WAVY

OFF SHORE POWER TOWERS

how to visualize the connection between resource and use of electricity
and make the Southern Archipelago autonomous on wave power

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Master Thesis in Architecture and Urban Design
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ABSTRACT

Transformation of energy is a precondition for our society and culture. Water and wind have been utilised for driving boats, mills and saws since the beginning of our civilisation. And with the knowledge of how to transform kinetic energy to electricity we experienced one of the most dramatic cultural turns in history.

But as the objects supplying us with electricity grow more and more hidden and fail proof and the international energy exchange grow wider, the source have disappeared from our range of experience. And as the global market is fragile to geopolitical changes, take current phenomenas such as Nordstream 2 or fracking for example, local energy production will become important both as a strategy for national security and environmental resilience. With more efficient technology, this could also mean autonomy, in an either dystopian or utopian regional future.

This thesis investigates the relationship between the machine and the landscape, by the concept of enhancement through contrast, with a wave power plant located in the Southern Archipelago of Gothenburg. Can electrical production be visualised to raise awareness of the source and thereby affect attitudes and use?

This is done by mapping of production, technology and resources globally, nationally and locally, and the result is both an urban strategy and a physical structure. The aim of the structure is to manifest how architecture can enhance the experience of the connection between resource and power, through an off shore structure, visual connections and the symbolical connection between electricity and light.

Even though autonomy might not be possible today, this project should be seen as an ideal concept, a strategy for a more beneficial site, or for future developed technology and inspire both acceptance and fascination for technology.

TABLE OF CONTENT

RESEARCH QUESTIONS

This thesis investigates which role architecture can take in the design of a technical system and how it can be used to change behaviours and attitudes of people in general and towards electrical consumption in particular.

The question focuses on how to visualise the connection between resource and use of electricity and thereby making it understandable, to inspire knowledge without forcing it. It is based from the standing point that knowledge will make people more inclined to change their behaviours.

The purpose of the project is to, through change of behaviours, create resilient societies, locally and nationally. But also to inspire an expansion of the role of architecture, to inspire a new perspective of infrastructure, to create a sense of coherence and to evoke curiosity.

AIM

The aimed result is an urban strategy for an autonomous electrical system through locally produced wave power, and a structure where the visitor can experience the connection between landscape and technology.

METHOD

Literature and documents of the current situation of electrical production and technology has been studied to create a base of knowledge of the electrical situation. The connection between geographical resource, use and possibilities is shown through critical cartography globally, nationally, regionally and locally.

Models has been used as an artistic research to find character of electricity and shapes. They are used to study relationships between the environment and the object. Finally the possibilities of architecture is shown through the proposal of a structure.

DELIMITATION

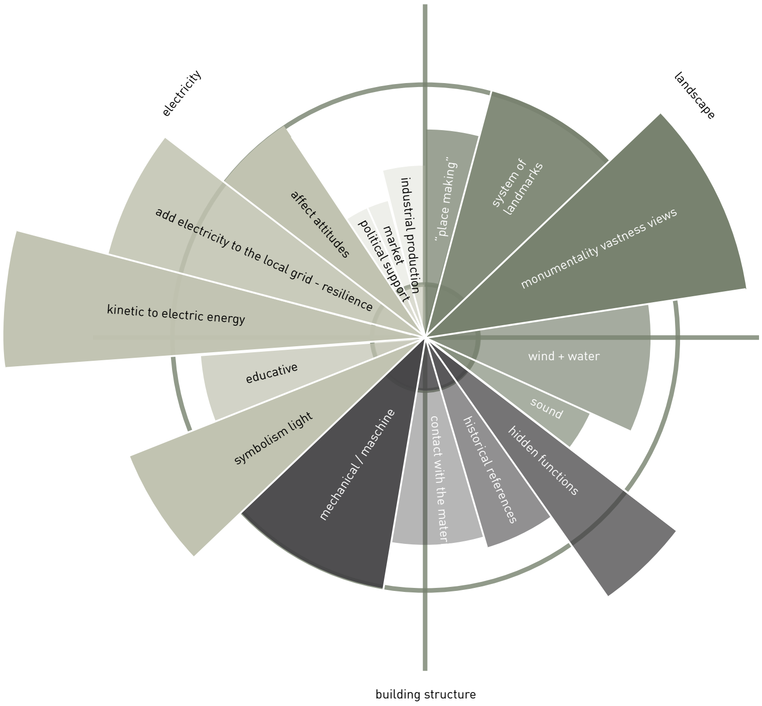
The focus of the thesis is to create a strategy by combining urban design, architecture and technology. It will not consider developing new technology, which is left for the experts. The thesis is to be considered as inspiration and is developed without direct connection with researchers on wave power.

DEFINING THE PROJECT

FOCUS

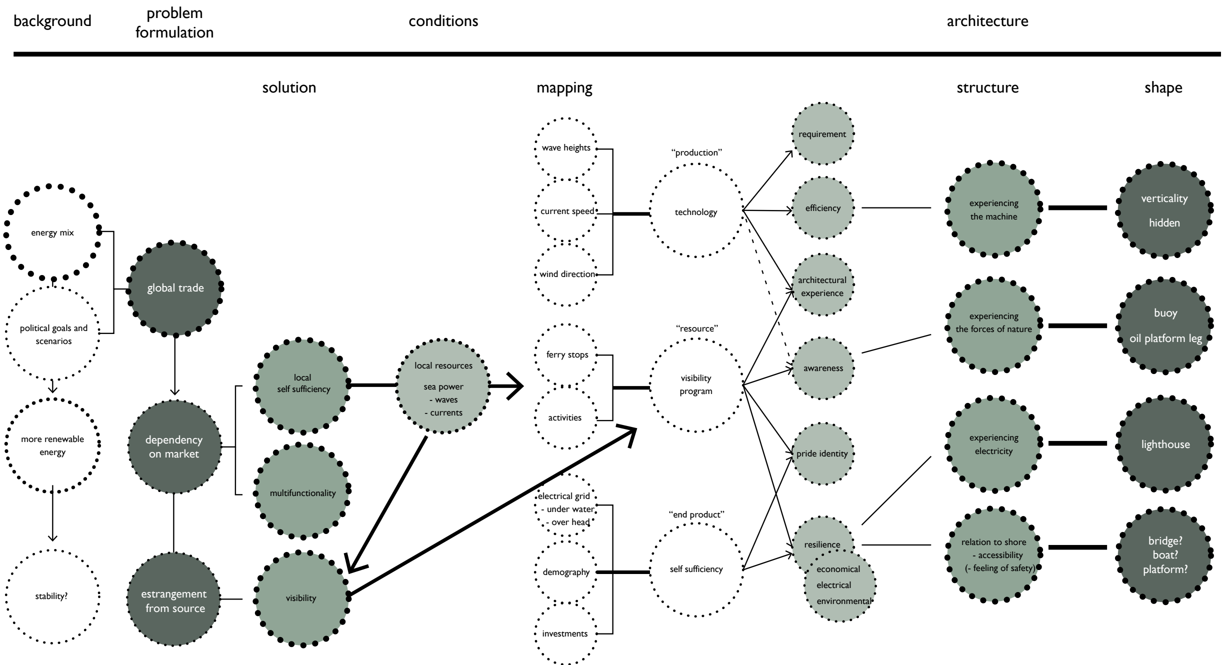
The diagram shows the areas included in the thesis. It is divided in three equally important parts, through which the chapters of the thesis follows; electricity, landscape and building structure. The parts are however connected, and depend on eachother.

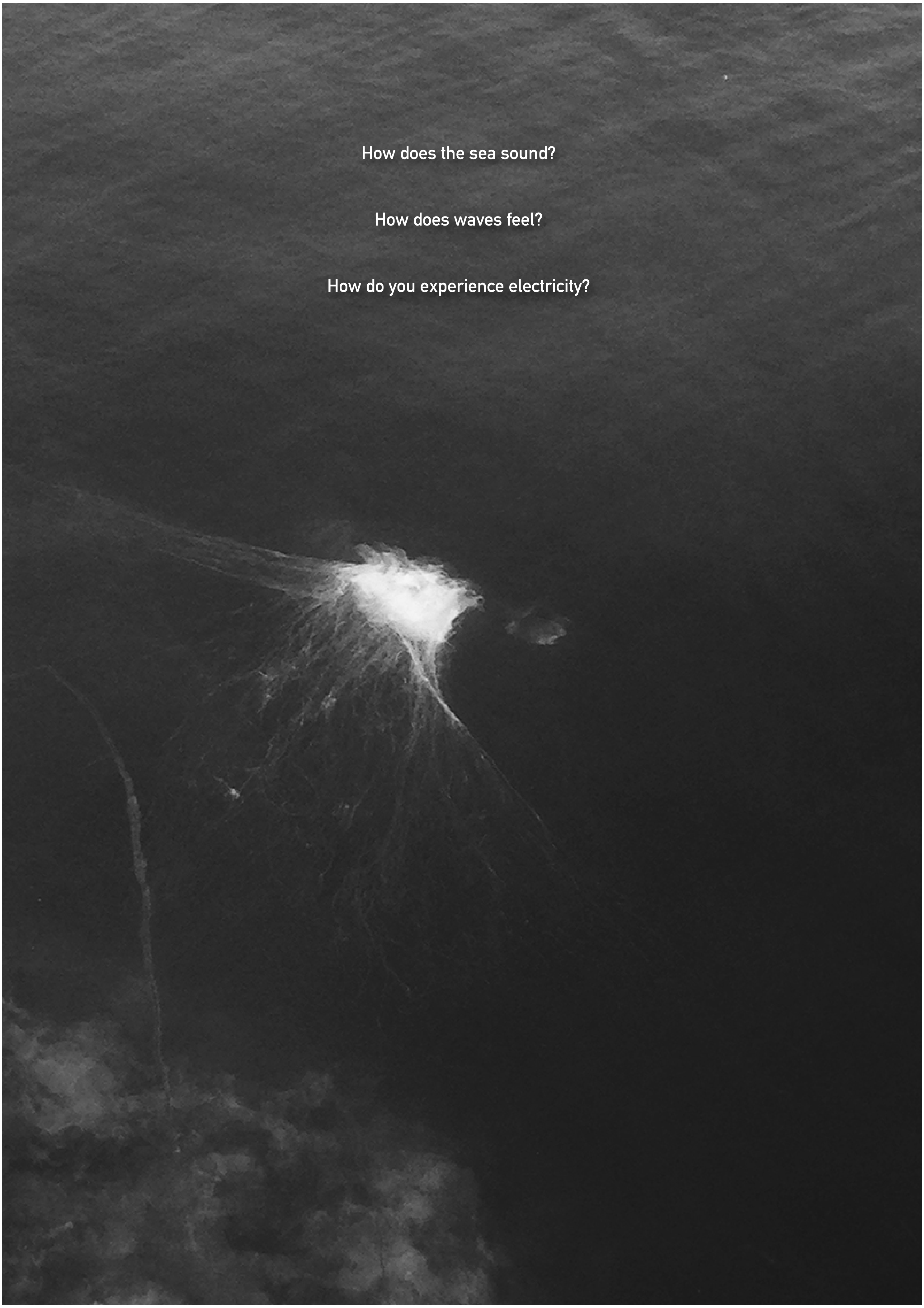
The chart shows the intention to put emphasis on the symbolization of kinetic energy to electricity, and how the structure is placed in the landscape.



STRUCTURE

The flow chart below shows how the problem formulation is based on the background and leads to methods and possible architectural solutions.

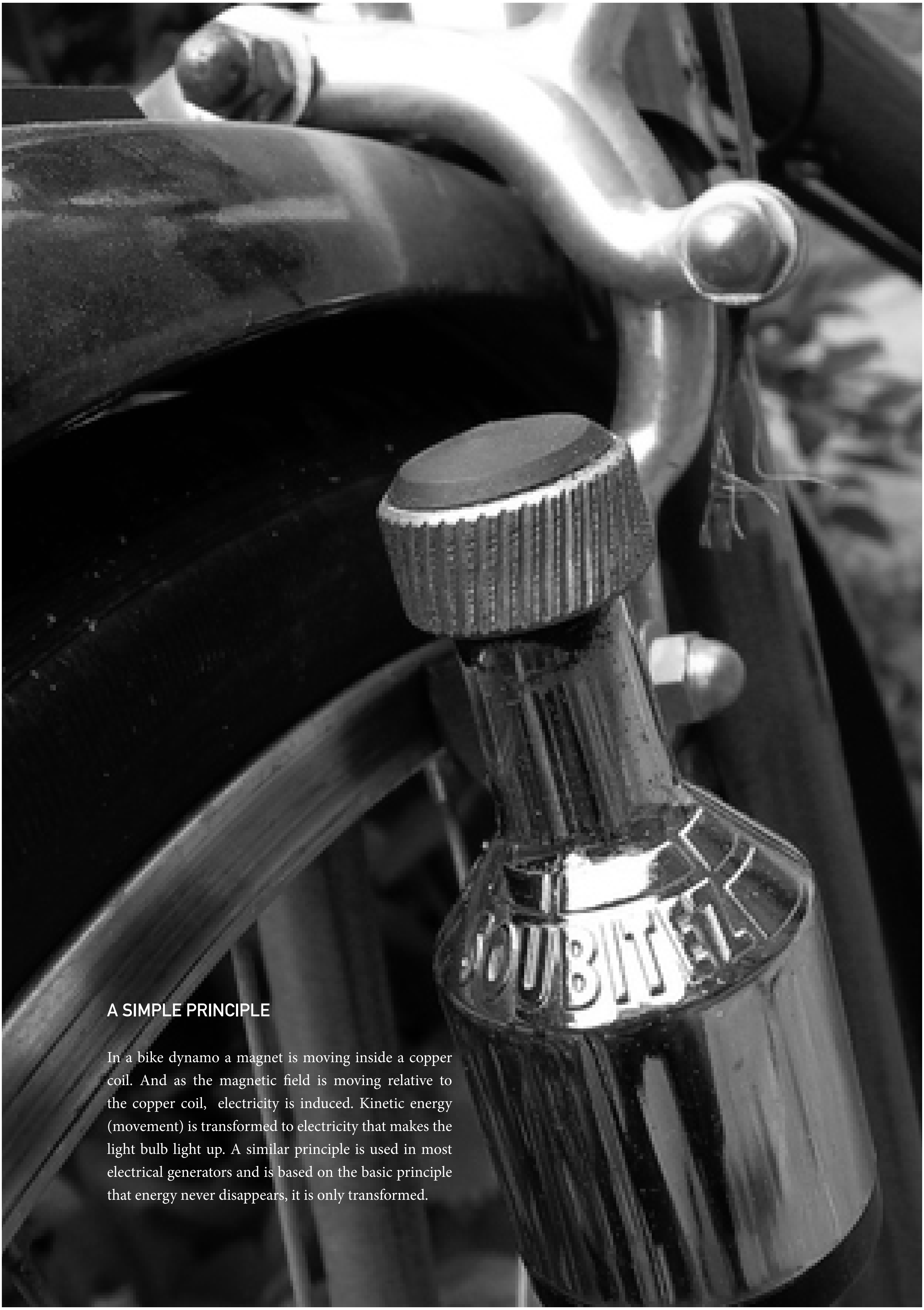



How does the sea sound?
How does waves feel?
How do you experience electricity?

"En kultur kan ju inte uppstå utan den energikälla som gör den kulturen möjlig. När vi skaffar oss tillgång till den energi som krävs leder det också till att vi anammar vissa värderingar samtidigt som vi utesluter andra. Och (...) de värderingar som kommer med den dominerande energikällan ligger i botten för hela samhällets värdegrund. Om samhället sedan skiftar till nya kraftkällor förändras hela kulturen. En omställning till en ny energikälla innebär alltså en omställning till helt nya kulturella värderingar. Det nya bränsle som dominerar ger oss en ny uppfattning av vad det är att vara människa"

(UDDENFELDT, 2017)

EARTH AT NIGHT (NASA, 2014)



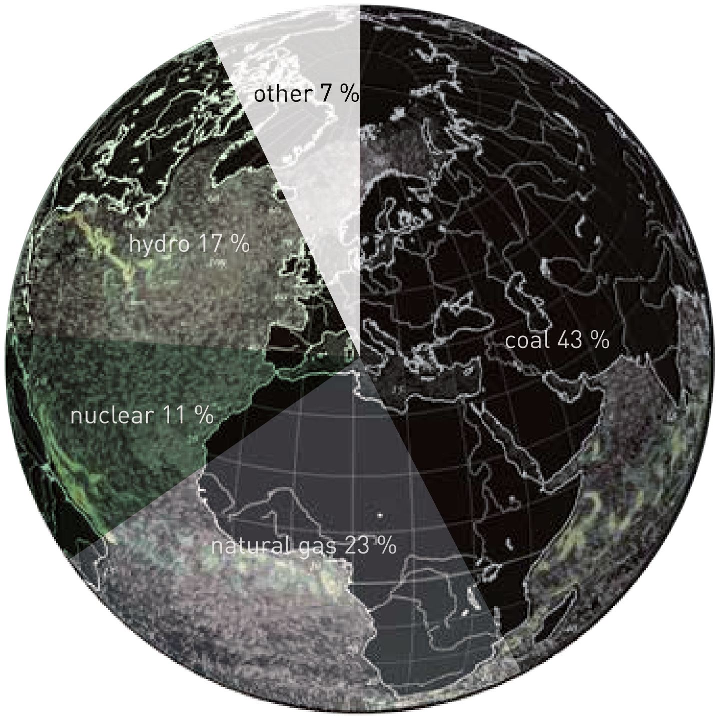
A SIMPLE PRINCIPLE

In a bike dynamo a magnet is moving inside a copper coil. And as the magnetic field is moving relative to the copper coil, electricity is induced. Kinetic energy (movement) is transformed to electricity that makes the light bulb light up. A similar principle is used in most electrical generators and is based on the basic principle that energy never disappears, it is only transformed.

2.

ELECTRICITY

PHYSICAL RESOURCES



WORLD ELECTRICITY MIX 2016
(INTERNATIONAL ENERGY AGENCY [IEA], 2017)

WORLD ELECTRICITY MIX

At the same time as industries and technology worldwide continues to become more and more electricity efficient the consumption still expects to continue increase. This is mainly due to growing populations and continued urbanization, wind and hydro power also expands as relatively simple and cheap alternatives, but parallel to even more creative ways of finding sources for fossil fuel.

Globally, the electrical production is still largely depending on coal and natural gas. This is partly due to the large energy markets in China and the USA together with the expanding markets in developing countries in Asia and Africa, and with the fact that coal still is one of the cheapest energy resources (IEA, 2017).

THE ROLE OF SWEDEN

The Swedish political agreement the Commission on Energy describes how the the global market affect Sweden, which means that even though Sweden has a relatively clean energy mix, it still depends largely on global oil and coal prices. But even though the Nordic market is such a small percentage of the overall energy mix, The Commission on Energy enhances the role Sweden can take in developing new renewable technologies. Either if it is for the Swedish market or for places where the natural conditions are better. They also enhances the attractivity for international investors Sweden gets from its environmental friendly profile (SOU, 2017:2).

EU ELECTRICITY MIX

According to the European Wind Energy Association (EWEA, 2016) the EU increased the installed wind power capacity from 2,4 % to 15,6 % between 2000 and 2015. This makes it almost as much as the installed hydro power, traditionally one of the strongest parts of the electricity mix. The increase was mostly made possible by international political goals. Comparing to the world electricity mix, coal percentage is less, but still dominating in many countries. Fuel oil has decreased as an electrical source, and remarkable is also the increased amount of installed solar power to 10,5 % in just a few years. In total, renewable power capacity in the EU has increased from 24 % to 44 % since 2000 (EWEA, 2016).

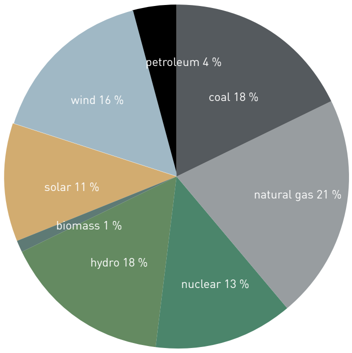
The central scenario made by the EWEA is to increase the installed capacity of wind power to 26% until 2030 mostly located in western and central Europe (France, Germany, UK). The development has however ceased to increase, proving the scenario wrong (ex. SOU 2017:2).

SWEDISH ELECTRICITY MIX

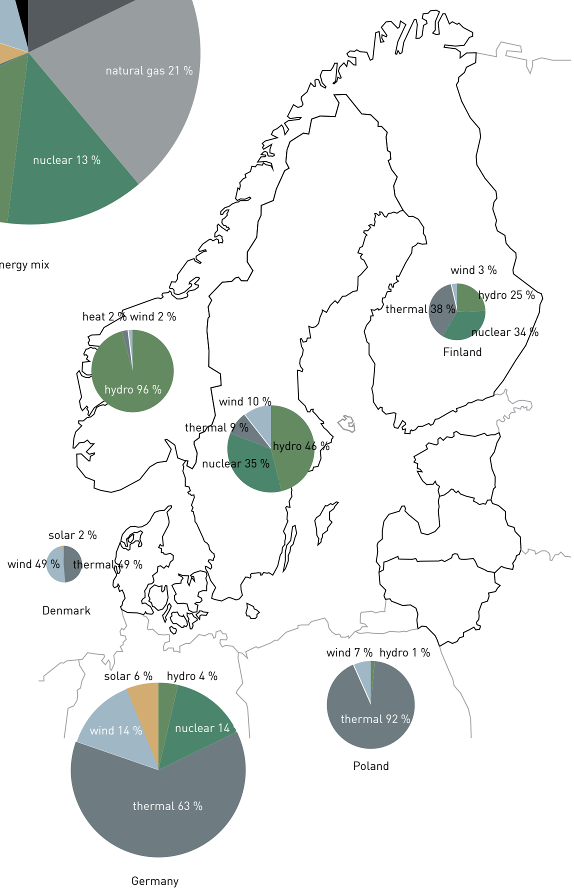
Sweden is often proud to claim an 98% fossil free electricity mix. The rivers and mountains in the north provides the main source of the Swedish electric grid, with the 46% hydro power. Therefter comes nuclear power with 36% and wind power with 10%.

Hydro power is however considered to be built to its limits and due to increased population and an electricity dependant transportation sector - Sweden will have to look for new sources of electricity when the need expands.

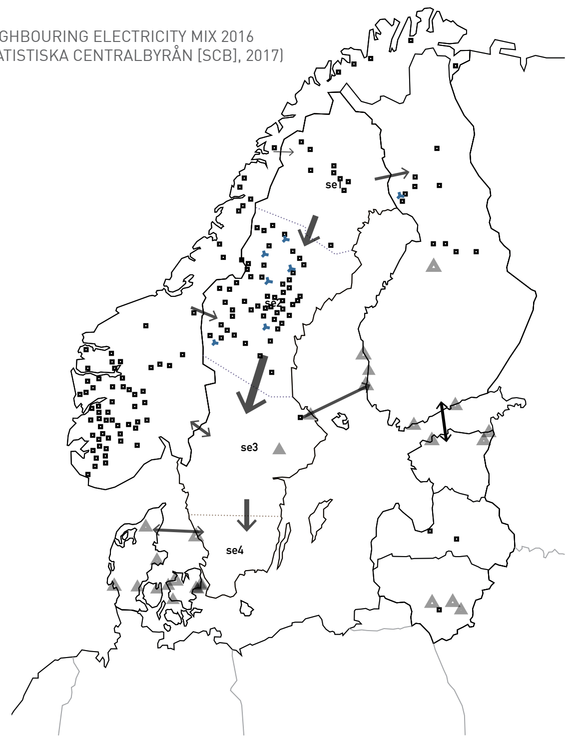
As seen in the diagram, the power plants are also unevenly distributed geographically.



EU energy mix



NEIGHBOURING ELECTRICITY MIX 2016
[STATISTISKA CENTRALBYRÅN [SCB], 2017]



THE POWER PLANTS AND STAMNÄTET
[SVENSKA KRAFTNÄT [SVK], 2017]

PHYSICAL INFRASTRUCTURE

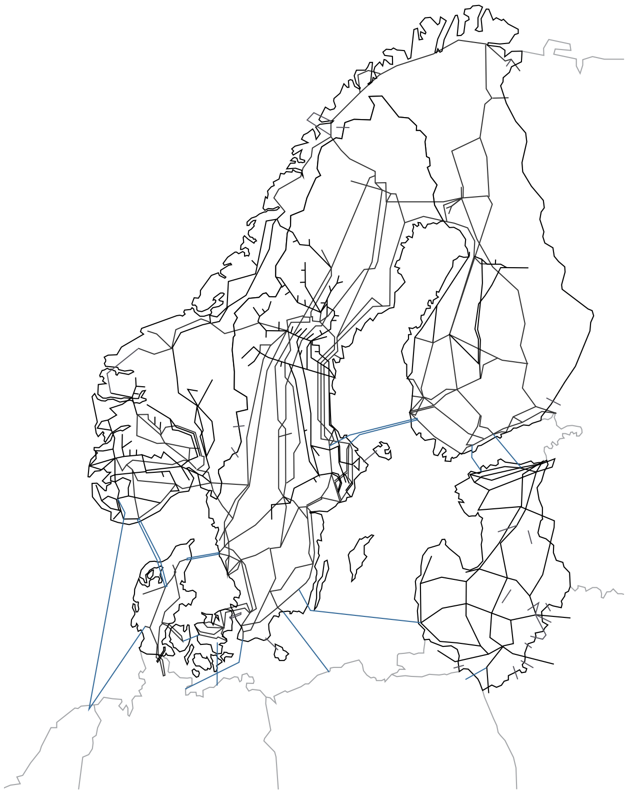
THE ELECTRICAL GRID

The electrical grid has been called the worlds biggest machine as it is the physical infrastructure that connects the production and use of electricity. In Sweden it is divided to the national grid (stamnätet), the regional grid (regionnätet) and the local grid (lokalnätet), a division that can be compared with the road network of highways and local roads. The national grid is the highway-like overhead lines that transport electricity from (mostly) north to south and the local grid is often buried under ground. The local grid covers approximately 312 000 km, whereas the national grid covers around 15 000 km (Svenska Kraftnät [SVK], 2017).

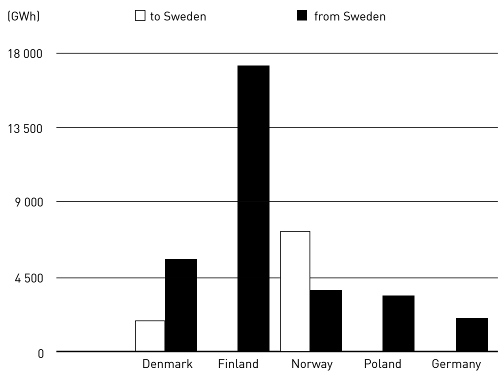
Since electricity losses is less the higher voltage that is transported, the national grid can contain electricity up to 400 kV, but to be used in households, the electricity has to be transformed down to a voltage of around 230V. This is done in transformer stations, or sub stations.

The national grid also extends over the national borders which makes it possible to balance the distribution when the production is high or low. As seen in the diagram to the right, Sweden exported more electricity than we imported in 2015 (SCB & Energimyndigheten, 2016).

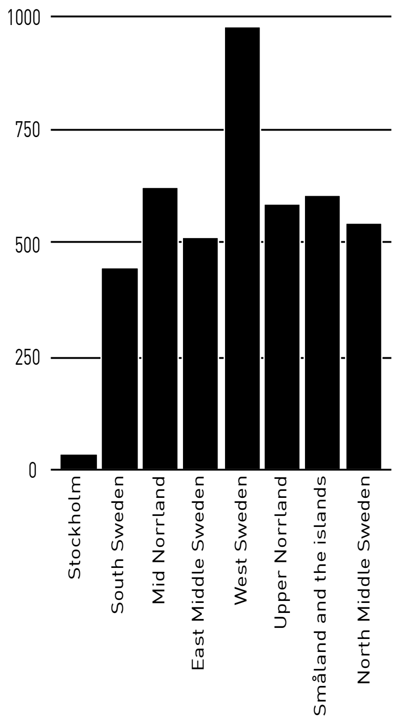
The main producers of electricity in Sweden lies in the north, while the consumers are located in the city areas in the south. In Gothenburg, most of the electricity comes from the rivers in Norway (Göteborg Energi, 2017). Interesting enough, the number of power stations in the south is higher than in the north, since windmills doesn't produce as much electricity per unit (next page).



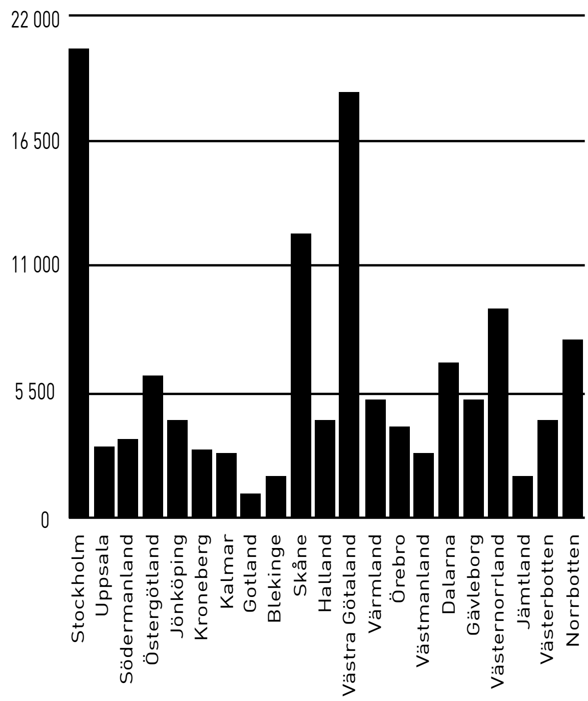
THE NATIONAL GRID (SVK, 2017)



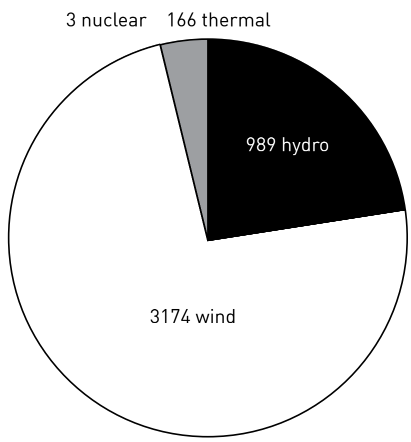
IMPORT AND EXPORT OF ELECTRICITY (SCB, 2017)



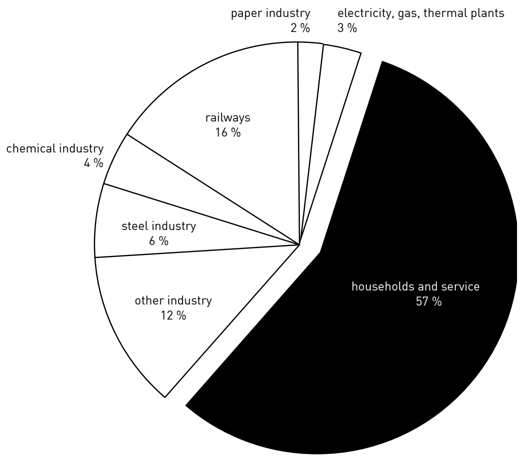
DISTRIBUTION OF POWER PLANTS BY REGION (SCB, 2017)



ELECTRICITY CONSUMPTION BY COUNTIES (SCB, 2017)

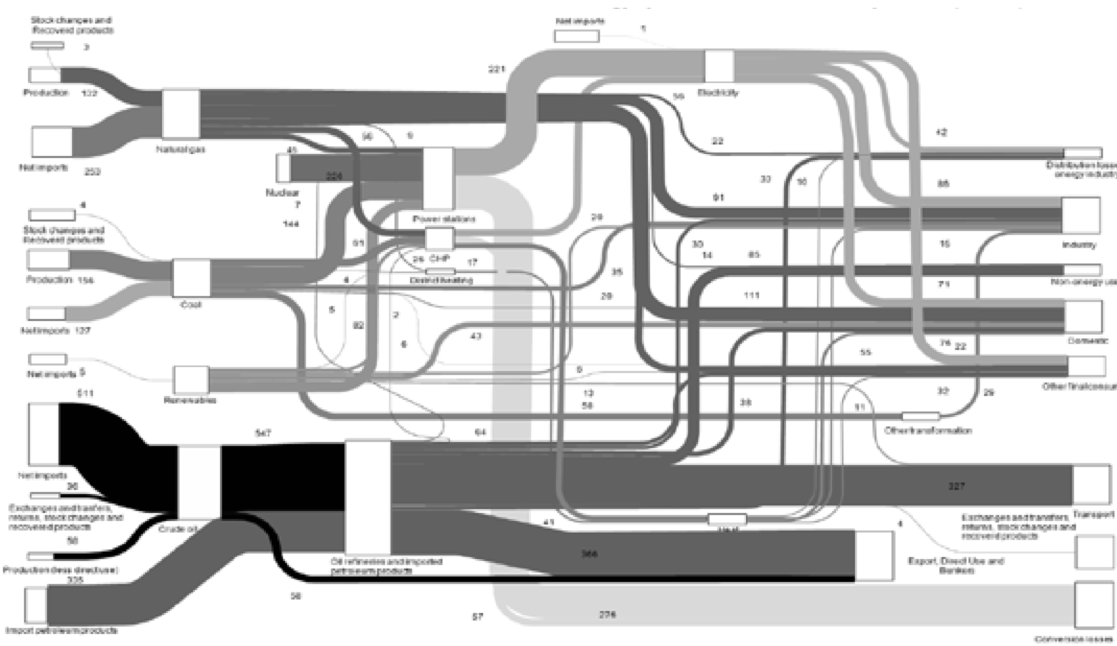


TOTAL NUMBER OF POWER PLANTS (SCB, 2017)



ELECTRICITY CONSUMPTION (SCB, 2017)

ECONOMICAL PRECONDITIONS



THE OVERALL PICTURE OF THE ENERGY SYSTEM IN THE EU 2013
(EUROPEAN ENVIRONMENT AGENCY (EEA), 2015)

THE SWEDISH ELECTRICITY MARKET

The electricity market in Sweden was deregulated in 1996, making it shared, first between Norway and Sweden, and now between the Nordic and Baltic countries, see image on p.14. The aim is to expand the exchange market even further to include more European countries (SOU 2017:2).

The prices are set on a common power exchange market called Nordpool, where the producers sell electricity to the electrical companies. The grid owners stand for the infrastructure that supply electricity to the end consumers and the electrical companies provide with the electricity. Sometimes the same company offers both grid supply and electricity, for example Göteborg Energi in Gothenburg.

The electricity market can be divided in both gross trade and detail trade, and differentiate between private consumption and industrial, and it can be divided in two flows - one physical infrastructure and one economical.

The supply and demand of electricity affect the prices, and is basically depending on the weather. A cold winter will increase the need of heating, but during winters the wind and precipitation are often stronger and more electricity is produced in hydro stations and wind mills. The supply is also affected if a nuclear reactor are closed for reparation. However since the exchange is interconnected, prices will also be affected by current exchange rates and the prizes of fossil fuels. And even though the deregulation, the government still have the power to affect the productions sources with fundings.

A PART OF THE TOTAL ENERGY MIX

The electricity mix is however only a small part of the over all energy mix. As shown in the diagram above, most energy goes to industry, heating, cooling and transportation. Due to different efficiency in energy types, different sources fits different purposes. Electricity can hence be seen both as a resource and end product depending on if it is transformed into another energy category (heat) or used directly.

The benefit with electricity is that it can be transported long distances without loosing energy, but it is difficult to store, preferably it has to be used immediately. Since the technology for electricity storage is not yet proficient, a challenge within the electricity supply is to have a balanced distribution and a constant flow.

DIRECTIONS AND POLITICAL AGREEMENTS

In the Energy Agreement (Energiöverrenskommelsen) by the Commission on Energy (Energikommissionen), five out of the eight political parties agreed on the aim of 100 % renewable energy by 2040 (SOU, 2017:2). Almost all of Sweden's electricity is already fossil free, but more than a third comes from nuclear power, which will be a challenge to exchange to renewable sources.

In February 2016, it was decided to shut down the nuclear reactor Oskarshamn 1 in the first half of 2017. Oskarshamn 2 shut down in 2015, leaving only one reactor running. The main reason was said to be lack in profitability due to low energy prices and high security demands (OKG, 2017 & Strålsäkerhetsmyndigheten, 2017). Ringhals 1 is planned to be shut down 2020 Ringhals 2 in 2019, both in advance. This leaves Sweden with 6 out of 10 reactors remaining.

In the report, the Commission on Energy promote small scale local electricity production. Ways to reach this is to abolish the connection fee for the national grid, which today is a big expense especially for off shore power plants. They also propose making it easier to connect excessive electricity from household solar panels to the grid. A small scale electrical production, and flexible use of electricity is also seen as a geopolitical strategy to secure the electricity distribution to changes in the global economy (SOU 2017:2).

The electricity exchange between the neighbouring countries is expected to increase, which can be a potential for renewable resources, when the demand and supply is more easily balanced in a greater region. An even more connected electricity market can also offer opportunity for export of new technology (SOU, 2017:2).

FUTURE SCENARIOS

Just as worldwide, the electricity use in Sweden is expected to follow the trend of increase. The Commission on Energy states three parameters below:

- The total *energy* demand in the transportation sector is expected to decrease due to higher efficiency in engines. Gasoline is predicted decrease, diesel to be stable and biofuel to increase. A substantial part of the private vehicles is predicted to be electrical by 2030.

- National industry will continue to be of importance and with higher efficiency, digitalization and electrification of processes, the electricity demand is expected to rise.

- The population is expected to grow 20% until 2050 to 12.5 million, which will make the heating and the electricity demand in households and services grow.

IN NEED OF A FLEXIBLE SYSTEM

In the report "Anpassning av elsystemet med en stor mängd förnybar elproduktion", Svenska Kraftnät writes that hydro power have the potential of balancing a yearly production of 30-40 TWh from weather dependant sources (wind, solar). This gives a potential for changeable energy resources to increase from today's 10% (wind) to 25-30%. Stored flexible capacity, external energy storage and a more decentralized production will avoid bigger investments in a new grid (SVK, 2015).

RENEWABLE RESOURCES

ARCHITECTURAL POSSIBILITIES IN RENEWABLE ENERGY

Renewable energy sources are usually what we call hydro-, wind-, solar power and biomass since they are based on limitless resources. They have different advantages and disadvantages.

HYDRO POWER is one of the oldest energy sources. It is possible to store in magazines and dams to let out when needed for a balanced supply, and is thereby relatively stable. But it has a big impact on the environment, the ecosystem and the ways of fish, as it shuts up the rivers. There are both small and big scale hydro plants, but more and more small scale plants have been shut down, partly due to lack of profitability and to restore the ecosystems. The structures are often hidden or integrated in the landscape. The architectural potentials in hydro power lies in redevelopment, redesign and cultural heritage since it has a long tradition and considered built to its limits. There is a potential of showing the cultural values and heritage of an age of Swedish industrial expansion.

WIND POWER is also one of the oldest energy sources, used for mills, saws and ships. The windmills that we are used to see today however took their shape in the early 20th Century, and the design has not changed much since. The last ten years, the wind power plants has increased exponentially. The increase have however slowed down lately, due to low electricity prices, and profitability is more difficult in small scale production. They have also received critique because of the visual impact in the landscape. The wind potential has however not reached its limits. The question is where to put them since off shore has expensive costs for grid connection and Norrland lacks capacity of the grid (SVK, 2015).

Another expanding energy source is the SOLAR POWER. The technology is developing quickly, and it is a technology most efficient in small scale. The horizontal design of it makes it suitable to integrate in façades, roofs and public spaces. However, they also often contains rare materials and more research on the life cycle is needed to prevent unforseen environmental dangers.

Similar to hydro power BIOMASS has potential of bringing balance and flexibility to a varying system. It is often based on wood industry and household waste. It can be used in power plants previously used for fossil fuel as they often require large scale industrial sites.

Last, we also have WAVE POWER which at the moment is not developed enough for reaching the commercial market. There are numbers of different shapes, and it is predicted a continue variety of different shapes depending on different conditions. Wave power could be integrated in an architectural system. The largest potential for wave power today is on islands and off shore structures, such as oil rigs, where electricity is expensive.

ENERGY STORAGE

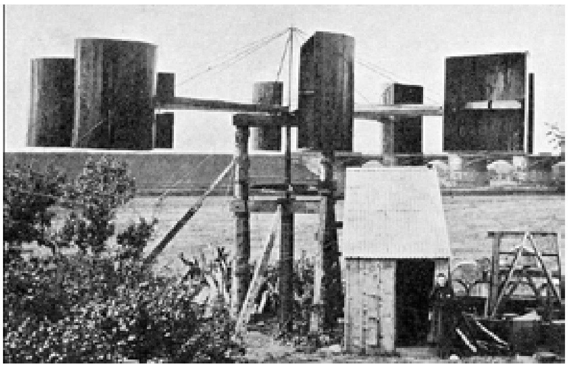
There is always a loss, when energy is transformed into another type, but different types of energy have less loss than others. Basically hydro, wind and wave power are stored kinetic energy, movement.

Historically, wind has been used in pumping system, creating compressed air or a reservoir of water to run a generator when wind is low. Flywheels can also be used for big forces.

Recently batteries are becoming more and more efficient even though they still contain materials that are hard to access and produce hazardous waste. However, with long lifetime and efficient way of charging they can provide flexibility and autonomy to a smaller system such as a car, boat, a home and even a small society.

THE DAM IN STWLAN, WALES (PINGSTONE, 1988)

CRITIQUE



LEARNING FROM WIND POWER

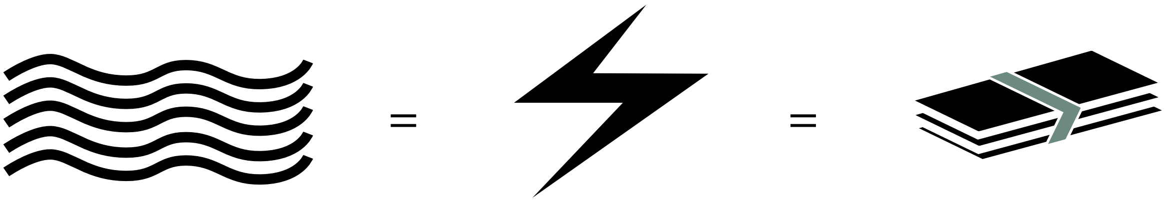
The wind power development started to take speed in the years after the oil crisis in the 1970s when many national research programs started to investigate the potentials of renewable energy. In Germany and Great Britain the focus was often put on big plants, usually developed by the aircraft industry, power industry and bigger companies. Denmark however, took a different path, and developed wind power plants in smaller scale. It was mainly the agriculture, boat and fishing industry that started developing windmills, making them small and robust, appropriate for agriculture. It was common that families co-financed their own windmill, making 120 000 Danes part owner of wind power plants. Sweden didn't have the same investments as Denmark and Germany until 1990s (Wizelius, 2003).

The difference between the wind mills and traditional thermal and hydro plants are many, but one is that they were built in times of different zeitgeist and attitudes towards technology, infrastructure and development. They have a small footprint, but is visible from long distances, do not necessarily require large monofunctional areas and they have often received critique for destroying the view, noise and shadow.

The sociologist and political researchers Michael Klintman and Åsa Waldo describes the main arguments against wind power as either aesthetic, that they destroy the view, or a combination of substantive and ethical; that they are not efficient enough. There is also a fear of how the windmills effect ecosystems, both at sea and at land (Klintman & Waldo, 2010). They mean that the best way to handle negative and hesitant attitudes is by early participation. Even though participation often have limited possibilities on affecting the decisions, it means opening up a dialogue. There is a particularly good potential when there is a possibility of co-ownership.

Investors complain mainly on the profitability, the lack of investments and political support. There are potential development areas at sea for a capacity between 150-300 MW, but it is not calculated as efficient enough. Instead many Swedish investors turn to the UK and Germany (Sydsvenskan, 2017). Recently, most production of wind turbines is exclusively exported. According to Energimyndigheten the reason for this is low energy prices, low subventions and that Sweden already reached the previous goal for wind power for 2030. (Energimyndigheten, 2017)

POWER = POWER = POWER



REFLECTION

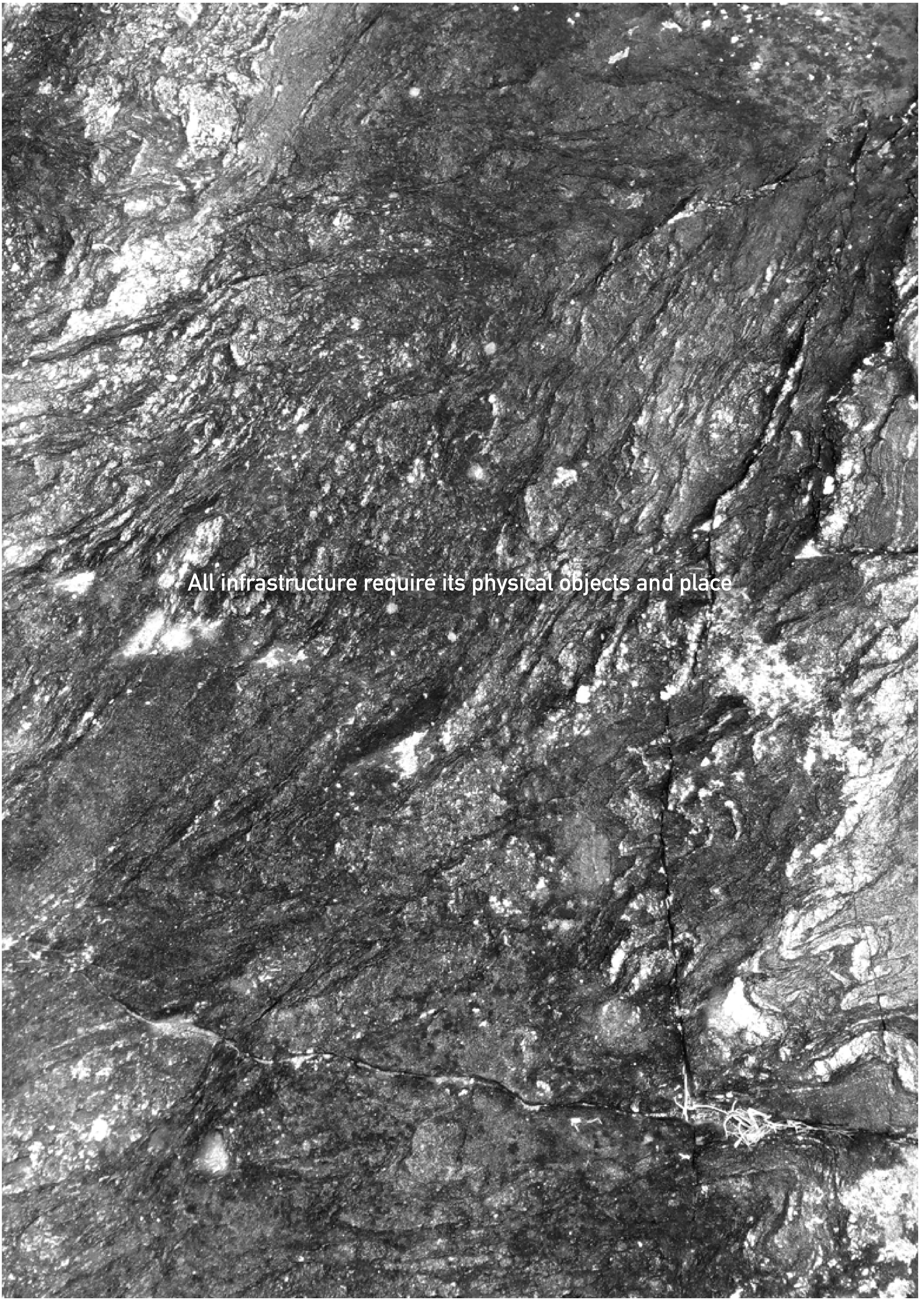
The electricity in our sockets is based on a simple principle, but it is also depending on complex economical and political situations and a huge physical infrastructure that covers the Nordic and Baltic countries.

There will be a need in the future for expansion of renewable energy, when transportation gets electrified, industry more efficient and the population grow. Renewable and local energy will however mean plants closer to the societies, something that windmills have received a lot of critique for. City-people are used to having electricity production on a distance. Creating an awareness of how electricity is created, and co-owning the power plants could however change attitudes. Small scale can also create a smaller visual impact and possibly even pride.

The discussion of Swedish electrical mix in political documents is today pragmatical. Renewable energy is considered both as an economical necessity and environmental. The electrical mix in Sweden will not affect the emissions in the world but by developing renewable technology, Sweden can both be a role model and gain economical attractivity.

A system depending on global market is fragile to geopolitical changes, small scale electricity production will create additional robustness.

With a renewable system, we will however need storage methods and more flexible energy sources to secure a more weather dependant electricity mix. Large scale plants are often monofunctional. Small scale can offer a multifunctionality that will also affect attitudes.


All infrastructure require its physical objects and place

3.

LANDSCAPE AND MACHINE

PRODUCTION LANDSCAPE

WILLIAM TURNER, FISHERMEN AT SEA, 1796

ROMANTIC LANDSCAPES

In the mid 1800's romantic era, nature was considered wild, unkept and essentially good. It was idealized. With today's expansive rise of new technology and distance to nature it seems that we have a similar longing for the authentic/natural today. It might be a reaction towards a post industrial age; we feel disconnected to nature and long for it. And it might be a legitimate longing when industrial mono-functional areas mean death of biological life and fenced environments.

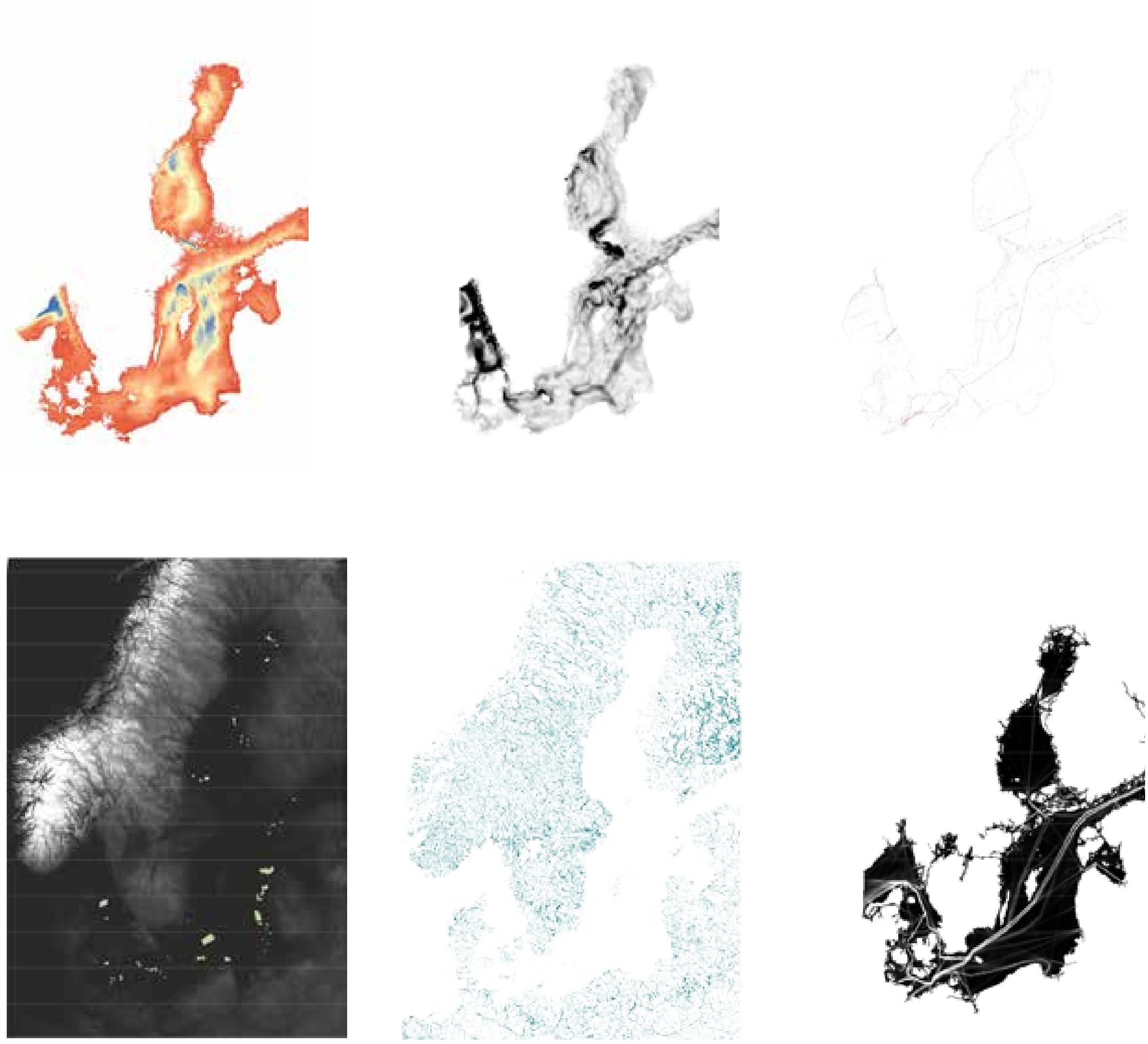
People have however always used nature for production and it is a recent luxury to consider the purpose of landscapes mainly for recreation and visual beauty, something picturesque. My stand point is that the dichotomy between landscape and technology, nature and culture is essentially false, they are connected and depend on each other. There is also a visual beauty in the mystery of technology, something the nature romantics were opposing and the modernist embracing. Why not romanticise both?

Through history the sea has been the common way to travel. It is also weighed by symbolisms of longing, vastness and a harsh life. To navigate, sea marks where put as landmarks to contrast the landscape, often with several functions, it could be a church-top, or just a printed field on the rocks.

Trade by sea is just as important as before in Gothenburg, but as the cargo ships travel on greater fairways, the need of sea marks on islets and rocks is less. The fishing industry is also moving further out at sea, and the production landscapes change and disappear from our range of experience.

The romantic pictures in the 1800's were not realistic, rather the artist tried to visualize something they wanted to tell a feeling they wanted to express. Should we accept the notion that we long for the feeling of wilderness - and provide it? Could it also include a change of natural landscapes into landscapes of power?

GEOGRAPHICAL RESOURCES



FROM TOP LEFT TO RIGHT; BATHYMETRY, CURRENTS, PIPELINES AND BOTTOM TOPOGRAPHY, TOPOGRAPHY AND OFF SHORE WIND SITES, RIVERS AND TRADEWAYS. (HELCOM, 2017)

The source of electricity comes from our landscape, as with other preconditions for our society. Geographical preconditions ultimately decides what is possible to produce.

When expanding local energy production, first thing is to look for the preconditions. And when it comes to Gothenburg - there is wind and sea. And as a consequence of that: waves.

WAVES

WAVE POWER

The energy density of water is estimated to be 20 times higher than the energy density of wind. According to the Ocean Energy Centre [OEC] the realistic potential of wave power in Sweden can thereby be up to 7%, or 10 TWh/year. But the strong forces from the sea is however also the biggest challange, since the same forces tend to destroy the technology. This makes it necessary with as few moving parts as possible or parts that are easily exchangeable. Other strategies to prevent destruction are to lower parts under water or stopping electrical production during storm.

The commercial breakthrough of wave technology is thereby also held back by highs costs for maintance, operating, manufacturing and grid connection. There are few wave power plants running to date and the biggest industries for testing the technology are countries with a long coast towards open sea, like the USA, UK and South East Asia where there are strong waves and big tidal forces (Lewis, Estefen, Huckerby, Musial, Pontes, & Torres-Martinez, 2011).

Closer to us, in the Northern Sea, there are larger test sites at the coast of Orkney and the southern parts of Cornwall (map next page). Both test sites have underwater cables connecting electricity to the grid, but most plants have failed to provide electricity for a longer period of time.

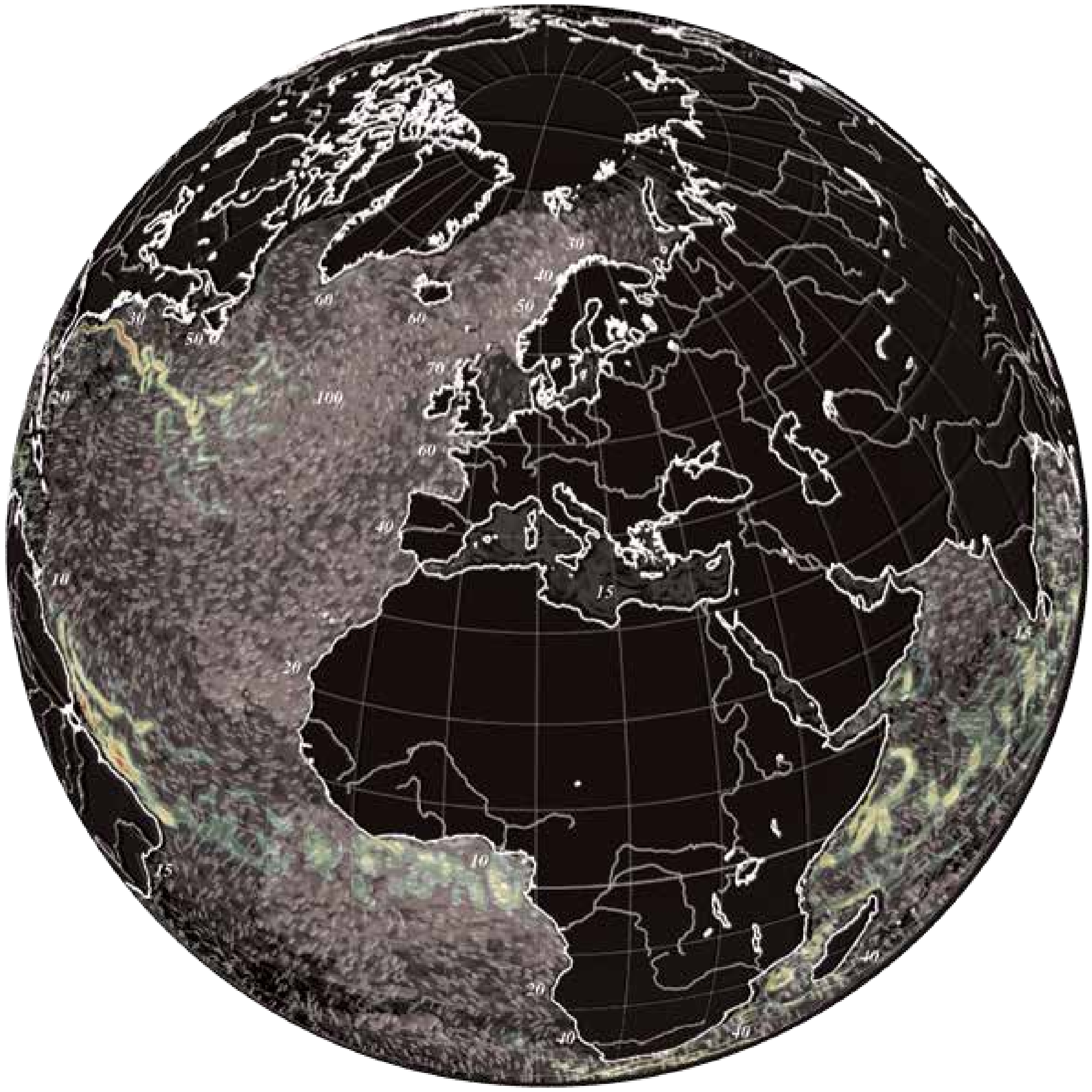
On the test sites of the Northern Sea and Atlantic Ocean, the waves carry a large amount of energy, with wavelength up to 40 m, and at Cornwall and Orkney it is not unusual with storm waves of over 12 m. The technology tested on these sites often require these bigger waves. The hydraulic system for example operates well on low velocity waves with big forces (such as in the coast of Norway) and the Pelamis is an example of a heavy structure working well on big forces from large ocean swells (Elforsk, 2011) (see diagram p. 30).

On the coast of Sweden however, with calmer waters and avarage wave heights of 1-3 m, smaller technologies have been developed and tested, mainly by Uppsala University. The so called linear generator operates on small wind driven waves - and is able to act on changes in the speed and wave direction. With less energy in each wave, there is less risk of damage and with arrays of smaller technology, the researchers are trying to find if this could be a commercial strategy (Bernhoff, Sjöstedt, & Leijon, 2006).

Outside Lysekil, the company Seabased started to provide electricity to the grid from 2015 but as for now their future is however unclear. The transformer stations are placed under water which makes them less exposed for the waves at the surface, but their weight makes them difficult to change. According to NyTeknik, the plants themself produced too much electricity for the transformer stations to handle, forcing Seabased to shut down generators, and reduce the sizes of the buoys (NyTeknik, 2017).

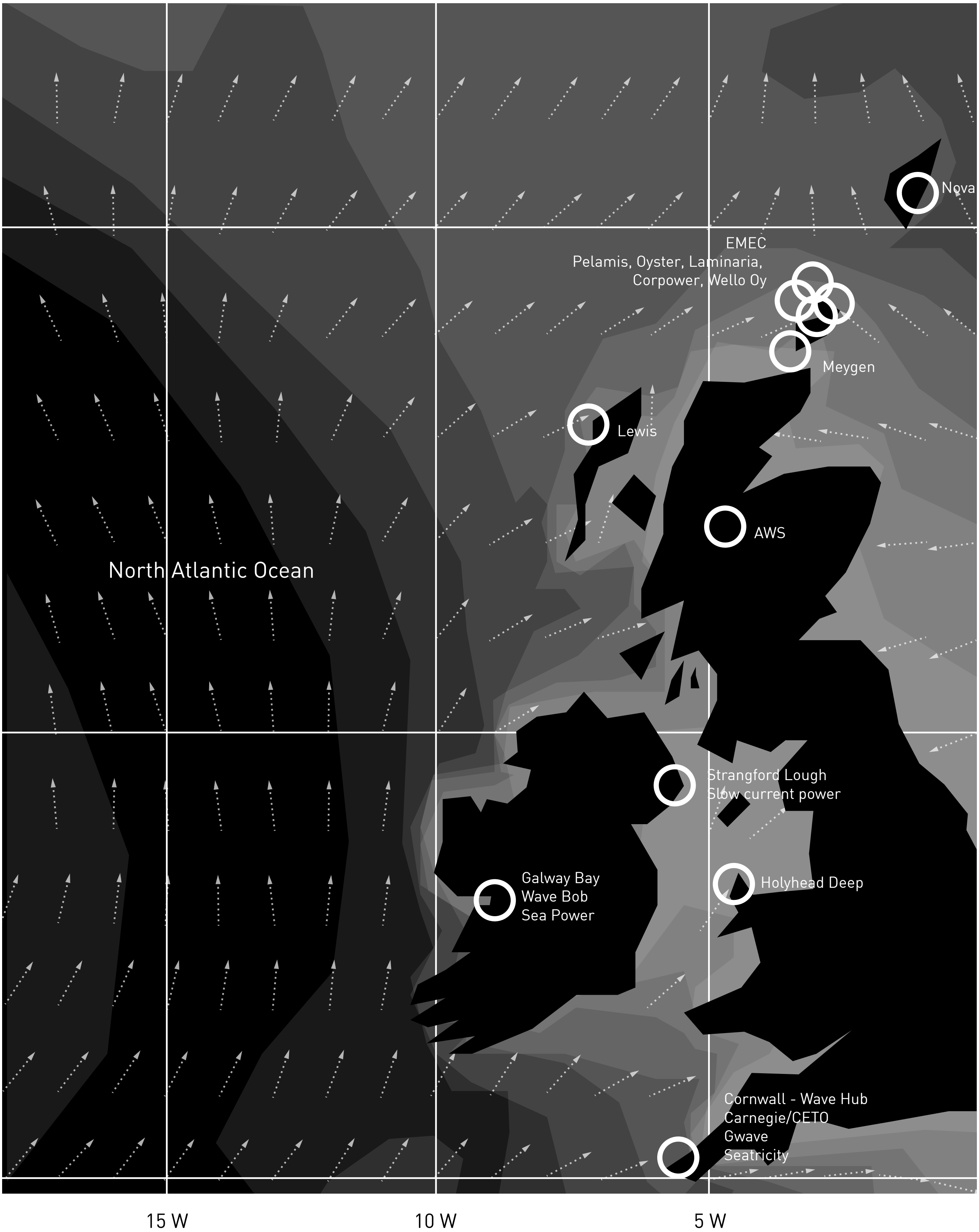
PLANNING

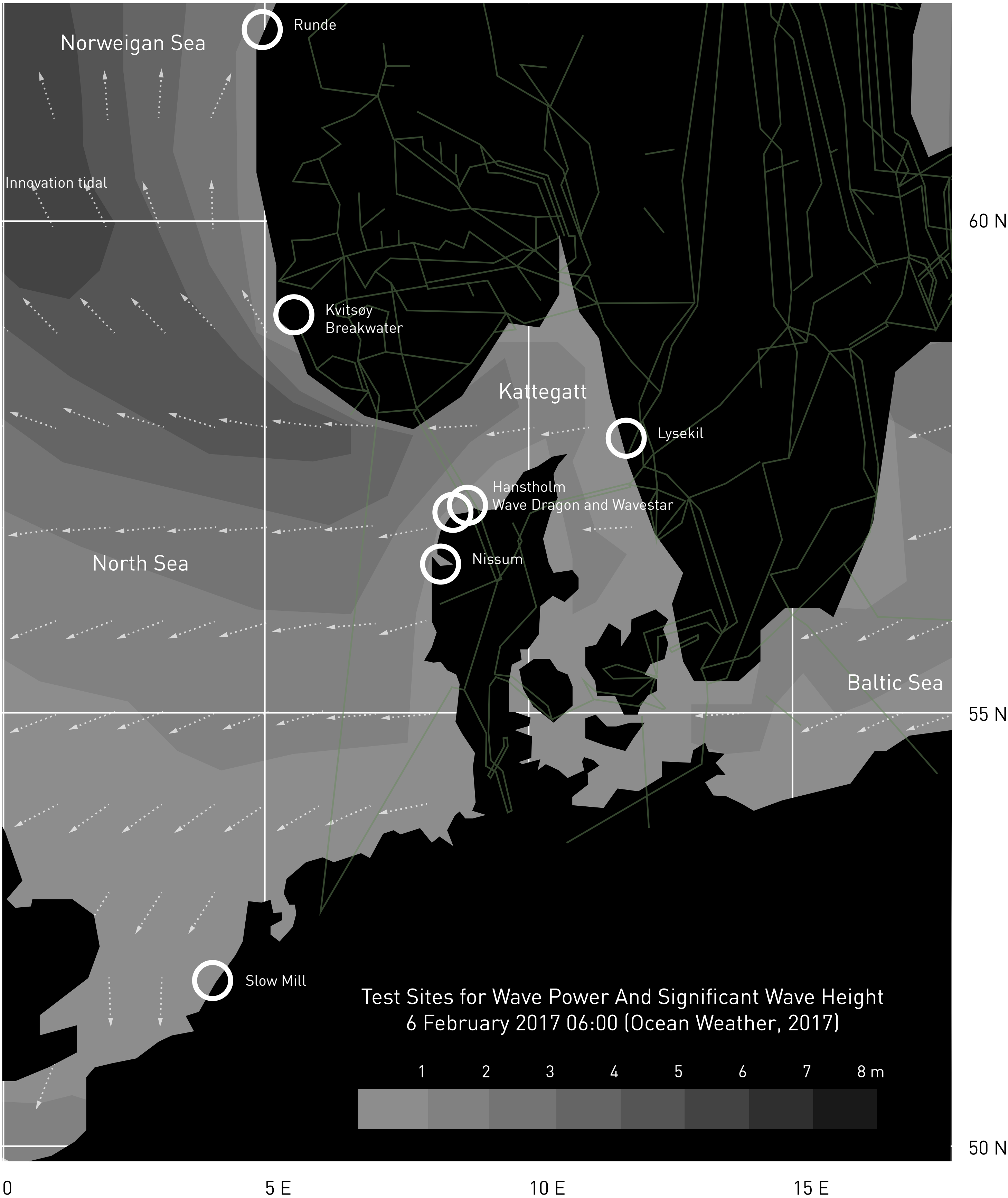
When deciding a place for wave power, the amount of power in the waves are just one factor to consider. Security distances, effects on marine life, financing and the neighbouring society is just as important.



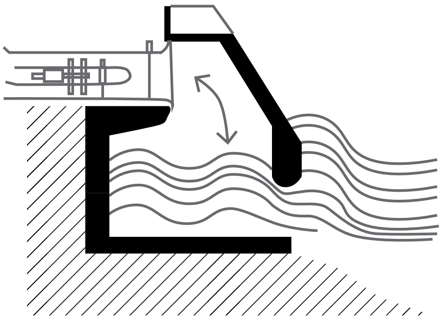
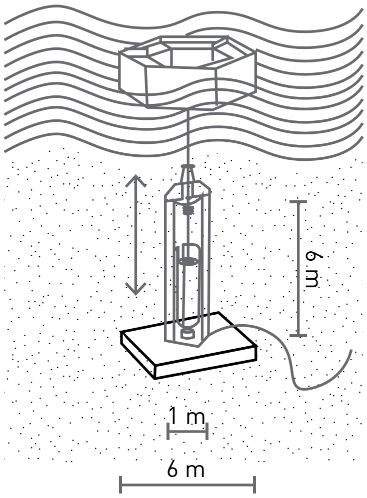
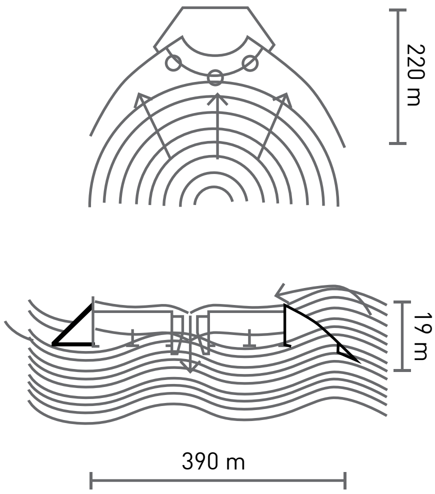
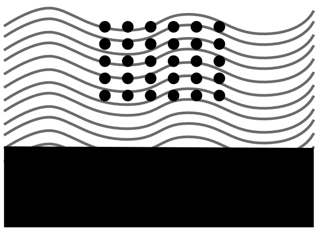
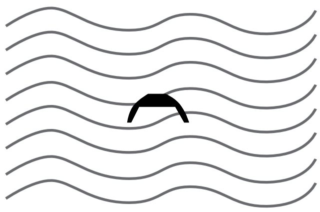
CAPACITY IN TWH, CURRENTS AND WAVE DIRECTIONS OF THE WORLD (EARTH WINDMAP, 2017)

EXISTING LOCATIONS

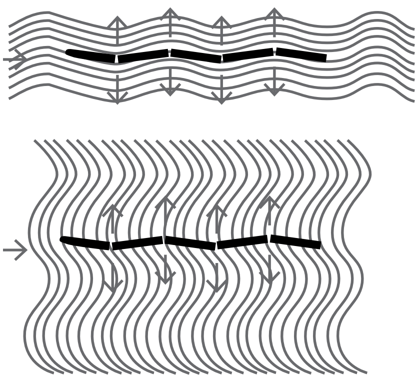
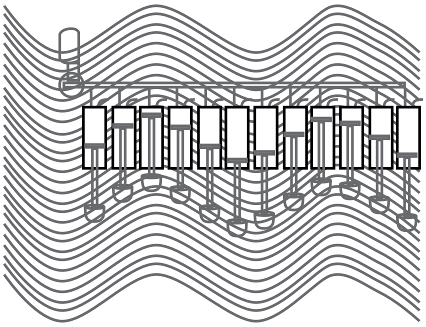
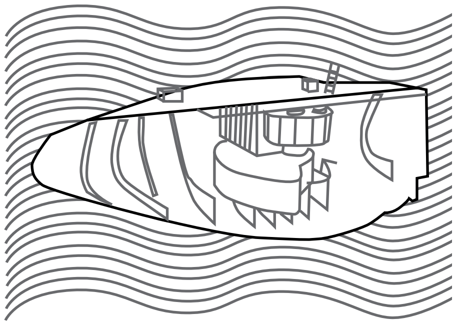
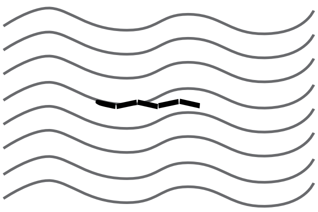
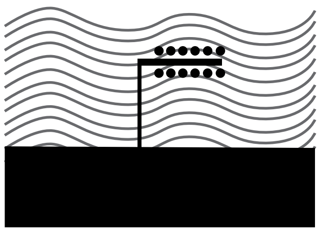
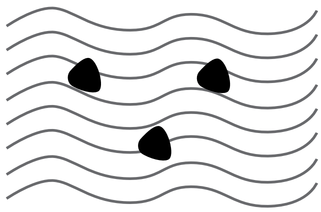



Norweigan Sea
Runde
Innovation tidal
Kvitsøy
Breakwater
Kattegatt
Lysekil
Hanstholm
Wave Dragon and Wavestar
Nissum
North Sea
Baltic Sea
Slow Mill
Test Sites for Wave Power And Significant Wave Height
6 February 2017 06:00 (Ocean Weather, 2017)
1
2
3
4
5
6
7
8 m
60 N
55 N
50 N
0
5 E
10 E
15 E

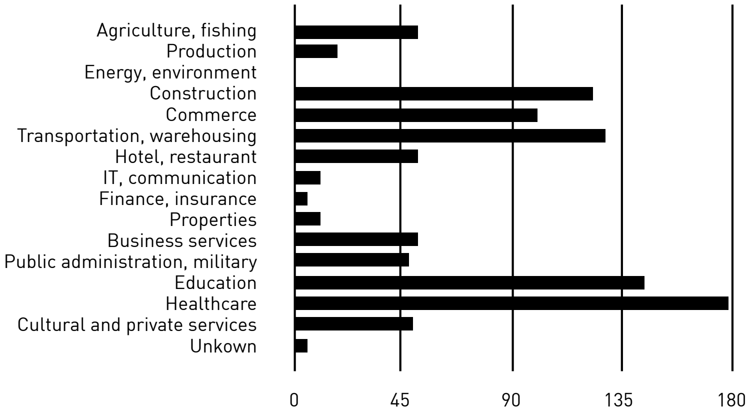
EXISTING TECHNOLOGY

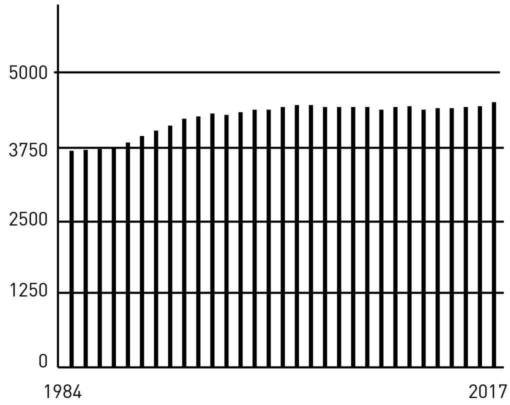
	oscillating water columns	point absorbers	overtopping devices
			
capacity	400 kW (Pico plant Azores) suppose 4000 full load hours	30 kW/each x 30 (Seabased) full load hours: 3000-4000	1,5 - 12 MW (Wave Dragon) suppose 4000 full load hours
output	→ 1,6 GWh / year	→ 90 - 120 MWh/year each	→ 6 - 35 GWh / year
amount of people	→ 320 people / year	→ 600 - 800 people/year total	→ 1200 - 7000 people / year
dimensions	–	tube: 6 m high, 1,1 m diameter buoy: 6 m diameter	390 x 220 m, height 19 m. 16-24 turbines
requirements	big waves?	water depth min 20 m 1-3 m small, fast waves	water depth → 30 m large, slow waves
relation to shore	 on shore	 close to shore	 open sea

3. LANDSCAPE AND MACHINE

hinged attenuators	hydraulic systems	rotating mass
 180 m	 5 m 75 m	 30 m
750 kW (Pelamis) suppose 4000 full load hours	600 kW (Wave Star) around 4000 full load hours	500 kW (Penguin) suppose 4000 full load hours
→ 3 GWh / year	→ 2,4 GWh / year	→ 2 GWh / year
 → 600 people / year	 → 480 people / year	 → 400 people / year
Pelamis P2.001 4 m diameter, 180 m long	float 5 m diameter x 20 platform 70 m (double size = 10 times power)	9 m high draft 7 m width 30 m
2-10 km from coast	1-3 m waves 7 m water depth	3 - 60 m water depth
 open sea	 on shore	 open sea

LOCATION





DAY POPULATION SOUTHERN ARCHIPELAGO 2014
(GÖTEBORG STAD, 2017)

INHABITANTS IN THE SOUTHERN ARCHIPELAGO 1986-2017
(GÖTEBORG STAD, 2017)

GOTHENBURG ARCHIPELAGO

The landscape of the district the Southern Archipelago in Gothenburg is unique with its smooth rolling cliffs, grounded by the inland ice, and the scarce wind swept vegetation. The man made objects placed in the wild nature is a well known part of the landscape. Lighthouses, sea marks and other aids to navigate stand out as the landmarks they are supposed to be. They are often in bright colours and in either stubborn thick shapes, standing on land, or floating in strange shapes.

CHARACTERISTIC AND DEMOGRAPHIC

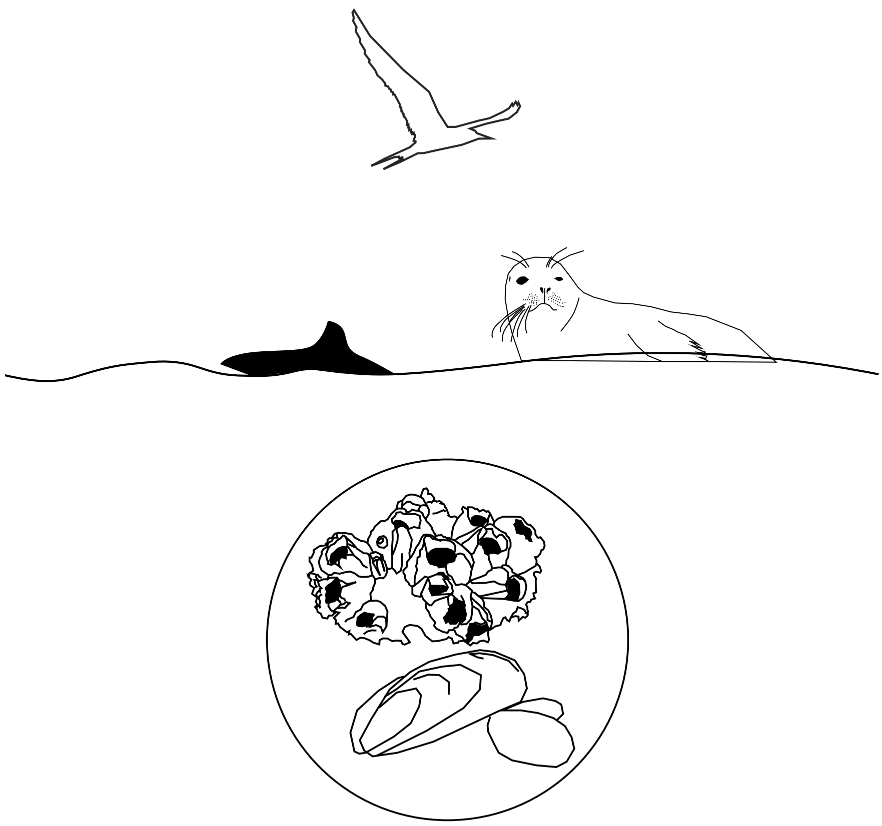
The islands in the area has been inhabited since the stone age and saw a blossom in the 18th century due to rise in importance of shipping. During the 19th century it developed as seaside resort for the wealthy of Gothenburg and today it is both all year round living and important recreation area during the summer.

There are no private car use, instead the common transportations are mopeds, bikes and boats. The main population live in small houses and work in the area. The work places are however few (Beskrivning av Stadsdelen Södra Skärgården, 2008). The district contains around 30 islands, the six islands Styrsö, Donsö, Asperö, Brännö, Köpstadsö and Vrångö with all round inhabitants, and further six islands with inhabitants during the summer.

Many inhabitants commute to Gothenburg, but around 1500 and 1000 people work locally, which gives the district the biggest percentage of people working locally after Central Gothenburg. There are good possibilities of local production of technology due to a long tradition of shipbuilding industry.

Even though shipping and fishing has been reduced and moved further out at sea it is still one of the main industries. The fishing industry peaked in the 1950s and is today counted as national interest.

ENVIRONMENTAL EFFECT



STATUS TODAY

In general the west coast is inhabited by a rich wildlife. The west side of the Southern Archipego is exposed with no wind protection and the water is relatively clean with the salt water rich in oxygen from the open sea. But it is also close to the port, with large cargo ships and dumping sites that add to the pollution which risk to lead to overfertilization and growth.

The biggest unknown environmental effect with off shore power stations, such as wave or wind power, is the electromagnetic field around the sub sea cables that might disturb the navigation of fishes. It is however not yet proven that this has actually happened (Ström, 2014). Hard bottom surfaces created by the foundation attracts more biological life especially crayfish, crabs and fishes, which also attracts mammals like seals a.

A crucial moment is the building and demolition process, disturbing the bottom fauna - but studies on off shore wind farms show that this the bottom fauna quickly adjusts back (Ström, 2014)

REEF EFFECT

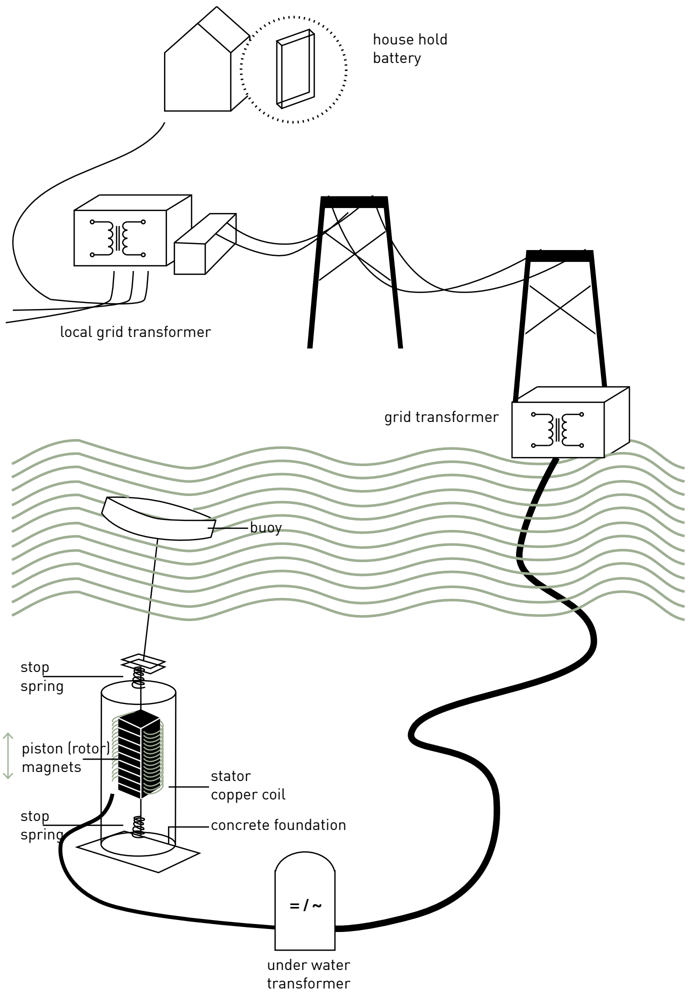
When placing objects in a poor sea environment the natural growth can cause a so called reef effect. It is a phenomenon that has been studied, for example, under the Öresundsbron which means that mussels and sea weed grow on the foundation. It creates a better environment when alive, but also when they die, sink to the bottom and create a diverse seabed.

Under Öresundsbron, fish life has increased since the foundations and birds find the artificial island Pebersholm, made by the mud from the dredging an interesting nesting place.

MUSSELS

The common blue mussel, however, takes advantage of the growth. They take up approximately 1% nitrogen and 1 /15 phosphor per gram, meaning that 1000 ton mussels clean the sea of 10 ton nitrogen and 650 kg phosphor. Mussel farms have been used as a method of removing nitrogen outside of Lysekil (Naturvårdsverket, 2013).

CHOSEN TECHNOLOGY



NECESSARY INFRASTRUCTURE

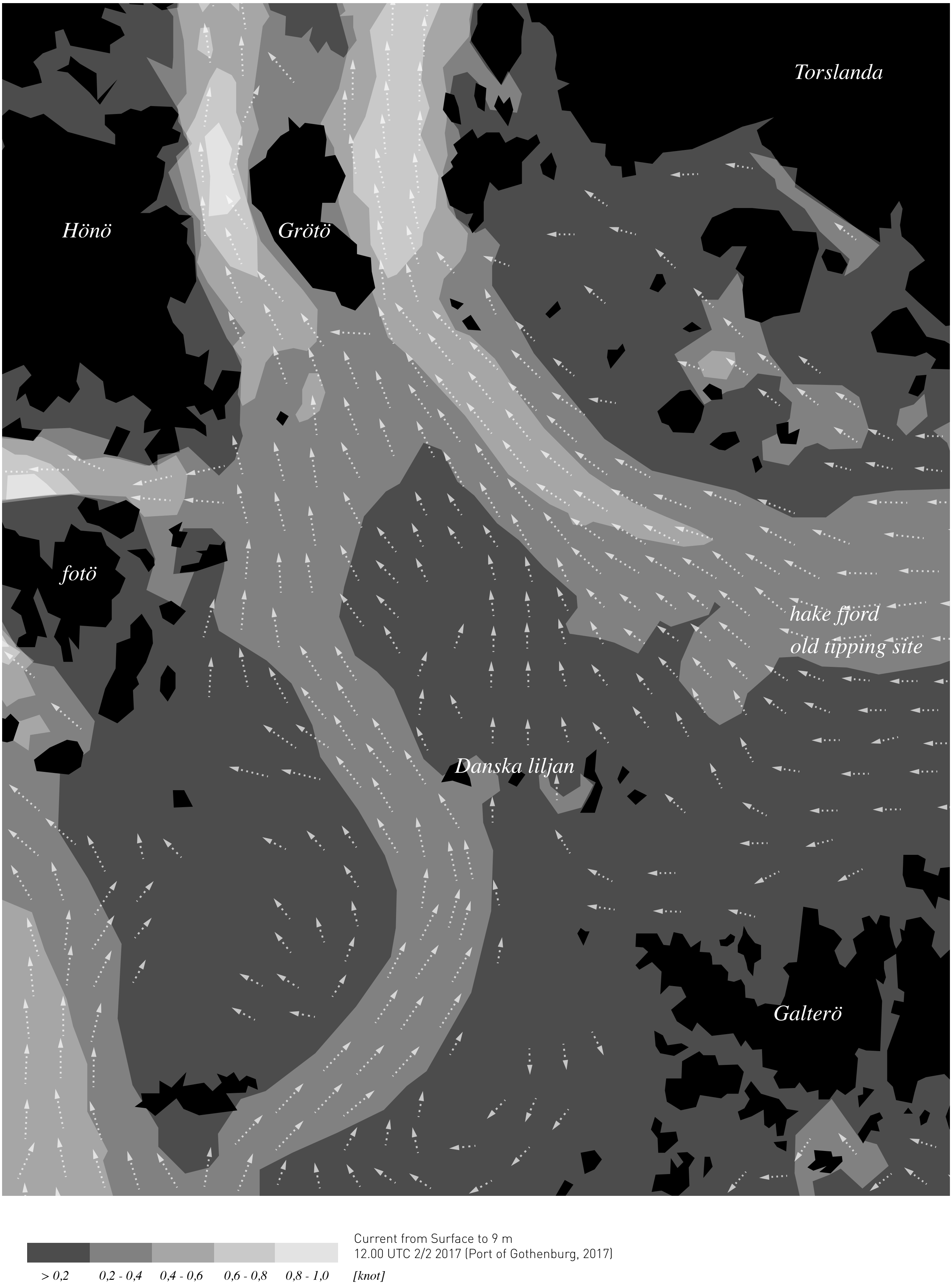
By investigating what it would require to make the Gothenburg Archipelago autonomous on wave power, the technology of the point absorbing linear generator (see p 30) tested by Seabased in Lysekil is chosen since it is the most tested technology on the Swedish coast.

The technical infrastructure however require more objects than the generator; sub sea cables, transformer stations, the grid in itself and a local substation that transforms the electricity to the right voltage for the households.

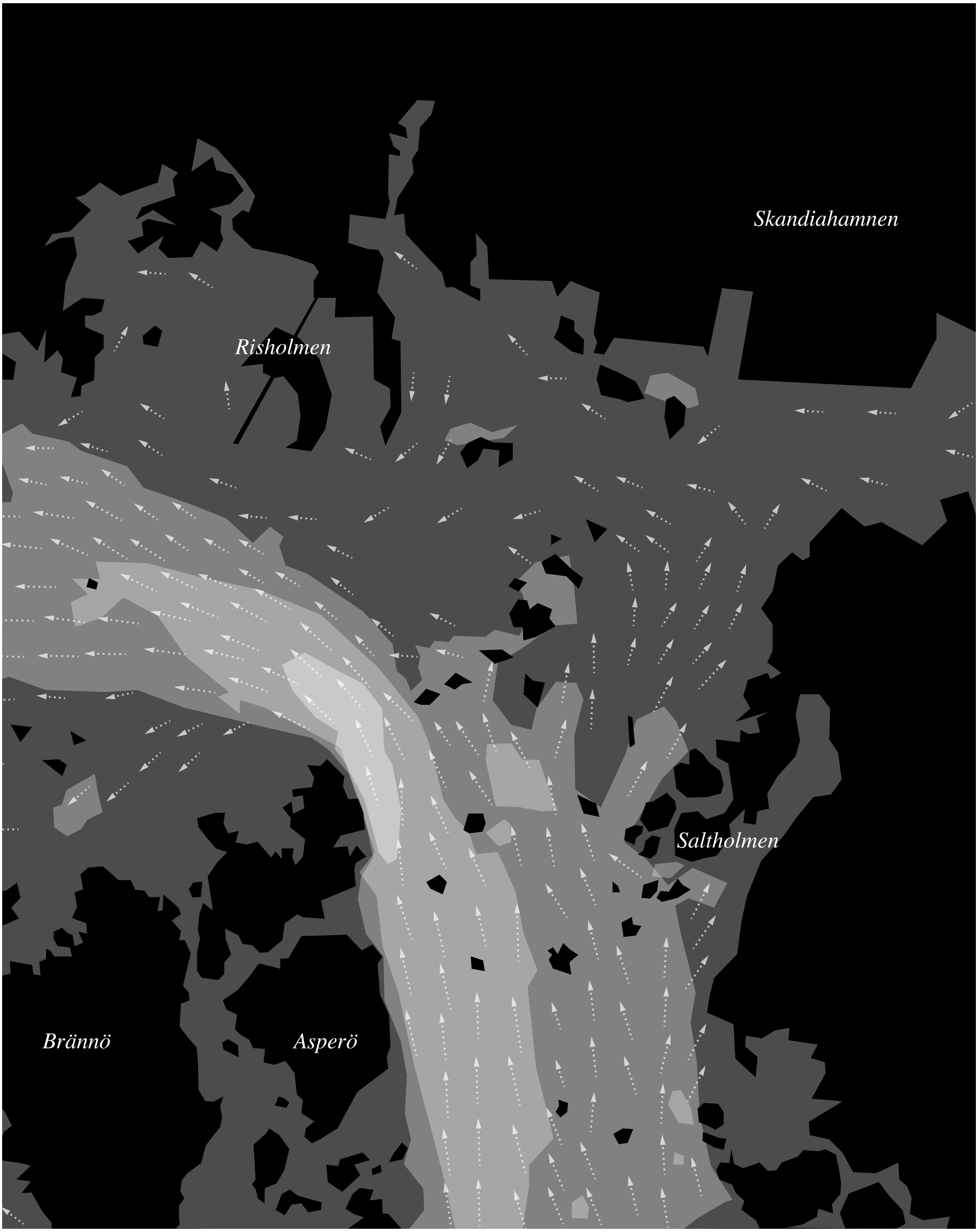
For complete autonomy with a weather dependent electricity source, electrical storage is needed. If a battery system is used, the batteries can be placed centrally or locally, close to the transformation or close to the end users depending on the size of the electrical production and the users.

The landscape has always been used by people for production. Marked with signs that contrasts with nature. It is only lately we have seen the landscape as something merely for recreation.

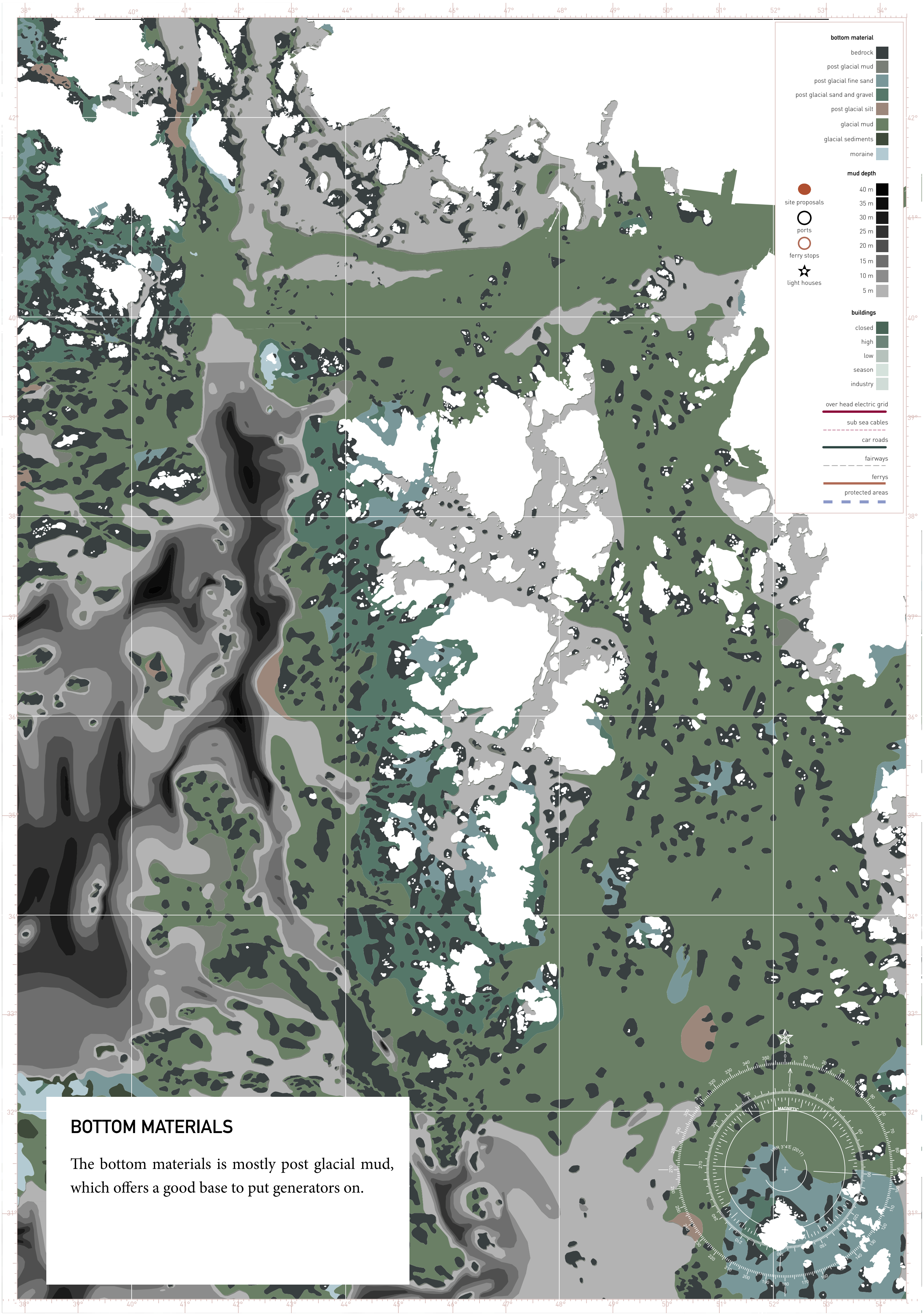
CURRENTS



Current from Surface to 9 m
12.00 UTC 2/2 2017 (Port of Gothenburg, 2017)

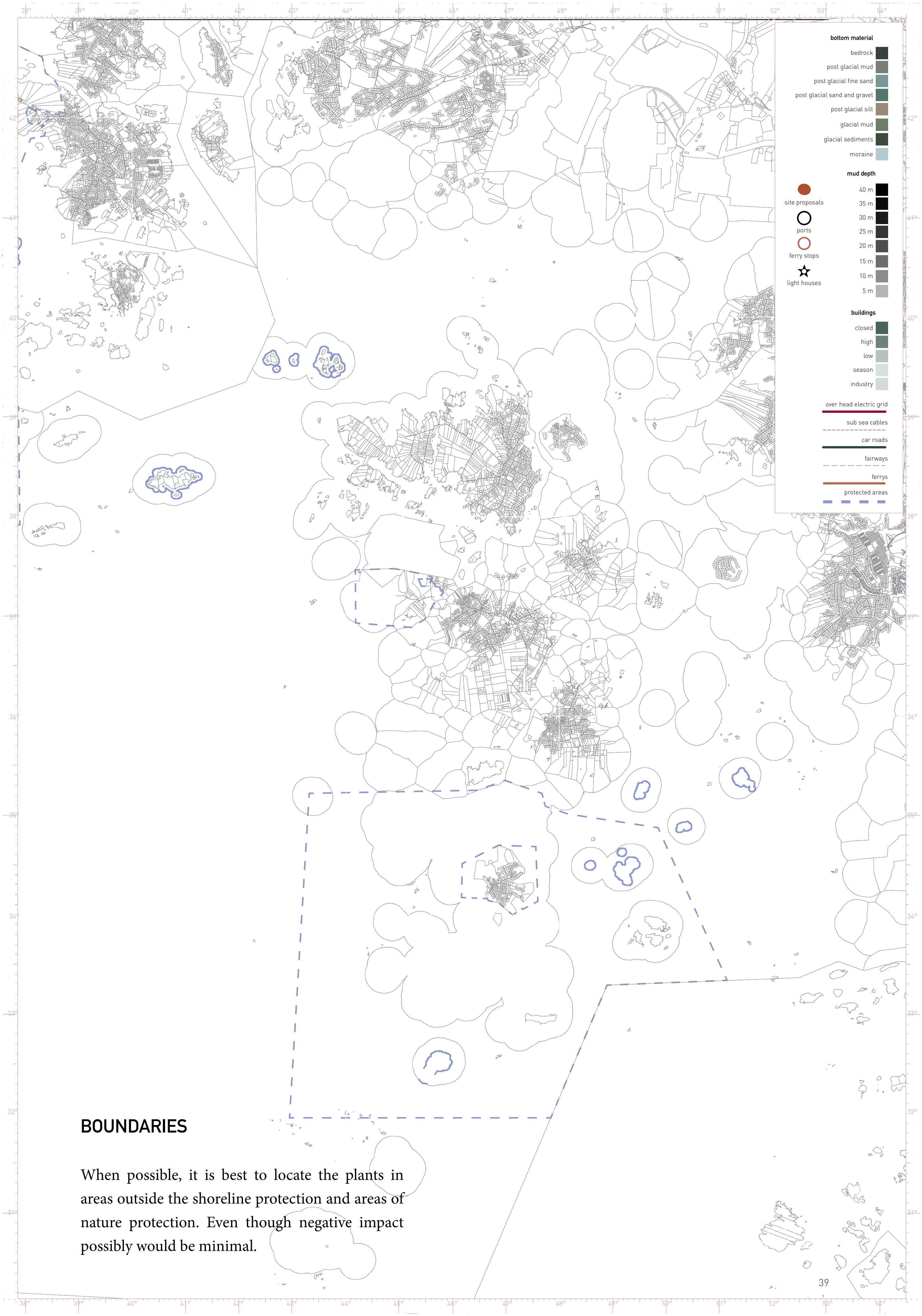

Skandiahamnen
Risholmen
Saltholmen
Brännö
Asperö

3. LANDSCAPE AND MACHINE



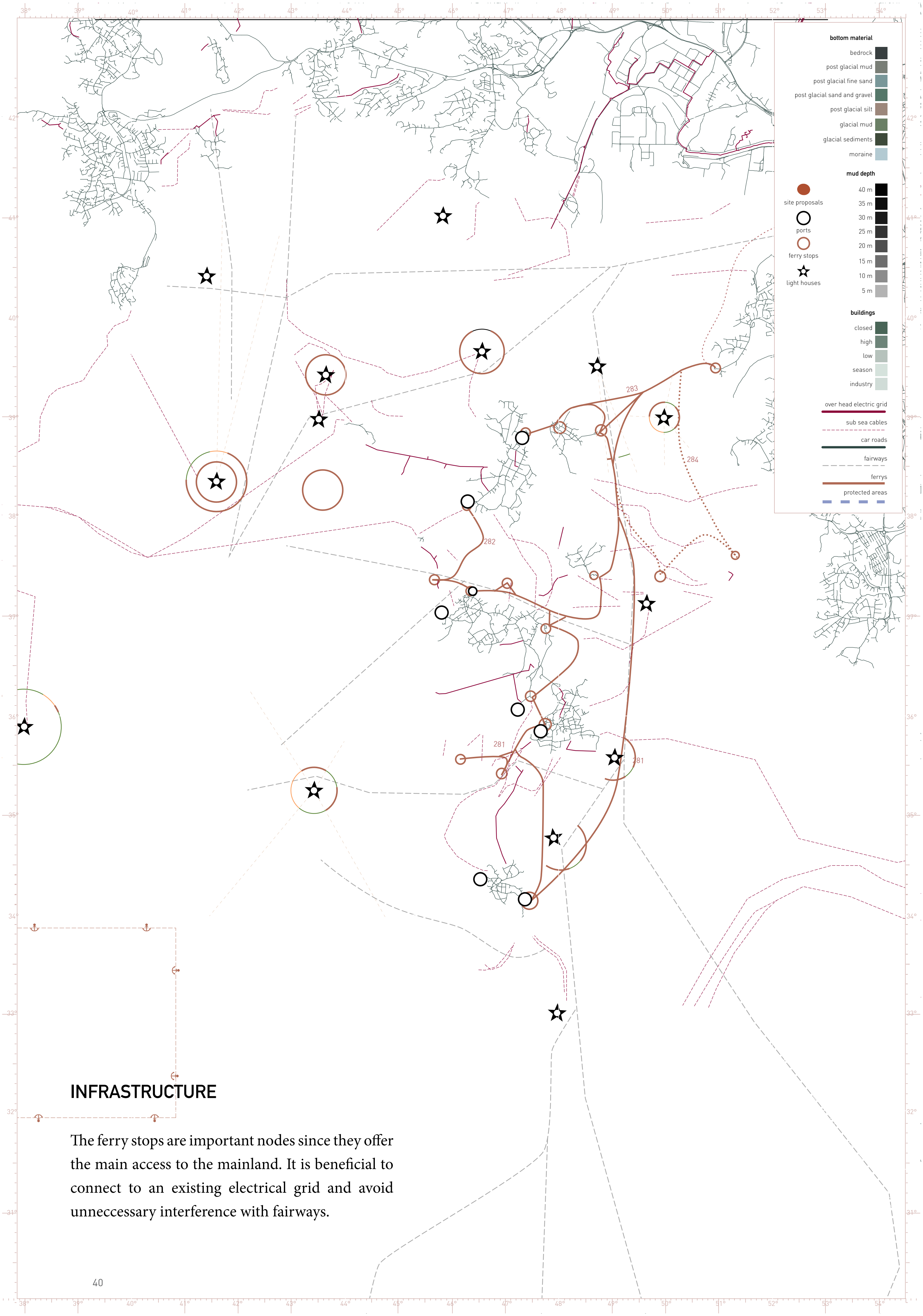
BOTTOM MATERIALS

The bottom materials is mostly post glacial mud, which offers a good base to put generators on.



BOUNDARIES

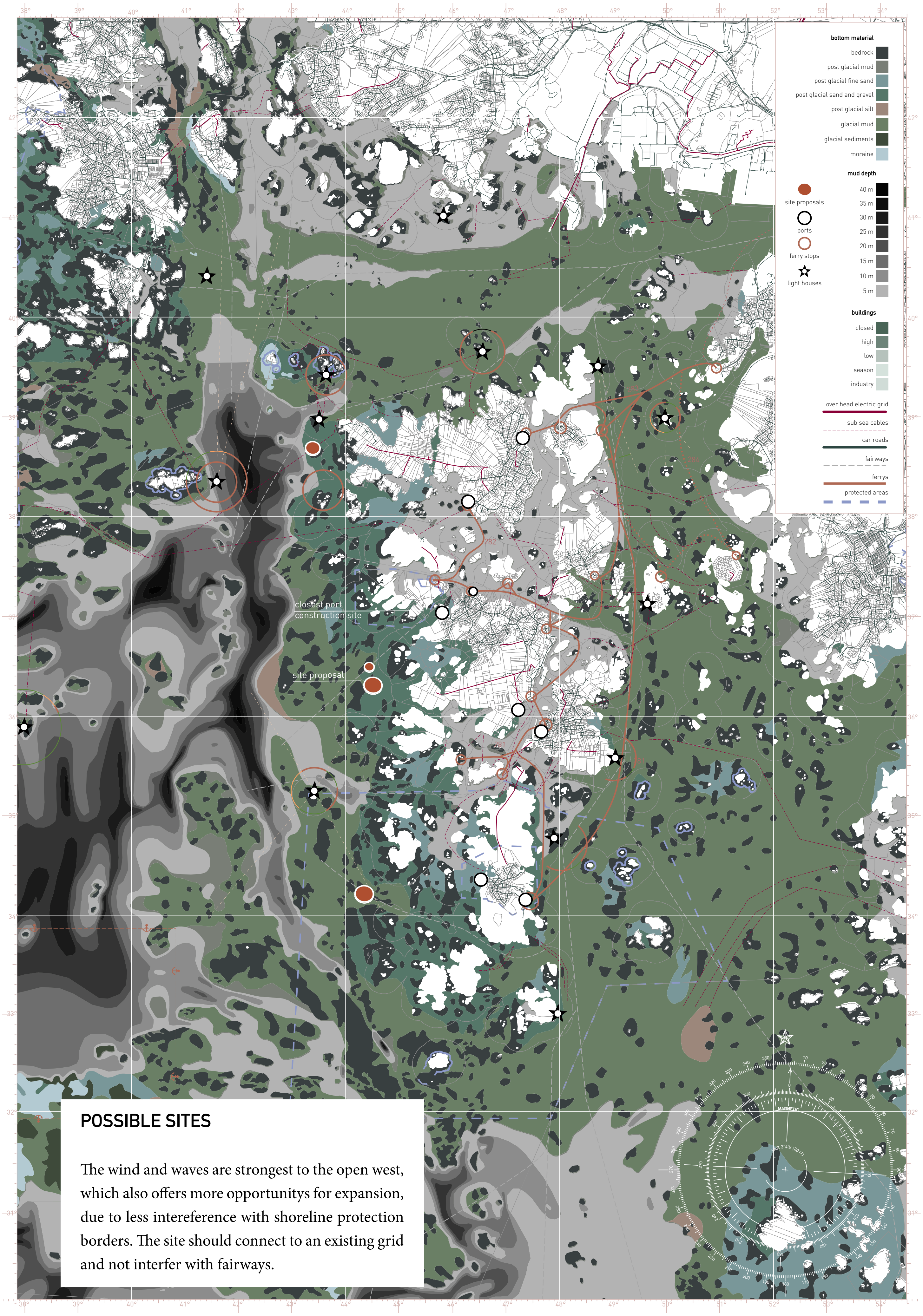
When possible, it is best to locate the plants in areas outside the shoreline protection and areas of nature protection. Even though negative impact possibly would be minimal.



INFRASTRUCTURE

The ferry stops are important nodes since they offer the main access to the mainland. It is beneficial to connect to an existing electrical grid and avoid unneccessary interference with fairways.

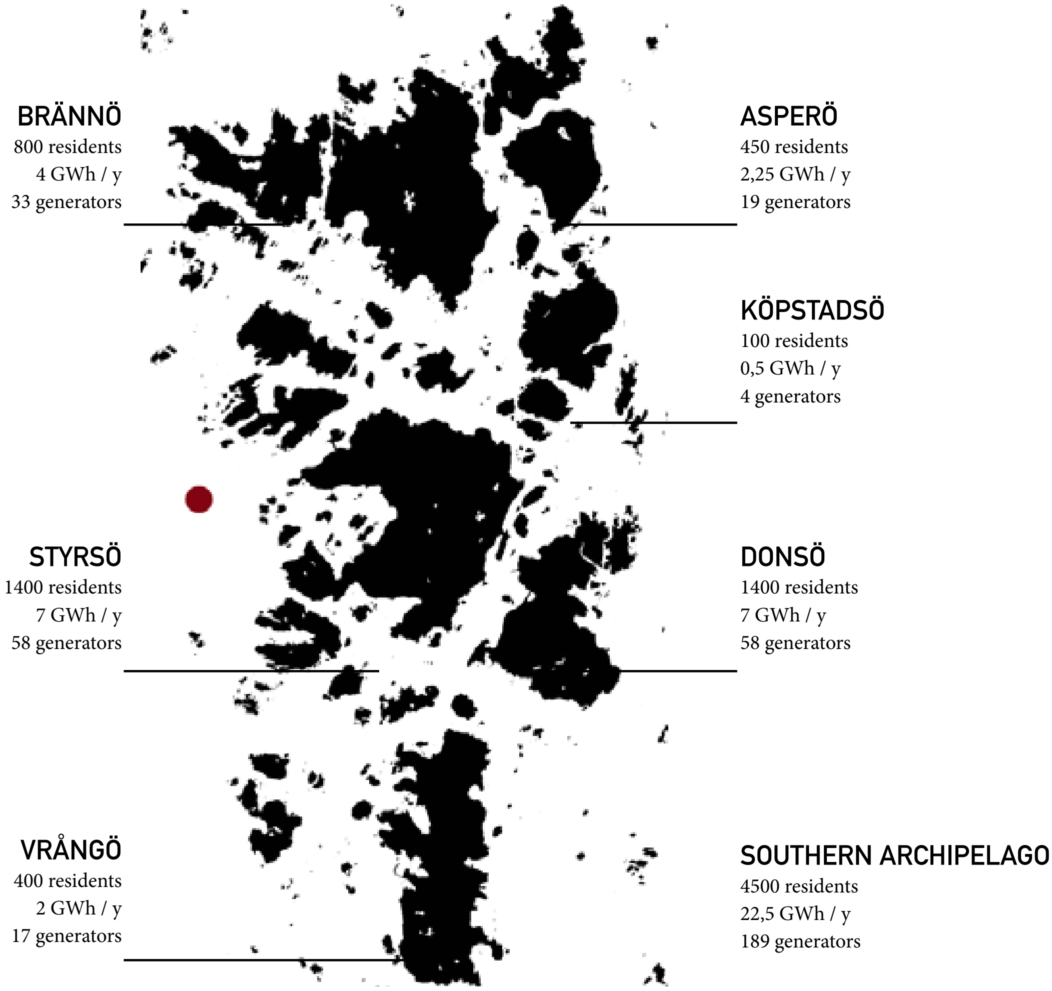
3. LANDSCAPE AND MACHINE



POSSIBLE SITES

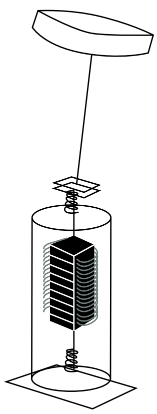
The wind and waves are strongest to the open west, which also offers more opportunitys for expansion, due to less intereference with shoreline protection borders. The site should connect to an existing grid and not interfer with fairways.

DIMENSIONING



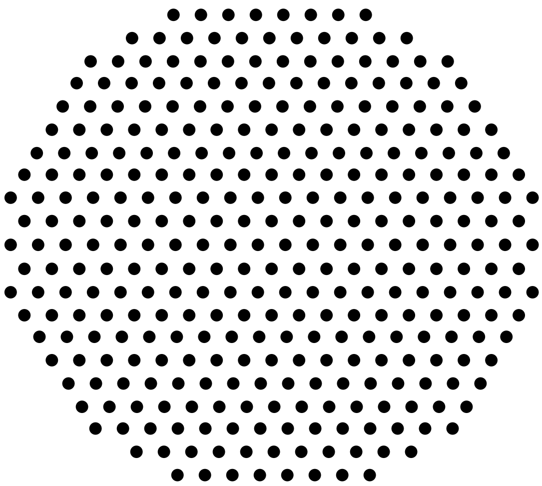
1 AVERAGE SWEDISH VILLA

5 MWh electricity / year

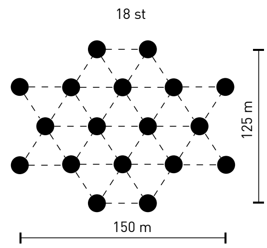


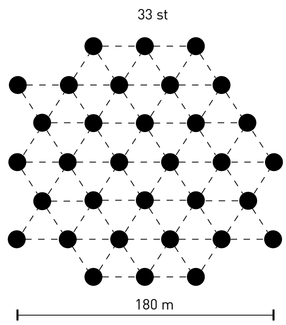
1 GENERATOR

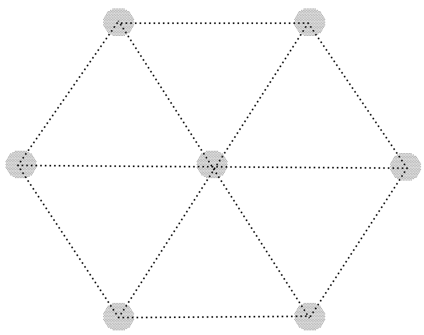
30 kW
~ 4000 full load hours
-> 0,12 GWh / year

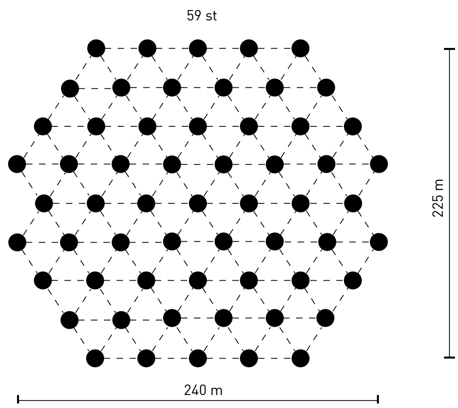


Array of 379 buoys, distance 30 m, diameter 600 m







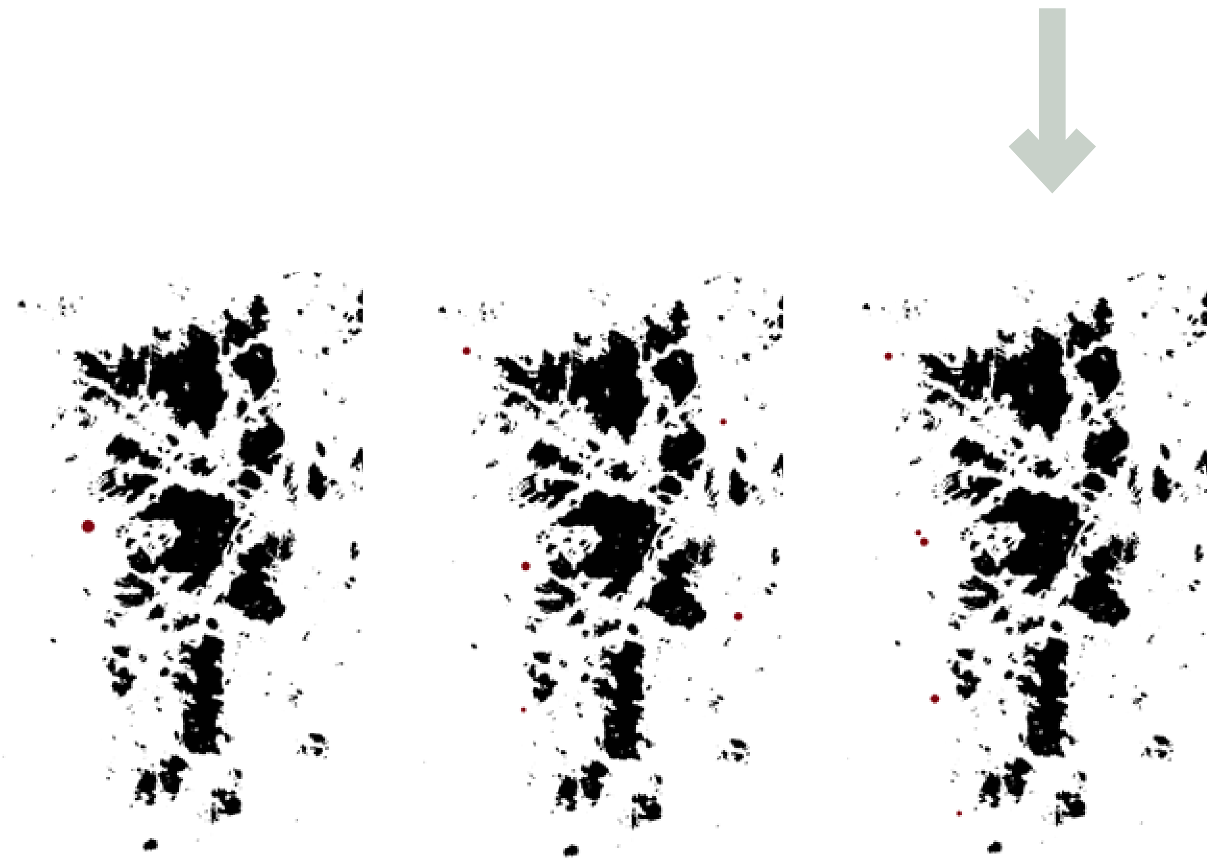


AREA REQUIREMENTS

After the buoys absorb the wave energy it takes around 30 m for the waves to retain the power. Depending on the wave direction the arrays can be arranged differently. The hexagonal array absorb the waves from all directions as efficiently. (Bernhoff, Sjöstedt & Leijon, 2006)

Calculating that each generator have the capacity of 30 kWh gives a total of 189 generator for the Gothenburg Archipelago, considering the avarege household use of electricity in Sweden.

DISTRIBUTION



SCENARIOS

1 - "CENTRAL"

One cluster of 200 generators located outside Styrsö, 400 meter in diameter. Provides electricity for the entire Southern Archipelago.

+ lower maintenance costs.
+ depth and powerful waves.
+/- one large restricted area
- vulnerable to changes.

2 - "CLOSE"

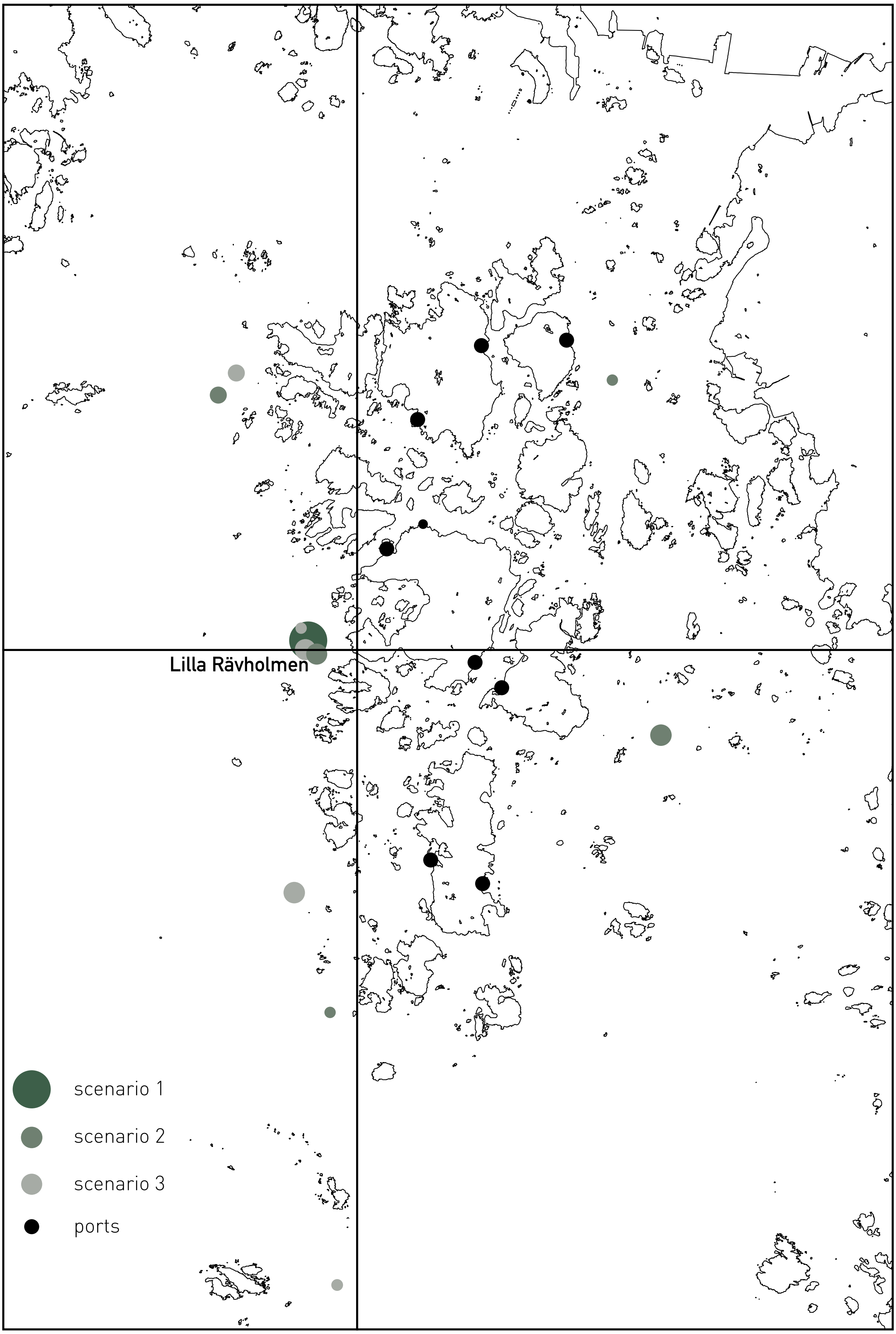
One cluster of generators to each island, located as close to the island as possible. Would not be the most efficient use of waves, since it includes more sheltered areas.

+ sense of ownership
+/- many small restricted areas
- less wave power
- higher maintenance costs

3 - "WEST"

One cluster of generators to each island. Located to the strong waves in west. Optimal use of waves and smaller restricted area.

+ sense of ownership
+ good use of waves
+/- many small restricted areas
- higher maintenance costs

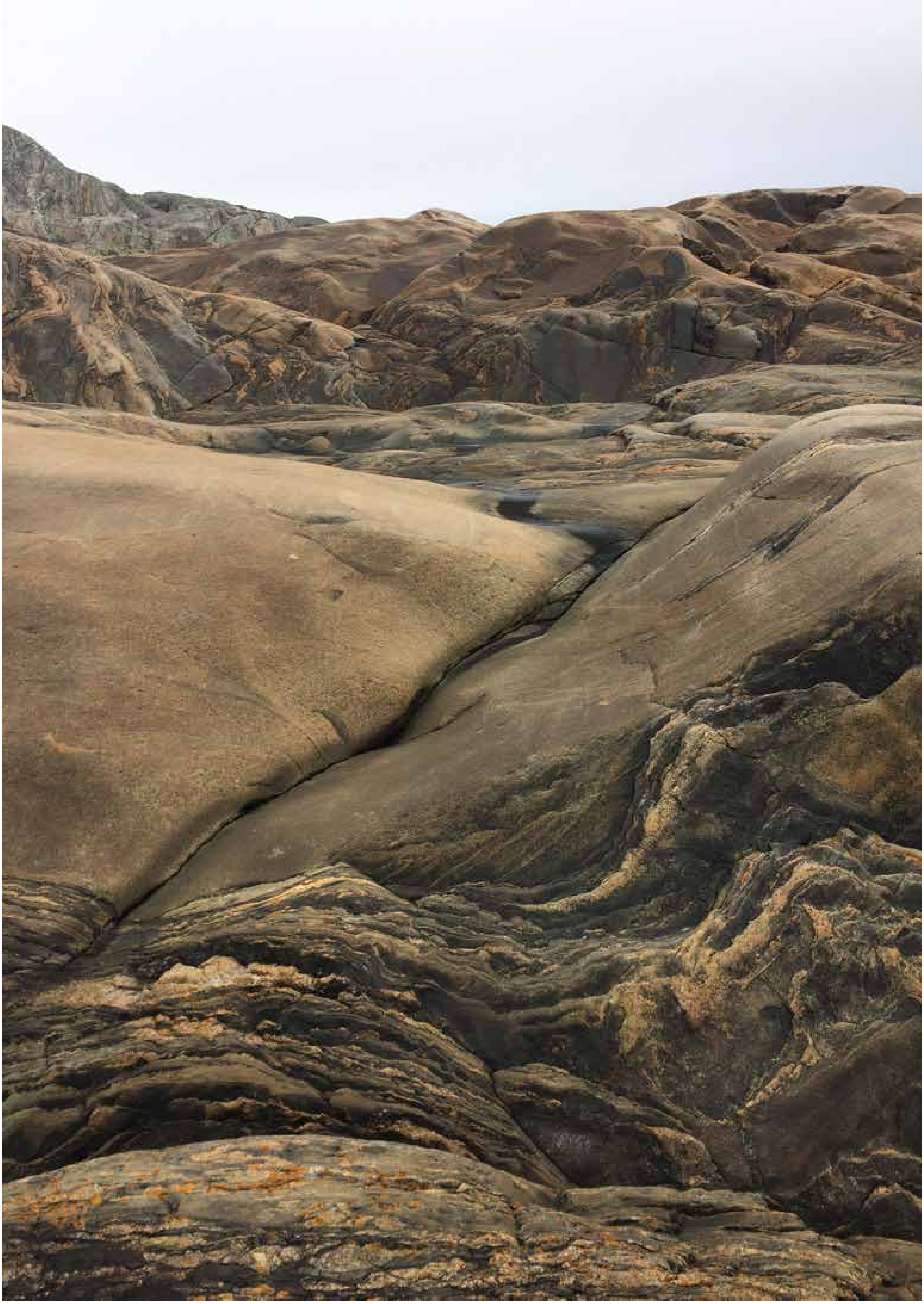

Lilla Rävholmen
scenario 1
scenario 2
scenario 3
ports

SITE

LILLA RÄVHOLMEN

Lilla Rävholmen is a small peninsula on the West of the main island Styrsö in the Southern Archipelago. It was once owned by the military, and is still used for exercises some parts of the year, the rest of the time it is available for leisure. There are remnants of old concrete foundations and a small port reside on the sheltered north west side. It opens to the sea to the windy west where the cargo ships lay anchored waiting to port.

There are remnants of an old overhead power line to the main island of Styrsö - connecting it to the grid. It is a fitting expansion to a technical islet - the base for the infrastructure is already there.



Färg !?

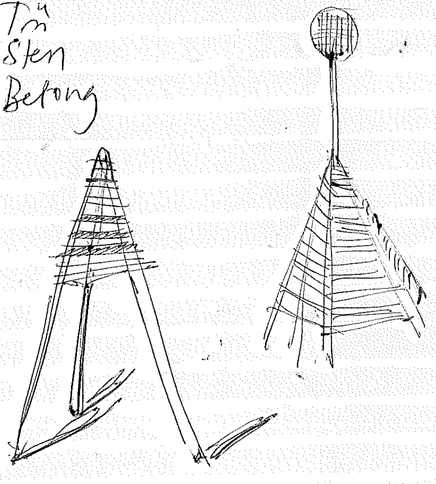
– samma utformning?

Ljus !?

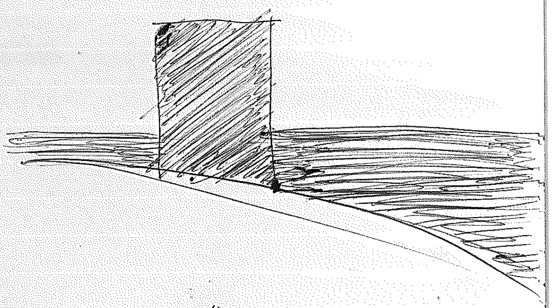
Sjömärken: Kontrastfärger symboler.

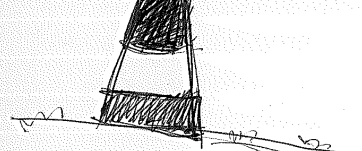
Konstruktion.

Trä
Sten
Betong

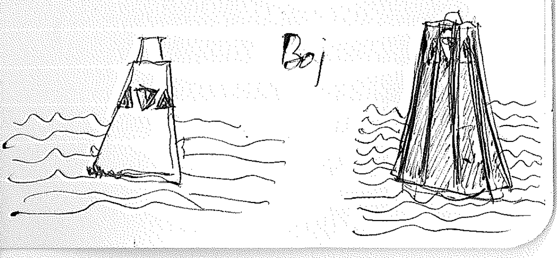


Stångmärke





Kummel



Boj

4.

LANDMARK

ARCHITECTURAL REFERENCES

THERMAL PLANT MONUMENTALISM: AN INDIAN NUCLEAR STATION AND BATTERSEA POWER STATION, LONDON.

ELECTRICITY AND ARCHITECTURE

There are different approaches on the architecture of power stations and electrical substations are differently approached. They are rarely meant to be used by the public, only for those with specific access, rarely to be experienced but rather engineered for its specific purpose. However, in the early age of electricity, designing the facade of a power station could be a prestigious work for an architect.

The power stations are often monolithic closed buildings, with the chimneys and cooling towers reaching for the sky. The big thermal power plants, have both now and historically taken monumental shapes, either if they stand in the natural landscape or in an industrial landscape. In cities, the most common electrical architecture are the transformer stations, often a small closed building, sometimes designed. In both cases they are often surrounded by a fence.

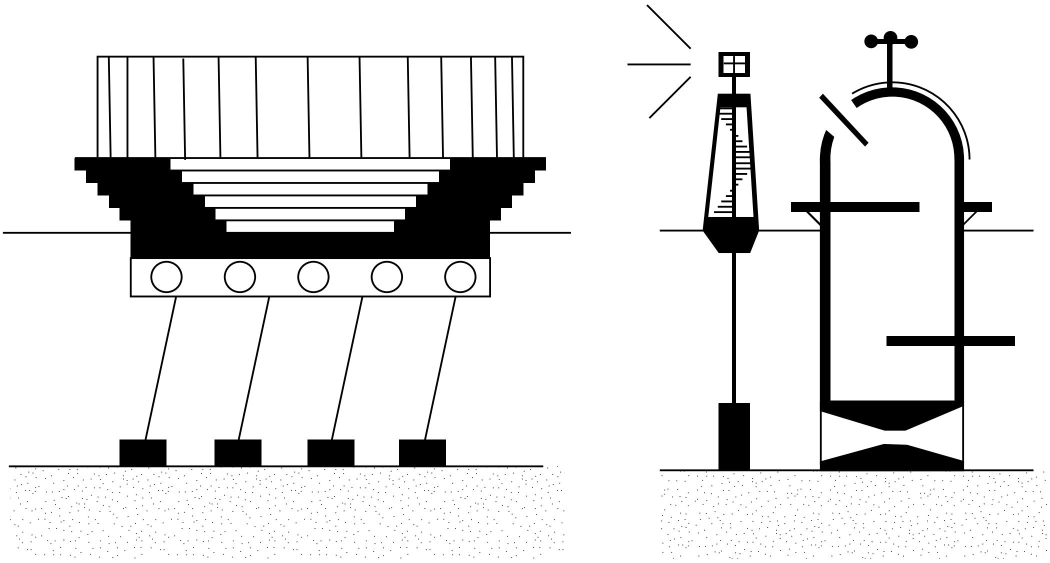
TOYO ITO. (1986). *TOWER OF WINDS*, YOKOHAMA

BARBER AND OSGERBY. (2016). INSTALLATION: *FORECAST*. LONDON BIENNALE

VISUALIZING ELECTRICITY

There are some examples of artists and architects working with symbolising electricity. The tower of wind by Toyo Ito (1986) lights up as the wind blows through it. The installation of Barber and Osgerby is not producing electricity, but instead movement. It evokes fascination and recognition - what is more typical London than wind and rain?

PROGRAM



EARLY SKETCHES AND IDEAS OF RELATION TO SHORE AND FUNCTION

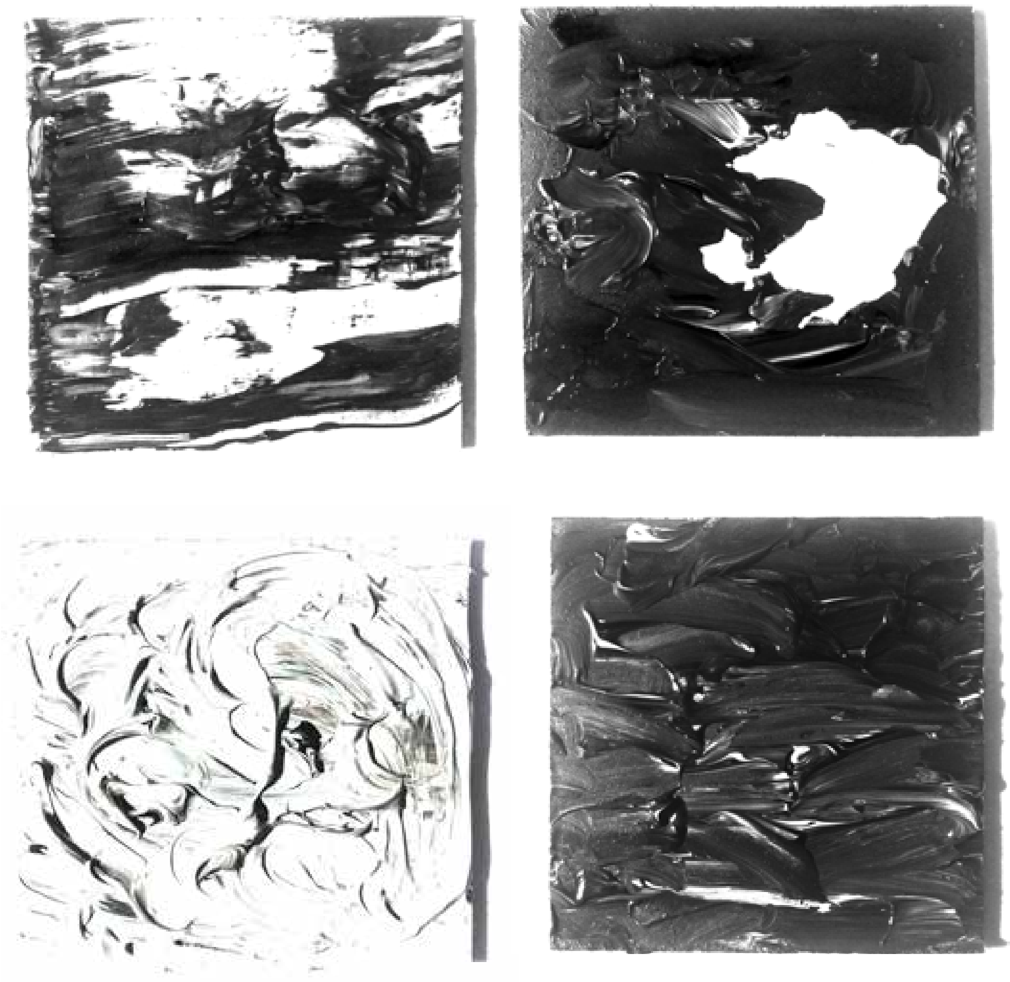
DESIGN PROBLEMS

a floating structure
experiencing the sea, both underwater and over water
experiencing the electrical light or buzz
accessibility
connection to the grid.
few moving part
visible mechanics
plausibility
storms
organic growth

POSSIBLE (MULTI-) PROGRAMMING

orientation tower
observation tower
watch tower
shooting tower
sea mark
sauna
desalination
electricity generation
electricity transformation
control station/office
diving tower
fountain
wind protection
light house
anchor point
information

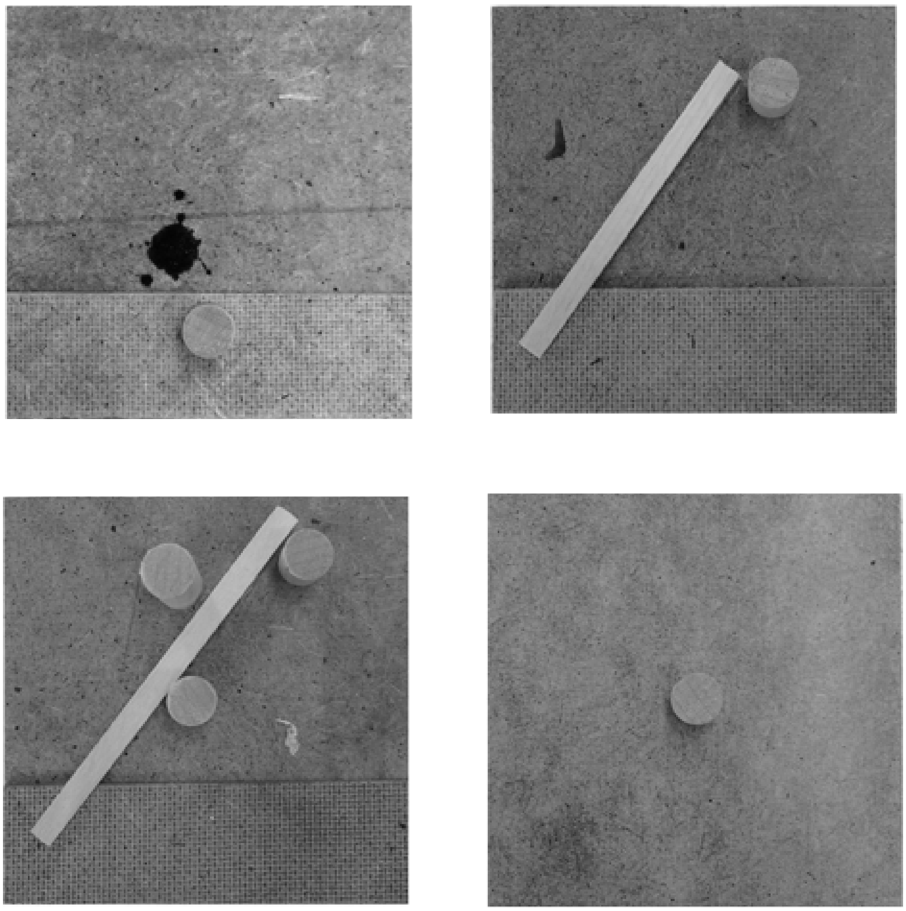
INVESTIGATIONS



WATER

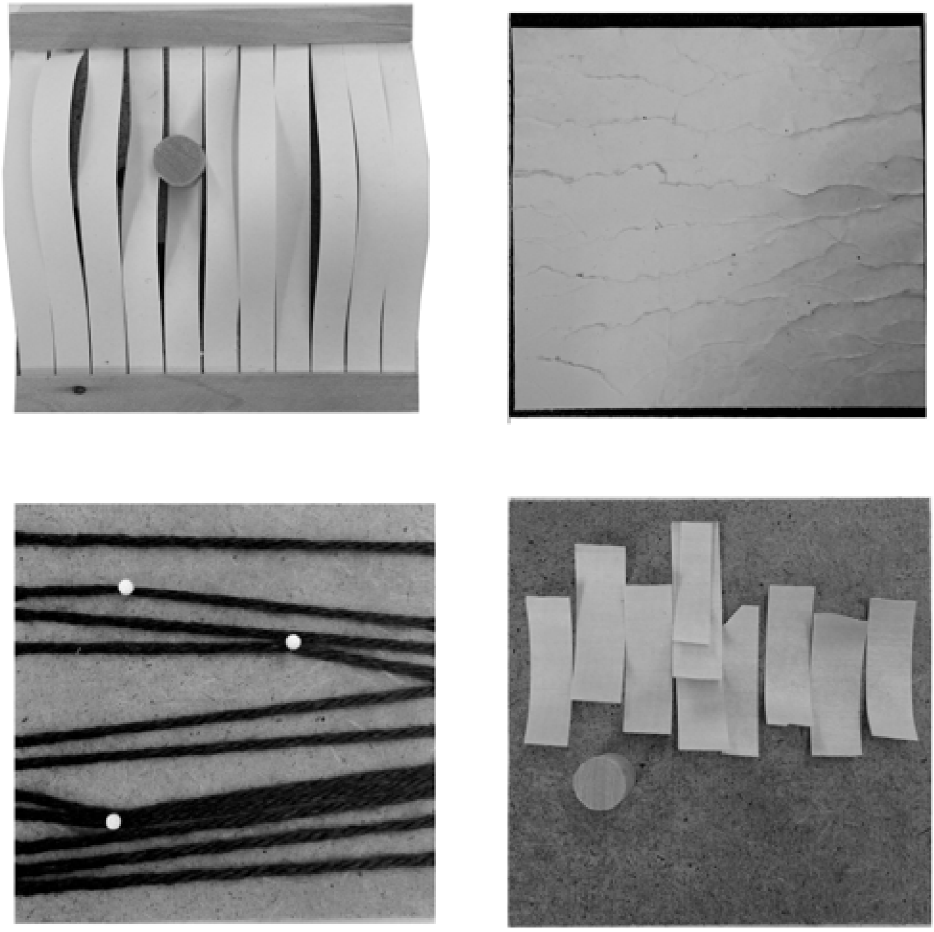
How is constant flux experienced?

MODELS



ACCESSIBILITY

Is it reached with or without boat?

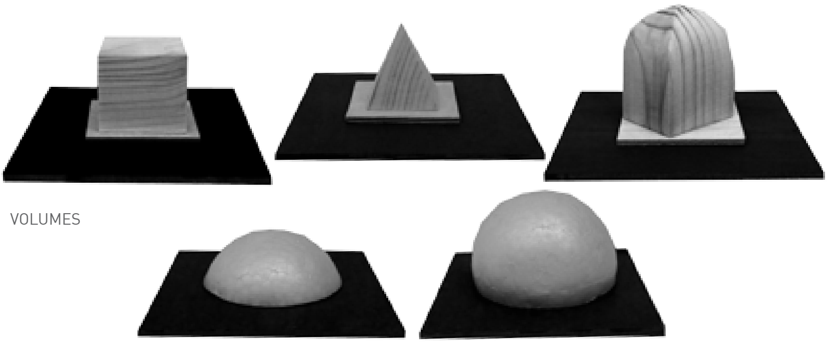


FORCES

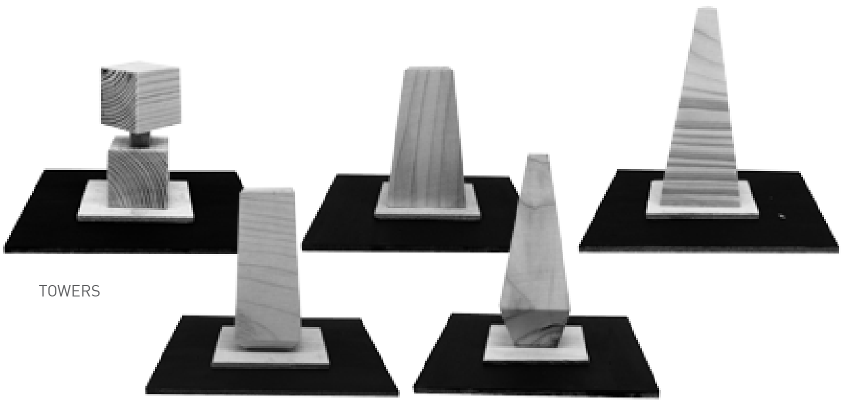
How does the structure affect the sea?

How does the sea affect the structure?

MODELS



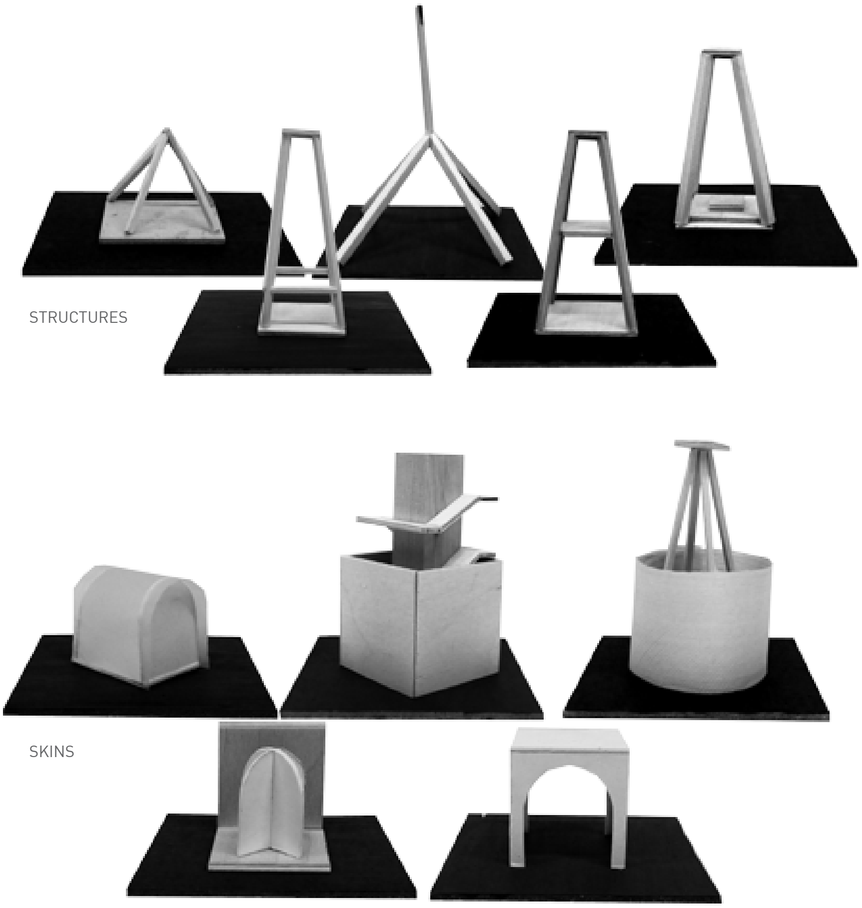
VOLUMES



TOWERS

What is seen above the water surface?

How far?

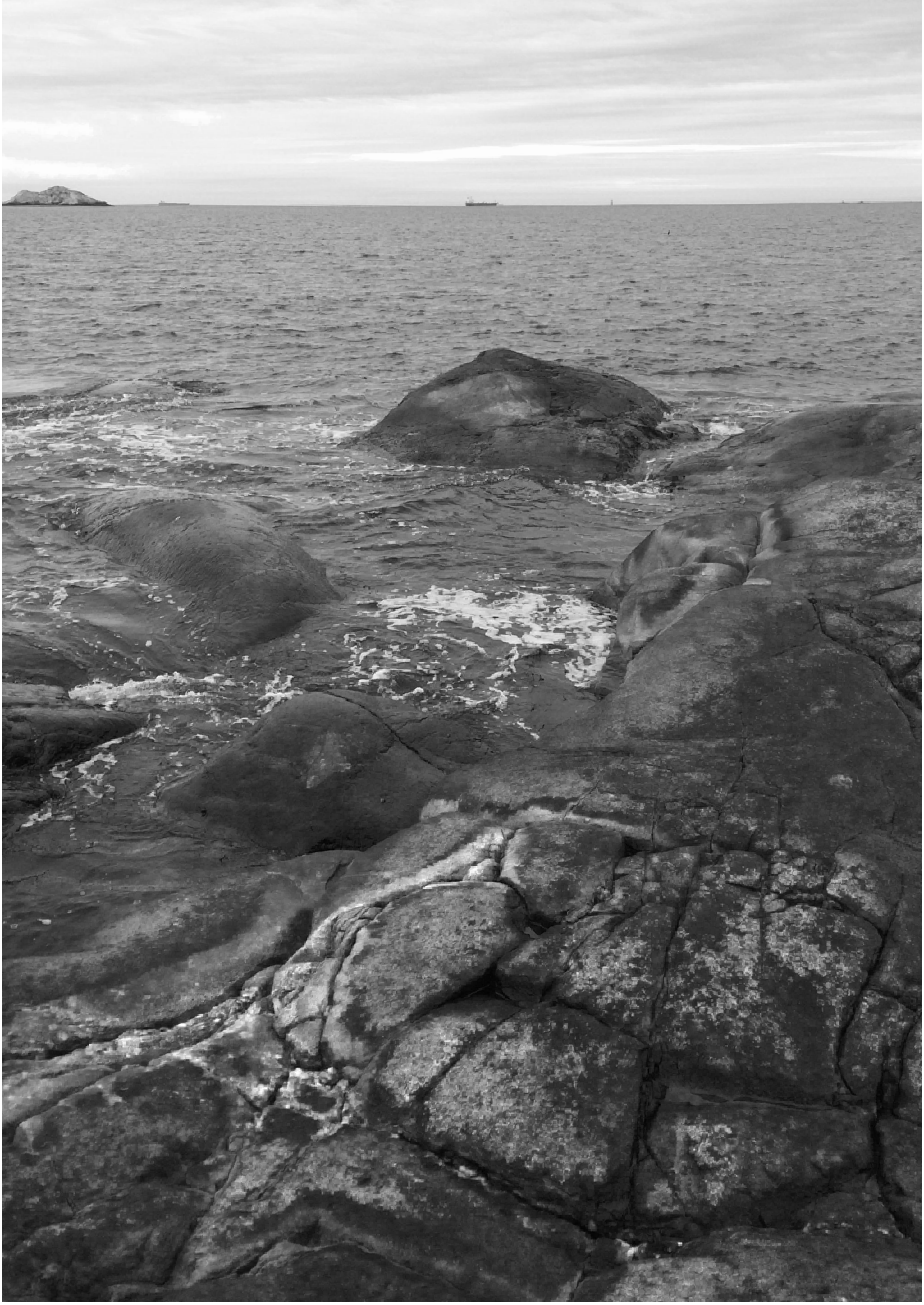


Which spatial experience exist inside?

ATMOSPHERICAL SKETCHES

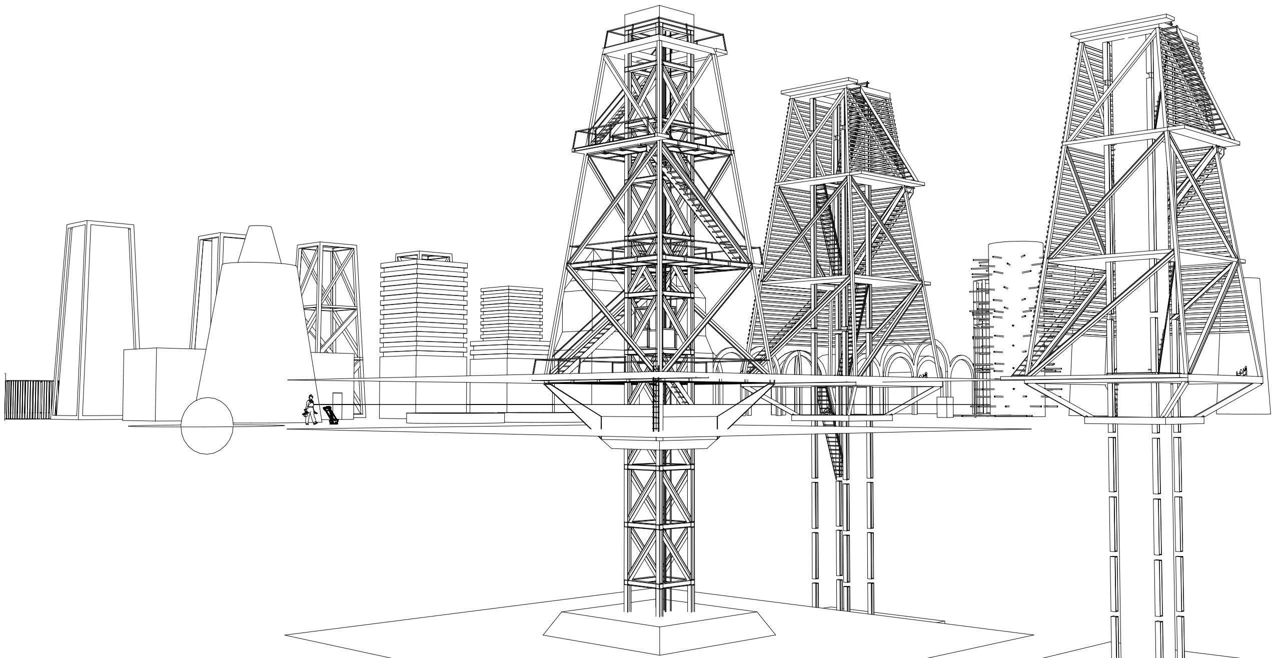
What do you see at the horizon?

How do you recognize electricity?



5.

THE OBSERVATION TOWER



CONCEPT

THE OBSERVATION TOWER

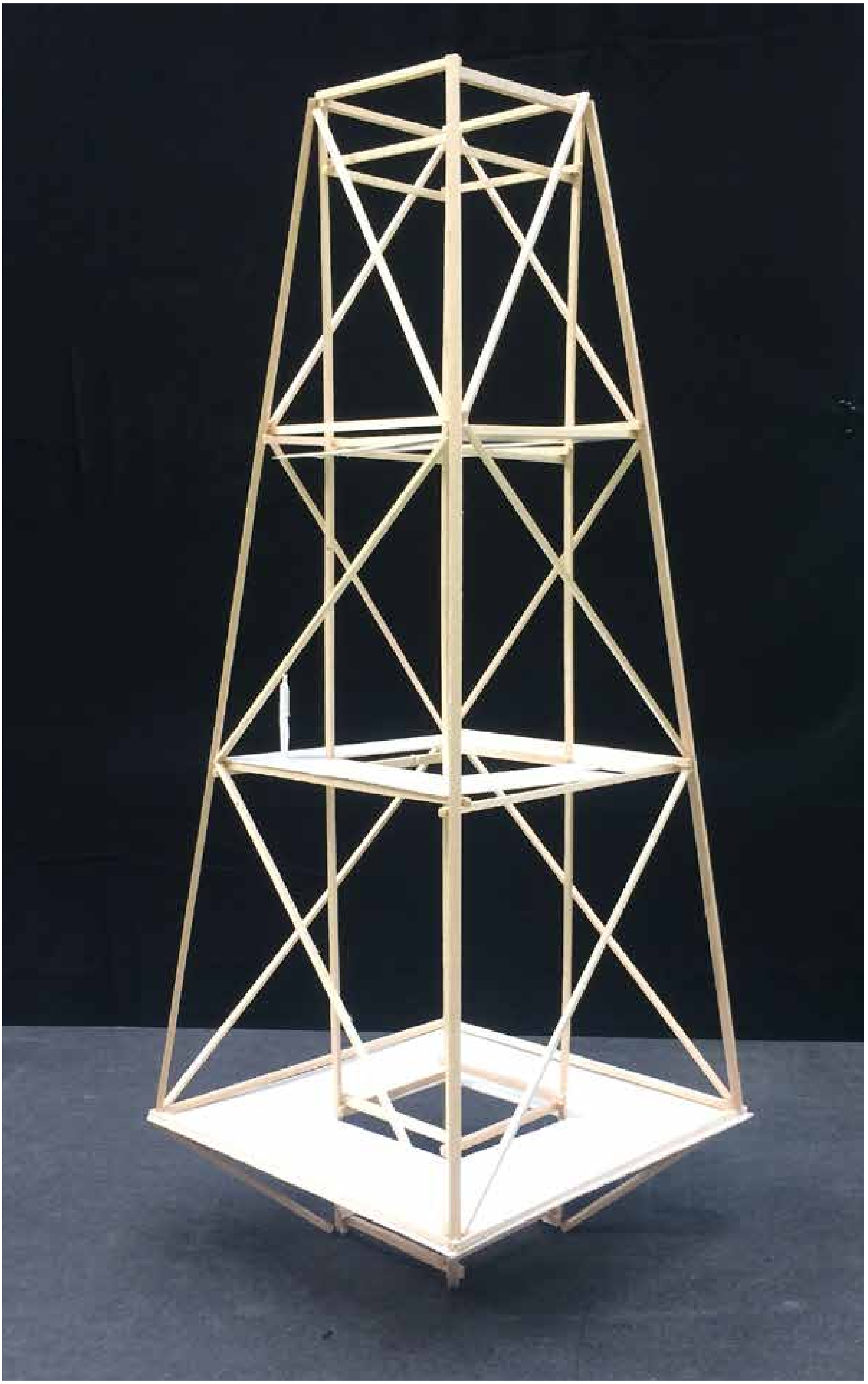
As exhibited at Chalmers University of Technology on the 1st of June 2017, the final part of this master thesis is the observation tower.

It is a structure in the borderline between infrastructure and object. As the waves move and the buoys produce electricity, the observation tower stands in the middle, in the water, also producing electricity with the same technology.

As electricity produces the observation tower lights up. The inhabitants on the islands see from the shore, and the cargoships from sea, when electricity is produced and not.

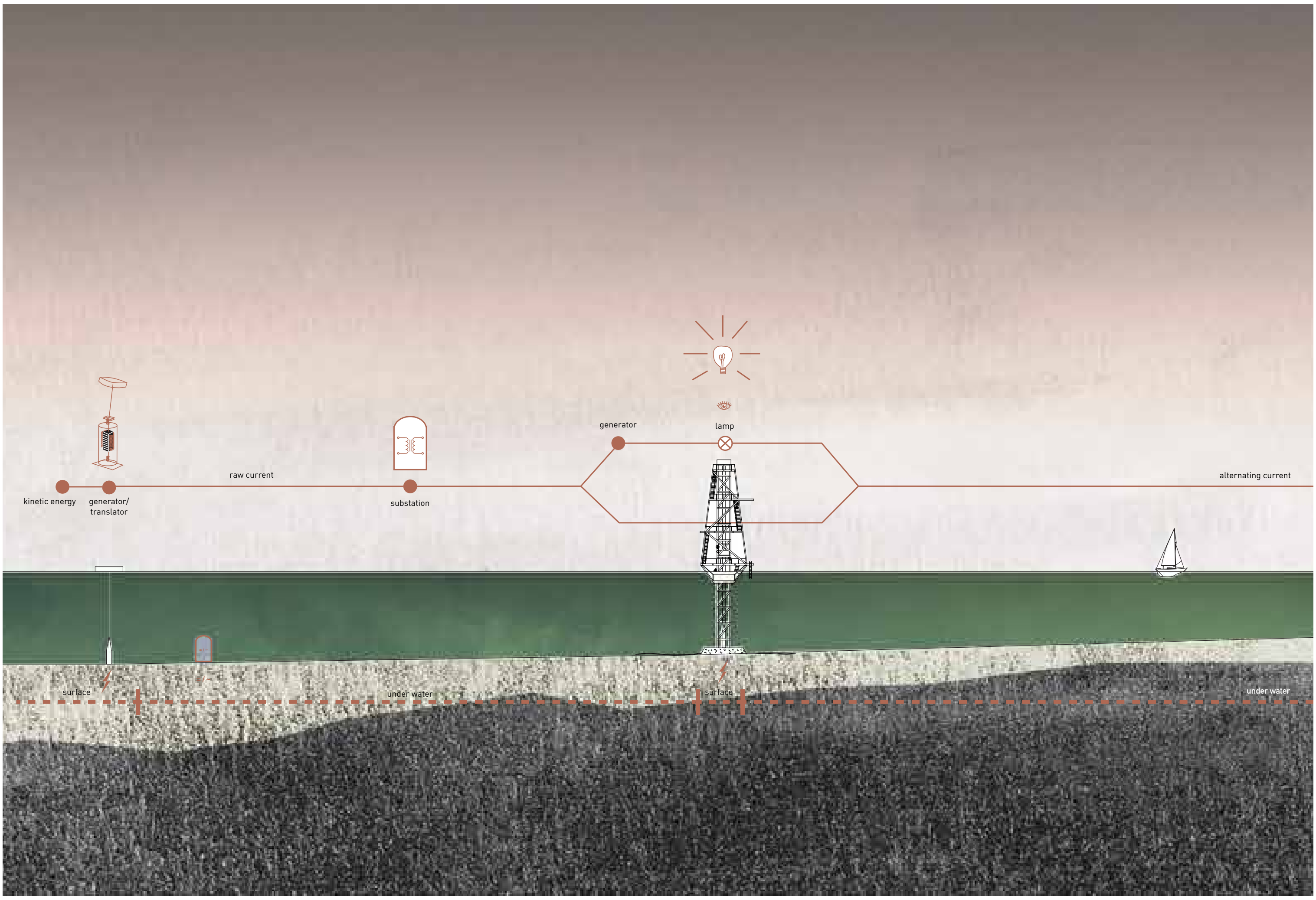
The rest of the time the tower is a visiting point. An adventure which the visitor can choose to explore. In the summer it can be used as a jumping tower.

It is an island among other islands. But also a machine out of red structural steel and wood.

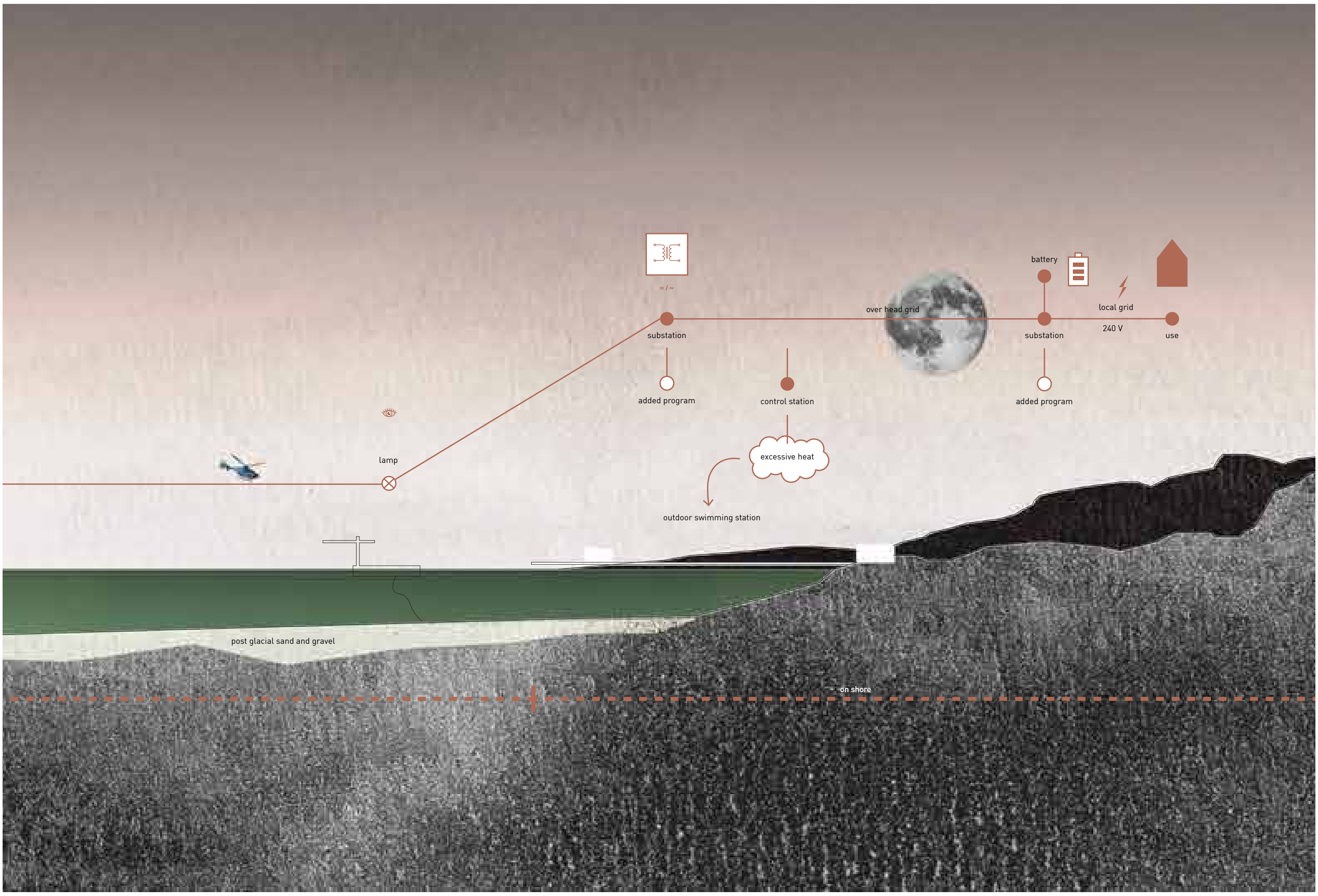


SKETCH MODEL OF THE STRUCTURE

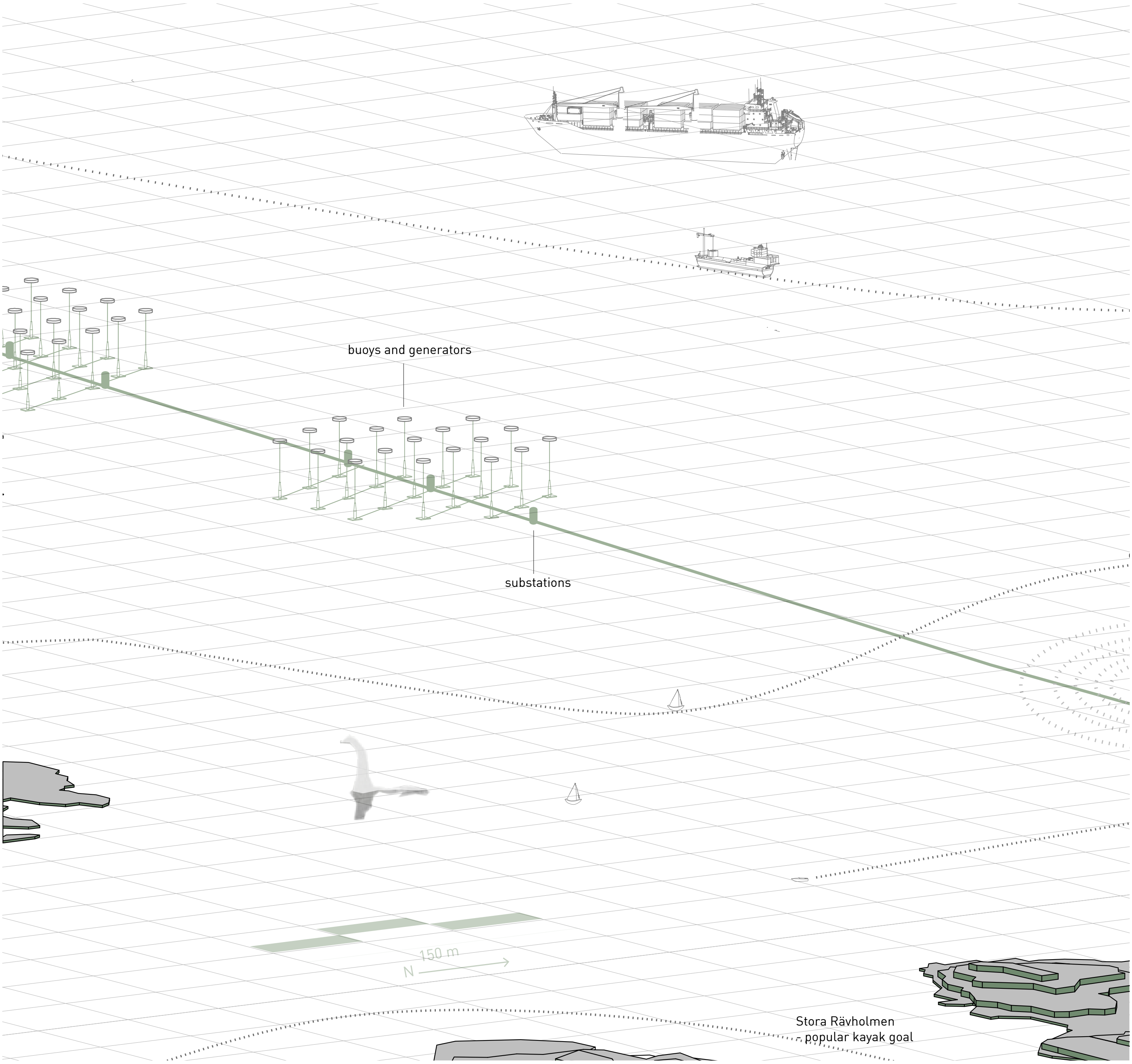
LONG SECTION



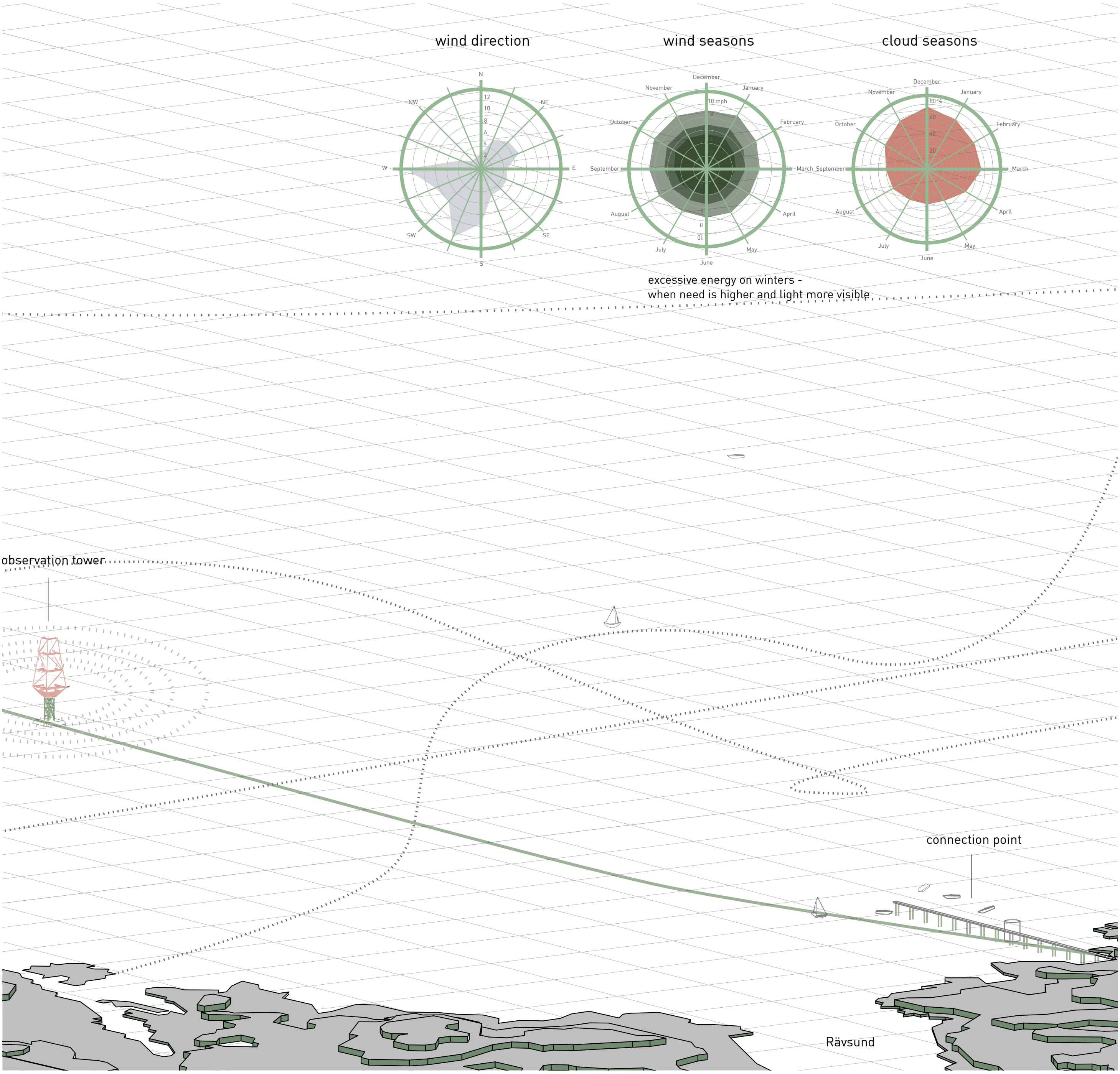
5. THE OBSERVATION TOWER



AXONOMETRY

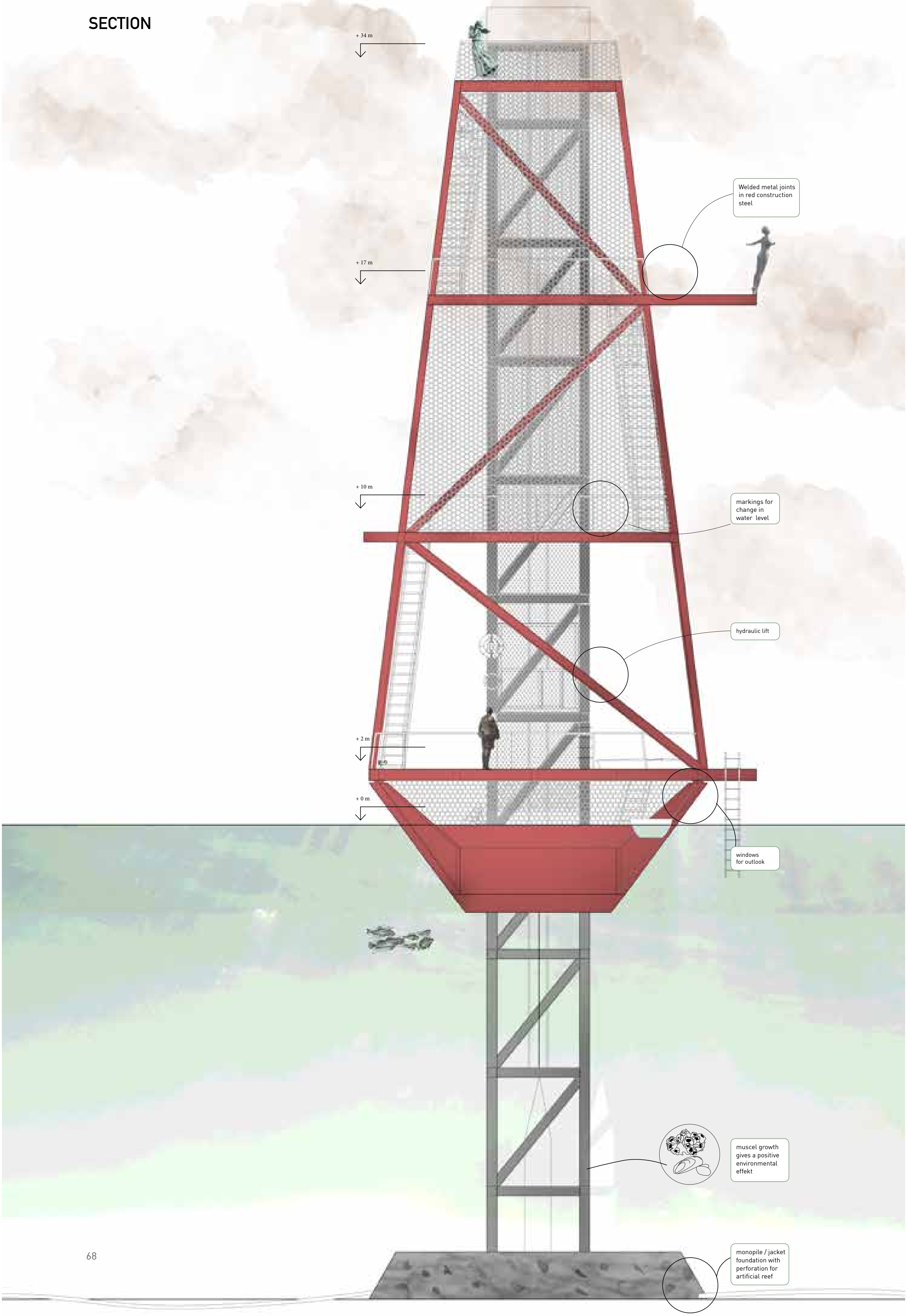

buoys and generators
substations
150 m
N
Stora Rävholmen
- popular kayak goal

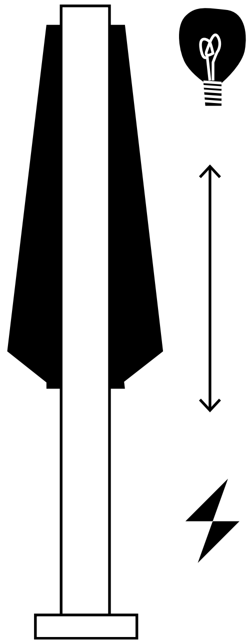
5. THE OBSERVATION TOWER

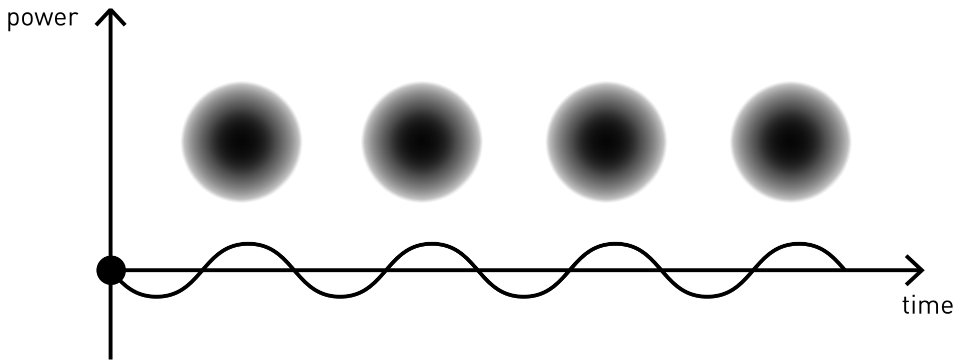


5. THE OBSERVATION TOWER

SECTION



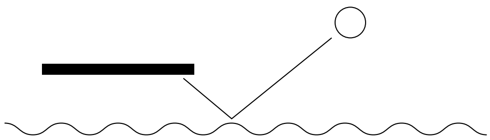




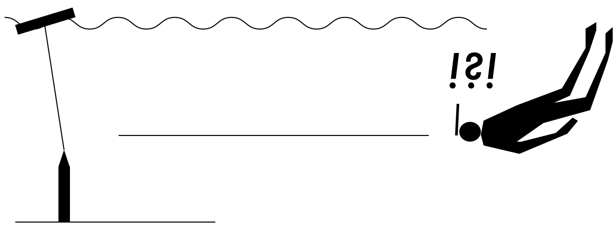
PULSATING LIGHT

Connecting the infrastructure at sea and the use at land the observation tower becomes a landmark that produces a pulsating light as the generators are producing electricity.

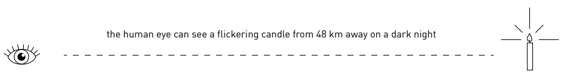
EXPERIENCE



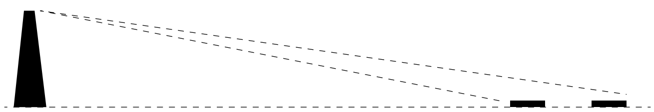
Sun reflections

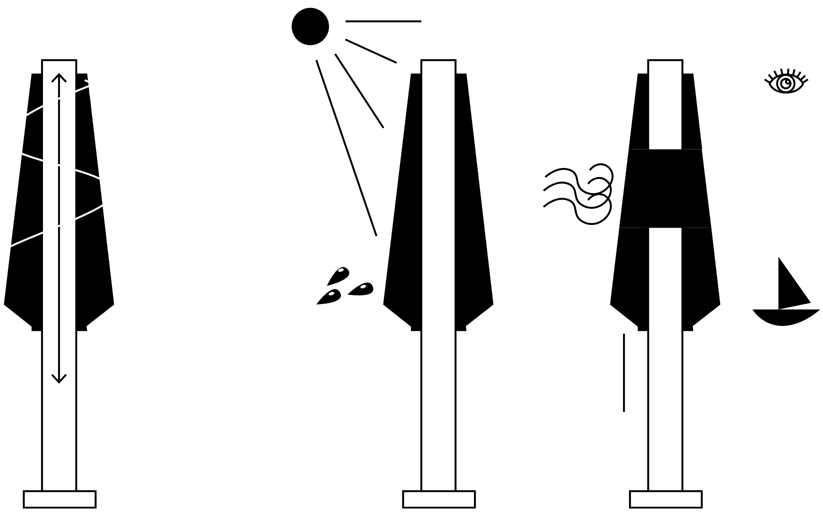


Under water experience



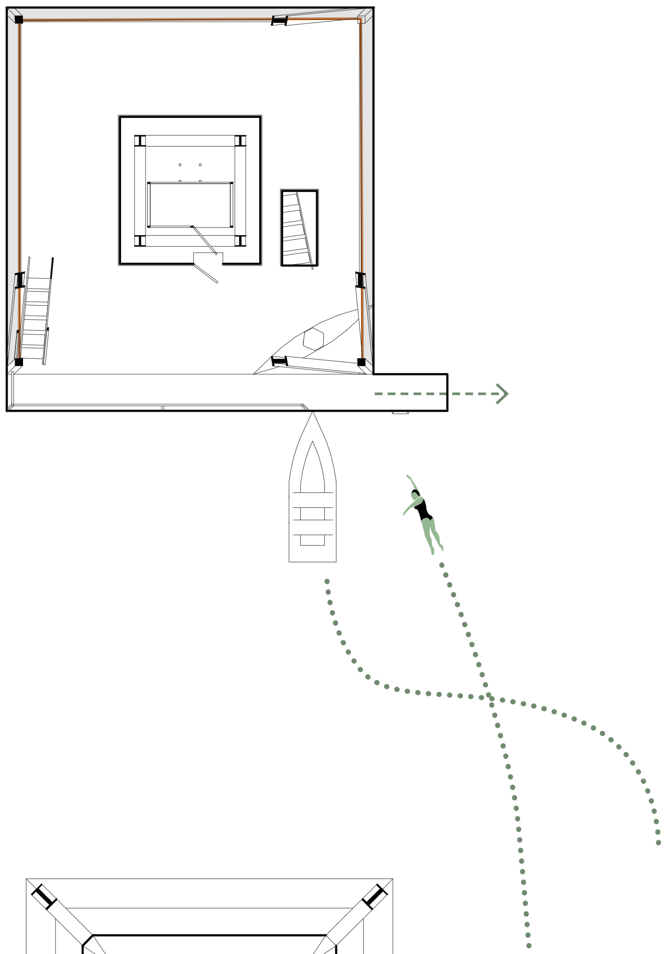
Over water experience





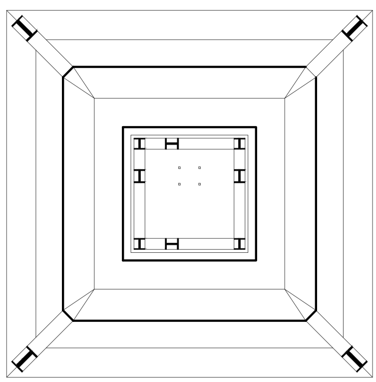
Movement **Exposure to nature**

FLOOR PLANS



0 level

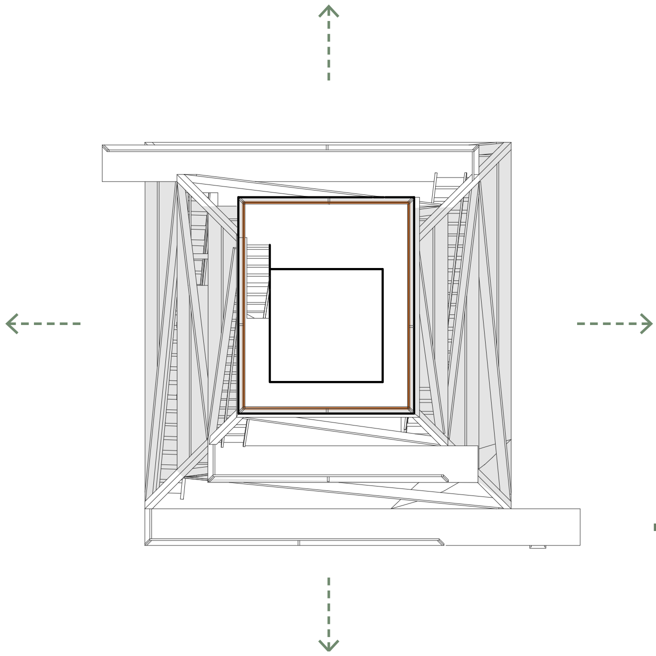
4 M N



-1 level

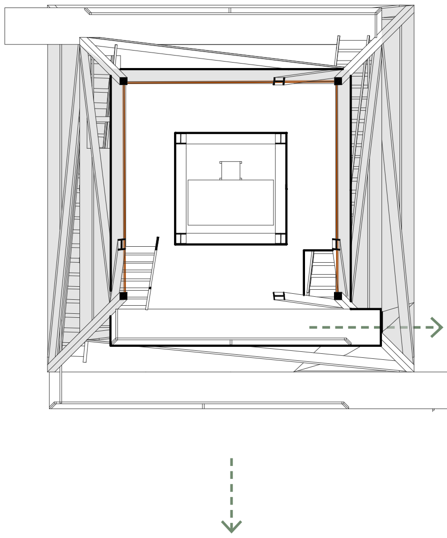
4 M N

5. THE OBSERVATION TOWER



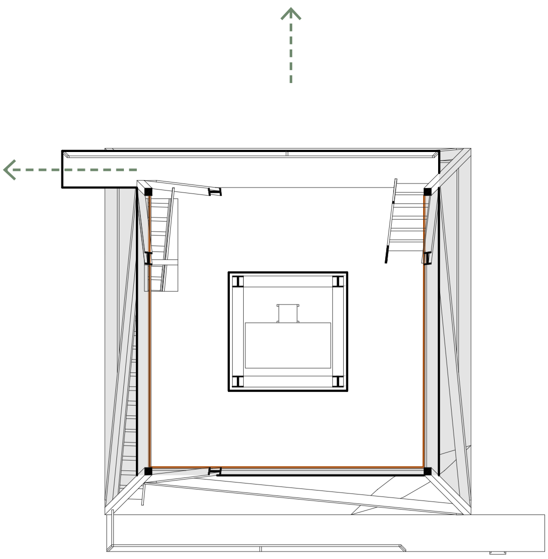
top level

4 M N



3 level

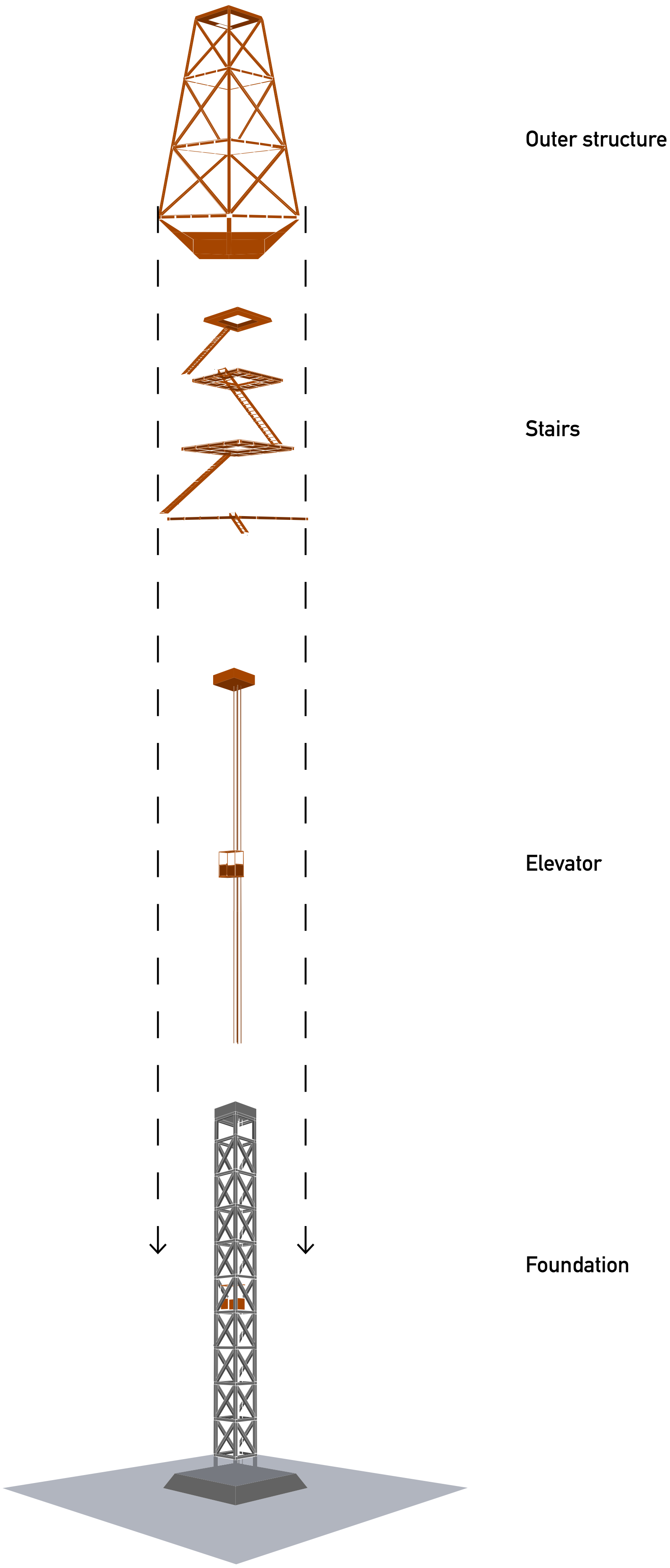
4 M N



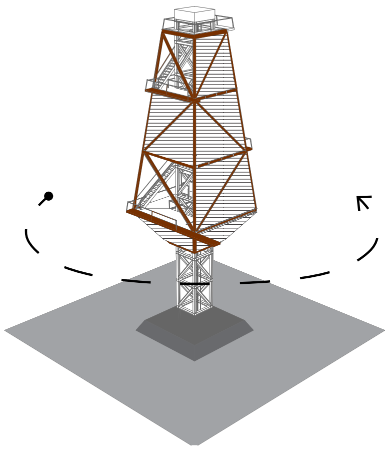
2 level

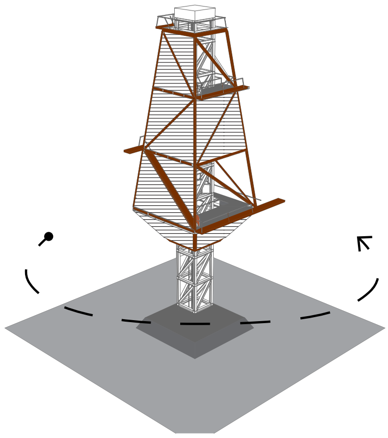
4 M N

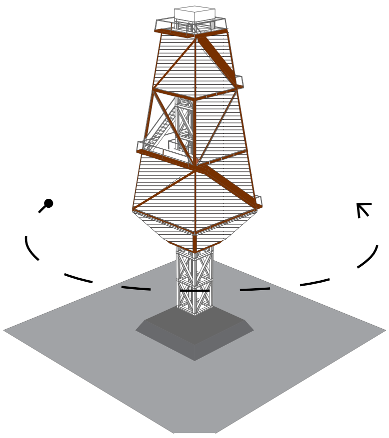
STRUCTURE

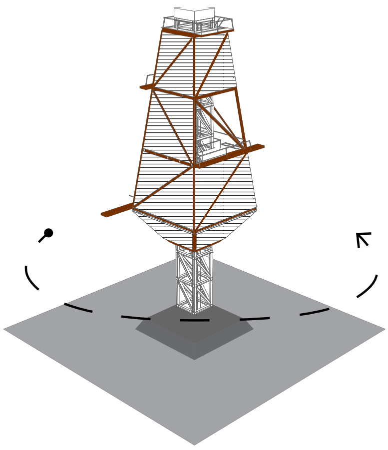


OPENINGS

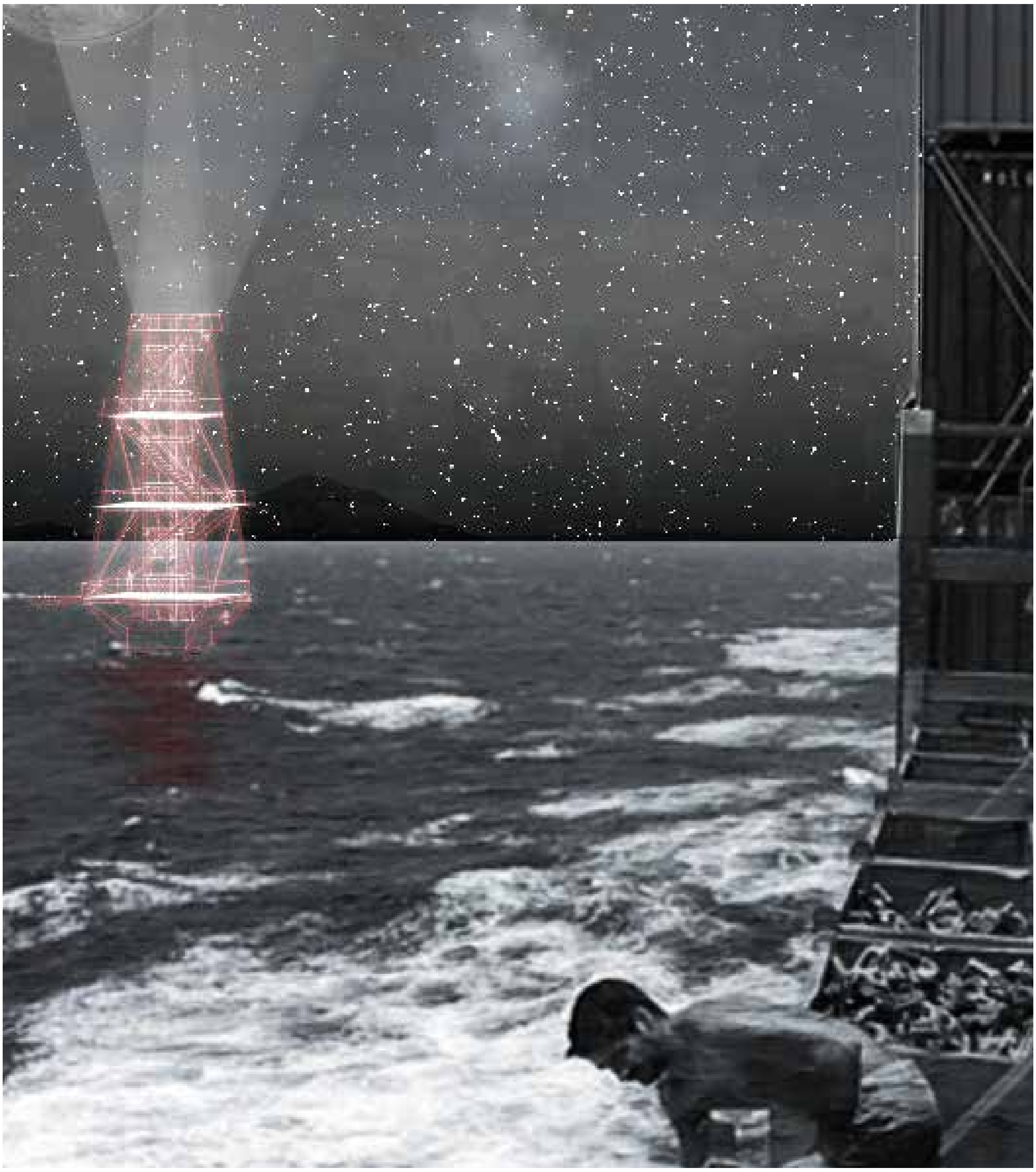


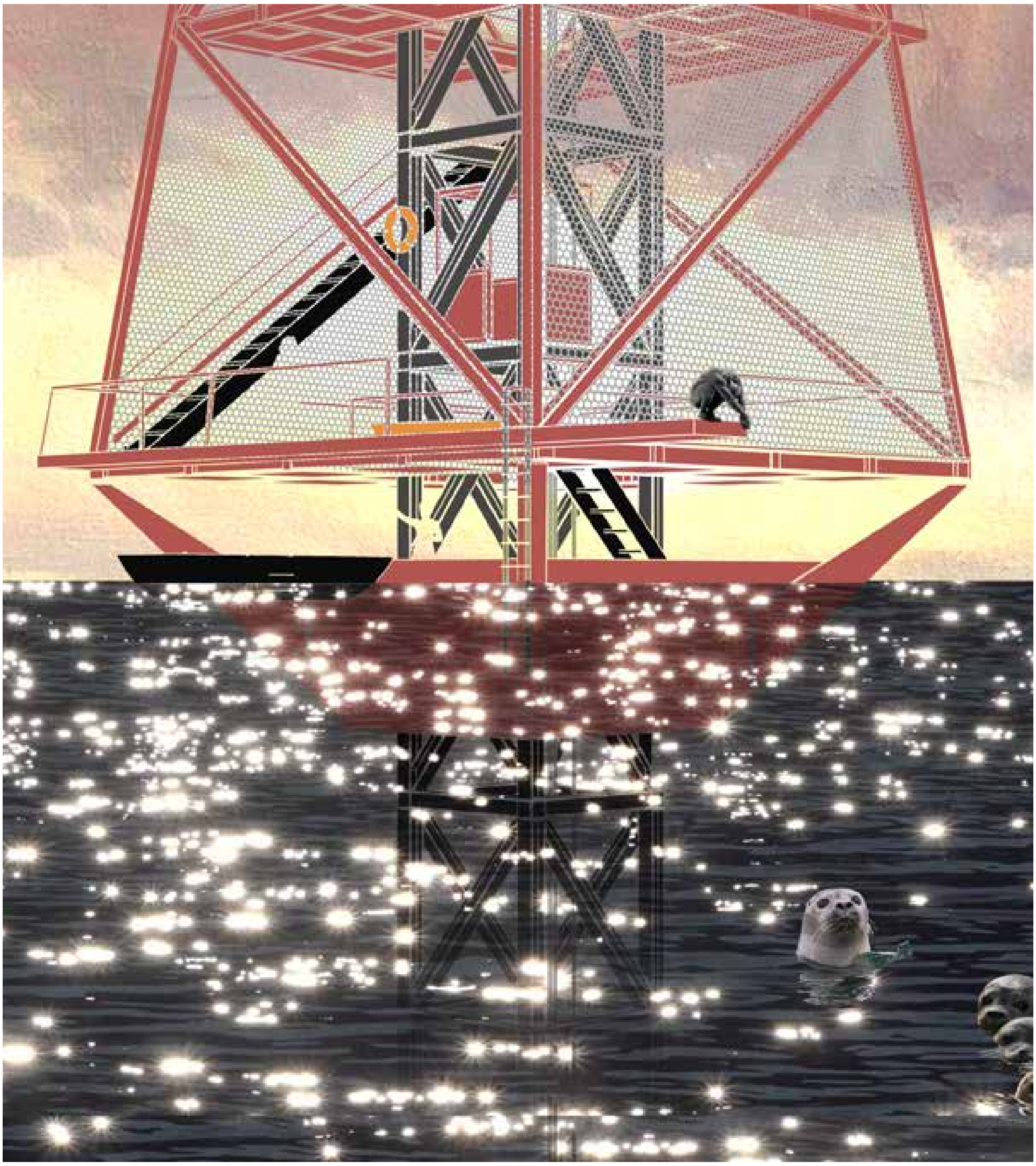


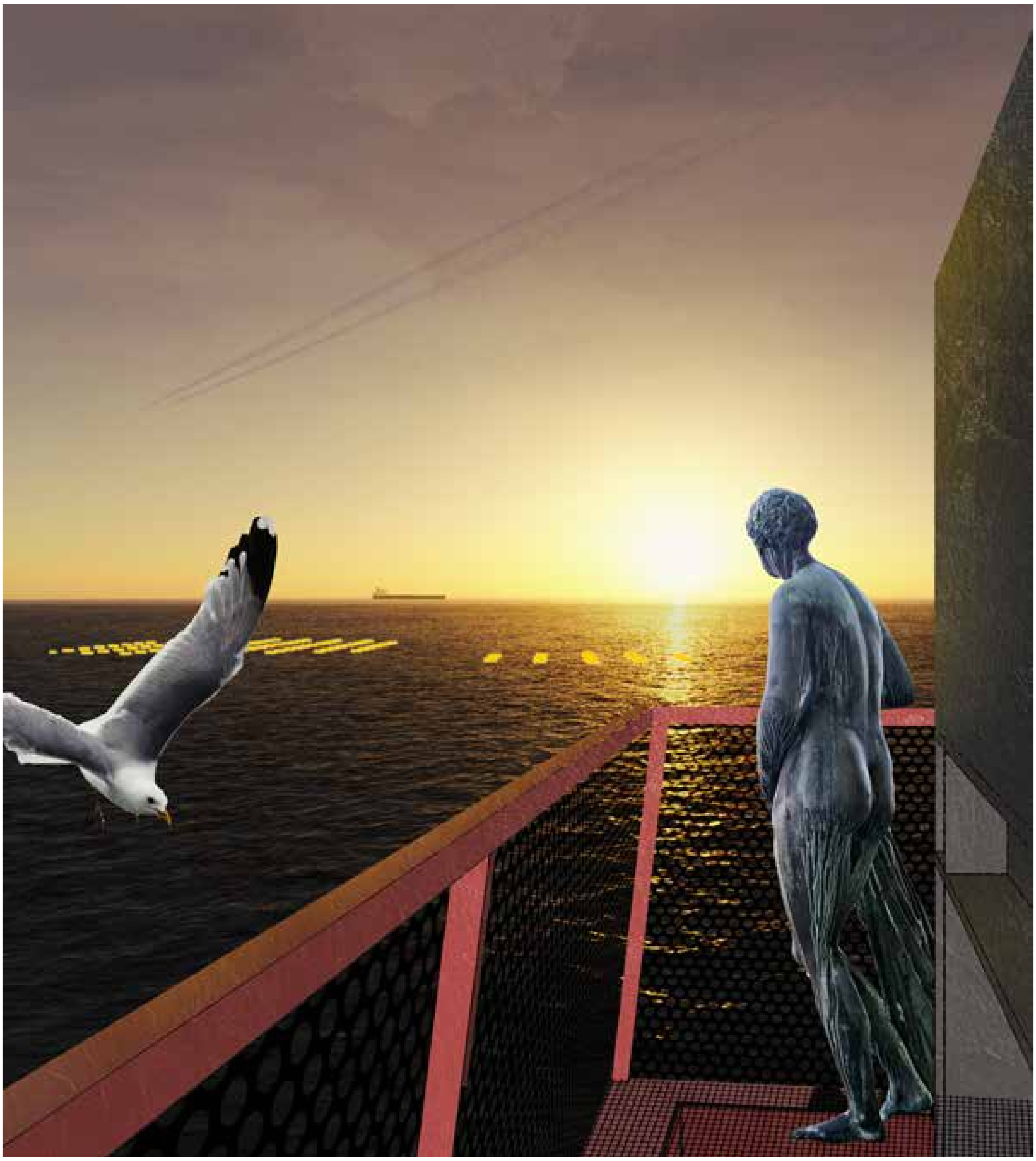




VIEWS







LANDSCAPE MODELS

When I started thinking about my master thesis, my first idea was to make something contrasting to landscape, or rather, contrasting to the idea of the untouched nature. I had an image in my head of man made geometrical shapes towards natural backdrops, cliffs or trees. Then I saw a weird looking gate cleaner for an intake gate to a hydro power plant in Tollered. And I also got interested in technical infrastructure.

Technical infrastructure is a precondition for the functionality of our modern society, and it inevitably leaves its physical marks in the landscape. It can be huge spaces, such as highways or the over head lines that transport electricity from the rivers up north down to the many users in the south, often monofunctional industrial areas. But it can also be small machines hidden in the forest, electrical boxes or manholes. Often it is hidden underground because that is the way we are usually dealing with infrastructure - either we let it take huge space or it is hidden. But it is not meant to be experienced

At the same time, we take the light that comes out of our light bulbs, the electricity that comes out of our sockets, for granted, we grunt at the ”high electricity prices”, trying to find the cheapest company, but not really understanding the difference, kind of wanting so called “green electricity”, but complain when they build wind mills in our beautiful landscapes and destroy our well known silhouettes to the horizon.

Infrastructure is not meant to be understood. It is meant to function. It is hidden because it is seen as an intrusion to the image that we have of the ideal romantical recreational landscape. But the physical objects gives us some clues, it hints of the existence of a hidden purpose. It evoked my curiosity. And often also provoked me by its ugliness and inaccessibility.

This thesis is about visualising the connection between resource and use. Between electricity and the original natural forces, the landscape. It is an urban strategy for making the Southern Archipelago outside of Gothenburg self sufficient on household electricity. And it is an architectural object making the system understandable, relatable and possible to experience.

It is called Wavy - because if we search for natural forces in the municipality of Gothenburg, wind can be said to be one of those - and as an effect of wind transmitted into water, there are waves.

I have researched the conditions of producing electricity globally, nationally and regionally, and tried to map the geographical preconditions of the site. I have through model works searched for a way to symbolise electricity - and by contrasts enhance both landscape and object.

Creation of electricity is based on a really simple principle, we see it in the dynamo that we are having on our bikes where a magnet moving in a copper coil creates an electrical field. It is kinetic energy, or movement, transformed to electrical energy, and the lamp lights up. Most electricity is created this way, with a big difference, at least here in the south; it is transported from very far away. The electricity in Gothenburg, for example, is actually mainly produced in Norway. The production landscapes are unevenly distributed over the country, to where the biggest resources have been. Small scale production is long gone.

And with one company owning the power plants, another supplying the grid, and numerous others selling the electricity to the end users it is quite difficult to understand how the system actually works and we are estranged from the original simple principle and source.

Swedes can proudly say that the electricity mix in Sweden is almost completely fossil free, with main contributors from hydro power in the north and nuclear power, both around 40 %. And it stands in contrast to the total electricity mix in the world and in EU that in large still depends on coal and natural gas. But the electrical market is interconnected, we already share electricity over the Nordic countries, to regulate the flow, but the prices also depend on the global oil market. Oil is generally affecting the profitability on electricity - and consequently which sources and technology that is promoted and developed. This means that something our society is so completely dependent on is also actually quite unstable and fragile, especially in a fragile political situation.

The Commission on Energy was political agreement over the Swedish political parties with the purpose to formulate a common strategy for the future of Swedish energy. Last winter they came with a report, covering the energy network globally and nationally. They claimed that we will need more electricity in the future, despite more efficient machines, that the population will grow and the electrical transportation market as well - something we already see with the break through of Tesla and electrical buses getting more common in Gothenburg.

They also agreed on decommissioning nuclear power (with some exceptions) until 2040. With the hydro power built to the maximum, this means new energy sources will be needed. They see small scale electricity as a mean to reach that goal and encourage local electricity production as a national security strategy for a more robust system. As a consequense of this, more people would get closer to the production. The technical infrastructure would get planted as an object in our consciousness. But wind parks in the south, however, often receive critique for being an intrusion in the landscape.

A solution to this critique could be found in Denmark where co-ownership of windmills was an early funding strategy - and it has been proven an efficient way of creating acceptance, and consequently self sufficiency. If the power plants are based on initiatives from the inhabitants, they can be a ground pillar for creating acceptance, even evoke positive feelings and sense of identity. However, as the design for windmills today is very defined, I decided to investigate the technology of wave power. And its preconditions is a bit different.

Wave power technology is still in its cradle even though the technology has been tested since the 70s and despite the fact that the estimated power of the sea is more than 20 times the amount of wind. The thing is, sea power also tends to destroy the technology. Most wave power test sites is located around the big coasts towards open sea where the strongest waves are. When mapping the test sites in our neighbouring countries we find many around the British coast. This is partly because of the strong waves, but also that Great Britain has a generous funding system for sea power, in an otherwise still fossil dominated electricity mix.

There are several wave power designs, functioning in different ways, and it is said that unlike wind, wave technology might stay diverse, with designs fitting for specific conditions and this might leave space for even more diverse design and possibility of integration in other systems.

On the Swedish coast, there is however calmer waters, and outside Lysekil researchers have tested a technology fitting for these small waves. The pros with the small waves are that the destructive forces are less and Seabased, which is the name of the company, was actually the first wave technology to connect electricity to the grid in early 2016. So, based on today's research, the most fitting technology for Gothenburg would be the so called point absorber developed by Seabased, which is basically a buoy connected to a linear generator and creating electricity as the buoys move up and down, the same technology as the magnet moving in the copper coil.

Delimiting the site to the district the Southern Archipelago, with its 4500 inhabitants this technology would mean arrays of 189 buoys. For optimal wave absorption they would be placed with 30 m distance in the wave direction. In optimal situations this would create hexagonal arrays. Optimal situations, however, doesn't exist, in this case the wind mainly comes from west, but for the proposal I have assumed that arrangement.

To find the proper site I started mapping the sea conditions outside Gothenburg. I mapped the bottom conditions for proper grounding, the shore line protection and the borders for natural reserves to avoid protected sites, I mapped ship fairways and light houses to avoid unnecessary interference with the existing infrastructure. And one of the most important things - the existing electrical grid, to connect with both the sub-sea cables and the overhead grid at land. I marked possible ports for reparation and construction sites, there is a tradition of port work on the islands and many of the inhabitants still work and live in the same area.

By choosing site, there were different alternatives, either to gather them in one big cluster or spreading them out in smaller clusters towards the west. I chose the second smaller clusters, to create a stronger connection between each island and each clusters of buoys, a strategy for creating ownership. The inhabitants then, will be able to point towards the sea and tell: ”Those are the buoys supplying my island with electricity”.

But with only a system of buoys, hidden at sea surface, and substations under water - we would have been where we started, with hidden technology and restricted monofunctional areas. And my purpose was to show and visualise the electricity.

I thought of how to make the buoys integrated in a structure, if they could be walkable islands, connected somehow, and it would have been theoretically possible. But with today's restrictions, you are not allowed to get close to the buoys, and I decided to take another approach and to accept those restrictions for the sake of plausibility. And with the urban strategy formulated, I then reached the point of what role architecture can take in the system. Substations and transformer stations on land can be designed, they can be designed into shelters, and excessive heat from the transformations can be used for other purposes.

But I decided to place an addition.

It can be called a visitors centre with minimum program. But it is basically a power generating observation tower. Its purpose is to make a stand, being a sea mark. It marks the place. It is the connection point between the production and the use, the open sea landscape and land. It is reachable by boat, kayak, or swimming. It is a floating island partly accessible and partly hard to get to. An experience in itself.

It contains of two parts, the floating outer structure connects to a firm anchor in the middle. As the floating structure moves with the waves and water levels it is connected to a generator and, with the same technology as the point absorbers, electricity is created and provides the structure with a light, showing from far when electricity is created. Pulsating with the speed of waves.

It is made of red structural steel, symbolising machinery and industry. The skin of the structure is made of perforated steel, making it half see through but still a volume. It opens up, offering different views alternating to east and west as you move up the stairs, where you get a 360 degree view. From the top you have the sea and the buoys in their mathematical order to the west and to the east the land is lit up by the created electricity. The whole and full system is in front of your eyes.

The structure offers both shelter and exposure, depending on weather and purpose and preference of the visitor. Experiencing the structure, the nature is close. The sun reflects on the sea surface up in and on the structure. The movement up the structure is divided in two system. You can either move along the facade of the outer floating structure or in the anchor with a hydraulic lift, driven by the electricity the structure produces.

On the anchor underneath the surface mussels and sea tulips are allowed to grow, creating a reef effect. So even though there might be disturbances of wild life in the building phase, the ecosystem will be able to adjust and even improve.

So what are my conclusions then on this process? Except that I learned a lot about electricity that I had forgotten? I have tested the plausibility of an autonomous wave power system and shown that it is theoretically possible. What is needed is mainly funding in an early stage, and an additional battery system, which ought to be placed close to the end consumers.

But I also want to questions our attitudes towards electricity in general. Is it really reasonable to assume constant electricity flow in our sockets or should we do the laundry on the windy days instead?

If this was a real scenario for autonomy - wave power would of course not be the only type of electricity used. It would be mixed with wind, and even smaller systems such as house hold solar panels. And with these additions there might be enough electricity for the whole society, not just the households, also transportation and service.

If I would have continued this work I would have gone further into the construction. To define details, to manifest the ideas more concretely. How to get close and experience the machine, the placement of bolts. This is not the only way to create a structure showing electricity But it is meant as an inspiration for another way of thinking of traditional architectural tasks, to question monofunctionality and to question how we experience both nature and technology. To create an understanding of our societal preconditions.

To create a sense of coherence. And to encourage curiosity.

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PINGSTONE, A. (1998) *STWLAN DAM.* RETRIEVED FROM COMMONS.WIKIMEDIA.ORG/WIKI/FILE:STWLAN.DAM.JPG

P. 50. RETRIEVED FROM SCIENCING.COM/DIFFERENCES-BETWEEN-NUCLEAR-POWER-FOSSIL-FUELBURNING-POWER-PLANTS-21387

P 50. *BATTERSEA POWER STATION* RETRIEVED FROM HTTP://WWW.TELEGRAPH.CO.UK/PROPERTY/HOUSE-PRICES/BATTERSEA-POWER-STATION-DESPERATE-TIMES-OR-STILL-DESIRABLE/

P 51. OHASHI, T. RETRIEVED FROM WWW.ARCHDAILY.COM/344664/AD-CLASSICS-TOWER-OF-WINDS-TOYO-ITO

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NASA. (2014). EARTH AT NIGHT. [DIGITAL MAP]. RETRIEVED FROM WORLDVIEW.EARTHDATA.NASA.GOV/

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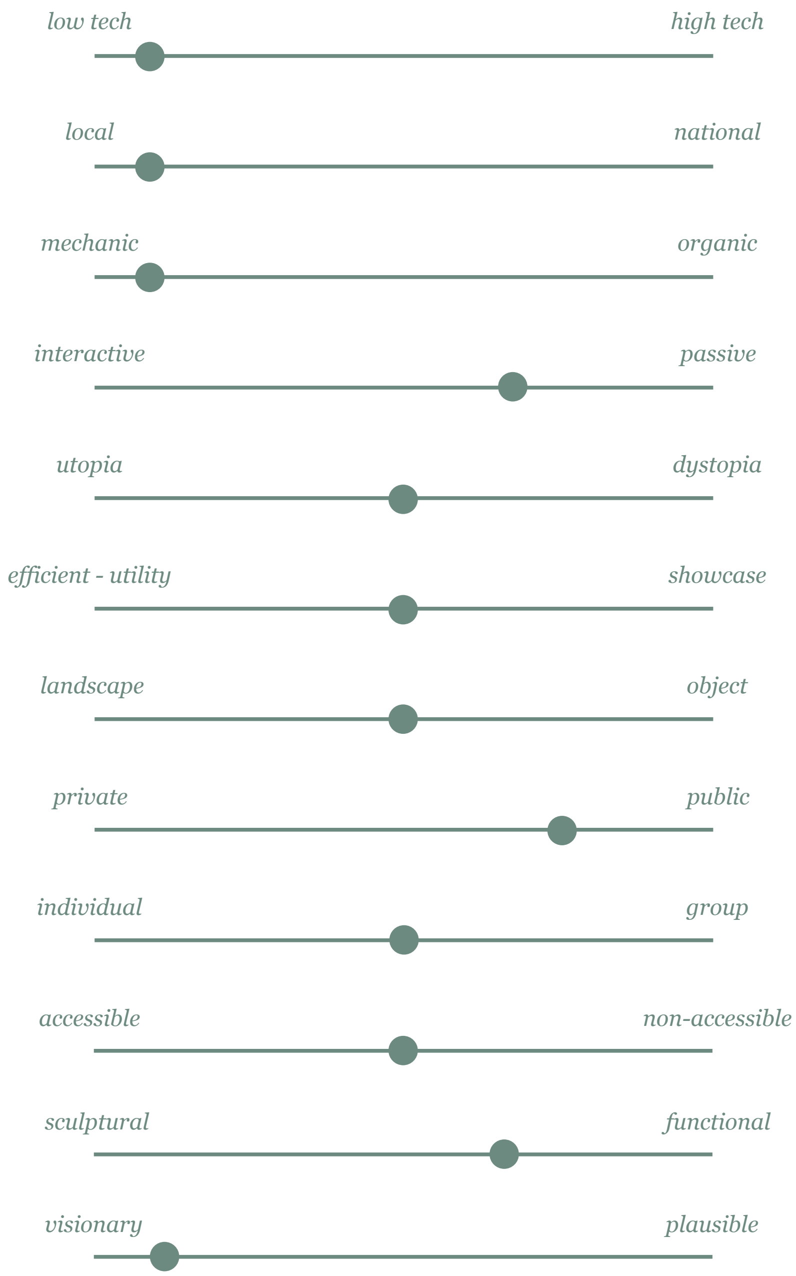
HELCOM.NET ?

MAPS.SGU.SE

LINJEKARTA, STYRSÖBOLAGET, WWW.STYRSOBOLAGET.SE/UPLOAD/STYRSOBOLAGET/PDF%20KARTOR/LINJEKARTA%20281-284.PDF

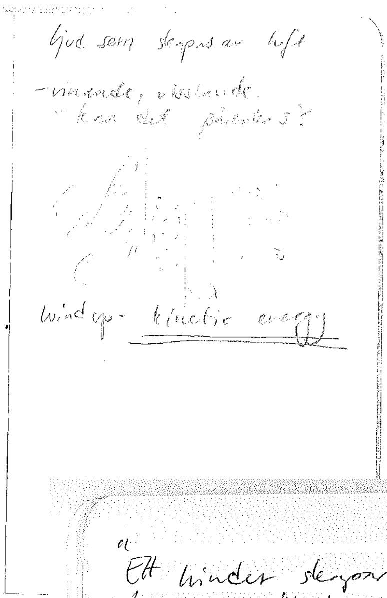
SEACHART 9313, SJÖFARTSVERKET

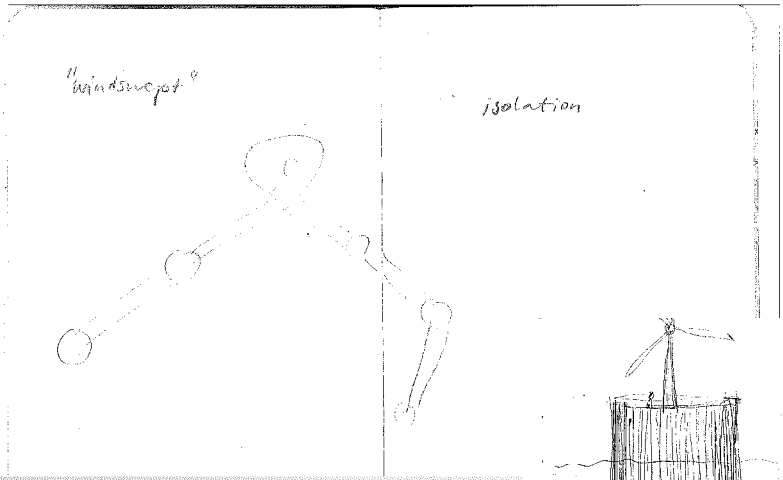

low tech
high tech
local
national
mechanic
organic
interactive
passive
utopia
dystopia
efficient - utility
showcase
landscape
object
private
public
individual
group
accessible
non-accessible
sculptural
functional
visionary
plausible

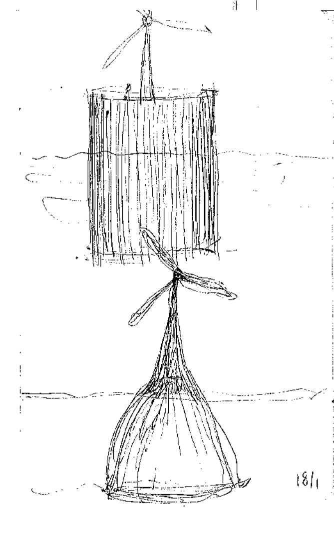
APPENDIX

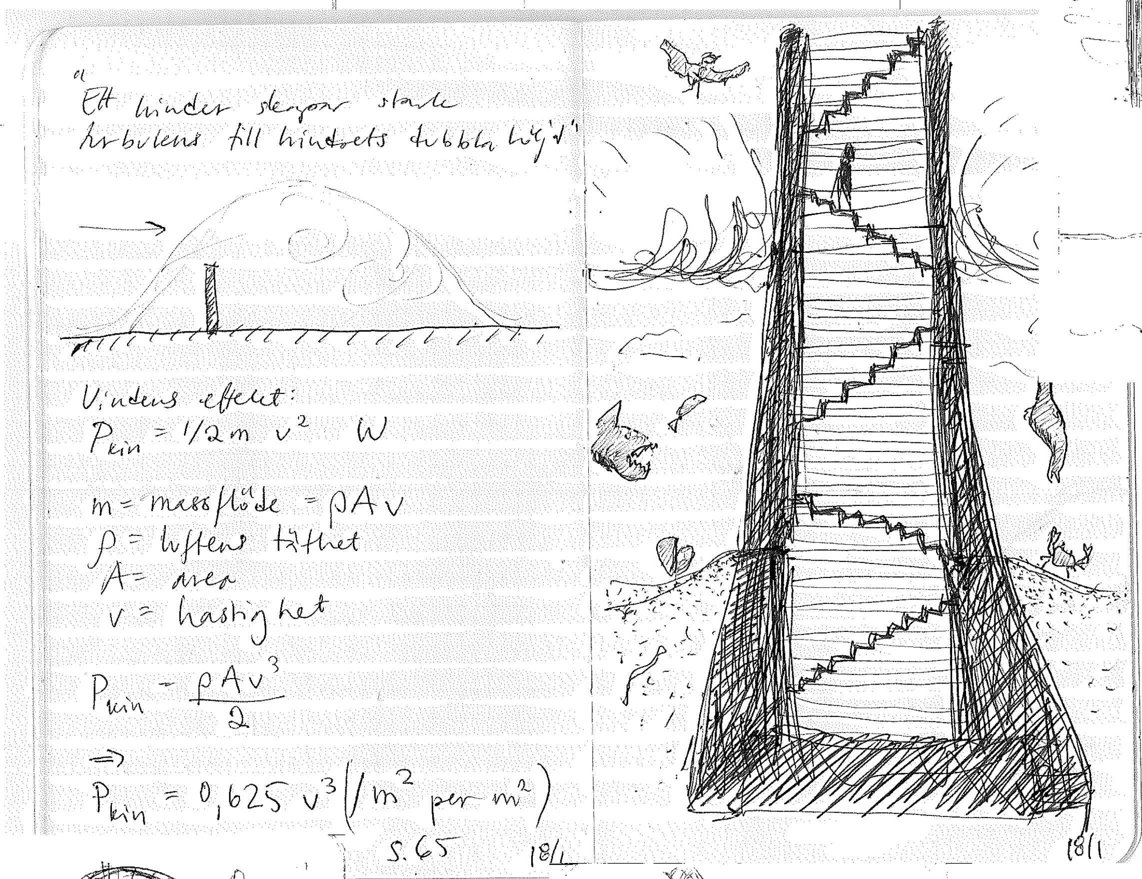

electricity
landscape
landmark

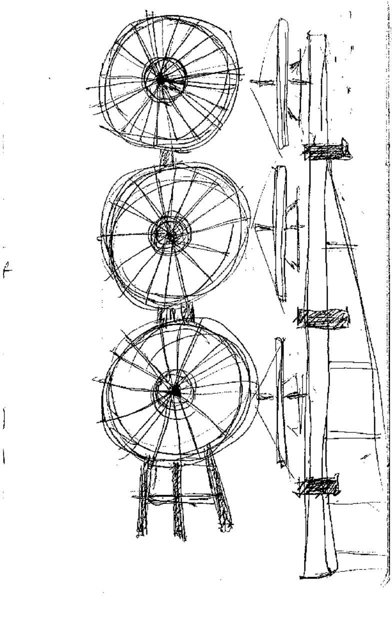

object
machine
OBSERVATION TOWER

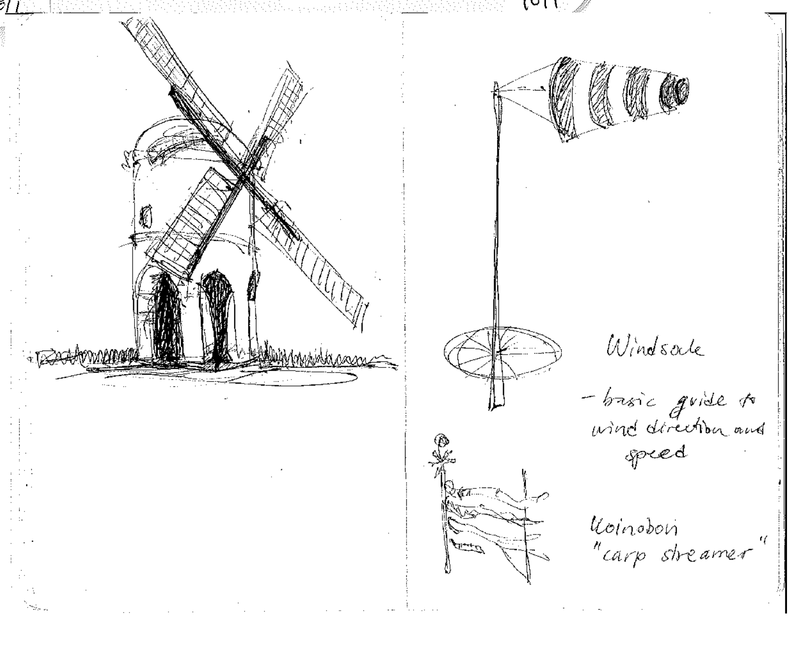

wind up - kinetic energy


"windsuget"
isolation


18/1


"Ett hinder skapar stark turbulens till hinderets dubbla höjd"
Vindens effekt:
$P_{kin} = 1/2 m v^2$ W
m = massflöde = $\rho A v$
ρ = luftens täthet
A = area
v = hastighet
$P_{kin} = \frac{\rho A v^3}{2}$
$\Rightarrow$
$P_{kin} = 0,625 v^3$ (/m² per m²)
s. 65
18/1
18/1

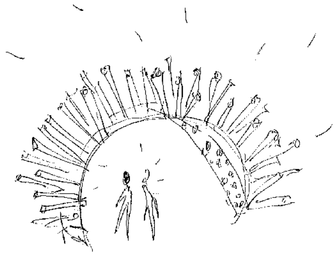



Windsock
- basic guide to wind direction and speed
Koinobori
"carp streamer"

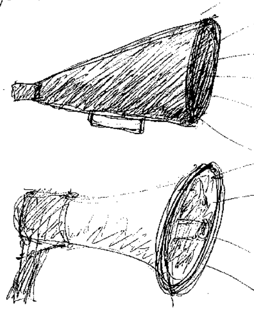
Kärnfråga – resilience

affect peoples attitudes and create resilience

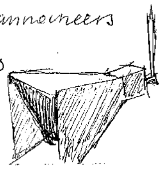
self sufficiency



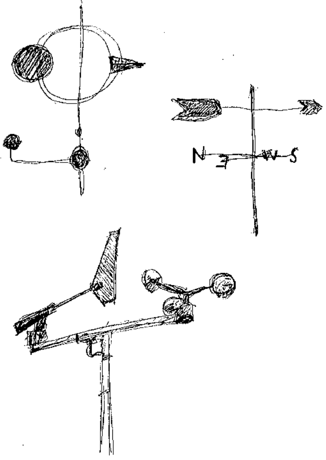
Objects.

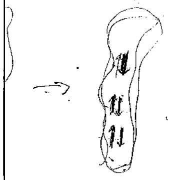


Megaphone announcers amplifiers



Weather vanes





…re even spread energy production

Färg !?

Ljus !?

– samma utformning?

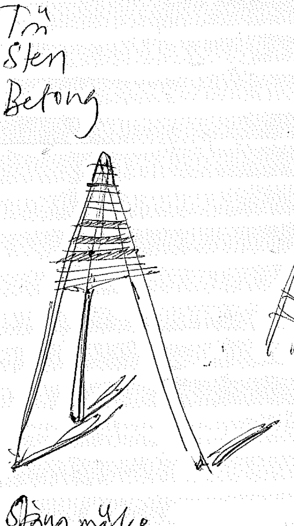
Sjömärken: Kulturarvsbärare symboler.

Konstruktion.

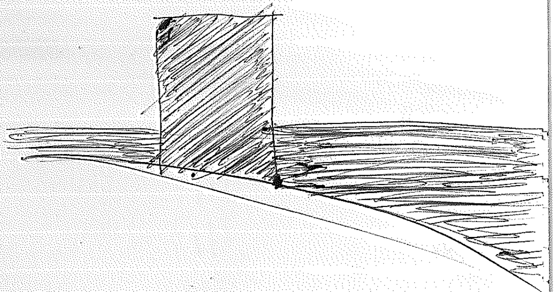
Trä

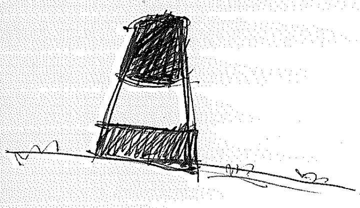
Sten

Betong



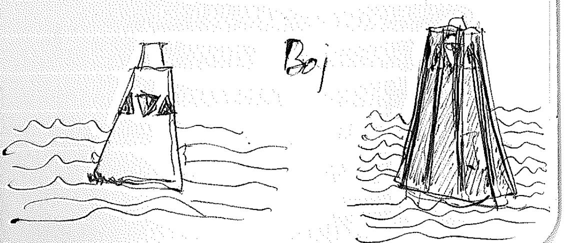
Stångmärke





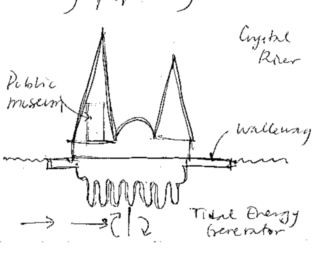
Kummel

Boj

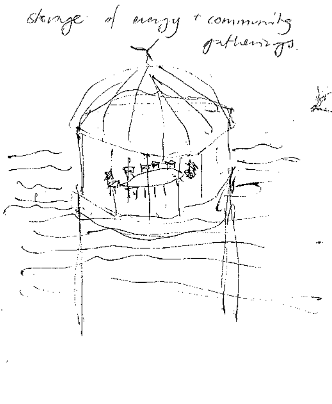


"Skälet till att ingen vill investera är att varje investering ökar tillgången på elproduktion och sänker priset"
Daniel Torstensson, Vi Kommuner
Gunilla Ståhle, Vi Kommuner
lösning – långsiktigt ansvar för elproduktion

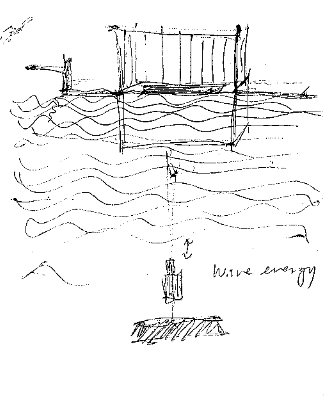
"Building performing"

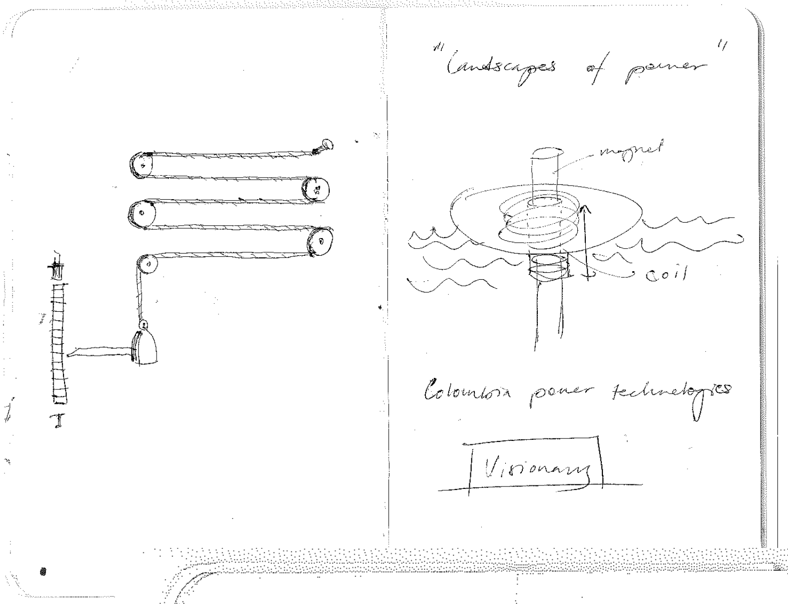


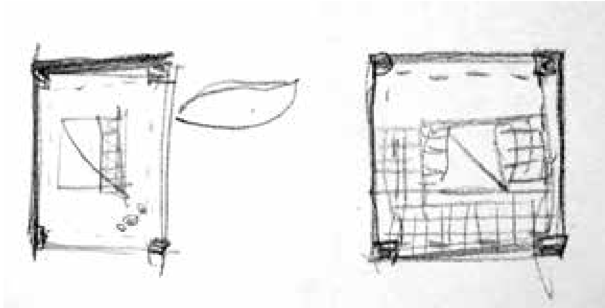
storage of energy + community gatherings

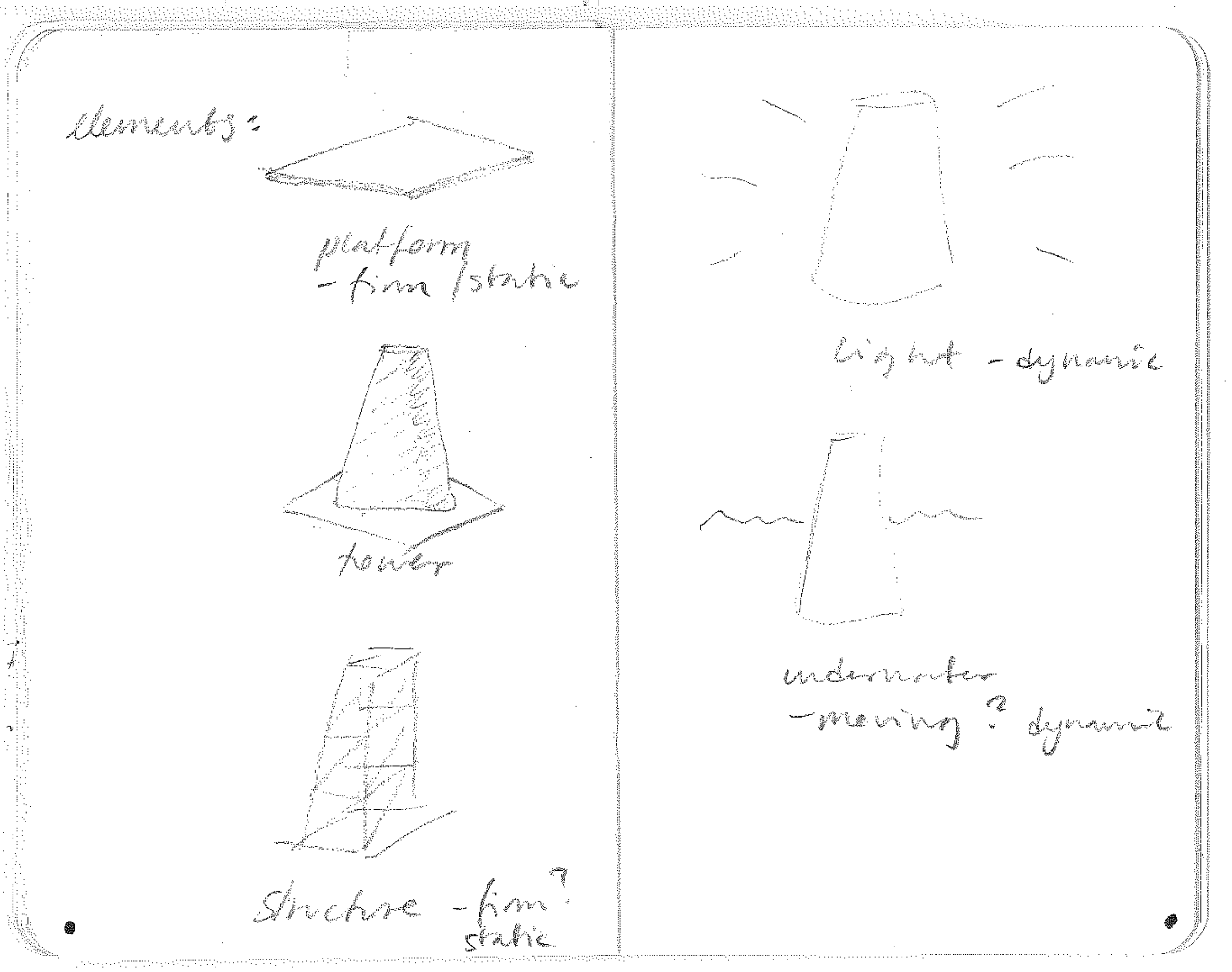


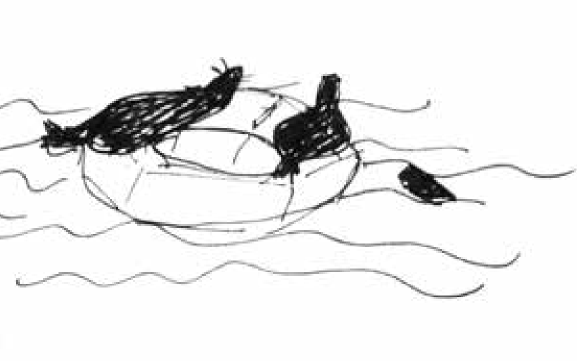
main house – energy production

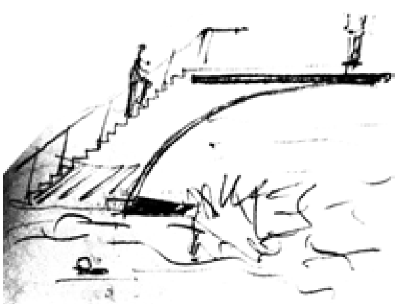


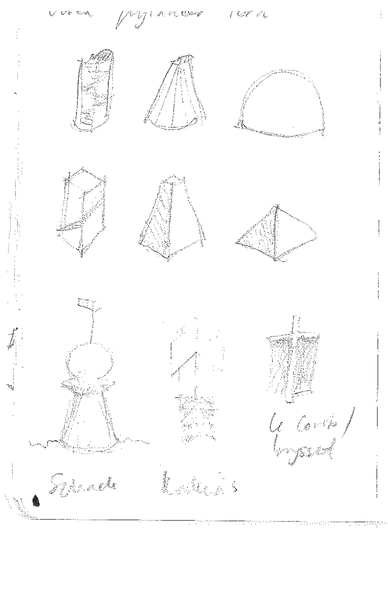

"Landscapes of power"
magnet
coil
Visionary

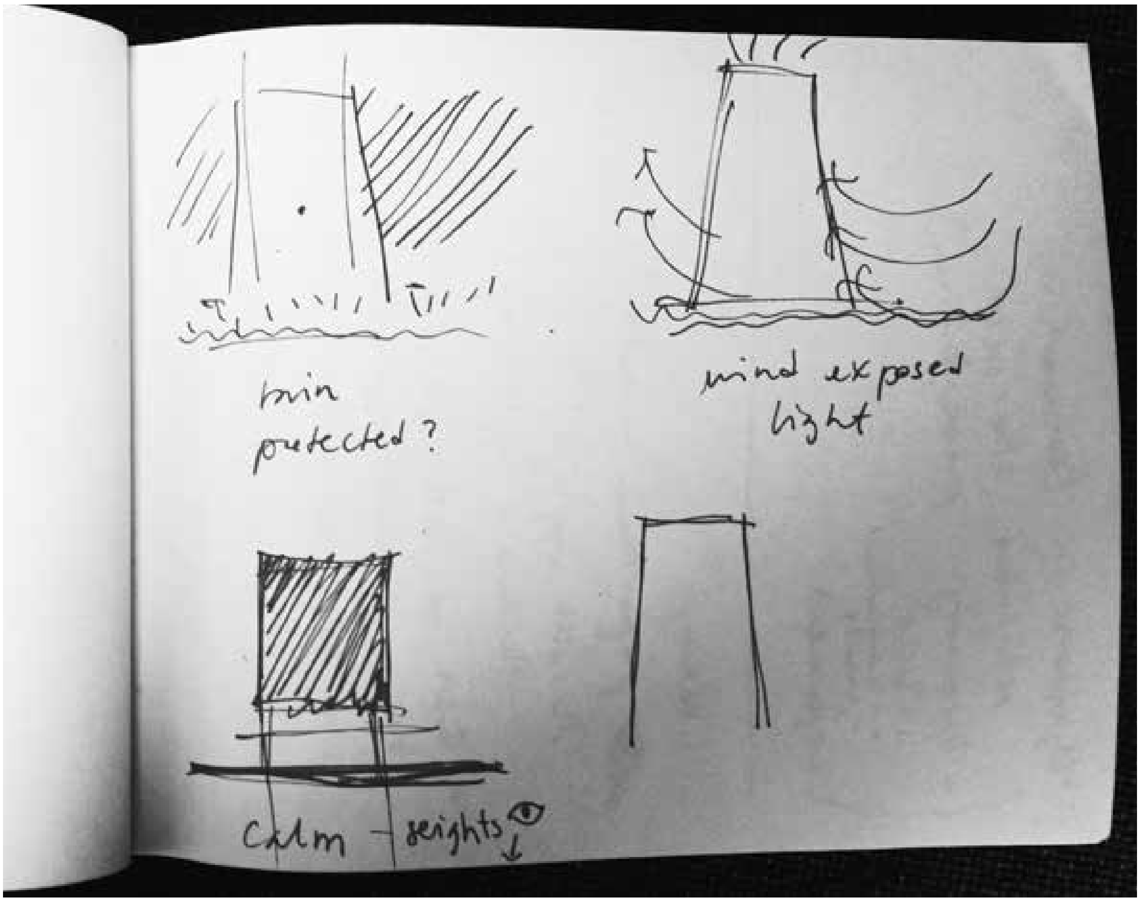


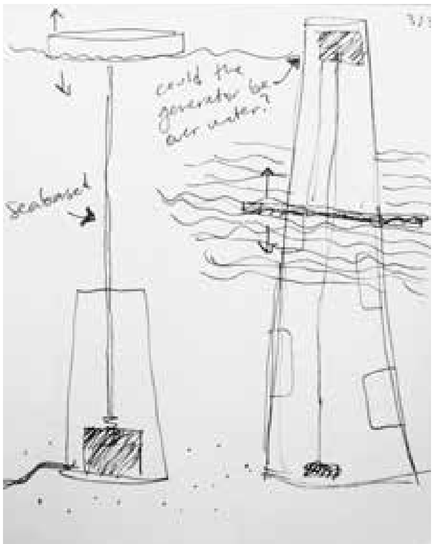

elements:
platform
- firm / static
tower
Structure - firm?
static
Light - dynamic
underwater
- moving? dynamic

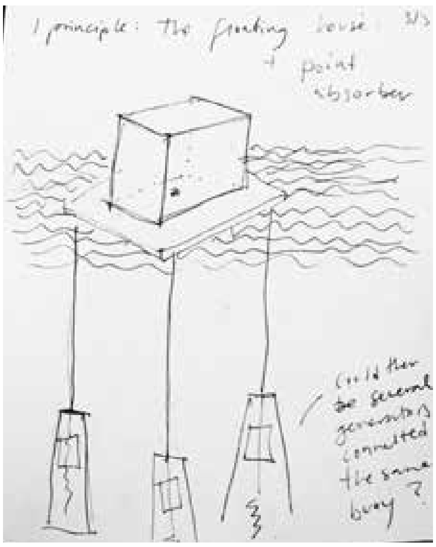

Seals + buoys

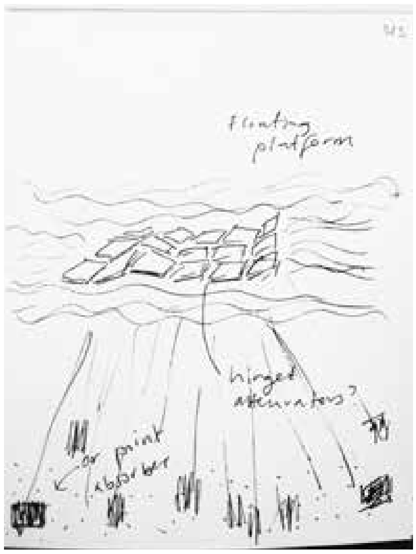




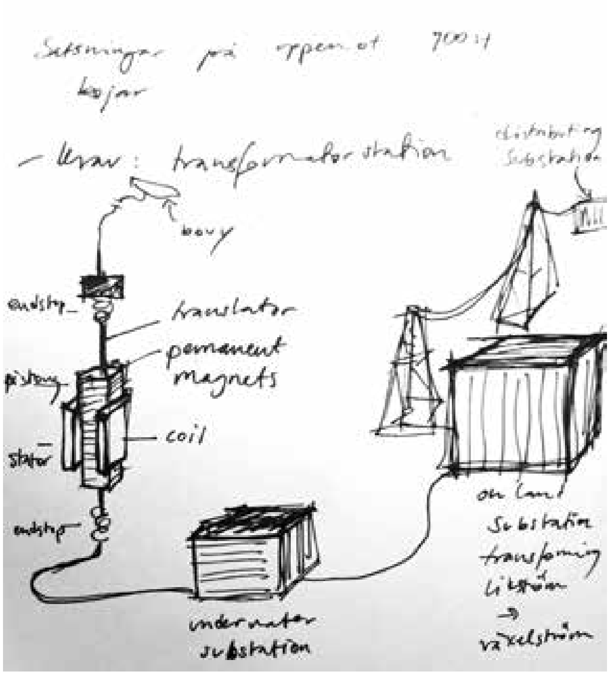

rain
protected?
wind exposed
light
Calm - sights

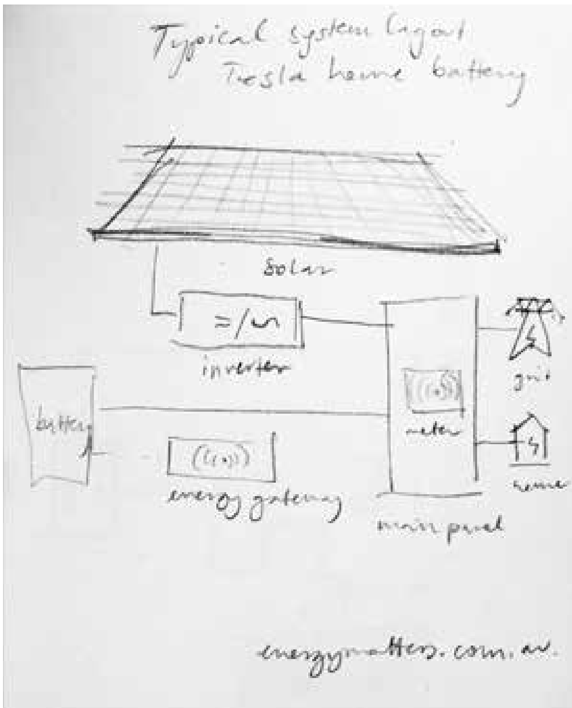

could the generator be over water?
Seabased

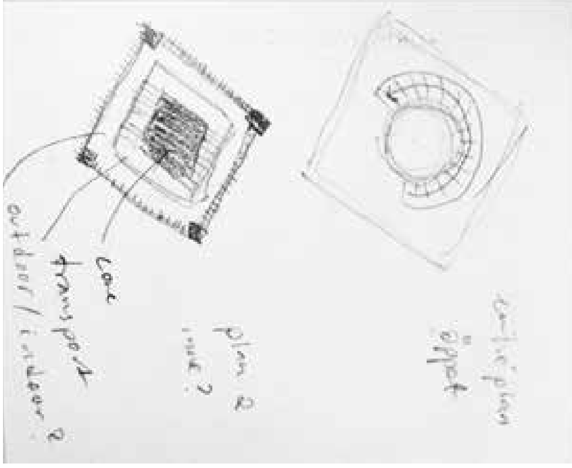

1 principle: the floating house
+ point absorber
Could there be several generators connected the same buoy?

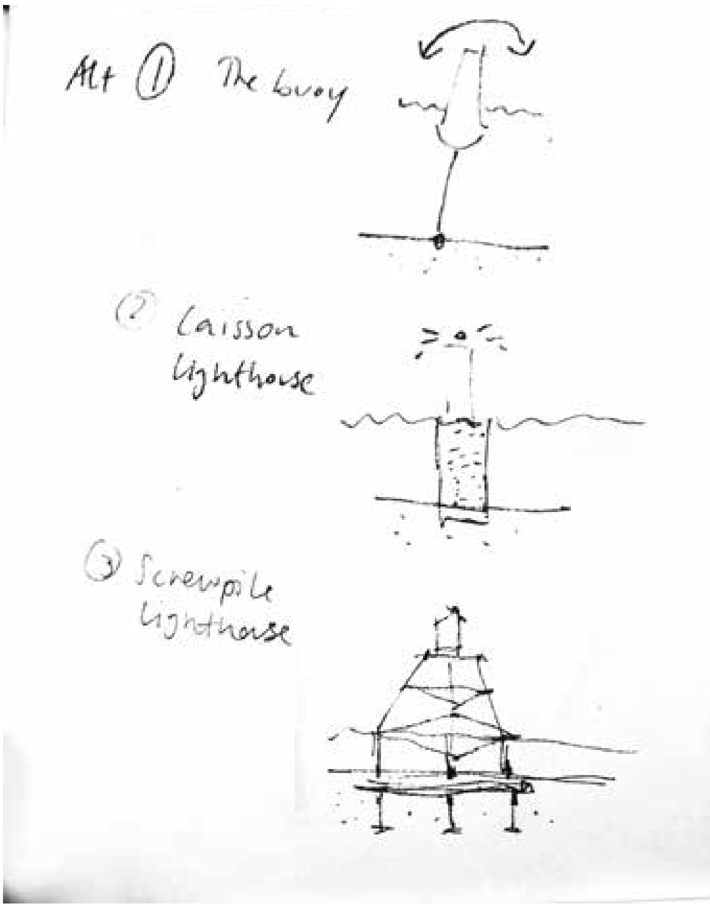

floating platform
hinged attenuators?
or point absorber

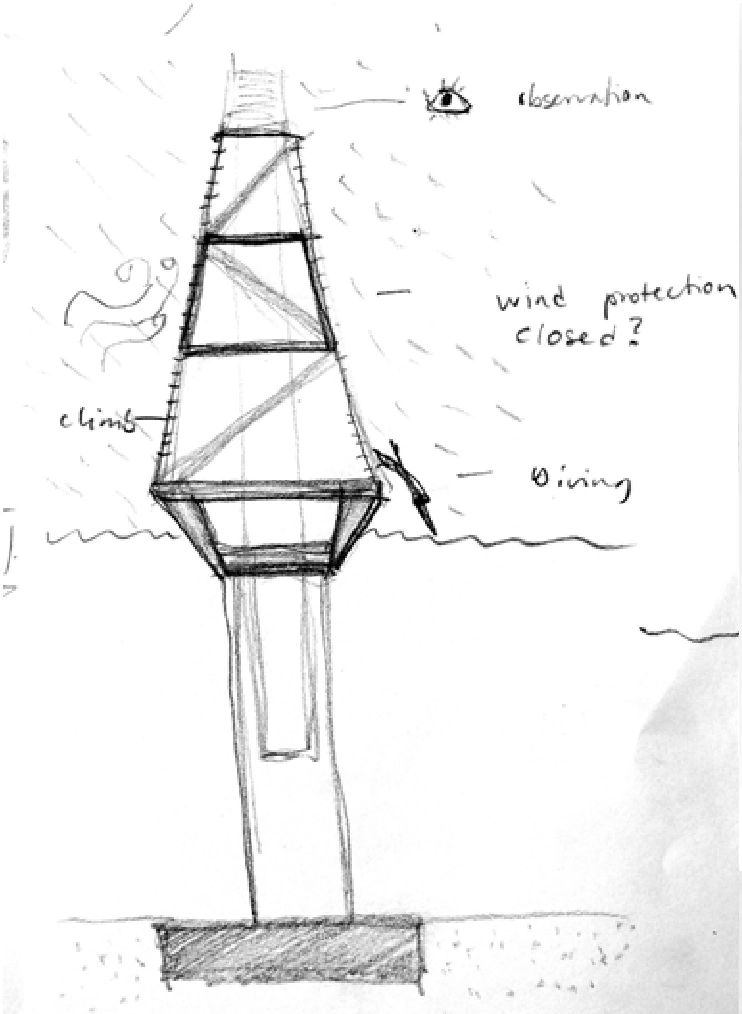

nage person jumping from tower

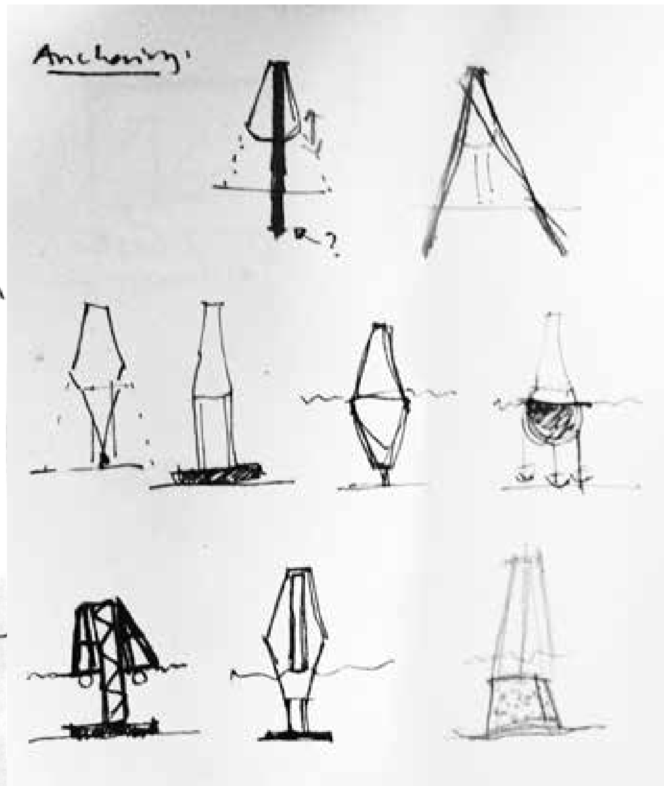

Satsningar på typen of 700 st
bojar
– Urav: transformator station
distributing substation
buoy
endstop
translator
permanent magnets
piston
coil
stator
endstop
underwater substation
on land substation
transforming
likström
→
växelström

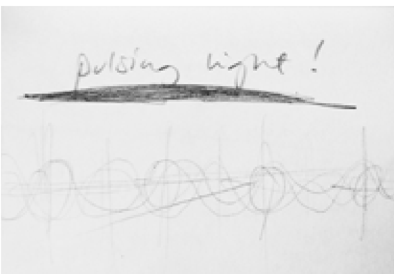

Typical system layout
Tesla home battery
solar
inverter
grid
battery
meter
home
energy gateway
main panel
energymatters.com.au.


core
transport
outdoor / indoor ?
plan ?
ytplan
öppet


Alt ① The buoy
② Caisson lighthouse
③ Screwpile lighthouse


observation
wind protection
closed?
climb
Diving


Anchoring:


pulsing light!