concrete with wood flooring on top, as it takes up more forces and is in direct connection with the ground. References of potential material choices are displayed as a collage on the next pages to visualize the materiality and the desired atmosphere of different spaces.

ill. 202 National Gallery of Art

ill. 203 Mona Hobert

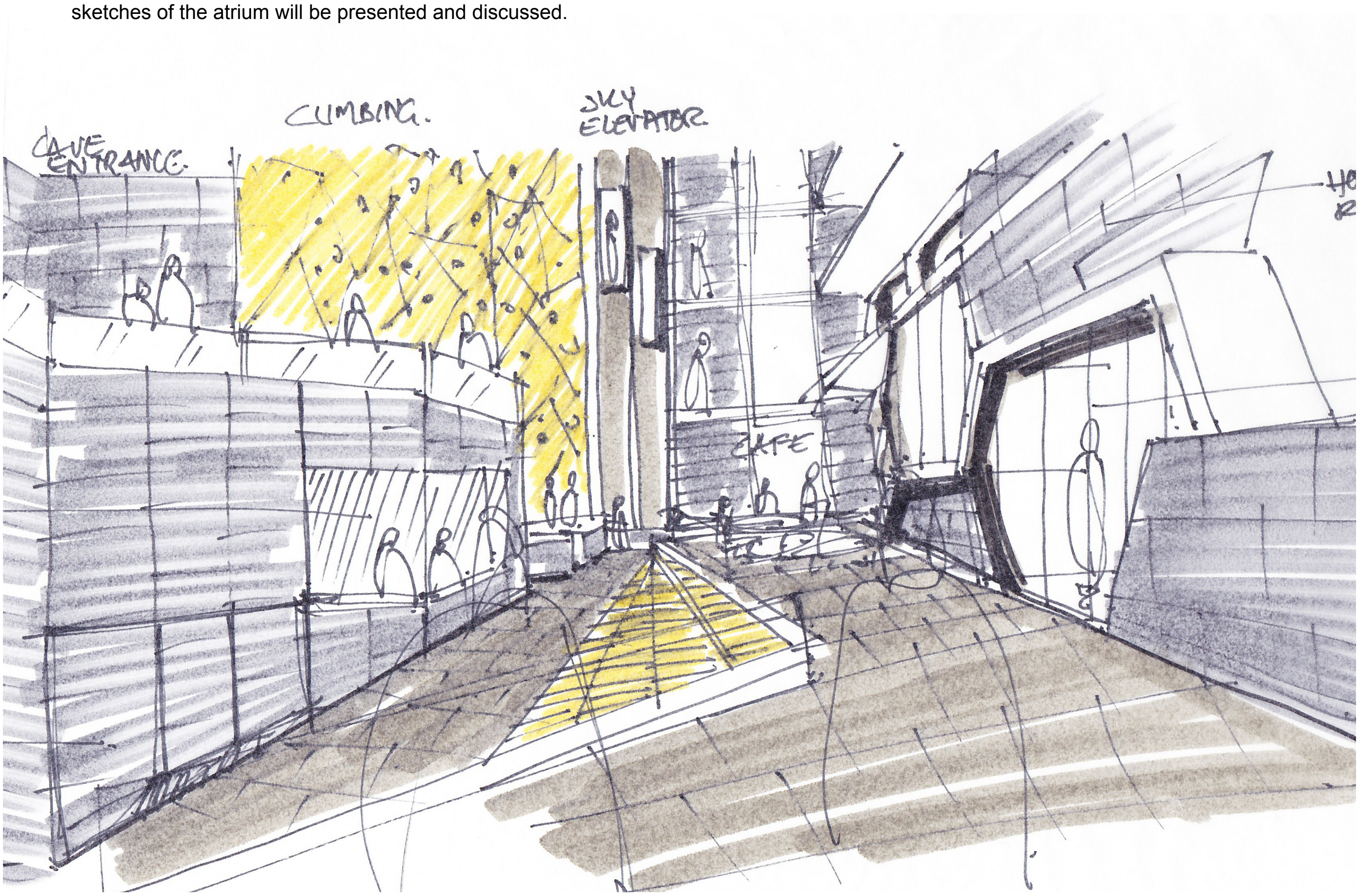
ill. 204 . Tadao Ando - Rokko Housing

ill. 205 Elysium Lot 176

ill. 206 Mona museum atrium

ATRIUM SKETCHING

To provide the users the ability to identify themselves with the place, it is essential to make a design that relate to the landscape, nature and the building context [Meagher, 2008]. With this taken into consideration, an underground atrium cave as an inspiration of the mines found in the area, has been elaborated. An atrium that works as a central point of the hotel, refers and responds to the many mines of Kongsberg city. This is done due to the desire of telling about the history of the city and make a design that is unique and suited only for this specific building site - a design with its own “rootedness”. In this chapter, sketches of the atrium will be presented and discussed.



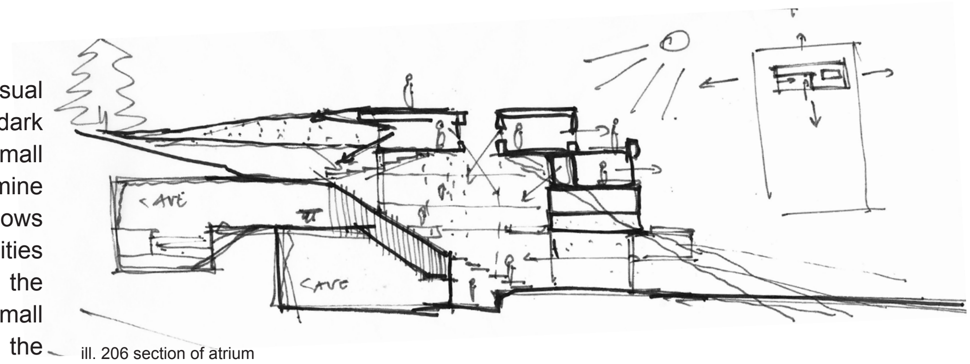
ill. 207 Idea sketch of the atrium

When entering the atrium one discover a big cave with natural rock in the background. Parts of the natural rock wall function as a climbing wall, where people climbs up towards a small narrow opening with light streaks that penetrates the dark open cave-atrium. A dark cosy atmosphere with functions that invite the users to explore by walking in small paths leading to different cave functions. Moguls are extruded in various depths, making a play towards the atrium, which refers to mountain cuts. A main path is separating the reception/cave activities and the hotel rooms. This path is leading towards the sky elevators that takes the users all the way up to the top level. This idea imitates the lifts used in a mine to transport the mine workers to different levels in the mine.

An underground room is dug out becoming a cave cinema and auditorium for conferences. On top of the reception a lounge area is to be found with sitting areas for guest waiting and enjoying the cave atmosphere, with connections to cave functions as cave spa and cave swimming facilities. A big stair element emphasizing the flow in the atrium that invites the users to the cafeteria area with both indoor and outdoor sitting facilities. The moguls on the bottom floor consist of public functions like a small shop and a cafeteria to activate the space, creating a more lively atmosphere. A dark and “rocky” atmosphere that arouse the visitors curiosity - making them explore to discover the cave functions.

SECTION OF ATRIUM

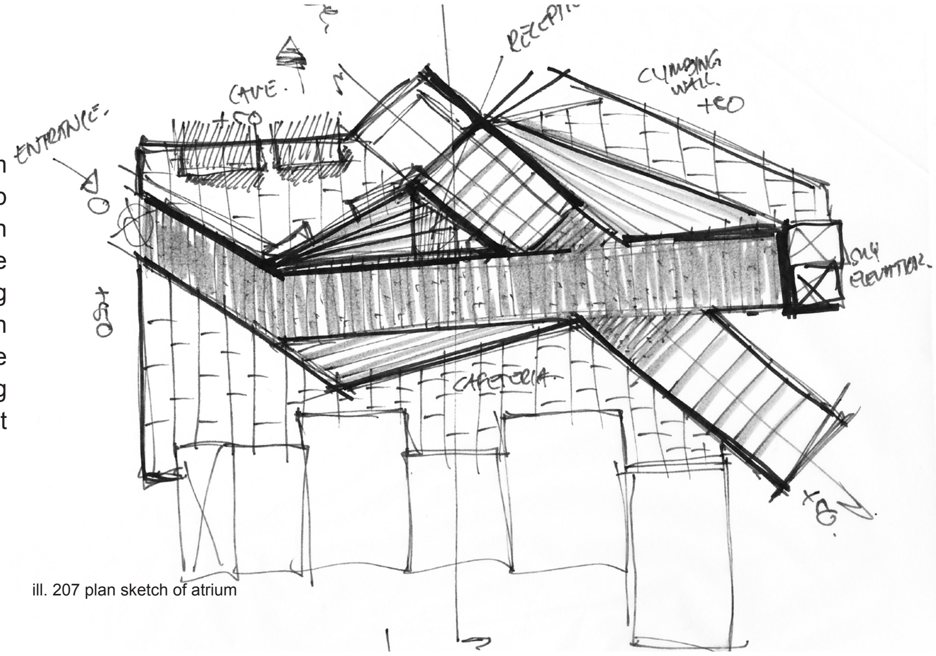
The essence of the section is to emphasize the visual connection to the atrium space. An open and dark space with few light streaks penetrating through small openings in the roof top, to create a underground mine cave. A section of bioclimatic conception which allows the functions towards south to have great possibilities for sun and daylight intake. The open space in the atrium is fragmented in cave functions and small narrow path systems letting the users explorer the "hidden" cave functions.



ill. 206 section of atrium

PLAN SKETCH ATRIUM

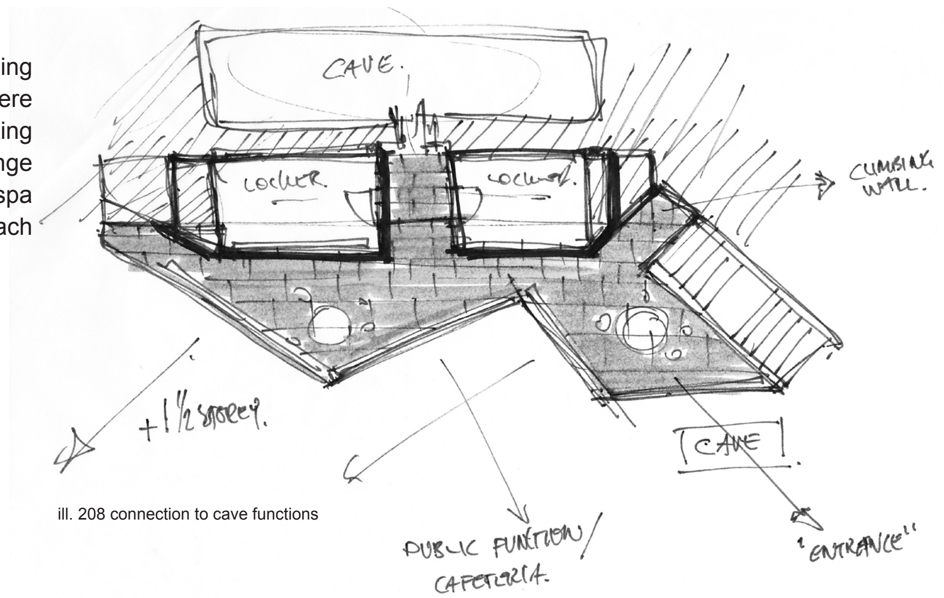
The directions and orientation made in the atrium reflects the outer shape of the hotel, which has sharp breaks in the shape to emphasize the visual connection points of the context. The main path leads straight to the skyelevators and all lines creating "guide lines" inviting to the different functions found in the end of each path. The moguls makes a shifting play towards the atrium both creating a play in the facade, and inviting to attract the users attention. A plan suggestion that is elaborated of connection and controlled guidelines.



ill. 207 plan sketch of atrium

CONNECTION TO CAVE FUNCTIONS

When entering the atrium, a big stone stair is leading up the first level of the atrium. A lounge area is here to be found with sitting facilities with visual connecting points to opposite functions. In the back of the lounge area is the entrance to cave functions like cave spa and swimming facilities, with locker rooms on each side for changing.



ill. 208 connection to cave functions

CONCLUSION

The architectural idea of the atrium was inspired by the statement by Meager of having an design proposal that relate to the building site and its context. A contemporary hotel design that responds to the history of the city and defines its own rootedness, enable the users to identify and relate to the surrounding context. With these considerations a cave atrium was sketched seeking an underground atmosphere, giving the visitors a unique and a phenomenological experience.

Strategies of letting the visitors by their own to explorer and discover "hidden" cave functions, which are kept as "natural" as possible. Underground cave atmosphere implemented in a new and contemporary interpretations of attractive activities such as cave cinema, cave spa and cave swimming facilities. An atrium that reflects the identity of the skicenter and the history of Kongsberg city. To evaluate on this proposal, the atrium will be further analized in the synthesis phase.

SPREADSHEETS

24 hour average spreadsheets will be used to analyze indoor climate based on different types of moguls (p.112), while the monthly average spreadsheet will be used to analyze the yearly energy consumption of a larger part of the complex.

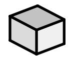
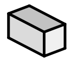
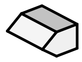
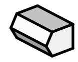
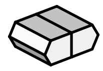
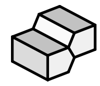
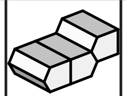
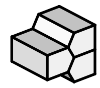
24 HOUR SPREADSHEETS

The 24 hour average Spreadsheets will be used to do analysis on different shapes to find the heating need and ventilation rates required to give a good indoor climate. Shape 1 to 4 consist of 4 different shapes, while shape 5 to 8 is combination strategies of how shape 4 can be put together. The window areas for each shape is set to be 90% of the square facade part facing south, since this is the main facade facing outdoor. Even so, the shapes will for the analysis be treated as standalone shapes with all walls being external walls to the outdoor.

For each 18m² there is counted one person. With person loads being active from 17:00 to 08:00 (80% between 24:00 and 08:00) Lighting load is between 17:00 and 23:00. Other loads are active between 07:00 and 23:00. Lighting is set to 100lux and person activity is set to sitting during daytime (66W), and laying down during night time (56W).

For summer time July will be looked at, while for winter time January will be used as these are the warmest and coldest months in the year.

The spreadsheets work around a climate file for Copenhagen, so the results will not be correct for our design, but since this analysis is only for comparing the different shapes it will not be a problem. The temperatures has been override with Kongsberg values, but sun income is still Copenhagen values. There will later be done Simien analysis of the chosen designs in the synthesis chapter.

24 HOUR SPREADSHEET ANALYSIS								
	Shape 1	Shape 2	Shape 3	Shape 4	Shape 5	Shape 6	Shape 7	Shape 8
								
Height [m]:	3	3	3	3	3	3	3	6
Depth [m]:	4,5	6	6	6	6	6	6	6
User width [m]:	4	3	3	3	6	6	9	6
Width [m]:	4	3	5,1	3,9	7,7	6,9	10,7	6,9
User area [m²]:	18	18	18	18	36	36	54	54
Roof area [m²]:	18	18	30,6	23,4	46,2	41,4	64,2	41,4
Floor area [m²]:	18	18	18	18	36	36	54	54
Wall area N [m²]:	12	9	12,1	10,3	20,6	20,6	30,9	30,9
Wall area E [m²]:	13,5	18	18	18	18	27	27	36
Wall area S [m²]:	12	9	12,1	10,3	20,6	20,6	20,6	30,9
Wall area W [m²]:	13,5	18	18	18	18	27	27	36
Total Wall area [m²]:	51	54	60,2	56,6	77,2	95,2	105,5	133,8
Glass area S [m²]:	10,8	8,1	8,1	8,1	16,2	16,2	24,3	24,3
Volume [m³]:	54	54	72,6	61,8	123,6	123,6	185,4	185,4
24 HOUR INPUTS								
Persons:	1	1	1	1	2	2	3	3
Person active [W]:	66	66	66	66	133	133	199	199
Lighting active [W]:	336	336	336	336	672	672	1008	1008
Infiltration [h^-1]:	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
24 HOUR RESULTS SUMMER								
24h average [°C]:	22,3	22,5	22,5	22,5	22,5	22,4	21,2	21,5
Max. temp. [°C]:	25	24,9	25	24,9	24,3	24,2	22,7	23
Heating need [W]:	0	0	0	0	0	0	0	0
Ventilation [h^-1]:	5	4,1	2,4	3	1,5	1,5	1,5	1,5
Airflow [l/s/m²]:	4,3	3,5	2,8	3	1,5	1,5	1,5	1,5
24 HOUR RESULTS WINTER								
24h average [°C]:	22	20,8	21,6	21,2	20,3	20,3	20	20,1
Min. temp. [°C]:	16,5	16	16,2	16,1	16,2	16,1	16,2	16,2
Heating need [W]:	1200	1200	1800	1450	2850	2950	4300	4300
Heating need [W/m²]:	66,7	66,7	100	80,6	79,2	81,9	79,6	79,6
Ventilation [h^-1]:	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Airflow [l/s/m²]:	1,3	1,3	1,8	1,5	1,5	1,5	1,5	1,5

The heating need value is actual heat need, sun heat gains and equipment heat gains combined. Only person load and lighting load is not included in this value.

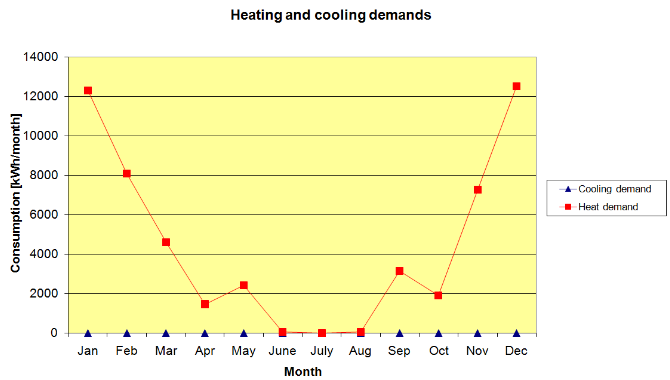
ill.209

CONCLUSION

From shape 1 to 4 it shows that in summer time compared to the square shapes, the mogul shapes need less ventilation rate, while in winter time they also need more heating. Shape 5 to 8 shows that there is not much difference in energy usage and ventilation needs based on how the mogul shapes are combined. but for all the combined solutions the ventilation rate per square meter is lower than for the stand alone Shape 4. Heating need is about 80 W/m² and ventilation airflow 1.5 l/s m² for all the combinations. It is expected that the airflow rate should be higher in summertime than in wintertime, and this will be looked at when making the Simien analysis.

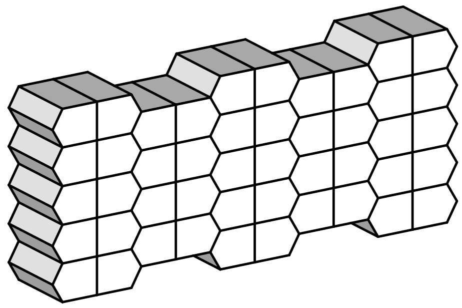
MONTHLY SPREADSHEET

The monthly spreadsheet takes the mogul shape and puts it into a system going 5 stories high. The values chosen will be based on the Shape 5 values. The analysis is done to get an idea of how the energy consumption can be like when several of these moguls are combined into a larger cluster. Like the 24 hour spreadsheet this spreadsheet also mix Copenhagen and Kongsberg values, and should only be used as a rough estimate. The goal for this analyze is to get the cluster inside the spreadsheets comparison for public buildings of 73.3 kWh/m² yearly, and to ensure there is no cooling needs.



ill.210

MONTHLY SPREADSHEET ANALYSIS	
West wing (based on Shape 5 values)	

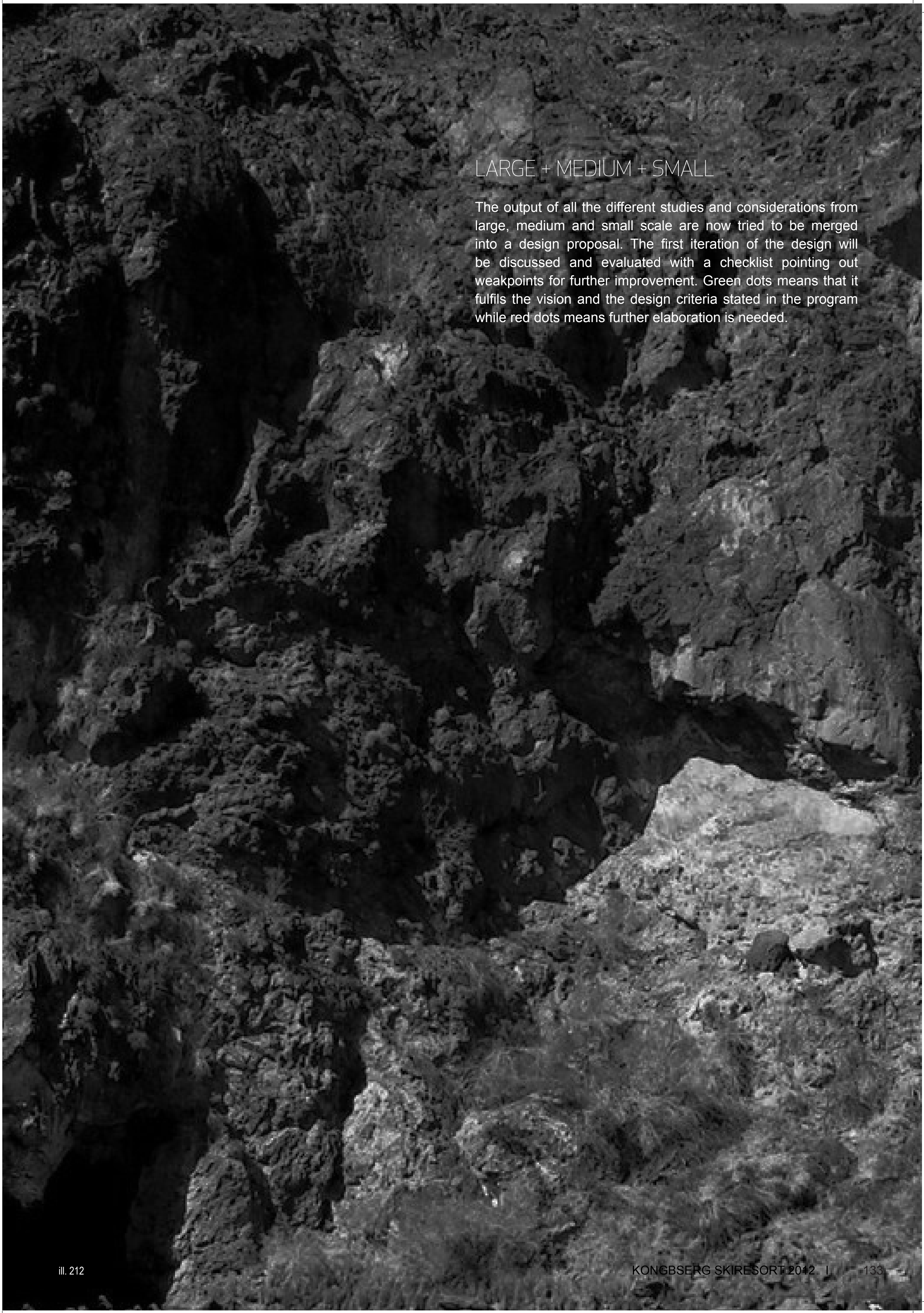


Area [m²]:	828
Roof area [m²]:	211.2
Floor area [m²]:	211.2
Wall area N [m²]:	473.8 (82.4 + 391.4)
Wall area E [m²]:	90
Wall area S [m²]:	473.8
Wall area W [m²]:	90
Glass area S [m²]:	414
Volume [m³]:	2842.8
MONTHLY INPUTS	
Persons:	46
Person active [W]:	3503 (18:00-8:00)
Lighting active [W]:	6624 (18:00-24:00)
Vent summer [l/s m²]:	2.78 / 0.83
Vent winter [l/s m²]:	0.83
MONTHLY AVERAGE RESULTS	
Energy consumption:	65.0 heating, 0.0 cooling [kWh/m² y]
Spreadsheet comparasions:	73.3 energy frame public

ill.211

CONCLUSION

This spreadsheet use a mix of Copenhagen and Kongsberg and will only be considered a rough estimate of what the cluster can give. The analysis shows that the cluster can get inside the energy frame for public buildings, and that it do not need any cooling during summertime as long as the ventilation rate is not too high. Furthermore the graph shows that the heating is not needed for the three summer months, but there are still some peaks in May and September which could be solved by lowering the ventilation rates, but they are already at a minimum. More accurate and detailed estimates will later be done on the final design through Simien in the synthesis phase, where it will also be measured up against the Norwegian regulations.



LARGE + MEDIUM + SMALL

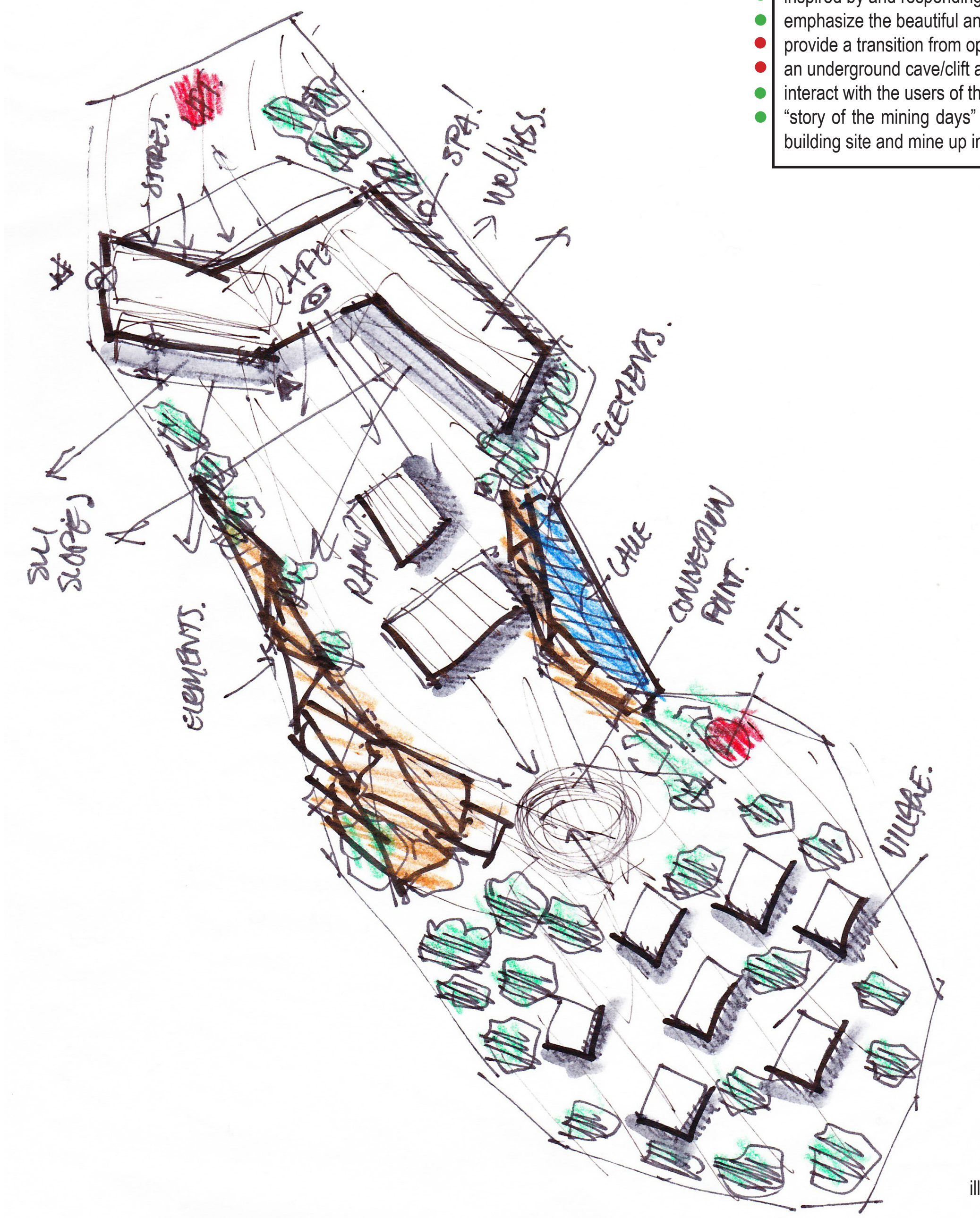
The output of all the different studies and considerations from large, medium and small scale are now tried to be merged into a design proposal. The first iteration of the design will be discussed and evaluated with a checklist pointing out weakpoints for further improvement. Green dots means that it fulfils the vision and the design criteria stated in the program while red dots means further elaboration is needed.

ill. 212

LARGE - 1ST ITERATION MASTERPLAN

ARCHITECTURAL CONSIDERATIONS

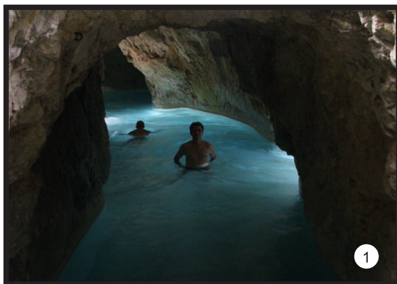
- relate to and integrate with the landscape
- attractive activities to activate the site
- inspired by and responding to the city history
- emphasize the beautiful and dramatic nature
- provide a transition from open nature to underground
- an underground cave/clift atmosphere
- interact with the users of the skicenter
- “story of the mining days” with the village in the bottom of the building site and mine up in the hills



ill. 213 initial masterplan

The idea of the master plan is to make a design of hotel that emphasize and relates to the surrounding context. A plan that consist of many attractive functions to bring lively activities(XXX) to the site both during winter and summer. The layout of the hotel is situated on the top of the slope with ski shop, ski rental and restaurant in connection with the ski lift area. The restaurant with its wide open facade creating spetacular panoramic views of the area, nature and the city.

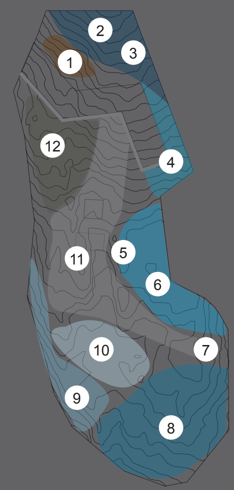
A skithrough under the restaurant connecting the “central point”, skilift and the village area. A ramp is located in extension with the skithrough for more extreme activities. Each side of the ramp has urban sitting elements allowing the users for both sitting and to ski on. A lake on the east for ice skating in winter time but also relaxation in summer. The qualities and atmosphere of the different activities are tried to be described using various references and mood pictures (ill. 214). According to the checklist the missing points needs to be implemented in the further development of the masterplan.





WINTER

Winter is high season for Kongsbergs Skiresort. The winter activities are arranged and placed at the most conveniently areas for every single activity, by that meaning, iceskating by the frozen lake, skiing at the steep area and stressless zone in the quiet area. The sites many advantages has been exploited to the fullest.







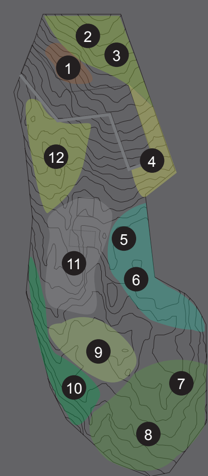






SUMMER

To keep the skiresort active during summer, it is necessary to implement summer activities. When the snow is gone, a beautiful green landscape of great summer activities appears. Bathing in the lake, skating at the ramps and running or biking in the sloped areas.





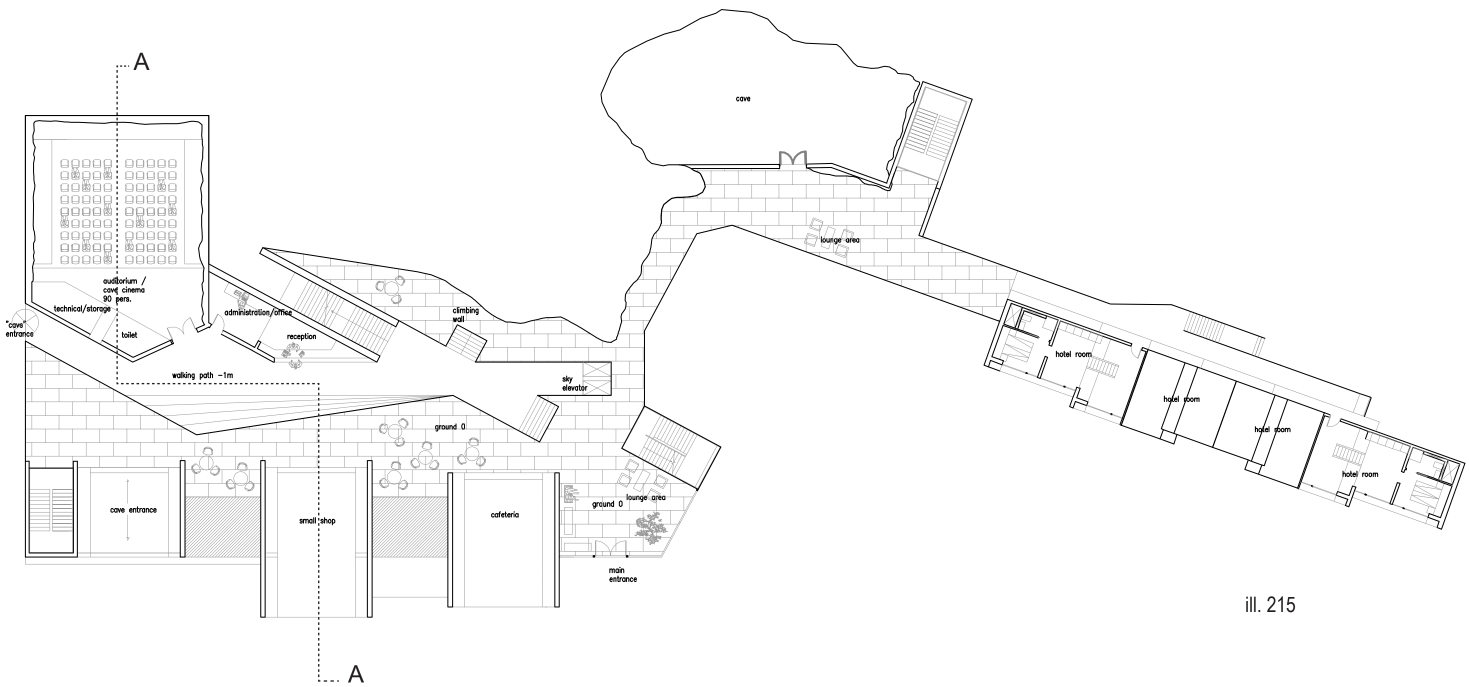



ill. 214

ARCHITECTURAL CONSIDERATIONS

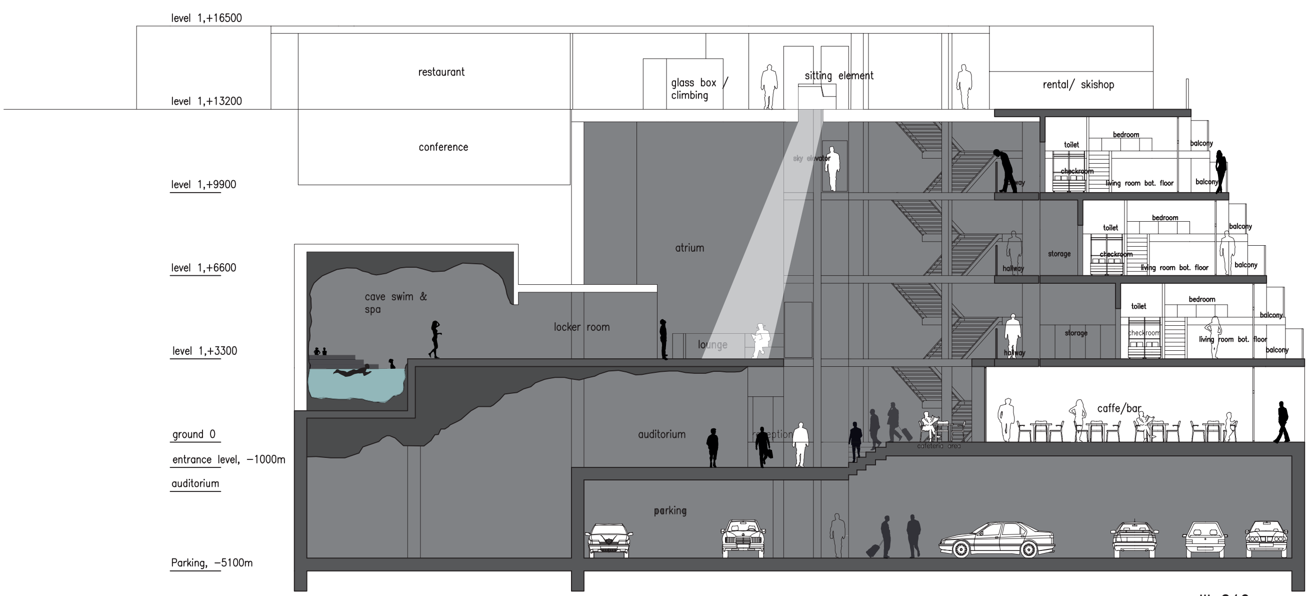
- narrow dark paths allowing to discover “hidden” caves
- maintaining natural mountain rock as walls
- attractive cave activities
- provide a transition from open nature to underground
- an underground cave/clift atmosphere
- small light streaks penetrating the open atrium
- easy access to hotel rooms
- an atrium for phenomenological explorations
- auditorium for cave cinema and conferences
- high utilization of spaces
- visual interactions with the atrium

1ST ITERATION PLANDRAWING 1:1000



ill. 215

1ST ITERATION SECTION A-A 1:300



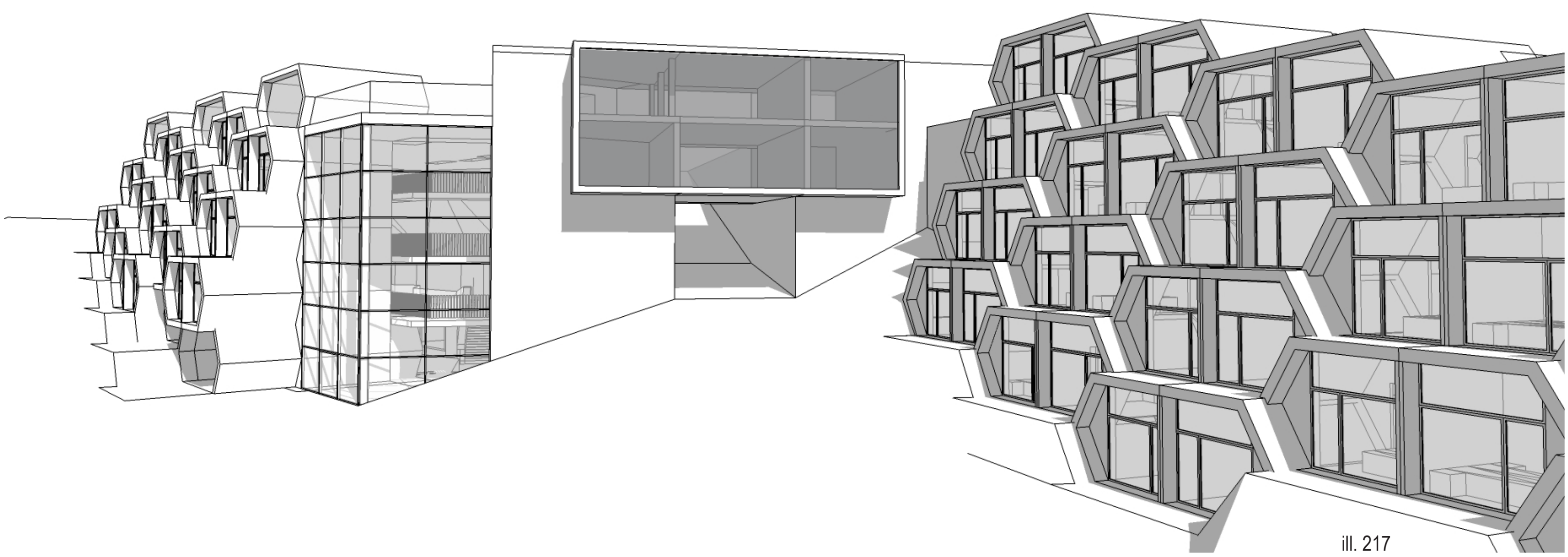
ill. 216

As seen on the checking list, different aspects need to be further developed. Easy access to the hotel rooms are highly prioritized. In the first iteration of the design proposal, too much space are wasted on “storages”, which are located before entering the hotel room. Due to the way hotel rooms are stepping down with half storey jumps, it has been difficult to create hallways that can ease the access to the different hotel rooms without wasting to much space in front of each entrances. As a proposal this space can function as a “storage” space, where the users can unload their wet ski clothes and equipments for safe storage before entering their hotel rooms. An improvement of this solution and the cave cinema will be further elaborated in the synthesis phase.

ARCHITECTURAL CONSIDERATIONS

- combination of the moguls
- visible and open main entrance
- moguls making a play in the facade
- a skithrough that connects north and south
- relate to and integrate with the landscape
- emphasize the beautiful view
- daylight intake for each hotel room
- restaurant with panoramic view
- view post from roof
- bridging connect between the east and west moguls

MEDIUM - MOGULS & THE CLIFT

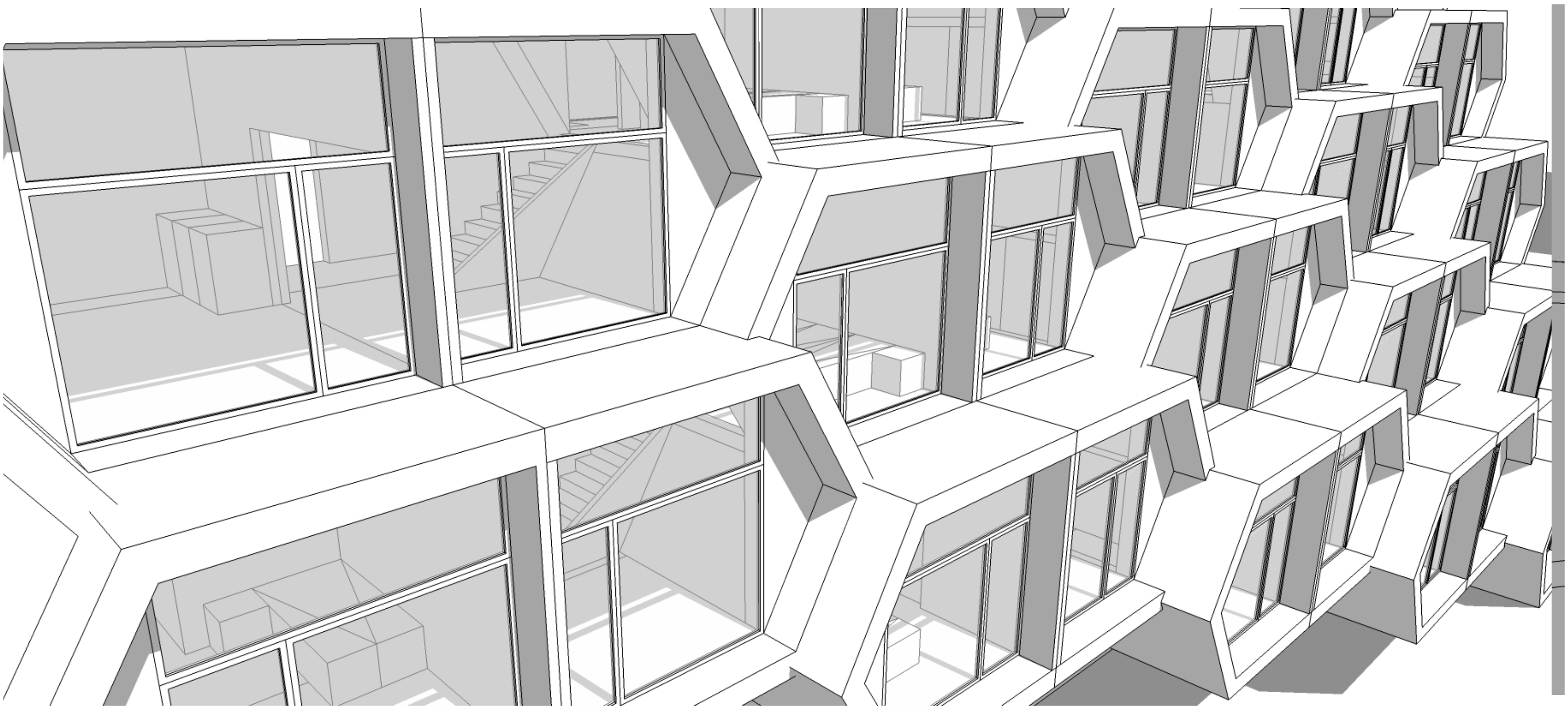


ill. 217

This design proposal has a combination of moguls that makes an interesting play in the facade and spaces for balconies, which are located on the West and East wing. The restaurant with a big panoramic view, bridges the hotel rooms on each side, and there is a large entrance with an open atrium. This design proposal does not emphasize the relation between the "bridge" from a aesthetic point of view. The shapes used for the "bridge" connection and the main entrance differs from the moguls shapes and makes the design not coherent, which are considerations that needs to be improved in further development of the hotel design.

SMALL - FLOOR PLANS

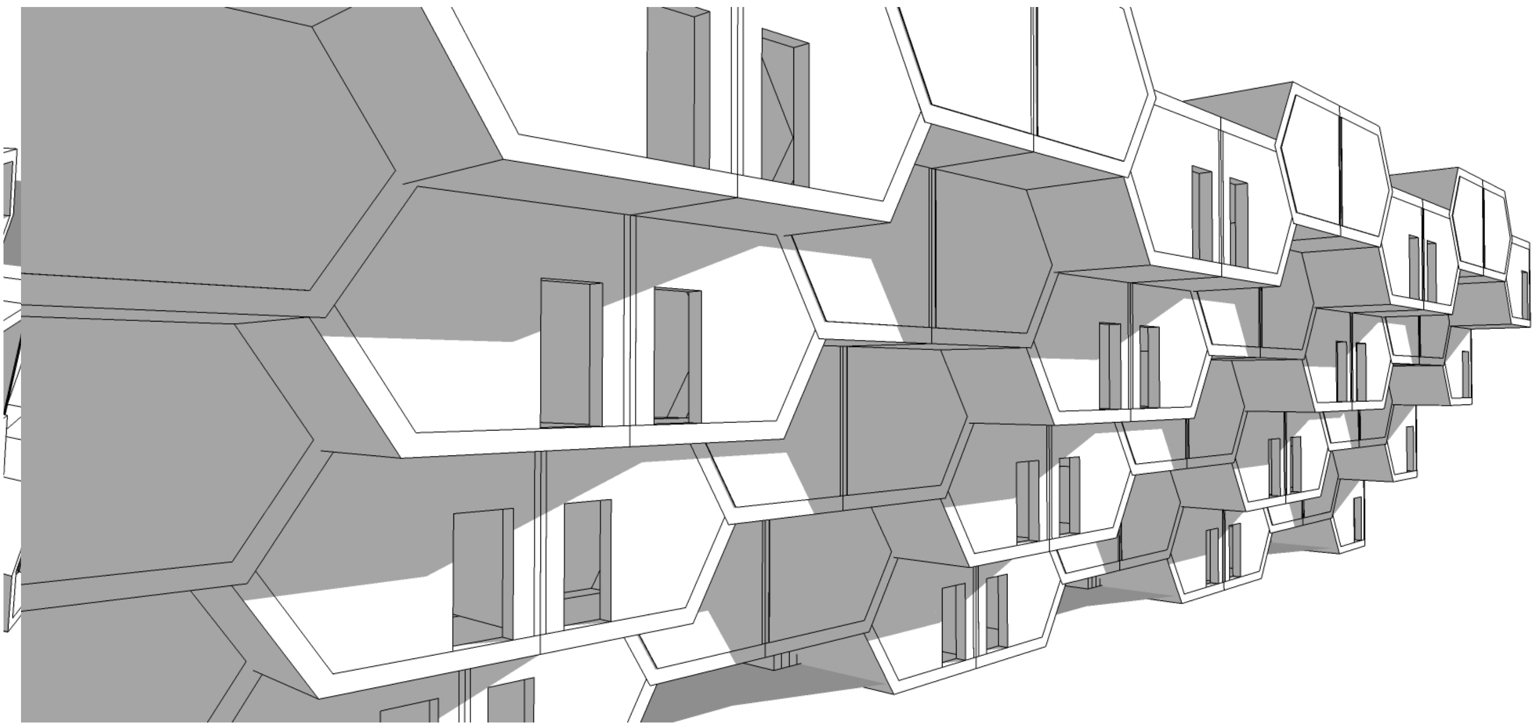
By the flexibility of the grid system and the moguls, many various combination strategies can be done. This proposal combines the moguls in a system that makes an interesting play both in the facade but also towards the atrium. This combination allows the moguls to be connected with each other to create double storey hotel rooms and spaces for outdoor balconies. When observed from the atrium it also creates a play due to the way moguls are stepping down every half storey. This leads to the issue of designing a hallway that can ease the access to the different hotel rooms without overusing the area space (ill 219). Different strategies for solving this design problem and shading strategies will be look at in the synthesis.



ill. 218 facade with balconies

ARCHITECTURAL CONSIDERATIONS

- various possibilities of assembling the moguls
- outdoor spaces for hotel rooms
- systemized combination
- daylight intake for hotel rooms
- half storey entrances for hotel rooms
- facade defined by functions
- shading strategies



ill. 219 play towards atrium

FURTHER DEVELOPMENT

This design proposal will function as a basis for the synthesis phase. All the “scales” need to be further developed and further detailed according to the missing points and architectural goals. Calculations, simulations, facades and materials will also be implemented through different iterations, before the final design proposal is presented.

06 SYNTHESIS

The concept for SMALL SCALE - the hotel rooms, MEDIUM SCALE - the building design and LARGE SCALE - the masterplan, is further elaborated and detailed. Throughout this chapter, technical aspects will be evaluated and held against a checklist to see if the design fulfils the different requirements, goals and architectural vision. The absolute criteria is to fulfil all requirements from the TEK10 building regulations, while there will also be a goal to achieve a low energy house rating based on NS3700.

ill. 220

SMALL SCALE

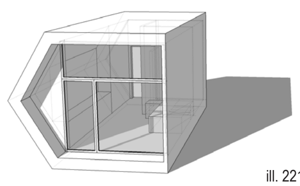
- THE HOTEL ROOMS

The small scale will present the final hotel room designs and analyse them towards requirements and goals. The technical and architectural aspects of each room will be evaluated, and the indoor climate will be tested through Ecotect with Radiance (daylight factors), and Simien (room temperature and ventilation rates).

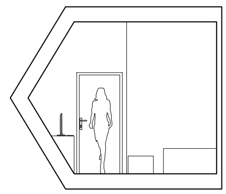
THE MOGUL ROOMS

SINGLE

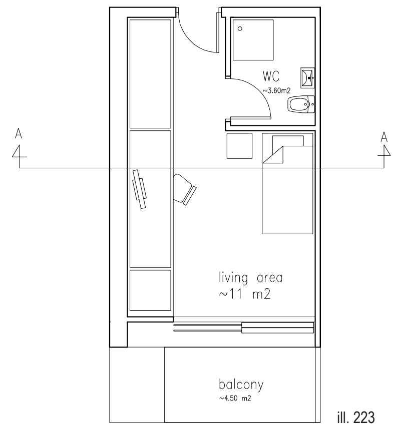
The single room use half a mogul which provide 16.6 m² of user area. The room was designed very minimalistic, due to the needs of a single person and the space utilization. When entering the single room, ones are provided with a large glass facade and panoramic view towards the beautiful landscape and a outdoor balcony facing south. Living area with a bed and a small working desk are arranged in the southern part, while functions that does not need 2% of daylight are placed to the north.



ill. 221



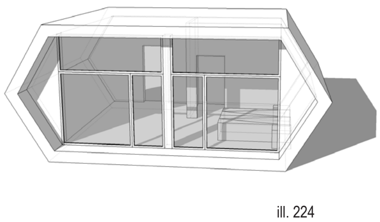
ill. 222



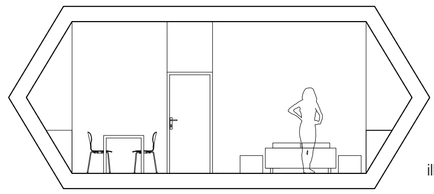
ill. 223

DOUBLE

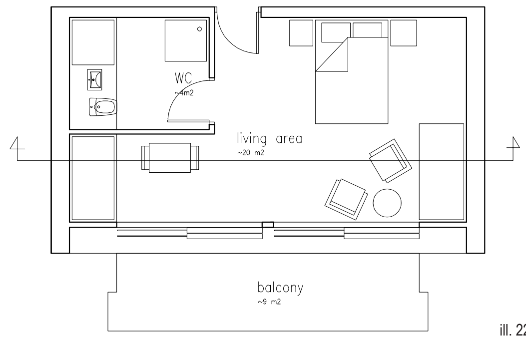
The double room covers one full mogul, and gives 28m² of user area. The room welcomes the users with an open solution where only the bathroom is shielded from the rest. The double bed can be separated to make a twin room, and there is a living space with working desk and storage possibilities on the diagonal wall. The mogul facade consist of large areas of glass and gives a beautiful view towards the nature and the ski slopes.



ill. 224



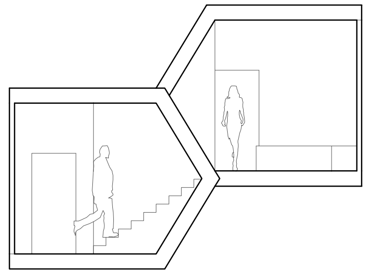
ill. 225



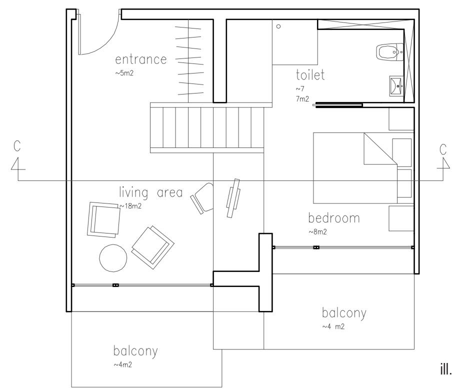
ill. 226

DOUBLE (two storey)

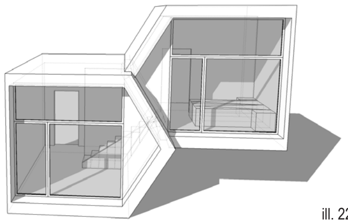
The double room of two storeys covers two half moguls giving it vertical walls on each side. The user area is 28.2 m². Ones enter the lower part of the room where a wardrobe is located, with the living area facing south. The middle part works as a open transition zone with a stair leading up to the upper floor with more private functions. By having a hotel in two storeys with clear separation of private and social zones, the users are provided with an open hotel room that provides the feeling of climbing up to their “nest” for relaxation and to gain even better view towards the landscape. Outdoor balconies in connection with both storeys provides opportunities for barbequing and enjoyment with a spectacular view towards the landscape.



ill. 228



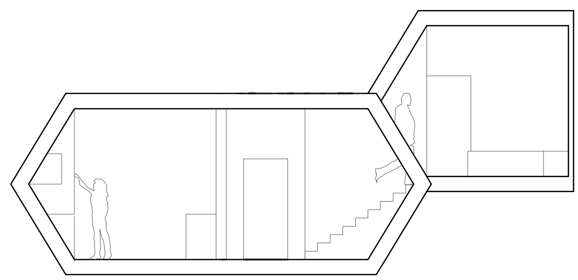
ill. 229



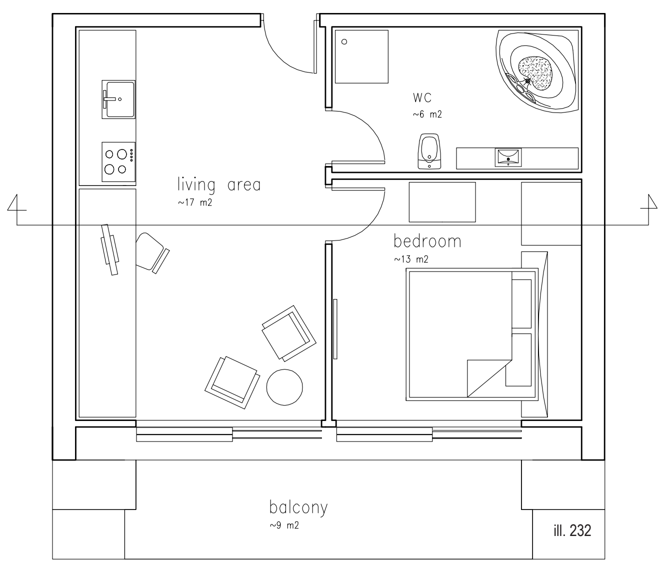
ill. 227

PENTHOUSE

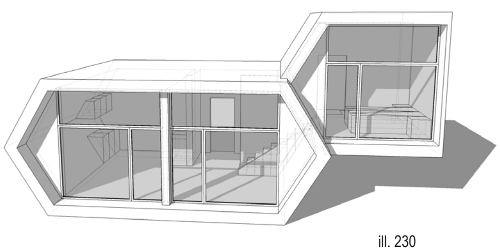
The penthouse room is introduced to give the users a luxury stay at the hotel with a large amount of space that consist of one and a half mogul, and moves over two stories giving it a user area of 43.5 m². This penthouse is intended for couples that wants a stay with great indulgence and enjoyment of the facilities that the hotel has to offer. The entrance is located on the lower full size mogul with a large open living space and big glass facades providing the room with plenty of daylight and a spectacular view towards the landscape. A small kitchen is incorporated in the NW part with eating arrangement in connection with a big living area facing south. The open transition zone leads up to the private space which are located on the upper floor. A double bed is here to find with visual interaction with the bottom floor due to the opening in the transition zone. There is a big outdoor balcony at the bottom floor with plenty of space for barbequing and sunbathing in summer, and a smaller balcony in connection with the bedroom for enjoyment of the sunset before going to bed.



ill. 231



ill. 232



ill. 230

CONCLUSION

The described moguls are designs that holds the hotel room functions, which provides different facilities according to the size and arrangements. From single to penthouse rooms, the designs are tried to be optimized according to the space utilization and qualities that the moguls are able to provide. Each with its own qualities that fulfills the users groups needs when choosing Kongsberg skiresort as a accommodation. Each room design will through the next chapter be tested and analyzed for daylight factors, temperatures, CO_2 levels, ventilation rates and shading solutions in order to ensure a comfortable stay both winter and summer.

DAYLIGHT ANALYSIS

- ECOTECT WITH RADIANCE

Ecotect with Radiance is used for analysing the amount of daylight entering each room. The requirement from TEK10 is to always have a daylight factor of at least 2% in the rooms people stay in over time [TEK10, 2012]. This covers the living room, bed room and kitchen area. The bathroom and entrance do not need to have a 2% daylight factor. In addition we have a goal of reaching 5% DF in parts of the living room and bedroom to allow for a good working light. These 5% do not need to cover the entire room [TEK10, 2012].

When modelling the rooms for the analysis, the volumes for each room has been simplified to inner room shells, but with all details on the outside present to simulate correctly all obstacles from overhangs and next door rooms that block daylight. The weather data file used is from Oslo in Norway, which is located only 45 minutes drive by car away from Kongsberg.

The contour lines in the 3D render is created by calculating the image based on the same lux level as the analysis is run with (100LUX). This allows a result of 10lux inside the room to correspond to a 10% DF. This simplifies the process of displaying the DF.

DAYLIGHT FACTORS		
	Min. Req.	Goal
Daylight factor [%]:	2	5

ill. 233

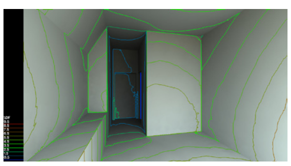
RADIANCE DAYSIM SETUP	
Kind of image to generate:	Daylight Factors (%DF) [21st of December, overcast sky, 100lux]
How to present the lighting analysis:	Final render + Surface and/or point analysis
Values calculated for:	Analysis grid
Type of views to generate:	Interior views
Accuracy:	High model detail, high lighting variability & high image quality
Indirect reflections:	9 [max]

ill. 234

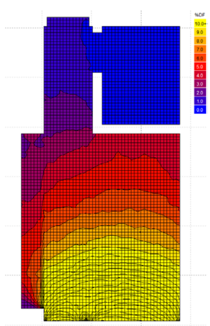
SINGLE ROOM

The entrance and bathroom are situated on the northern part, while the bed and living area are to the south with the glass facade.

2%DF: Covering the entire bed and living room area.
5%DF: Covering most of the bed and living room area.



ill. 235 view towards entrance

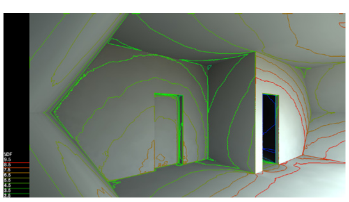


ill. 236 single room - DL grid

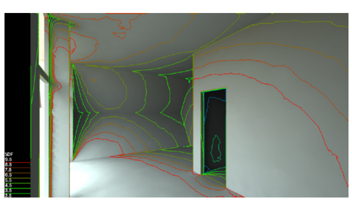
DOUBLE ROOM

The bathroom and entrance area is on the northern part, while the bed and living areas are situated on the southern part with the facade.

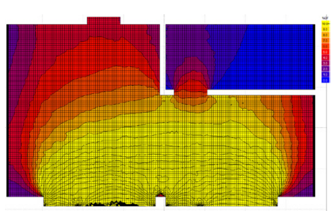
2%DF: Covering the entire bed and living room area.
5%DF: Covering most of the bed room and much of the living room.



ill. 237 view towards entrance



ill. 238 view towards entrance

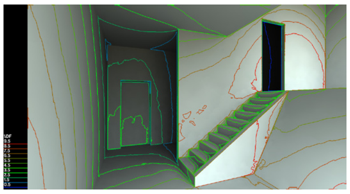


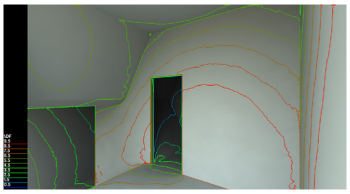
ill. 239 double room DL grid

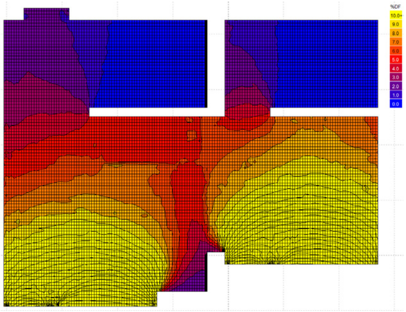
DOUBLE ROOM (two storey)

Entrance and bathroom is located on the northern part, while the bed and living area is on the southern side with the facade.

2%DF: Covering the entire living and bedroom.
5%DF: Covering the entire living and bedroom.


ill. 240 towards entrance

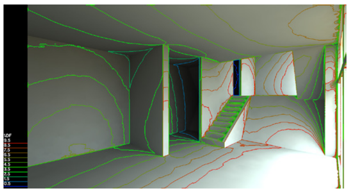

ill. 241 from top floor

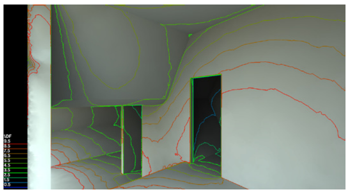

ill. 242 double room (two storey) DL grid

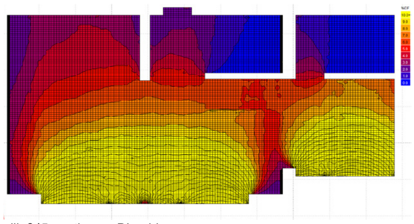
PENTHOUSE (two storey)

The entrance, kitchen and bathroom area is on the northern side, while the bed and livingroom area is on the southern side with the facade.

2%DF: Covers the entire bedroom, kitchen and livingroom area.
5%DF: Covers the entire bed and living room area, and most of the kitchen area.


ill. 243 view from living area


ill. 244 from top floor


ill. 245 penthouse DL grid

CONCLUSION

By optimizing the depth and removing some of the interior wall in the double hotel room, the final proposal improves the daylight coming in and all rooms get sufficient daylight. For all the rooms both the requirement from TEK10 of 2%DF in all primary rooms, and the goal of parts of the primary rooms having 5%DF for working light, has been fulfilled. Since these results are from an overcast winter day and still plenty of daylight enters the building, it is likely that there will be need for shading in summer time. Shading need and how overhangs and blinds can be used to limit sun- and daylight coming into the rooms, will be looked at in the upcoming Indoor climate chapter. For shadow analysis of the building, see [Appendix 27].

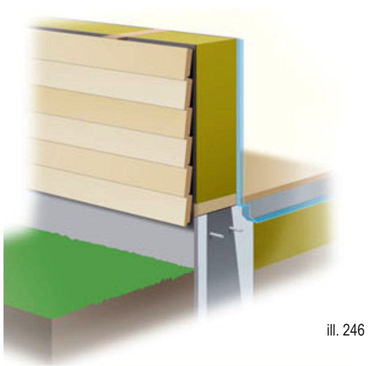
CONSTRUCTION ELEMENTS
- ROCKWOOL

This chapter will look at the walls, floors and roofs used to build up the hotel rooms. It's important that all the elements satisfy the minimum U-value requirements for individual elements, and that the elements combined have a mean U-value meeting the requirements in TEK10.

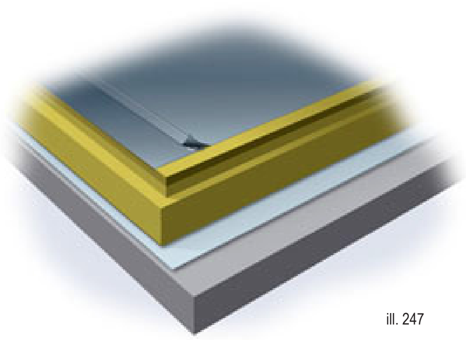
Rockwool's Norwegian homepage [rockwool.no] provides a program for calculating U-values. This program let you define all parts of the wall, roof and floor layer by layer with thickness and material choice to easily customize the element you want, and to see how all the choices impact the U-value instantly.
This program will be used to determine the inputs for the wall, floor and roof elements later going into Simien. Rockwool's program is chosen over the built in Simien function because of it's broad material database and powerful functionality.

One of the benefits from using a honeycomb grid for the hotel rooms is that it allows for a more lightweight and slim structure (p. 116), This means less material usage and more space inside the rooms. One of the design goals is building elements of maximum 300 mm for the mogul hotel rooms to avoid them looking massive. Because of this there will be used building elements with a higher than average U-value for the moguls, to lower the thickness, and thicker elements with lower than average U-values in other building parts. The following U-value requirements in TEK10 has to be met.

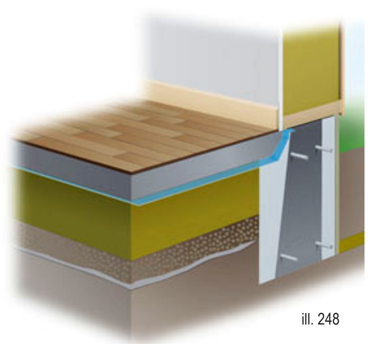
U-VALUE REQUIREMENTS		
Element	Max individual U-value	Max average U-value
Wall:	0.22	0.18
Roof:	0.18	0.13
Floor:	0.18	0.15


ill. 246

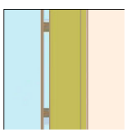
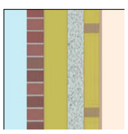
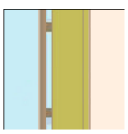
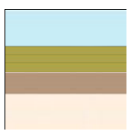
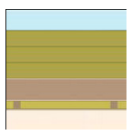
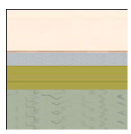
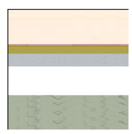
Example Wall structure


ill. 247

Example roof structure


ill. 248

Example floor structure

CONSTRUCTION ELEMENTS								
	WALL 1	WALL2	WALL3	ROOF 1	ROOF 2	FLOOR1	FLOOR2	ROCK
								
Thickness [mm]:	301	436	329	304	455	244	320	1011
Insulation [mm]:	228	246	228	160	300	150	180	-
U-value [W/m²K]:	0.18	0.15	0.18	0.18	0.09	0.15	0.09	-
Bearing:	Wood	Concrete	Mix	Wood	Massive wood	Concrete	Concrete	-
Cladding:	Wood	Stone	Mix	Wood	Mix	Parquet	Stone	Stone

More details about each element can be seen in [Appendix 16].
[ROCKWOOL, 2012]

ill. 249

CONCLUSION

These elements will be used further in Simien for both the indoor climate and energy usage analysis. Due to the way the model is simplified into larger elements when making the Simien analysis, the elements with mixed bearing or cladding is a result of other elements mixed to get a mean value. See [Appendix 16] for more details.

INTERIOR MATERIALITY

The interior materials for all hotel rooms will in this chapter be visualized and described. Due to the similarity of interior finishing for all rooms, only one visualisation has been chosen for this purpose.

The material choices has been inspired by the context and the underground cave atmosphere. Two contrasting environments that with its materiality relate to its context. The concept is to have warm and comfortable hotel rooms that reflects on the idea of being one with the surrounding nature. Therefore pine wood has been chosen to represent the hotel rooms. On all floors and walls, the wood has been arranged in horizontal lines that points out to the rich forest landscape to give the users a direction of the view towards the beautiful context. Another aspect is to use a local material to lower the transportation and production cost and reuse the many pines trees that needs to be cut down, when building this hotel.

In contrary to the warm and natural look expression on the outer part of the hotel, a darker and colder atmosphere has been chosen for the inner part. A transition from being out in the open green landscape to a dark and closed cave atrium, with only small light streaks penetrating the open dark space that uplights the natural rock wall. Regarding materiality of the atrium, it has been kept as "natural" as possible, with rock clift walls that was created when the atrium was dug out. In combination with dark stone tiles that defines the added hotel functions, it creates a dark an intimate atmosphere with small narrow paths leading into cave functions which also are tried to be maintained natural.

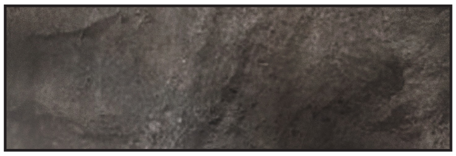
ill. 250

The mogul hotel rooms resting down the hillside is cladded with wood giving a warm and cozy atmosphere for the guests. The restaurant, cafe and shops resting over ground all have a wooden cladding, giving them a natural feel that links to the views they behold, and the context they are in - surrounded by the forest landscape.

ill. 251

The atrium, tunnels and cave rooms are using the natural rock wall. The massive rock surfaces has a cold and hard finish which gives an unique atmosphere inside the cave environment. The deep caves get only minimal of daylight in contrasts to the well lit and softer moguls.

Pine wood ill. 252



Rock surface ill. 253

Stone tiles ill. 254

CONCLUSION

The mogul shaped functions which connects to the surrounding nature and forest landscape, use wooden cladding to give a natural and warm atmosphere that relates to the given context. The inner cave functions which is found inside the ground, use the natural rock surfaces and stone tiles to emphasize an underground ambience. The choices of the materials is to enhance an unique atmosphere in relation with the context.

INDOOR CLIMATE
- SIMIEN

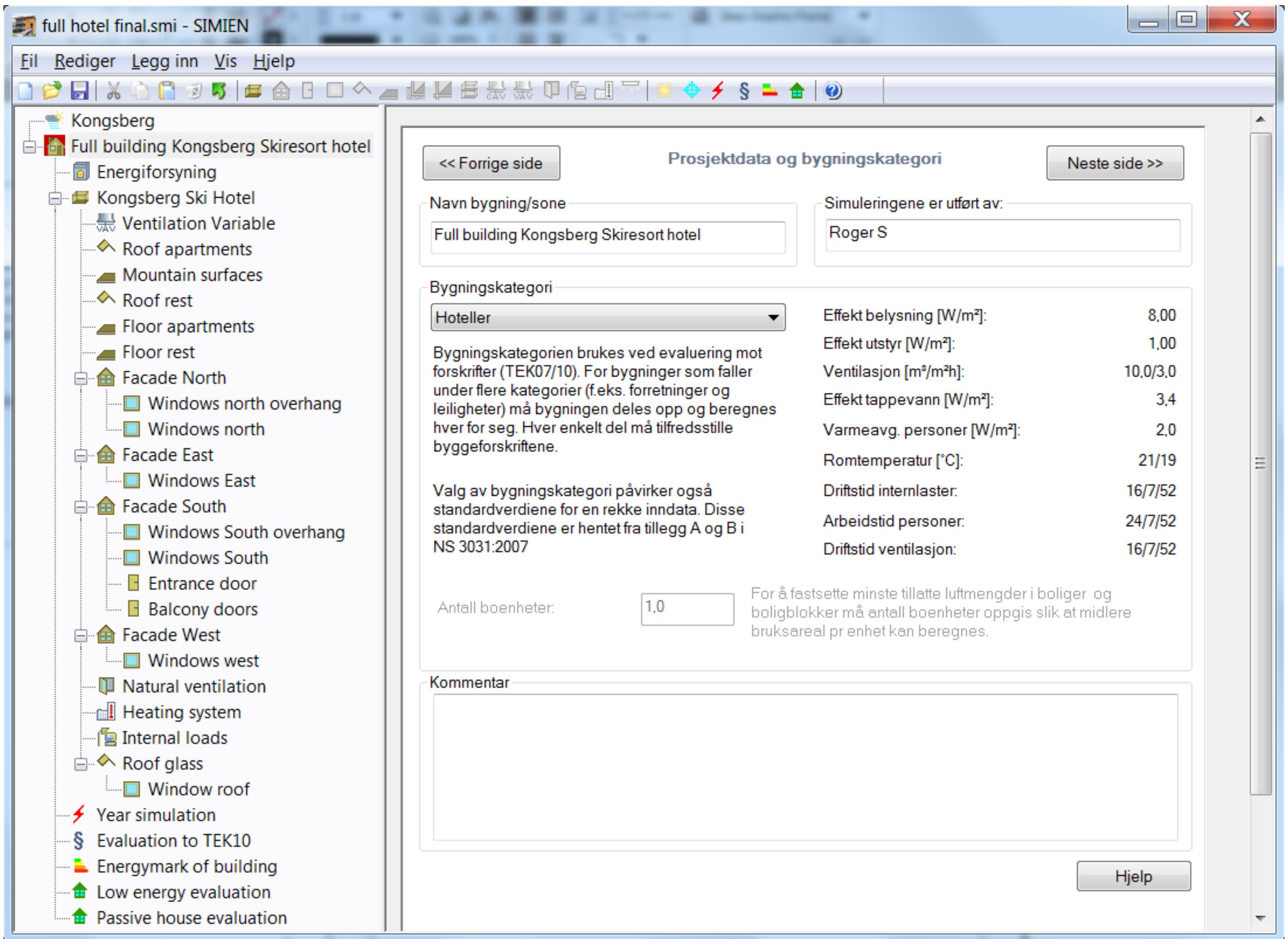
It is important to ensure that the hotel rooms provides a pleasant place to stay, and thus that they have a good indoor climate both summer and winter. Indoor temperatures, ventilation rates and CO_2 levels are aspects that will be looked at to ensure a comfortable stay at all times. Simien will be used to analyze those aspects, and to dimension the heating and ventilation systems needed to keep a good indoor climate. The resulting dimensions for the heating and cooling systems will later be used as input for the larger Simien model to evaluate the energy usage in MEDIUM SCALE. There will be done one test of winter time and one of summer time, as the systems operate different based on time of year. Since the project is using Simen a description of the program and a comparison towards BSIM/BE10 has been made below.

SIMIEN

Simien is a Norwegian program for analysing indoor climate and energy consumption of a building. The program is based on the new Norwegian technical standard TEK10 and will be used to replace BSIM and BE10 for the project since the hotel is designed in Norway. In Simien, one must like in BSIM make two separate models. The first model will be focusing on a single room/zone that will be used to analyse the indoor climate. The second will be a larger model of the whole building that is used for calculating energy consumption during the MEDIUM SCALE. [simien, 2012]

THE PROGRAM

In contrast to BSIM where you model up the zones in 3D, Simien only allows you to input all the details for walls, floors, roofs and other details by typing values. This makes the process a bit easier since you can enter modeldata that may be difficult to model in BSIM's modelling tool, but it also means that all data must be carefully entered as it is harder to notice if something is missing or made wrong. Therefore after entering all wall, floor and roof values one should do a quick analyse, and check that the total floor, roof and wall areas are correct according to your building. The program is a bit more user-friendly than BSIM and have a more articulated user interface. The program also cover both BSIM and BE10's functions and simplifies the process of estimating the rooms indoor climate and the buildings energy consumption.



ill. 255 screenshot - Simien

INDOOR CLIMATE REQUIREMENTS

The indoor climate will be determined for the different hotel rooms to find the dimensions for the heating and cooling systems.
The values listed below are requirements from TEK10 that has to be fulfilled, and they will be used as inputs and minimum/maximum goals for results in the analysis. Most of these values are integrated with the program from start when choosing building category.

Limit values for all rooms will be as follows (ill. 256).

INDOOR CLIMATE REQUIREMENTS TEK10		
	Minimum	Maximum
CO2 value [PPM]:	-	800
Indoor air temperature [°C]:	19	25*
Indoor air temperature while heating [°C]:	19	22
Daily temperature difference [°C]:	-	4
Air flow operating hours [m³/m²h]:	10	-
Airchange rate operating hours [l/s/m²]:	2.78	-
Air flow outside operating hours [m³/m²h]:	3	-
Airchange rate outside operating hours [l/s/m²]:	0.83	-
Effect Hot Water [W/m²]:	3.4	-

[SIMIEN]
*During summer it is allowed to exceed the maximum indoor air temperature for a maximum of 50 hours.
A full list of all inputs going into the analysis can be found in [Appendix 17].

ill. 256

THE ANALYSIS

The different hotel rooms will be analysed in Simien to find the dimensions for the heating and cooling systems in each of them. The construction elements made in the Rockwool program will be used, and all values will follow the requirements from TEK10.

The table below shows variables given when choosing the building category. These values are the frame of the setup and are not supposed to be changed as they are absolute values based on TEK10 and NS3031 for the chosen building category.

PROJECT DATA AND BUILDING CATHEGORY		
Building cathegory:	Hotel	
Effect ligthing [W/m²]:	8	
Effect equipent [W/m²]:	1	
Ventilation [m³/m²h]:	10/3	in operating hours/outside operating hours
Effect tapwater [W/m²]:	3.4	
Heatgains per person [W/m²]:	2	
Room temperature [C°]:	21/19	in operating hours/outside operating hours
Operation hours internal loads:	16/7/52	hours/days/weeks of the year
Working hours people:	24/7/52	hours/days/weeks of the year
Operation hours ventilation:	16/7/52	hours/days/weeks of the year

[TEK10, 2012] & [NS 3031:2007]

ill. 257

See [Appendix 17] for more details on all the inputs for the simulations.

The following are the simulation setups used to analyse the indoor climate in each room. Different inputs are shown in the scheme below:

SIMULATION SETUP

The settings for both simulations are listed in the table (ill. 258). It sets the starting temperature and day of the simulation as well as the initial room temperature at simulation start. The amount of clothing is only usable for creating the graph showing how many people are unsatisfied with the room temperature, see [Appendix18] for these graphs.

INDOOR CLIMATE SUMMER		
[SIMULATION DATA]		
Roomtemperature at simulation start [°C]:	19	Default
Simulation date:	July 20	Default
Number of simulated days:	20	Max
[INDOOR CLIMATE]		
Clothing:	0.5	0.3 = Shorts & T-shirt, 1.5 = Jeans, shirt & jacket
Activety level:	1	0.8 = sit and relax, 2.0 = standing middle activity
[CLIMATE DATA]		
Use temperature data:	n50	Shows maximum temperature below 50 hours

INDOOR CLIMATE WINTER		
[SIMULATION DATA]		
Roomtemperature at simulation start [°C]:	19	Default
Simulation date:	January 16	Default
Number of simulated days:	20	Max
[INDOOR CLIMATE]		
Clothing:	1	0.3 = Shorts & T-shirt, 1.5 = Jeans, shirt & jacket
Activety level:	1	0.8 = sit and relax, 2.0 = standing middle activity

ill. 258 simulation setup table

SIMULATION RESULTS

The output and result of the simulations are shown in table (ill.260), consisting main numbers from each of the analyse results. The maximum temperature for all hotel rooms is 25 °C, the minimum temperature is 19 °C. The maximum CO_2 level is 562 PPM and the maximum mechanical ventilation rate is 2.8 l/s m².

RESULTS SUMMER						
	Single		Double	Penthouse		Max
	East	West	East	East	West	
Maximum room temperature [°C]:	25	25	25	25	25	25
Maximum operative temperature [°C]:	27.8	27.8	27.7	29.8	29.7	29.8
Maximum CO2 concentration [PPM]:	562	562	562	562	562	562
Max effect cooling battery [W/m²]:	39	38	33	31	34.5	39
Installed effect capacity cooling battery [W/m²]:	39	38	33	31	35	39
Max total ventilation rate [l/s m²]:	2.8	2.8	2.8	2.7	2.7	2.8
Min total ventilation rate [l/s m²]:	0.6	0.6	0.6	0.5	0.5	0.6

RESULTS WINTER						
	Single		Double	Penthouse		Min/ Max
	East	West	East	East	West	
Minimum room temperature [°C]:	19	19	19	19	19	19
Maximum operative temperature [°C]:	19.3	19.3	19.1	19.9	20	20
Maximum CO2 concentration [PPM]:	559	559	559	559	559	559
Max effect heating battery [W/m²]:	13.1	13.1	13.1	13.2	13.2	13.2
Installed effect capacity heating battery [W/m²]:	14	14	14	14	14	14
Maximum effect heating system [W/m²]:	21.1	21.1	22	21.3	21.2	22
Installed effect capacity heating system [W/m²]:	22	22	22	22	22	22
Max total ventilation rate [l/s m²]:	1.9	1.9	1.9	1.9	1.9	1.9
Min total ventilation rate [l/s m²]:	0.6	0.6	0.6	0.5	0.5	0.6

ill. 260 simulation setup table

MONTHLY TEMPERATURE DATA

This is a table showing the average, max and minimum temperatures. The minimum temperature of 19 °C occurs between November and March, while the maximum temperature of 25 °C occurs between May and August.

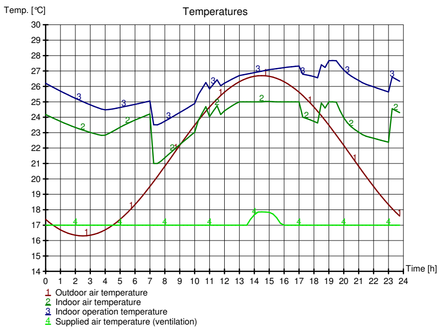
Monthly temperature data (air temperature)						
Month	Mean out	Max out	Min out	Mean inside	Max inside	Min inside
January	-7,0 ℃	5,4 ℃	-21,0 ℃	20,4 ℃	21,0 ℃	19,0 ℃
February	-5,8 ℃	6,9 ℃	-20,6 ℃	20,4 ℃	21,2 ℃	19,0 ℃
March	-0,7 ℃	10,4 ℃	-13,3 ℃	20,5 ℃	21,8 ℃	19,0 ℃
April	4,0 ℃	15,3 ℃	-7,9 ℃	21,5 ℃	23,4 ℃	19,4 ℃
May	10,6 ℃	23,5 ℃	-1,3 ℃	23,2 ℃	25,0 ℃	20,6 ℃
June	15,3 ℃	27,3 ℃	4,2 ℃	24,0 ℃	25,0 ℃	22,2 ℃
July	16,5 ℃	27,2 ℃	5,2 ℃	24,3 ℃	25,0 ℃	22,8 ℃
August	14,7 ℃	24,6 ℃	2,6 ℃	23,6 ℃	25,0 ℃	22,3 ℃
September	9,4 ℃	19,9 ℃	-0,4 ℃	22,2 ℃	24,2 ℃	20,4 ℃
October	5,4 ℃	15,7 ℃	-3,9 ℃	20,9 ℃	22,2 ℃	19,2 ℃
November	-1,0 ℃	8,6 ℃	-11,1 ℃	20,5 ℃	21,0 ℃	19,0 ℃
December	-6,0 ℃	6,2 ℃	-19,9 ℃	20,4 ℃	21,0 ℃	19,0 ℃

ill. 261 simulation setup table

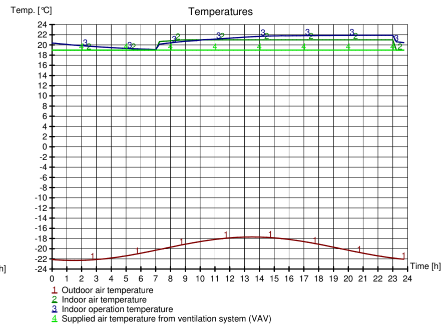
SELECTED GRAPHS FROM DOUBLE ROOM

To show more in depth the variation of temperatures, ventilation and heat gains over the course of a day, some graphs will be displayed showing a 24 hour cycle. The mogul shapes and facades for each room do not differ much, which causes only differences in the indoor climate for the different rooms. Because of this only graphs for one of the rooms will be shown. The Double room has been chosen as its the most common size for a room in the hotel.
More graphs can be found in [Appendix 18]

SUMMER



WINTER



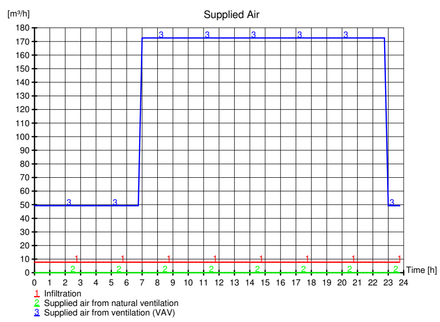
TEMPERATURES

In summer time the indoor air temperature never go above 25 °C and reach max between 1pm and 8pm.

In winter time the temperature never go below 19 °C, and never below 21 °C during operating hours.

SUMMER

WINTER

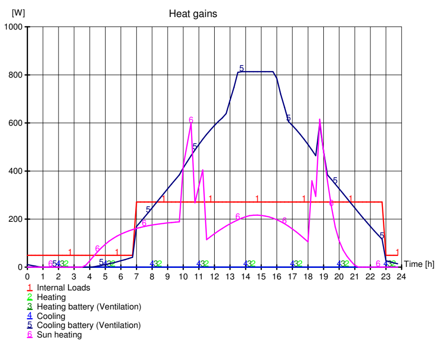


SUPPLIED AIR

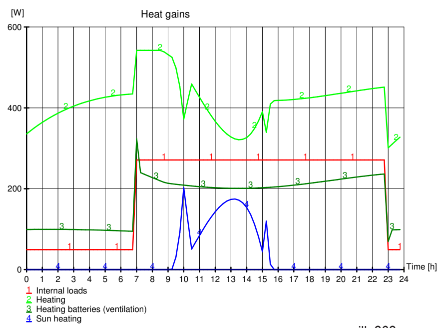
In summer time most of the supplied air comes from natural ventilation between 7am and 5am. The rest of the day only mechanical ventilation is used. Max ventilation rate is 2.8 l/s m² (0.6 outside operation h).

In winter time there is no natural ventilation used, and the mechanical ventilation has operation hours between 7am and 11pm, but is always running. Max ventilation rate is 1.9 l/s m² (0.6 outside operation h).

SUMMER



WINTER



ill. 262

HEAT GAINS

In summer time the internal loads, sun heating and cooling batteries for ventilation are the heat gain sources. Heating and heating batteries are not active in summer time.

During winter time the internal loads, heating batteries from ventilation and sun heating are the heat gain sources. No cooling is used during winter time.

CONCLUSION

The analysis show that the indoor climate works well for all the 4 rooms, both on the east and west wing. Important changes to get the temperature down during summer was to add the overhang of 0.5 meters, blinds with good shading as well as good ventilation. For winter time it was important to adjust the maximum effect for room heating and ventilation heating in order to maintain 19 °C. For more details on all values put into the calculations see [Appendix 17], and for more results see [Appendix18].

VENTILATION

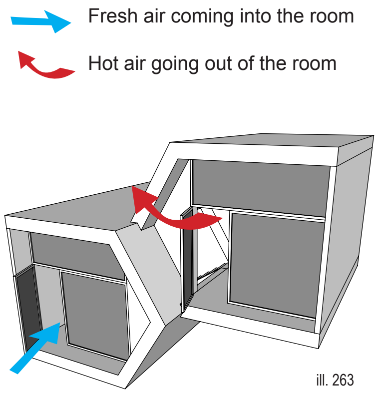
This chapter will look at how the natural and mechanical ventilation works for the hotel rooms. The ventilation will be covered by mechanical ventilation with heat recovery during winter time to save heatloss, and mechanical ventilation combined with natural ventilation during summer time to save energy usage.

MECHANICAL VENTILATION

The mechanical ventilation will take fresh air from outside the bottom level for the hotel, and outside the parking level for the parking part (not inside the parking). The hotels mechanical ventilation will exhale on the top level and in this way use thermal buoyancy to save energy used to transport the air. In winter time the air is heated to 19 °C before going into the rooms [TEK10]. Heat recovery will help heating up the new air coming in to save energy for the process.

NATURAL VENTILATION

The natural ventilation will also use thermal buoyancy as much as possible to improve the effect it has on the room cooling during summer. For the double height rooms there will naturally be a height difference when opening doors on both floors, where the fresh air could circulate from the lower to the higher floor. For rooms with only one story height the top window can be tilted out to allow air to come in through the door, and then circulate to exit through the upper window opening.



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Natural ventilation

TABLES

The following tables are created based on results from the indoor climate analysis in Simien and show how the natural and mechanical ventilation works for summer and winter for each of the rooms. The mechanical ventilation only differ slightly for the different rooms, while the natural ventilation range from 3.3 l/s m² to 8.0 l/s m² in summer time. In winter time the natural ventilation rate is 0.0 l/s m² as its not active.

For more info about the values behind the tables, see [Appendix 18].

RESULTS SUMMER						
	Single		Double	Penthouse		Max / Min
	East	West	East	East	West	
Max mechanical ventilation rate [l/s m²]:	2.8	2.8	2.8	2.7	2.7	2.8
Max natural ventilation rate [l/s m²]:	8.0	8.0	5.6	3.3	3.3	8.0
Infiltration rate [l/s m²]:	0.1	0.1	0.1	0.1	0.1	0.1
Min mechanical ventilation rate [l/s m²]:	0.6	0.6	0.6	0.5	0.5	0.6

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RESULTS WINTER						
	Single		Double	Penthouse		Max / Min
	East	West	East	East	West	
Max mechanical ventilation rate [l/s m²]:	1.9	1.9	1.9	1.9	1.9	1.9
Max natural ventilation rate [l/s m²]:	0.0	0.0	0.0	0.0	0.0	0.0
Infiltration rate [l/s m²]:	0.1	0.1	0.1	0.1	0.1	0.1
Min mechanical ventilation rate [l/s m²]:	0.6	0.6	0.6	0.5	0.5	0.6

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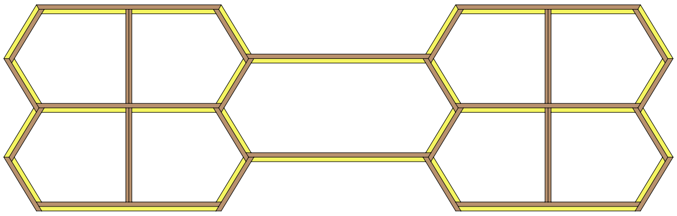
CONCLUSION

A combination of mechanical and natural ventilation is used for summer time to save energy usage. The maximum total ventilation rate reach about 10 l/s m² in summer peak time. with almost 80% of this being covered by natural ventilation. Mechanical ventilation with heat recovery is used in winter time to save energy, as the outdoor temperature is too cold to be ventilated naturally into the building. Thermal buoyancy is used for both mechanical and natural ventilation to help the effectivity of the systems and to save energy.

BUILDING ELEMENTS

Due to the shape of the moguls that perfectly fits together when assembled, gives the opportunities for prefabrication. This chapter concerns on how the structure of the moguls can be solved considering bearing and insulation. The structure needs a repeative pattern with similar parts that easily can be brought on site and assembled.



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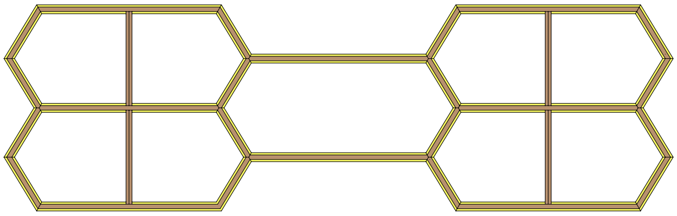
Design 1
This design alternates between having the bearing structure and the insulation as the inner layer. This works structurally, but cold bridges are created in the joints.



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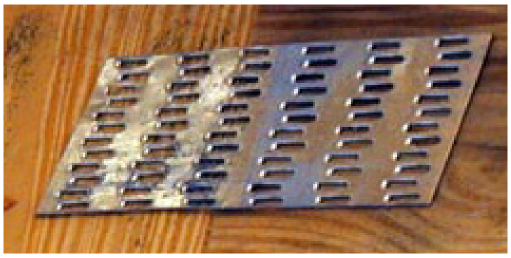
Design 2
This solution place the bearing structure in the middle and covers it with half of the insulation on each side. This eliminates the problem in design 1 with the cold bridges.

JOINTS

The structural joints are solved with Punched metal plate connectors that holds 2 or 3 meeting wood elements together. This works well for connecting coplanar wooden elements. One can save upto 30% of the wood material use by using these joints over traditional structures with nails. [Bovanail, 2012]
When insulation and the wooden decks has been placed outside the construction these joints will not be visible to the users. [Bovanail, 2012]



Example of metal plate connector used to connect two coplanar wooden elements.

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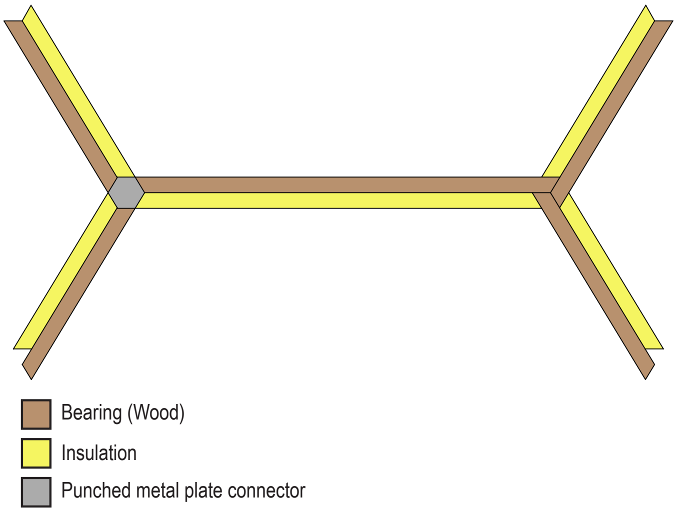

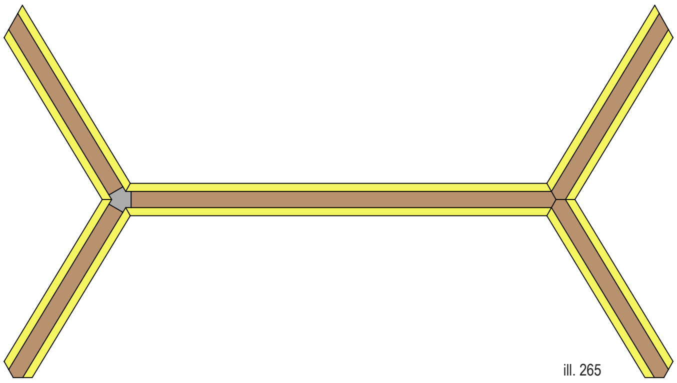

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CONCLUSION

Design 2 creates less cold bridges than design 1 and is the chosen design. It is also easy to construct as it has similar angles in the meeting ends, and there will be few special components. It should be noted that this image shows the solution for external walls, while internal parts of the walls do not need all the insulation.

PREFABRICATION

Prefabrication can save both time and money [prefab, 2012], and will be used for the mogul elements. This chapter gives an example of the procedure and will not go into assembling details etc. All illustrations are examples and not final pre fabrication solutions.

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Moguls as prefabricated elements placed ontop of each other

If needed, unique parts can also be prefabricated and placed with ease into the system without braking it.

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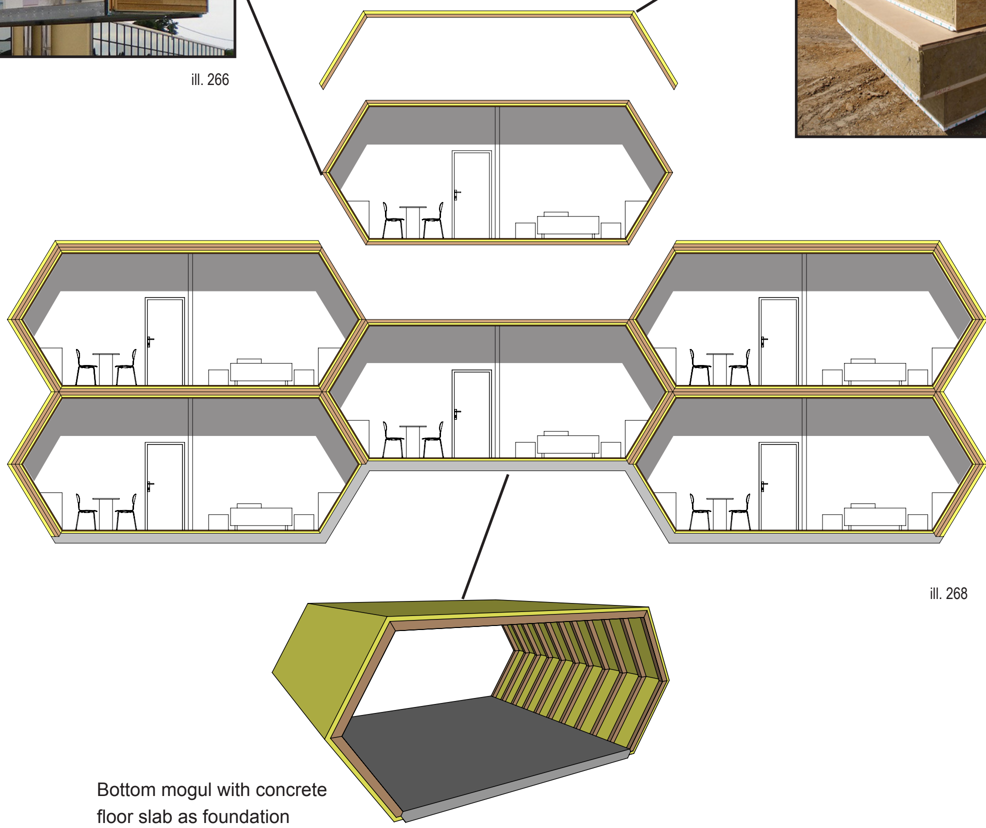

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Bottom mogul with concrete floor slab as foundation

CONCLUSION

With the mogul shape being flexible and easy to combine it makes an excellent module for prefabrication. The bottom moguls will rest on concrete foundation slabs, and the top moguls will have a different cladding on the roof, but all the moguls can be prefabricated in the same way and fit together in a system. Each mogul will have its own bearing making each part rigid even before assembled. When connected to each other and attached with the punched metal plates, the moguls gain their full strength. Prefabrication can save construction cost as well as production time, and often leads to less material waste which affordable and cheaper to produce.

DESIGN CONSIDERATIONS

A checklist is made to ensure the different technical and architectural considerations have been met. All mogul rooms combined are evaluated in this process. All points on the checklist should be passed before the process moves on to the MEDIUM SCALE.

CHECKLIST - MOGULS

TECHNICAL CONSIDERATIONS

INDOOR CLIMATE
- Max. temperature 25°
- Min. temperature 19°
- Min. ventilation 10/3 m³/m² h
- Max. CO_2 800 PPM

DAYLIGHT
- Daylight factor 2%
- Part daylight factor 5%

SOLAR GAIN
- Facade towards south - heating
- Shaders

ARCHITECTURAL CONSIDERATIONS

ROOM PROGRAM
- Single room area 16.6 m²
- Double room area 26.0/28.2 m²
- Penthouse room area 43.5 m²

DESIGN PRINCIPLES
- Some 2 story rooms
- Entrance from north
- South / southwest balconies
- Minimizing waste spaces
- Prefabrication friendly design

CONCLUSION

With all 4 mogul room designs analyzed and each of them passing both the technical and architectural consideration checklist, the process can move on to the MEDIUM SCALE where the whole building will be analyzed.

MEDIUM SCALE

- THE BUILDING

The first design proposal of the building will in this chapter be improved by another iteration phase. This will cover the aesthetic as well as technical requirements stated in the design criteria chapter. The technical and architectural aspects of the building will be evaluated, and the buildings energy consumption will be simulated in Simien. The building will also be evaluated towards the TEK10 building regulations, NS3700 low energy and passive house requirements. Lastly the buildings energy efficiency rating will be tested.

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FURTHER ELABORATION

As seen on the initial visualization and the checklist, several points stating the weak points that needs to be further articulated due to the critique given during the design process. The entrance needs to be further elaborated in order to differ from a standard entrance solution and the big panoramic restaurant should have a shape the makes the connection more coherent as one united building shape. A skithrough that also could relate to the shape of the moguls.

CHECKLIST

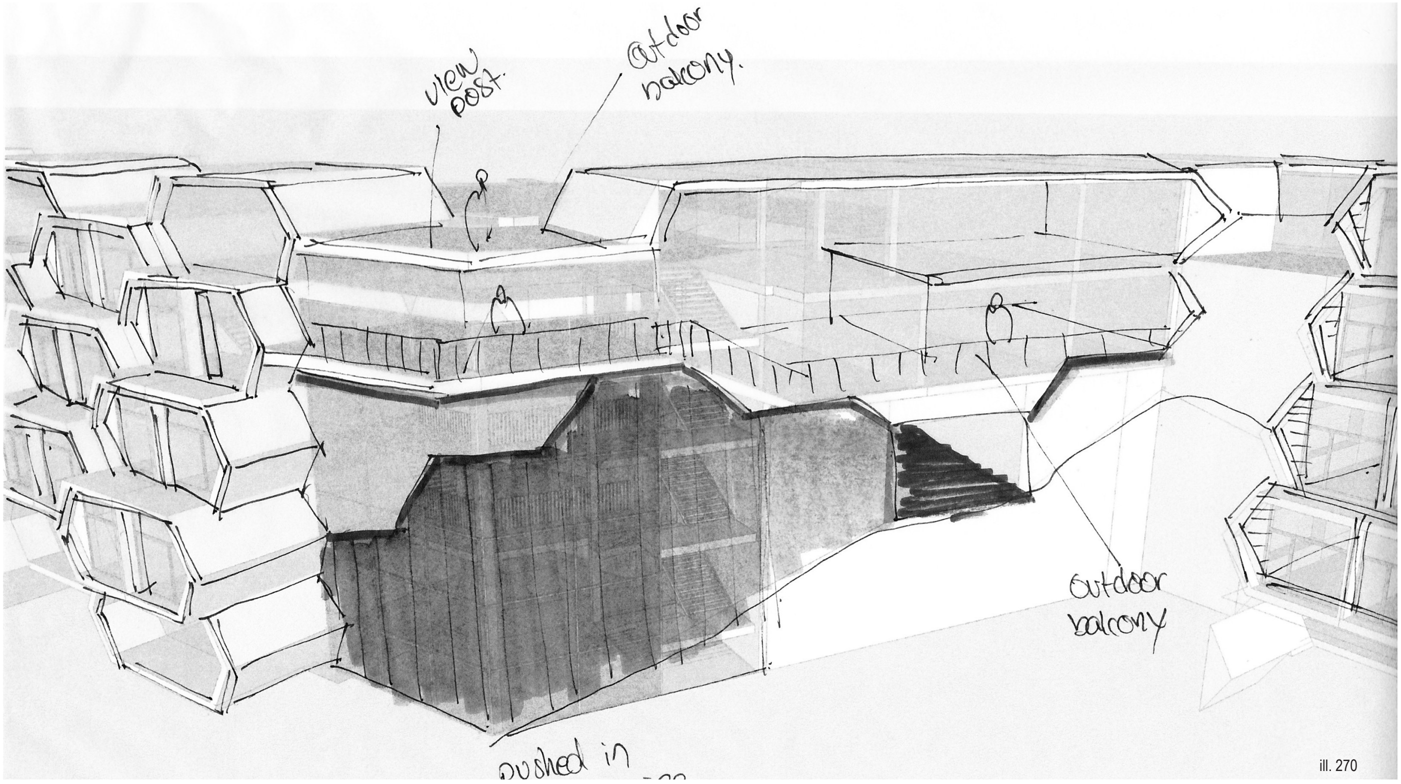
- Good view from restaurant
- Double storey height
- Restaurant design fitting moguls
- Outdoor balcony for restaurant
- Skithrough exit away from rooms
- Entrance design fitting moguls
- Viewpoint meeting with mogul shape
- Restaurant view to the west slopes

2nd ITERATION OF BUILDING

Based on the aforementioned weakpoints, several models and sketches were made and analysed to gain useful qualities that could be implemented in the final design. Both architectural and technical qualities were taken into consideration and final sketch is shown and evaluated.

CHECKLIST

- Good view from restaurant
- Double storey height
- Restaurant design fitting moguls
- Outdoor balcony for restaurant
- Skithrough exit away from rooms
- Entrance design fitting moguls
- Viewpoint meeting with mogul shape
- Restaurant view to the west slopes



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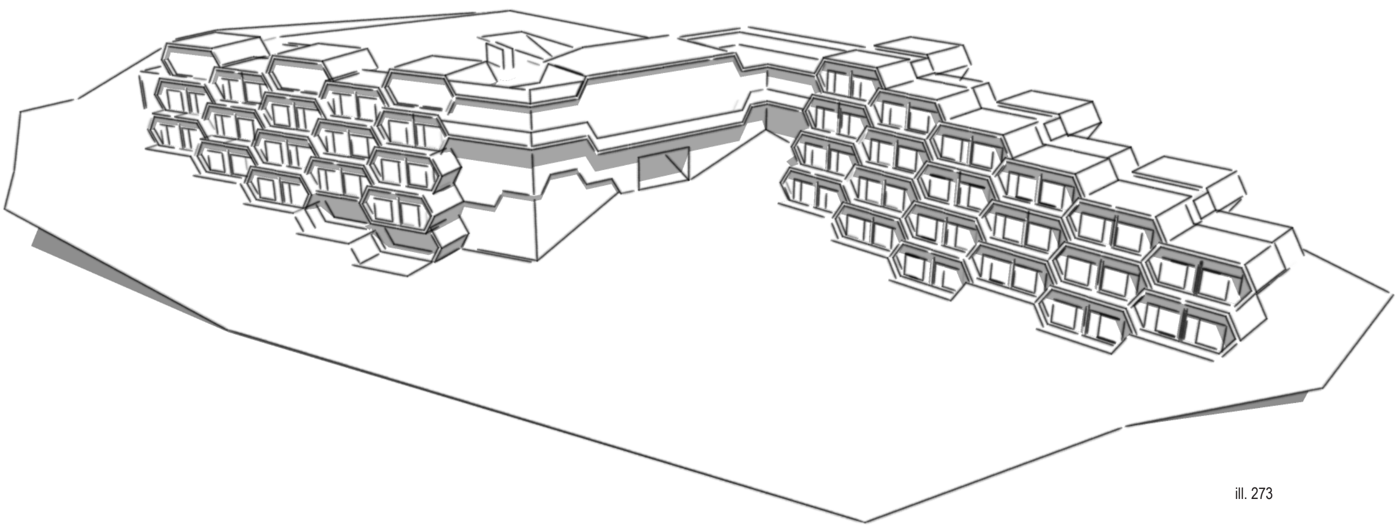
CONCLUSION

By taking the design through another iteration phase, new ideas and solutions was presented. The new idea emphasizes the continuity of the horizontal lines from the mogul shape and use these to outline the restaurant function. The idea of having a “bridge” connecting the two apartment zone, which open up for a skithrough underneath is done with same movement and flow in the moguls to make the building coherent. The entrance opening is also using the mogul shapes for inspiration and lets the stone surface above it arch from east to west to carry the loads down on each side of the entrance. All facades facing south are pushed in to work as shading and to emphasize the shape of the moguls.

HOTEL CAPACITY

With the grid system and the shape of the moguls various combinations can be made, because each moguls fits perfectly together. This design proposal can host up to 63 people [Room program]. 70% of the hotel capacity is in couple/twin rooms, 16% in penthouse and 14% in single rooms. The village cabins capacity is planned to accommodate around 72 people, tottaling 135 people for the whole hotel. The hotel's public functions are dimensioned to be for both the people living at the hotel and in the village, as well as for other guests coming by for the surrounding activities.



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WEST WING

The west wing has the largest mix of functions, and it also house the atrium with the sky elevators, climbing wall and reception. This wing also house the cave cinema/auditorium, cave pool, cafe and shop. The activities are focused in a cave environment.

CENTER

The center part holds public functions such as the restaurant, conference rooms, sky elevator access, main entrance with lounge area and the festive cave hall that can be rent out in the bottom floor. The ski through is also going through this part.

EAST WING

The East wing consist of both hotel rooms and wellness activities with focus on a strong connection with the natural environment above ground.

HOTEL ROOM CAPACITY					
	West	East	Total	People	%
Double	8	14	22	44	70
Single	3	6	9	9	14
Penthouse	3	2	5	10	16
Sum	14	22	36	63	100

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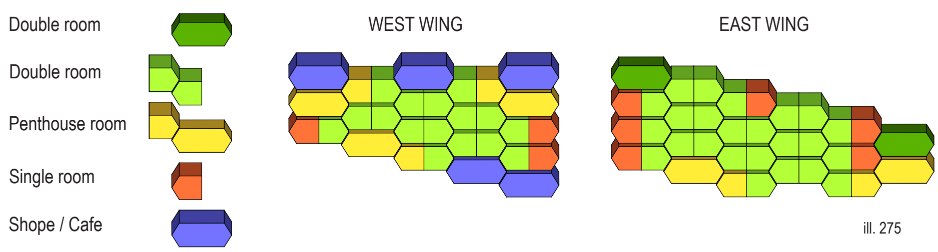

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EXTERIOR MATERIALITY

As previous stated in the interior chapter, one can find similarity of the material choices of the exterior finishes. The two main materials of the area is wood and stone, and those are also the two materials used for the building's exterior cladding.

Wood

Stone tiles

The Eastern part of the hotel covers what used to be a hillsides crowded with pine threes, which has been an inspiration for the material choice. By respecting the context, we "give" back what was taken from there. Pine wood cladding on the outer refering to the idea of the pine trees being cut and assembled on site. The pine wood which is a renewable and local building material has also been chosen due to the sustainable aspect,

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The restaurant is resting on the edge of a cliff, a straight cut going down to the ground level below. When making this cut stone will be excavated from the site. Stone tiles from this will be the facade element of this cut. This way the stone is also reused and respected for its place. The material will also be used further up the ski through where the vertical cut continues. The entrance to the cave atrium is found on the ground level where a glass facade covers up the cave opening. The cave opening use the lines from the moguls in an arch-like way, in order to bring forces down on each side of the cave opening. This glass facade is the source of daylight coming into the entrance lounge area. Sunlight may reach deep into the atrium space from this facade in early winter mornings.

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CONCLUSION

The building is shaped after the nature and landscape of the site, and the material also reflects on this. The mogul shapes housing the hotel rooms, restaurant, shops and wellness functions above the ground are all cladded in wood, which comes from the trees that used to grow in the very same hillside. The restaurant rests over the edge of a cliff, where the vertical wall under it is covered by stone tiles from the mountain. There are two openings in the cliff wall, the first being the ski through, which is also covered with stone tiles. The second is the main entrance facade which is covered with glass. The facade is pushed in and represents a cave opening as the rock wall arcs above the entrance, leading the forces down on each side of the opening.

ENERGY CONSUMPTION
- SIMIEN

Simien will be used to estimate the energy consumption in the building. A simplified model has been used to input walls, floor, roofs, windows and other details to simulate the structure as a whole. Inputs about heating and ventilation systems has been based on the values found in the indoor climate analyses.

5 different tests will be run. The first is a year simulation of energy usage, 3 tests are evaluating the building against different set of requirements (TEK10 building regulations, NS3700 Low energy requirements, and NS3700 passive house requirements). The last test will begiving the building an energy efficiency rating.

The primary goal is to meet the requirements from TEK10, which is crucial to be allowed to make a building, while secondary goals are to meet the NS3700 regulations for low energy houses, and to achieve a energy efficiency rating of A or B. The test for passive house will also be done, but its not a goal to pass this, as it requires alot from the building to do a passive house in Norwegian climate conditions.

TEK10 BUILDING REGULATIONS

The following are rules and requirements that has to be followed according to TEK10. This will be used when setting up the model in Simien, and the results from the tests will be checked against these values to ensure each of them are fulfilled.

The energy measures are average value requirements for the whole building. Individual elements may go outside these values as long as the mean value is still within the energy measures.

ENERGY MEASURES	
Total window and door area compared to total floor area [%]:	Max. 20 / Min. 10
Total average U-value for walls [W/m²K]:	0.18
Total average U-value for roofs [W/m²K]:	0.13
Total average U-value for floors [W/m²K]:	0.15
Total average U-value for windows and doors [W/m²K]:	1.2
Value for Normalized cold bridge:	0.06
Efficiency on heat gain for ventilation [%] (70 in TEK07):	80
Specific fan effect:	2

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The minimum requirements are absolute values that must be held by any and all individual components in the building. If the energy measures are met without meeting the minimum requirements, the building will still not pass the TEK10 building regulations.

MINIMUM REQUIREMENTS	
Individual U-value external walls [W/m²K]:	0.22
Individual U-value external roof [W/m²K]:	0.18
Individual U-value external floor [W/m²K]:	0.18
Individual U-value external windows and doors [W/m²K]:	1.6
Individual leakage number:	3
Heat loss figures for windows/doors may not exceed:	0.14*
Total sunfactor for glass/window must be less than	0.15**
Heating need that should be covered with other energy sources than direct el. [%]:	60***

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* This means that one must compensate with lower U-values if window area exceeds 20% of the floor area.
** Does not count if the building has no cooling needs.
*** For buildings with more than 500 m² of heated floor area.

ENERGY FRAME

When calculating energy frame there are some set parameters to follow.

- Oslo climate is to be used
- Number of operating days are set by building category
- For infiltration calculations there should be chosen 'moderate shielding' and 'more than one wind exposed facade'. This gives an infiltration rate of 0.07 times the leakage number.
- There are used fixed values for effect and heatgain from lighting, equipment, people and dhw. It should also be used a fixed value for setpoint temperature of the heating system.

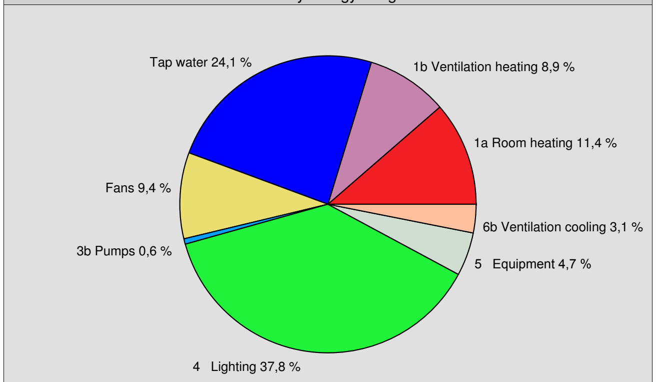
http://www.programbyggerne.no/SIMIEN/bruk

YEAR SIMULATION OF ENERGY USAGE

The first analyse which is the ones used for adjusting most settings and values, is the year simulation. This simulation let you analyse the whole building over the course of a year, and gives you a full feedback on yearly energy budgets, delivered energy sources, heatloss budgets etc. It displays both a table of the values, and diagrams for easy visualisation of the data. These tables and diagrams will be used to show how the building performs according to energy usage.
For info about inputs going into these analysis see [Appendix 19].

RESULTS

Yearly energy budget



Energy post	Energy need	Specific energy need
1a Room heating	99185 kWh	14,0 kWh/m²
1b Ventilation heating (heat batteries)	77714 kWh	11,0 kWh/m²
2 Hot water (tap water)	210622 kWh	29,8 kWh/m²
3a Fans	82006 kWh	11,6 kWh/m²
3b Pumps	5175 kWh	0,7 kWh/m²
4 Lighting	330332 kWh	46,7 kWh/m²
5 Equipment	41291 kWh	5,8 kWh/m²
6a Room cooling	0 kWh	0,0 kWh/m²
6b Ventilation cooling (cooling batteries)	27142 kWh	3,8 kWh/m²
Total netto energy need, sum 1-6	873468 kWh	123,6 kWh/m²

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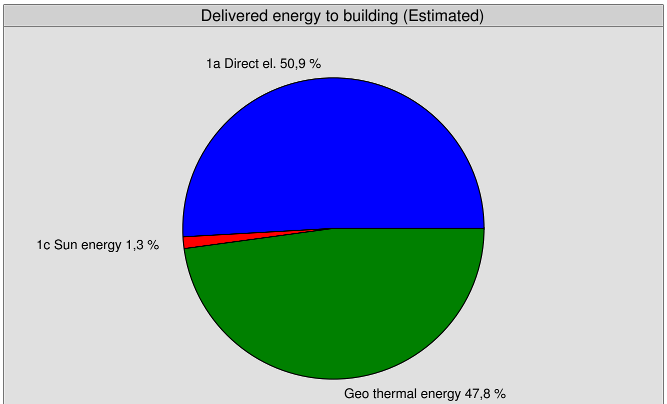
Delivered energy to building (Estimated)



Energy type	Delivered Energy	Specific
1a Direct el.	412347 kWh	58,3 kWh/m²
1b El. Heat pump	0 kWh	0,0 kWh/m²
1c Sun energy	10196 kWh	1,4 kWh/m²
2 Oil	0 kWh	0,0 kWh/m²
3 Gas	0 kWh	0,0 kWh/m²
4 District heating	0 kWh	0,0 kWh/m²
5 Biofuel	0 kWh	0,0 kWh/m²
Geo Thermal heating	387522 kWh	54,8 kWh/m²
Total delivered energy, sum 1-6	810064 kWh	114,6 kWh/m²

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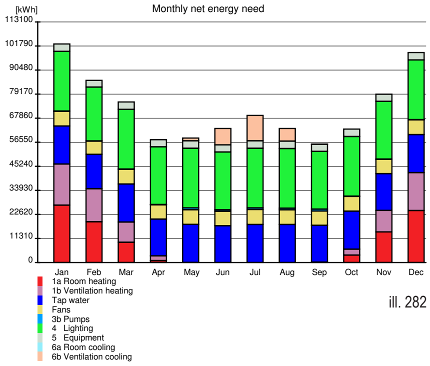
This table and diagram shows the amount and share of energy that is used from each post. It shows that most of the energy goes to lighting (37.8%), while the second and third largest post are tap water (24.1%) and room heating (11.4%). Summed up it shows that 44.4% of all the energy usage goes to some sort of heating, while only 3.1% goes to ventilation cooling.

This table and diagram shows the amount and share of each energy source used to cover the energy need. It shows that 50.9% of the total energy need of the structure is covered by direct electricity, 47.8% is covered by geo thermal energy and 1.3% is covered by the energy saving from the hybrid light system. 58.3 kWh/m² is the direct electrical usage, which could be lowered by using solar panels.



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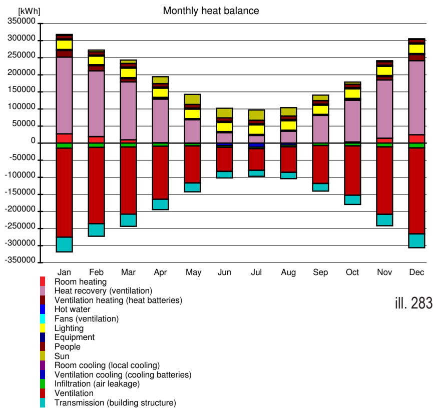
This diagram shows the monthly net energy need of each post. One can see that room heating and ventilation heating is active from October to April, with no room heating in the summer. The ventilation cooling is active only from May to August. Lighting, fans and tap water is active all year long.



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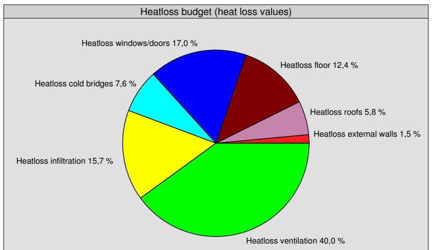
This diagram shows the monthly heat balance of each post. This is useful to see where the heat is gained from, and by which mean its lost. It shows that most heat is lost from ventilation, while most of the heat gain is from the ventilations heat recovery.

Heatloss budget (heat loss values)



Heatloss external walls	0,01 W/m²K
Heatloss roofs	0,04 W/m²K
Heatloss floor to ground/free air	0,08 W/m²K
Heatloss glass/windows/doors	0,11 W/m²K
Heatloss cold bridges	0,05 W/m²K
Heatloss infiltration	0,10 W/m²K
Heatloss ventilation	0,26 W/m²K
Total heatloss value	0,66 W/m²K

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This table and diagram shows the amount and share of each heatloss post. It shows that most of the loss (40%) comes from ventilation. The total heatloss value is 0.66 W/m²K.

CONCLUSION

During this process different inputs has been tweaked, and all the values gotten from the previous analysis has been added to ensure that the building give a good indoor climate. The energy usage has been lowered by adding elements with lower U-values for other elements than the moguls. These figures are good for estimating the energy usage and to see how much energy each post use. It is also good for tracking how changes done affect the different results, but its the next test that will be the crucial one, as it will check if the building meets the requirements in TEK10, the Norwegian building regulations. See [Appendix 19] to see details of all the inputs going into this phase, and [Appendix 20] to see more details about the results from the test.

EVALUATION TOWARDS TEK10, NORWEGIAN BUILDING REGULATIONS

After adjusting the different systems and getting a low energy usage while still meeting all the requirements found to keep a good indoor climate, the building is evaluated towards the Norwegian building regulations TEK10. These are absolute requirements, and has to be met for the building to be allowed to be built. See [Appendix 21] for more details.

INPUTS OF EVALUATION TOWARDS TEK10 REQUIREMENTS		
Reduced effect lighting [W/m²]:	6.4	-20% from steering system [NS3031] [SIMIEN]

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RESULTS

This table show that the different paragraphs in the Norwegian building regulations [TEK10] are met. Results in green mean they pass the requirement, while results in red means they do not pass.

RESULTS FROM EVALUATION	
Energy measures:	The building satisfies the requirements for energy measures in paragraph § 14-3
Heat loss frame:	The building satisfies the requirements for heat loss figures according to § 14-3
Energy frame:	The building satisfies the energy frame according to § 14-4
Minimum req.:	The building satisfies the minimum requirements in § 14-5
Airchange rate vent.:	The airchange volume satisfies the minmum req. given in NS3031:2010 (Table A.6)
Energy supply:	The building satisfies the requirements for energy supplies in § 14-7
Overall evaluation:	The building satisfies the energy requirements in the building regulations.

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These following tables are showing in depth comparasion of the values from the test towards the required value from the building regulations.

Cells in blue are the required value, cells in green are building values that pass the requirement, while cells in red are building values that do not pass the requirement.

ENERGY MEASURES		
	REQ.	VALUE
Total glass-, window and door area according to user area [%]:	20	19.9
U-value exernal walls [W/m²K]:	0.18	0.18
U-value roof [W/m²K]:	0.13	0.13
U-value floor toward ground and to the outdoor [W/m²K]:	0.15	0.12
U-value glass/windows/doors [W/m²K]:	1.2	0.56
Normalized cold bridge value [W/m²K]:	0.06	0.05
Leakage value (tightness at 50 Pa preassure difference) [Airchanges per h.]:	1.5	1.5
Yearly average temperature efficiency of heat recovery in ventilation [%]:	80	85
Specific fan effect (SFP) [kW/m³/s]:	2	1.5

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REDISTRIBUTION ENERGY MEASURES		
	REQ.	VALUE
Heat loss figures external walls:	0.01	0.01
Heat loss figures roof:	0.04	0.04
Heat loss figures floor on groun/to the outdoor:	0.1	0.08
Heat loss figures glass/windows/doors:	0.24	0.11
Heat loss figures cold bridges:	0.06	0.05
Total heat loss figures:	0.45	0.29

ENERGY FRAME (§ 14-4, Total net energy need)		
Total estimated energy need:	117.5	kWh/m²
Regulatory requirements:	220.0	kWh/m²

MINIMUM REQUIREMENTS (§ 14-5)		
	REQ.	VALUE
U-value external walls [W/m²K]:	0.22	0.18
U-value roof [W/m²K]:	0.18	0.13
U-value floor to ground or to the outdoor [W/m²K]:	0.18	0.12
U-value glass/windows/doors [W/m²K]:	1.6	0.56
Leakage value (Air tightness at 50 Pa preassure difference) [Airchanges per h]:	3	1.5
Heat loss figures glass/windows/doors:	0.24	0.11

ENERGY SUPPLY (§ 14-7)		
	REQ.	VALUE
Share of heat need covered by other sources than direct electricity or fosil fuels:	60%	96%
Oil fired boiler as the base load:	No	No

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CONCLUSION

All the requirements from TEK10 are met, with all the posts meeting or surpassing their required value. As the goal is not only to pass the standard building requirements, but also to pass the low energy standards, there has to be done more testing. The next test will be done towards the NS3700 low energy and passive house standards.

EVALUATION TOWARDS NS3700 LOW ENERGY AND PASSIVE HOUSE STANDARD

With all the TEK10 requirements fulfilled, it will be done tests toward NS3700 regulations for low energy and passive houses, to see if it can meet any of those. both tests will be run, and the building's values will be compared towards the requirements for each of the two regulations. The goal is for the building to pass the low energy requirements, while the passive house requirements is not a goal to be reached. See [Appendix 22] and [Appendix 23] for more details.

RESULTS

RESULTS FROM EVALUATION		
	LOW ENERGY	PASSIVE
Heat loss frame:	Satisfied	Not satisfied
Energy performance:	Satisfied	Not satisfied
Minimum req.:	Satisfied	Not satisfied
Airchange rate vent.:	Satisfied	Satisfied
Overall evaluation:	Satisfied	Not satisfied

HEAT LOSS BUDGET			
	RESULT	LOW ENERGY	PASSIVE
Total heat loss figures:	0.66	0.85	0.65

ENERGY PERFORMANCE			
	RESULT	LOW ENERGY	PASSIVE
Net Heating need [kWh/m²]:	28.9	50	20
Net Cooling need [kEh/m²]:	6.8	15	10
CO_2 emission [kg/m²]:	42	55	40

MINIMUM REQUIREMENTS INDIVIDUAL COMPONENTS			
	RESULT	LOW ENERGY	PASSIVE
U-value external walls [W/m²K]:	0.18	0.18	0.15
U-value roof [W/m²K]:	0.13	0.13	0.13
U-value floor to ground and to outdoor [W/m²K]:	0.12	0.15	0.15
U-value glass/windows/doors [W/m²K]:	0.56	1.2	0.8
Normalized coldbridge value [W/m²K]:	0.05	0.05	0.03
Year average temperature efficiency of heat recovery for ventilation [%]:	85	70	80
Specific fan effect (SFP) [kW/m³/s]:	1.5	2	1.5
Leakage value (Air tightness at 50 Pa pressure difference) [air changes per h]:	1.5	1.5	0.6

ill. 289

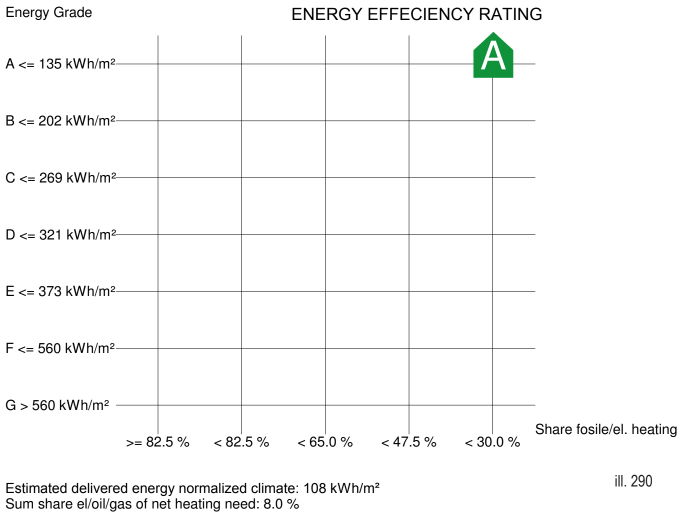
CONCLUSION

The analysis shows that all requirements for low energy buildings are met. Some values are spot on, while others are surpassed. For the passive house requirements several of the requirements are not met, and it's a long way to go to achieve this standard. These are still satisfactory results as this project is not aiming to achieve a passive house standard.

Several adjustments could however be made to get closer to a passive standard, like covering up more of the natural rock walls with insulated walls, make thicker elements allowing for more insulation and lower u-values, and to cover up more of the glass facades to minimize heat loss. These are however changes that would lower other qualities in the project.

ENERGY EFFICIENCY RATING

The last Simien analyse on the building is made to evaluate the energy efficiency rating of the building. The rating is a way to tell how much non renewable energy the building use. The goal is to get an A (less than 135 kWh/m²) or a B (less than 202 kWh/m²), as the goal is to create a energy efficient building. The worst rating possible is a G, which means more than 560 kWh/m².



ill. 290

Before adding the geothermal heating, the energy efficiency rating was on B, but after adding it the energy efficiency rating gets an A with 106 kWh/m². The rating is also on the right side of the chart which indicates that it use less than 30% of the energy for heating based on non fossile/el. heating.
[Appendix 24].

ENERGY CONSUMPTION CONCLUSION

The building meets all the requirements from TEK10 building regulations as well as NS3700 requirements for achieving low energy house standard. The building also scores an A rating for energy efficiency, and thus all the goals are met. The building is still far from meeting some of the passive house standard requirements, but this was not among the goals. In conclusion the building's energy consumption is performing satisfactory.

CONSIDERATIONS

ARCHITECTURAL
Integrate with the landscape
Interaction between hotel & activeties
Max. 30m to staircase
Large atrium common space

TECHNICAL
Pass TEK10 requirements
Pass NS3700 Low energy
Pass NS3700 Passive house
Energy Effeciency rating: A

LARGE SCALE

- THE MASTERPLAN

The large scale will show the masterplan and explain the layout and connectivity. The buildings functions and the surounding activities will be shown in detail.

In order to reach the final proposal and the goals for the masterplan, the missing points (ill. 291) according to the architectural consideration and our vision, needs to be fulfilled. The final proposal has been designed with considerations upon these.

The overall development plan for the entire building site is based on the initial analysis and mapping stated in the context analysis chapter. As the area should work as a new fulcrum that unites the existing adjacent functions to become the new skiresort, it is important that the right layout is defined in order to accommodate and connect to the functions of the current skicenter. As the mapping and the visit to the site revealed, it is essential to prioritize the spectacular view towards the dramatic nature and to make a design that are integrated and relates to the sensitive landscape. The placement of the hotel should emphasize the idea of providing a strong visual interaction with the outdoor areas and to gives all hotel room sufficient daylight. The inclination of the slope has also been an inspiration for function placements to enhance a bioclimatic concept, by letting the hotel rooms stepping down with the slope. Due to the local plans [app. 1] suggestion of having a skilift connection running through the Eastern part of the site connecting the North and South, which has been used as an overall strategy of the masterplan development. The final proposal will in this chapter be described and evaluated up the stated criteria and vision.

ARCHITECTURAL CONSIDERATIONS

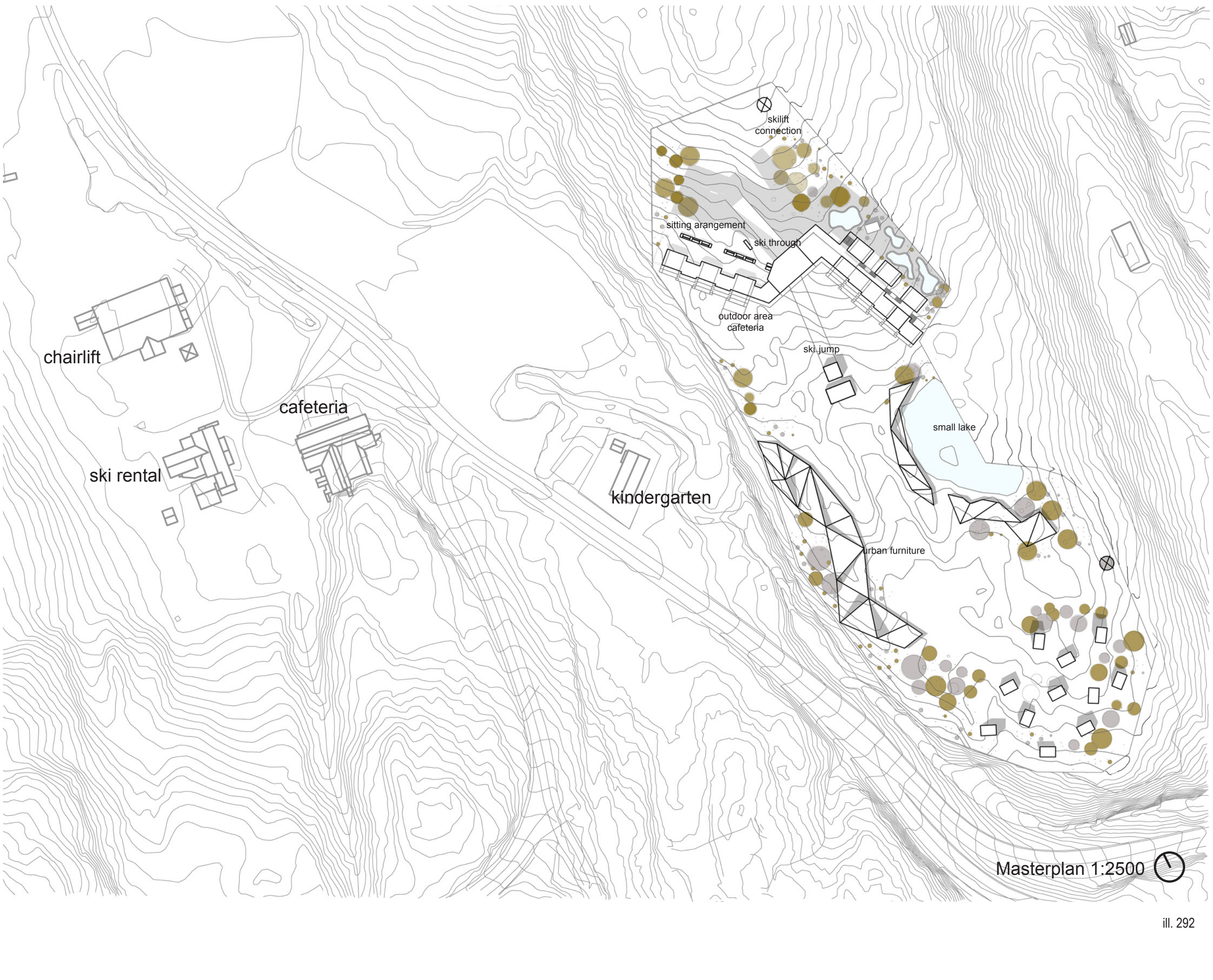
- relate to and integrate with the landscape
- attractive activities to activate the site
- inspired and responding to the city history
- emphasize the beautiful and dramatic nature
- provide a transition from open nature to underground
- an underground cave/clift atmosphere
- interact with the users of the skicenter
- “story of the mining days” with the village in the bottom of the building site and mine up in the hills

ill. 291

FINAL MASTERPLAN

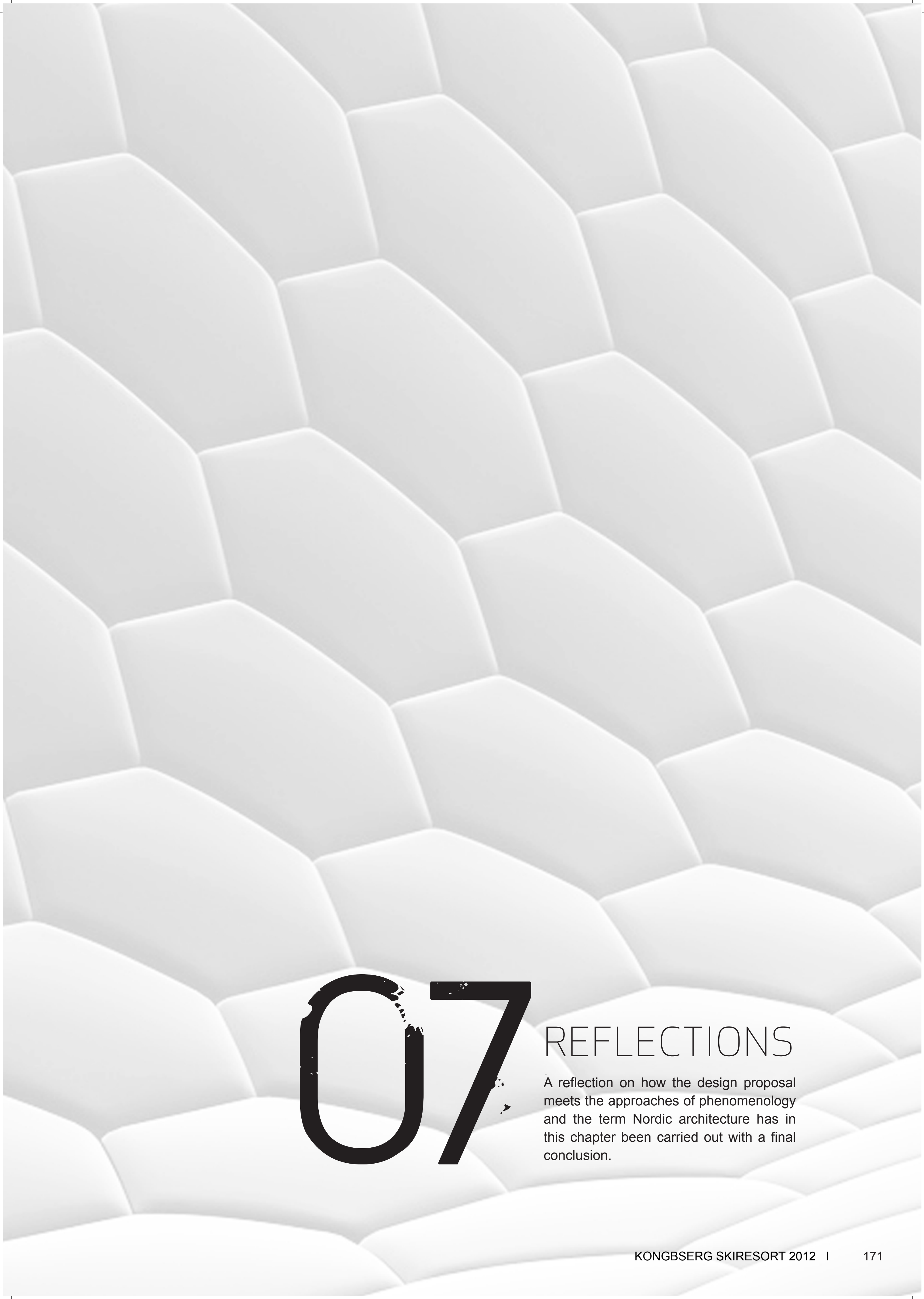
Due to fulfilling the aforementioned aspects, a final proposal has been elaborated. This masterplan takes in considerations of how a new hotel can be placed on the site becoming a new fulcrum of the area, which connects the adjacent functions and activities. The hotel with its placement on the hill top emphasizes the essence of providing each hotel room with panoramic view towards the landscape and sufficient daylight intake. The building shape are oriented to make visual connections and to have outdoor balconies facing S&SW. The lift connection point is situated on the northern part of the area, while a skithrough under the restaurant connects to the village area and the southern lift. The middle part of the site works as a social and active public domain that consist of a big urban furniture that allows different activities. The urban element becomes “ramps” that provides sitting possibilities for the users which allows them to use as benches to observe the skiers and snowboardes rushing down the skithrough and making tricks over the ski jump. The element with triangle sitting areas are orientated in various directions to give the users the opportunities to define their own desirable spot and enjoy the different activities. A small lake which functions as iceskating in winter embraced by the element to provide sitting areas for the observers.

An village area in the bottom part of the area for cabins in close connection with the nature, which in this project are not further detailed, gives the opportunities for a larger group/familie to have their own privat accommodation. Due to the idea of responding to the history of the city, an underground atrium representing the mines, with different attractive cave functions are incorporated in the hotel. This provides a transition from being in the open nature to an underground cave atmosphere. With the final design proposal the missing points and the architectural considerations are met, which makes the masterplan to be a satisfactory solution for the project.



ill. 292

ill. 292



07 REFLECTIONS

A reflection on how the design proposal meets the approaches of phenomenology and the term Nordic architecture has in this chapter been carried out with a final conclusion.

REFLECTION

After a visit to the building site, a discussion was initiated due to the vision of how a hotel design proposal could be done without “ruin” the untouched dramatic landscape. The overall idea, was to emphasize the landscape and come up with a proposal that integrates and respects the surrounding context. “When I build on a site in nature that is totally unspoiled, it is a fight, an attack by our culture on nature. In this confrontation, I strive to make a building that will make people more aware of the beauty of the setting, and when looking at the building in the setting, a hope for a new consciousness to see the beauty there, as well” [www.nytimes.com, 2009]. In the meantime, also to make a proposal that makes a strong rootedness to the site in terms of building expression and material use. When working with the materiality in this project, a clear vision was already stated in the beginning of the process. The materials should be rooted to the site, defining two contrasting environments and atmospheres. A cold and dark atmosphere in the underground atrium, and a warm and soft material on the outer parts of the hotel, each representing their own environment. The material should be local and the rock walls in the atrium should allow one to immediately set ones context. Like the journey to the baths in Therme Vals [Zumthor, 2010], where the materials are well considered. Zumthor takes you on a journey, like a slow introduction setting each scene which titillates all your senses in terms of visually framing certain views, choice of materiality, . “In my opinion, the use of a given material should never happen by choice or calculation, but only though intuition and desire [www.nytimes.com, 2009]. This proposal emphasizes these approaches, by letting the underground atrium be dark with narrow spaces, allowsing the users to explore the cave activities that are uniquely designed only for this specific place. Another approach was to enhance the contrast from being inside the atrium to the hotel room. Moving from a dark cave into the hotel rooms, ones horizon and perspective explodes outwards towards the landscape, making the experience very dramatic and theatrical.

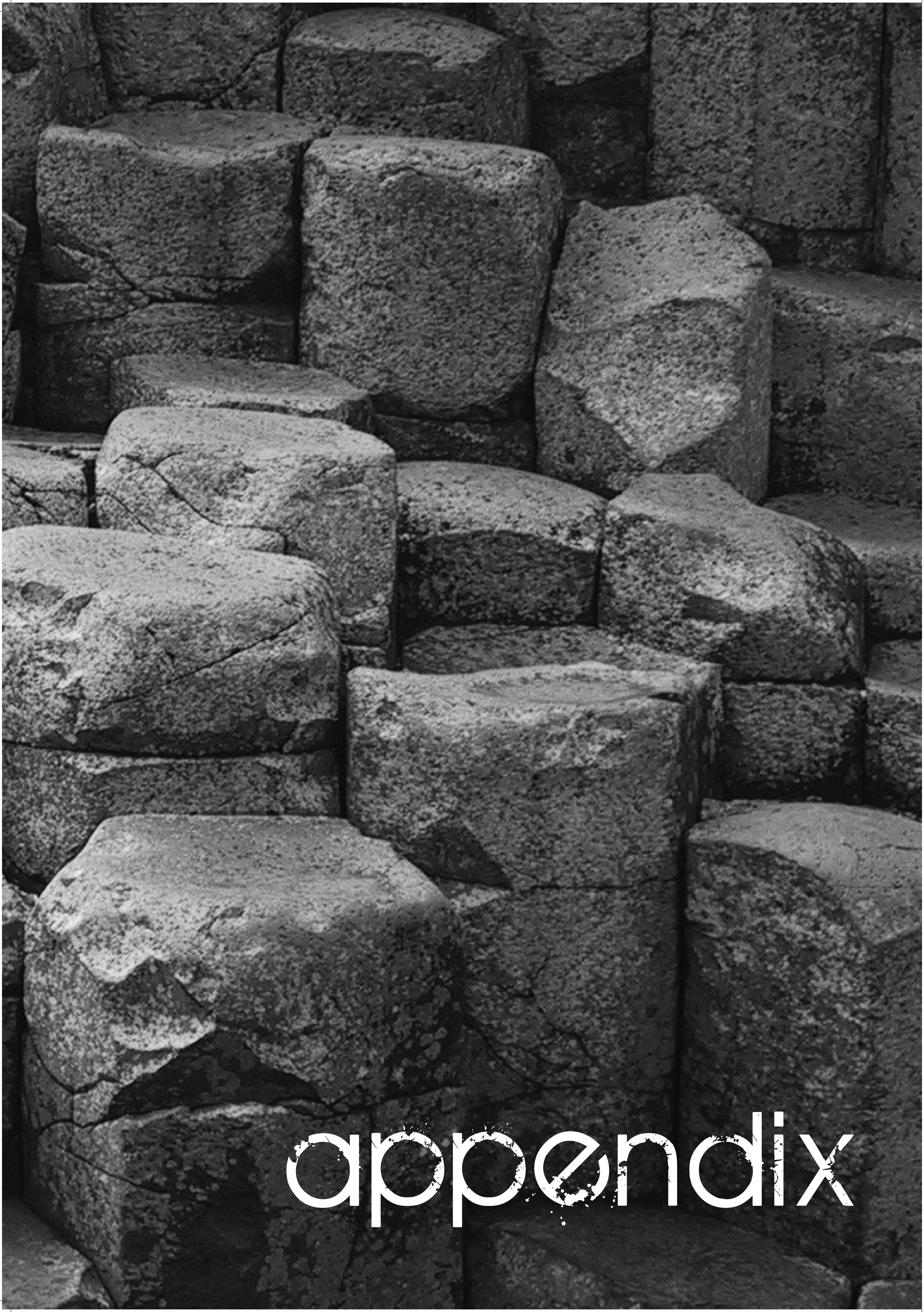
Meagher whom was an important figure of the phenomenological approach to architecture, has been a big inspiration for this project regarding his theories and statements. He believes that modern contemporary architecture suffers from what he defines as “loss of place” due to the buildings that exist in a “nowhere”, which doesn’t relate to the landscape and not to a coherent, urban whole [Meagher, 2008, p151]. The sketches during the design phase has been produced upon these statements. It was important for the group to have a concept that reflects on the importance of understanding the specific given context, in order to let the users identify themselves with the place [Meagher, 2008, p 151].

CONCLUSION

Due to the new Skiresort proposal being next to the current Skicenter, the site has been designed and reinterpreted into an attractive area. With a contemporary hotel design that has created its own identity which has become a new landmark for Kongsberg city. A hotel with an expression that relates to its surrounding context and integrates with the sensitive landscape reflecting upon Nordic architecture and phenomenological approaches. The design of the hotel makes a strong rootedness to the site in terms of material use and functions that responds to the mining history of the city. Kongsberg city was founded in 1624 by a Danish king Christian IV, as a result of silver being found in the area. During the year 1623-1958, 1350 tons pure silver was dug out from the mountain, which has left remarkable traces of mines in the area and created a trademark and an identity for the city. These parts of the city history has been reflected and reinterpreted into a design proposal that tells this story to the coming users of the hotel. When arriving from the city, the visitor will immediately observe a beautiful landscape dominated by pine forest, with slopes in the background and hexagonal shapes that slowly reveals through the massive forest of cluttered forest. A big straight cut rock wall with a stretched hexagonal shape, bridging between two “honeycomb” structures with hotel rooms firmly stepping down with the declination of the slope. The structures consisting of “moguls” which are stacked upon eachother, reflects on the idea of “reusing” the fallen trees to make individual hotel rooms for the visitor. By that the design proposal gives back to nature what was taken, which creates a strong reference and rootedness to the site both in scale and design. When arriving to the site, an underground parking is provided for the guest. From here a journey of sensorial experiences begins.

When parking the car, sky elevators take the visitors up towards the “light” into a big atrium cave that only has a few light streaks penetrating the dark space and uplights the natural cave walls. The atrium consisting of the reception, a small shop and a cafeteria that brings more life and activity to the space. There is also a climbing wall located in the background, where the users can climb 18m up towards the “light”. When reaching the top, the material changes from natural rock to a glass box, which awakens the observers attention and curiosity of the underground activities. From the atrium, small narrow and dark paths leading the visitors to explore different cave functions. Kongsberg Skiresort consists of activities over, inside and also under the building, due to the desire of designing functions that responds to the atmosphere found in the mines. An underground cave for rental, cave cinema and swimming facilities are cave functions to be found within the hotel. The cave for rental is intended to unforgettable events and arrangements, while the cave cinema provides the visitors an ultimate movie experience. An underground intimate cave for both movies and video presentations, which provides a very intense experience due to the rooms dark cave atmosphere. The underground cave swim allows the visitors to dig even deeper into the mystery of the mountain. The rock structure and materiality is kept, to ensure a rough and natural finish on the surfaces. Here the visitors has the opportunity to take a swim in a natural underground environment benefiting from geothermal heating. Back to the atrium, the visitors takes the sky elevators up to the different floors leading to their hotel rooms. A transition from an open and dark space with rough rock materiality, into a “mogul” shape hotel room, with a warm, uplighted and soft atmosphere. The qualities of these room are based on the idea of transitions and contrasts. Moving from a dark cave space into the hotel rooms, the visitors are provided with a spectacular view towards the surrounding context. With its form, the building embraces the best view of the landscape and presents for the visitors this great Norwegian context. The combination of the hotel rooms allows private balconies with a spectacular view towards the landscape and surrounding context. When moving to the top, a skishop and skirental is found. Here is a sitting arrangement that provides the uses with a comfortable place to take the skis off before entering the shops or restaurant, or taking the elevator down to the atrium. Every now and then the building is broken, resulting in ones vision to be exploded in and outwards towards the landscape. After renting the skis, there is direct access to the ski lift and a ski through to the “village” area on the bottom of the site. On the east wing of the building, a wellness zone has been designed with hot tubs, spa, massage, sauna and steam baths providing the users the opportunity to loosen up all tension after a long day of skiing. This area holds a spetacular view towards the city and is in close interaction with the nature.
Underneath the melting snow reveals an area that is programmed with attractive facilities to make the resort also functional during summer. Ski and snowboard are replaced with rollerblades and skateboards, cross country ski with running shoes and mountainbikes and lastly iceskating with lake bathing. The urban furniture allows the users to define their own spot for observation and relaxation, with a green area near the lake for sunbathing, which are activities that generates more life to the area, to make it become a public domain [Hajer & Reijndorf – In search of new Public Domain].

The proposed hotel creates a building that imitates and becomes part of the landscape itself, by emphasizing the qualities of the site and the surrounding context. It is a design that is intended for the specific site that respond to the landscape, surrounding context and not least the history of Kongsberg city.


appendix

appendix 1

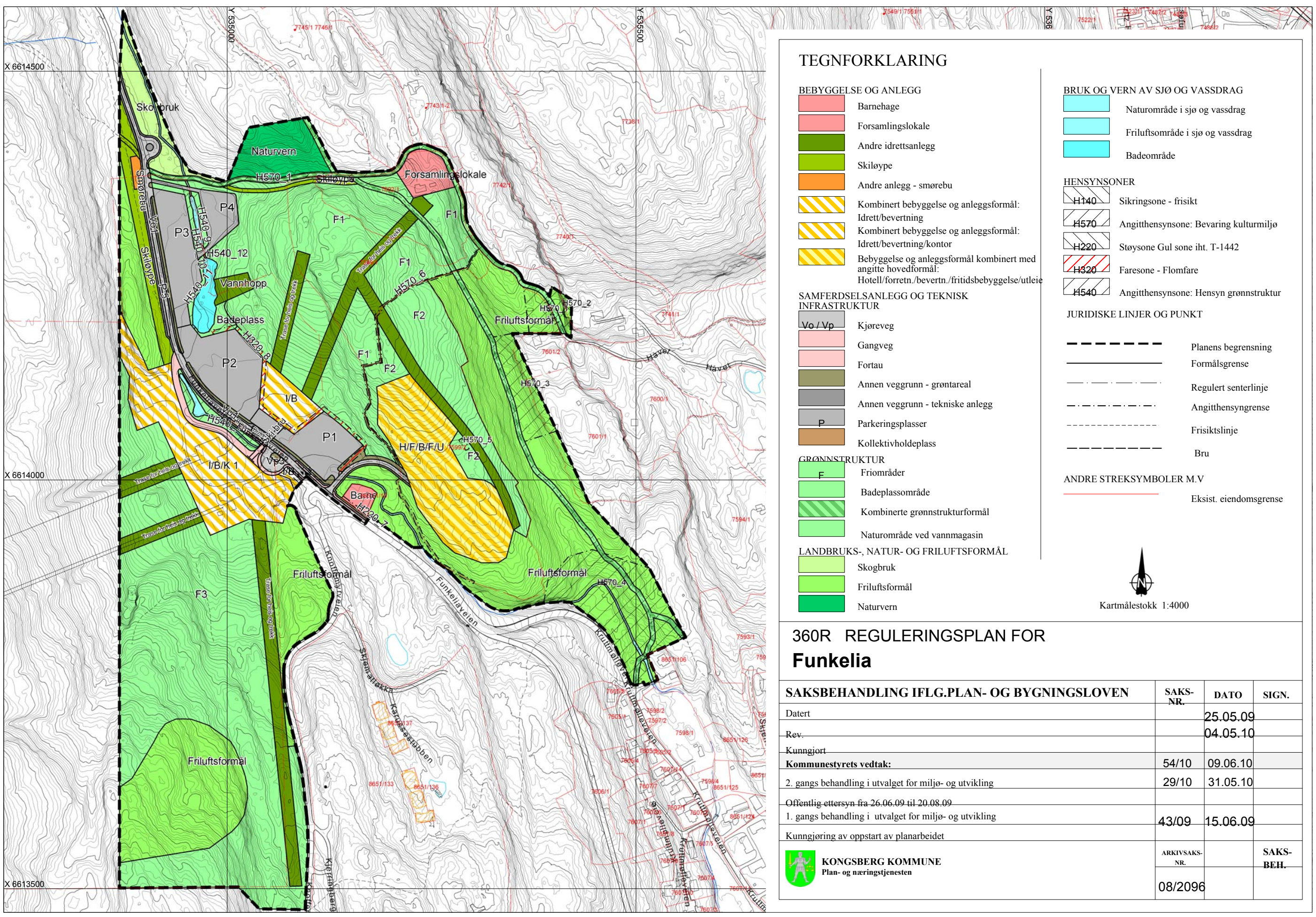
LOCAL PLAN KONGSBERG
ALPINE CENTER

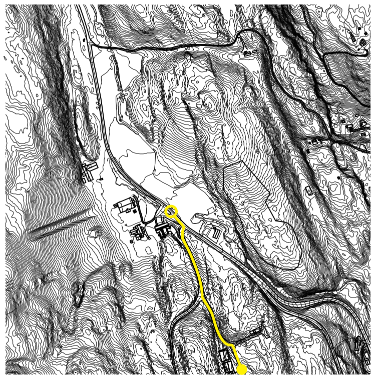
The local plan for the area was last revised May 5th 2010. The local plan already includes the site where a hotel can be placed in the area. It is a large site of about 18140 m².

According to the local plan, new buildings shall take into consideration the character of the buildings in the area, but should have a modern expression to make clear what is new. Placement, size, material usage, detailing, color and planting should work in harmony with existing structures and buildings in the area. Buildings and facilities shall have a good esthetical design of high quality fitting the surroundings and be made of lasting materials. Buildings in the subarea shall fit each other esthetically and have a shared architectural design. The area should aim for a modern architectural design.

The design of each area in the local plan should take into consideration all the surrounding area, and it's important to include access for pedestrians, bicycles, cars and handicapped.

For the area where a hotel can be built there are some regulations:
• The area can be used for hotel, business, catering, leisure houses, cabins or rental.
• There can be made a parking basement under the ground.
• A maximum of 50% of the sites area can be used for building. This means a maximum ground floor area of 9070m².
• Maximum cornice height is 10m.
• The building shall be adapted to the terrain to avoid large ground intervention or fillings.
• The buildings shall have pitched roofs, gable roofs or shed roofs.
• The direction of the roof should follow the terrain, but can be varied.
• The buildings shall have exterior cladding mainly in wood in a natural color scale.
• The facades may have elements in natural stone. Roofs shall have non-reflective materials.
• There shall not be placed any fences or hedges in the area.





ill. 033 - 1:16000 Route B

ROUTE B

From the roundabout we drove southeast of our site to an apartment complex with accommodations for rent.

When we drove up the road, the first thing that came into our minds was; "what a perfect location with excellent views towards the city", but this feeling was quickly downgraded. The first glance of the building, gave us the impression of; "have we not seen this before? It looks very much like all the buildings in the city". The building wasn't welcoming and introduced a small garage and a backstairs element as the first view. The materials were black painted pine wood as the skin of the building and orange light painted pine wood on different elements such as stairs, windowframes etc. With this observation it clears one of our goals for this project. "Our design should be more unique and integrated, emphasizing the context."

From the roundabout towards the city, there is a small road leading up to apartments on another hill top. The apartments can be seen in the distance.

ill. 034 - view to apartments

The apartments has a combined living room/kitchen and lounge area. Kitchen division is equipped with stove/oven, dishwasher and fridge/ small freezer. There are 3 types of apartments.
Type A: 70 m² for 5 pers.
Type B: 70 m² for 10 pers.
Type C: 140 m² for 12 pers.
[Funkelia, 2012]

ill. 035 - Funklia apartments

The buildings are covered with black painted pinewood, with orange light pinewood on different elements and detailing.

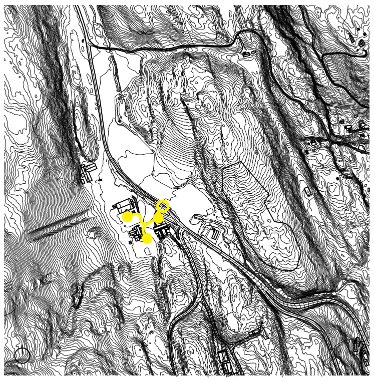
ill. 036 - Stairs

A panoramic view of the city from the top of this hill. There is a small lift for beginners and kids for practicing, but it is not connected to the main slopes as one have to cross a road going between the slopes and the apartments.

ill. 037 - View from "Funklia" top

ill. 038 - Entrance to “Funklia” apartments

The area doesn't stand still at all! When walking towards the building with ski rental to gain a better view towards the big slopes that disappears behind the mountain, we almost jumped aside trying to avoid skiers and snowboarders that rush with full speed down the slopes which ends at this point. This area works as a central point with all the facilities around. Equipment was lying all over the ground, which gave the place a feeling of homeliness and enjoyment - This atmosphere should be extracted and used for our hotel!


ill. 039 - 1:16000 Route C

ROUTE C

The last observations were at the skicenter and its facilities in and around the three buildings.

This 3 storey building contains a small storage area for bags, shoes etc. and a small cafeteria with tables where you can bring and eat your own food on the bottom floor. 2nd and 3rd floor is the main cafeteria where you have an overview of the place while enjoying your meal.


ill. 040 - 'Skikroa'

The small storage room where you can store your bags and shoes while skiing. It also has bench space where you can sit down while changing shoes.


ill. 041 - Storage room

In front of the cafeteria's bottom floor you have the opportunity to put your skis and snowboards before entering the building. They sell locks for these stands if you want to secure your equipment. These locks are standard around the country.

ill. 042 - Skis and snowboards

In front of the cafeteria it is possible to bring your own food for barbecuing. People easily gather around to enjoy a warm snack when having a break from the skiing.


ill. 043 - BBQ area

ill. 044 - Chair lifts

The central point of the skicenter, where people just leave the skis, staves and snowboards everywhere when entering the different buildings.

ill. 045 - Central point

View towards the building where you can rent skis or snowboard, and buy cards for the skilifts. The building also contains a small store where you can buy ski equipment, as well as the ticket office and T-lifts on the far end of the building.

ill. 046 - Rental building

Standing outside the rental building you have a great and undisturbed view towards the site.

ill. 047 - From center towards site

The access to the T-lift, which will take you 2 km up the mountain. The material of this building is pine wood panels and stone.

ill. 048 - T-lifts

The building containing the chair lifts. There is a small kiosk outside with lots of eating benches around this area.

ill. 049 - Chairlifts building

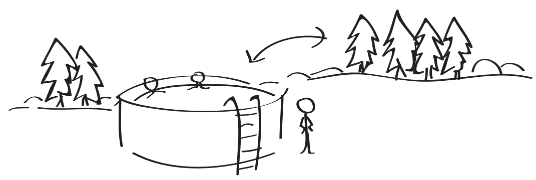
Evening picture of the slopes and center from parking lot 1 next to our site. The atmosphere is totally changed from daytime with the yellow lights showering the slopes giving them a warm and welcoming feel.

ill. 050 - Slopes at night

ill. 051 - Ski slope evening

appendix 3 BRAINSTORMING

- 'NEW SLOPES'
- CAFETERIA / BAR
- LOUNGES
- JAQUZZI
- CABINS
- PARKING (CARS, SNOW, SKI)
- BBQ AREA
- OPEN AREA
    - CONCERT
    - MAIN EVENTS



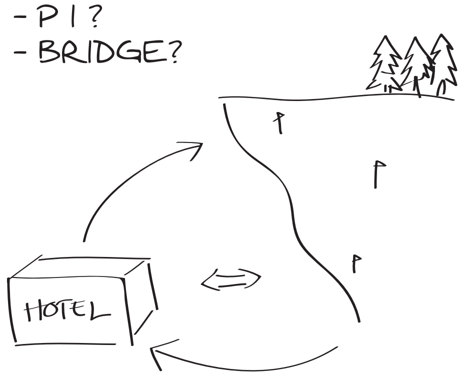
SUMMER
- NATURE 'TRIPS'
- EVENTS
    - MOUNTAIN BIKE
    - RUNNING RUTES
    - OUTDOOR ACTIVITIES

WINTER
SNOW BOARD COMPETITIONS
SKI COMPETITIONS

KONGSBERG SKIRESORT

- CONCERT
- EDUCATION
- BUSINESS MEETINGS
- CONFERENCES
    - PARTY
    - BIRTHDAY

- EASY ACCESS
    - SLOPE > HOTEL / CABINS
- CONNECTION TO 'CENTER POINT'
    - P 1 ?
    - BRIDGE?
- LIFTS



SKI CENTER — OPEN 9:00 – 21:00

SKIRESORT — ?

appendix 4 SCALE

Dombås Skisenter in connection with Trolltun Gjestegård is a skiresort a bit smaller than Kongsberg skisenter that allready house a hotel and cabins on site for users of their ski facilities. Their hotel is a small cosy hotel built in 1988. The scale of their hotel and cabins could be a good idea of what the scale could be like in Kongsberg. It will be taken into consideration that Kongsberg has a city environment that Dombås lacks, and that Kongsberg allready have hotels in the city center that for some will still be more attractive than to staying at a skihotel up by the slopes. Thus we look at the dimention compared to Dombås and will make a rough estimate to use as a goal.

Comparison of Dombås Skiheiser and Kongsberg Skisenter:

	Dombås Skiheiser	Kongsberg Skisenter
Number of slopes	4	10
Height difference top/bottom (m)	350	330
Height above sealevel (m)	1110	600
Lifts	2	5

The amount of slopes and lifts in Kongsberg Skisenter is 2,5 times more than at Dombås.

Because there are allready a hotel network in Kongsberg we will assume that every second person would like to stay the ski hotel. This gives a multiplier of 0.5 on top of the 2.5 multiplyer mentioned above. This results in a multiplyer of 1.25. Some functions will use the 1.25 mulitplier while other functions will us the 2.5 - the reason is that there will be people visiting the hotels activeties that is not staying the night there - as this hotel is an integrated part of the ski resort.

	Dombås Skiheiser	Multiplier	Kongsberg Skisenter
Number of hotel rooms	26	1.25	33
Number of single rooms	2	1.25	3
Number of double rooms	24	1.25	30
Capacity of hotel rooms (ppl)	50	1.25	63
Capacity in hotel restaurant (ppl)	80	2.5	200
Capacity in hotel cafe (ppl)	40	2.5	100
Total capacity for eating (ppl)	120	2.5	300
Capacity in meeting room (ppl)	35	2.5	88
Number of cabins (45-48m²)	11		11
Capacity of cabins (ppl)	60		66
Capacity for accomodation (units)	37		74
Capacity for accomodation (ppl)	110		129
Capacity for eating (ppl)	120		300

These numbers are based on the multiply factors and is only a rough estimate of what the dimensions could be [Wiki-Liste, 2012] [Trolltun, 2012]

The largest load of people coming to Kongsberg skisenter is during winter weekend days where it is 1500-3000 people coming in a day. Based on this accommodation for around 150 people would cover 5% of the total peak users of the area today [Bakke, 2012].

ROOM SCALE

The accomodation capacity will be 150 people (75 rooms) while the total capacity for other activeties in the hotel will be 300ppl. (equilent to 150 rooms)
With a capacity of 300ppl we expect there to be rooms for 2, and the areas are calculated as if all the hotels were in the hotel. This gives 150 rooms for the calculations.

Usual distribution of areas in Hotel's:

- Accommodation including rooms, bathrooms, hallways etc.: 50-60%
- Public guest rooms, Reception, Lounges and halls: 4-7%
- Hospitality areas and bars/restaurants: 4-8%
- Banqueting area with conference and meeting rooms: 4-12%
- Domestic areas, personnel rooms, kitchens and stores: 9-14%
- Administration and management including secretarial: 1-2%
- Maintenance and repairs: 4-7%
- Sport, shops, leisure, hairdressing etc.: 2-10%

Other areas for health centers, seminars, outdoor facilities etc. can have very varied space requirements [Neufert].

Guideline table for restaurant/catering scaling.

Hotel Size (rooms)	Coffee shop, cafe, brasserie (seats)	Main or speciality restaurants (seats)	Ethnic or gourmet restaurants (seats)
50	50-75	-	-
150	80	60	-
250	100	60	50
Space provision/seat	1.6 m²	2.0 m²	2.0 m²

Hotel room size depending on Hotel type.

Hotel Type	m² per room
Standard hotel with large conference room, night clubs, shops	55-65
City-centre hotel	45-55
Motel	35-45
Holiday hotel	40-55
Low-medium class hotel with seperate bathrooms and small range of meals on offer	18-20

GROSS AREA

The table below shows the gross areas per room for different types of hotel [Neufert]

Area/department	200 rooms in suburb setting m² per room	500 rooms in central location m² pre room	Total m² based on 150 rooms	Total m² based on 75 rooms
Hotel room	24	26.5	3600	1800
Corridors, lifts, stairs	3.2	9.3	480	240
Service	0.6	0.7	90	45
Total per room	27.8	36.5	4170	2085
Entrance area including lifts for personnel and service	1.6	1.8	240	120
Reception, WC, reservations, telephones, luggage, cloakroom	0.4	0.4	60	30
Administration	0.3	0.4	45	23
Restaurant	1.1	0.6	165	83
Coffee bar	0.6	0.5	90	45
Bar 1, plus counter	0.9	0.4	135	68
Bar 2, plus counter	0.5	0.3	75	38
Lounge	0.5	0.3	75	38
Toilets	0.4	0.3	60	30
Conference/lecture rooms	1.1	1.3	165	83
Ancillary rooms		0.5		
Furniture store	0.1	0.2	15	8
Private bedrooms and living rooms	0.4	0.9	60	30
Shops		0.2		
Total entrance/guest area	7.8	8.2	1170	585
Kitchen, provisions	3.8	2.5	570	285
General stores	0.9	0.9	135	68
Workshops, maintenance	0.8	0.4	120	60
Laundry, linen store	0.3	0.7	45	23
Staff dining room, WC, changing rooms	1.0	1.1	150	75
Personnel rooms, accounts, supervision, caretaker	0.3	0.5	45	23
Circulation areas, service lifts	0.8	0.9	120	60
Total rear hotel service area	7.9	7.7	1185	593
Total area, without heating services or inside/outside parking facilities	43.5	51.7	6525	3263

Numbers calculated from the 200 room suburb values.

appendix 5 BASED VALUES

Here are the values used for the calculations of the previous tables.

Personal load and corresponding maximal airflow in typical rooms

Typical Room	Person Load	Airflow
Two-bed room	5 m²/person	6 m³/hm²

Base values for person heat

People	Equipment
2 W/m²	1 W/m²

Mean airflow with users

Primary Area	Person Density	Presence amount	Airflow Materials	Mean Airflow
60 %	6 m²/person	60%	4.3 m³/hm²	5.8 m³/hm²

Factors to use for CO2 emission per kWh delivered

Energy Product	CO2-factor (g/kWh)
Biofuel	14
District Heating	231
Gas (Fossil Fuel)	211
Oil	284
Electricity from powergrid	395

Operation time

Operation Time	Airflow outside operation time
16/7/52	1 m³/hm²

Base values for lighting calculations

Effect Without Management	Primary Area	Presence amount	Calculated Effect with Management
6.4 W/m²	60 %	50 %	4.5 W/m²

- For small rooms one consider manual ventilation a working solution while for larger rooms there should be CO_2 controlled ventilation with a setpoint of 800 ppm.
- It's calculated an airflow of 7l/s per person (25.2 m³/h) when people is in a room [sintef, 2012].

Ventilation in living units

Ventilation in living units should ensure a minimum intake of fresh air of 1.2 m³ pr. hr. pr. m² floor area when the living area is in use, and 0.7 m³ pr. hr. pr. m² floor area when not in use.
Bedrooms should get a minimum of 26m³ fresh air per bedspace when space is in use
Rooms that are not meant for long stay needs 0.7 m³ pr. hr. pr. m² floor area.
Fireplace needs 150-300 m³ fresh air pr. hr. (42-84l/s)
Norwegian recommendation of 1000ppm. To stay below 1000ppm its needed a utilization of exhaled air of 26 m³ pr. hour pr. person.

Extraction volume for apecial rooms in buildings [byggregler-13-2, 2012]

Room	Basic ventilation	MAX fan speed
Kitchen	36 m³/h	108 m³/h
Bath	54 m³/h	108 m³/h
Toilet	36 m³/h	36 m³/h
Laundry	36 m³/h	72 m³/h

Ventilation in public buildings

Average fresh air flow of 26 m³ pr. hr. pr. person for light activity.
Minimum fresh air flow of 2.5 m³ pr. hr. pr. m² floor area when rooms are used, or 0.7 m³ pr. hr. pr. m² floor area when rooms are not used.
With exception of office and sales areas, net area is used for calculations. For offices and sales areas gross area is used including storage, communication areas etc [byggregler-13-3, 2012].

Dimention numbers for ventilation

Building type	m² pr. person
Assembly halls without fixed seats	0.6 m²
Standing room	0.3 m²
Dining places with chairs and tables	1.4 m²
Offices	15 m²
Sales premises	2.0 m²
Schools and Kindergartens	2.0 m²

Minimum exhaustvolume for hygene- and special rooms.

Room	Exhaust Volume
Bath/Shower	54 m³/h pr. shower
Toilet	36 m³/h pr. toilet/urinal
Elevator shaft	30 m³/h pr. m² elevator shaft
Basement	2.5 m³/h pr. m² gross area
Garage for long term parking	3 m³/h pr. m² gross area
Garage for short term parking	6 m³/h pr. m² gross area

Thermal indoor climate

- In rooms for long term stay there should be at least one openable door or window to the outside.
- It's recommended to keep the indoor temperature below 22 °C when heating is needed. With exception of system errors or other malfunctions the minimum values should never be exceeded.
- On days with high outdoor temperatures it is difficult to keep temperatures down to the recommended values at all times and they can as such exceed the set values. During a normal year the value should not exceed the recommended values more than 50 hours.
- Passive measures that can help keeping the temperature down can be reduced window areas on facades receiving much sun, exposed thermal mass, outdoor sunscreening, openable windows for ventilation and positioning of ventilation systems to avoid intake of warm outdoor temperature.
- For residential buildings without installed cooling a higher indoor temperature can be accepted for short periods. This is because these buildings allows users to easier affect the situation and adapt to the high indoor temperature through lighter clothing and manual control of ventilation in the living space.
- Day to day temperature variations of more than 4 °C can be uncomfortable.
- Openable windows gives possibilities to quickly ventilate during activities like cooking or cleaning that requires a large volume of air ventilated. For working- or public room there can be windows with fixed frames if this is practical.

Recommended values for operational temperature (collected effect of air temperature and thermal exposure) [byggregler-13-4, 2012].

Activity group	Easy work	Medium work	Hard work
Temperature °C	19-26	16-26	10-26

[byggregler-14-1, 2012].

- Small houses in this chapter involves single residentials, double to four man residentials, townhouses and linked houses.
- Energy required for heating and warm water should as much as possible be covered with energy other than electricity and/or fossil fuels.
- BRA is the user area for a building inclusive open overhang areas, walls etc.
  Heated BRA is the amount of the BRA that recieves heating from the buildings heating system.
- Storage rooms or other rooms that do not receive heating can be subtracted and calculated as part of the U-value.
- For leisure apartments with one unit between 50 and 150 m² heated BRA, only the minimum requirements apply.
- The U-value is considered being the average of different building elements like outer wall, roof, floor, windows and doors.
- For windows and doors, frames shall be included in the calculation of the U-value.

Energy Measures

Buildings should have the following energy qualities [byggregler-14-3, 2012]:

Transmission loss:

1: Amount of window and door area ≤ 20 % of heated BRA
2: U-value outer wall ≤ 0.18 W/(m² K)
3: U-value roof ≤ 0.13 W/(m² K)
4: U-value floor ≤ 0.15 W/(m2 K)
5: U-value glass/window/door including frame/sash ≤ 1.2 W/(m2 K)
6: Normalized cold bridge, where m² is indicated in heated BRA:
- Small houses ≤ 0.03 W/(m 2 K)
- Other buildings ≤ 0.06 W/(m 2 K)

Infiltration- and ventilation heat loss:

1: Leakage at 50 Pa pressure difference:
- Small houses ≤ 2.5 air changes per hour
- Other buildings ≤ 1.5 air changes per hour

2: Yearly average temperature efficiency for heat recovery in ventilation system:
- Residential buildings, and areas where heat recovery causes spreading of pollution/infection ≥ 70 %
- Other buildings and areas ≥ 80 %

Other measures:

1: Specific fan power of the ventilation system
- Residential buildings ≤ 2.5 kW/(m 3 /s)
- Other buildings ≤ 2.0 kW/(m 3 /s)

2: Possibility to lower the indoor temperature during nights and weekends
3: Measures that eliminates the buildings need for local cooling

GENERAL REQUIREMENTS FOR ENERGY

[byggregler-14-1, 2012].

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2: Possibility to lower the indoor temperature during nights and weekends
3: Measures that eliminates the buildings need for local cooling

Total net energy need for buildings should not exceed the limits of the table [byggregler-14-4, 2012]:

Energy frames

Building Category	**Total net energy needs (kWh/m² heated BRA pr. year)**
Small Houses, and Recreational Residential over 150 m² heated BRA	120 + 1600/m² heated BRA
Residential Block	150
Kindergarten	140
Office Building	150
School Building	120
University/High school	160
Hospital	300 (335)
Nursing Home	215 (250)
Hotel	220
Sports Building	170
Commercial Building	210
Cultural Building	165
Light Industry/Workshops	175 (190)

Values given in parentheses apply to areas where heat recovery of ventilated air causes a risk for spreading of pollution/contamination.
For multifunction buildings the buildings should be divided into zones based on building category and the energy frame requirements should be met in each zone.

Minimum Requirements

Following minimum requirements should be met [byggregler-14-5, 2012]:

Minimum requirements

U-value outer wall [W/(m² K)]	**U-value roof W/(m² K)]**	**U-value floor on ground and towards the open W/(m² K)]**	**U-value windows and doors, including frame/sash W/(m² K)]**	**Leakage numbers at 50 Pa pressure difference (airchange pr. hour) W/(m² K)]**
≤ 0.22	≤ 0.18	≤ 0.18	≤ 1.6	≤ 3.0

<u>In addition the following minimum requirements should be met (except for small houses):</u>

- U-value for glass/window/door including frame/sash multiplied with ratio window- and door area of buildings heated BRA should be less than 0.24
- Total sunfactor for glass/window (g_t) should be less than 0.15 on sunloaded facade, unless it can be documented that the building do not require cooling.

<u>Additional requirements:</u>

- There is a maximum limit of U-value for windows/doors/glass and share of windows/doors/glass in the facade relative to the buildings heated BRA. The product should not exceed 0.24.
- Sunloaded facades are facades oriented between North-East (45°) and North-West (315°).
- Total sunfactor for glass/window (g_t) less than 0.15 can be achieved by using blinds or screening systems outside, between the glasses or in linked functions.

- The expected requirement for hotels is set to 20 kWh/m²year
- It should be possible to get satisfying summer comfort with an installed cooling system of 10W/m² (ventilation cooling), this leads to a yearly energy need of 9.3 kWh/m²year. Based on this the net energy need for cooling set to not surpass 10 kWh/m²year
- With a requirement of at least 40% of the heat demand getting covered of renewable energy the CO2 emission becomes 35.7 kg/m²year, thus the requirement is set to 40 kg/m²year

Component values to reach 20 kWh/m²year

Feature	Value
U-value external wall	0.10 W/(m²K)
U-value floor	0.08 W/(m²K)
U-value roof	0.08 W/(m²K)
U-value window	0.8 W/(m²K)
U-value door	1.2 W/(m²K)
Heat Recovery Efficiency, ηT	85 %

Examples from a calculated hotel using the mentioned values

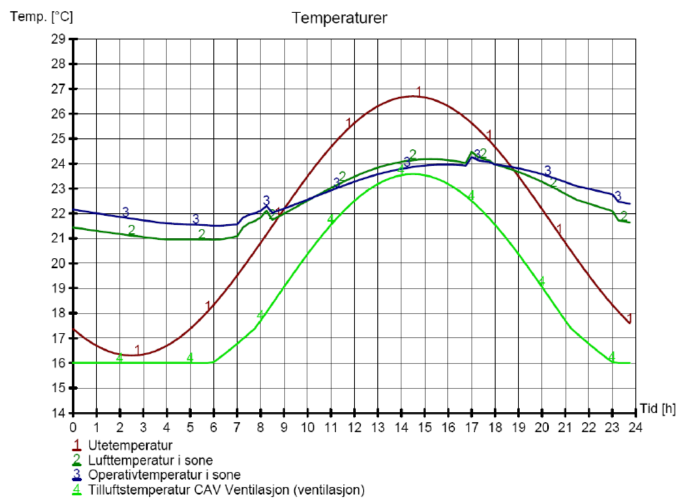
Energy item	Specific Enery Usage
Room heating	19.9 kWh/m²
Ventilation heating	0.0 kWh/m²
Hot water heating	29.8 kWh/m²
Ventilation fans	15.2 kWh/m²
Pumps	0.0 kWh/m²
Lighting	29.2 kWh/m²
Technical equipent	5.8 kWh/m²
Room cooling	0.0 kWh/m²
Ventilation cooling	9.3 kWh/m²
Total	109.3 kWh/m²

Heat Loss Component	Heat Loss
External Wall	0.02 W/m²K
Roof	0.04 W/m²K
Floor to ground or to the outside	0.04 W/m²K
Glass/windows/doors	0.16 W/m²K
Coldbridges	0.03 W/m²K
Infiltration	0.03 W/m²K
Ventilation	0.21 W/m²K
Total	0.54 W/m²K

[sintef, 2012]

Temperature Analysis

For the example there is also calculated heat in a 32 m² hotel room during summer time to see if there would be problems with overheating. There are used outside sun screening for the windows, ventilation is running nonstop at the warmest days with an effect of 8 m³/m²h and installed cooling effect is 10W/m² (ventilation cooling). Calculations gave the room a maximum temperature of 24.3 °C. [sintef, 2012]



Simulated temperature flow for hotel room at dimensioned summer conditions. [sintef, 2012]

Extra information

Needed intake temperature to cover the simulated heat effect based on airflow.

Dimensioning heat effect	Airflow during operation	Needed intake temperature
18 W/m²	6 m³/hm²	23.3 °C

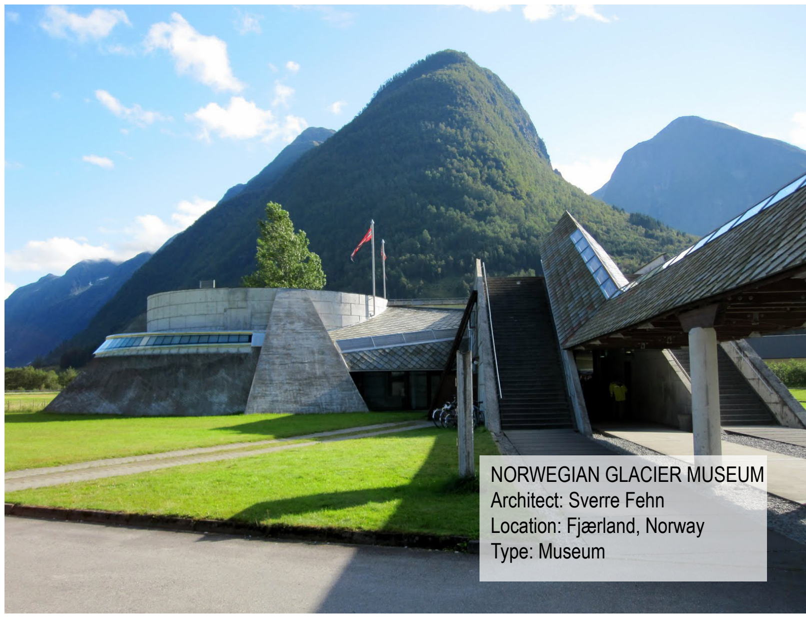
During the coldest periods it's likely to have to run this effect the whole day; this should not occur often and should not make trouble for the yearly average. [sintef, 2012]

appendix 9 Architectural references

ROKKO HOUSING ONE, 1983
Architect: Tadao Ando
Location: Rokko Kobe, Japan
Type: multifamily housing

LAP - Koutalaki Ski Village, 2011
Architect: BIG arkitects
Location: Levi, Finland
Type: Ski village

THERME VALS, 1996
Architect: Peter Zumthor
Location: Vals, Austria
Type: Spa resort



NORWEGIAN GLACIER MUSEUM
Architect: Sverre Fehn
Location: Fjærland, Norway
Type: Museum

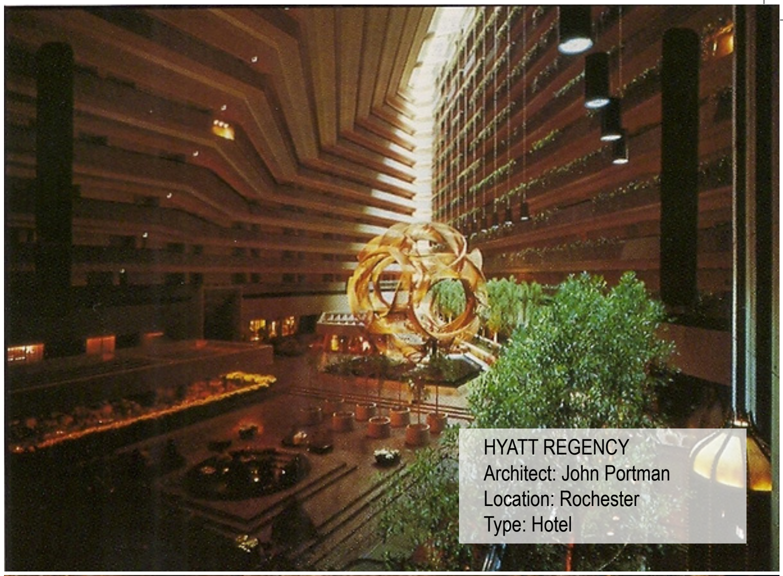
TRYSIL SKI RESORT
Architect: BIG arkitects
Location: Trysil, Norway
Type: Ski resort

PAVILION, MONO HOBART
Architect: “Mixed”
Location: Hobart, Australia
Type: accomodations

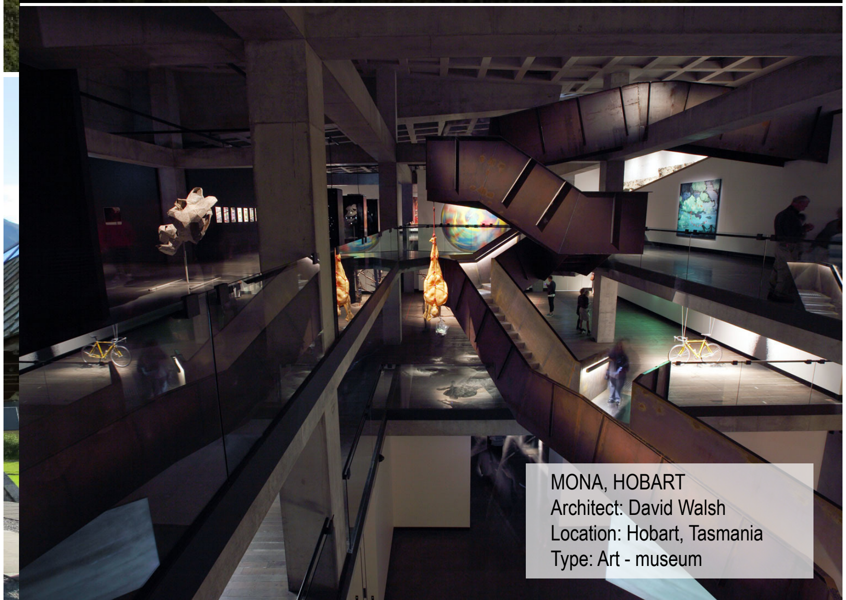
ADELPHI HOTEL,
Architect: BIG arkitects
Location: Melbourne
Type: hotel

SKI JUMP

SOFIA METRO AND STATION
Architect: Shaga Studio
Location: Amsterdam, Nederland
Type: Metro station



HYATT REGENCY
Architect: John Portman
Location: Rochester
Type: Hotel

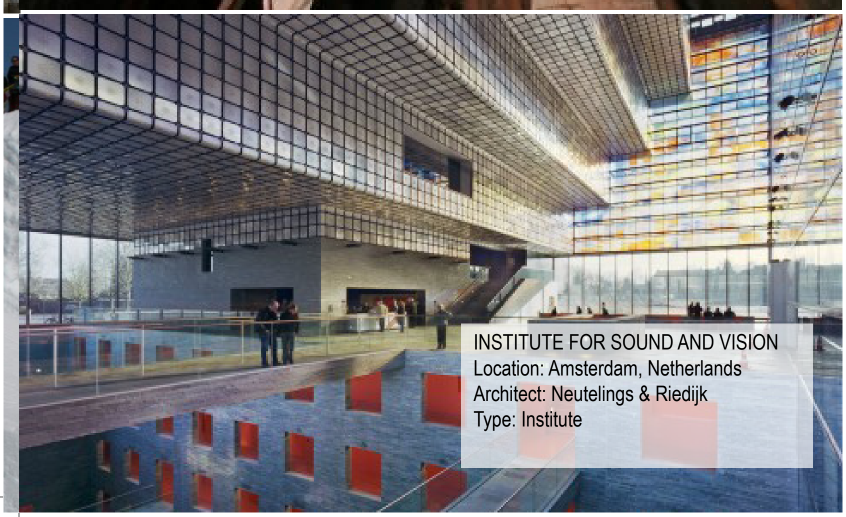


MONA, HOBART
Architect: David Walsh
Location: Hobart, Tasmania
Type: Art - museum

KONGSBERG SILVERMINE
Location: Kongsberg, Norway
Type: MINE / MUSEUM

KONGSBERG SILVERMINE
Location: Kongsberg, Norway
Type: MINE / MUSEUM

TRIPOLO CONGRESS CENTER
Location: Tripolo, Lebanon
Architect: Tabanlioglu Architects
Type: congress center

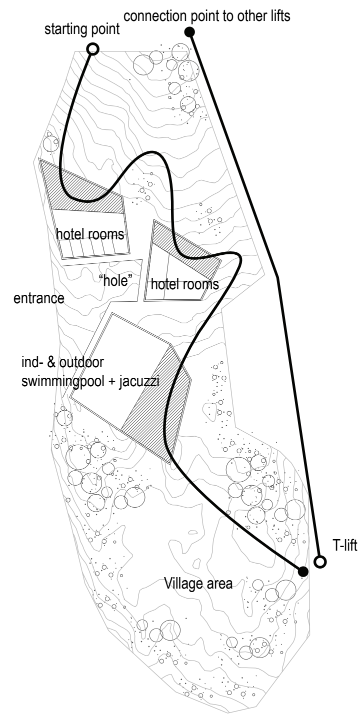


INSTITUTE FOR SOUND AND VISION
Location: Amsterdam, Netherlands
Architect: Neutelings & Riedijk
Type: Institute

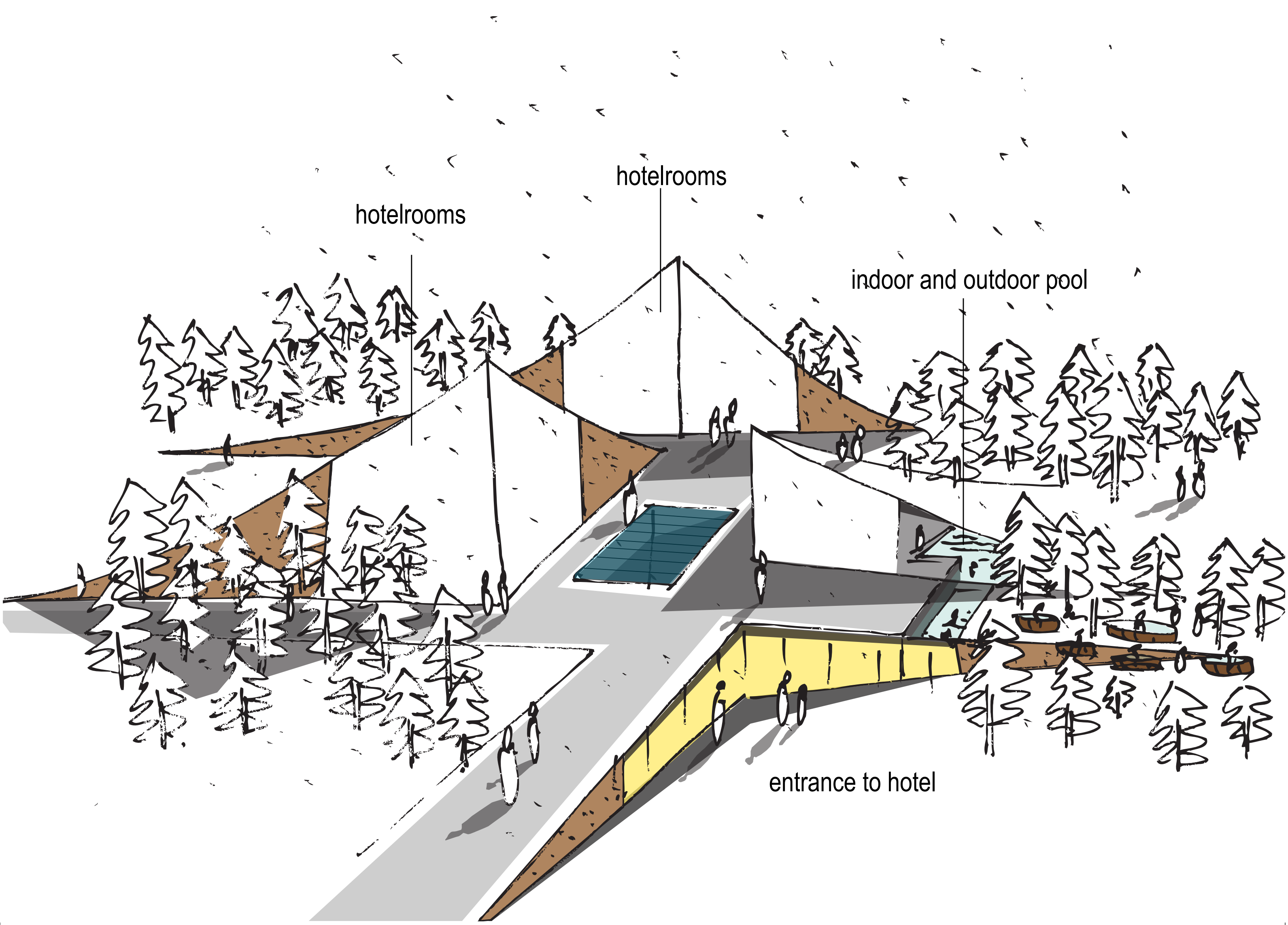
AMAGERFORBRÆNDINGEN
Location: COPENHAGEN, DK
Architect: BIG Architects

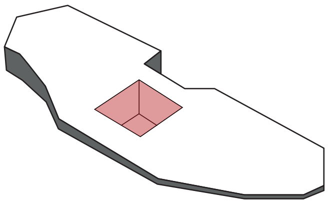
appendix 10 THE CUTS

The design of the hotel seeks to create an underground cave/ clift atmosphere, by digging most functions deep down into the ground. When approaching the hotel it starts to reveal by unpacking itself, which provides different peeks to the functions underneath. Earth and stones that remains from digging, will be reused to create slopes for the users as well as part of the cabin facade. Narrow paths defined by tall walls that has its inspiration from horizontal cuts into the mountain, which will provide the observers a feeling of walking between a clift. A shape that allows a strong coherence between simplicity and rationality vs the dramatic nature landscape. A hotel inspired by a cross-section of a typical underground mime to gain an atmosphere of being one with the nature. The design will emphasize the untouched nature, by gently raising the landscape that helps and give the skiers and snowboarders an extra atmospheric dimension when maneuvering through and above the landscape. When maneuvering through the landscape, the users will end up in a village like atmosphere in the bottom of the slope where the area is almost flat. Different sizes of cabins are here to find both placement and shape is metaphorically inspired by the outcome of the elements found from“digging”.

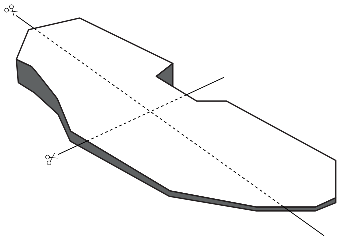


ski and snowboard route

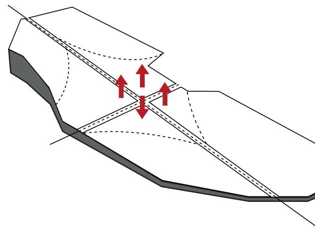




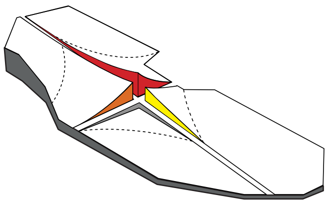
The hotel is buried under ground.



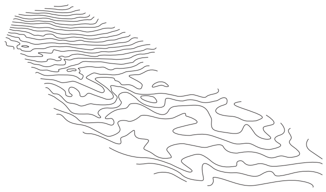
The landscape is cutted in the four main connection points.



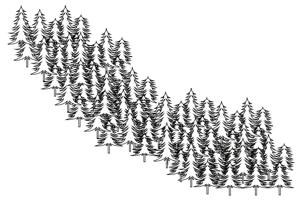
The landscape is cutted in the four main connection points and liftet at a central point.



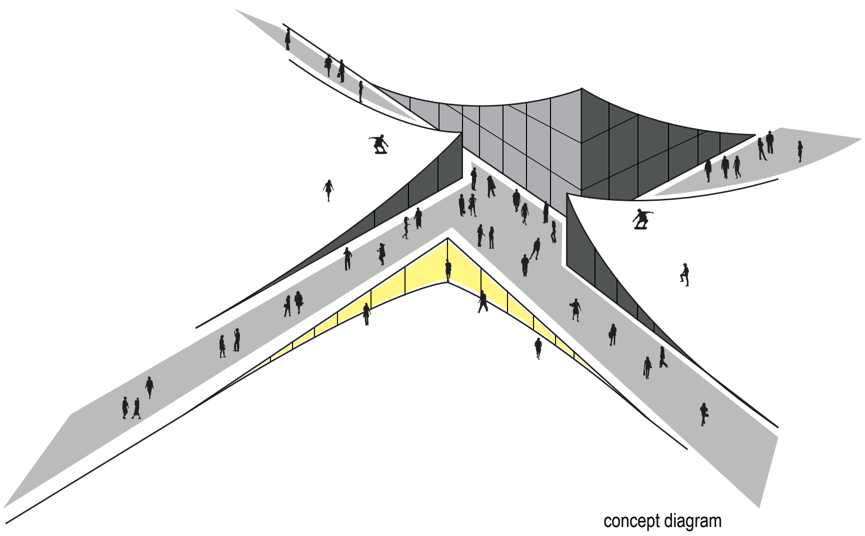
when raising the landscape spaces underneath can be programmed.



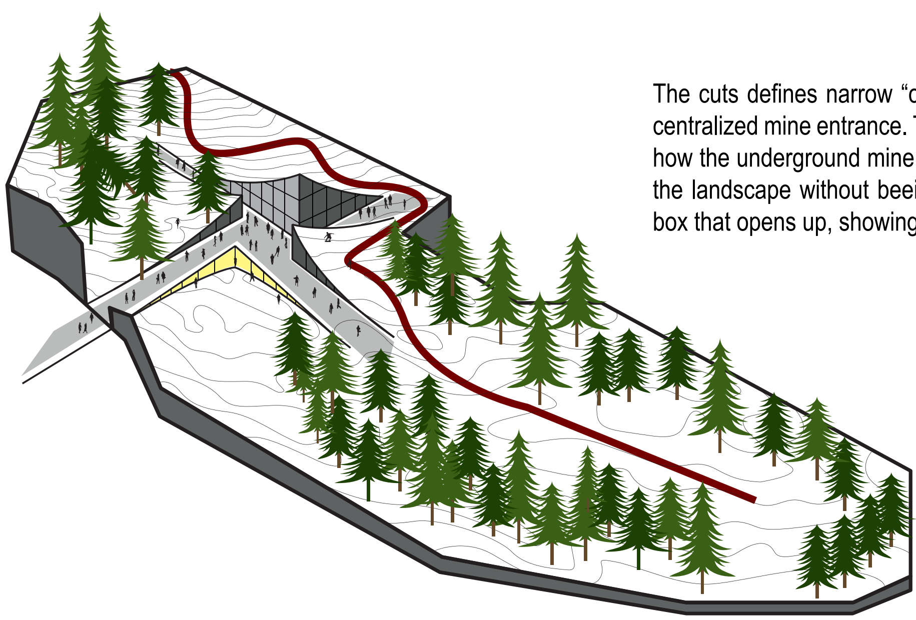
adaption to the existing landscape



adaption to the existing landscape

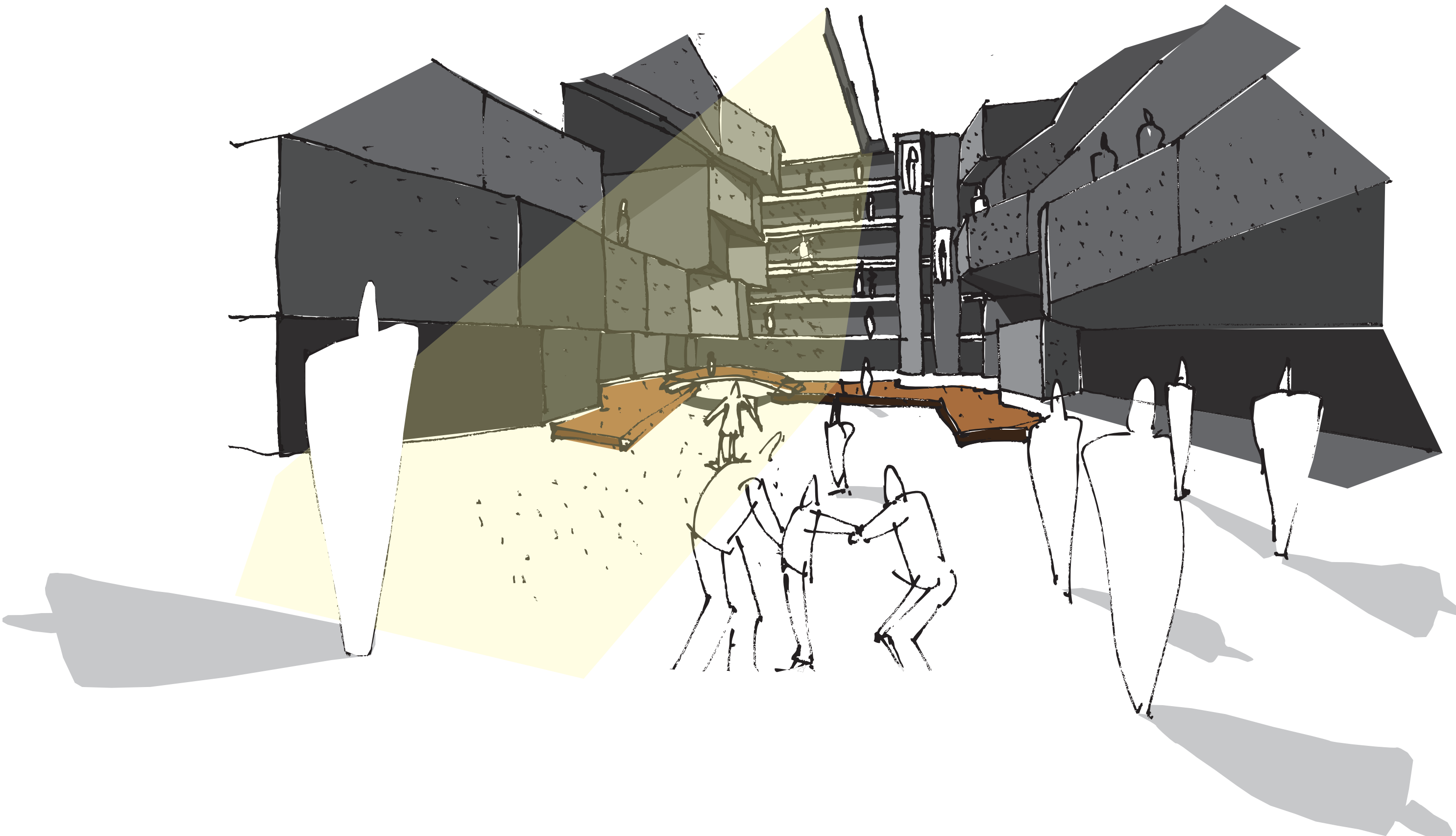


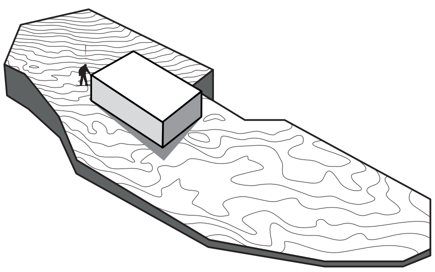
concept diagram



The cuts defines narrow “clift” pathes leading to a centralized mine entrance. The concept is based on how the underground mine hotel, can be shown on the landscape without beeing revealing. A present box that opens up, showing whats inside. bla bla

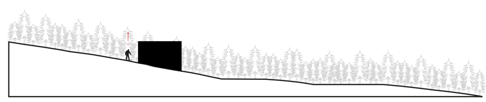
appendix 11 THE RAMPS



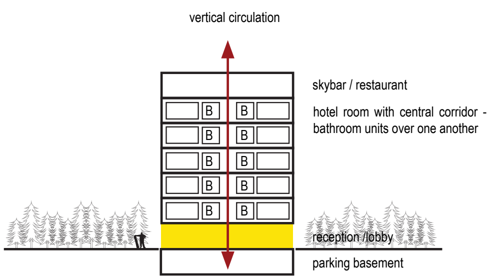


CURRENT INCLINATION

The site topography has a very good inclination for skiers and snowboarders, but when placing a volume on the site it stops the natural flow when rushing down the slope. The volume appears dominating and not as an integrated part of the landscape.

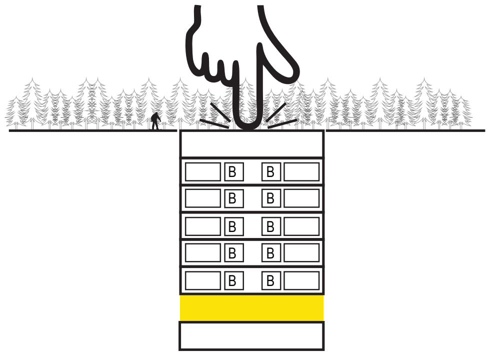


traditional hotel principal



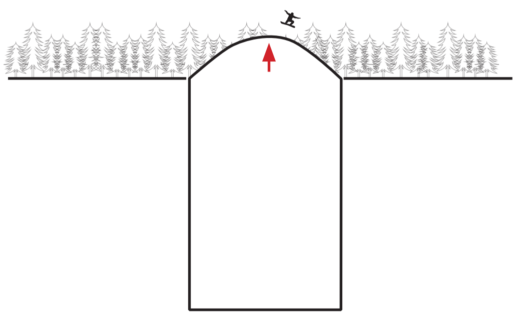
PUSHED DOWN

Emphasizes the landscape and creates a mine atmosphere



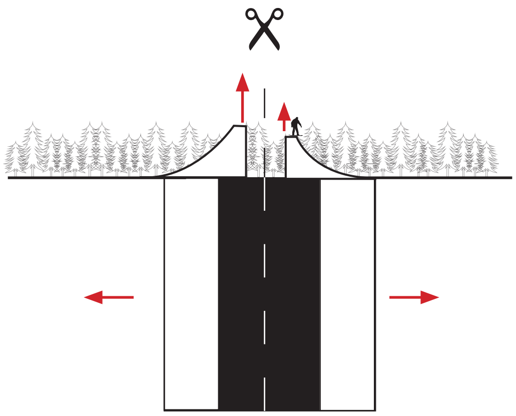
PEAK

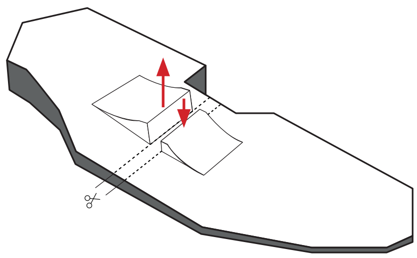
To emphasize the untouched landscape a peak is created to strengthen the interaction between the users and the building. The lifted landscape opens up for the possibility of programming underneath.



INTEGRATION & MINEHSAFT

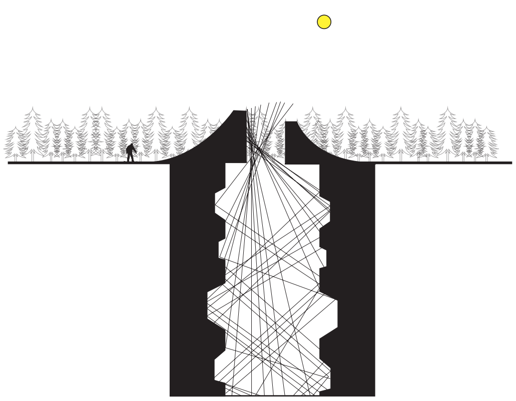
Emphasize the landscape and the activities by creating a ramp for the users. The volumes underneath imitates a layout of a mine shaft.





DAY- & SUNLIGHT

The volumes underneath are separated and the facades of staggered (mountain cuts) for bouncing the incoming day- & sunlight.



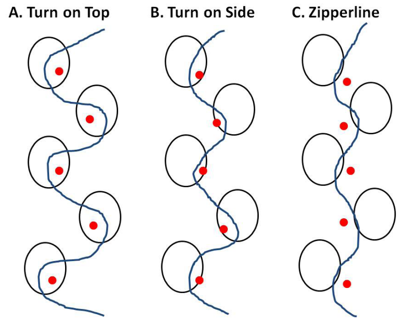
appendix 12 MOGULS

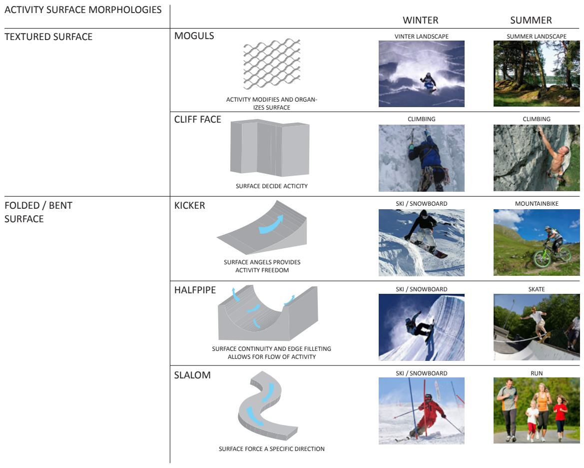
The concept is based on the landscape stepping downwards. Hotel room are placed so it follows this movement for daylight intake and close interaction with the surrounding nature. The shape has its inspiration from the landscape found in the area. A landscape that is define by ski-activities which creates this so-called moguls. The moguls has been analyzed and used to create individual hotel rooms.

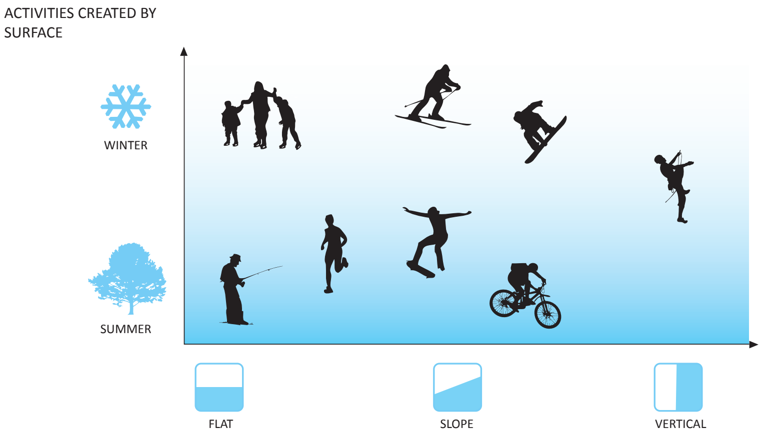
When maneuvering through the landscape, the users will end up in a village like atmosphere in the bottom of the slope where the area is almost flat. Different sizes of cabins are here to find both placement and shape is metaphorically inspired by the outcome of the elements found from“digging”.

MOGULS

Moguls are a series of bumps on a trail formed when skiers push the snow into mounds or piles. This tends to happen naturally as skiers use the slope. They can also be constructed (seeded) on a slope for freestyle skiing competitions or practice runs. Once formed, a naturally occurring mogul tends to grow as skiers follow similar paths around it, further deepening the surrounding grooves known as troughs. Since skiing tends to be a series of linked turns, moguls form together to create a bump field. At most ski resorts certain pistes (trails) are groomed infrequently or left completely ungroomed to allow moguls to develop. These mogul trails are generally relatively steep. Some trails cannot be groomed because they are too steep, too narrow, or they have obstacles that cannot be overcome by a snowcat. Such trails often form moguls. Mogul trails that can be groomed are usually groomed when the moguls get so big and the troughs so deep that the moguls become difficult to ski on or around. Some mogul fields are also groomed when they become too icy or too hardened to ski safely and enjoyably. Many times a section of a trail will be left ungroomed and allowed to bump up to prevent skiers from gaining too much speed and getting out of control. [WIKI]





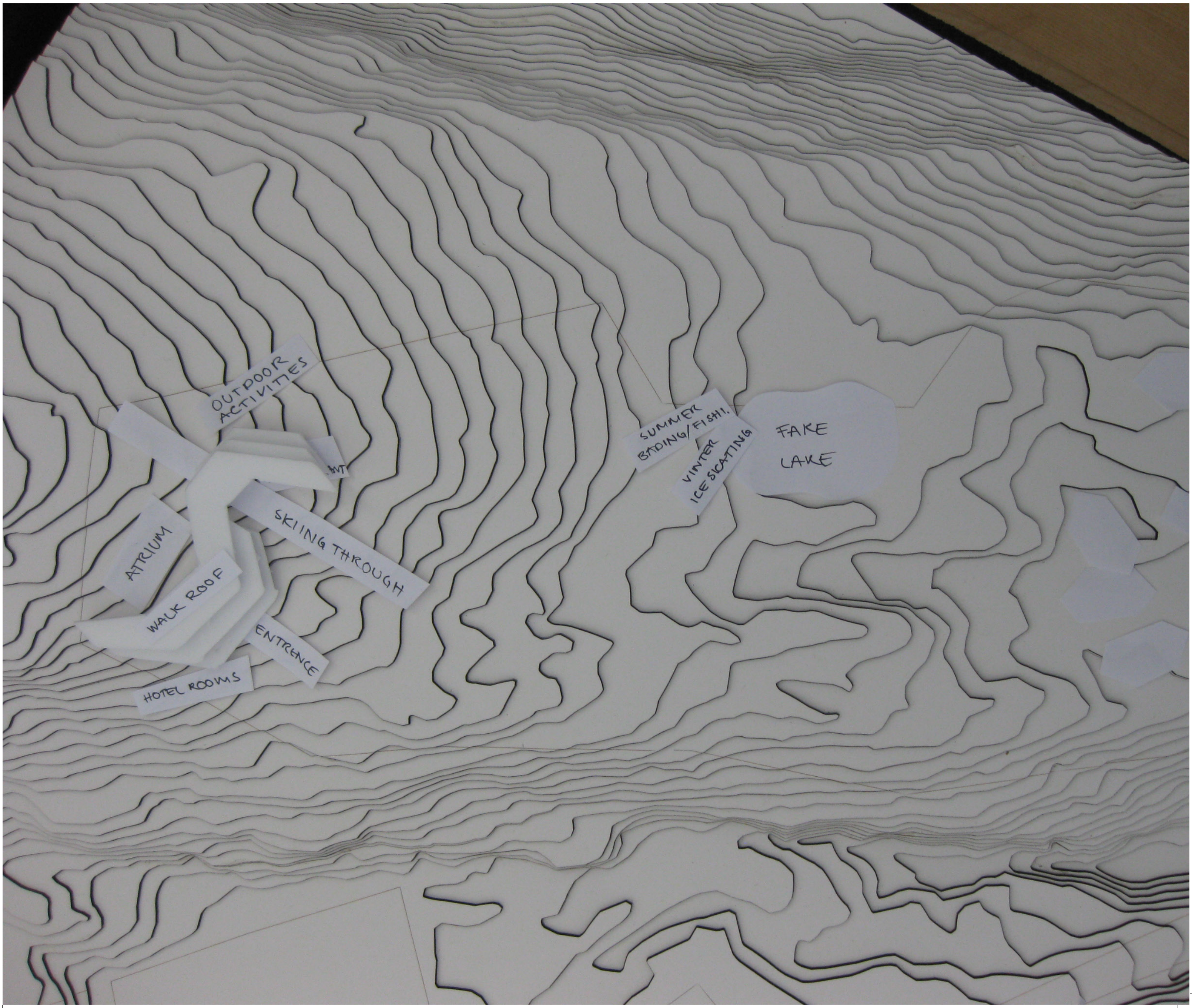


The first criterion is to respect the environment and its surroundings, by integrate the building into the nature.
Also this place is use for many sport activities, which leads to a concept where the activities modify and shape
 the building. The buildings shape also has to embrace and catch up all the best areas, to exploit the areas different functions and benefits. For instance the best view, best outdoors place, best location etc. It's also important to involvethe users to add more "traffic" and movement to the place, and thereby more life and good atmosphere. Last but not lest, make a connection to nature. One thing is to integrate the building into the nature, another thing is to connect the user to the nature and force them to use and enjoy it.

Through research, it turned out that the term Moguls fits perfectly to this project. The wish was to let the activities modify and shape this building, which makes Moguls a big inspiration to both concept and form.
Moguls are a series of bumps on a trail formed when skiers push the snow into mounds or piles. This happens naturally when skiers use the slope. They can also be constructed on a slope for freestyle skiing competitions ore practice runs.

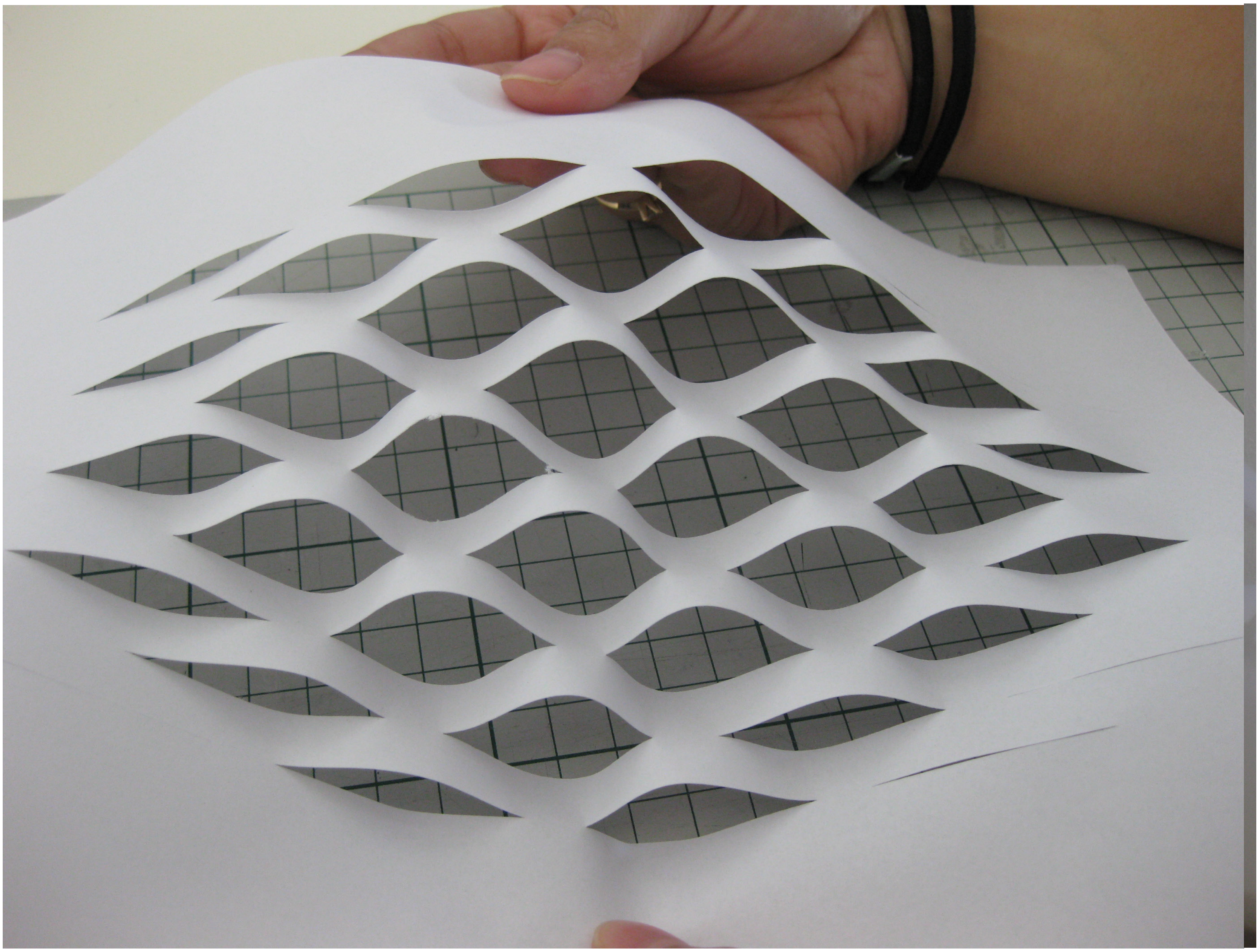
Once formed, a naturally occurring mogul tends to grow as skiers follow similar paths around it. Since skiing tends to be
a series of linked turns, moguls form together to create a bump field. At most ski resorts certain trails are groomed infrequently or left completely ungroomed to allow moguls to develop. Many times a section of a trail will be left ungroomed and allowed to bump up to prevent skiers from gaining too much speed and getting out of control.

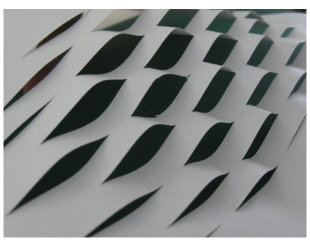
By imitating the mogul structure, the building will fade into the surroundings and be a part of the whole ski resort context in a natural way. These moguls differ both in shape and size, which also will be done in the building, to meet every rooms needs.

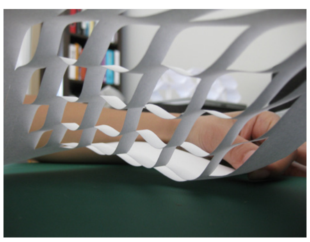


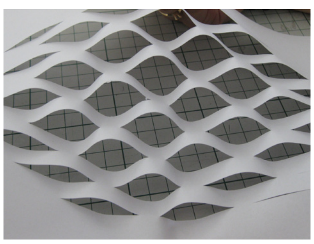
MOGULS

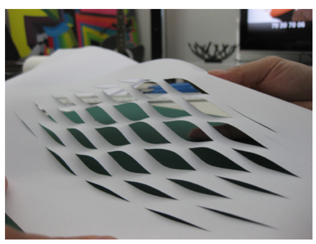
Moguls becomming a structural element and grid for hotel room+function stepping down the landscape.

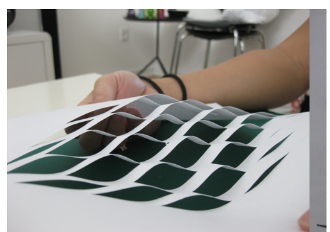












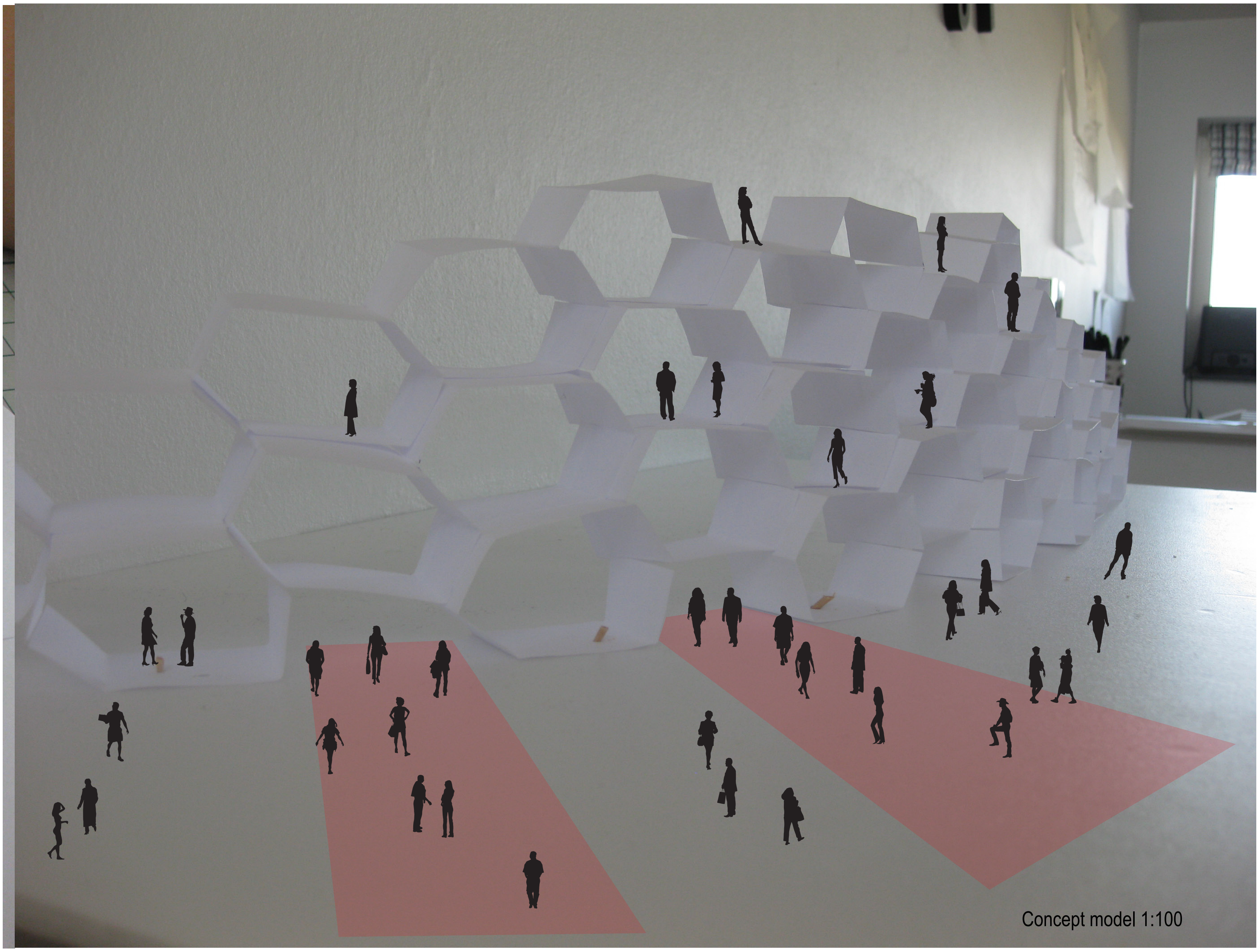
Paths and terraces

Shape visible from atrium

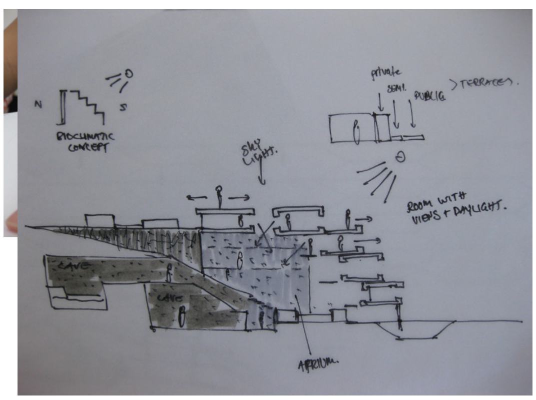
Hotel rooms leaning and stepping with the landscape

Hotels rooms

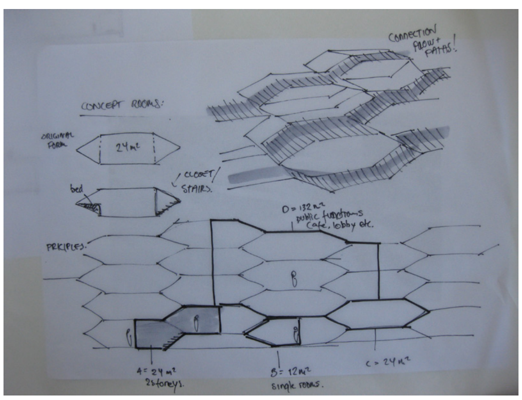
Hotel rooms



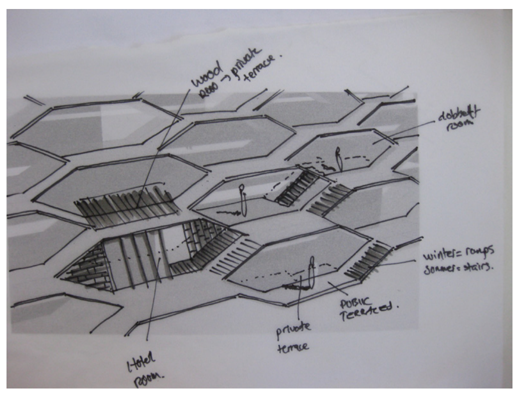
Concept model 1:100



Princip section



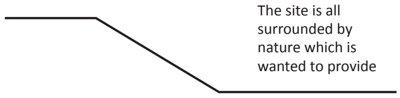
Room connection principles



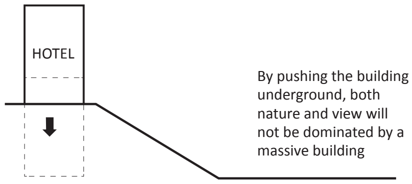
Private terraces
semi public terraces
Public paths
shaders for hotel rooms

appendix 13 THE CLIFT

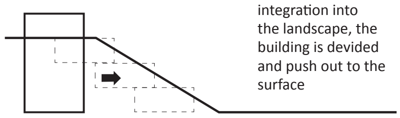
THE SITE



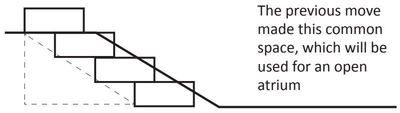
The site is all surrounded by nature which is wanted to provide



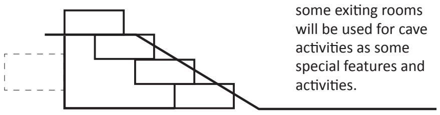
By pushing the building underground, both nature and view will not be dominated by a massive building



To get daylight into the building and integration into the landscape, the building is devided and push out to the surface



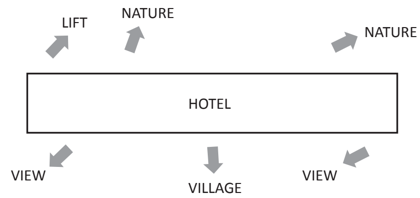
The previous move made this common space, which will be used for an open atrium

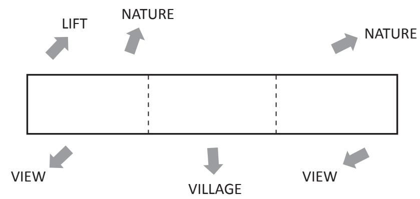


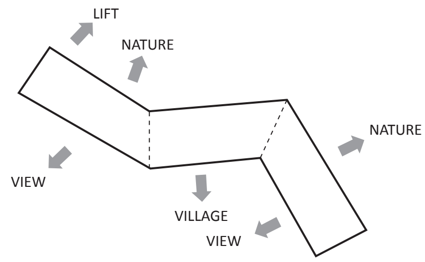
By digging further, some exiting rooms will be used for cave activities as some special features and activities.

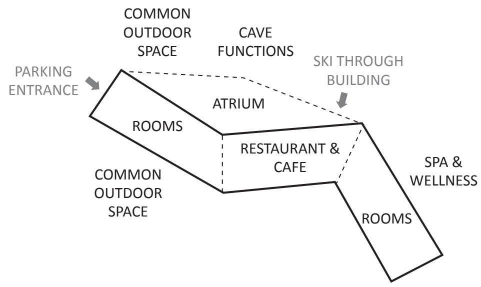
THE FORM

THE ENVIRONMENT SHAPES THE BUILDING



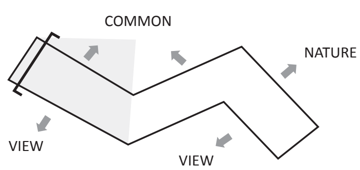


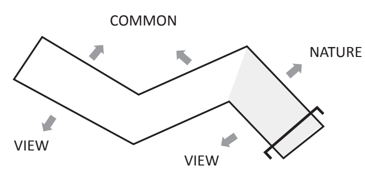


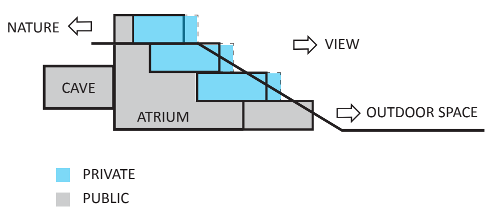


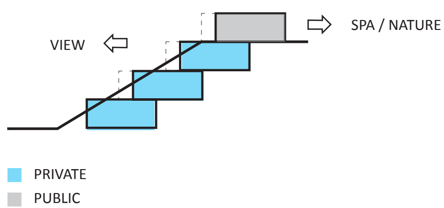
ROOM FUNCTIONS

PLAN LAYOUT PRINCIPLE
VISUAL INTEGRATION ON SITE

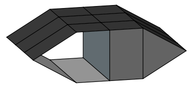
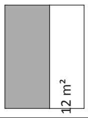
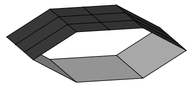
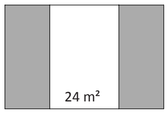
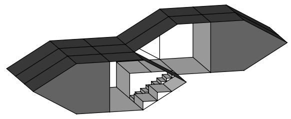
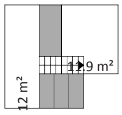
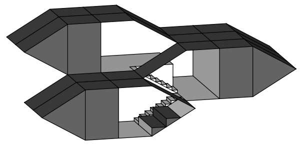
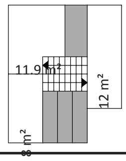
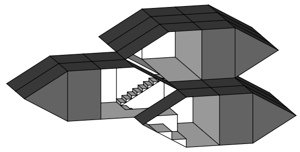
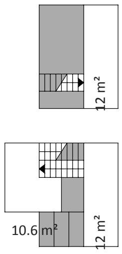
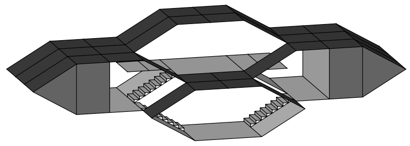
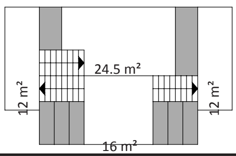
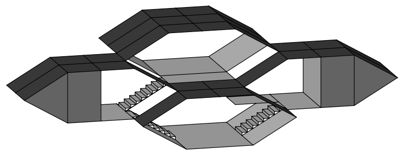
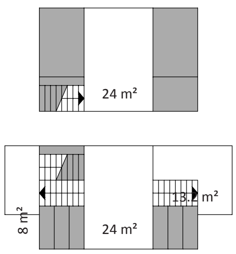
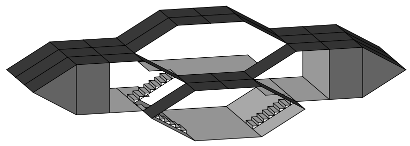
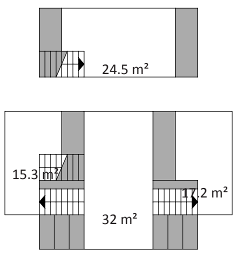
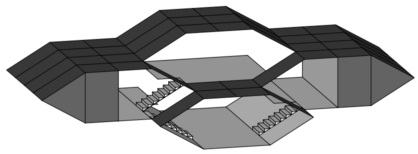
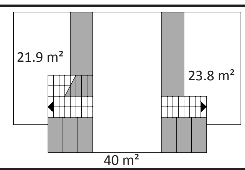








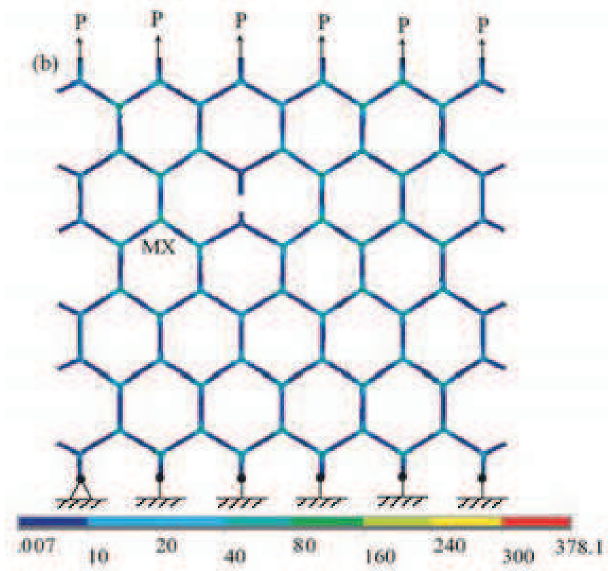
appendix 14 ROOM AREA ANALYSIS

1	Single room of 12 m² using only one floor. This is convenient for moving impaired people as well and singles.			Cell: 0.5 Area: 27.6 m² Usable: 12.0 m² Ratio: 43.5 %
2	Double room of 24m² using one floor. This is convinient for moving impaired and couples.			Cell: 1.0 Area: 55.2 m² Usable: 24.0 m² Ratio: 43.5 %
3	Double room of 23.9 m² using two floors. The entrance is on the bottom floor, while sleeping is on the top floor.			Cell: 1.0 Area: 35.6 m² Usable: 23.9 m² Ratio: 67.1 %
4	Luxury double room of 31.9 m² using three floors. The entrance is on the middle floor, sleeping on the top floor and work/leisure on the bottom floor.			Cell: 1.5 Area: 48.8 m² Usable: 31.9 m² Ratio: 65.4 %
5	Luxury double room of 34.6 m² using three floors. The entrance is on the bottom floor (optionaly also on the top floor), sleeping on the middle floor and work/leisure on the top floor.			Cell: 1.5 Area: 63.2 m² Usable: 34.6 m² Ratio: 54.7 %
6	Other functions room of 64.5 m² using 3 floors. The entrance is on the middle floors.			Cells: 3.0 Area: 97.6 m² Usable: 64.5 m² Ratio: 66.1 %
7	Other functions room of 69.2 m² using 3 floors. The entrance is on the bottom (optionaly also on top)			Cells: 3.0 Area: 126.4 m² Usable: 69.2 m² Ratio: 54.7 %
8	Other functions room of 89 m² using 3 floors with extended depth. The entrance is on the middle floors.			Cells: 3.0 Area: 134.4 m² Usable: 89.0 m² Ratio: 66.2 %
9	Other functions room of 123.4 m² using 3 floors with extended depth. The entrance is on the bottom floor.			Cells: 3.0 Area: 179.2 m² Usable: 123.4 m² Ratio: 68.9 %

CONCLUSION

The larger rooms tend to have a better ratio of usable area than the smaller ones. This is because some of the diagonal walls can be removed and used by extending the adjenct floors. For the 3 story luxury rooms the highest ratio is reached when having the entrance on the middle floor, this also goes for the larger rooms for other functions which also extends for 3 floors. The only exception is the last design where the entrance is on the bottom floor and all stories are extended in depth to fit the top floor. In this design it is more benefitial to have the entrance on the bottom floor.

Super honeycomb shows more potential for carbon nanotubes



When one tube in the honeycomb structure is broken, the surrounding arms can easily carry the load due to the structure's ability to transfer forces. The colors show the von Mises stress distribution, with dark blue as lowest stress and MX referring to the place with maximum stress. Image credit: Xiong Zhang, et al.

The hexagonal network structure makes these nanotubes look a bit like a honeycomb—or, when stretched a bit, like a hammock or fish net. In fact, the stretchiness of these 20-nm-long carbon nanotubes enables them to do what straight nanotubes find difficult: namely, transfer tensile forces and possess high ductility, or malleability.

Scientists Min Wang, Xinming Qiu, and Xiong Zhang from Tsinghua University in Beijing recently investigated the mechanical properties of super honeycomb structures, which are made of periodically repeating carbon nanotube Y junctions that form hexagonal patterns. While straight nanotubes—such as those compiled in bundles or ropes—have renowned strength and elasticity, the honeycomb structure can also transfer these forces to different parts of its structure.

"The basic properties of super structures are due to their excellent structures: the hollow structure of arms and perfect honeycomb structure to combine the arms," Zhang told *PhysOrg.com*. "Compared with the straight nanotube, the honeycomb structure optimizes the force-transferring."

Although the honeycomb structure may look like a fishnet, the forces that determine the nanostructure's properties are actually quite different from those of a macroscopic honeycomb or fishnet because of the great scale difference. For example, the scientists indicate that the van der Waals interactions and the recombination of bonds at the atomic level would affect the results when the structure is stretched.

"In our article, the shell model is used to analyze the mechanical properties of the super honeycomb structure," Zhang said. "The method is based on the continuum theory, but the material parameter is obtained from the atomic level."

The scientists found that, when the nano honeycomb was stretched, the structure still maintained high tensile strength. This result arises due to the honeycomb structure's unusual tendency to become very thin (which is called having a high "Poisson's ratio"), and gain great flexibility. The scientists found that, the more junctions, the greater strength and ability to "shift" weight to different parts of the structure.

“Because the honeycomb structure has the ability to transfer forces, the structure ensures the good distribution of stress and avoids the local stress concentration,” said Zhang. “Even when some tubes are broken from others, the whole structure can still bear the load, which embodies high ductility.”

Because the shape of a single Y junction looks like that of a carbon-carbon bond in graphite, the periodically repeating Y pattern has earned the name “super graphite.” Therefore, by rolling up a sheet of honeycomb, you get what the scientists call a “super carbon nanotube.” Using super carbon nanotubes, scientists could build high-strength, large-scale super structures with relatively short tubes that have many junctions as opposed to using longer straight tubes.

“Super carbon nanotubes are composed of the lower-order nanotubes by replacing the atomic bonds in the carbon nanotubes, which hold the superior properties of carbon nanotubes and the optimal ductility, which is due to the honeycomb structures,” Zhang explained.

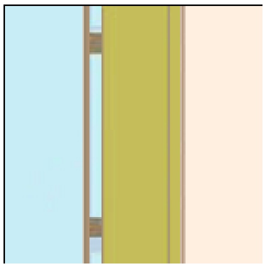
The super honeycomb’s ability to transfer forces means that these structures could provide scientists with resources to improve nanoelectronics devices for computers, and also fiber-reinforced composites.

“Many nanoelectronic devices based on Y-junction carbon nanotubes have been proposed recently,” said Zhang. “Scientists [Coluci] have discussed the electronic properties of the super structures, and indicated that they have great applications as actuators and as hosts for large biomolecules. Regarding fiber-reinforced composites, just as its name implies, the mechanical properties of materials such as resin and concrete can be improved by adding some fiber components.”

Citation: Wang, Min, Qiu, Xinming, and Zhang, Xiong. “Mechanical properties of super honeycomb structures based on carbon nanotubes.” *Nanotechnology*. 18 (2007) 075711 (6pp).

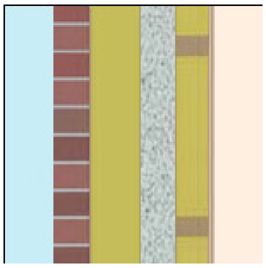
appendix 16 ROCKWOOL

These are the full details of all the elements created with the rockwool u-value program.



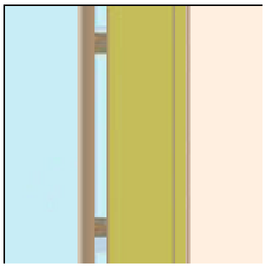
WALL1 - WOOD WALL		
[GENERAL]		
Area exclusive window and doors [m²]:	94.64	
Wall facing:	Free air	
Heatloss factor:	1	
Length coldbridge [m]:	20	
Coldbridge value [W/mK]:	0.1	
[CLIMATE SCREEN]		
Cladding:	Wood	
Thickness [mm]:	22	
Heat conductivity [W/m²K]:	0.14	
Air layer:	Yes	Yes/No
Air Change:	Good	Good/Poor/None
Air layer thickness [mm]:	36	
Sheating:	On roll	
Thickness of sheating [mm]:	1	
Heat conductivity of sheating [W/m²K]:	0.1	
[BEARING]		
Timber frame:	36mm solid wood	(cc 60 cm)
Area of timber frame [%]:	9	
Heat conductivity of timber frame [W/mK]:	0.14	
Main insulation:	198mm rockwool	Flexi A-plate
Heat conductivity [W/mK]:	0.037	
[INTERNAL]		
Inner cladding:	15mm wood panel	
Heat condictivity of inner cladding [W/mK]:	0.14	
Inner insulation:	30mm Rockwool	Soundplate
Heat conductivity [W/mK]:	0.034	
[RESULTS]		
U-Value [W/m²K]:	0.18	0.18 max, 0.22 individual max
Construction thickness [mm]:	301	

[ROCKWOOL, 2012] http://www.rockwool.no/r%C3%A5d+og+veiledning/u-verdiprogram



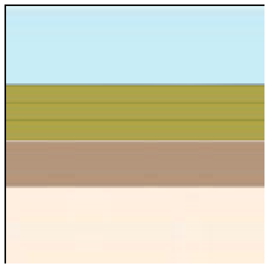
WALL2 - STONE TILE WALL		
[GENERAL]		
Area exclusive window and doors [m²]:	94.64	
Wall facing:	Free air	
Heatloss factor:	1	
Length coldbridge [m]:	20	
Coldbridge value [W/mK]:	0.1	
[CLIMATE SCREEN]		
Cladding:	Stone	
Thickness [mm]:	105	
Heat conductivity [W/m²K]:	0.75	
Air layer:	No	Yes/No
[EXTERNAL]		
External insulation:	148 mm Rockwool	Flexi A-plate
Heat condictivity [W/mK]:	0.037	
[BEARING]		
Timber frame:	100mm concrete	
Heat conductivity of timber frame [W/mK]:	1.8	
[INTERNAL]		
Inner cladding:	15mm wood panel	
Heat condictivity of inner cladding [W/mK]:	0.14	
Inner insulation:	98mm Rockwool	Flexi A-plate
Heat conductivity [W/mK]:	0.037	
[RESULTS]		
U-Value [W/m²K]:	0.15	0.18 max, 0.22 individual max
Construction thickness [mm]:	466	

[ROCKWOOL, 2012] http://www.rockwool.no/r%C3%A5d+og+veiledning/u-verdiprogram



WALL3 - MIX OF WOOD AND STONE TILES		
[GENERAL]		
Area exclusive window and doors [m²]:	94.64	
Wall facing:	Free air	
Heatloss factor:	1	
Length coldbridge [m]:	20	
Coldbridge value [W/mK]:	0.1	
[CLIMATE SCREEN]		
Cladding:	Wood/Stone	
Thickness [mm]:	50	
Heat Conduction [W/m²K]:	0.3	
Air layer:	Yes	Yes/No
Air Change:	Good	Good/Poor/None
Air layer thickness [mm]:	36	
Sheating:	On roll	
Thickness of sheating [mm]:	1	
Heat Conduction of sheating [W/m²K]:	0.1	
[BEARING]		
Timber frame:	36mm solid wood	(cc 60 cm)
Area of timber frame [%]:	9	
Heat conductivity of timber frame [W/mK]:	0.14	
Main insulation:	198mm rockwool	Flexi A-plate
Heat conductivity [W/mK]:	0.037	
[INTERNAL]		
Inner cladding:	15mm wood panel	
Heat condictivity of inner cladding [W/mK]:	0.14	
Inner insulation:	30mm Rockwool	Soundplate
Heat conductivity [W/mK]:	0.034	
[RESULTS]		
U-Value [W/m²K]:	0.18	0.18 max, 0.22 individual max
Construction thickness [mm]:	329	

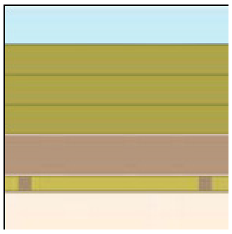
[ROCKWOOL, 2012] http://www.rockwool.no/r%C3%A5d+og+veiledning/u-verdiprogram



ROOF1 - Apartments		
[GENERAL]		
Area [m²]:	4.8	
Length coldbridge [m]:	15.2	
Coldbridge value [W/mK]:	0.1	
[CLIMATE SCREEN]		
Cladding:	Mixed	
Thickness [mm]:	4	
Heat conductivity [W/m²K]:	50	
Amount of fasteners per m²:	4	
Diamater per fastener [mm]:	4	
Heat conductivity of fastener [W/mK]:	17	
Sheating:	On roll	
Thickness of sheating [mm]:	1	
Heat conductivity of sheating [W/m²K]:	0.1	
[INSULATION]		
Heat conductivity of 50mm Hardrock Energy [W/mK]:	0.036	3'rd insulation layer
Heat conductivity of 50mm A-surfaceplate energy [W/mK]:	0.037	2'nd insulation layer
Heat conductivity of 60mm A-surfaceplate energy [W/mK]:	0.037	1'st insulation layer
[BEARING]		
Bearing material:	wood	140mm massive wood
Heat conductivity of timber frame [W/mK]:	0.14	
[RESULTS]		
U-Value [W/m²K]:	0.18	0.13 max, 0.18 individual
Construction thickness [mm]:	304	Goal 300 for apartments

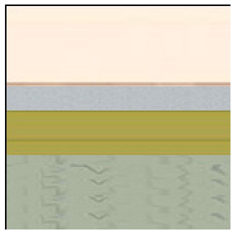
[ROCKWOOL, 2012] http://www.rockwool.no/r%C3%A5d+og+veiledning/u-verdiprogram

This roof has the highest allowed u-value to allow for a slimer construction for the hexagon apartments, the u-value of the other roofs will be lower to give a good average u-value.



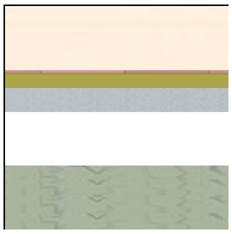
ROOF2 - Rest		
[GENERAL]		
Area [m²]:	4.8	
Length coldbridge [m]:	15.2	
Coldbridge value [W/mK]:	0.1	
[CLIMATE SCREEN]		
Cladding:	Mixed	
Thickness [mm]:	4	
Heat conductivity [W/m²K]:	50	
Amount of fasteners per m²:	4	
Diamater per fastener [mm]:	4	
Heat conductivity of fastener [W/mK]:	17	
Sheating:	On roll	
Thickness of sheating [mm]:	1	
Heat conductivity of sheating [W/m²K]:	0.1	
[INSULATION]		
Heat conductivity of 100mm Hardrock Energy [W/mK]:	0.036	3'rd insulation layer
Heat conductivity of 100mm A-surfaceplate energy [W/mK]:	0.037	2'nd insulation layer
Heat conductivity of 100mm Conrete surface energy [W/mK]:	0.035	1'st insulation layer
[BEARING]		
Bearing material:	wood	140mm massive wood
Heat conductivity of timber frame [W/mK]:	0.14	
[RESULTS]		
U-Value [W/m²K]:	0.09	0.13 max, 0.18 individual
Construction thickness [mm]:	455	Goal 300mm

This roof has a lower u-value to cover up for the higher u-value of the apartments (Roof1).



FLOOR1 - Apartments		
[GENERAL]		
Area [m²]:	941.5	
Length coldbridge [m]:	123	
Coldbridge value [W/mK]:	0.03	
Soil conditions:	Rock	
Heat conductivity of rock [W/mK]:	3.5	
Heat capasity [Wh/m³K]	556	
[EDGE INSULATION]		
Edge insulation direction:	Vertical	
Heat conductivity of edge insulation [W/mK]:	0.037	50mm Rockwool Ground pl.
Edge insulation depth [m]:	0.6	
[INSULATION]		
Heat conductivity of 100mm Rockwool ground pl. [W/mK]:	0.037	1'st insulation layer
Heat conductivity of 50mm Rockwool ground pl. [W/mK]:	0.037	2'nd insulation layer
[CONCRETE LAYER]		
Heat conductivity of 80 mm reinforced concrete [W/mK]:	1.7	
[INTERNAL LAYER]		
Heat conductivity of 14mm Parquet [W/mK]:	0.13	
[RESULTS]		
U-Value [W/m²K]:	0.15	0.15 max, 0.18 individual
Construction thickness [mm]:	244	Goal 300 for apartments

[ROCKWOOL, 2012] http://www.rockwool.no/r%C3%A5d+og+veiledning/u-verdiprogram



FLOOR2 - Rest		
[GENERAL]		
Area [m²]:	1849	
Length coldbridge [m]:	110	
Coldbridge value [W/mK]:	0.03	
Soil conditions:	Rock	
Heat conductivity of rock [W/mK]:	3.5	
Heat capasity [Wh/m³K]	556	
[EDGE INSULATION]		
Edge insulation direction:	Vertical	
U-value edge insulation [W/mK]:	0.037	50mm Rockwool Ground pl.
Edge insulation depth [m]:	0.6	
[INSULATION]		
Heat Conductivity of 100mm Rockfoam (XPS) [W/mK]:	0.034	1'st insulation layer
Heat Conductivity of 80mm Polystrene 20-S80 [W/mK]:	0.038	2'nd insulation layer
[CONCRETE LAYER]		
Heat conductivity of 80 mm reinforced concrete [W/mK]:	1.7	
[INTERNAL LAYER]		
Heat conductivity of 10mm Stone Tiles [W/mK]:	0.75	
Heat conductivity of 50mm Rockwool Stepsound [W/mK]:	0.037	Inner insulation layer
[RESULTS]		
U-Value [W/m²K]:	0.09	0.15 max, 0.18 individual
Construction thickness [mm]:	320	

[ROCKWOOL, 2012] http://www.rockwool.no/r%C3%A5d+og+veiledning/u-verdiprogram

"FLOOR3" - Rock surfaces		
[GENERAL]		
Area [m²]:	1694	
Length coldbridge [m]:	160	
Coldbridge value [W/mK]:	0.03	
Soil conditions:	Rock	
Heat conductivity of rock [W/mK]:	3.5	
Heat capasity [Wh/m³K]	556	
[INSULATION]		
Heat Conductivity of 1000mm mountain rock [W/mK]:	3.5	No other insulation
[SECOND LAYER]		
Heat conductivity of 1 mm rock [W/mK]:	3.5	Layer must be present
[INTERNAL LAYER]		
Heat conductivity of 10mm Stone Tiles [W/mK]:	0.75	
[RESULTS]		
U-Value [W/m²K]:	0.36	
Construction thickness [mm]:	1011	

[ROCKWOOL, 2012] http://www.rockwool.no/r%C3%A5d+og+veiledning/u-verdiprogram

This floor is used to simulate the rock surfaces, also walls and ceilings. The rock itself works as the insulation as the outer part will be heated up over time. This layer is chosen to be 1000mm and gives a U-value of 0.36 in total. if this layer is set to a minimum of 1mm the U-value would be 0.43.

appendix 17 INDOOR CLIMATE / SIMIEN INPUT

THE ANALYSIS

The different hotel rooms will be analysed in Simien to find the dimentions for heating and cooling systems in each of them. The construcion elements made in the rockwool program will be used and all values will follow the requirements from TEK10.

Values in gray are values we are not allowed to change according to rules and requirements.

PROJECT DATA AND BUILDING CATHEGORY		
Building cathegory:	Hotel	
Effect ligthing [W/m²]:	8	
Effect equipent [W/m²]:	1	
Ventilation [m³/m²h]:	10/3	in operating hours/outside operating hours
Effect tapwater [W/m²]:	3.4	
Heatgains per person [W/m²]:	2	
Room temperature [C°]:	21/19	in operating hours/outside operating hours
Operation hours internal loads:	16/7/52	hours/days/weeks of the year
Working hours people:	24/7/52	hours/days/weeks of the year
Operation hours ventilation:	16/7/52	hours/days/weeks of the year

[TEK10, 2012] & [NS 3031:2007]

TECHNICAL INPUT

INNPUT DATA FOR ENERGY SOURCES		
[ELECTRICITY]		
System efficiency:	0.9	middle system value [SIMIEN]
System effect factor cooling:	2.5	air to air cooling, smaller larger aggregate
Energy price [Kr/Kwh]:	-	[NOT USED]
CO2 emissions [g/kWh]:	395	Base value [SIMIEN]
Room heating [%]:	8	Amount of heating coming from electricity
Heating of tapwater [%]:	8	Amount of heating coming from electricity
Heating batteries ventilation [%]:	8	Amount of heating coming from electricity
Cooling batteries ventilation [%]:	100	Amount of cooling coming from electricity
Local cooling (room cooling) [%]:	100	Amount of cooling coming from electricity
El. specific energy need [%]:	80	El specific energy use for lighting, equipment, fans & pumps.
[SUN]		
System efficiency:	9	Middle temperature sun cathcers [SIMIEN]
System effect factor cooling:	2.5	air to air cooling, smaller larger aggregate
Energy price [Kr/Kwh]:	-	[NOT USED]
CO2 emissions [g/kWh]:	0	
Room heating [%]:	0	Amount of heating coming from sun
Heating of tapwater [%]:	0	Amount of heating coming from sun
Heating batteries ventilation [%]:	0	Amount of heating coming from sun
Cooling batteries ventilation [%]:	0	Amount of heating coming from sun
Local cooling (room cooling) [%]:	0	Amount of heating coming from sun
El. specific energy need [%]:	20	El specific energy use for lighting, equipment, fans & pumps.
[GEO THERMAL HEATING]		
System efficiency:	0.92	
System effect factor cooling:	2.5	air to air cooling, smaller larger aggregate
Energy price [Kr/Kwh]:	-	[NOT USED]
CO2 emissions [g/kWh]:	29	[ens, 2012]
Room heating [%]:	92	Amount of heating coming from geo thermal heating
Heating of tapwater [%]:	92	Amount of heating coming from geo thermal heating
Heating batteries ventilation [%]:	92	Amount of heating coming from geo thermal heating
Cooling batteries ventilation [%]:	0	Amount of heating coming from geo thermal heating
Local cooling (room cooling) [%]:	0	Amount of heating coming from geo thermal heating
El. specific energy need [%]:	0	El specific energy use for lighting, equipment, fans & pumps.

8% of the energy in a geo thermal energy plant is electrical energy used to run the pumps, thus only 92% of the heating is set to be covered by geo thermal heating. [ens, 2012] [conserve, 2012]

30% of the lighting energy comes from the sunlight in the hybrid lighting system. With lighting covering 66.7% of the El. specific energy it means that the sunlight in the hybrid system covers 20% of the total el. specific energy need. [APPENDIX: Hybrid daylight saving calculation]

GLOBAL INPUTS

INNPUT DATA - (for all rooms)		
Heated floorarea [m²]:	-	Different for each apartment type
Heated air volume [m³]:	-	Different for each apartment type
[INFILTRATION]		
Airchange at 50Pa [1/h]:	1.5	leak pr. h. w.preassure dif. of 50Pa [SIMIENX] [TEK10]
Airchange at normal state [oms/h]:	0.11	Calculated based on model in program
Screening class:	Moderate	Building in countryside with threes or other buildings
Facade situation:	Default	More than one wind exposed facade [forced]
[OTHER]		
Heat capacity [Wh/m²K]:	4	Medium furnitured room
Operating:	All days	
Normalized coldbridge [W/K/m²]:	0.05	Wood bearing structure [NS 3031, Appendix A:2007]

FACADES TO THE EAST & WEST - (for all rooms)		
Total area including windows [m²]:	1.8	East and west is 1.8 each
Construction U value [W/m²K]:	0.18	[Wall1]
Heat capacity inner layer [Wh/m²K]:	13	Medium heavy wall
Orientation east[°]:	110/130	[west/east wing apartments], 0=North, 180=South
Orientation west[°]:	290/310	[west/east wing apartments], 0=North, 180=South

NATURAL VENTILATION - (for all rooms)		
Opening area [m²]:	1.75	
Opening height [m]:	2	
Number of openings:	1	
First operating month:	May	
Last operating month:	September	
Start operating hour:	7am	
End operating hour:	5pm	

Air change rate is controlled by outdoor temperature and wind speed according to EN 15242.

HEATING - (for all rooms)		
Maximum given effect [W/m²]:	-	Different for each apartment type
Convective portion of the heat output:	0.8	[SIMIENX]
[HYDRONIC HEATING]		
Flow temperature [°C]:	70	[GEOTERMISK, 2007] temp water inn
Return temperature [°C]:	40	[BE10 vejledning.pdf] temp water out
Specific pump effect (SSP) [kW/(l/s)]:	0.5	
Set point in operating hours [°C]:	21	[TEK10] maximum temp while heating = 22
Set point outside operating hours [°C]:	19	[TEK10] minimum temp
Start operating hour:	7am	
End operating hour:	11pm	
Running in summer:	No	Yes/No [No heating need during summer]

FACADE TO THE SOUTH - (for all rooms)		
Total area including windows [m²]:	-	Different for each apartment type
Construction U value [W/m²K]:	0.18	[Wall1]
Heat capacity inner layer [Wh/m²K]:	13	Medium heavy wall
Orientation [°]:	200/220	[west/east wing apartments], 0=North, 180=South
[TOP WINDOWS]		
Number of windows:	-	Different for each apartment type
Window width incl. frame [m]:	2.8	
Window height incl. frame [m]:	2	
Area share of frame:	0.10	10% of total window area is the frame
Overhang depth [m]:	0.5	
Ovehang distance from window [m]:	0	Distance between top of window and the overhang
[BOTTOM WINDOWS]		
Number of windows:	-	Different for each apartment type
Window width incl. frame [m]:	1.94	
Window height incl. frame [m]:	2	
Area share of frame:	0.10	10% of total window area is the frame
Overhang depth [m]:	0.5	
Ovehang distance from window [m]:	1	Distance between top of window and the overhang
Vertical sidehang on each side [m]:	0.38	Covering just half of the window
Vertical sidehang distance from w [m]:	0	
[HEAT LOSS PROPERTIES]		
U-value window [W/m²K]:	0.5	3 glass layers, kryptongass, 2 low emissivity coating
U-value frame [W/m²K]:	0.65	Superisolated woodframe, warmedge (superspacer)
Coldbridge border zone[W/mK]:	0.03	
Totat U-value whole window:	0.58	U-value for window and frame combined
[HEAT GAIN PROPERTIES]		
Sunscreening type:	Adjustable	Outside screen, 3-layer glass, 1 energy glass
Sun factor in activated position:	0.04	4% light let into the room
Sun factor in non-activated position:	0.40	40% light let into the room
Sun screening controll:	Manual	Activated by sunflux given in NS 3031
[BALCONY DOOR]		
Area including frame [m².]:	1.8	
U-value for balcony door [W/m²K]:	0.8	Superinsulated door.

ROOF TOWARDS THE OUTSIDE - (for all rooms)		
Total roof area [m²]:	-	Total roof area to the outside
U-value construction [W/m²K]:	0.18	[Roof1]
Heat capacity [Wh/m²K]:	4.6	Medium heavy inner cladding
Roof pitch:	0°	0° = Flat, 60° = Steep
Orientation:	180°	0°=North, 180°=South [does not matter when roof pitch is 0°]

INTERNAL HEAT GAINS - (for all rooms)		
[LIGHTING]		
Middle effect [W/m²]:	8/0	Inside/Outside operating hours [TEK10]
Heat gains:	100%	The entire effect goes to heat
Heat added based on zonesize [W]:	-	Different for each apartment type
Operating hours:	7am/11pm	Starting/Stopping
[TECHNICAL EQUIPMENT]		
Middle effect [W/m²]:	1/0	Inside/Outside operating hours [TEK10]
Heat gains:	100%	The entire effect goes to heat
Heat added based on zonesize [W]:	-	Different for each apartment type
Operating hours:	7am/11pm	Starting/Stopping
[TAP WATER]		
Middle effect [W/m²]:	3.4	[TEK10] [SIMIEN]
Heat gains:	0%	
[PEOPLE]		
Middle effect [W/m²]:	2	Always operating [TEK10]
Heat gains:	100%	The entire effect goes to heat
Heat added based on zonesize [W]:	-	Different for each apartment type

VARIABLE VENTILATION (VAV) - (for all rooms)		
Keep CO2-value below [PPM]:	800	[SIMIEN] TEK10 req. = outdoor + 500 PPM
Keep indoor air temperature below [°C]:	25	Max. allowed indoor air temp. [TEK10]
[AIR VOLUME]		
Max airchange rate in operating hours [m³/hm²]:	-	Different for each apartment type
Min airchange rate in operating hours [m³/hm²]:	-	Different for each apartment type
Airchange rate outside operating hours [m³/hm²]:	2	(Minimum from NS3031), 13581 m³/h
Airchange rate weekends/vacations [m³/hm²]:	-	NOT USED (operating all days)
SFP-factor fans (at max airchange rate) [kW/m³/s]:	1.5	[SIMIENX]
[SUPPLIED AIR TEMPERATURE]		
Normal supplied air temperature [°C]:	19	
Summertime supplied air temperature [°C]:	17	
First summer month:	May	
Last summer month:	August	
Operation hours:	7am/11pm	Starting/Stopping
[COMPONENTS]		
Max Capacity Heating battery [W/m²]:	-	Different for each apartment type
Delta-T waterside for water heating [K]:	30	
Specific pump effect [kW/(l/s)]:	0.5	
Max capacity Cooling battery [W/m²]:	-	Different for each apartment type
Delta-T waterside for water cooling [K]:	6	
Specific pump effect [kW/(l/s)]:	0.6	
Temperature efficiency of Heat exchanger:	0.85	85% (Minimum req. is 80%) [TEK10]

The previous values are for all the different apartments, the following tables will display the specific values for each apartment.

INPUTS SINGLE ROOM

INNPUT DATA - Single room	
Heated floorarea [m²]:	16.6
Heated air volume [m³]:	50

HEATING - Single room		
Maximum given effect [W/m²]:	22	Maximum effect based on floor area: 365 W

FACADE TO THE SOUTH - Single room	
Total area including windows [m²]:	9.9
[TOP WINDOWS]	
Number of windows:	1
[BOTTOM WINDOWS]	
Number of windows:	1

ROOF TOWARDS THE OUTSIDE - Single room		
Total roof area [m²]:	2.1	Total roof area to the outside

INTERNAL HEAT GAINS - Single room	
[LIGHTING]	
Heat added based on zonesize [W]:	133
[TECHNICAL EQUIPMENT]	
Heat added based on zonesize [W]:	17
[PEOPLE]	
Heat added based on zonesize [W]:	33

VARIABLE VENTILATION (VAV) - Single room		
[AIR VOLUME]		
Max airchange rate in operating hours [m³/h m²]:	10	Airchange rate based on area: 166 m³/h
Min airchange rate in operating hours [m³/h m²]:	7	Airchange rate based on area: 116 m³/h
[COMPONENTS]		
Max Capacity Heating battery [W/m²]:	2	Airchange rate based on area: 33 m³/h
Max capacity Cooling battery [W/m²]:	2	Airchange rate based on area: 33 m³/h

INPUTS DOUBLE ROOM

INNPUT DATA - Double room	
Heated floorarea [m²]:	24.6w
Heated air volume [m³]:	74

HEATING - Double room		
Maximum given effect [W/m²]:	22	Maximum effect based on floor area: 542 W

FACADE TO THE SOUTH - Double room	
Total area including windows [m²]:	19.9
[TOP WINDOWS]	
Number of windows:	2
[BOTTOM WINDOWS]	
Number of windows:	2

ROOF TOWARDS THE OUTSIDE - Double room		
Total roof area [m²]:	4.3	Total roof area to the outside

INTERNAL HEAT GAINS - Double room	
[LIGHTING]	
Heat added based on zonesize [W]:	197
[TECHNICAL EQUIPMENT]	
Heat added based on zonesize [W]:	25
[PEOPLE]	
Heat added based on zonesize [W]:	49

VARIABLE VENTILATION (VAV) - Double room		
[AIR VOLUME]		
Max airchange rate in operating hours [m³/h m²]:	10	Airchange rate based on area: 247 m³/h
Min airchange rate in operating hours [m³/h m²]:	7	Airchange rate based on area: 173 m³/h
[COMPONENTS]		
Max Capacity Heating battery [W/m²]:	2	Airchange rate based on area: 49 m³/h
Max capacity Cooling battery [W/m²]:	2	Airchange rate based on area: 49 m³/h

INPUTS PENTHOUSE ROOM

INNPUT DATA - Penthouse room	
Heated floorarea [m²]:	43.5
Heated air volume [m³]:	131

HEATING - Penthouse room		
Maximum given effect [W/m²]:	22	Maximum effect based on floor area: 957 W

FACADE TO THE SOUTH - Penthouse room	
Total area including windows [m²]:	29.8
[TOP WINDOWS]	
Number of windows:	3
[BOTTOM WINDOWS]	
Number of windows:	3

ROOF TOWARDS THE OUTSIDE - Penthouse room		
Total roof area [m²]:	6.4	Total roof area to the outside

INTERNAL HEAT GAINS - Penthouse room	
[LIGHTING]	
Heat added based on zonesize [W]:	348
[TECHNICAL EQUIPMENT]	
Heat added based on zonesize [W]:	44
[PEOPLE]	
Heat added based on zonesize [W]:	87

VARIABLE VENTILATION (VAV) - Penthouse room		
[AIR VOLUME]		
Max airchange rate in operating hours [m³/h m²]:	11	Airchange rate based on area: 479 m³/h
Min airchange rate in operating hours [m³/h m²]:	7	Airchange rate based on area: 305 m³/h
[COMPONENTS]		
Max Capacity Heating battery [W/m²]:	2	Airchange rate based on area: 87 m³/h
Max capacity Cooling battery [W/m²]:	2	Airchange rate based on area: 87 m³/h

SIMULATION SETUP

The following are the simulation setups used to analyse the indoor climate in each apartment.

INDOOR CLIMATE SUMMER		
[SIMULATION DATA]		
Roomtemperature at simulation start [°C]:	19	Default
Simulation date:	July 20	Default
Number of simulated days:	20	Max
[INDOOR CLIMATE]		
Clothing:	0.5	0.3 = Shorts & T-shirt, 1.5 = Jeans, shirt & jacket
Activety level:	1	0.8 = sit and relax, 2.0 = standing middle activity
[CLIMATE DATA]		
Use temperature data:	n50	Shows maximum temperature below 50 hours

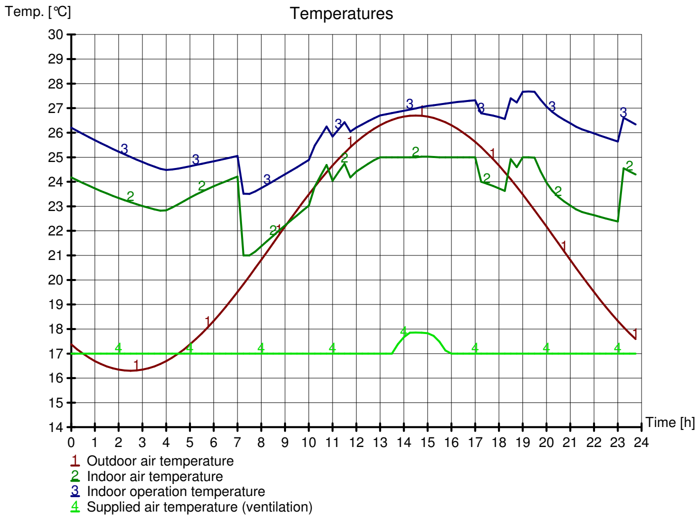
INDOOR CLIMATE WINTER		
[SIMULATION DATA]		
Roomtemperature at simulation start [°C]:	19	Default
Simulation date:	January 16	Default
Number of simulated days:	20	Max
[INDOOR CLIMATE]		
Clothing:	1	0.3 = Shorts & T-shirt, 1.5 = Jeans, shirt & jacket
Activety level:	1	0.8 = sit and relax, 2.0 = standing middle activity

SIMULATION RESULTS

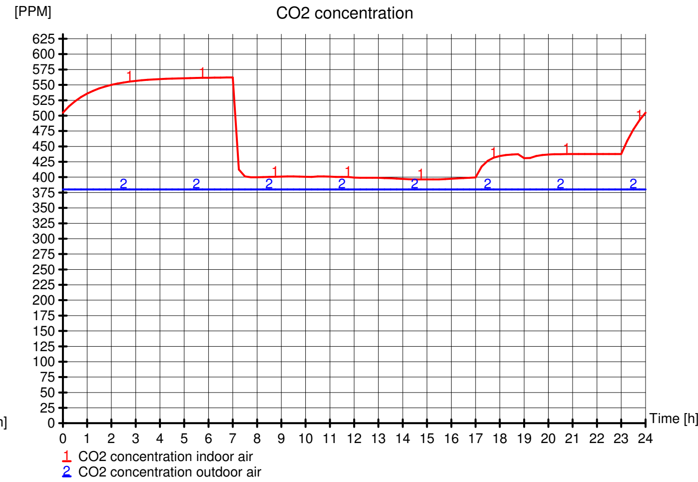
RESULTS SUMMER						
	Single		Double	Penthouse		Totals
	East	West	East	East	West	
Maximum room temperature [°C]:	25	25	25	25	25	25
Maximum operative temperature [°C]:	27.8	27.8	27.7	29.8	29.7	29.8
Maximum CO2 concentration [PPM]:	562	562	562	562	562	562
Max effect cooling battery [W/m²]:	39	38	33	31	34.5	39
Installed effect capacity cooling battery [W/m²]:	39	38	33	31	35	39

RESULTS WINTER						
	Single		Double	Penthouse		Totals
	East	West	East	East	West	
Minimum room temperature [°C]:	19	19	19	19	19	19
Maximum operative temperature [°C]:	19.3	19.3	19.1	19.9	20	20
Maximum CO2 concentration [PPM]:	559	559	559	559	559	559
Max effect heating battery [W/m²]:	13.1	13.1	13.1	13.2	13.2	13.2
Installed effect capacity heating battery [W/m²]:	14	14	14	14	14	14
Maximum effect heating system [W/m²]:	21.1	21.1	22	21.3	21.2	22
Installed effect capacity heating system [W/m²]:	22	22	22	22	22	22

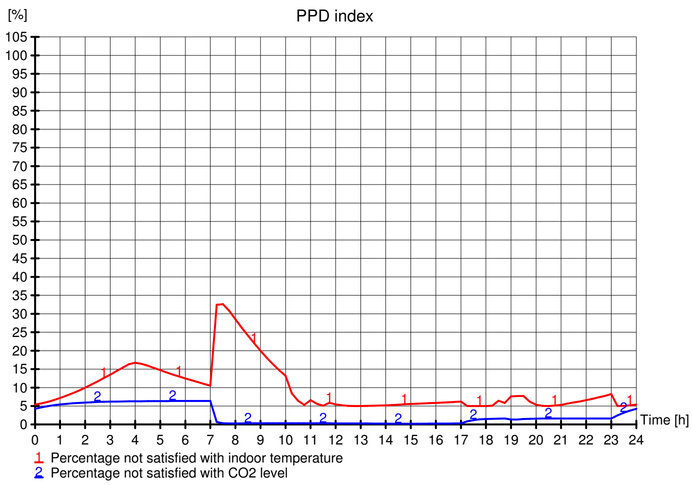
Graphs for Double room summer



The indoor air temperature never go above 25 °C and max between 1pm and 8pm.

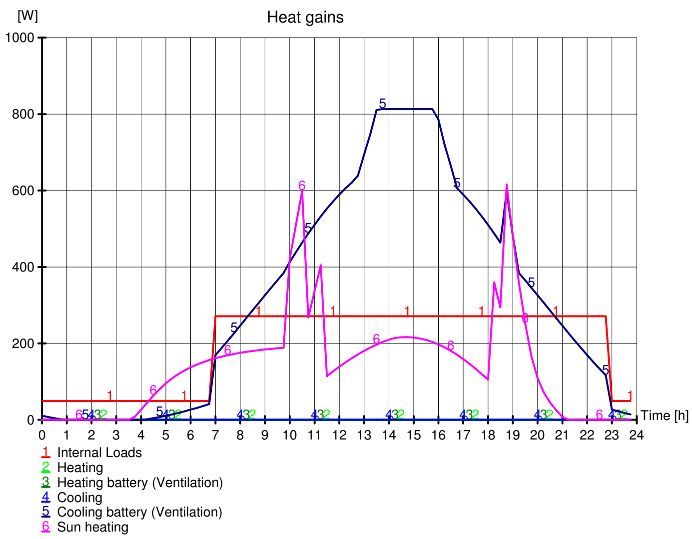


The CO_2 concentration stays well below 800 and max at 562PPM at 7am just before the ventilation system goes into operational hours.

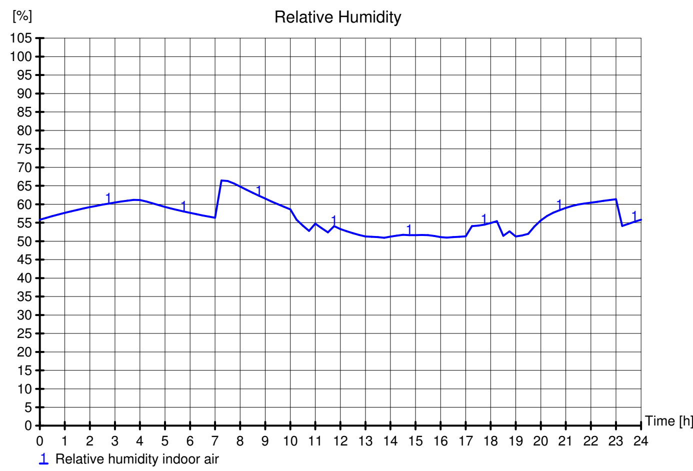


Max 33% (avg. 10%) is not satisfied with the indoor temperature. Max 6% (avg. 3%) is not satisfied with the indoor co2 level.

Between 7am and 5am most of the supplied air comes from natural ventilation. The rest of the day only mechanical ventilation is used.

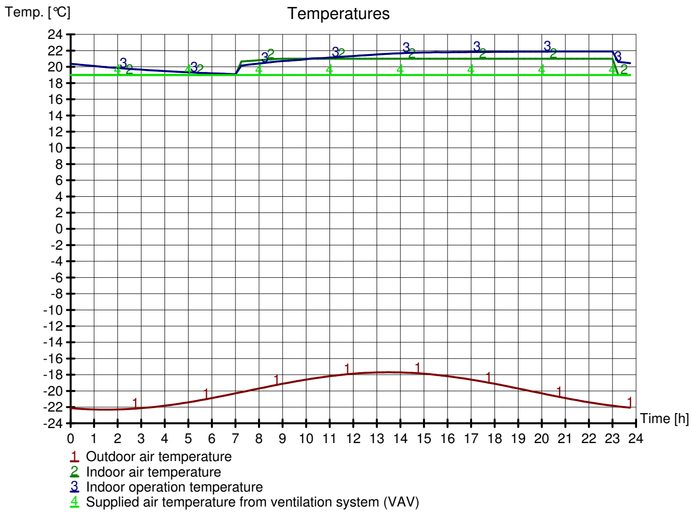


The sun, internal loads and cooling batteries from ventilation is the heat gain sources during summer. Heating and heating batteries are not active in summer time.

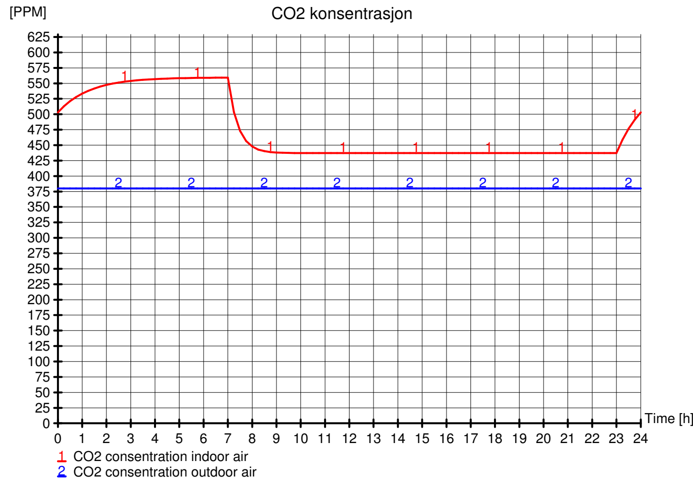


Maximum humidity: 67%
Minimum humidity: 51%
Average humidity: 57%

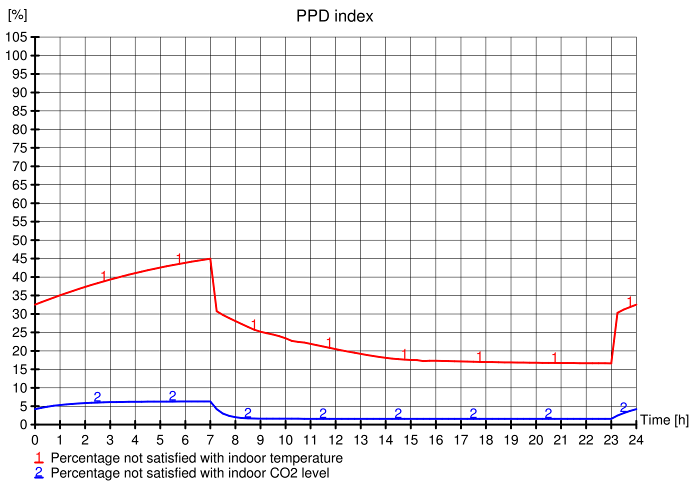
Graphs for Double room winter



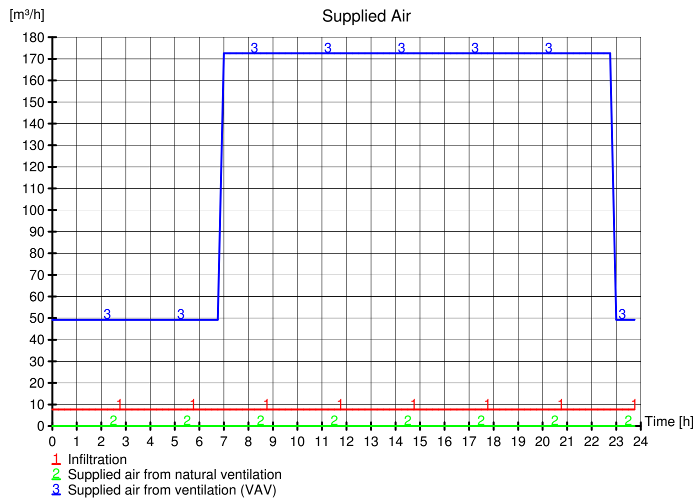
The indoor air temperature never go below 19 °C.



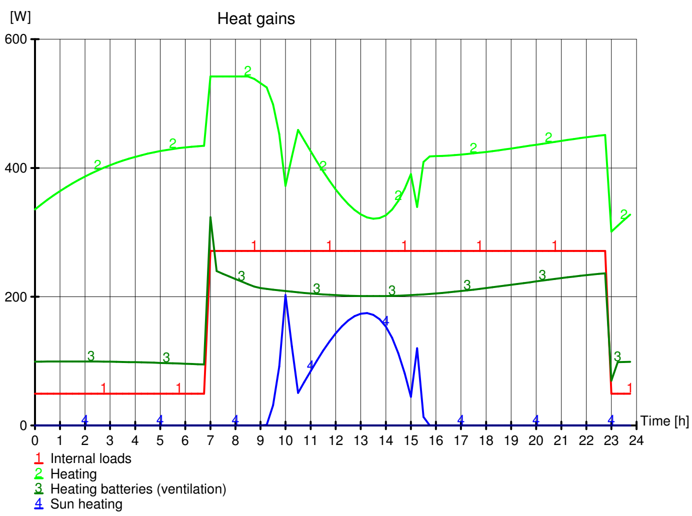
The CO_2 concentration stays well below 800 and max at 559PPM at 7am just before the ventilation system goes into operational hours.



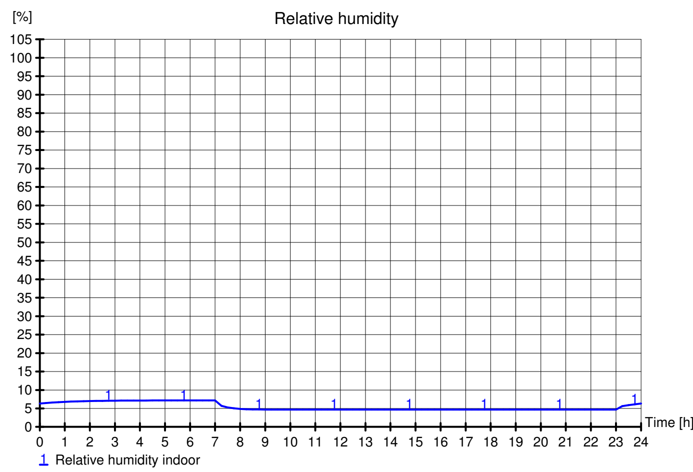
Max 45% (avg. 28%) is not satisfied with the indoor temperature.
Max 6% (avg. 3%) is not satisfied with the indoor co2 level.



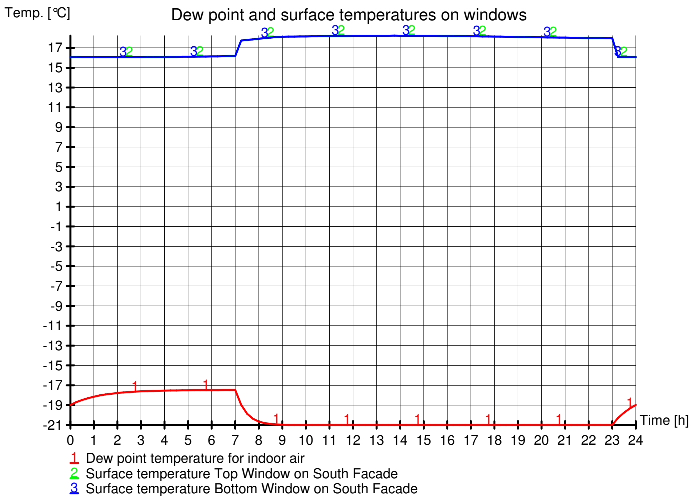
There is no natural ventilation during winter time. The mechanical ventilation has operation hourse between 7am and 11pm, but is always running.



Internal loads, heating, heating batteries from ventilation and sun heating is the sources of heat gains during winter. No cooling is used in winter time.



Maximum humidity: 7%
Minimum humidity: 5%
Average humidity: 6%



Surface temperature windows: Min 16 °C / Max 18 °C
Dew point temperature indoor: Min -21 °C / Max -17 °C

Monthly temperature data (air temperature)

Month	Mean out	Max out	Min out	Mean inside	Max inside	Min inside
January	-7,0 °C	5,4 °C	-21,0 °C	20,4 °C	21,0 °C	19,0 °C
February	-5,8 °C	6,9 °C	-20,6 °C	20,4 °C	21,2 °C	19,0 °C
March	-0,7 °C	10,4 °C	-13,3 °C	20,5 °C	21,8 °C	19,0 °C
April	4,0 °C	15,3 °C	-7,9 °C	21,5 °C	23,4 °C	19,4 °C
May	10,6 °C	23,5 °C	-1,3 °C	23,2 °C	25,0 °C	20,6 °C
June	15,3 °C	27,3 °C	4,2 °C	24,0 °C	25,0 °C	22,2 °C
July	16,5 °C	27,2 °C	5,2 °C	24,3 °C	25,0 °C	22,8 °C
August	14,7 °C	24,6 °C	2,6 °C	23,6 °C	25,0 °C	22,3 °C
September	9,4 °C	19,9 °C	-0,4 °C	22,2 °C	24,2 °C	20,4 °C
October	5,4 °C	15,7 °C	-3,9 °C	20,9 °C	22,2 °C	19,2 °C
November	-1,0 °C	8,6 °C	-11,1 °C	20,5 °C	21,0 °C	19,0 °C
December	-6,0 °C	6,2 °C	-19,9 °C	20,4 °C	21,0 °C	19,0 °C

This is a table showing the average, max and minimum temperatures. The minimum temperature of 19 °C occurs between November and March, while the maximum temperature of 25 °C occurs between May and August.

appendix 19 ENERGY CONSUMPTION / SIMIEN INPUT

These are the inputs used for Simien when doing the different analysis. See [Appendix 25] for the full excel sheet with the calculations of the buildings different floor, roof, wall and window areas.

ENERGY SIMULATION IN SIMIEN

CLIMATE AREA	
Place:	Kongsberg
Latitude [°]:	59° 24'
Longitude [°]:	9° 22'
Middle temp. dim summer [°C]:	21.4
Middle temp. dim winter [°C]:	-25.9
Year middle temperature [°C]:	4.7
Middle horizontal sunflux [W/m²]:	110.3
Year middel wind speed [m/s]:	1.6

[SIMIEN, 2012]

PROJECT DATA AND BUILDING CATHEGORY		
Building cathegory:	Hotel	
Effect ligthing [W/m²]:	8	
Effect equipent [W/m²]:	1	
Ventilation [m³/m²h]:	10/3	in operating hours/outside operating hours
Effect tapwater [W/m²]:	3.4	
Heatgains per person [W/m²]:	2	
Room temperature [C°]:	21/19	in operating hours/outside operating hours
Operation hours internal loads:	16/7/52	hours/days/weeks of the year
Working hours people:	24/7/52	hours/days/weeks of the year
Operation hours ventilation:	16/7/52	hours/days/weeks of the year

[TEK10, 2012] & [NS 3031:2007]

INNPUT DATA FOR ROOM/ZONE		
Name:	Hotel	Data for the whole hotel
Heated floorarea [m²]:	7068.6	Square meters of heated floor area
Heated air volume [m³]:	21206	Cubic meters of heated air volume
[INFILTRATION]		
Airchange at 50Pa [1/h]:	1.5	Leaked airchanges pr. h. preassure difference of 50Pa
Airchange at normal state [oms/h]:	0.11	Calculated based on model in program
Screening class:	Moderate	Building in countryside with threes or other buildings
Facade situation:	Default	More than one wind exposed facade [forced]
[OTHER]		
Heat capacity [Wh/m²K]	4	Medium furnitured room
Operating:	All days	
Normalized coldbridge value [W/K/m²]:	0.05	Building with bearing structure of wood

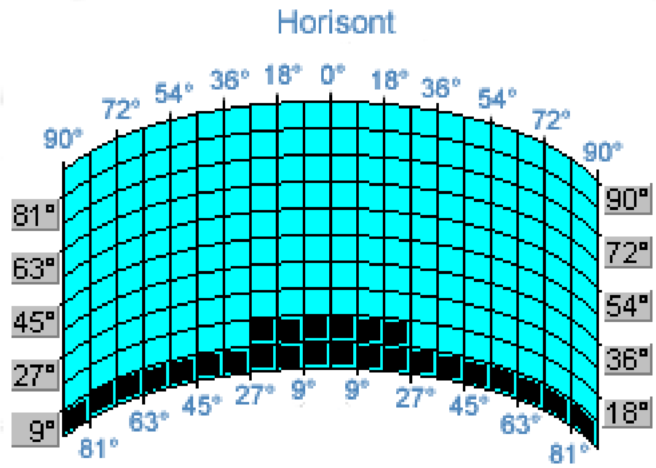
[SIMIEN, 2012]

INNPUT DATA FOR ENERGY SOURCES		
[ELECTRICITY]		
System efficiency:	0.9	middle system value
System effect factor cooling:	2.5	air to air cooling, smaller larger aggregate
Energy price [Kr/Kwh]:	0.8	Base value [NOT USED]
CO2 emissions [g/kWh]:	395	Base value
Room heating [%]:	8	Amount of heating coming from electricity
Heating of tapwater [%]:	8	Amount of heating coming from electricity
Heating batteries ventilation [%]:	8	Amount of heating coming from electricity
Cooling batteries ventilation [%]:	100	Amount of cooling coming from electricity
Local cooling (room cooling) [%]:	100	Amount of cooling coming from electricity
El. specific energy need [%]:	80	El specific energy use for lighting, equipment, fans & pumps.
[SUN]		
System efficiency:	9	Middle temperature sun cathcers
System effect factor cooling:	2.5	air to air cooling, smaller larger aggregate
Energy price [Kr/Kwh]:	0.8	Base value [NOT USED]
CO2 emissions [g/kWh]:	0	
Room heating [%]:	0	Amount of heating coming from sun
Heating of tapwater [%]:	0	Amount of heating coming from sun
Heating batteries ventilation [%]:	0	Amount of heating coming from sun
Cooling batteries ventilation [%]:	0	Amount of heating coming from sun
Local cooling (room cooling) [%]:	0	Amount of heating coming from sun
El. specific energy need [%]:	20	El specific energy use for lighting, equipment, fans & pumps.
[GEO THERMAL HEATING]		
System efficiency:	0.92	
System effect factor cooling:	2.5	air to air cooling, smaller larger aggregate
Energy price [Kr/Kwh]:	0.8	Base value [NOT USED]
CO2 emissions [g/kWh]:	29	[ens, 2012]
Room heating [%]:	92	Amount of heating coming from geo thermal heating
Heating of tapwater [%]:	92	Amount of heating coming from geo thermal heating
Heating batteries ventilation [%]:	92	Amount of heating coming from geo thermal heating
Cooling batteries ventilation [%]:	0	Amount of heating coming from geo thermal heating
Local cooling (room cooling) [%]:	0	Amount of heating coming from geo thermal heating
El. specific energy need [%]:	0	El specific energy use for lighting, equipment, fans & pumps.

[SIMIEN, 2012]

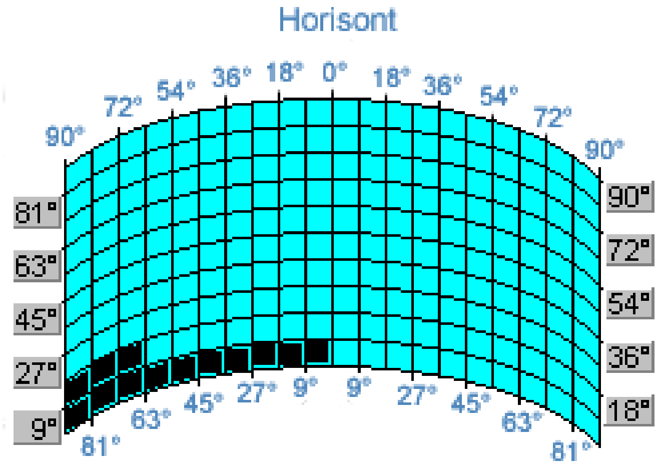
8% of the energy in a geo thermal energy plant is electrical energy used to run the pumps, thus only 92% of the heating is set to be covered by geo thermal heating. [ens, 2012] [conserve, 2012] [geotermisk, 2007]
30% of the lighting energy comes from the sunlight in the hybrid lighting system. With lighting covering 66.7% of the El. specific energy it means that the sunlight in the hybrid system covers 20% of the total el. specific energy need. [APPENDIX: Hybrid daylight saving calculation] [NS 3031, Appendix A:2007] & [TEK10]

FACADE TO THE NORTH		
Total area including windows [m²]:	247.5	
Construction U value [W/m²K]:	0.18	[Wall2], 0.18 max, 0.22 individual max
Heat storage of inner layer [Wh/m²K]:	13	[Wall2]
Orientation [°]:	30°	0=North, 180=South (Based on an average)
[WINDOWS WITH OVERHANG]		
Number of windows:	1	
Window width incl. frame [m]:	20.22	Based on total area of 60.66m²
Window height incl. frame [m]:	3	Based on room height
Area share of frame:	0.10	10% of total window area is the frame
Depth of overhang above window [m]:	0.5	
Distance from window top [m]:	0	Distance between top of window and the overhang
[WINDOWS WITHOUT OVERHANG]		
Number of windows:	1	
Window width incl. frame [m]:	28.5	
Window height incl. frame [m]:	3	Based on room height
Area share of frame:	0.10	10% of total window area is the frame
[HEAT LOSS PROPERTIES]		
U-value window [W/m²K]:	0.5	3 glass layers, kryptongass, 2 low emissivity coating
U-value frame [W/m²K]:	0.65	Superisolated woodframe, warmedge (superspacer)
Coldbridge border zone [W/mK]:	0.03	
Totat U-value whole window [W/mK]:	0.54	U-value for window and frame combined
[HEAT GAIN PROPERTIES]		
Sunscreening type:	Adjustable	Outside screen, 3-layer glass, 1 energy glass
Sun factor in activated position:	0.04	4% light let into the room
Sun factor in non-activated position:	0.40	40% light let into the room
Sun screening controll:	Manual	Activated by sunflux given in NS 3031



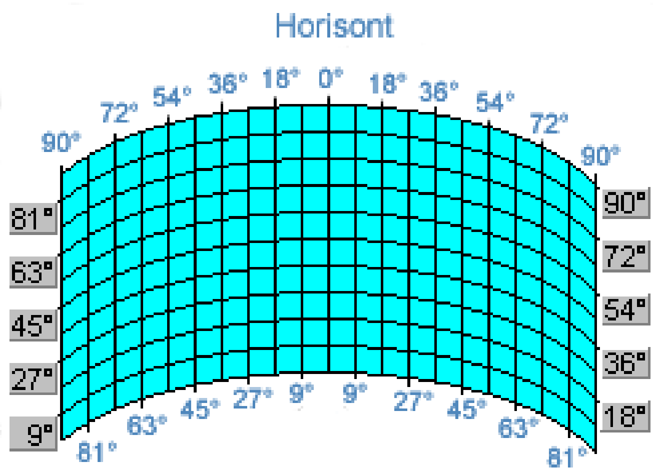
This diagram shows the amount of the horizon that is covered by mountains or other buildings, the blue dots is the clear sky and the black dots are area covered by obstacles.

FACADE TO THE EAST		
Total area including windows [m²]:	315.6	
Construction U value [W/m²K]:	0.18	[Wall2], 0.18 max, 0.22 individual max
Heat storage of inner layer [Wh/m²K]:	13	[Wall2]
Orientation [°]:	120°	0=North, 180=South (Based on an average)
[WINDOWS]		
Number of windows:	1	
Window width incl. frame [m]:	65.19	
Window height incl. frame [m]:	3	Based on room height
Area share of frame:	0.10	10% of total window area is the frame
[HEAT LOSS PROPERTIES]		
U-value window [W/m²K]:	0.5	3 glass layers, kryptongass, 2 low emissivity coating
U-value frame [W/m²K]:	0.65	Superisolated woodframe, warmedge (superspacer)
Coldbridge border zone [W/mK]:	0.03	
Totat U-value whole window [W/mK]:	0.54	U-value for window and frame combined
[HEAT GAIN PROPERTIES]		
Sunscreening type:	Adjustable	Outside screen, 3-layer glass, 1 energy glass
Sun factor in activated position:	0.04	4% light let into the room
Sun factor in non-activated position:	0.40	40% light let into the room
Sun screening controll:	Manual	Activated by sunflux given in NS 3031



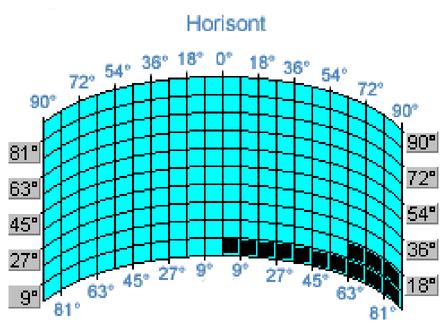
This diagram shows the amount of the horizon that is covered by mountains or other buildings, the blue dots is the clear sky and the black dots are area covered by obstacles.

FACADE TO THE SOUTH		
Total area including windows [m²]:	859.5	
Construction U value [W/m²K]:	0.18	[Wall3], 0.18 max, 0.22 individual max
Heat storage of inner layer [Wh/m²K]:	13	[Wall3]
Orientation [°]:	210°	0=North, 180=South (Based on an average)
[WINDOWS WITH OVERHANG]		
Number of windows:	1	
Window width incl. frame [m]:	156.83	
Window height incl. frame [m]:	3	Based on room height
Area share of frame:	0.10	10% of total window area is the frame
Depth of overhang above window [m]:	0.5	
Distance from window top [m]:	0	Distance between top of window and the overhang
[WINDOWS WITHOUT OVERHANG]		
Number of windows:	1	
Window width incl. frame [m]:	56.75	
Window height incl. frame [m]:	3	Based on room height
Area share of frame:	0.10	10% of total window area is the frame
[HEAT LOSS PROPERTIES]		
U-value window [W/m²K]:	0.5	3 glass layers, kryptongass, 2 low emissivity coating
U-value frame [W/m²K]:	0.65	Superisolated woodframe, warmedge (superspacer)
Coldbridge border zone [W/mK]:	0.03	
Totat U-value whole window [W/mK]:	0.54	U-value for window and frame combined
[HEAT GAIN PROPERTIES]		
Sunscreening type:	Adjustable	Outside screen, 3-layer glass, 1 energy glass
Sun factor in activated position:	0.04	4% light let into the room
Sun factor in non-activated position:	0.40	40% light let into the room
Sun screening controll:	Manual	Activated by sunflux given in NS 3031
[DOORS]		
Area entrance doors [m²]:	5	
U-value entrance doors [W/m²K]:	0.8	
Area blacony doors [m²]:	119	
U-value balcony doors [W/m²K]:	0.8	



This diagram shows the amount of the horizon that is covered by mountains or other buildings, the blue dots is the clear sky and the black dots are area covered by obstacles.

FACADE TO THE WEST		
Total area including windows [m²]:	197.7	
Construction U value [W/m²K]:	0.18	[Wall2], 0.18 max, 0.22 individual max
Heat storage of inner layer [Wh/m²K]:	13	[Wall2]
Orientation [°]:	300°	0=North, 180=South (Based on an average)
[WINDOWS]		
Number of windows:	1	
Window width incl. frame [m]:	42.57	
Window height incl. frame [m]:	3	Based on room height
Area share of frame:	0.10	10% of total window area is the frame
[HEAT LOSS PROPERTIES]		
U-value window [W/m²K]:	0.5	3 glass layers, kryptongass, 2 low emissivity coating
U-value frame [W/m²K]:	0.65	Superisolated woodframe, warmedge (superspacer)
Coldbridge border zone [W/mK]:	0.03	
Totat U-value whole window [W/mK]:	0.54	U-value for window and frame combined
[HEAT GAIN PROPERTIES]		
Sunscreening type:	Adjustable	Outside screen, 3-layer glass, 1 energy glass
Sun factor in activated position:	0.04	4% light let into the room
Sun factor in non-activated position:	0.40	40% light let into the room
Sun screening controll:	Manual	Activated by sunflux given in NS 3031



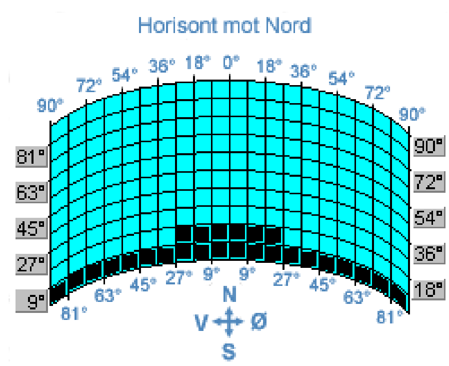
This diagram shows the amount of the horizon that is covered by mountains or other buildings, the blue dots is the clear sky and the black dots are area covered by obstacles.

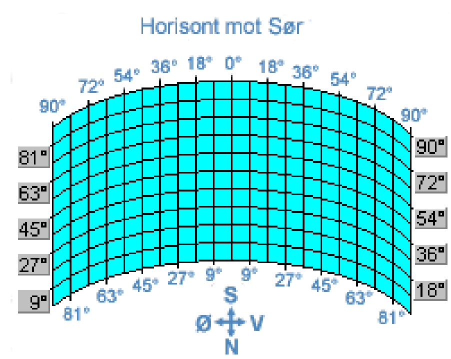
ROOF APARTMENTS		
Total area including windows [m²]:	941	
Construction U value [W/m²K]:	0.18	[Roof1], 0.13 max, 0.18 individual max
Heat storage of inner layer [Wh/m²K]:	13	Medium heavy ceiling
Roof pitch angle [°]:	0°	0°=flat, 60°=steep
Orientation [°]:	180°	0=North, 180=South [don't count due to flat roof]

ROOF REST		
Total area including windows [m²]:	1154.5	
Construction U value [W/m²K]:	0.09	[Roof2], 0.13 max, 0.18 individual max
Heat storage of inner layer [Wh/m²K]:	63	Heavy ceiling
Roof pitch angle [°]:	0°	0°=flat, 60°=steep
Orientation [°]:	180°	0=North, 180=South [don't count due to flat roof]

ROOF GLASS		
Total area including windows [m²]:	174.24	Minimum equal to windows area
Construction U value [W/m²K]:	0.01	Not used as whole area will be window
Heat storage of inner layer [Wh/m²K]:	2.4	
Roof pitch angle [°]:	0°	0°=flat, 60°=steep
Orientation [°]:	180°	0=North, 180=South [don't count due to flat roof]
Window area [m²]:	174.24	
Area share of frame:	0.05	5% of the window area is frame
[HEAT LOSS PROPERTIES]		
U-value window [W/m²K]:	0.5	3 glass layers, kryptongass, 2 low emissivity coating
U-value frame [W/m²K]:	0.65	Superisolated woodframe, warmedge (superspacer)
Coldbridge border zone [W/mK]:	0.03	
Totat U-value whole window [W/mK]:	0.57	U-value for window and frame combined
[HEAT GAIN PROPERTIES]		
Sunscreening type:	Fixed	3 glass layers, 2 of them energy saving glass
Sun factor in non-activated position:	0.45	45% light let into the room

for Roof1 and Roof2 details, see Rockwool chapter.





FLOOR APARTMENTS		
Floor type:	On ground	
Total floor area [m²]:	941.5	
Outer circumference [m]:	128	Length of walls leading to the outside
Thickness foundation [m]:	0.3	
Construction U-value [W/m²K]:	0.15	[Floor1]
Heat storage of inner layer [Wh/m²K]:	13	Medium heavy floor
Soil conditions:	Rock	
Thermal Condictivity of rock [W/mK]:	3.5	
Heat capasity [Wh/m³K]	556	
Edge insulation direction:	Vertical	
Insulation depth/width [m]:	0.6	
Insulation U-value [W/mK]:	0.03	50mm XPS
Equivalent U-value [W/m²K]:	0.11	0.15 max, 0.18 individual max

FLOOR REST		
Floor type:	On ground	
Total floor area [m²]:	1849	
Outer circumference [m]:	110	Length of walls leading to the outside
Thickness foundation [m]:	0.3	
Construction U-value [W/m²K]:	0.10	[Floor2]
Heat storage of inner layer [Wh/m²K]:	63	Heavy floor
Soil conditions:	Rock	
Thermal Condictivity of rock [W/mK]:	3.5	
Heat capasity [Wh/m³K]	556	
Edge insulation direction:	Vertical	
Insulation depth/width [m]:	0.6	
Insulation U-value [W/mK]:	0.034	50mm XPS
Equivalent U-value [W/m²K]:	0.06	0.15 max, 0.18 individual max

MOUNTAIN SURFACES - (All threated as floor to ground)		
Floor type:	On ground	
Total floor area [m²]:	1925.5	Wall, floor and roof areas of natural rock surface
Outer circumference [m]:	197	Length of walls leading to the outside
Thickness foundation [m]:	1	Estimated thickness of insulating part of the rock
Construction U-value [W/m²K]:	0.36	[Floor 3]
Heat storage of inner layer [Wh/m²K]:	63	Heavy floor
Soil conditions:	Rock	
Thermal Condictivity of rock [W/mK]:	3.5	
Heat capasity [Wh/m³K]	556	
Equivalent U-value [W/m²K]:	0.18	0.15 max, 0.18 individual max

INTERNAL HEAT GAINS - (for all rooms)		
[LIGHTING]		
Middle effect [W/m²]:	8/0	Inside/Outside operating hours [TEK10]
Heat gains:	100%	
Heat added based on zonesize [kW]:	56.5	
Operating hours:	7am/11pm	Starting/Stopping
[TECHNICAL EQUIPMENT]		
Middle effect [W/m²]:	1/0	Inside/Outside operating hours [TEK10]
Heat gains:	100%	The entire effect goes to heat
Heat added based on zonesize [kW]:	7.069	
Operating hours:	7am/11pm	Starting/Stopping
[TAP WATER]		
Middle effect [W/m²]:	3.4	[TEK10] value for hotels
Yearly energy use for water heating [kWh/m²]:	29.8	
[PEOPLE]		
Middle effect [W/m²]:	2	Always operating [TEK10]
Heat gains:	100%	The entire effect goes to heat
Heat added based on zonesize [kW]:	14.1	

Values for pool water etc. is not included as the tap water value is calculated according to standard per m² for hotels.

VARIABLE VENTILATION (VAV) - (for all rooms)		
Keep CO2-value below [PPM]:	800	
Keep indoor air temperature below [°C]:	25	Maximum allowed indoor air temperaure
[AIR VOLUME]		
Max airchange rate in operating hours [m³/hm²]:	11	77755 m³/h based on area
Min airchange rate in operating hours [m³/hm²]:	7	49480 m³/h based on area
Airchange rate outside operating hours [m³/hm²]:	2	(Minimum from NS3031), 14137 m³/h
Airchange rate weekends/vacations [m³/hm²]:	2	NOT USED (operating all days)
SFP-factor fans (at max airchange rate) [kW/m³/s]:	1.5	[SIMIEN]
[SUPPLIED AIR TEMPERATURE]		
Normal supplied air temperature [°C]:	19	
Summertime supplied air temperature [°C]:	17	
First summer month:	May	
Last summer month:	August	
Operation hours:	7am/11pm	Starting/Stopping
[COMPONENTS]		
Max Capacity Heating battery [W/m²]:	14	Based on indoor climate analysis
Delta-T waterside for water heating [K]:	30	
Specific pump effect [kW/(l/s)]:	0.5	
Max capacity Cooling battery [W/m²]:	39	Based on indoor climate analysis
Delta-T waterside for water cooling [K]:	6	
Specific pump effect [kW/(l/s)]:	0.6	
Temperature efficiency of Heat exchanger:	0.85	85% (Minimum req. is 80%) [TEK10]

[SIMIENX, 2012] http://www.programbyggerne.no/SIMIEN/eksempel

NATURAL VENTILATION - (for all rooms)		
Opening area [m²]:	1.75	
Opening height [m]:	2	
Number of openings:	68	One for each apartment
First operating month:	May	
Last operating month:	September	
Start operating hour:	7am	
End operating hour:	5pm	

Air change rate is controlled by outdoor temperature and wind speed according to EN 15242.
Only natural ventilation for apartments has been added since the actualt openable door areas of other parts has not been designed.

HEATING - (for all rooms)		
Maximum given effect [W/m²]:	22	Max effect based on area: 155.5 kW
Convective portion of the heat output:	0.8	[SIMIENX]
[HYDRONIC HEATING]		
Flow temperature [°C]:	70	[GEOTERMISK, 2007] temp water inn
Return temperature [°C]:	40	[BE10 vejledning.pdf] temp water out
Specific pump effect (SSP) [kW/(l/s)]:	0.5	
Set point in operating hours [°C]:	21	[TEK10] maximum temp while heating = 22
Set point outside operating hours [°C]:	19	[TEK10] minimum temp
Start operating hour:	7am	
End operating hour:	11pm	
Running in summer:	No	Yes/No [No heating need during summer]

RESULTS - YEAR SIMULATION OF ENERGY USAGE

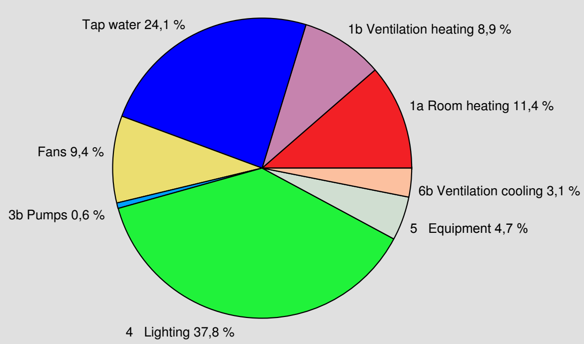
Energy Budget

Energy post	Energy need	Specific energy need
1a Room heating	99185 kWh	14,0 kWh/m²
1b Ventilation heating (heat batteries)	77714 kWh	11,0 kWh/m²
2 Hot water (tap water)	210622 kWh	29,8 kWh/m²
3a Fans	82006 kWh	11,6 kWh/m²
3b Pumps	5175 kWh	0,7 kWh/m²
4 Lighting	330332 kWh	46,7 kWh/m²
5 Equipment	41291 kWh	5,8 kWh/m²
6a Room cooling	0 kWh	0,0 kWh/m²
6b Ventilation cooling (cooling batteries)	27142 kWh	3,8 kWh/m²
Total netto energy need, sum 1-6	873468 kWh	123,6 kWh/m²

Delivered energy to building (Estimated)

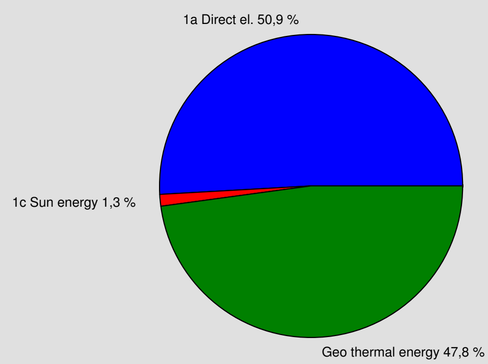
Energy type	Delivered Energy	Specific
1a Direct el.	412347 kWh	58,3 kWh/m²
1b El. Heat pump	0 kWh	0,0 kWh/m²
1c Sun energy	10196 kWh	1,4 kWh/m²
2 Oil	0 kWh	0,0 kWh/m²
3 Gas	0 kWh	0,0 kWh/m²
4 District heating	0 kWh	0,0 kWh/m²
5 Biofuel	0 kWh	0,0 kWh/m²
Geo Thermal heating	387522 kWh	54,8 kWh/m²
Total delivered energy, sum 1-6	810064 kWh	114,6 kWh/m²

Yearly energy budget

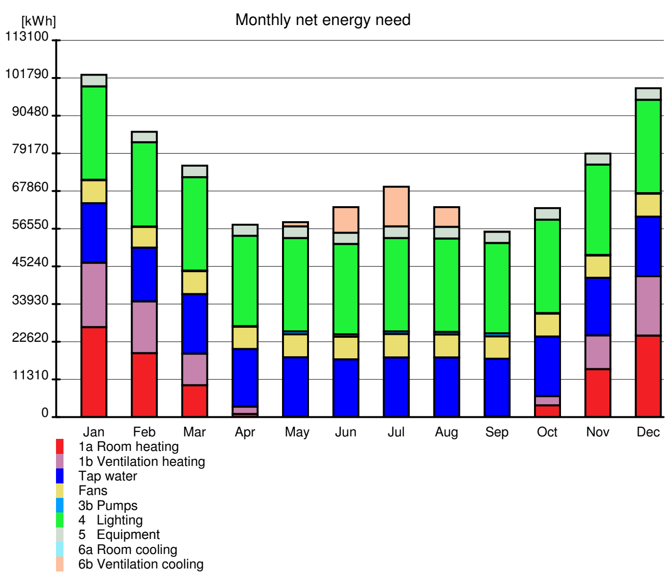


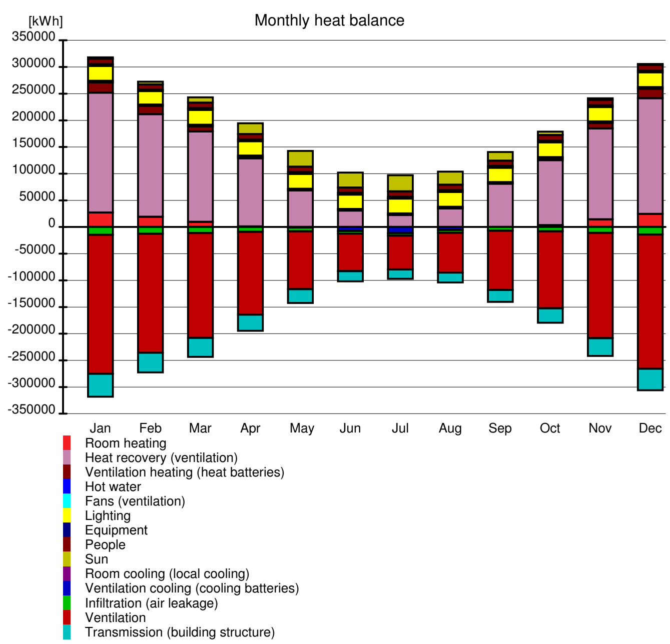
1a Room heating	99185 kWh
1b Ventilation heating (heat batteries)	77714 kWh
2 Hot water (tap water)	210622 kWh
3a Fans	82006 kWh
3b Pumps	5175 kWh
4 Lighting	330332 kWh
5 Equipment	41291 kWh
6a Room cooling	0 kWh
6b Ventilation cooling (cooling batteries)	27142 kWh
Total net energy need, sum 1-6	873468 kWh

Delivered energy to building (Estimated)

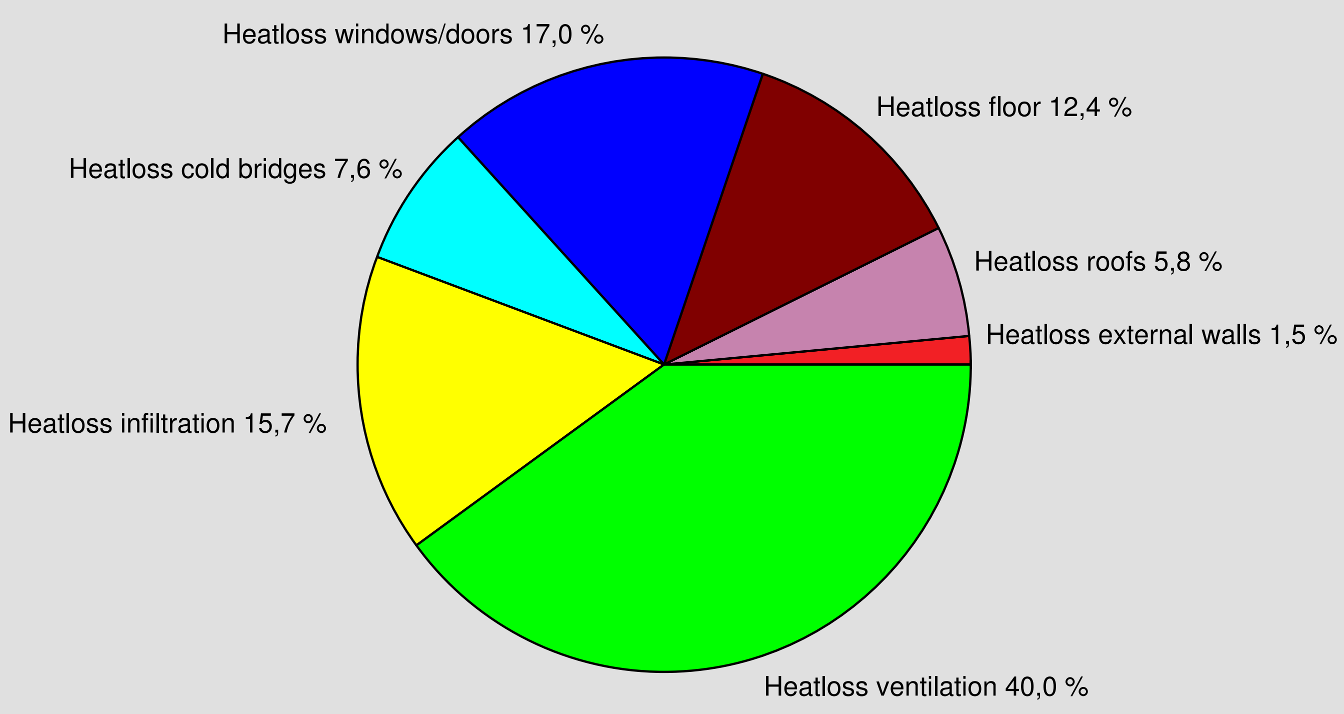


1a Direct el.	412347 kWh
1b El. Heatpump	0 kWh
1c Sun energy	10196 kWh
2 Oil	0 kWh
3 Gas	0 kWh
4 District heating	0 kWh
5 Biofuel	0 kWh
Geo thermal heating	387522 kWh
Total delivered eneryi, sum 1-6	810064 kWh

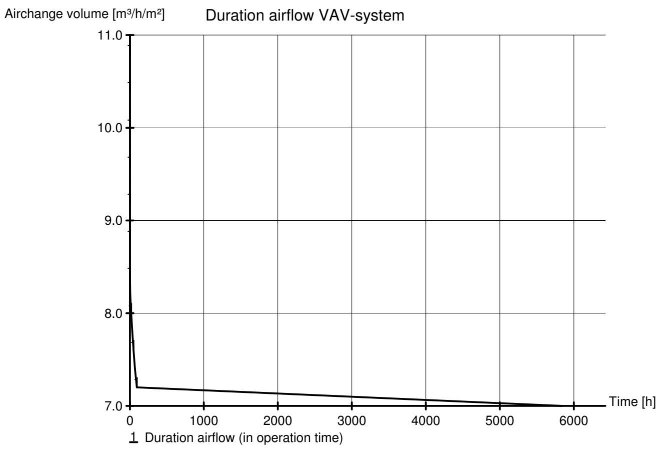


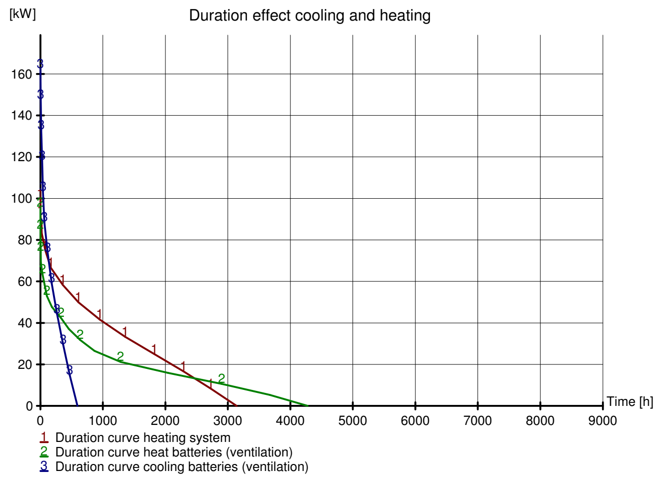


Heatloss budget (heat loss values)



Heatloss external walls	0,01 W/m²K
Heatloss roofs	0,04 W/m²K
Heatloss floor to ground/free air	0,08 W/m²K
Heatloss glass/windows/doors	0,11 W/m²K
Heatloss cold bridges	0,05 W/m²K
Heatloss infiltration	0,10 W/m²K
Heatloss ventilation	0,26 W/m²K
Total heatloss value	0,66 W/m²K





appendix 21 ENERGY CONSUMPTION / SIMIEN / RESULT 2

EVALUATION TOWARD TEK10 BUILDING REGULATIONS & NS3700

INPUTS OF EVALUATION TOWARDS TEK10 REQUIREMENTS		
Evaluation towards:	TEK10	(TEK07/TEK10)
Reduced effect lighting [W/m²]:	6.4	-20% from steering system [NS3031] [SIMIEN]

RESULTS FROM EVALUATION	
Energy measures:	The building satisfies the requirements for energy measures in paragraph § 14-3
Heat loss frame:	The building satisfies the requirements for heat loss figures according to § 14-3
Energy frame:	The building satisfies the energy frame according to § 14-4
Minimum req.:	The building satisfies the minimum requirements in § 14-5
Airchange rate vent.:	The airchange volume satisfies the minmum req. given in NS3031:2010 (Table A.6)
Energy supply:	The building satisfies the requirements for energy supplies in § 14-7
Overall evaluation:	The building satisfies the energy requirements in the building regulations.

ENERGY MEASURES		
	REQ.	VALUE
Total glass-, window and door area according to user area [%]:	20	19.9
U-value exernal walls [W/m²K]:	0.18	0.18
U-value roof [W/m²K]:	0.13	0.13
U-value floor toward ground and to the outdoor [W/m²K]:	0.15	0.12
U-value glass/windows/doors [W/m²K]:	1.2	0.56
Normalized cold bridge value [W/m²K]:	0.06	0.05
Leakage value (tightness at 50 Pa preassure difference) [Airchanges per h.]:	1.5	1.5
Yearly average temperature efficiency of heat recovery in ventilation [%]:	80	85
Specific fan effect (SFP) [kW/m³/s]:	2	1.5

REDISTRIBUTION ENERGY MEASURES		
	REQ.	VALUE
Heat loss figures external walls:	0.01	0.01
Heat loss figures roof:	0.04	0.04
Heat loss figures floor on groun/to the outdoor:	0.1	0.08
Heat loss figures glass/windows/doors:	0.24	0.11
Heat loss figures cold bridges:	0.06	0.05
Total heat loss figures:	0.45	0.29

ENERGY FRAME (§ 14-4, Total net energy need)		
Total estimated energy need:	117.5	kWh/m²
Regulatory requirements:	220.0	kWh/m²

MINIMUM REQUIREMENTS (§ 14-5)		
	REQ.	VALUE
U-value external walls [W/m²K]:	0.22	0.18
U-value roof [W/m²K]:	0.18	0.13
U-value floor to ground or to the outdoor [W/m²K]:	0.18	0.12
U-value glass/windows/doors [W/m²K]:	1.6	0.56
Leakage value (Air tightness at 50 Pa preassure difference) [Airchanges per h]:	3	1.5
Heat loss figures glass/windows/doors:	0.24	0.11

ENERGY SUPPLY (§ 14-7)		
	REQ.	VALUE
Share of heat need covered by other sources than direct electricity or fosil fuels:	60%	96%
Oil fired boiler as the base load:	No	No

EVALUATION TOWARDS NS3700 LOW ENERGY HOUSE CLASS 1

RESULTS FROM EVALUATION	
Heat loss frame:	The building satisfies the requirements for heat loss figures
Energy performance:	The building satisfies the energy performance requirements
Minimum req.:	The building satisfies the minimum requirements for individual components
Airchange rate vent.:	The airchange volume satisfies the minmum req. given in project report 42 (Table2)
Overall evaluation:	The building satisfies all the requirements for low energy houses

HEAT LOSS BUDGET	
Heat loss figures external walls:	0.01
Heat loss figures roof:	0.04
Heat loss figures floor to ground/ floor to outdoor:	0.08
Heat loss figures glass/windows/doors:	0.11
Heat loss figures cold bridges:	0.05
Heat loss figures infiltration:	0.1
Heat loss figures ventilation:	0.26
Total heat loss figures:	0.66
Requirement for heat loss figures:	0.85

ENERGY PERFORMANCE		
	REQ.	VALUE
Net Heating need [kWh/m²]:	50	28.9
Net Cooling need [kEh/m²]:	15	6.8
CO_2 emission [kg/m²]:	55	42

MINIMUM REQUIREMENTS INDIVIDUAL COMPONENTS		
	REQ.	VALUE
U-value external walls [W/m²K]:	0.18	0.18
U-value roof [W/m²K]:	0.13	0.13
U-value floor to ground and to outdoor [W/m²K]:	0.15	0.12
U-value glass/windows/doors [W/m²K]:	1.2	0.56
Normalized coldbridge value [W/m²K]:	0.05	0.05
Year average temperature efficiency of heat recovery for ventilation [%]:	70	85
Specific fan effect (SFP) [kW/m³/s]:	2	1.5
Leakage value (Air tightness at 50 Pa pressure difference) [air changes per h]:	1.5	1.5

EVALUATION TOWARDS NS3700 PASSIVE HOUSE

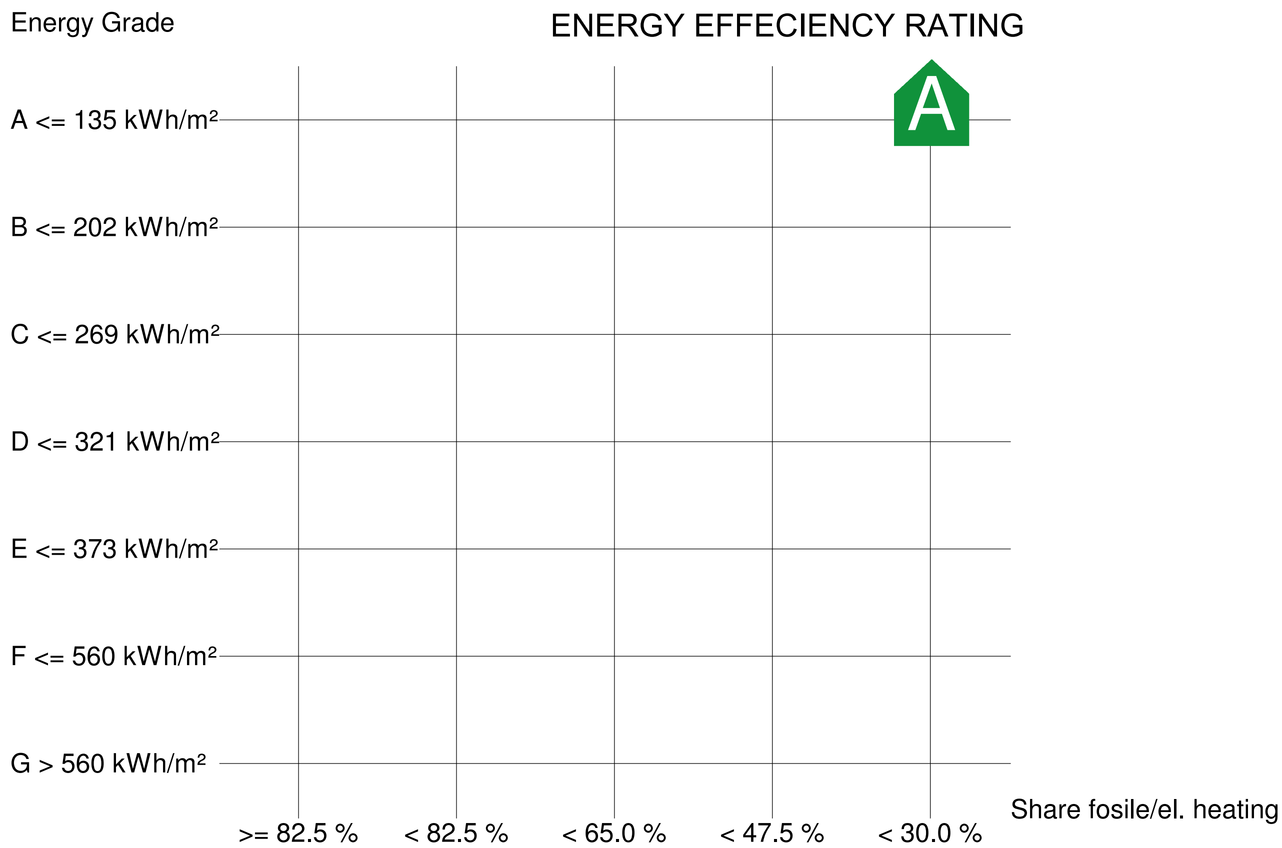
RESULTS FROM EVALUATION	
Heat loss frame:	The building do not satisfy the requirements for heat loss figures
Energy performance:	The building do not satisfy the energy performance requirements
Minimum req.:	The building do not satisfy the minimum requirements for individual components
Airchange rate vent.:	The airchange volume satisfies the minmum req. given in project report 42 (Table2)
Overall evaluation:	The building do not satisfy all the requirements for passive houses

HEAT LOSS BUDGET	
Heat loss figures external walls:	0.01
Heat loss figures roof:	0.04
Heat loss figures floor to ground/ floor to outdoor:	0.08
Heat loss figures glass/windows/doors:	0.11
Heat loss figures cold bridges:	0.05
Heat loss figures infiltration:	0.1
Heat loss figures ventilation:	0.26
Total heat loss figures:	0.66
Requirement for heat loss figures:	0.65

ENERGY PERFORMANCE		
	REQ.	VALUE
Net Heating need [kWh/m²]:	20	28.9
Net Cooling need [kEh/m²]:	10	6.8
CO_2 emission [kg/m²]:	40	42

MINIMUM REQUIREMENTS INDIVIDUAL COMPONENTS		
	REQ.	VALUE
U-value external walls [W/m²K]:	0.15	0.18
U-value roof [W/m²K]:	0.13	0.13
U-value floor to ground and to outdoor [W/m²K]:	0.15	0.12
U-value glass/windows/doors [W/m²K]:	0.8	0.56
Normalized coldbridge value [W/m²K]:	0.03	0.05
Year average temperature efficiency of heat recovery for ventilation [%]:	80	85
Specific fan effect (SFP) [kW/m³/s]:	1.5	1.5
Leakage value (Air tightness at 50 Pa pressure difference) [air changes per h]:	0.6	1.5

ENERGY EFFICIENCY RATING



Estimated delivered energy normalized climate: 108 kWh/m²
Sum share el/oil/gas of net heating need: 8.0 %

appendix 25 HOTEL VALUES

This is the excel file used to calculate and sum up the amount of different floor, wall, roof and glass areas in the building. The data is used when building the large model for simulation in Simien for different analysis.

WALLS				
629,4	Walls top floor		m²	
	wall n	21,2		63,6
	wall e	29,1		87,3
	wall s	21		63
	wall w	25,6		76,8
	wall g			0
	glass n	34,3		102,9
	glass e	17		51
	glass s	33		99
	glass w	28,6		85,8
608,73	Walls 4th floor		m²	
	rock walls	52,51		157,53
	walls facing north	5,6		16,8
	falls facing east	5,7		17,1
	walls facing south	7,6		22,8
	walls facing west	6		18
	glass facing north	10,1		30,3
	glass facing east	29,3		87,9
	glass facing south	66,1		198,3
	glass facing west	9,8		29,4
	walls to ground	10,2		30,6
837,9	Walls 3rd floor		m²	
	rock walls	61,7		185,1
	walls facing north	15,2		45,6
	falls facing east	13,6		40,8
	walls facing south	68,2		204,6
	walls facing west	7,5		22,5
	walls to ground	91,4		274,2
	glass facing north	8,2		24,6
	glass facing east	5,7		17,1
	glass facing south	7,8		23,4
	glass facing west			0
908,4	walls 2nd floor			
	rock walls	113,7		341,1
	walls facing north			0
	falls facing east	15,3		45,9
	walls facing south	70,8		212,4
	walls facing west	3		9
	walls to ground	75,3		225,9
	glass facing north	7,4		22,2
	glass facing east	9,5		28,5
	glass facing south	7,8		23,4
	glass facing west			0
1133,7	walls 1st floor			
	rock walls	171,1		513,3
	walls facing north	36		108
	falls facing east	17,9		53,7
	walls facing south	60,4		181,2
	walls facing west	20		60
	walls to ground	44,6		133,8
	glass facing north			0
	glass facing east	5,7		17,1
	glass facing south	22,2		66,6
	glass facing west			0

TOTALS			
3453,63	ROCK	1197,03	m²
	WALL N	247,5	m²
	WALL E	315,6	m²
	WALL S	859,5	m²
	WALL W	197,7	m²
	GLASS N	166,5	m²
	GLASS E	130,8	m²
	GLASS S	235,2	m²

See GLASS

FLOOR AREAS		
1st floor	1725,4	m²
2nd floor	1723,4	m²
3rd floor	1381,2	m²
4th floor	1472,9	m²
top floor	765,7	m²
area	7068,6	m²
volume	21205,8	m³

WINDOWS	
7,413	per single
504,084	all flats
60,66	shop hex n
101,1	shop hex s
85,5	entrance s
63,9	entrance e
96,6	restaurant e
99,8	restaurant w
92,2	walkpath north
17,3	walkway e
16,3	walkway w

AREA			
Roof1	Rooms	941,514	m²
Roof2	Rock	497,5	m²
Roof3	Atrium	649,281	m²
Roof4	Glass	174,24	m²
Roof5	Restaurant	505,54	m²

GLASS	total	overhang	normal	overhang minus doors
glass n	146,146	60,66	85,486	
glass e	195,58			
glass s	759,7524	589,5	170,2524	470,5
glass w	127,71			

TOTALS		
1408,4284	area of glass	m²
7068,6	total area	m²
19,9	% of glass area compared to floor area	

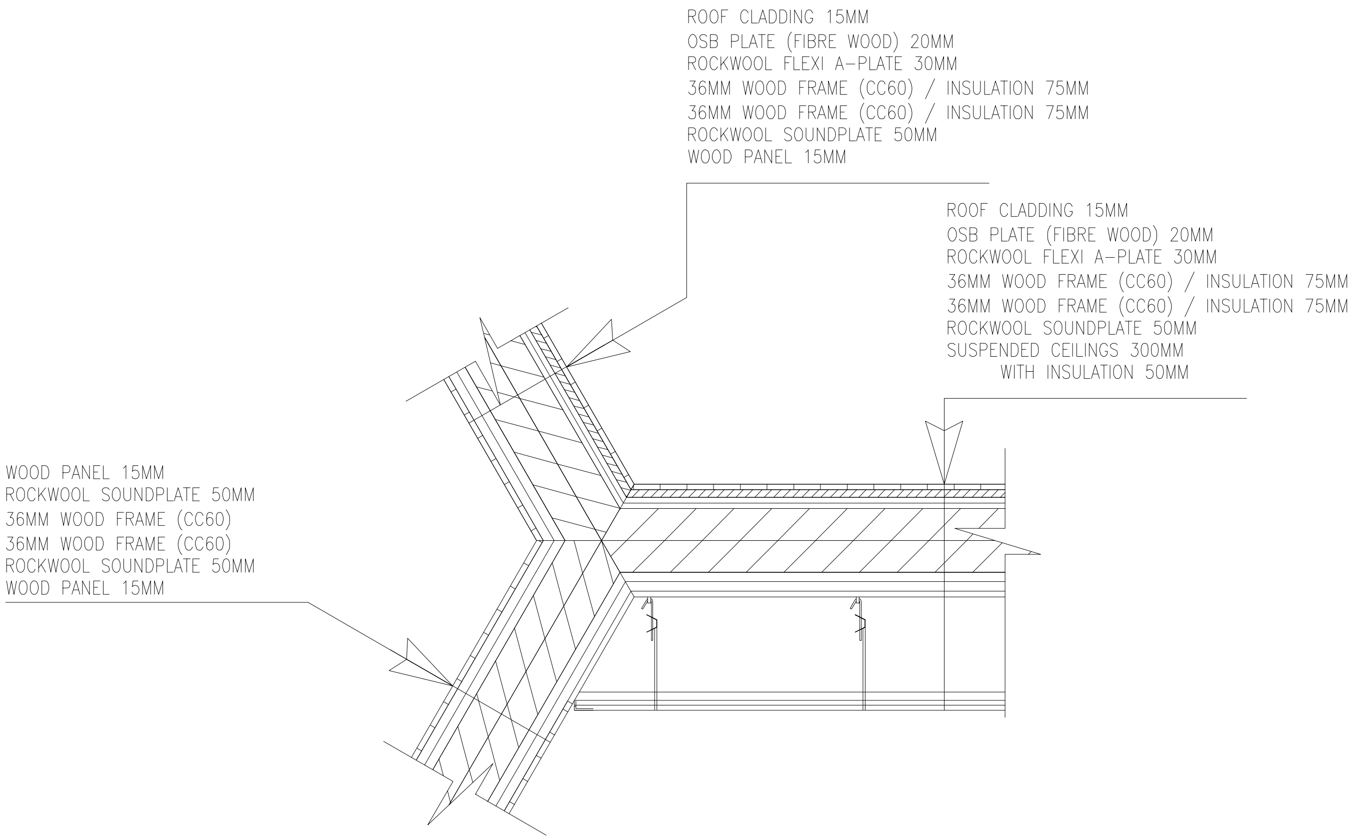
FLOORS		
wall+roof	ROCK	1910,53
	floor a	941,514
	floor o	1826,561
	floor t	2768,075

ADDED	
171,5	26,2m wall
60	15,5m wall
	41,7
1925,5	1735,7

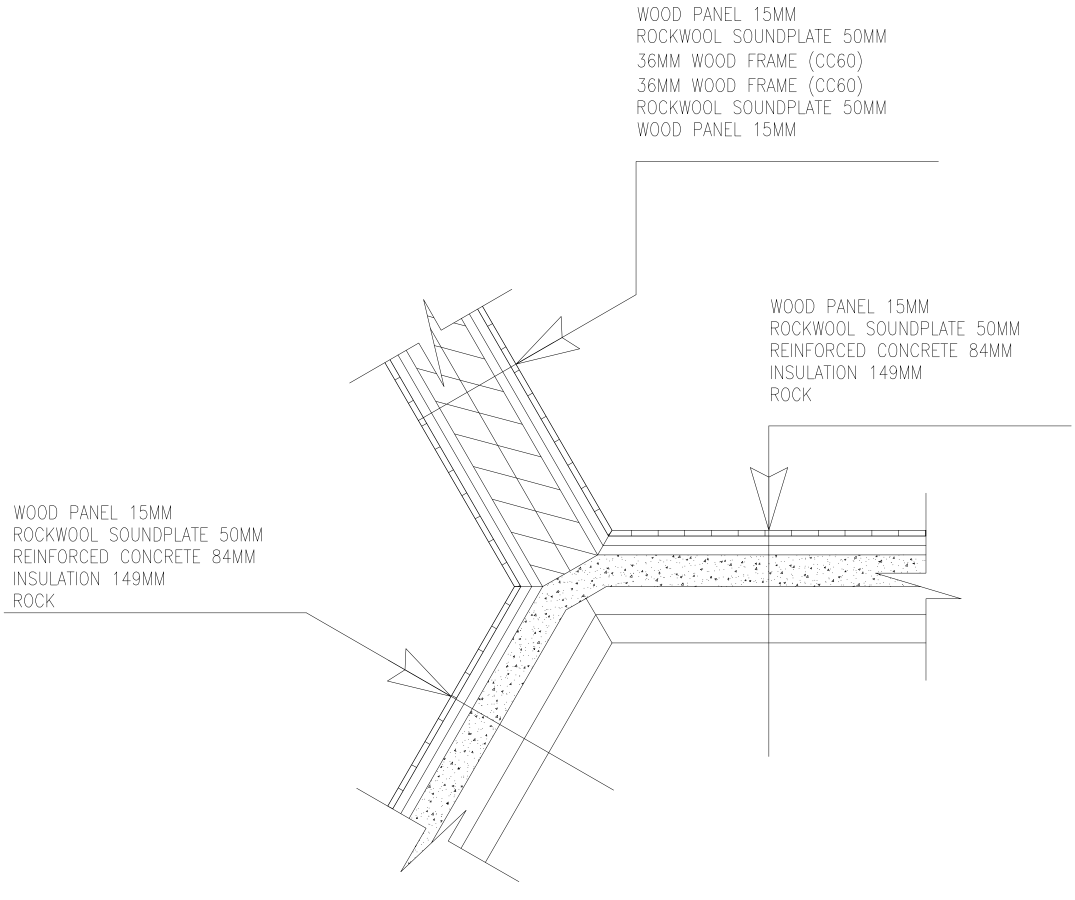
appendix 26 DETAIL OF JOINTS

D-1 Shows a joint where the lower element is between two stories, while the two other elements connects to the outside balcony area.
D-2 Shows a joint internal between two moguls, and connection to the concrete slab foundation leading to the ground.

D-1 - MOGUL CONNECTION EXTERNAL & INTERNAL



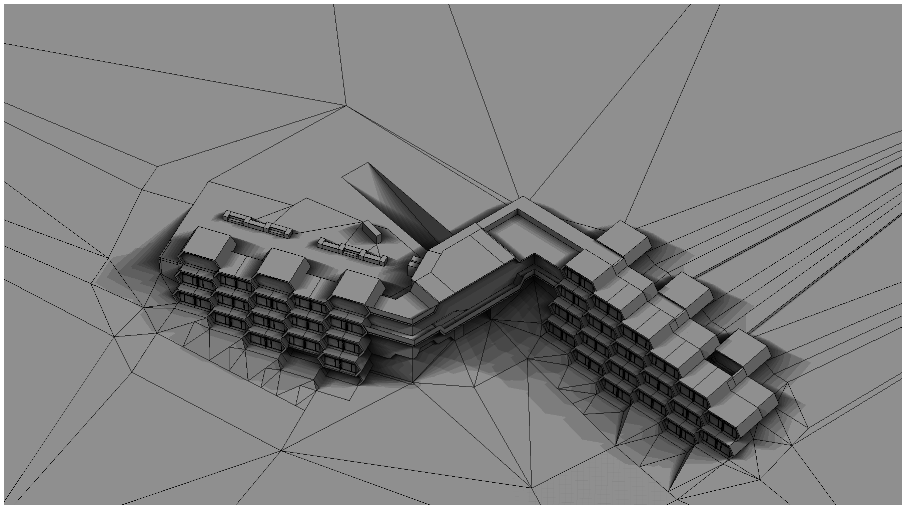
D-2 - MOGUL CONNECTION INTERNAL & SLAB TO GROUND



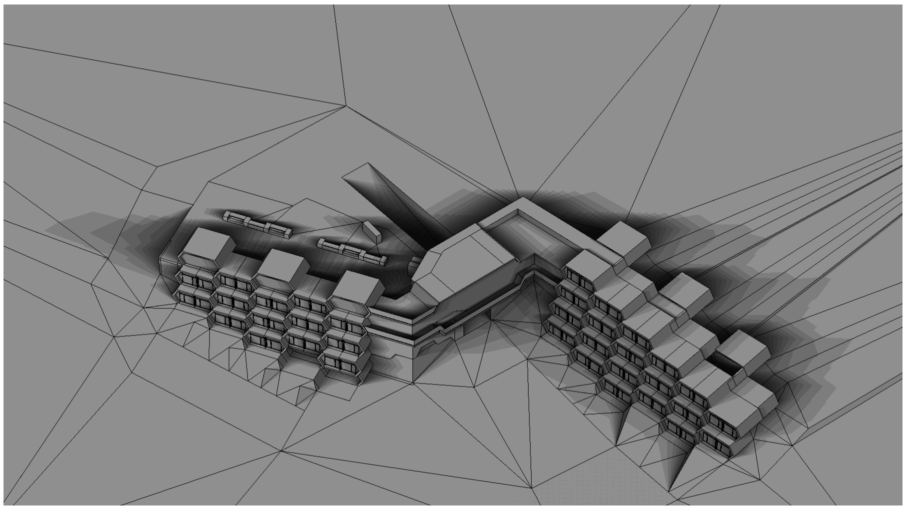
appendix 27 SHADOWS

These shadow analysis done in Ecotect shows buildings shading during a day. A new shadow is cast every 30 minute thoughout the day.

21st of June, 30 minute steps from 07:00 to 17:00



21st of September, 30 minute steps from 08:00 to 16:30



21st of December, 30 minute steps from 09:45 to 14:45

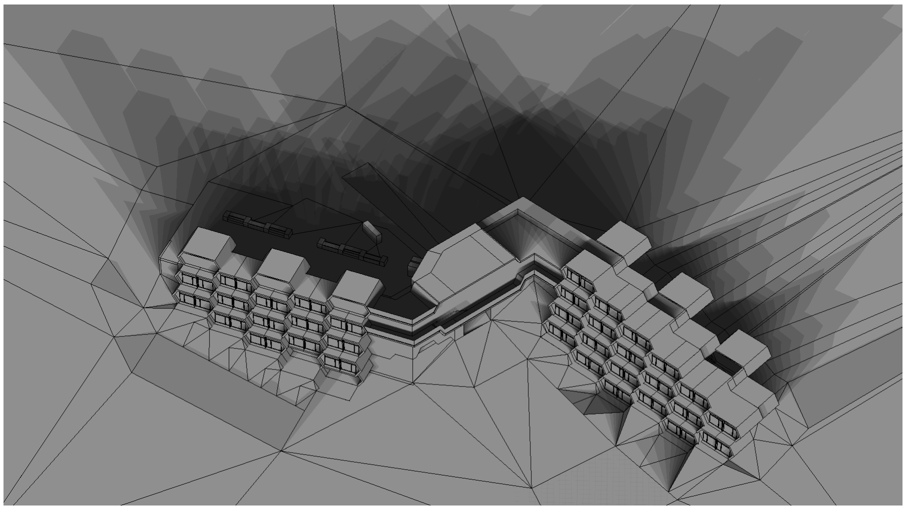


ILLUSTRATION LIST

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