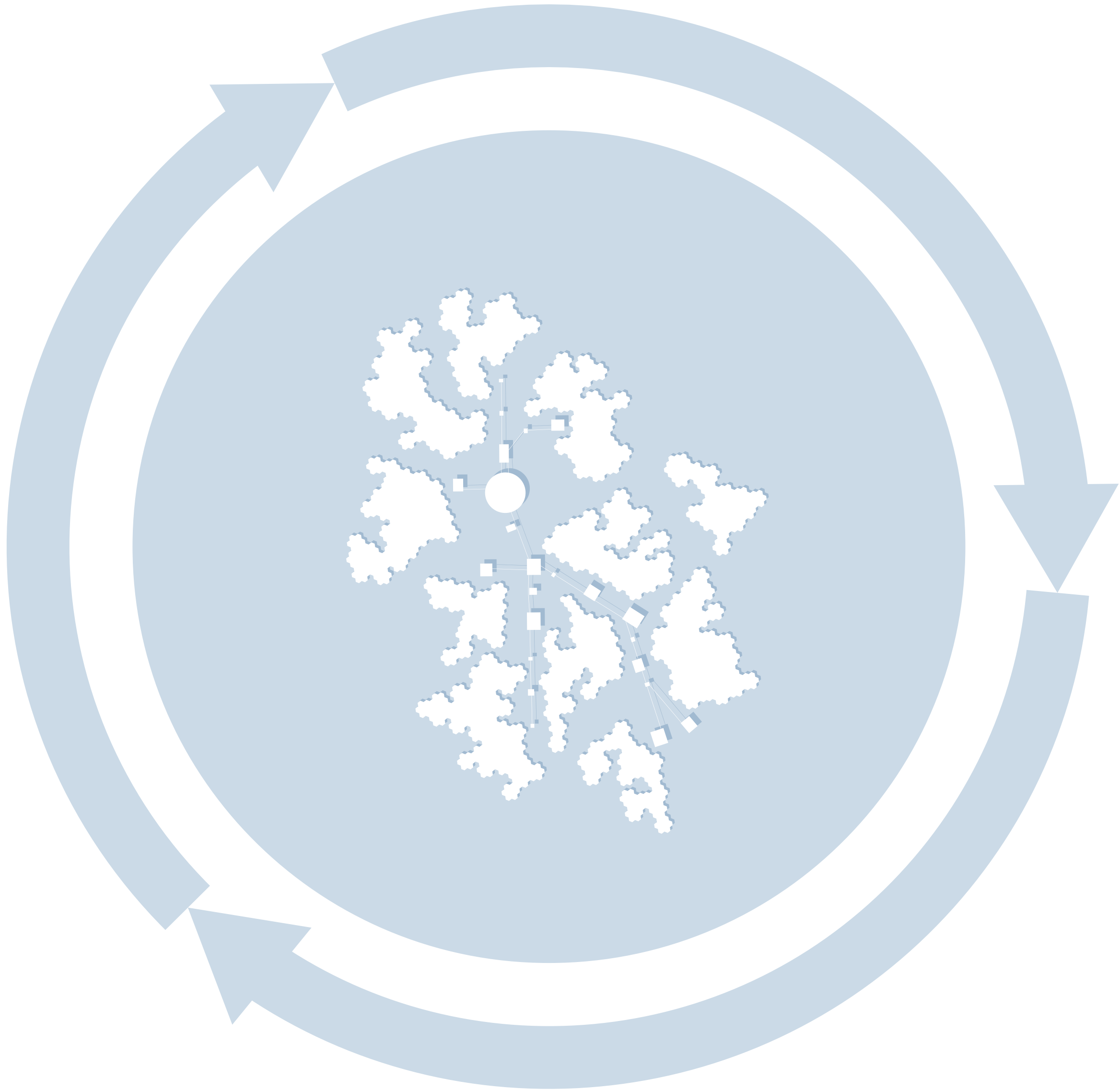


NEW NORTH SEA PROJECT

Alexandre Arcens

New North Sea Project

The re-appropriation of the Ekofisk complex

The New North Sea Project draws on the prophetic nature of science fiction. Inspired by René Barjavel's 'Ravage (Ashes, Ashes)' (1943) which depicted the consequences of the sudden disappearance of electricity in 2052 France. It proposes the creation of an ecology-based sustainable community after the oil has run out.

The project researches and develops a design for the re-appropriation of the billion dollar North Sea Ekofisk oil platforms at the end of their service life, a re-inhabitation as a relatively self-sustaining base dedicated to the protection of wildlife via the use of cheap technologies. Using the potential of current scientific and technological research coupled with low-tech design, the thesis envisions the strategy for accommodation, food and energy that will function as an intrinsic part of a sustainable ecosystem in an open water context.

In this holistic scenario, sustainable design is not just a kit of technological remedies for both ecological and energy crisis. The thesis is a manual of spatial and phenomenological implications for planning a new city and the establishment of an ecological symbiosis between obsolete industrial infrastructures and a sustainable aware community.

The North Sea is a marginal sea of the Atlantic Ocean shared by Great Britain, Denmark, Norway, Germany, the Netherlands, Belgium, and France. It is more than 970 kilometres long and 580 kilometres wide, with an area of around 750,000 square kilometres. It is one of the world's most productive ecosystems thanks to its diverse physical nature which provides an equally diverse range of habitats. Some 10 million sea birds and around 230 different species of fish are to be found almost year-round. [1]

The North Sea has long been the site of important European shipping lanes as well as a major fishery. While its surface represents only 0,002% of the world's marine area, approximately 4% of all the fish caught around the world is taken from here. [2]

It is as well a popular destination for recreation and tourism in bordering countries and more recently has developed into a rich source of energy resources including fossil fuels, wind, and early efforts in wave power. The North Sea contains western Europe's largest oil and natural gas reserves and is one of the world's key producing regions.

As early as 1859, oil was discovered in onshore areas around the North Sea and natural gas as early as 1910. Test drilling began in 1966 and then, in 1969, Phillips Petroleum Company discovered the Ekofisk oil field distinguished by valuable, low-sulphur oil. [3]

Due to the dense population, heavy industrialization, and intense use of the sea and area surrounding it, there have been a number of environmental issues affecting the sea's ecosystems. Environmental concerns—commonly including overfishing, industrial and agricultural runoff, dredging, and dumping among others—have led to a number of efforts to prevent degradation of the sea while still making use of its economic potential.

In recent decades, overfishing has left many fisheries unproductive, disturbing marine food chain dynamics and costing jobs in the fishing industry. Herring, cod and plaice fisheries may soon face the same plight as mackerel fishing, which ceased in the 1970's due to overfishing. The objective of the European Union Common Fisheries Policy is to minimize the environmental impact associated with resource use by reducing fish discards, increasing productivity of fisheries, stabilising markets of fisheries and fish processing, and supplying fish at reasonable prices for the consumer.

Reckless use of fossil fuels and overfishing has led to an ecological and energetic crisis in the North Sea. In 2040, the Ekofisk oil field -the first and most productive one of the area, will be depleted. At the same time, fish stocks are jeopardized due to unconscious, unreasonable catching.

Europeans governments, through the Common Fisheries Policy together with environmental NGOs such as Greenpeace advocate a more sustainable behaviour for the simple survival of the North Sea essential ecosystem.

Offshore oil platforms are the symbol of the petroleum industry in the North Sea. Mythic image of a towering hyper structure painted with vibrant colours, decorated with helipad and derricks, they are symbol of roughness and associated with danger, pollution and globalization.

[1] The North Sea Atlas
[2] Rescuing the North and Baltic Seas: Marine Reserves - a key tool, Greenpeace, July 2004
[3] Ekofisk I disposal: Impact Assessment Environmental and Societal Impacts, 2000, Introduction

"I'm no prophet. My job is making windows where there were once walls."
Michel Foucault

What will happen to those incredible structures when fossils energy will run off ? Do those obsoletes heterotopias of the industrial age deserve the same fate as coal mines before them ?

The New North Sea Project envisions the poetic reconversion of the billion dollar Ekofisk Oil rigs complex into a marine protection centre. Taking inspiration from the precursor novel Utopia from Thomas More[4] and the phylosophy of Heterotopias by Michel Foucault [5], the project depicts -as in both precedents- the idea of a counter space that evolves in the fringe of our society while being intrinsically linked to its proper functioning.

Fed by pop culture proposals from the 1960's such as Instant City and the work of Archigram [6], the project investigates the joyful re-appropriation of space by its inhabitants through the principle of self-building, thus actualising the question raised by Yona Friedman[7] in the 1970's about the traditional role of the architect.

In those time of crisis, the position of the architect is changing. From planner, designer or organizer, it becomes consultant, bringing its construction, spatial and ecological knowledge to the community.

The New North Sea Project, located amongst these abandoned oilrigs, will become a hub for marine activities in the North Sea. Dedicated to bio-energy production and the protection of marine wildlife. This sea base will host volunteers, providing adapted living and working infrastructures and technologies for the establishment of a self sustained community in the open sea.

It proposes an architectural framework for a further domestic appropriation of this industrial infrastructure. Although involving a minimal heavy engineering stage -that will be provided by the oil company as a cheaper disposal alternative- the rest of the work will be done by the volunteers thanks to the establishment of cheap, low-tech and man-manageable elements

Accommodation and food are developed through the concept of coupling prefabricated 'beach hut' and 'greenhouse' that will work as an integrated system to provide year-round accommodation and food via hydroponics.

The main energy resource of the city is provided by a large-scale micro-algae culture that will fulfil the needs for both boats patrols in the North Sea and comfort -heating, hot water… for the base.
The farming consists in the deployment of floating growth modules where an adapted strain of micro-algae will grow in recycled plastic foils, attached to boat fenders made of recycled rubber.

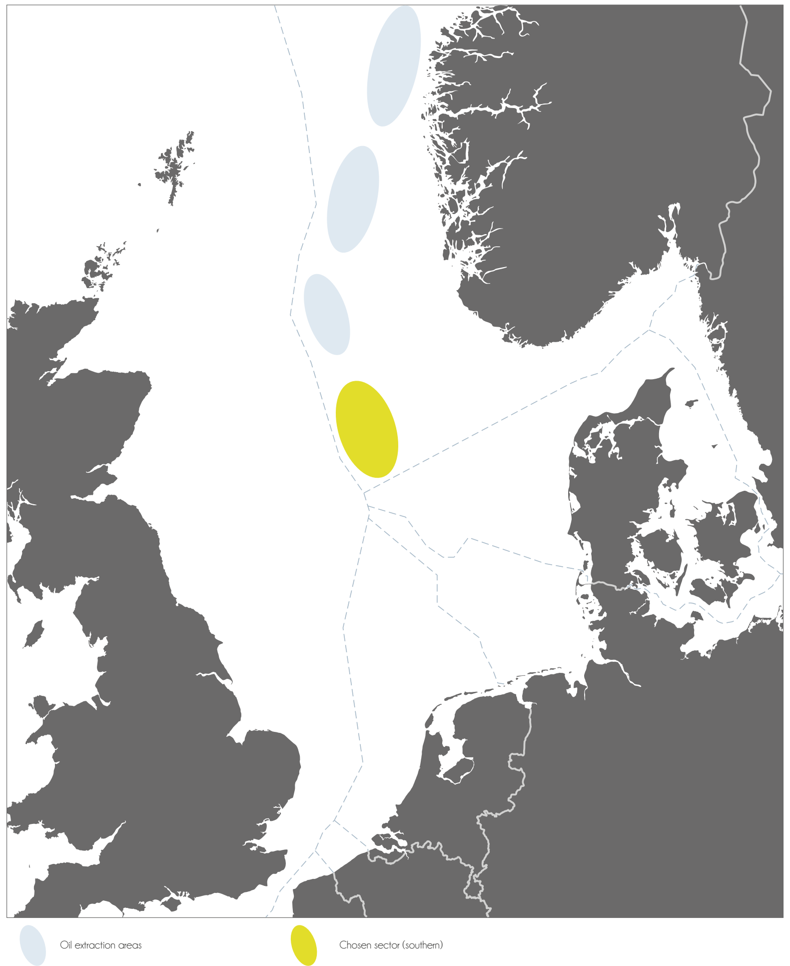
The proposal plays on the poetic duality in the transformation of this unsustainable infrastructure into a ecologically friendly community. As a symbolic gesture, the architecture serves a purpose beyond aesthetics, formal or spatial considerations. The project takes the opportunity of a potential new land to imagine a urban paradigm based on contemporary environmental and ethical concerns.

Decentralisation of activities together with extensive urbanisation and retail development has led to a gap between production and consumption. Consumerism promoted the globalization of society. However, behaviours go in favour of the self-built and prefabricated architectural components. People are building, modifying, or repairing without the aid of experts or professionals. People are undertaking home improvement and various other small craft together with construction projects as both a creative-recreational and cost-saving activity.

The projects demonstrates how a simple, direct strategy regarding re-use and rehabilitation can lead to a highly tailored, differentiated architectural language. The expedient use of appropriate technology in the reuse of the Ekofisk oil platforms for a very different purpose has lead to the development of a playful, expressionist architecture that, whilst having very different drivers, has some parallels with the utopian work of Peter Cook and Archigram while echoing the investigations of Yona Friedman.

Thus, it questions the position of the architect in regards to the empowerment of the individual choice. The role of the architect must adapt those constraints, choreographing the spatial framework, where architecture becomes the canvas for individual expression and domestic appropriation.

[4] Thomas More, Utopia, 1516
[5] "Of Other Spaces: Utopias and Heterotopias" by Michel Foucault.
[6] Archigram : architecture without architecture, Simon Sadler, Cambridge, Mass.London : MIT, 2005
[7] Yona Friedman, Utopies réalisables, Paris, L'Éclat, 2000



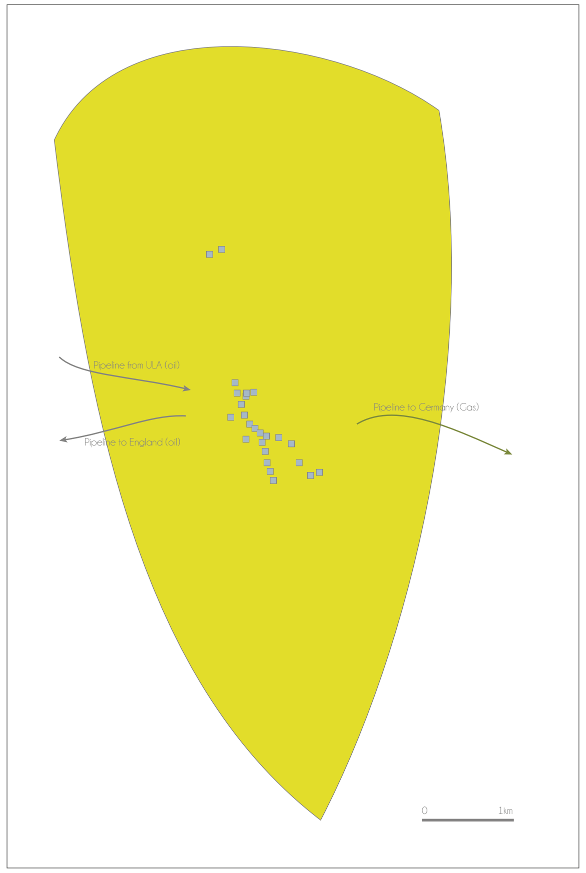
Norwegian Oil extraction areas

The Phillips Norway Group (PNG) discovered the Ekofisk Field, located in the southern extration sector (Left) in 1969. The development of Ekofisk and nearby fields (below) transformed Norway into an oil and gas nation. The infrastructure in the Ekofisk Area has evolved continuously over the last twenty-five years, and today the Ekofisk Area has the highest concentration of offshore facilities and pipelines in the North Sea.

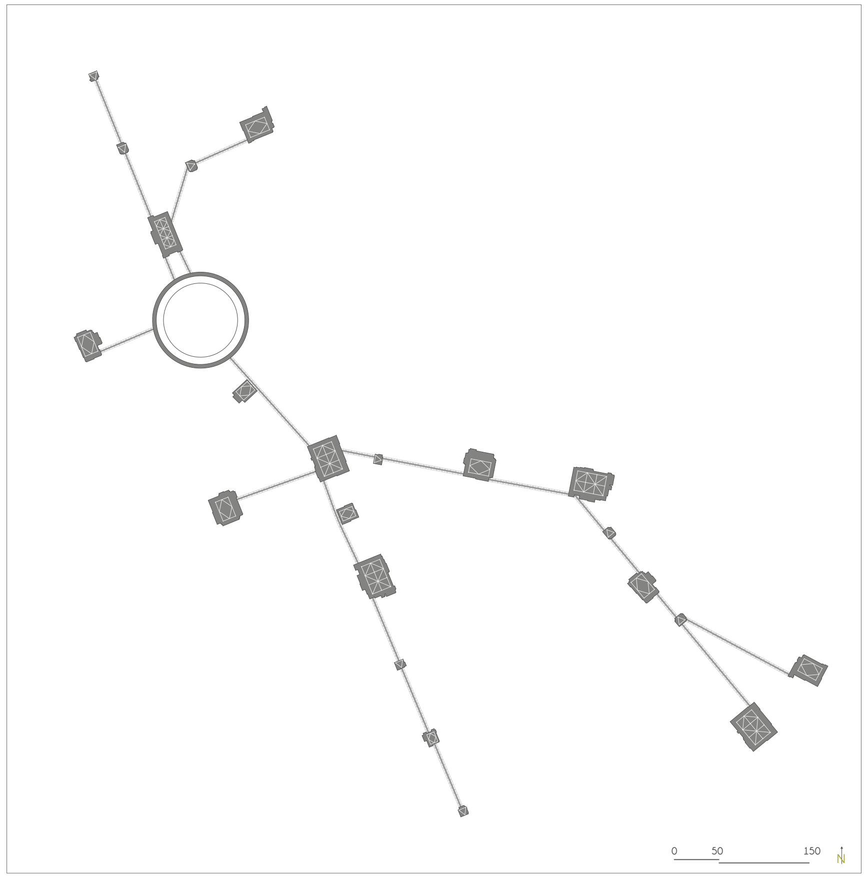
The development and operation of the Ekofisk Area fields, however, has not been without challenges. In the mid-1980's, the PNG observed that the seabed at Ekofisk was subsiding. To combat the effects of subsidence, the PNG elevated six platforms at the Ekofisk Center by six meters in 1987. In 1989 the PNG floated a concrete Protective Barrier Wall (PBW) in two parts to the field and installed it around the concrete Ekofisk 2/4 Tank to protect it against increased wave loads resulting from subsidence. [8]

Despite the mitigating actions taken to combat subsidence, by the early 1990's the Ekofisk facilities (first right) were showing their age, operating costs were rising, and new safety requirements for continued use of the Ekofisk Tank facilities and continued seabed subsidence presented uncertainties about the future. As a result, the PNG, in consultation with the Norwegian Authorities, decided to redevelop the facilities at the Ekofisk Center. The new facilities – known as «Ekofisk II» – were completed and put into use in August 1998. Ekofisk II will allow production of the Ekofisk Area long into the next century to the benefit of the PNG and Norwegian society.

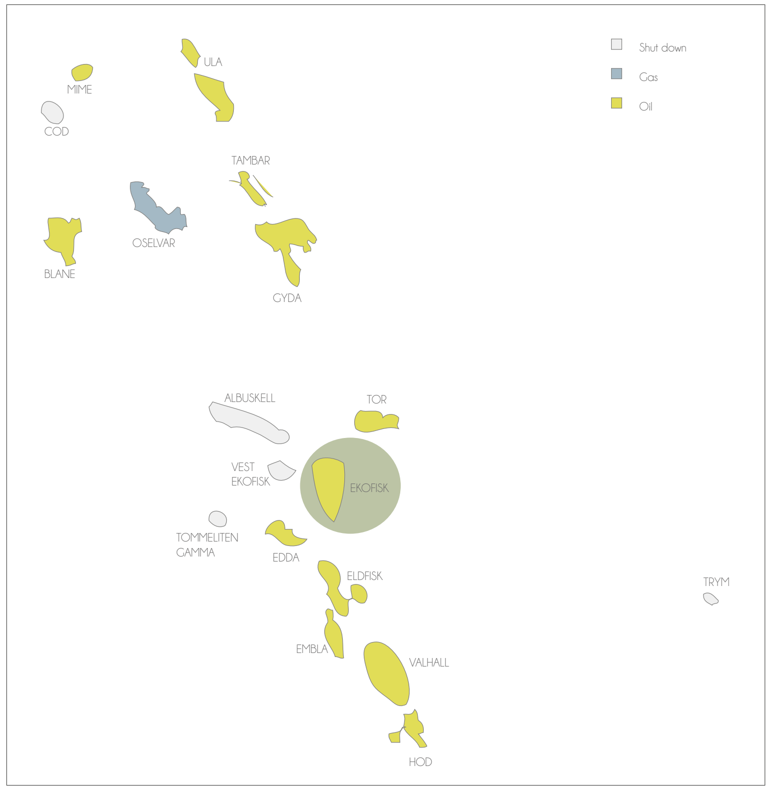
As a result of subsidence and the Ekofisk II (top right) development, and the fact that several outlying fields have reached the end of their economic life, thirteen platforms in the Ekofisk Area – twelve steel structures of varying sizes and the 2/4 Tank and its Protective Barrier Wall – are or will become redundant over the next fifteen years. Two additional steel platforms on the Norpipe Oil Pipeline are also redundant, and thus a total of fifteen redundant offshore structures require disposal solutions. [9]



The Ekofisk Field map



The Ekofisk Complex map



Fields in the southern sector

[8] Ekofisk I disposal: Impact Assessment Environmental and Societal Impacts, 2000 ,p9
[9] Ekofisk I disposal: Impact Assessment Environmental and Societal Impacts, 2000 ,p9

//CONCEPT

Due to very particular weather conditions and security reasons, every part of the program is placed above the “safety” zone of 20 meters. The living and working areas are often separated between different platforms and are prefabricated monolithic elements with few windows and outdoor spaces. The relationship with the outside is almost non-existent.

The verticality of the structures creates a strong opposition to the wind and blocks the sunlight, thus creating indoors self centred spaces.

Moreover, nothing is happening in this established “safety zone”, even though this space could be used most of the time.

The architecture is designed to resist against the possible drastic conditions of the site. It is strong and resistant but without any regards towards the potential of its location.

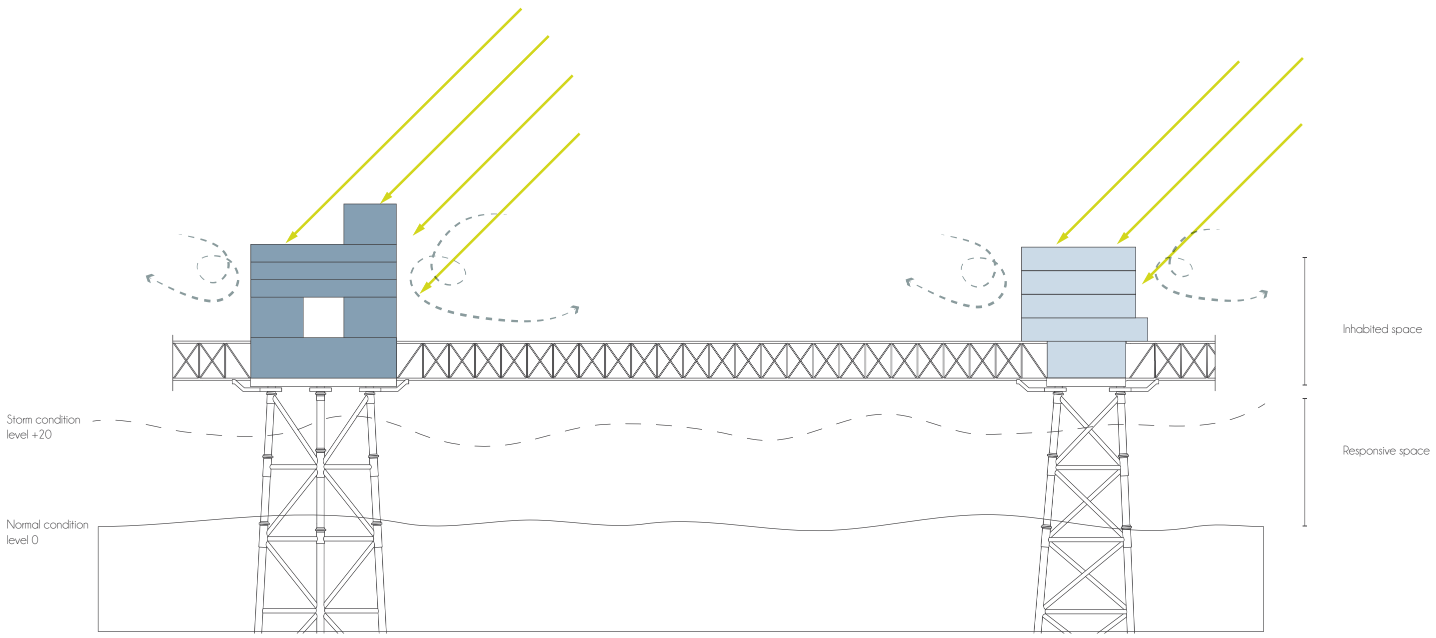
Breaking the verticality was a very important aspect of the concept. The platforms are left empty for outdoor spaces while the bridges become main communication axis and living clusters.

The horizontally brings a more evenly spread light and doesn’t create opposition to the wind, allowing the use of passive technologies for heating and cooling.

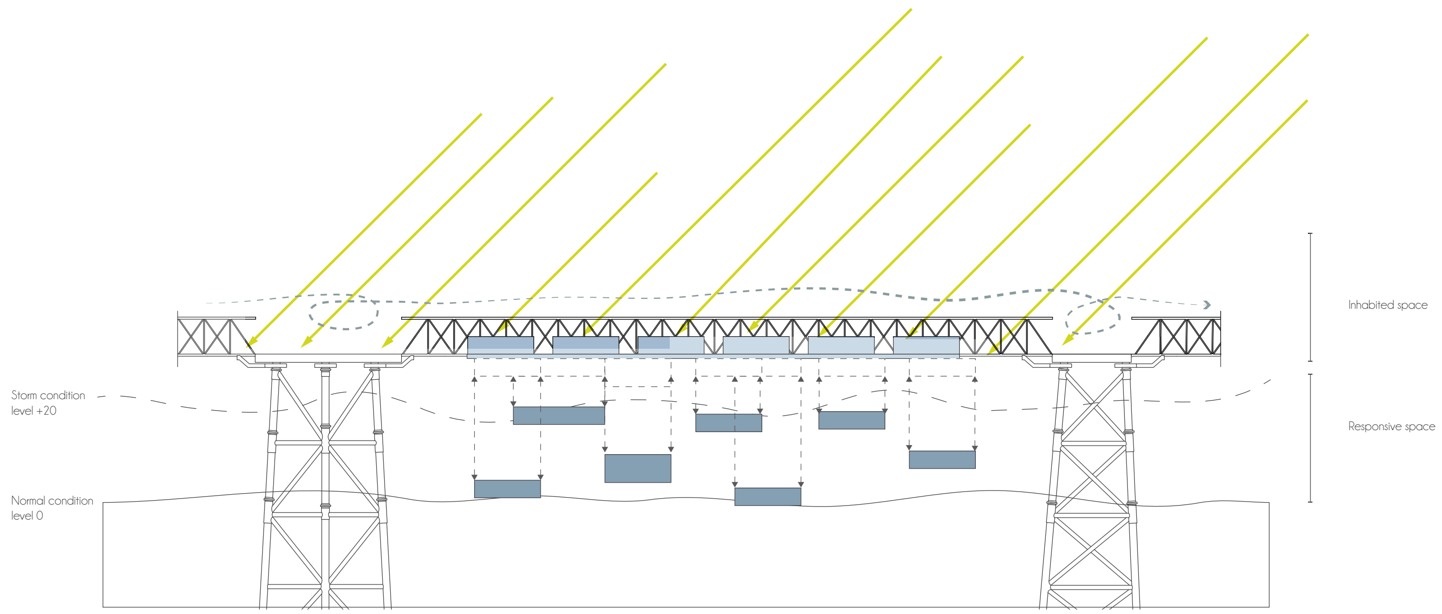
Living units are deployed along the bridges while the communal activities take place in the layer under, as a three dimensional interactive space.

The “safety zone” can be appropriated, bringing the possibility of a strong relationship with the water. The different elements can be lifted or lowered depending on the weather conditions.

The architecture is designed to interact with its environment, taking maximum advantages of it while being able to protect from it when necessary. It is resilient and responsive.



Architectonic diagram of the actual infrastructure



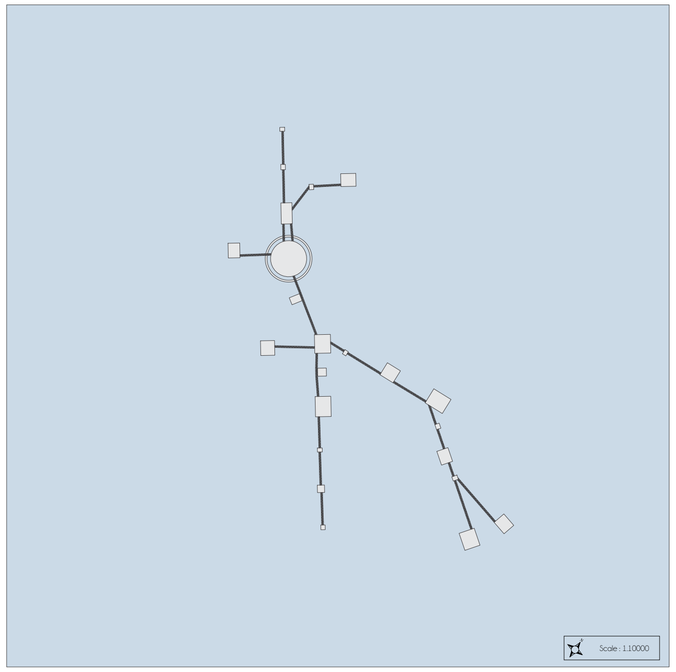
Concept proposal diagram

Living

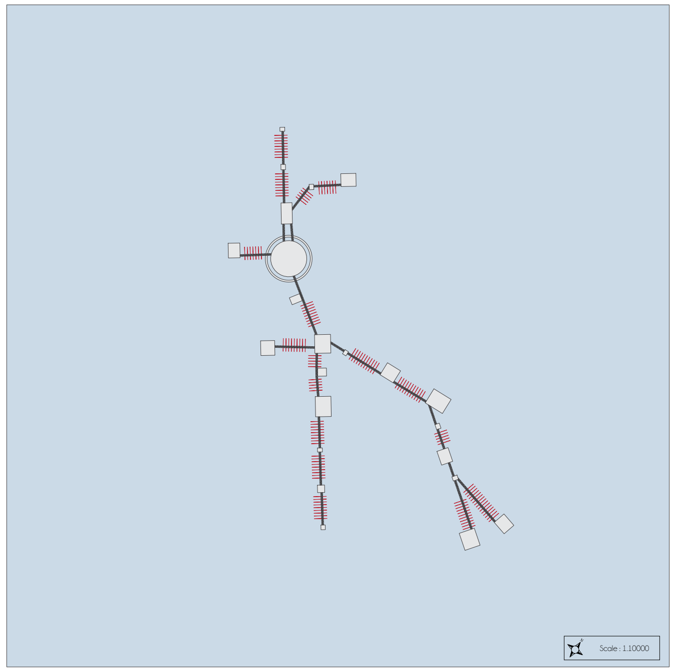
Working

///CONSTRUCTION STAGES

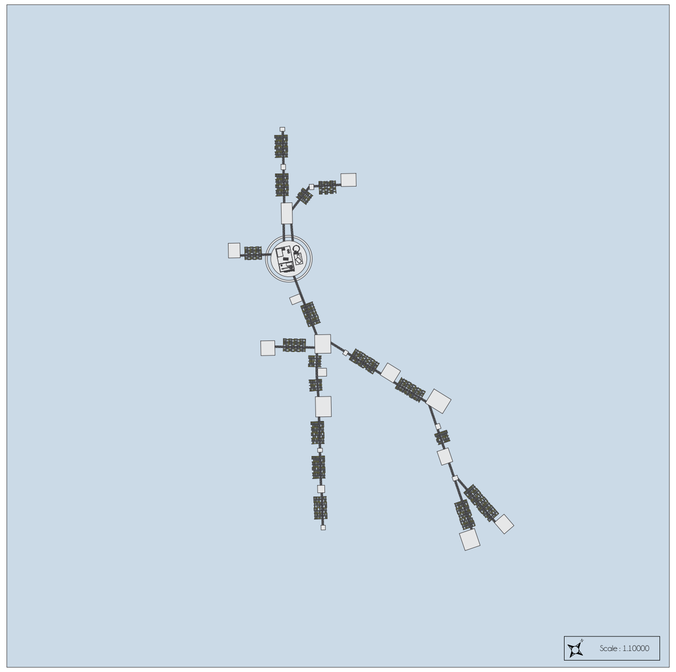
STAGE 0 : Abandoned facilities



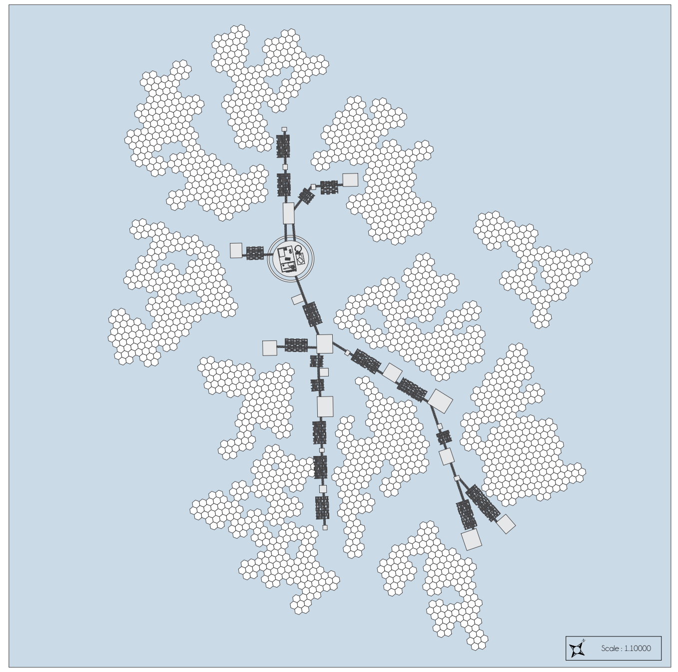
STAGE 1 : Transversal beam structure addition

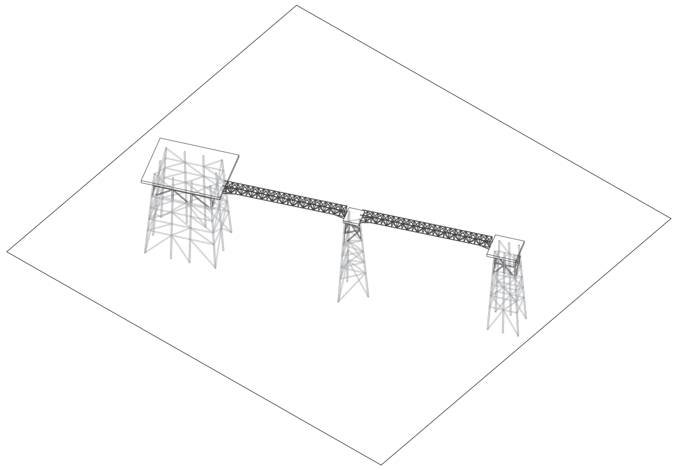


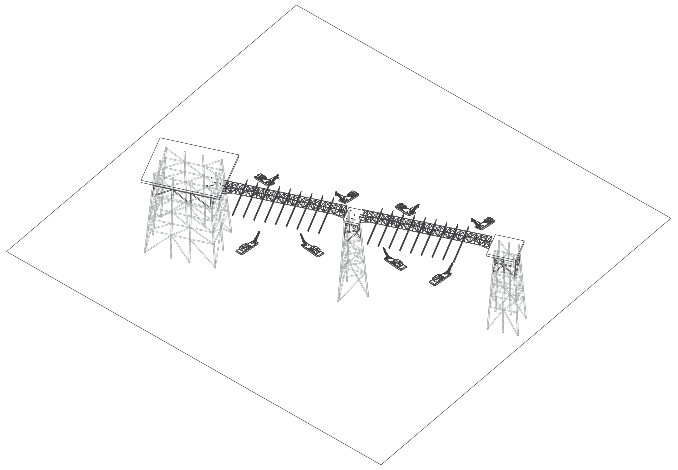
STAGE 2 : On site assembly

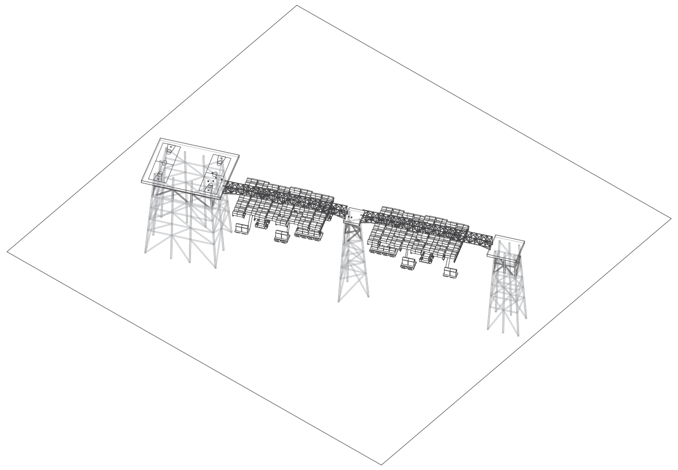


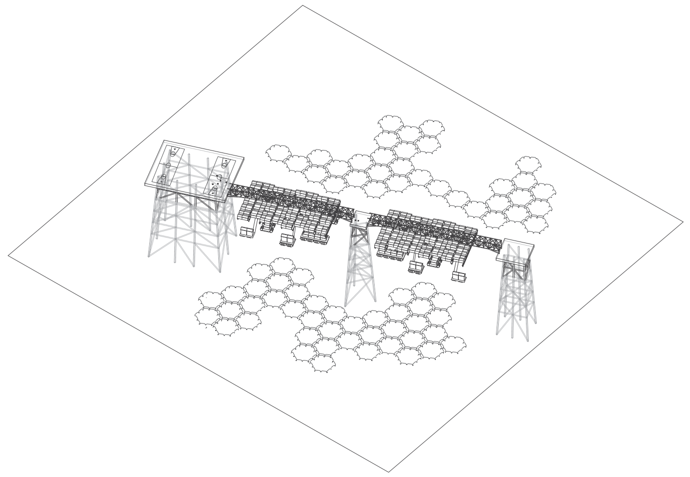
STAGE 3 : Farming



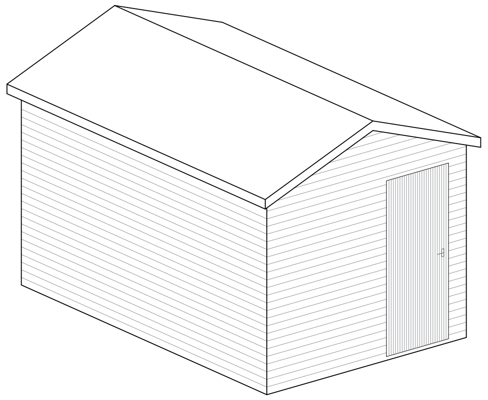




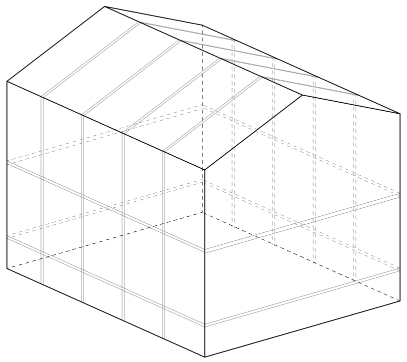




////LIVING UNIT



Living space



Greenhouse

Construction elements :

1: Transversal 35x2m Warren Beam 300x100mm
2: Secondary I beam 200x100mm
3: Tertiary timber structure 200x50mm

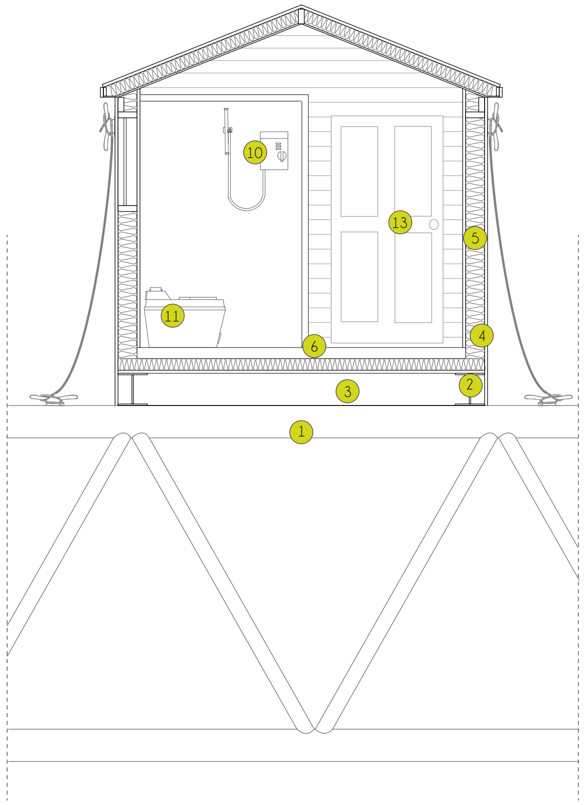
4: Reinforced Timber Frame Beach Hut 75x50mm
5: Cellulose insulation from newspaper 18mm
k= 0.035 W/mK
6: Brick floor(high thermal inertia)

7: Steel frame
8: Polycarbonate panel 4mm
k= 0.19–0.22 W/mK
9: Roof Ventilation

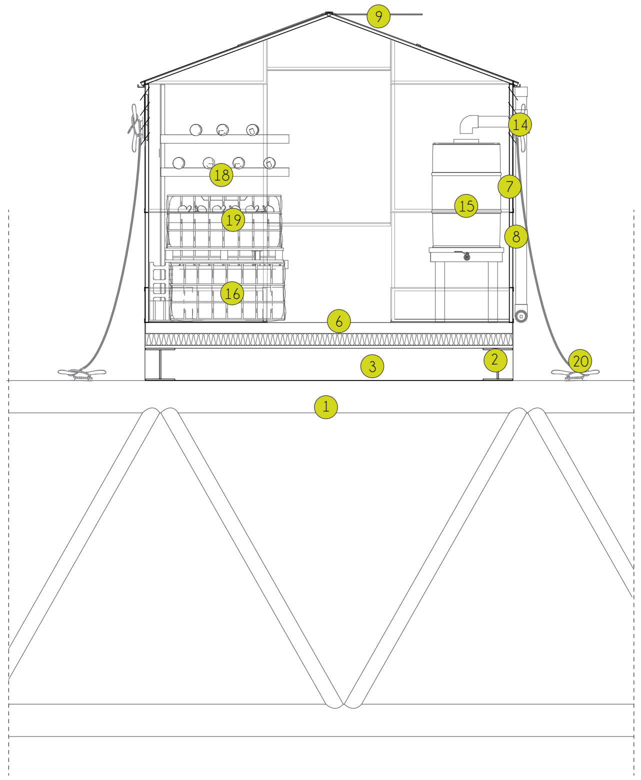
Furniture :

10: Camping shower + Hot water device
11: Composting toilet 12: Bed + drawers
13: Communication door

14: Rain water catcher
15: Water storage
16: Water pump
17: Water filter
18: Dripping system
19: Culture tanks



Transversal section through Beach Hut 1.50



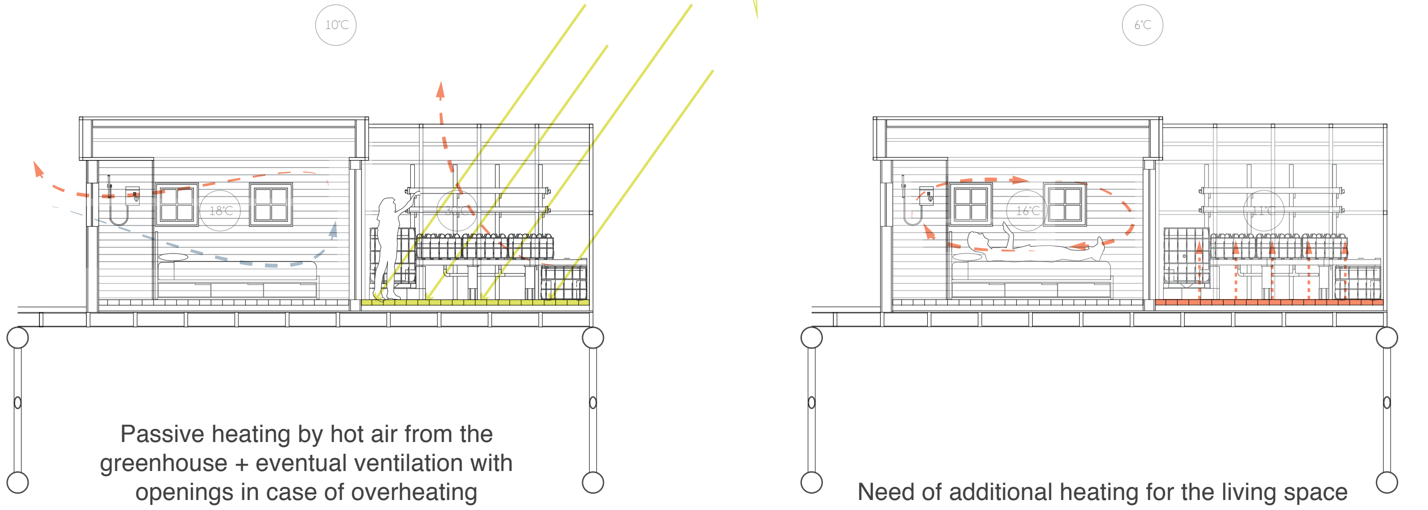
Transversal section through Greenhouse 1.50

Longitudinal section 1.50

/////PASSIVE STRATEGIES

Sunligh Conditions	Good		Average		low		Night	
Month	Average temperature out (C°)	Average temperature in (C°)	Average temperature out (C°)	Average temperature in (C°)	Average temperature out (C°)	Average temperature in (C°)	Average temperature out (C°)	Average temperature in (C°)
January	6	30	6	15	6	11	0	5
February	5	31	5	17	5	11	0	5
March	6	32	6	20	6	13	1	6
April	8	32	8	22	8	15	2	7
May	10	30	10	23	10	17	3	8
June	13	30	13	24	13	19	5	10
July	15	31	15	27	15	20	7	12
August	16	33	16	27	16	21	9	14
September	14	33	14	25	14	19	5	10
October	11	32	11	22	11	15	4	9
November	9	29	9	17	9	13	3	8
December	7	28	7	14	7	11	2	7

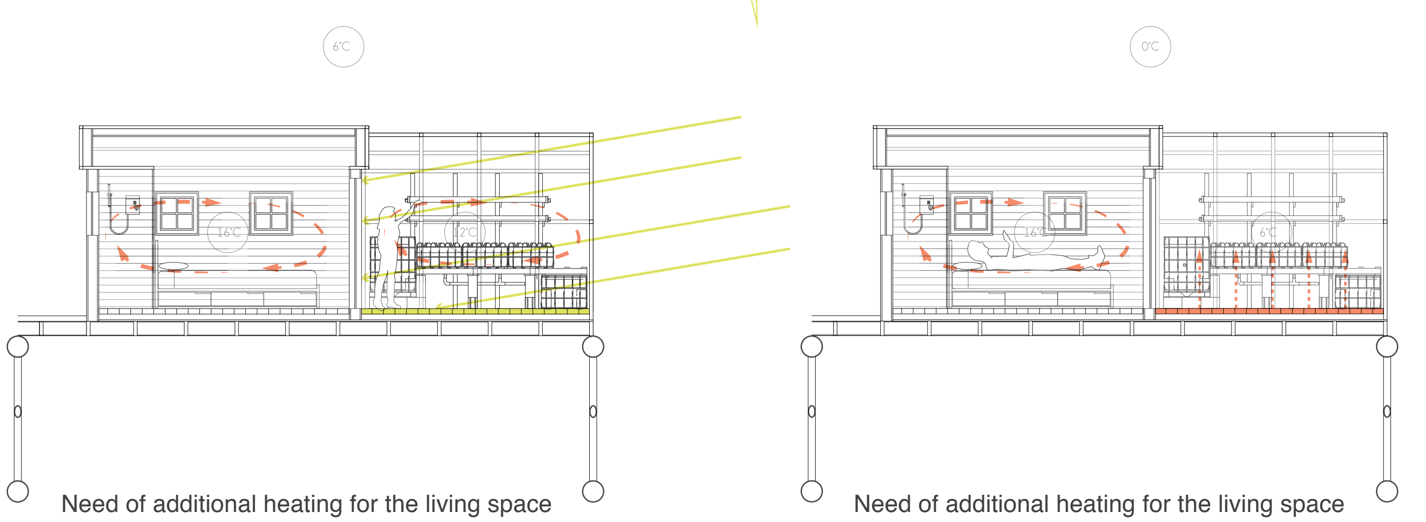
Vegetable growth :
Cucumber
Squash
Green beans



Environmental diagram :Hot season

Sunligh Conditions	Good		Average		low		Night	
Month	Average temperature out (C°)	Average temperature in (C°)	Average temperature out (C°)	Average temperature in (C°)	Average temperature out (C°)	Average temperature in (C°)	Average temperature out (C°)	Average temperature in (C°)
January	6	30	6	15	6	11	0	5
February	5	31	5	17	5	11	0	5
March	6	32	6	20	6	13	1	6
April	8	32	8	22	8	15	2	7
May	10	30	10	23	10	17	3	8
June	13	30	13	24	13	19	5	10
July	15	31	15	27	15	20	7	12
August	16	33	16	27	16	21	9	14
September	14	33	14	25	14	19	5	10
October	11	32	11	22	11	15	4	9
November	9	29	9	17	9	13	3	8
December	7	28	7	14	7	11	2	7

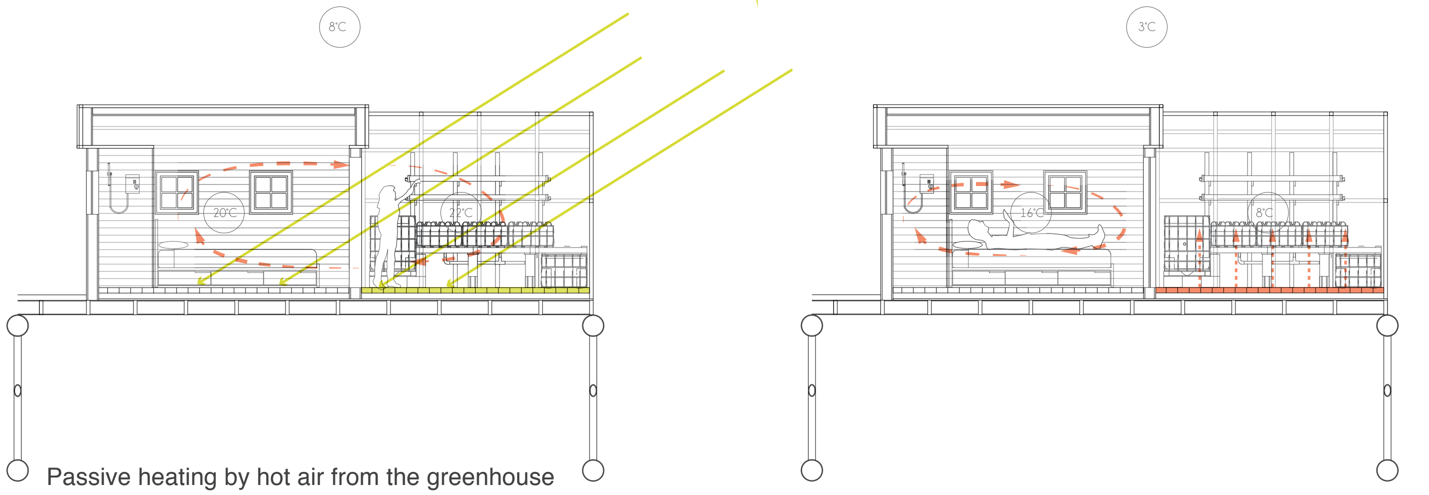
Vegetable growth :
Potato
Green peas
Cabbage



Environmental diagram : Cold season

Sunligh Conditions	Good		Average		low		Night	
Month	Average temperature out (C°)	Average temperature in (C°)	Average temperature out (C°)	Average temperature in (C°)	Average temperature out (C°)	Average temperature in (C°)	Average temperature out (C°)	Average temperature in (C°)
January	6	30	6	15	6	11	0	5
February	5	31	5	17	5	11	0	5
March	6	32	6	20	6	13	1	6
April	8	32	8	22	8	15	2	7
May	10	30	10	23	10	17	3	8
June	13	30	13	24	13	19	5	10
July	15	31	15	27	15	20	7	12
August	16	33	16	27	16	21	9	14
September	14	33	14	25	14	19	5	10
October	11	32	11	22	11	15	4	9
November	9	29	9	17	9	13	3	8
December	7	28	7	14	7	11	2	7

Vegetable growth :
Tomato
Carrot
Lettuce
Beet



Environmental diagram :Mid season

Fresh water supply

Fresh water management is a difficult resource in an open water context. From desalination to consumption, every step has to be thoroughly thought. The strategy is to work within the clusters to fulfil the need in a small scale. Minimizing the needs by limiting the consumption is vital.

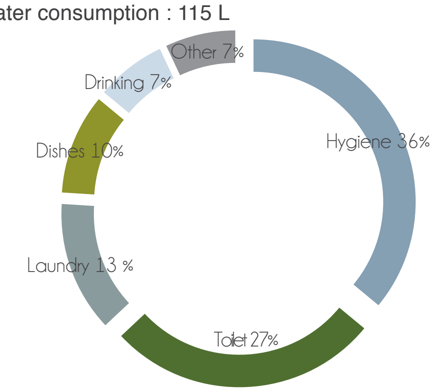
Therefore, toilets are dry, vegetables are grown in hydroponics -using as much rainwater as possible, food is managed for the community and individual use is limited.

For its low Denmark will be taken as reference for the amount of fresh water consumed :
115 L per capita per day.

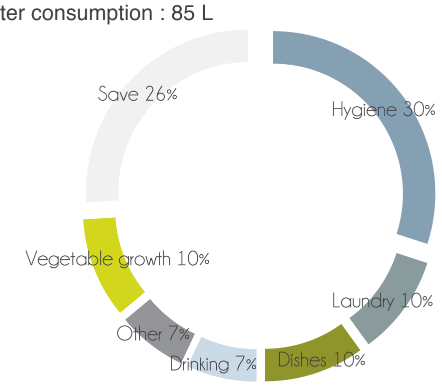
By suppressing the use of water in the toilet, and setting up individual water restrictions, the amount of water needed is reduces by 26% even by adding the average needs of water for hydroponic growth.

Basically, 85L of fresh water per inhabitants will be needed.

Normal water consumption : 115 L



Aimed water consumption : 85 L



The push for alternatives to petroleum fuels has forced researchers to look for highly productive, renewable, non-food resources. The global market for biodiesel has been growing rapidly during the past few years, and it is poised for explosive growth in the next years. However, the lack of oil feedstocks limits the large-scale development of biodiesel to a large extent. Recently, micro-algae have attracted increasing attention due to their many advantages for biodiesel production. Compared to traditional feedstocks such as rapeseed and soybean, micro-algae can rapidly grow on non-agricultural land or in brackish water with high oil content and rapid growth rate (see talbe).

Therefore , the proposal investigates a low technology and cost design based on existing research that works with a local strain of algae. The Phaeodactylum tricornutum is a micro-algal specie growing in the water of the North Sea. It has been subject of scientific interest for its promising properties in terms of oil content and yields. [11]

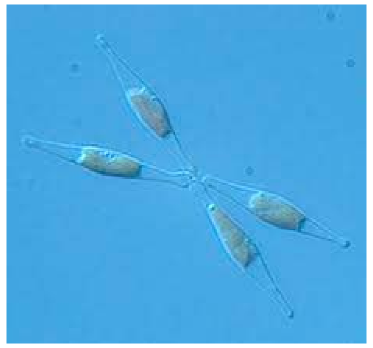
Strain	Maximum Cell Density (Cells per mL)	Time to maximum Cell density (days)	Oil yield (mg)	Oil content (%)
Phaeodactylum tricornutum	10,782,316.48	8	97.5	45.93

Phaeodactylum tricornutum data table

Although algae live in water most of the actual technologies are land based. Two land-based methods used today are open ponds and closed bioreactors. Open ponds are shallow channels filled with freshwater or seawater, depending on the kind of algae that is grown. The water is circulated with paddle wheels to keep the algae suspended and the pond aerated. They are inexpensive to build and work well to grow algae, but have the inevitable problem of water evaporation. To prevent the ponds from drying out or becoming too salty, conditions that kill the algae, an endless supply of freshwater is needed to replenish the evaporating water.

Yields for different feedstock [10]
(Gallons of oil per acre per year)

Corn	18
Soybeans	48
Safflower	83
Sunflower	102
Rapeseed	127
Oil Palm	635
Micro Algae	5000-15000



Phaeodactylum tricornutum

An algal bloom in the north sea

Open ponds [12]

Open ponds are trenches or levees in the ground constructed as "racetracks" filled with water where algae culture is inoculated in order to assure maximum algae cell growth. This is done by continuously circulating the algae water media, injecting carbon dioxide and supplying nutrients. Paddle wheels provide the flow of the "racetrack". These ponds should be kept shallow in order to allow sunlight to penetrate in full depth, reaching the maximum number of micro-algae cells. These ponds are operated in such a way that new water and nutrients would be fed daily into it, while water with high algae densities would be harvested daily to keep media translucency at a set level.

Open ponds drawbacks :

- More difficult to sustain Commercial Production yields due to lack of control of parameters such as Temperature, Sunlight, Contamination of rival species, etc
-Difficulties for oil-extraction planning due to yield variability
- Can only be deployed in specific locations with adequate solar irradiation, temperatures and fresh water sources (need fresh water)
-These systems could not be suitable for food due to contamination by biological and air contaminants

Photobioreactors [13]

A photobioreactor (PBR) is a device that provides a suitable environment for optimum algae growth, supplying light, nutrients, air, and adequate temperature to the algae cells at all times.
Photobioreactors are usually made of clear vessels where the algae culture is closed to the environment having no direct exchange of gases and contaminants with the external environment. The algae culture is fed with CO_2, nutrients and light and agitated by mechanical means to move algae cells and expel Oxygen. It usually has airlocks that allow the escape of Oxygen but block the entrance of external air or contaminants. Its light source could be artificial for indoors or natural light for outdoors.

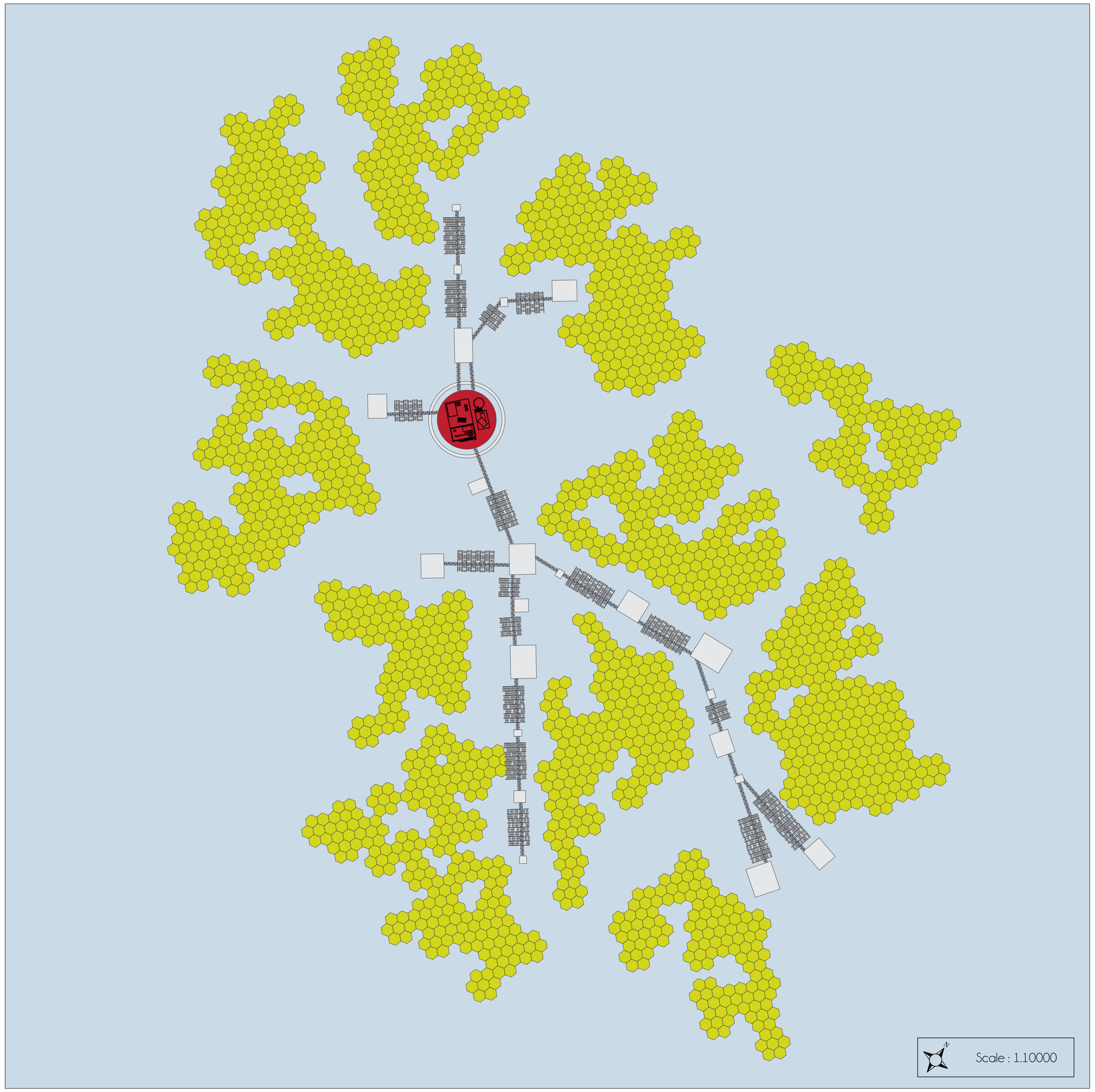
Photobioreactors drawbacks :

-Capital cost is very high. This is one of the most important bottlenecks that is hindering the progress of algae fuel industry.
-Despite higher biomass concentration and better control of culture parameters, data accumulated in the last two decades have shown that the productivity and production cost in some enclosed photobioreactor systems are not much better than those achievable in open-pond cultures.
-The technical difficulty in sterilizing these photobioreactors has hindered their application for algae culture for specific end-products such as high value pharmaceutical products.

[10] http://www.oilgae.com/algae/oil/yield/yield.html
[11] The effect of nitrogen deprivation on the growth, oil yields and fatty acid production of the diatoms Phaeodactylum tricornutum and Nitzchia sp. in laboratory cultures, Yuval Kulinsky, Southern Cross University 2009

[12-13] Basic Information on Algae Production Systems, Jose L. Sanchez Piña, June 2011

///////LARGE SCALE FARMING



Diagrammatic Masterplan

Refinery + Storage	(lvl 0, +20)
Algae farm	(lvl +20)
Sea	(lvl 0)

Assumed data

Knowing that the Ekofisk Complex is located in a similar climatic context as Denmark, we will use existing data to prove that the energetic strategy envisioned by this project is viable.

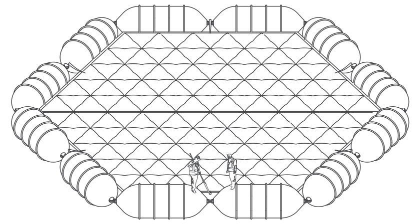
In 2011, the Danish energy use (kg of oil equivalent per capita) was about : 3200. [14]
.
Knowing that 800 people can be hosted in the NNS

3200x800 = 2.560.000 kg of oil equivalent
2.560.000x0,8 (density) = 2.048.000 L of oil

Thus the amount of energy to fulfil the needs of the population in terms of energy is about 40%.

Therefore, around 60% of the total of biofuel produced by the community can be used for :
- The monitoring of the north sea (powering the boats)
- Sustaining the city operation
- Storage (and eventual trading)

[14] http//data.worldbank.org/indicator/EG.USE.PCAP.KG.OE



Data for 1 farm

Capacity
- 210 m^2 of culture
- 15 m^3 volume
- 15 000 Litres

Yields [15]
- 70g of biomass per m^2 per day
- 1kg of biomass = 500 ml of biofuel
- 1 farm produces about 15kg of biomass per day
- 1 farm produces about 7,5L of biofuel per day

Data for 2025 farms (total)

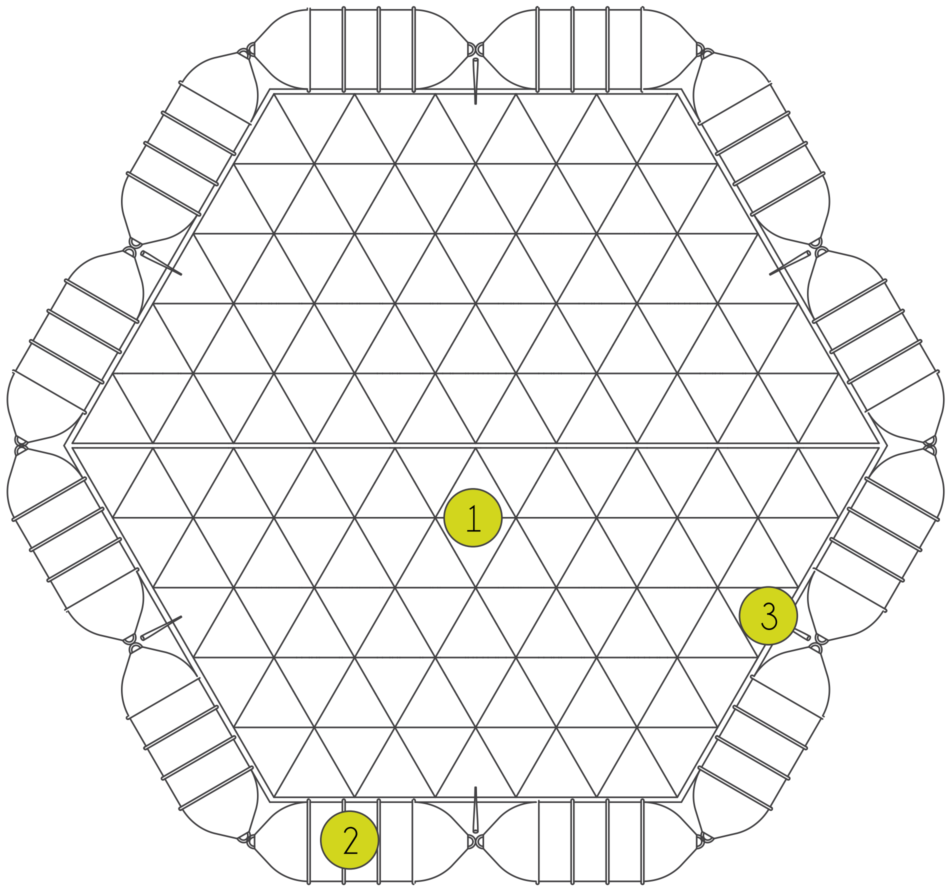
Yields

- 15.200L of biofuel per day
- 5.500.200L of biofuel per year

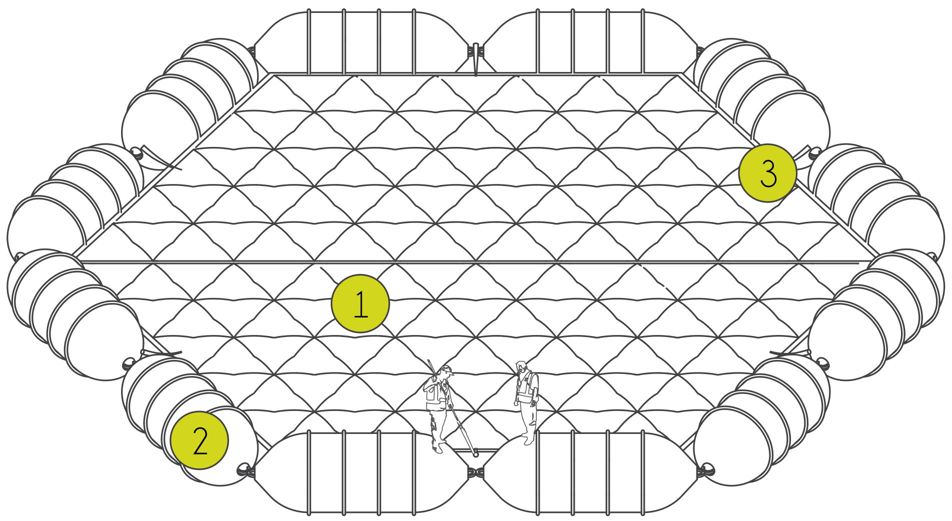
[15] Estimations on existing technologies from Algasol and Origin Oil

Energy use repartition

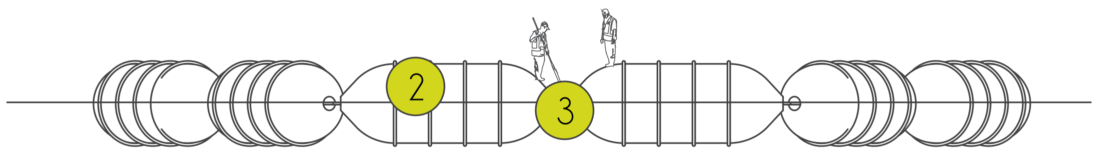
Self operation	10%
Marine operation	40%
Heat	20%
Electricity	20%
Storage	10%



Plan of algae farm 1.200



Axonometry of algae farm 1.200



Elevation of algae farm 1.200

It is a simple, but elegant concept. Floating on the sea surface, the inexpensive plastic bags will be collecting solar energy as the algae inside produce oxygen by photosynthesis. The algae will feed on the nutrients in the sewage, growing rich, fatty cells. Through osmosis, the bag will absorb carbon dioxide from the air, and release oxygen and clean water. The temperature will be controlled by the heat capacity of the sea, and the waves will keep the system mixed and active thanks to the use of resilient materials.

When the process is completed, biofuels will be made and sewage will be processed. For the first time, harmful sewage will no longer be dumped into the ocean. The algae and nutrients will be contained and collected in a bag. Not only will oil be produced, but nutrients will no longer be lost to the sea.

1 Reinforced high density polyethylene (HDPE) Membrane

It is the plastic used for most inflatable structures, very resistant and resilient.

HDPE is also the most-often recycled plastic, , into plastic lumber, tables, roadside curbs, benches, truck cargo liners, trash receptacles, stationery and other durable plastic products and is usually in demand.

The micro-algae will grow in a media with sea water and sewage in a membrane inspired by ice cube plastic bags for the required time (8days) and then be harvested for processing into biofuel.



2 Marine fender

Massive rubber fenders, originally designed for avoiding boats to get damaged in harbours will be use to enclose the farms, thus making individual modules able to be harvested one by one. They will create a path on which the operators can walk to plug the boat pumps for filling or extracting the algae culture.

The high resistance and floating capacity of the material will make the farms embrace the movement of the waves and thus keep the culture mixed.


3 Fill / Extract pipe connector

As the membrane works like an ice cube bag, it needs to be filled with the growing media (Algae + Sea water + Sewage). This will be done by plugging the pump from a boat to the farm through this connector that works as a watering hose connector
.
After the required growing time (8days), the boat will plug to the farm again and harvest the media for then transport it to the processing refinery to be transformed into biofuel.