A Master Thesis at Chalmers Architecture
By: Anders Winlöf 2009/2010
Examinator: Morten Lund (CTH)
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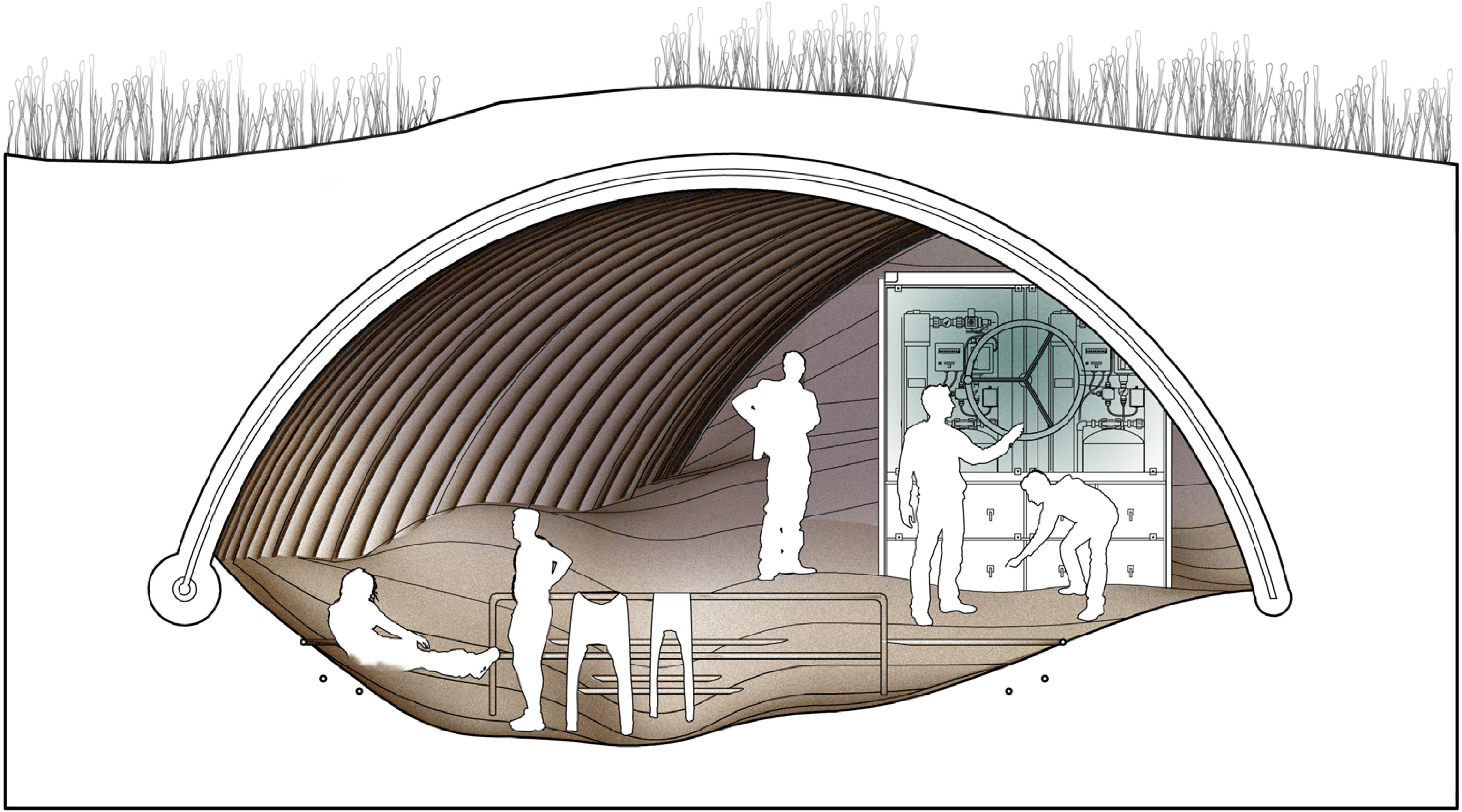
See You in September!



ABSTRACT

The lack of energy is not a problem. Renewable energy sources can provide our planet's energy consumption up to 15.000 times. When we choose to fully harness these energy sources new possibilities will rise.

This Master Thesis asks: How can we create architecture that is built by energy and what are the advantages?

Due to a wave power plant, the project offers facilities for wave surfers in the sand dunes of Kåsa, Varberg. It is designed by premises of the wind, materialized by sand and powered by the waves. Since the surf season in Sweden is limited the facilities only exist during fall & winter. When spring arrives, the power is turned off and the structure cease to exist.

That is why my project is called See You in September!

Anders Winlöf 2010.01.21

CONTENT

WHAT?

'See you In September!' proposes a combination of highly technical systems that create a synergy effect which handles the contextual and cultural problems of the program. At the same time, these technical systems give the opportunity of an evanescent architecture that follows the seasons over the year.

WHY?

The city of Varberg has during the last century had a strong cultural connection to the ocean. Apart from the fortification, several cultural institutions such as 'Kallbadhuset' and 'Nakenbadet' together with the beaches at Kåsa and Apelviken confirm Varberg as a typical City by the Sea.

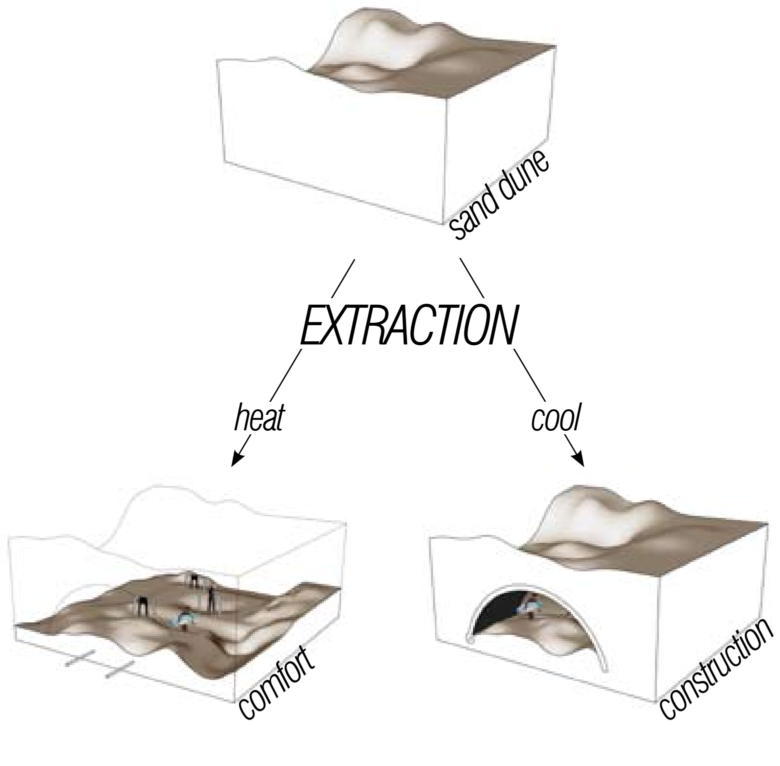
To strengthen this identity, my advice to the municipality of Varberg is to harness the energy in the ocean and to support also newer types of water cultures. What I propose is a wave power plant that also offers facilities for the surfers at Kåsa, one of the most popular surf beaches in Sweden.

HOW?

In contrary to the hi-tech systems, the architecture is a low tech solution that brings the surfers closer to their right element: the nature. In this way the rough lifestyle of surfing can be kept and consolidated.

To fit in the context this project is designed by premises of the wind, materialized by sand and powered by the waves. To adjust to the cultural phenomenon of surfing, the facilities only exist during the wave season of fall and winter, when the spring arrives and the surf season is over, the facilities cease to exist.

A quick explanation of how I intend to do this is to extract the heat from the sand dunes, so that a frozen shell of sand is created. The excess heat is used to warm up another part of the dune. In other words, the cool is used for construction and the heat for comfort.



PROGRAM

As the daylight breaks the clear sky a car rolls down towards Kåsa. A westerly wind has increased during the night and four impatient surfers intently trying to discern the waves from the snowdrifts through the car window. They drive up onto the promenade for pedestrians just to make the distance to the beach as short as possible. The four heavily dressed get out and start to fight the 15 meters per second strong wind to get a proper look at what the ocean has to offer today. After 10 minutes of observation in the icy winds, they agree, the waves are good enough for surfing.

They hurry back to the car and throw off their jackets, sweaters and trousers until they stand naked in the cold outside the Varberg Kurorts Hotel. With more or less graceful movements begins on the first challenge, to get the 5mm thick neoprene wetsuit on.

When dressed they unload the lashed boards of the roof and head for the sandy beach. Behind the small public toilet building they drag the boards out of the board bags and store the empty bags up against the wall of the toilet, the only lee warded place the beach has to offer. As surfboards are fragile, the heather half-covered with snow has to support when the already frozen fingers tries to rub the wax on the board, so in order to increase the grip well on top of the wave.

After a quick warm up the four adrenaline fuelled surfers run out in the 5 degree warm water, throw themselves on the boards and start paddling out through the waves. On the beach the board bags, wax and car keys are waiting behind the half wind protective hexagonal public bathroom.

Soon they have all caught their first waves of the day and everyone has forgotten the early morning and the chilly wind. But after 40 minutes in the cold water a light rain turns into a whipping hail. It is time for the day's first break. They quickly reach the shore and put the boards in the bags, shove the board bags in under the car (causing 2 holes in the bottom board which will later be temporarily repaired with duct tape) and jump into the car with blue IKEA bags as seat covers.

The hail proves to be persistent and the soaked wetsuits unsustainable, despite the highest heat in the car. They decide to eat lunch and help each other to get out of the wet suits next to the car on the gravelled parking lot. The whipping wind hurts against the already chilled skin. From the trunk they pick a triangia kitchen and two cans of ravioli before they again start running towards the public toilet between the beach and the promenade. They push themselves through the door and put the stove on the toilet lid and pour in the ravioli while they hear how sound of the hail on the roof decreases. It sounds like it is time for another surf session after lunch and indeed the four of them carry out the same procedures 15 minutes later. However, this time in already wet wetsuits making the process, if possible, even colder.

Another forty five minutes later the feeling in their toes starts to disappear, which in turn affects the performance on the wave which determines that it is time to call it the day. With feet that feel like lumps of ice, two of them get onshore to observe the remaining surfers in the waves. But not for long since the wind almost is as agonizing as the water which means that they must trudge to the car to change into dry clothes, but cold. They put the soaking wet wetsuits that smells of salt, sweat and seaweed in the blue Ikea bags.

For the second time of the day the heater in the car is on full effect and after a while toes and fingers have regained their ability to move and feel.

While waiting for the others, there is now time to fix the holes in the fragile fibre glass shell that surrounds a softer core of polystyrene. With the tailgate opened they roughen up the surface around the damage and put a fast-drying resin onto and around the open wound. Just in time for when the second half of the group begins to paddle ashore, the adhesive mixture has dried and after some compassionate move by the fine-grained sandpaper the board looks as good as new. With pleased faces they back out of the gravel parking lot which they will soon see again. Tomorrow a storm is waiting.

heated area

This is not a sauna in the ordinary sense but an area where surfers can warm up after lying in the cold water. It is also where the wetsuit is heated and possibly dried.

dressing room

Semi heated space for changing from clothes to an unwieldy wetsuit which requires a bit of extra space. Men and women use the same area in order to create a tension between the users, the same way beach visitors check out each others tanned bodies in the summer.

food preparation

A feature that provides clean water as well as a surface to prepare food on. It is not a kitchen but requires that visitors have with their own triangia kitchen.

viewpoint

A wind protected area with a clear view towards the waves and the surfers in the water. For both visitors and users.

wetsuit dryer

The rinsed off wetsuits should be able to get dry or at least heated up in case of a pause from the surfing.

wetsuit rinse

To prevent odours from the wetsuit the surfers should be able to rinse the board and suit, before they hang it to dry.

boardrack

How can this function be integrated as part of the architecture? How can you maintain control of your board while changing clothes?

shower

In connection with the dressing room is one or more showers with hot water.

storage

In connection with the dressing space a possibility to store clothes and valuables is offered. Is it lockable or how will it be safe?

workspace

This is not a feature that offers tools or machinery, but only a large area where the surfer can wax or fix holes in the board. It should be designed to prevent damage to the surfboard. Ergonomics?

existing facilities

public toilets

There are today two public toilets at Kåsa.

waste sorting

Another existing feature is the waste sorting station in connection with the beach promenade.








UHU por

PROCESS

The following spreads will show the primary research that I found essential and it is also the result from this research that has formulated the concept: "Designed by the premises of the wind, materialized by sand and powered by the waves".

The research gave me information of the context of Varberg, the culture of surfing, the weather conditions, wave power techniques, characteristics of sand and how wind and sand interact.

These conditions gave the framework of the possibilities which has been the starting point of finding the appropriate space.

VARBERG

Source: www.visitvarberg.se

Photo: okänd

Source: http://www.raa.se/bok/pdf/sverigeskust.pdf

Photo: www.sj.se

Source: http://www.raa.se/bok/pdf/sverigeskust.pdf

Photo from Kåsa: Anders Winlöf 2009

A CITY BY THE SEA

Varberg Fortress was built around 1290s but it was first in 1666 that the city got its present location after Sweden conquered Halland. In 1830 the fort ceased to be a protective building and has since worked as a restaurant, hostel and museum.

To the west of the fortress the city spreads, originally planned as a grid plan protected by the fortress canons. As a wooden town Varberg were often exposed to large-scale fires, the largest in 1767 and 1863. In the end of the 1800s the stone city started to occur in the central part thanks to the massive stone industry, which completely dominated Varberg around the year 1900. In the early 1900s the industrial development characterizes the city with residential developers and home-owners outside the city centre.

Varberg Municipality had in late 2008 over 56 000 inhabitants, many of them commuters that choose to live in Varberg and work in for example Gothenburg.

The 7000 km coast of Sweden have three common denominators; fisheries, communications and defence. Fishing along the coast of Halland never led to any major expansion, instead it was the urban expansion and holiday villages that were built along the coast during the 1900s that characterizes Varbergs development.

Lighthouses were seen in Scandinavia already during the 1200s. However, during the development of the railways during the 1800s, the fairways on the water lost its importance. Water was now rather seen as a communication barrier than as a link. New transport routes led, as in Varberg, to large industrial plants were built along the coast to reach both land and waterborne transport.

Due to the strong exploitation of the holiday homes along the Halland coast during the 1900s first half, the historic characteristics of the landscape are limited. In the 1930s the parliament felt that the coastline and shores had to be protected by law. 1975 came the last existing shore protection law which bans the construction of new buildings or facilities which deter the public from the beach areas.

The Swedish west coasts characteristic granite outcrops makes itself visible also around Varberg. Around 1900 the stone industry was the dominant, with quarries at Hästhagabergen, Kohagen and Subbeberget just south of Kåsa. Here you can still find clear traces of their activity which took place one hundred years ago.

Hästhagabergen, a 29 ha large green area that is divided by the railways, can be found just north of the bay. The area is characterized by tall birch and heather, with a great number of trails that cuts through the vegetation. Closer to shore, there are traces of the old rail route from the 1880s.

The granite outcrops faces the water from both north and south of the bay while the beach is growing out of the water to the east. Since the completion of Apelviken coastal sanatorium the waves and the wind has kept building sand dunes against the surrounding stone wall.

Photo:
Kåsa, Mikael Pilstrand

Source:
www.visitvarberg.se

PhotoS:
www.nordicsurfermag.com

Photo:
www.nordicsurfermag.com
Kåsa, Sep-09

Varberg markets itself as The Health Resort of Sweden. The city is still characterized by the hot bath, Societetshuset as well as the oriental-inspired cold bath. In addition to these buildings, Varberg also has a long tradition of sea bathing. There are separated nude bathing for gentlemen and ladies at the cliffs south of the fort, which derived from the working class population taking dips in the sea during the year. Further south we find Kåsa, Apelviken, Träslövsläge etc., all of which offer sandy beaches.

1902, city physician in Varberg, Johan Severin Almer, started the Apelviken Sanatorium for tuberculosis patients. The activity was broadened later to include the treatment of polio and other orthopaedic bone and joint diseases. In the early 1970s, the county's main orthopaedic clinic was located here. Since 1991, there is intensive activity with health resort, recreation and spa.

Like the sanatorium has evolved, we can now see a more diversified use of Varberg coasts, including nude bathing and several different types of surfing.

Wind-, Kite- and wave surfing are relatively new phenomenon in Sweden. But it should be noted that the company Surfers (Paradise), established in Varberg since 1985. Today there are many activities that feed on surf culture in Varberg, but it should also be seen as an indirect access where, firstly attract young workers to the municipality and secondly, free of charge thanks to the forces of nature, offers good conditions for spontaneous activity.

Wind surfing, kite surfing and wave surfing are sports that are relatively closely related, but it is also much that divides them. The first two uses in addition to the board a sail or a kite to capture wind energy that pulls the surfers forward. For wave surfing, which only makes use of the board of fibreglass, wind plays no direct role. Instead, these guys use the energy of waves to catch and manage.

The bays around Varberg offer, thanks to their different shapes and landscape, various conditions for different types of surfing.

For surf-able waves to occur along the west coast, a major (minimum 12m/sek) onshore breeze are needed for a few hours. What makes Kåsa unique is that the wind direction can span from southwest to northwest, which allows a high frequency of waves compared to other surf spots in Sweden.

While Apelviken and Träslövsläge are shallow bays that better fits wind and kite surfers due to their need for large water surfaces, Kåsas sandy bottom rises steeply and is therefore better for wave surfing.

The municipality has announced a ban on kite surfing in Kåsa. Probably because it is a small bay often crowded with bathers which make it too dangerous to use kites. There is no wave surfing restriction but you will only spot them when the wind is blowing at least 12 meters per second. That is when it is the surfers turn to enjoy Kåsa.

SURFING

From the article:
`Kallt vatten, varmt blod´
Nordic Surfers Mag #1

Photo:
www.nordclothing.com

Source:
http://en.wikipedia.org/wiki/Surfing

Photo:
Fanny Holmqvist
Indonesia - 2008

Sources:
http://www.raa.se/bok/pdf/sverigeskust.pdf
www.nordsurf.se

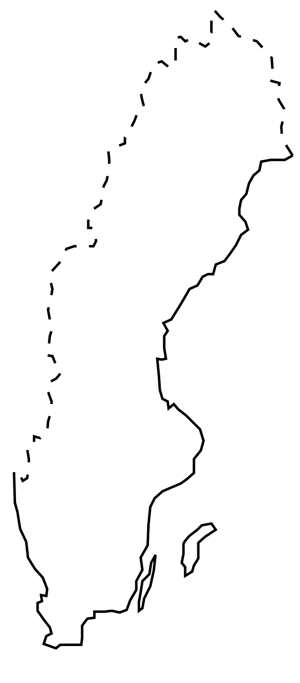
Photo from the Westcoast:
www.nordicsurfermag.com

COLD WATER WARM BLOOD

'The heat in the car is turned up to max, the fan is working frantically and the old stereo rasps out the Jimmy Cliff 'Sitting in Limbo'. The misty panes are doing their best to insulate the cold damp January air from attacking my bare back when I struggle to put my arms into the wetsuit. It is difficult to get the thick rubber over my limbs in the tight back seat. The car sways from side to side of my struggling /.../ Warmed up by the gymnastics my eagerness increase since I now know that I soon will receive a welcome dose of energy that the mind and body have a screaming need for. Waves, cold and warm, is the business for surfers around the world whether they are taken in a 6mm thick wetsuit or board shorts. This need is not something that has been imposed or is inherited. It is a choice.'

- Tony Johansson

Wave surfing has been an important part of Hawaiian culture since the sport incurred during 1400. Since then it has spread around the world and the number of surfers is growing every day. Where you find the coast, you will find the waves.



The Swedish coast is about 7000km long. Yet it is rarely empty in the water when the popular surfspots offer waves. One reason is that there are about 5000 active surfers in the country, but also because only a fraction of the waves that hit our coast are good for surfing. This is due to:

Size – Since neither the Kattegat or the Baltic Sea are particularly large oceans, strong onshore wind are required to build up a reasonable wave size good for surfing. At least 12 meters per second on shore wind in a couple of hours is needed to create decent waves.

Wind direction - From which direction the waves hits the coast is essential for any surf spot.

Bottom - On a shallow beach waves are usually too flat to surf while on an increasingly steep bottom hit the waves usually directly on the rocks. Something in between is usually best.

Photo:
www.billabong.com

Photo:
http://surfing.about.com

Photos:
www.nordicsurfermag.com
www.nordclothing.com

Not only do we have to wait for the right weather conditions, we must also manage to catch the wave to be able to surf on it. A typical surf session consists of 80% of paddling, 19% of waiting and 1% of that actually standing on the board and surfing the wave.

Despite this, everything feels so worth it once you are on the wave. You have managed to tame the forces of nature and become one with them.

Originally surfboards were made of wood, making them heavy and unwieldy. Balsa wood was long considered to be the most suitable material, but it was only possible to use the fragile wood when fibre glass was invented during the 2nd World War.

Today, mainly polyurethane or polystyrene are used as a core wrapped in thin layers of fibre glass with polyester or epoxy. In the middle of the board runs a 'stringer', a thin wooden piece that strengthens the board. More recently, the balsa wood regained popularity, probably because of increased environmental awareness.

Surfboards are most often shaped by hand, but modern technology has in recent years made it possible to produce them in machines.

Source:
http://en.wikipedia.org/wiki/Surfing

Surfing is often portrayed as something flashy, with sunny beaches, tanned bodies and tropical temperatures in air and water. In some places in the world, this is also how it really is perceived, not to forget the hard work needed to catch a wave.

But in order to reconnect to the initial story, that is usually what surfing looks like in Sweden. As the wind blows most of autumn and winter, it is also in that climate a surfer in Sweden have to pull on his awkward wet suit before he throws himself into the icy water to challenge nature.

WEATHER

Source:
www.wikipedia.org

Photo:
unknown

METEOROLOGY

Meteorology is a part of the science of the atmosphere, specifically the science of weather, weather events and weather forecasts. Meteorological phenomena are observable events that can be explained by activity in the atmosphere and how these energies interact with each other. These activities are temperature, barometric pressure and humidity.

Meteorology has been studied for thousands of years, but the ability to provide relatively accurate forecasts came first in 1900 with the computer breakthrough. The concept of meteorology was coined by Aristotle as early as 350 BC. One of the most impressive parts of Aristotle's works is his description of the water cycle.

Source:
www.wikipedia.se

Picture:
Pont du Gard

HYDROLOGY

Hydrology is the science of water movement, distribution and quality of the earth that describes both the water cycle and Earth's water resources. What Arisoteles explain 300 years BC Leonardo Da Vinci came to describe in a more scientific way as the water cycle.

Hydrology has been the subject of studies and engineering for thousands of years. One example is the storage level of the Nile 6000 years ago, which created the growing possibility of a previously barren landscape. Mesopotamian cities protected themselves against flooding with major earthworks. The Greeks and the Romans built aqueducts, while the Chinese built the system for irrigation and flood control. The ancient Sinhalese used hydrological knowledge for building complex irrigation system of reservoirs, dams and canals in Sri Lanka for over 2000 years ago, many of which still exist today.

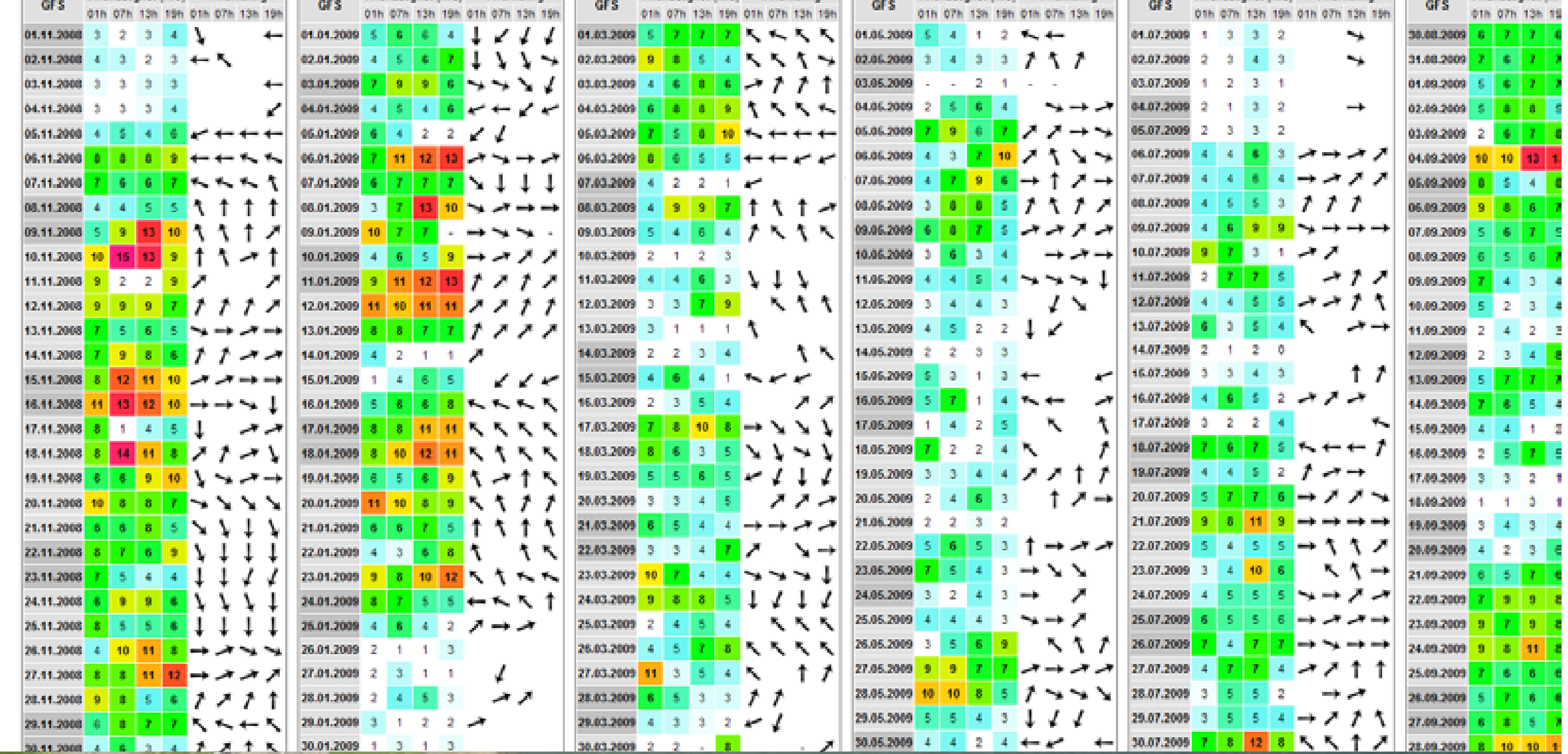
Source:
www.wikipedia.se

Photos:
unknown

WIND & WAVES

Wind is the flow of air in the atmosphere. Winds are created by horizontal differences in atmospheric pressure and can move in all directions; horizontally, vertically and in eddies. Wind speed/Velocity is measured by an anemometer and is usually stated in meters per second (m / s). Wind strength measures wind effects rather than the current wind speed and can be specified on the Beaufort scale. Wind direction is measured with a weathervane. The wind has an equalizing effect on both pressure and temperature. Wind is an interesting possibility to extracting energy from, i.e. windmills and wind turbines.

Water waves are surface waves in the top layer of a water body, such as in a sea. They can arise i.e. by wind, water currents or geological activity and can travel thousands of mil before they hit the coast. Sand dunes occur in the same way as water waves.



Wind statistics Apelviken, Varberg:

2008 Nov – Average velocity: 6,8 m/s
2009 Jan - 6,1 m/s
2009 Mar - 5,2 m/s
2009 May - 4,4 m/s
2009 Jul - 4,7 m/s
2009 Sep - 6 m/s

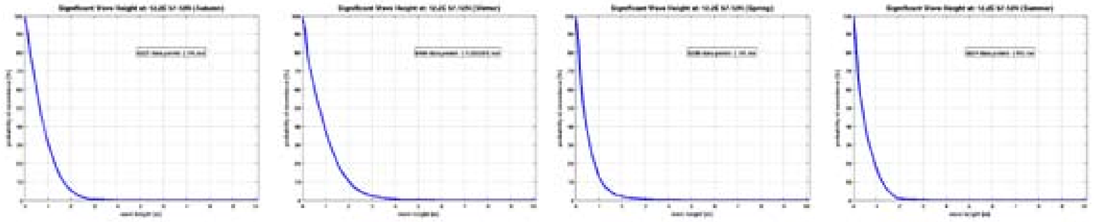
Source & graphics:
www.windguru.cz

On the west coast the water generally rise in a westerly wind and fall at easterly wind. At the westerly wind, a so-called storm surge occurs where the water quickly rises over one meter. Also the air pressure affects the sea level. At a high air pressure the water level drops while at low pressure the water level rises. The storm Gudrun occurred in January 2005. Along the west coast sea levels rose to more than +160 cm which was a new record since measurements began in Varberg in 1886.

Sources:
www.smhi.se
www.sjofartsverket.se

The UN Panel on Climate Change (IPCC) reported in 2007 a likely rise of sea level of 18-59cm, between the years 1980-1999 to 2090-2099. Sea level increase is not expected to happen at the same rate all around the earth. Some model calculations suggest that the seas around Sweden (and in the North Sea in general) may rise more than the global average.

Photo:
www.eniro.se



Source:
www.dmi.dk

Based this information (statistics from measurements outside of Getterön) Kåsa gets surfable waves between 40 to 50 days a year. These waves are of great joy for surfers, while other groups are trying to protect themselves against them. In the harbour of Varberg there are several jetties that protect the boats and buildings against the force of the waves. Another use for water is the moat that surrounds Varberg Fortress. This is not a protection against water, but the water that provides protection.

Photo:
Kåsa in Sep -09

SUMMARY

For thousands of years, man has studied and in many cases mastered, meteorology and hydrology. There are numerous examples throughout history of engineers and architects that controlled the natural cycle which led to cultural advantages. There are also local examples of this and my intention is to continue this tradition and enhance the Varberg identity as the City by the Sea.

WAVEPOWER

Photo:
Clark Little

Source:
www.wikipedia.se
www.surferspath.com

Image:
"the Wave" - Hokusai

Source:
www.surferspath.com

Photo:
unknown

WHY WAVE POWER?

A goal when I designed my task was to design a building that is powered by renewable energy. After studying the wind, wave and solar energy, wave power have turned out to be the energy source that best fits into my project. To show respect to birdlife and National Heritage Board's recommendation that wind turbines pollute the culturally sensitive environment around Varberg Fortress, wind power fell out. Photovoltaic solar panel options can be seen as complementary but, conceptually, wave power fits best into my project that aims to develop facilities for surfers in Kåsa.

Wave power in Sweden, with very moderate wave conditions, pointing to a usage rate of between 35-60% of the time compared to wind energy's average of 25%. Energy density of water is also much higher than in the wind and sun.

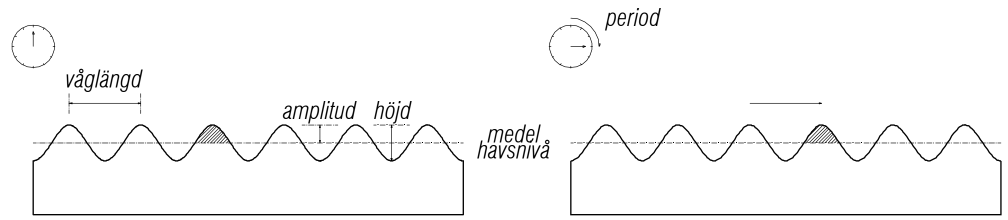
Today there are hundreds of different techniques for extracting energy from waves, but only a few commercial. There is no problem to create a wave power plant that produce energy, the problem is to make it efficient enough so that the business becomes profitable. To solve this problem I do not see as my task. What I instead want to show with my project is how a cultural phenomenon can take advantage of a wave power plant.

We are exposed to waves every day, often without noticing. Sound waves striking against our eardrums, light that meets our eyes, the heat from the sun or radio waves from our mobile phones and wireless routers. Some waves travel through time and space, some through vacuum while others are travelling through a medium.

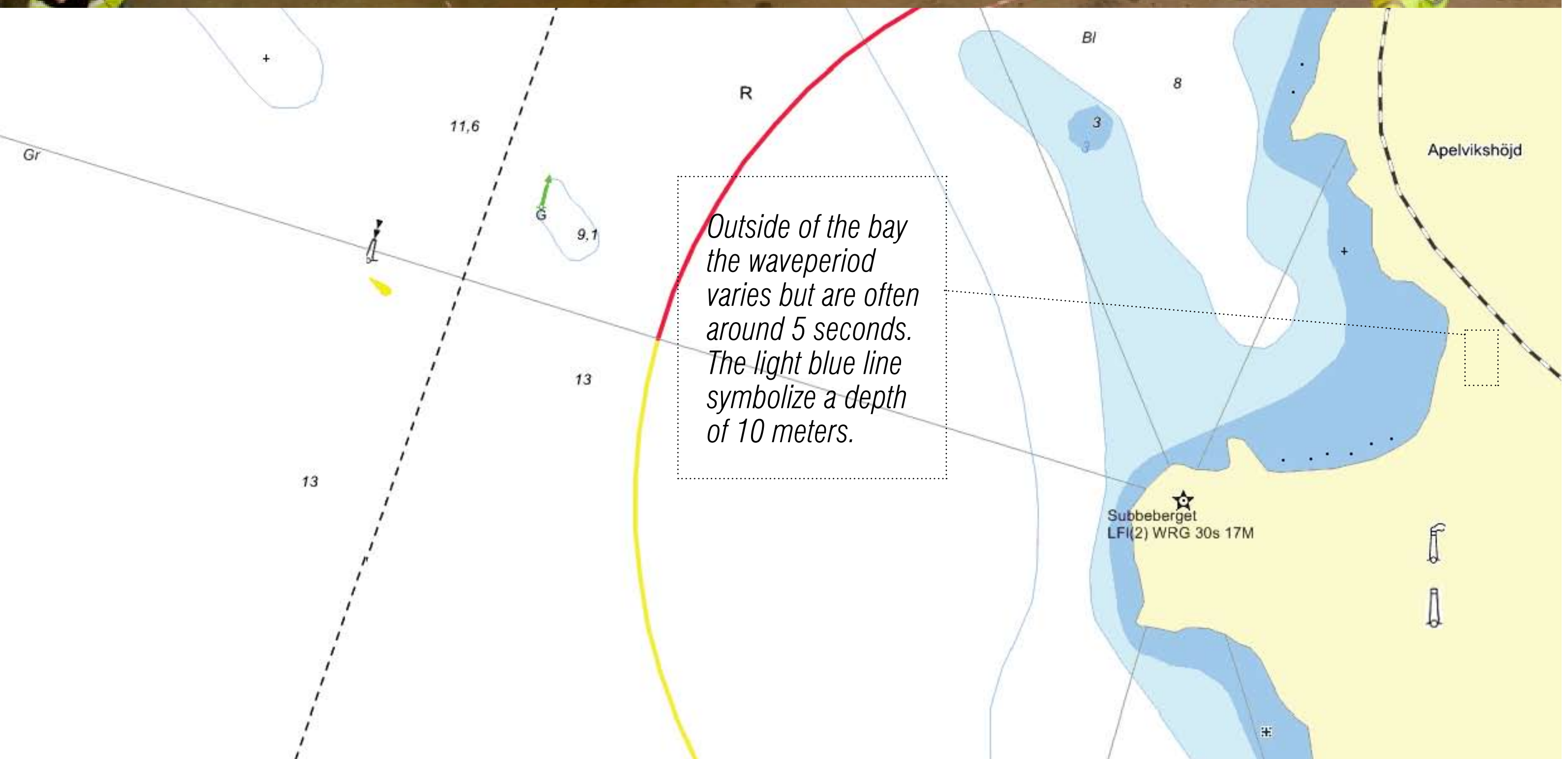
'Surfable' waves use water as a medium for transporting energy, but the medium itself is not moving. It can best be compared to a rope that is shaken. A clear wave occurs when the rope transports energy, but the rope itself doesn't move. Water waves are usually formed by wind blowing on the sea surface. The wind is in this case is the generating force and is one of two fundamental forces that create a wave motion. The second is called the restoring force and in this case is the earth's acceleration due to gravity.

A water wave is a surface wave and an example of a transverse wave, ie a wave where the medium moves perpendicular in relation to the transported energy direction. The opposite is the longitudinal wave where as the medium moves parallel.

The energy can be measured by different wave characteristics. The wavelength is the distance between two waves. Period is the time it takes from that one wave passes a point until the next passes the same point. Amplitude is the surface vertical displacement relative to the average sea level, while wave height is the distance between crest and trough. Wave frequency is the number of waves that passes a fixed point per second.



For wind and wave statistics, check out the folder about weather. According to Rafael Waters at Uppsala University, the conditions in the Kattegat are the same as in the southern Skagerrak, where as the University of Uppsala, Fortum and Seabased together are testing a wave energy park.



Despite hundreds of techniques you can divide them in 2 general classifications; fixed and floating. Examples which is presented in text follows.

The Wave Roller is a module placed on the seabed. It consists of plates that produce kinetic energy by following the back and forth motion on the ocean bottom. This energy can be converted to electricity through either a generator connected to the modules or through a closed hydraulic system in combination with a generator/turbine system. The advantages are that the system is hidden beneath the surface of between 10-25m deep, that it can be placed close to the land and that it is easy to maintain. The Finnish company AW Energy (www.aw-energy.com) is currently testing a prototype outside of Peniche, Portugal.

Oscillating Water Column, OWC, is a system used outside of Scotland since 2000. It's ideal for places with strong wave energy such as wave breakers. The plant is placed at the waterline and it takes advantage of energy by waves/water that push out air through the turbines. The drawback of this otherwise effective technique is that it makes a strong impression at land and it seems dangerous to get close to, especially in the water.

Info:
http://www.rise.org.au/info/Tech/wave/index.html

In 2008 the world's first commercial wave power plant was installed outside of Portugal. The Plants have been built by Pelamis Wave Power, and resembles a liquid Sea snake moving with the waves. The Movements drive a hydraulic motor which runs a generator which in turn generates electricity. The electricity is transmitted to the grid through a power cable. The advantage of this technique is that there already exists a commercial plant, the drawback is that the system decreases the quality of the waves from the surfers point of view.

Seabased wave technology are based on wave power units, called linear generators, located on the seabed. The aggregates are using wires attached to buoys on the surface that captures kinetic energy of the waves which are converted into electrical energy in generators. The aggregates are in turn interconnected with each other by underwater substation to a wave power park, from which an alternating current can be supplied via a submarine cable directly to the onshore electricity grid. This technique is tested today in a pilot plant outside of Lysekil where the wave condition is approximately the same as outside of Varberg. The disadvantage is that the buoys are floating on the water, making them visible and an obstacle to boats, wind & kite surfing. It is also difficult to reconcile with facilities for surfers. (www.seabased.com)

Sources:
www.seabased.com
www.pelamiswave.com

My choice has fallen on a technology that in August 2009 made it as the world's first successfully installed near shore wave energy converter outside of Orkney.

Oyster consists of an Oscillator fitted with pistons and fixed to the near shore (depths of 10-12m) sea bed. Each passing wave activates the Oscillator, pumping high pressure water through a sub-sea pipeline to the shore. Onshore, conventional hydro-electric generators convert this high-pressure water into electrical power. Oyster is designed to be deployed in multi-MW arrays. With a peak power of 300-600kW per Oyster, a commercial farm of just ten devices could provide clean renewable energy to a town of 3,000 homes.

Scource:
http://current.com/16pn64c
www.aquamarinepower.com

Aside from the energy and materials used in their manufacture, Oyster is relatively benign when it comes to the environment. It uses no toxic substances, has very few moving parts so it's safe to marine life, and because it uses seawater as hydraulic fluid, there is no chance of any oil leaking should one of the lines spring a leak. It's estimated one Oyster will save 500 tons of carbon from being released into the atmosphere every year.

Pictures:
www.eniro.se
www.aquamarinepower.com

SAND DUNES

Source:
www.wikipedia.org

SAND

Sand occurs when wind and other forces wear down stones or rocks, in Kåsas case granite. It is composed of finely divided rock and mineral particles in the size range from 0.0625mm to 2 mm. The next smaller size class is called silt and the next larger is called gravel.

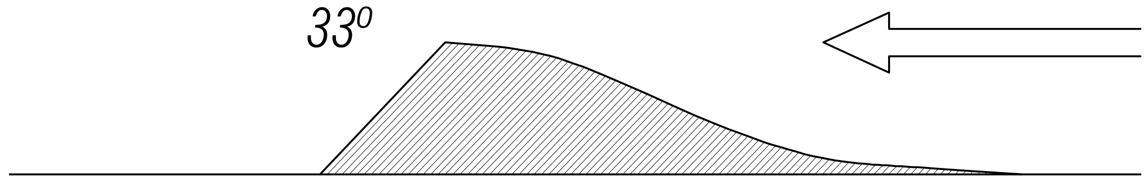


Photo:
www.wikipedia.org

Wind with the velocity of just a few meters per seconds can move sand and reshape the surface of the earth. This phenomenon is called an aeolian process and the sand dune is just one example. Most kinds of dune are longer on the windward side where the sand is pushed up the dune, and a shorter ”slip face” in the lee of the wind. The slip face angle at Kåsa is 33º.

Many stretches of coastline has one or more rows of sand dunes that extend parallel to the shore, they often function as protection against storm waves from the sea. The largest areas of sand dunes are found, however, in arid inland areas such as deserts.

As a dune forms, plant succession occurs. The conditions on an embryo dune are harsh, with salt spray from the sea carried on strong winds. The dune is well drained and often dry, and composed of calcium carbonate from seashells. Rotting seaweed, brought in by storm waves adds nutrients to allow pioneer species to colonize the dune. These plants are well adapted to the harsh conditions of the fore-dune typically having deep roots which reach the water table, root nodules that produce nitrogen compounds, and protected stoma, reducing transpiration. Also, the deep roots bind the sand together, and the dune grows into a fore dune as more sand is blown over the grasses. The grasses add nitrogen to the soil, meaning other, less hardy plants can then colonize the dunes. The dunes at Kåsa are overgrown with reed and rosehips.

Scource:
www.wikipedia.org

The images from 1905 (below), 1919 (top left) and 1993 (bottom left) shows an obvious development of the dunes at Kåsa. Because of the stone wall, built in the early 1900s to surround the sanatorium, the dune has piled up and grown to a 3-4 meter (2009) high dune.

Photos:
Varberg, staden vid västerhavet

Source:
www.wikipedia.org

Photo:
unknown

Sand is visible in architecture in many ways. It is a material easy to shape and it is often used in landscape formations. However, it contains no binders, unlike for example clay, which makes its design possibilities limited. There are, after all, houses built of sandbags stacked on each other or, as the picture on the left shows, in combination with other objects that holds the sand in place. The aggregate in concrete (cement, aggregates and water) are granular particles of different sizes, including sand.

Sand has a good sound-insulating ability. It was common in Sweden during the 1900s to fill slabs with sand to decrease impact sounds. Sand, gravel and other similar materials are also useful to store heat in. There are several systems, for example in combination with solar panels which capture the heat during the summer and store it in a sand layer beneath the building to heat the house during winter.

Source:
www.groundfreezing.com

As said earlier, sand lacks a binder that can hold it together. There are although one method that has been used since the late 1800s that can solidify sand and other soils.

What is today called the 'Austrian Tunnelling Method' F.H Poetsch originally developed in 1883 and involves the circulation of a refrigerated coolant through a series of subsurface pipes to extract heat, thus converting the soil water to ice, creating a strong, watertight material. The material is so strong in fact, that it is routinely used as the only method of groundwater control and soil support for the construction of shafts, hundreds of feet into water-bearing soils.

The single most important component of a ground freezing system is the subsurface refrigeration system, consisting of a series of refrigeration pipes, installed with various drilling techniques. Within each of the freeze pipes, a smaller diameter feed pipe is installed permitting the downward circulation of the cooling medium which then flows to the surface through the annulus of the larger pipe.

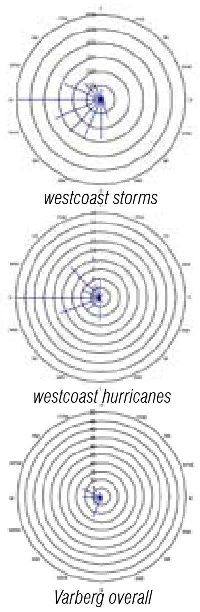
Photo:
Kåsa Sep-09

Source:
www.groundfreezing.com

The cooling medium varies depending on the required application. Where very rapid freezing is required for applications such as containment after a spill, liquid nitrogen is used with temperatures well below -I50^{o} C. For most applications however, a secondary coolant such as calcium chloride (brine) or ethylene glycol is used. This secondary coolant is chilled using large portable refrigeration plants which employ ammonia as a primary refrigerant.

These refrigeration plants are typically mounted on conventional over-the-road trailers and are electrically powered using commercially available electricity or by diesel generators. Once the system has been drilled and installed, it operates continuously as a closed system requiring constant monitoring with occasional plant adjustment and coolant flow modifications. After the initial freezing has been completed and the frozen barrier is in place, the required refrigeration capacity is significantly reduced to maintain the frozen barrier.

WIND STUDY



Source:
www.smhi.se

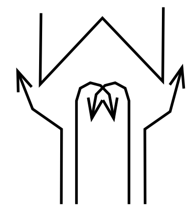
This wind study has been done with the help from models, sand, glue and a large fan that blows parallel wind towards the models. A transformer regulated the velocity of 5-15 meter per second.

West is the dominant wind direction on the west coast, although the wind outside of Varberg has a variation of SSW to NW. But since the bay at Kåsa is protected from both south and north, this study is based on the assumption that the dominant wind direction is west.

This page shows tests of different spaces and it proves that corners are a good way to create turbulence and stack the sand. To avoid this you should design open corners, as to the right. Notice also how the closest volume to the left steer the wind to the right.

The model in the middle created, surprisingly, a kind of invisible shield like an old motorcycle helmet with a funnel.

SPACES



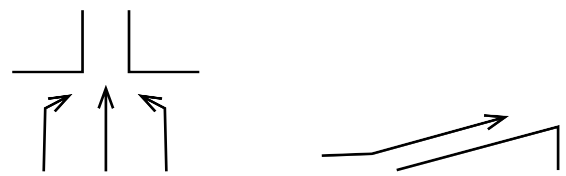
All the three shapes to the left have the common property of leeward areas surrounding the model, except the circular front.

The model to the right showed to be similar to the 'corner model' on previous side whereas the funnel neutralises the wind, except for occasional turbulence in the deep part of the inner corners.

Outer corners can more or less have the opposite effect and the velocity can sometimes exceed to the double and change directions.

Source:
Andbert, P-G

SHAPES



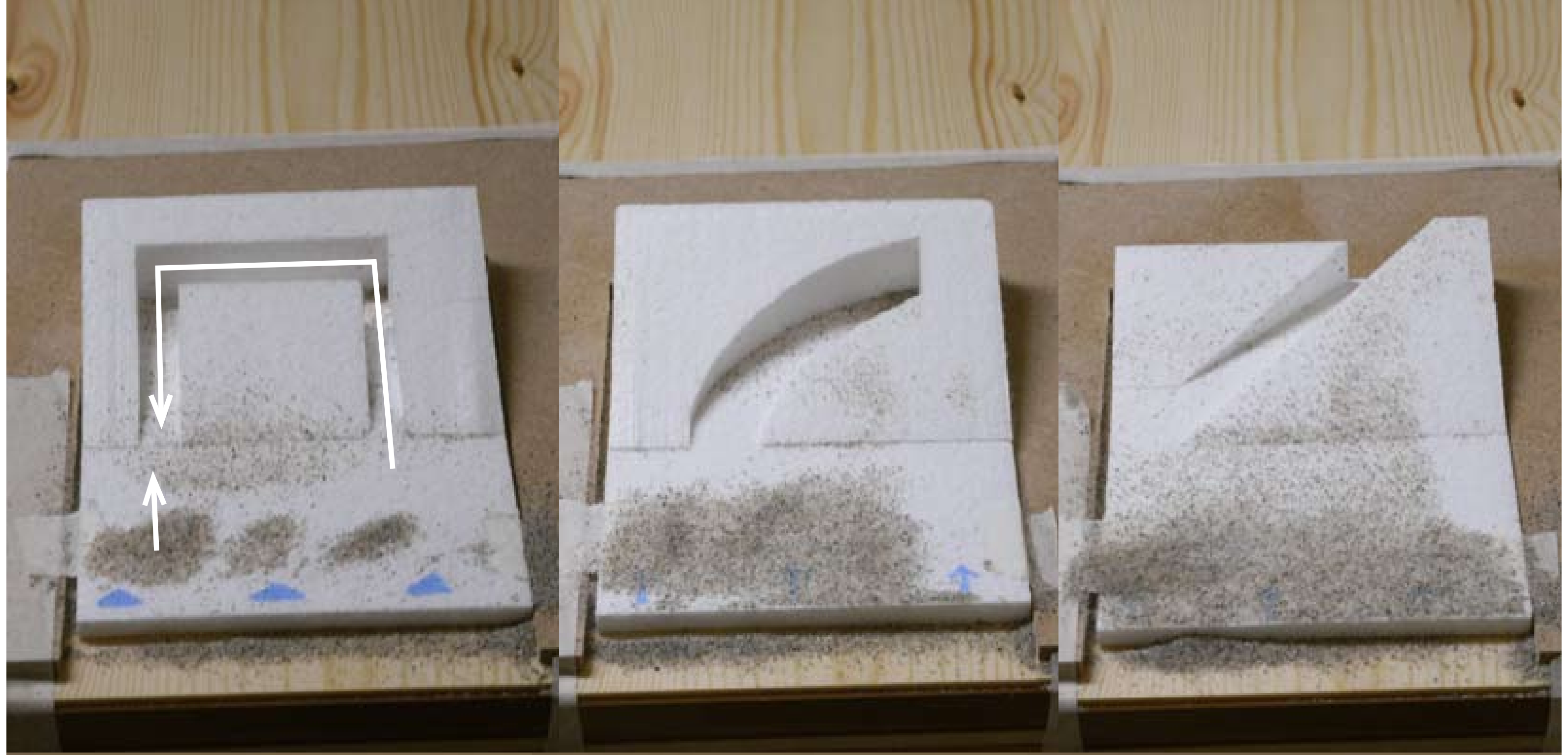
A tunnel will almost always increase the velocity since more air has to pass through a smaller opening. But the section of these models counteract that phenomenon and let the air on the sides follow the slope instead of in to the tunnel.

A closed end in the tunnel will slightly neutralise the speed but of course collect the sand, especially in the corners.

Source:
Andbert, P-G

CUTS 1

CUTS 2



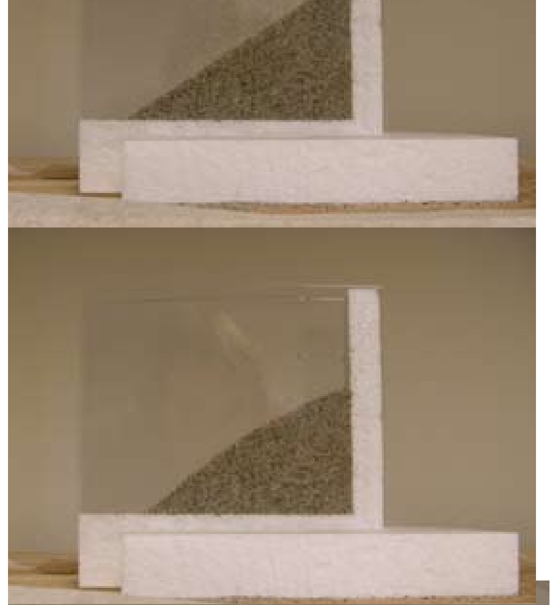
Source:
Andbert, P-G

To start from the left, this model created an interesting counter clockwise circulation where the wind going in the left opening were pressed back by the outgoing wind. The sand clearly gathers in the corners.

In the rounded cut the sand gathers at the outer wall leaving the inner wall free from sand and wind, same phenomenon as in the round shape shown in the earlier example.

The diagonal model provides a good wind protected cut since the front wall shelters the opening. In combination with windbreakers this solution works fine if you want a sand and wind free cut, as long as the wind direction is the same. To achieve the same result in other conditions/directions the design of the end of the 'tunnel' is crucial. See earlier examples.

SECTIONS



Source:
Andbert, P-G

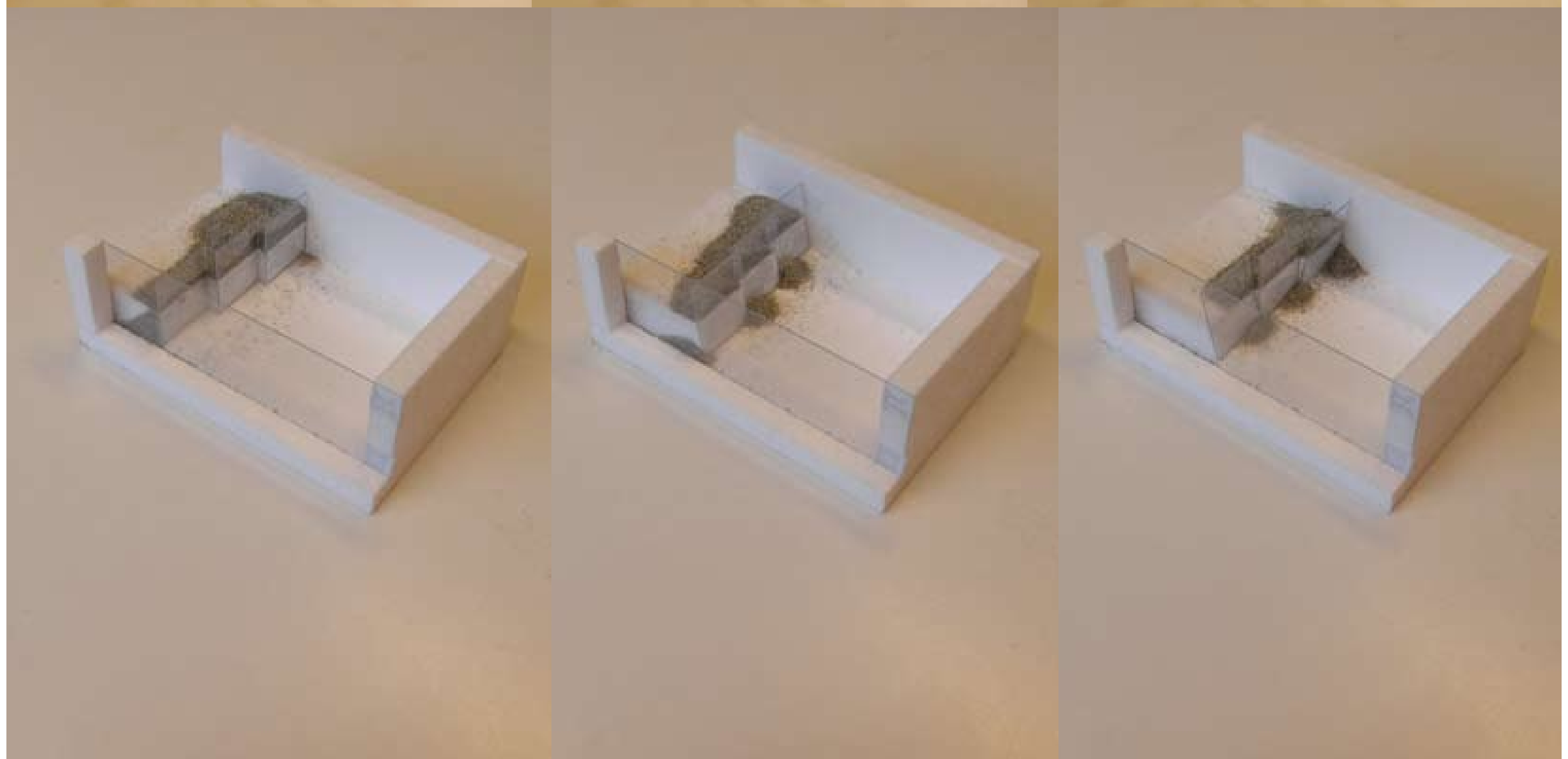
The different sections based on earlier pages solutions show that there are differences in the results, cause by the changing angles of the windbreakers. It is known that obstacles with a 'soft' profile create a leeward area behind it. At the same time, obstacles with a more sharp profile creates an leeward area with occassional turbulence.

The model in the middle is an example of a softer profile that follows the wind direction, opposite to the model right to it.

A windbreaker usually creates a more leeward area but already 5x the obstacles height away, the wind has regained 50% of its original speed. In other words, 15 meters behind a 3 meters high windbreaker, the velocity is 50%.

The sand at Kåsa has a slip face angle of 33 degrees. After a heavy wind, the slip face gets more of a rounded profile.

PERFORATION



Source:
Andbert, P-G

If the aim is to create a large lee warded area, it is better to use a windbreaker that let trough some of the air. Then you will have the maximum effect evenly distributed on an area 5 times the height of the windbreaker.

The designs of these examples, except the far left, follow this principle. They allow the sand to run through the perforation and be a visual proof of the natural movement of the sand. It is also easier to calculate the construction of the windbreaker since you now will know the limit of where the sand runs through the gap.

See posters for further wind studies.

SEE YOU IN SEPTEMBER!

a Master Thesis by Anders Winlöf Fall 2009

I. INTRODUCTION - WHY?

Renewable energy sources can provide our whole planet's energy consumption up to 15.000 times.

When we choose to fully harness these renewable energy sources new possibilities will rise.

How can we create architecture that is built by energy and thus save both material and CO^2 emissions?

Varberg has a long relationship with the ocean. During the last century the area has developed from a health institution to a recreational town that offers resorts, spas, nude bathing, saunas, winter bathing and indoor- as well as outdoor baths.

In the last decades Varberg has seen another cultural phenomenon develop along the coast. Different kinds of surfing such as wind, wave and kite surfing have filled the beaches with surfers in different ages and genders. Unlike traditional beach visitors, except maybe the winter bathers, this crowd populates the beaches and uses the power of the nature all year around, as long as the conditions allow it.

Kåsa, a k a Lilla Apelviken, has a high frequency of waves which makes it one of the best surfing spots on the west coast. My suggestion to the city of Varberg is to learn of the surfers harnessing the natural power by building a wave power plant that also gains the all year around surfers that visit Kåsa. In other words, adapt to both nature and to a growing cultural phenomenon.

As Varbergs most popular promenade, the beach walk brings the strollers all the way from the centre of Varberg. They pass amongst others the wooden outdoor bath, the fortification and Hästhaga Mountains, a caracteristic area with granite slabs and heather.

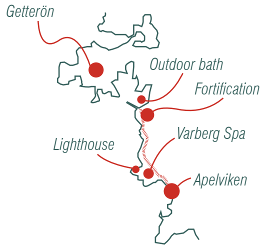
During the warm summer months the beach of Kåsa gets overcrowded by bathers that enjoy the salty west coast water, the sand dunes and the public facilities that the municipality offers: a public toilet and waste bins.

A hundred years ago the most frequent visitors of Kåsa were young children suffering from tuberculosis. Today, another type of customers visits the former sanatorium. Since early 1990 the buildings house health resorts and a spa.

Out on the peninsula the lighthouse watches over the bay. It can witness the wounds of the bedrock since the quarries in the 19th century. Wounds that will never heal.

RESEARCH
II. IDENTIFICATION - WHAT?

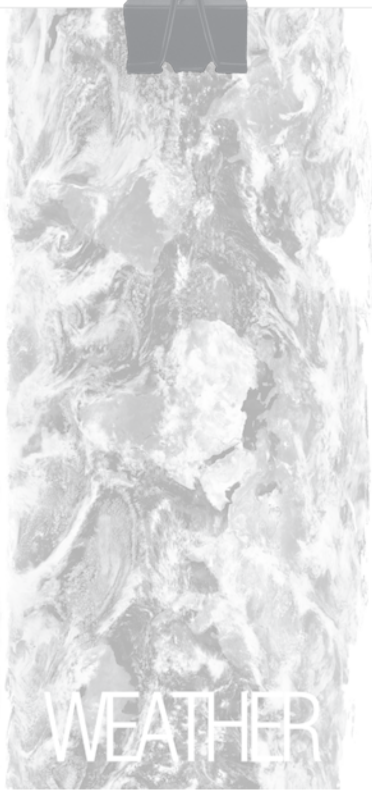
The beach walk, from early 20th century, stretches from the fortification all the way down to Apelviken. It is of significant cultural value and should be considered.



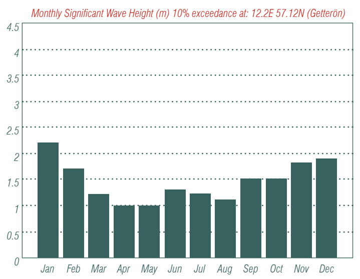
SENSITIVE CONTEXT

Surfrider Foundation is an organisation that organises cleaning days all around the world, including Sweden. In other words, a surfer has a huge awareness of nature and how to treat it.

MINIMAL FOOTPRINT

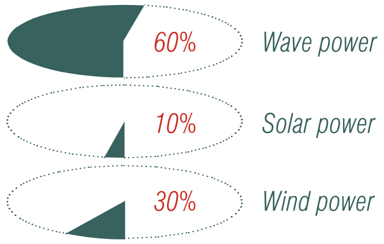


The weather condition in Sweden allows around 40 days with 'surfable' waves per year. Autumn and winter are the dominant seasons.



SEASONAL NEEDS

In the year 2010 60% of Sweden's energy production must be renewable sources. Compared to wind- & solar power, wave power has a higher utilization degree.



WATER AS ENERGIZER

The thermal property of sand makes it a good medium to store heath in. At this day several house heating systems use a sand layer underneath the building as heath storage.

SAND AS MATERIAL

Wind is air masses that flows through the atmosphere due to high and low pressure. Wind also has the ability to move sand and for example build sand dunes.

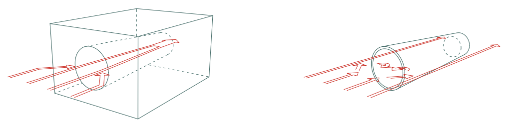
WIND BASED DESIGN

WIND

III a. DESIGNED BY WIND PREMISES

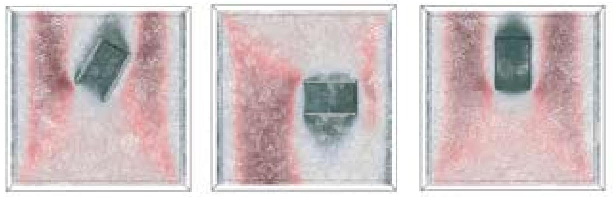
The analogue wind study presented in the folder resulted in several interesting observations. The most useful was the phenomenon of the closed funnel/cylinder. Thanks to the closed end of the cylinder an even air pressure is created inside the funnel which leads to a stagnation pressure at the opening. This pressure works as a pillow of air that stops the high velocity air to go inside the funnel. Instead it creates a secondary airflow that turns the incoming wind 180 degrees.

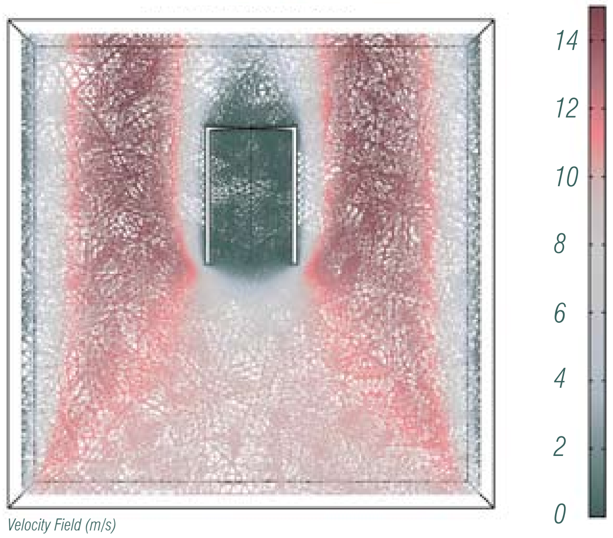
Metaphors & Relevance
Examples in both smaller and larger scales show that the wind principle of the funnel can be applied in high wind velocities. Being in the 'barrel' is considered as one of the most legendary surf moves. But to be surrounded by the waves requires courage, talent and to be at the right spot at the right time.



1. An opening through a wall creates a wind tunnel.

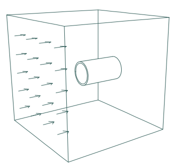
2. In a closed cylinder or cone an even air pressure is created that works as a cushion of air that forces the wind out of the cone.





Velocity Field (m/s)

The analogue wind study was followed by a digital study in the computer program Cosmol Multiphysics. The first model confirms the expectations of the funnel with a closed rear end and shows how the inside of the funnel stays lee while the velocity on the sides increases. The smaller charts shows that this phenomenon also works in different wind directions. The upper right one confirms that two cones with a connection has the same qualities.



SAND

III b. MATERIALIZED BY SAND

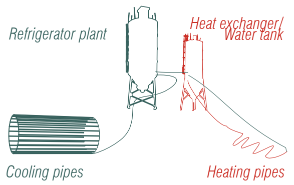
Sand has an interesting thermal conductivity. It is used in both house heating systems, where heat is stored in a sand layer underneath the house, and in ground freezing systems.

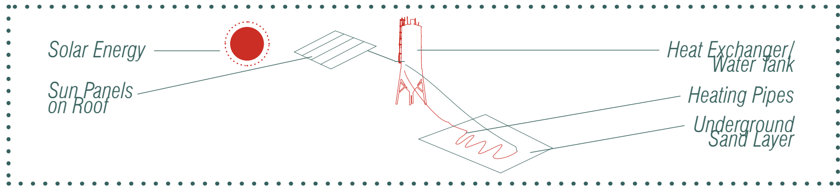
Ground freezing is a method that has been used since 1883. It is a method used for groundwater control and soil support during construction of shaft and complex tunnels (as the Austrian Tunnel Method), often hundreds of meters into water-bearing soils.

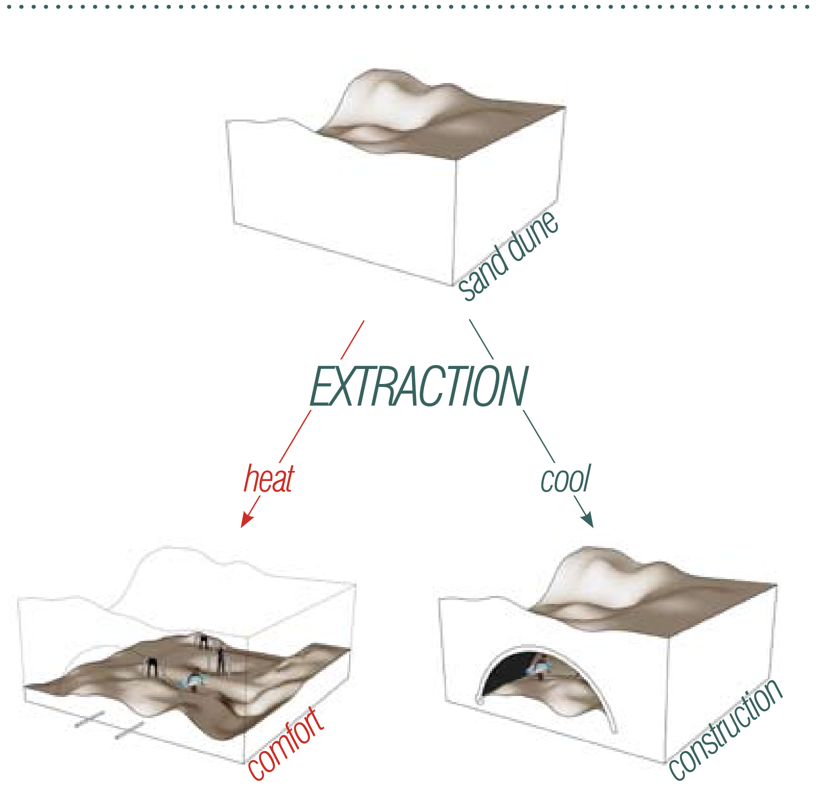
In these kinds of projects holes are drilled into the soil which are filled with steel pipes which contains a cooling medium that freezes the soil surrounding the pipes. Ethylene glycol is one example that also is environmentally friendly.

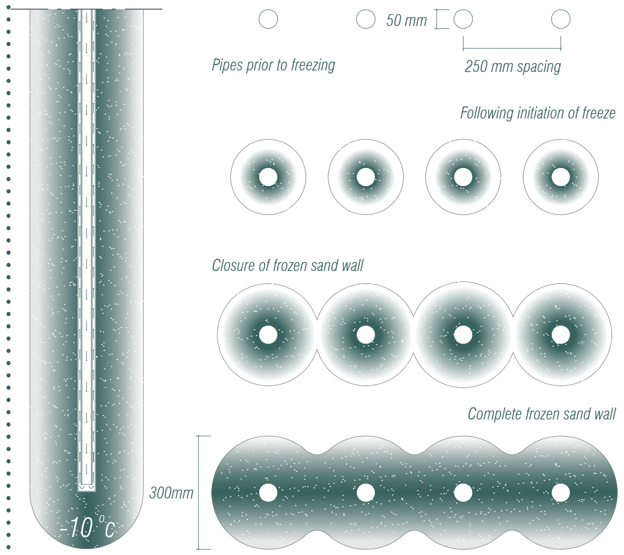
A refrigeration plant, usually electrically driven, runs the freezing system and with the help from centrifugal pumps they circulate the cooling medium trough the pipes. In the plant ammonia is used as the primary refrigerant which cools the ethylene glycol in a large heat exchanger.

The excess heat from the refrigerator is in my project taken care of by connecting it to a water tank that allocates heated water in pipes in the sand, working as floor heating for the surfers.

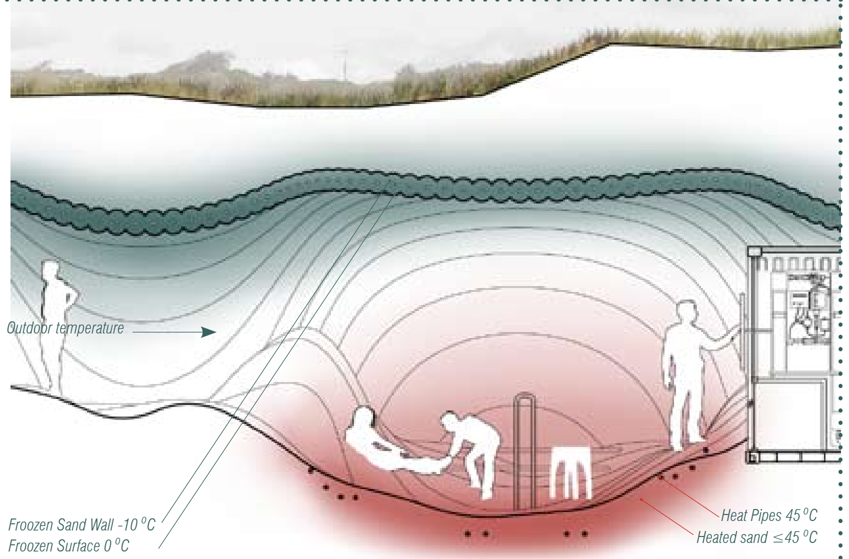








The pipes vary in diameter and spaces, but in a groundwater control project the pipes can have a diameter of 3inches with 3.5foot spacing and reach at least 50 meters down. The complete length of the piping can be over 3km. In this project a diameter of 5cm and a spacing of 25cm will be appropriate. With a constant degree of -10 °Celsius, this will create an approximately 30cm thick frozen sand wall.



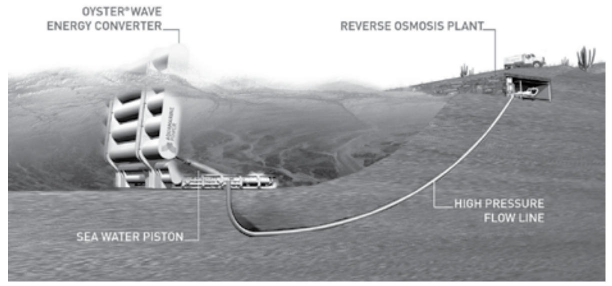
The freeze medium freezes moisture/water that binds the sand. Ice has a temperature of 0 °C, but the sand reaches a temperature of -10 °C. The surface of the sand wall has the temperature of 0 °C. When ice turns into water is when the sand starts to loosen. It takes the same amount of heat energy to convert 0 °C ice to 0 °C water as it takes to heat 0 °C water to 80 °C. The heat pipes of 45 °C heat the sand to temperatures between 0-45 °C, depending on depth, outdoor temperature etc. This heat is stored in the sand thanks to its thermal conductivity. Not until you walk around or sit down in the sand, the heat is exposed. Since heat rises natural ventilation is obtained.

WATER

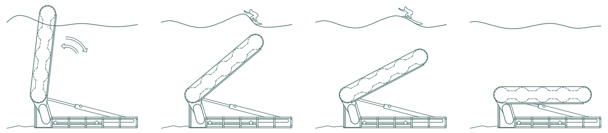
III c. POWERED BY WAVES

The Oyster® consists of an Oscillator fitted with pistons and fixed to the near shore sea bed (depths of 10-12m). Each passing wave activates the Oscillator, pumping high pressure water through a pipeline to the shore. Onshore, a conventional hydro-electric generator convert this high-pressure water into electrical power. With a peak power of 300-600kW per Oyster, a commercial farm of just ten devices could provide clean renewable energy to a town of 3,000 homes.

The water that are pumped through the pipeline can be taken advantage of by connecting a reverse osmosis plant that converts sea water into fresh water. In development since 2005, the unique Oyster® Desalination System utilises wave energy to power Reverse Osmosis (RO) desalination plant.



When harnessing energy from waves the Oyster will be in a loose and upright position but it can also, in a passive mode, be locked into a certain angle. By doing so, an artificial reef can be created and work as a additional breaking point for the waves. The angle of this 'artificial reef' are controlled by the surfer from shore. Different angle suits different kinds of boards i.e. longboard and shortboard.

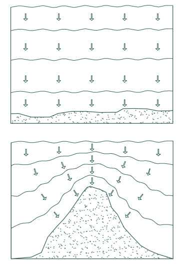


This artificial reef can now produce additional waves in the Kåsa bay thanks to a phenomenon that is called refraction.

Tony Butt, Doctor in Physical Oceanography at the centre for Marine Studies, University of Plymouth, England describes how this can work:

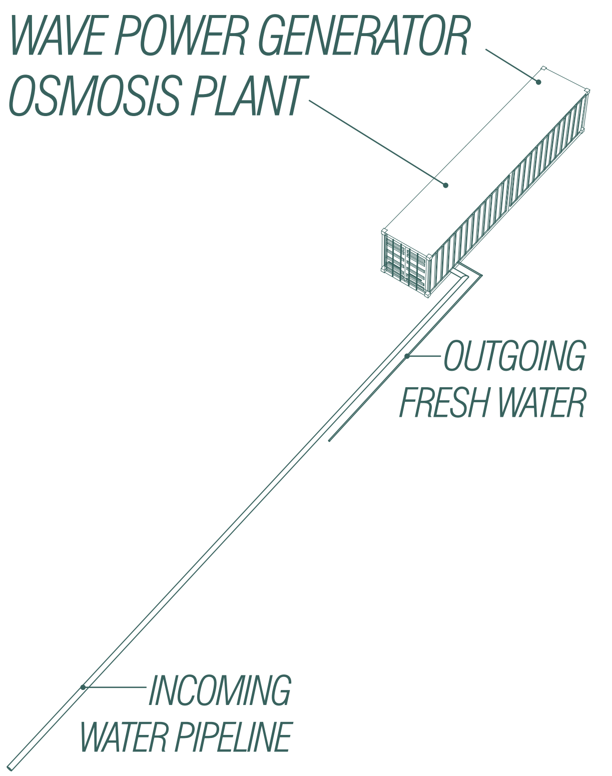
If a wave comes out of deep water and straight into really shallow water within a very short distance, the wave height will increase dramatically and eventually the wave will break. For example, if there is a deep trench next to a shallow reef, the part of the wave crest propagating over the trench might keep going at its deep-water speed, while the part that hits the reef will slow down considerably. So what is refraction?.

Refraction is when one part of a wave crest travels slower than another, making the wave bend towards that part which is travelling slower. This makes the wave bigger and more powerful. The reef acts as a 'swell magnet', and the increase in size can sometimes be surprising. A good analogy of refraction is if you are travelling along in your car and the brakes are binding on one side. The car will tend to veer off to that side.

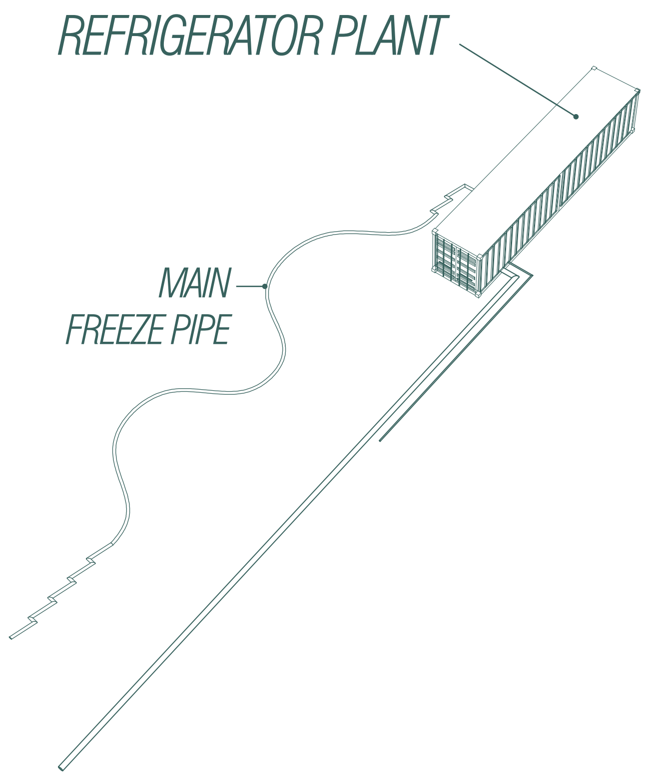


MIXED ELEMENTS

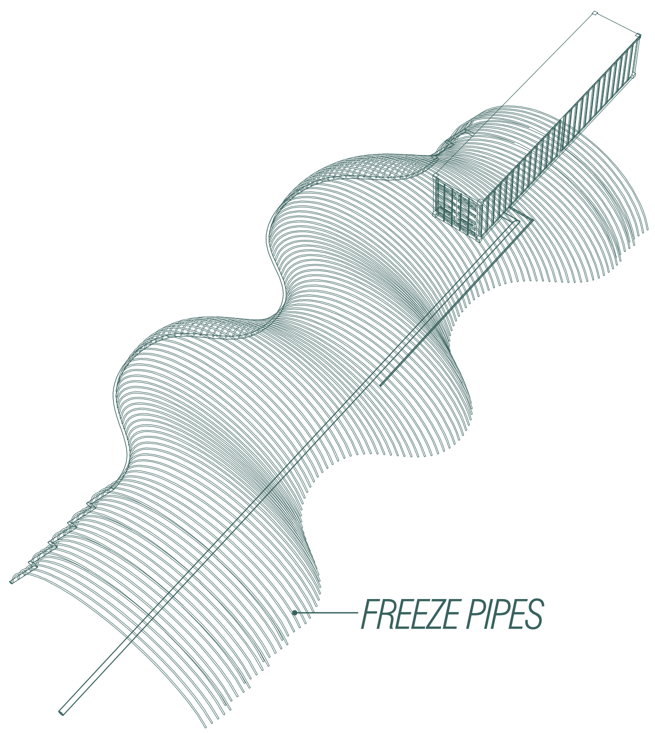
IV. COMBINED SYSTEM - HOW?



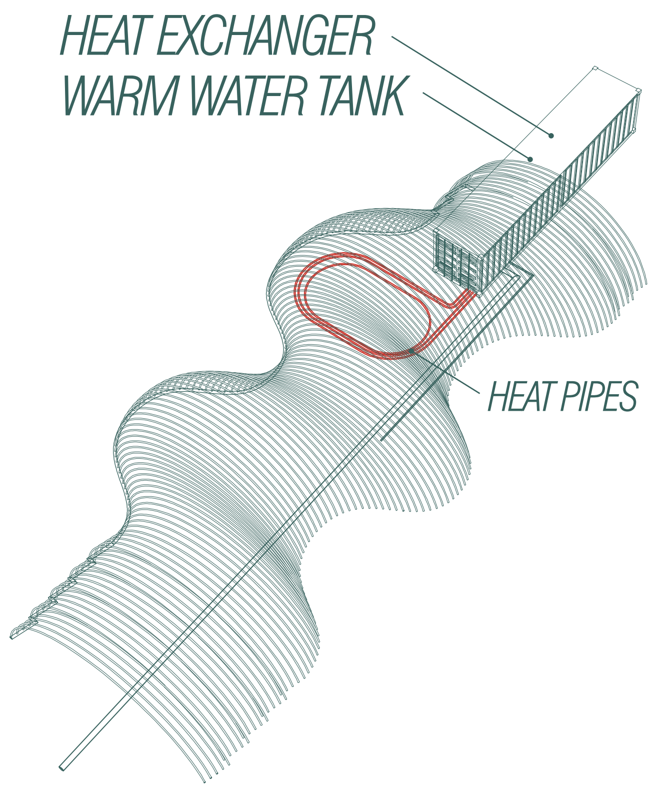
The high pressure water line reaches the generator which is placed in a container in the sand dunes on the beach. Next to the generator a reverse osmosis plant convert the salty water into fresh water, which now can be used by the surfers.



The generator converts the energy into electricity which runs the refrigerator plant. In a larger main pipe the cooling medium circulates and supplies the smaller freeze pipes (next step).



The freeze pipes are shaped as arcs to maximum the load bearing ability of the heavy sands lying on top of the structure.



The excess heat that the freeze pipes extract from the sand is taken care of by a heat exchanger connected to a water tank. From the heated water tank, pipes with warm water run through the sand dune creating local hot spots in the sand.

Section 1:400 (a1)

EFFECT

	ORKNEY, SCOTLAND (Existing Oyster plant)	VARBERG, SWEDEN (Project Site at Kåsa)
Wave Power Potential (kW/m annual average)	50 kW/m	5 kW/m
Power Output/ Effect	600 kW	60 kW
Number of households	300 homes	30 homes

DEMAND

	ICE RINK (Comparable System)	SAND SURF CENTRE (Project at Kåsa)
Length of Freeze Pipes	8000 m	1000 m
Energy Consumption	80 kW	10 kW

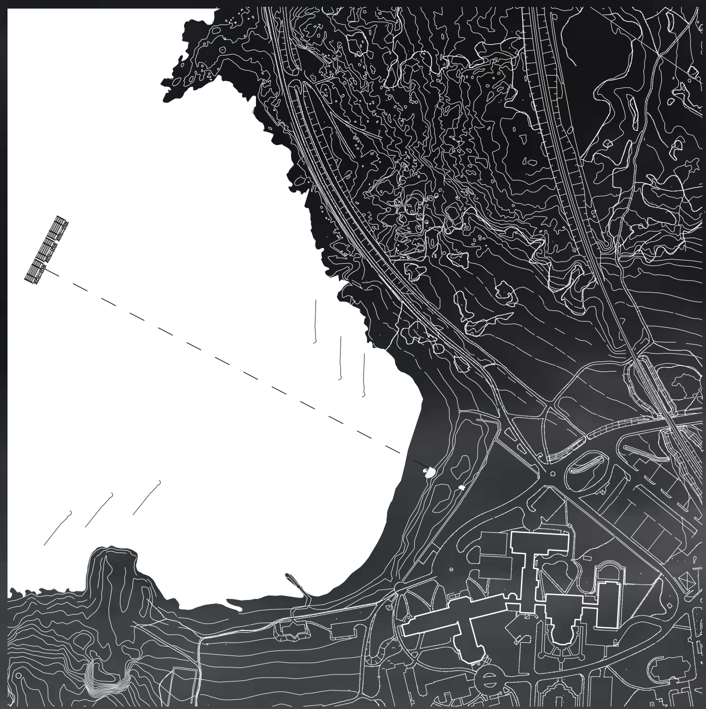
EXCESS

	SINGLE OYSTER (At Project Site in Kåsa)	SAND SURF CENTRE (Project at Kåsa)
Effect vs. Consumption	60 kW	10 kW
Excess Effect 50kW		

CONCLUSION

One single Oyster produces enough energy to supply the Surf Centre plus 25 households. Each additional Oyster will produce energy to supply 30 homes. An Oyster Wave Power Plant of for instance 3 Oysters provides energy for 85 households excluding the surfcentre.

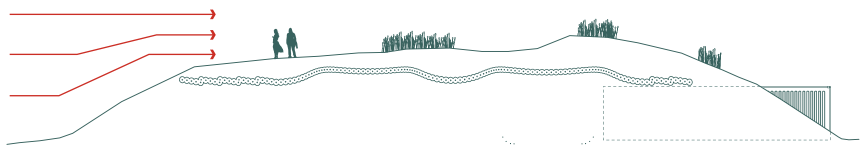
CONTEXT
V. RESPECTING CULTURE & LANDSCAPE



Site plan 1:6000 (A3)

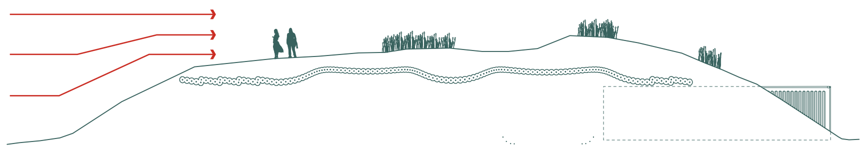
SEASONS

VI. ANNUAL LIFECYCLE - NO VISIBLE FOOTPRINT



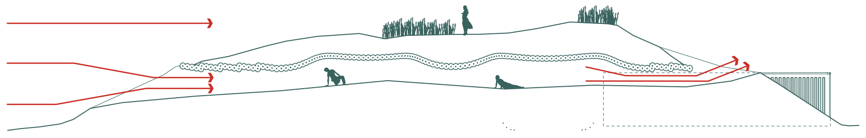
JUN-AUG

During low season of surfing the structure is hidden in the sand dunes. The sun bathers are clueless of what is lying beneath them.



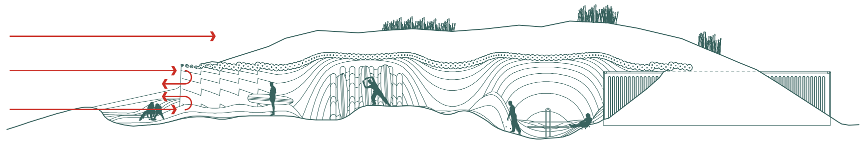
AUG

The refrigerator is activated and the hard shell is starting to take shape inside the dune.



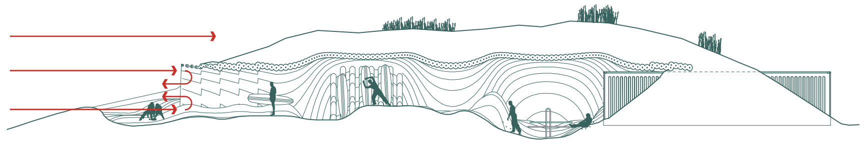
SEP

A small opening is dug through the structure which creates a wind funnel. The opening makes the wind do most of the hard work of emptying the space.



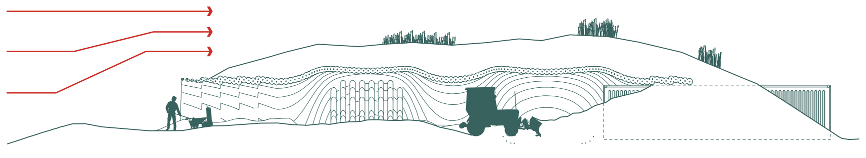
SEP-OCT

In September the surfers meet and together they clear the rest of the functions from sand. To celebrate another season of surfing they arrange an inauguration party in the sand dune.



OCT-MAR

The closed funnel offers wind shelters facilities for the surfers during the whole winter. The sand gathers in a pile in front of the structure.

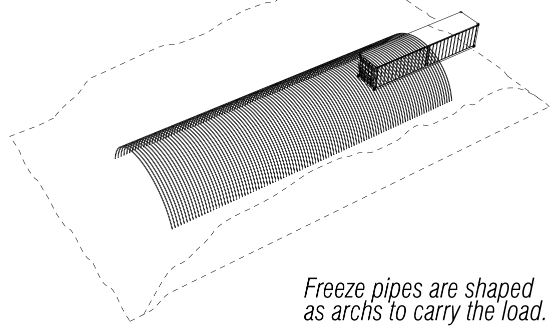


APR-MAY

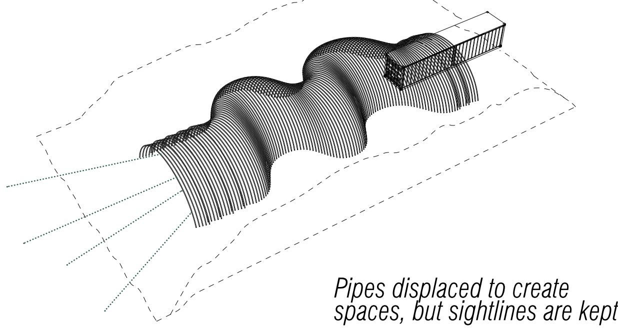
The season is over and the space is no longer needed. It is filled up with sand by the surfers with additional help from a tractor. The refrigerator is turned off and the season is over. See you in September!

EXTERIOR
VII. CONSTRUCTIONAL SHAPE

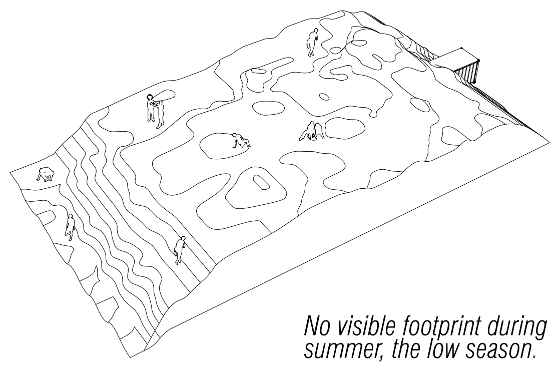
SPACES
VIII. PLANS - SECTIONS



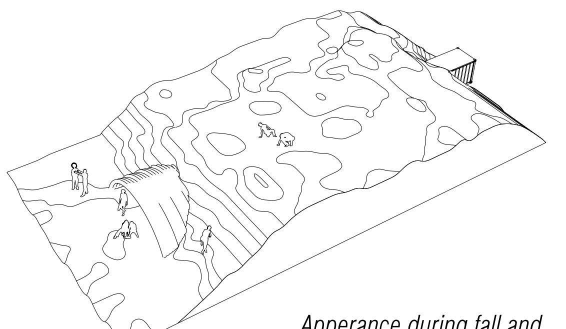
Freeze pipes are shaped as archs to carry the load.



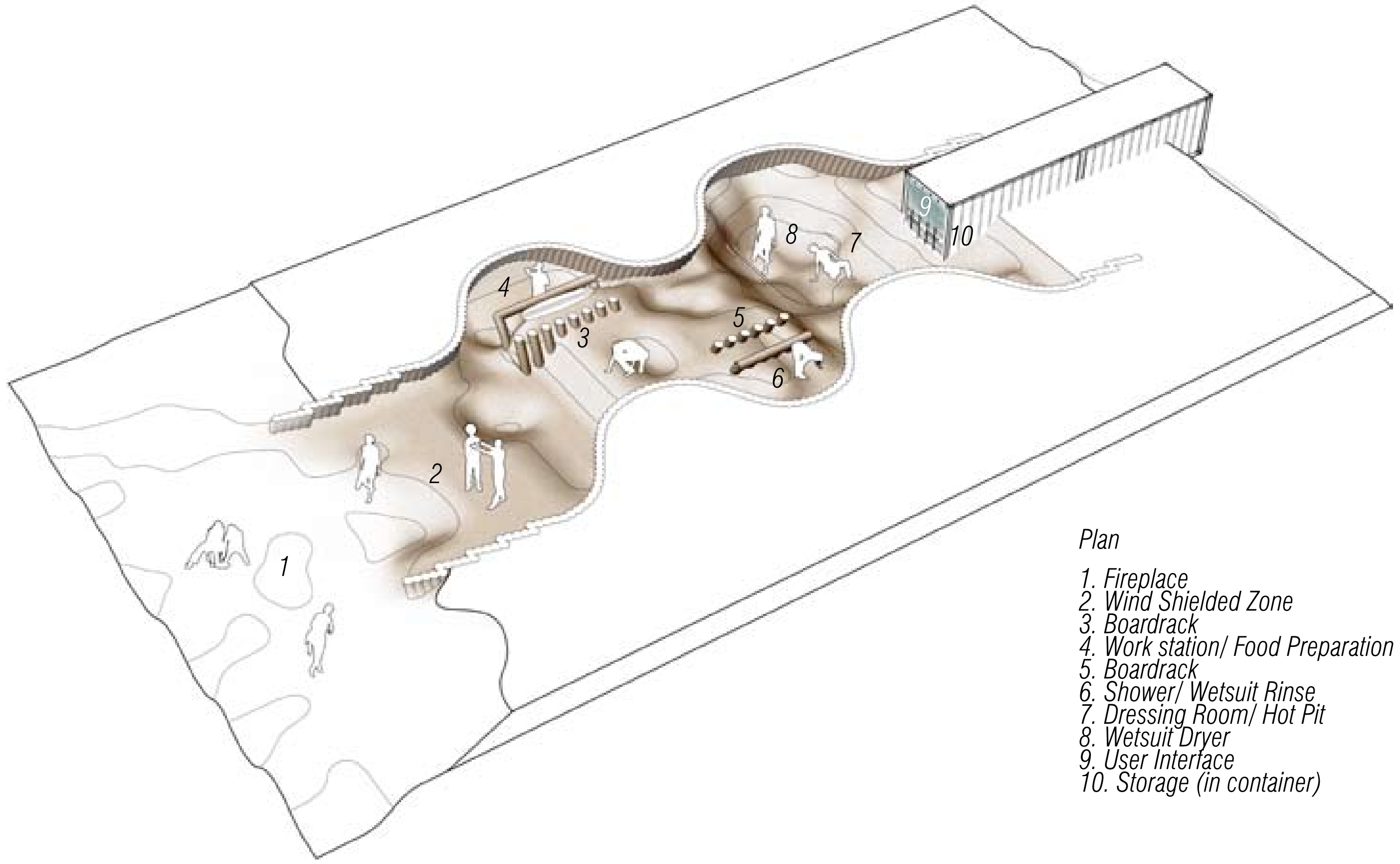
Pipes displaced to create spaces, but sightlines are kept.



No visible footprint during summer, the low season.

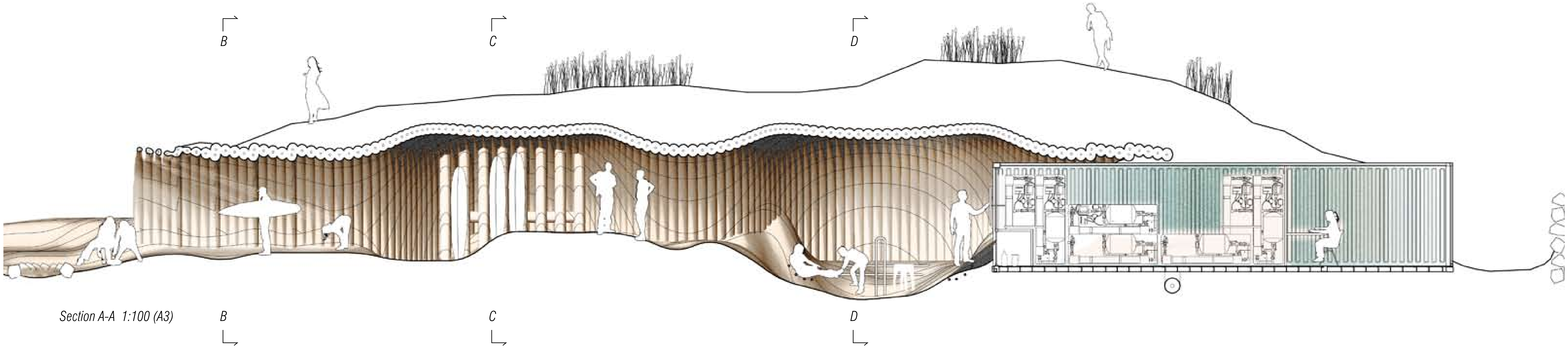


Apperance during fall and winter.



Plan

1. Fireplace
2. Wind Shielded Zone
3. Boardrack
4. Work station/ Food Preparation
5. Boardrack
6. Shower/ Wetsuit Rinse
7. Dressing Room/ Hot Pit
8. Wetsuit Dryer
9. User Interface
10. Storage (in container)

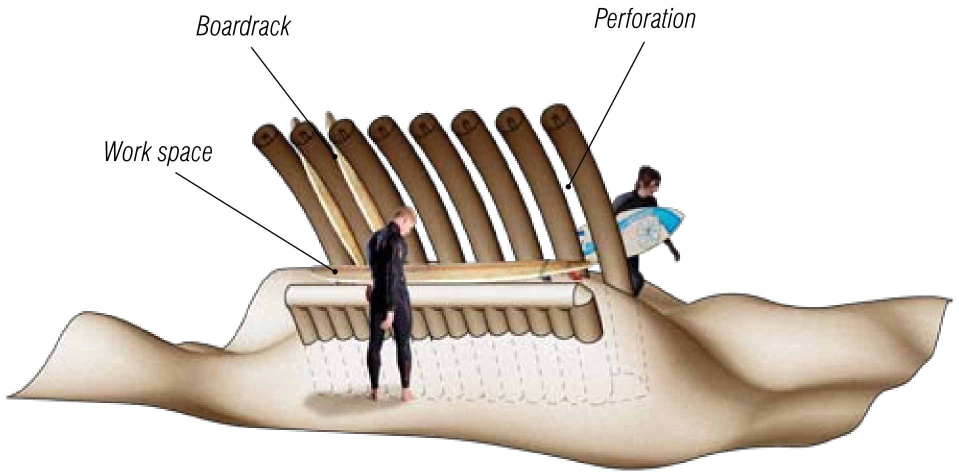


Section A-A 1:100 (A3)

INTERIOR

IX. VIEWS - LIGHT - STRUCTURE

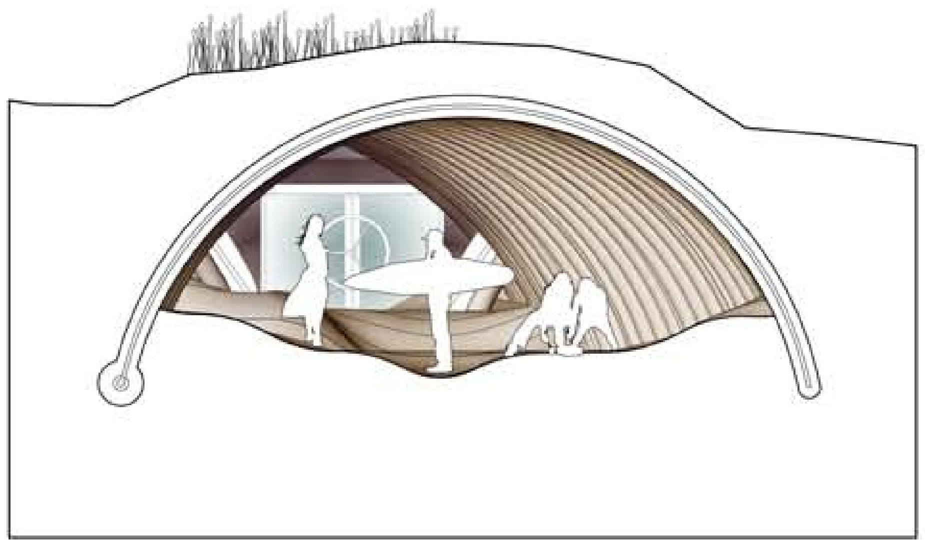
MATERIAL
X. UNIQUE CHARACTERISTICS



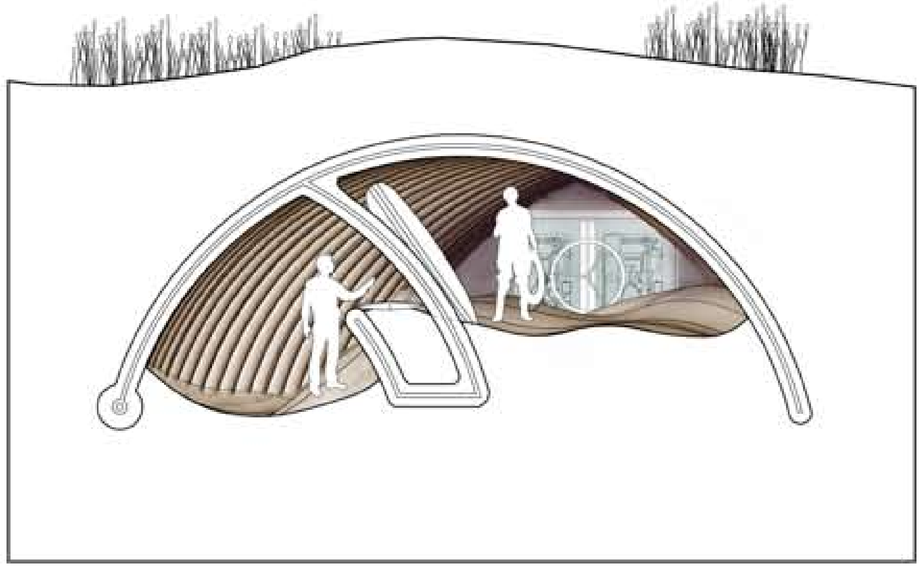
A combination of tightly and sparsely placed pipes gives opportunities to incorporate functions with in the structure of frozen sand. The tightly placed pipes create a bank that can hold sand and thus create different levels (see also section C-C). The sparsely placed pipes form pockets to place your board in and let the light in to the workspace.

The front part of the structure shoots out of the dune which makes it exposed to wind, rain and sun. The hard shell will therefore wear down which creates both a horizontal fence and a filtered light shining into the dune.

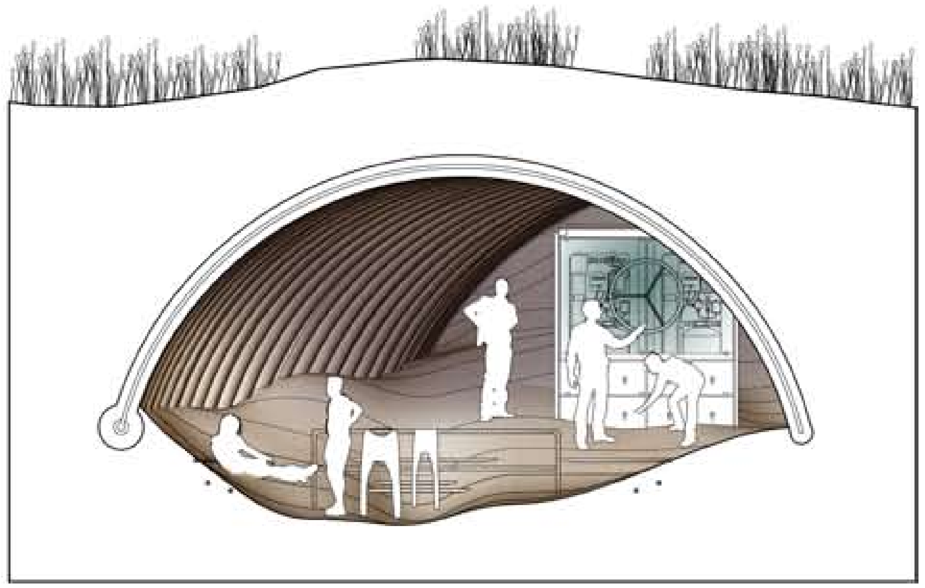
The front part of the hard shell is shaped to create a structure that meets the non frozen sand on the outside. This will force the soft sand to climb up the pockets of the structure.



Section B-B 1:100 (A3)



Section C-C 1:100 (A3)



Section D-D 1:100 (A3)

CONCLUSION

I believe that my project has shown that by building with energy one can save material, cost for material as well as carbon dioxide emissions. The later does require a renewable energy source such as wave power.

It gives us the opportunity to design a temporary or evanescent architecture which can be suitable in many situations. For example for temporary pavilions, season based projects or in emergency situations where you don't have the possibility to transport building material.

Another sector of application for my specific solution can for example be a wind shelter for camels and nomads in the dessert. By replacing the wave power plant with solar cells, the system can then offer a wind & sun proof shelter during the day and a heated space during the cool desert nights.

I have based my project on 2 existing systems, a heat storing system and a ground freezing system, where the later has been used since the 1880s. To strengthen my arguments I have used the competence at Chalmers, also outside of the Department of Architecture. I have been consulting my ideas with engineers of Fluid Mechanics to find the most appropriate shape and I have been discussing wind and sand loads with the professors at the Department of Building and Engineering. I have had several conversations with companies around the world that confirm the technologies behind my project in order to make this project as convincing as possible.

- Anders Winlöf 2010.01.21