FLEXIBLE AND ENERGY SELF-SUFFICIENT FLOATING CITIES IN THE NORTH SEA

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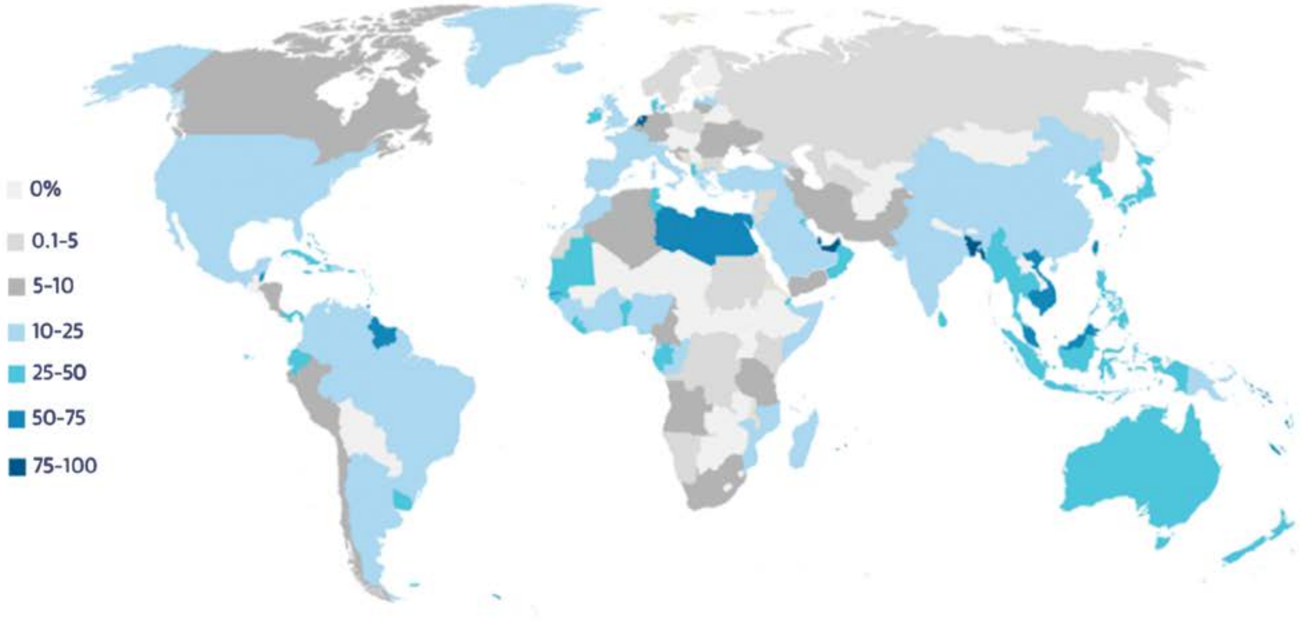
A warm thank you goes to my family, for giving me the opportunity to live this beautiful experience and for always supporting me in cheerful and difficult times.

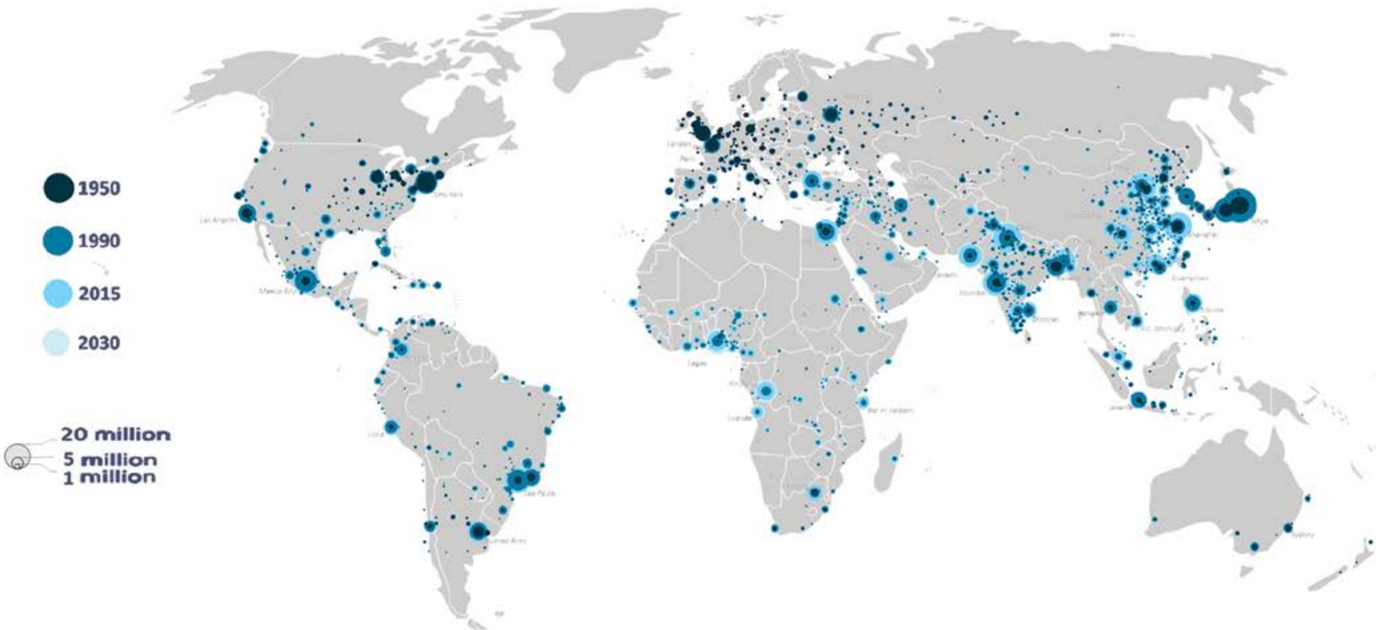
Last but not least, I would like to thank my friends, for being the most caring second family I have ever had abroad.

Delft, 4th November 2018

INTRODUCTION



Percentage of population at risk for Sea level rise
Data source: Nature climate change



Urbanisation rates
Data source: United Nations world urbanisation prospects 2014

WHY FLOATING CITIES?

Since late 18th century, urban population has been grown exponentially, to the point that is expected that by 2050, 64% to 86% of the world population will leave the countryside to settle in urban environment. Excluding seas, only one-eighth of earth surface is supposed to be suitable for humans to live in, and despite the fact we are currently occupying only 5% of it, the amount of available building ground in the vicinity of urban settlements is lacking. Often when countries and cities don't have space to build facilities for the fast growing population, they try to extend to the sea with the use of land reclamation. Unfortunately land reclamation is not always feasible, either because the water depth is too high or because there is not enough available sand for it. On the other hand, while increasing urbanization faces architects and engineers with a new problematic, global warming represents another issue designers should consider for future and present days project. As anticipated effects of the global average temperature rise, we are expecting sea level rise, deserts expansion and change in precipitations, with severe rainfall that can put cities facing water at a higher risk of floods.

Both increasing urbanization and climate change are encouraging architects and engineers to use water as building land, adopting floating structures as a favorable solution. Floating architecture not only could help coastline cities to develop through seas and face sea level rise, but presents many other positive aspects that can't be ignored. Some of them include safety in case of hurricanes and floods, sustainable energy solution through water (e.g. wave energy), flexible urban components and the possibility to move the structure according to the outside environment conditions. All this aspects make architects believe that sooner or later, building on water will become part of standard architectural planning, in the same way high rise buildings became a typical feature of fast growing cities in the 20th Century.

FLOATING COMMUNITIES

Floating architecture is not something new, examples can be found all over the world in smaller and bigger scales. Floating villages have been present from centuries in South-East Asia and South America, with dwellings made on top of rafts or boats. In Europe the first examples of people living on boats can be found in Amsterdam from the 17th century onwards, with the first mooring permit for houseboats in the early 20th century.

There is however a difference between houseboats and floating dwellings, as the second are proper buildings set on a floating foundation, either made out of steel or more commonly, concrete. Such floating houses have been increasingly spreading in the past 40 years, first in North America and then in Europe, especially in the Netherlands. Moreover, according to Koen Olthuis, one of the promoters of floating architecture, expanding the urban fabric of cities in need of space, through water, can be a well-accepted reality by the next 20 years[1].

What about entirely floating cities? Besides existing examples of floating neighborhoods (e.g. Ijburg, Amsterdam) the idea of an entirely floating city has been fascinating architects for years and many projects have been designed; most of them, promise self- sufficient settlements with the ability to move according to need. One fascinating example of larger scale, is the design by Vincent Callebaut Architects called "the Lillipad" for a self-sufficient Eco polis, which can stand alone in the ocean. Despite the futuristic and interesting look of this example, according to the Seasteading Institute, autonomous floating settlements could be a reality within the next 5 years[2]. As a matter of fact they are already, in collaboration with DeltaSync, developing a realistic design for a floating community, made out flexible floating components, which can be connected to form the urban settlement.

1 K. Olthuis, D. Keining, *Float! Building on water to combat urban congestion and climate change,* Frame,Netherlands 2010, p. 62

2 The Seasteading Institute, *The Floating City project*, 2014

Floating village of Halong Bay in Vietnam

Houses are built on top pf boats or rafts made out of wood and plastic barrels.

Image source: http://www.vietnamfamousdestinations.com

Houses in the floating neighborhood of Ijburg in Amsterdam

Dwellings are built on floating concrete foundations, have clean lines and a modern look. Most of the construction materials are, wood, steel and composites.

Image source: http://www.waterstudio.nl

Lilypad by Vincent Callebaut Architects

Design of a floating Eco polis for 50.000 climate refugees. Consists of three mountains, three marinas and a central artificial lagoon. Is made out of polyester fibers and titanium dioxide. It includes different forms of sustainable energy production; solar, wind, hydraulic, tidal and biomass. It is supposedly self-sufficient.

Image source: https://www.ireviews.com

The Seasteading Institute in collaboration with Deltasync.

Design of a floating city made out interconnecting concrete platform. Aim of the Seasteading institute is to develop the first floating city with political autonomy.

Image source:the Seasteading Institute, ***The Floating City project***, 2014

FASCINATION

Among the many architectural concepts of floating environments that can be gathered nowadays, particular interest has been developed in the concept of dynamic and energy self-sufficient cities.
The dynamic aspect of a floating city refers to its capacity of changing configuration and move its components according to the varying economic value of a certain location. More specifically, when a city on land grows rapidly, the value of a central location can rise faster than the material value of the buildings sited in the same area; in such scenario, constructions are often demolished before they reach the end of their technical life to make space for other constructions which value meets the value of the location. When the city is made out of flexible and movable components, buildings can fulfill their technical lifespan and cities can have vibrant configurations, with the possibility to change from one zoning model to another.
Moreover, as architects and engineers, it is our obligation to develop sustainable constructions for future developments. In this sense, the model of an autonomous floating settlement could involve a positive investigation in decentralized energy concepts using local and sustainable energy systems.

An open sea environment, could offer the possibility to use more renewable energy systems at one, compared to an inland location. Tidal energy, wave energy, energy from currents and/or from a water temperature difference, are all options that can be added to the well-known and commonly used wind and/or solar energy. These considerations, in theory, give floating cities an increased potential for the use of renewable energy sources which cannot be ignored.

PROBLEM STATEMENT AND AIM OF RESEARCH

It is inevitable to question if the increased potential of an open sea environment could in fact overcome the lack of a 100% reliability of renewable energy sources. As we know such supplies vary their efficiency according to location and weather condition; the presence of water will increase the potential of a location, but not guarantee the self-

sufficiency of an urban settlement in an open sea environment.
Additionally, it is unclear how flexible urban components could be part of a city energy grid or work alone by means of renewable resources.
Lastly, the harsh environment comes with consequences on the durability of the floating constructions and their lifespan could decrease compared to their inland competitors. This could in fact affect the need for flexible urban components, which will need to be as technically valid as they were set on fixed ground.

The aim of this graduation studio is to analyses the parameters that could guarantee an energy self-sustained floating city which is flexible in an urban point of view. The main object of the research is to define weather or not floating cities can realistically be energy self-sustained and in which capacity, by the use of today's renewable energy production systems and by maintaining the positive aspects on floating urbanism allowed by the presence of water.

RESEARCH QUESTIONS AND SUBQUESTIONS

Main questions:
Can a floating city be energetically self- sustained and flexible?

Sub questions:
1. How can a floating city be built?
- Which construction parameters need to be considered when building on water?

2. Which is the energy demand of a small city?
- How can this energy demand be reduced?

3. How and in which capacity can the energy demand be supplied in a sustainable way?
- Can the available renewable energy systems supply the need of a small city?
- In which capacity are the needs met?

APPROACH AND METHODOLOGY

To answer the research questions, this graduation projects aims to develop a simplified model for a small floating city which can give realistic energy need values. These values will be used to gather the analysis on the feasibility of an energetically self-sufficient city by the study of energy supply system available on water that can be used to meet such energy demand. The research is then defined by a first part dedicated on literature study to develop the basic knowledge for floating construction and the design of a simplified model. On such model are applied notions on urban flexibility, sustainable energy, and construction, relatively to the water environment, to reach conclusions and answer the main research questions.

BOUNDARY CONDITIONS

The location of study is set in the Dutch continental shelf, facing the Netherlands, with a distance of 20 to 40 km from the coast, facing the portion of the Netherlands with the major urban population. The idea is that a city could be built, as a consequence of growing urban population from the coast, or for other functions, such as the developments of a new floating airport or growing from existing settlement meant for offshore wind turbines maintenance.
The location is set at a distance from the coast to maximize the renewable energy resources efficiency but with enough proximity to minimize the danger of an open sea environment on an hypothetic floating city.
The area is characterized by a wind speed between 7 to 10 m/s according to season, a maximum wave height of 0.9 m, and a water depth of 20-30 m on average.

Postproducted Nasa satellite picture aquired the 18th December 2004
Source : https://visibleearth.nasa.gov/view.php?id=69721

The simplified city model considers the size of the center of Delft and emphasis is given to one building typology only, for specific energy calculations.

CONTENTS OF THE REPORT

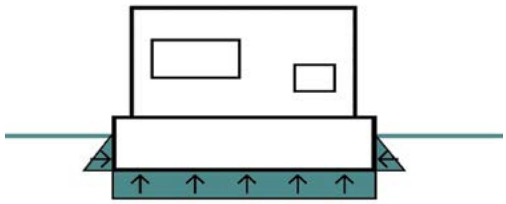
The report is a reflection of a research based on three levels: flexible urban development, energy demand and supply, and floating construction.
The first chapter, “Building on water”, is part of the preliminary research, which aim was to create the basic knowledge necessary to start the graduation studio.
‘Floating urbanism’ is dedicated to the development of urban configuration in open water. The chapter “energy” is dedicated to the study of energy need and the sustainable energy supply of the floating city. The “building construction” chapter refers to the behavior of building materials in the marine environment, and is meant to add useful information to the knowledge developed during the preliminary research. The research on this last three chapters has been conducted simultaneously, despite the order presented in this report.
The report ends with a reflection based on the conclusions of the three level of research.

CONTENTS

This chapter is the result of the first literature research done to develop the basic knowledge needed to design on water. There will be first a description on floating principles and then information on floating technologies.

FLOATING PRINCIPLES

Hydrostatic pressure



$$p=\rho_w g z \qquad [Pa]$$

In which:

p = hydrostatic pressure [Pa] or [N/m^2]

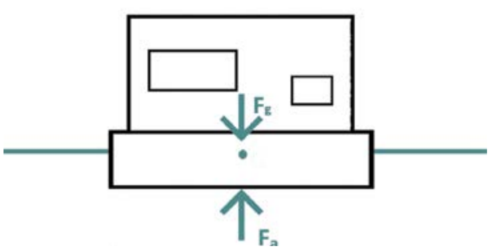
ρ_w = water density [kg/m^3]

g = gravitational acceleration [m/s^2]

z = depth (for stationary status) [m]

Hydrostatic pressure is described as the force per unit area exerted by a fluid on an object.
It increases in proportion to the depth from the surface because of the additional weight of the fluid above the point of measurement.
If the fluid is in a state of equilibrium, the hydrostatic pressure acts with the same magnitude in all directions and if the floating body is placed on calm water the formula above can be used; this is due to the fact that in calm water the difference with a relative slow flowing fluid is small, but if the floating body is placed in a fast flowing fluid situation, other formulas must be taken into account. Salt water is denser than fresh water and will have stronger pressure. All these characteristics can be seen in the defining function.

Buoyancy



$$F_a= \rho \cdot g \cdot V \qquad [N]$$
$$V = d \cdot A \qquad [m^3]$$

In which:

F_a = The buoyant or Archimedes force [N]

ρ = density of the water [kg/m^3]

g = gravitational acceleration [m/s^2]

V = volume of the displaced water [m^3]

d = draught [m]

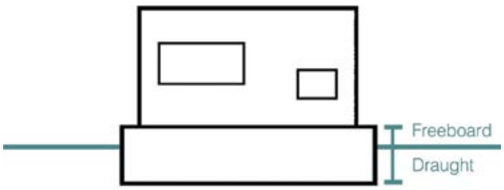
A = surface of the floating body [m^2]

Buoyancy is described by the Archimedes' principle, stated as:

Any object, wholly or partially immersed in a fluid, is buoyed up by a force equal to the weight of the fluid displaced by the object.

If the floating body is not in a state of equilibrium, it will move upwards and downwards until the equilibrium is reached. This happens when the buoyant force F_a is equal to the weight of the floating body Fg. On the other hand if Fg exceeds the buoyant force, the floating body will sink. The volume of displaced water equals the volume of the floating body below surface, and therefore can also be found by the draught times the surface of the floating body.

Draught and Freeboard



$d = F_a / p \cdot g \cdot V = F_g / p \cdot g \cdot V$ [m]

In which:

$f = h - d$ [m]

In which:

f = freeboard [m]

h = height of the floating body [m]

For floating structures, the word draught refers to its depth in water. For bodies with a rectangular section the draught equals to the distance from its bottom plane to the surface of the water. From Archimedes' law the draught can also be found as shown in the next page.

The freeboard refers to the distance between the surface of the water and the top plane of the floating body.

A beneficial requirement for the freeboard is to be higher than the strongest wave the floating body would face. This would avoid waves to collapse on the top surface of the floating structure.

Water density and gravitational acceleration

It is worth mentioning that small variations on the water pressure value can happen when changing location, and temperature of the water, although such variations are not playing an important role in this research. In fact, flexibility is considered within the floating city itself, but it is valuable to know that for movable components which can be relocated from fresh to salt water specific pressure calculations are required. To calculate the water density considering its temperature the formula below can be used; in general though the values of 1000 [kg/m³] for fresh water and 1045[kg/m³] for salt water are normally considered for generic calculations. Gravitational acceleration deepens on latitude and varies from 9.78 m/s² to 9.83 m/s², 9.81 m/ s² is the value for the Netherlands.

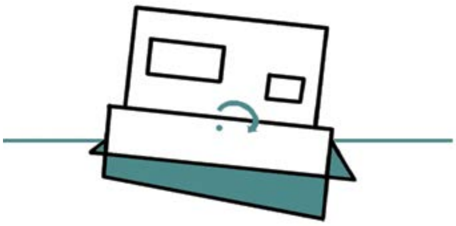
$\rho_w = 0.805 \cdot S\ 0.0166(T\text{-}4\ 0.212 \cdot S)^{1'69}$

In which:

ρ_w= water density [kg/m³]

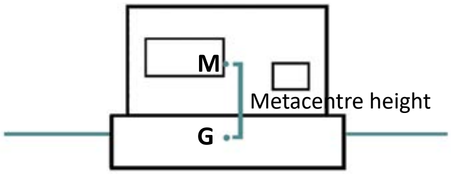
T = temperature [K]

Tilt



When the floating body is subjected to horizontal loads, a moment, called acting moment, will tilt the body on one side. More specifically one part of the body will have a larger draught then the other one, as a consequence, the side that gets deeper into the water, will receive a larger buoyant force, creating a second moment called righting moment. This will counter act the effect of the acting moment on the structure. To avoid the structure to overturn, the righting moment will need to be the same as the acting moment.
If a righting moment can bring back the structure to its original position after the load is taken away, then the floating body can be considered stable.

Static stability

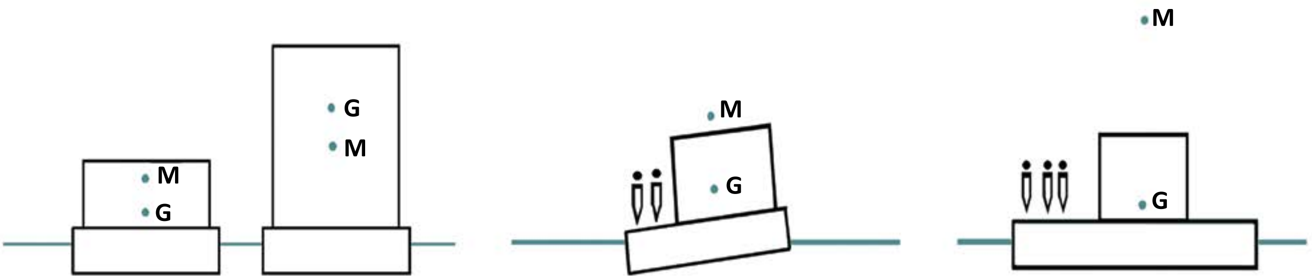


G=gravitational centre
M= meta centre

When a floating structure is forced to leave its equilibrium state by an external load or momentum, it can either come back to its original position, in which case the structure is ‘stable’, or no longer come to its original state in which case the structure is ‘unstable’; this is consider valid unless the floating body reaches a new equilibrium position in which case is considered ‘neutrally stable’. For two different bodies subjected to the same external force, the one which rotation is lower, is considered more stable.
Static stability mostly depends on the Meta center, the gravitational center and the distance between them, called metacenter height. The higher the distance, the more stability is reached.

Shape stability

It depends on the application point of the buoyant force, when the floating body rotates. Because of shape stability the wider the body is the more stable it is. This is explained by the fact that if the center of buoyancy can shift more given a certain rotation, then the metacenter height will get higher, ergo the structure is more stable.
According to M. Winkelen who in 2007 studied different shapes of floating bodies, a rectangular section of the floating body is the most stable, because the stability is ensured by enlarging the width to depth ratio.



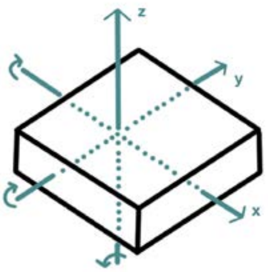
Shape stability also is responsible for the fact that a big platform with a small draught is more stable than the opposite. An aspect that must be taken into account when designing high rise buildings on water. The image above shows the change of the metacenter height and the relation between metacenter and gravitational center in relation to the height of the building and the difference between a less or more wide platform. As can be seen when the building gets higher the center of gravity takes place on top of the metacenter, which equals an unstable condition. When the platform is bigger the center of gravity stays low and the metacenter takes place higher increasing the metacenter height.

Weight stability

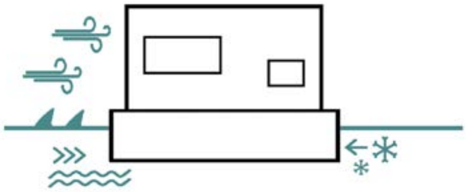
Weight stability can be easily explained by the structure of a sailboat. This type of craft often have a keel and a leeboard, as can be seen in the picture above. The kneel is much more heavy then the rest of the boat, so when the craft tills the keel ensures the stability by its own weight. This is due to the fact that because of the keel the center of gravity remains very low. When designing a floating building, this simple principle can be applied by the use of heavier material at the bottom, to maintain a lower center of gravity.

Degrees of freedom

A floating structure which is not fixed has a total of six different possible movements. Considering the axis shown in the image, these movements are described below. All these movements will vary according to the type of mooring the floating structure is connected to.



- Surge: when the body translate on the x axis
- Sway: when the body translate on the y axis
- Heave: when the body translate on the z axis
- Roll: when the body rotates around the x axis, or the longest direction.
- Pitch::when the body rotates around the y axis, or the less wide direction
- Yaw: when the body rotates around the z axis



Wind

Winds play as horizontal force acting on the building. On vast planar areas as water with no obstruction, wind can get very high speed which must be taken into account when designing on water. Another reason to prefer low rise buildings. Wind is also the primary responsible for surface waves.

Ice

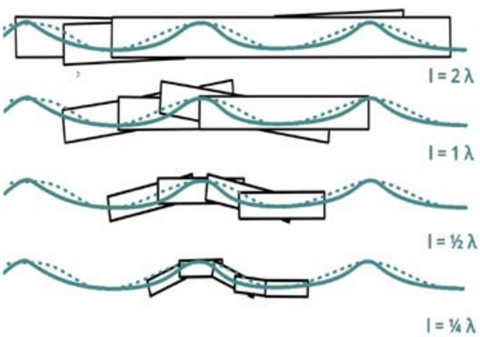
When water freezes, it expands applying an extra load to the buoyant body.

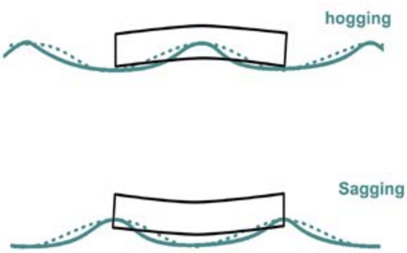
Currents

Currents can vary according to the location, but in general, they constitute another type of load acting on the buoyant body from underneath the water. For inland water they do not present a big issue although in open water, especially near the coast, they are considered a constant load on the draught of the structure for the drag they apply.

Waves

There is a relation between the length of the platform and the wave length. According to this relation, forces will apply on the structure through sagging and/or hogging. Wave height and length will change according to wind speed but breakwaters can be used to minimize the effect of waves of the floating platforms.





BUOYANT BODIES

In a floating construction foundations take the name of the buoyant body which primary function is to keep the building afloat. To do so the floating body has to be designed according to the rules presented in the previous paragraphs, dealing with water mechanics principles rather than earth mechanics. The main difference is then defined by the stability on a dynamic environment rather than a static one.
Buoyant bodies can be differentiated in three main categories; pontoon type floating structures, semi submerged floating structures and amphibious floating structures.

Pontoon like floating foundations are the most used in the floating building development and consist on a planar platform; the bigger the platform the more stable it is in the water environment. According to the size of the platform the buoyant body can deal with different wave lengths, although until now only small dimension platforms have been built which can resist on calm water. In an open water environment high waves compromise a pontoon like structure as it is placed on the same level of the water. For this reason in open water projects for floating cities is considered the use of breakwaters.

Semi-submerged floating structures are, as the name describes partly submerged in the water. They are characterized by a submerged structure sited under water which supports a raised platform on top of the water through columns or other structural elements. As the platform stands separated from the water it can withstand extreme wave conditions and is therefore used in offshore engineering. Comparing to pontoon platforms, these structures are rather expensive.

Amphibious foundations are made to work as normal foundations but become a floating structure when the underground floor gets flooded. They are built as floating pontoons but with extra reinforcement to remain strong enough when working as ground foundation. They are not being considered in this report since the main objective is to study floating cities, although it is worth mentioning this particular type of foundations.

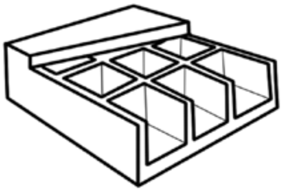
Flat boats and Barges can also be used as a base for a floating home, although they can work properly when they consist on a very low and wide structure as it is more stable in moored conditions. The hull of boats is in fact designed to be more stable when the boat is in motion rather than when it is moored. For this reasons barges and flat boats work better as buoyant bodies for building construction, as they used the same principles of pontoon like structures.

There are different material that can be used for floating foundations, although concrete and steel are the main adopted for durability, strength and price. Wood was one of the first material used to build on water but the high maintenance required made other materials a more suitable options. Composites are slowly replacing steel for boats construction but the high price and the lightness of the material make them unsuitable for floating bodies designed to support building construction.
This graduation studio will consider the use of floating pontoon structure with the addition of breakwaters to protect the city. The choice has been made considering the shallow waters of the location of interest (20-30 m maximum), and the possibility to have floating urban components which can be moved easily. Semi-submerged do not apply well to this criteria and are therefore not taken into account.
In the next pages examples of available pontoon type structures will be described according to the material used.

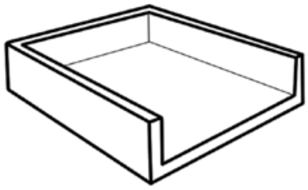
Concrete

Among all, concrete is now the preferred buoyant body material, for its plasticity and durability in water. In the current market for floating homes, it is usually poured all in one to avoid any crack, something that can be done easily in a close environment and for the small dimension of a single dwelling, before the construction is brought to location. Concrete platform take the name of caissons and can be closed, opened, pneumatic and/or filled with a lightweight and buoyant foam, like ESP (expanded polystyrene foam).

Open and closed caissons have been the most used since concrete made its appearance in floating construction. They are characterized by a large weight stability, a relatively cheap price and the possibility to use their internal space. Open caisson compared to closed caisson are lighter, they therefore reduce the weight and the draught of the construction, getting the center of gravity lower. As the space inside the buoyant body in empty, a crack on the outer shall would make them sinkable.

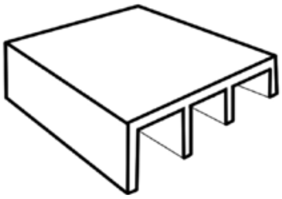


Closed caisson



Open caisson

Pneumatic caissons work by using the air compressed in between the water and the structure. As can be seen from the image in the below, they don't offer any internal usable space. Compared to the other caissons are less stable since the center of gravity is higher. They are as well sinkable.



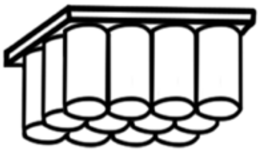
Oneumatic caisson

Platforms made of concrete filled with ESP use less concrete and are unsinkable. A crack on the outer shell will in fact not sink the construction as the internal space is filled with buoyant foam which also contributes to keep the building afloat and thermically insulate it from the water. They have a low self-weight hence a high buoyant capacity with a small draught. The negative aspect of this type of platforms remains its lack of usable internal space and a lower structural strength compared to normal caissons for the reduced use of concrete.

Steel

Steel has been largely used for ships and in the offshore industry despite its tendency to corrode easily. The reason sets in its strength at low temperatures. One of the main characteristics needed for such structures is in fact their resistance to fracture in bad weather conditions, and steel, in the right grade and application, can deal well with the problem. Off course, it also needs to be constantly treated against corrosion, one of the reasons is nowadays preferred to use concrete instead of steel for floating foundations. When applied in dwelling as a buoyant body steel is mainly used in pontoons. These can be closed, filled with air and placed horizontally under the construction or can be empty and open on one side, placed vertically. In the first case the steel structure only works as buoyant support.

In the second case if the opening is on the top, the space inside the tubes can be used for the dwelling. If the vertical steel tubes are opened on the bottom, and connected by a platform on the top, then they work with the same mechanism as a pneumatic caisson. This last type of structure is used in bigger dimension in the offshore industry, made in steel or concrete, and takes the name of PSP - Pneumatically Stabilized Platform.



PSP

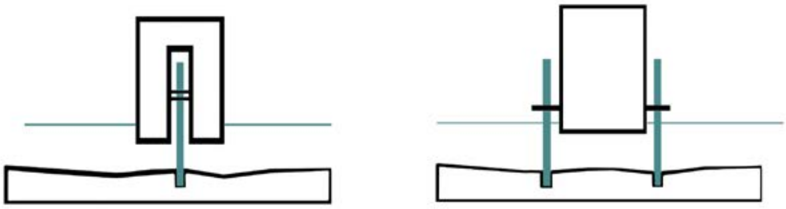
One advantage of steel floating foundation is the possibility to develop different shapes according to the design. It remains though a material which requires constant attention, which floating structure typologies remain sinkable, and that doesn't provide any insulation to the above house.

Other materials

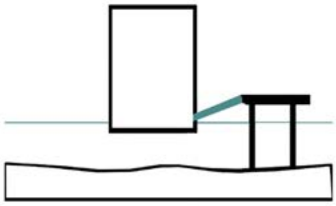
As mentioned before, flat boats can be and have been used as supporting structure. The Netherlands offers a great variety of these examples which can be seen in almost any Dutch city. Usually the hull of the barges and flat boats under the house are made of steel.
Wood is a material that can still be seen but rarely; its constant need of maintenance makes it very unsuitable for floating dwellings. A wooden platform could be made out of a wood raft with wood trunks as pontoons.
Plastic bottles are as well an option. As the air and the plastic density together are lower than the density of the water, in the appropriate number, they can build a very good floating platform, as good that the English artist Richard Sowa built more than a one small floating island out of them in the late 90s'.
Using the same principle of plastic bottles, a number of barrels can be adopted;; many empty barrels can be connected by an horizontal structure and they can work not only work as floating body but as storage unit as well. Even if very interesting, these last options are either requiring too much maintenance of they do not work well with bigger scales, which are on the attention of this research. Concrete and steel are considered more suitable for the floating city in the the north sea.

MOORING

For small scale building in inland waters, mooring is usually done in two ways; the house is either moored on piles or on a horizontal mooring to the nearest jetty or land.
When the house is moored on piles it can shift vertically with the water level change. The piles are attached to the ground floor underneath the water and connected to the house either internally or externally. They are usually made out of steel.
When the house is moored horizontally, it can be connected with more flexible mooring such as ropes or steel horizontal mooring which allow only vertical movement as the piles.

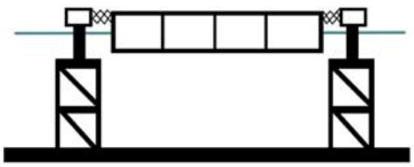


Pile systems

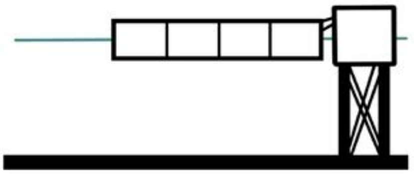


Horizontal mooring

For deeper waters four main types of mooring systems can be recognized.
The dolphin-frame guide and the pier/quay wall method both are reliable to withstand horizontal and vertical displacements/loads from the floating structure, they work similarly to the horizontal mooring for smaller scale.

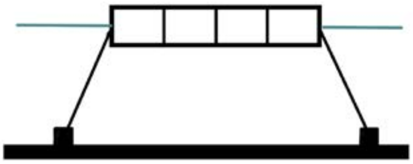


Dolphin frame



Pier/quay

The chain/cable and tension leg method on the other hand can handle horizontal forces and displacements very well, while they perform less good when there is a lot of vertical movement. To better resist the vertical loads, the moorings have to be anchored very deep into the seafloor.

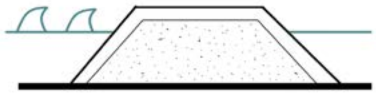


Chain/cable

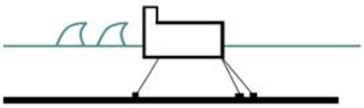
Tension leg

BREAKWATERS

In hydraulic engineering, breakwaters are designed to resist or dampen the wave-actions. Breakwaters can be a part of the floating city community to protect the floating structures from severe waves and are usually used when the wave height is higer than four meters. In our locations, waves have an average maximum height of 0.9 meters, which could avoid the use of breakwaters, although a protection from waves would preserve the floating platforms better. They can be made out of reclaimed sand, rubble or concrete blocks, and they can require an incredible amount of resources to be built if they are connected to the sea bed. To avoid such waste floating breakwaters are also possible.



Fixed breakwaters

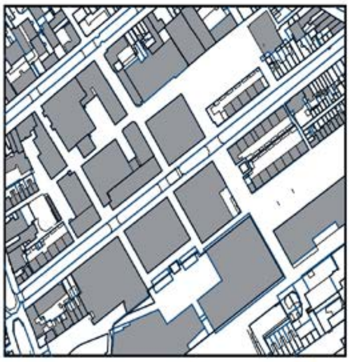


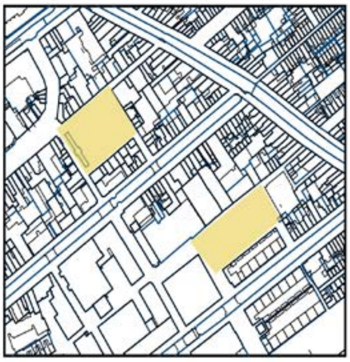
Floating breakwaters

INTRODUCTION

This chapter is dedicated to the analysis of urban development in water. Cities as we know them, are defined by A set of elements, by different geometries, densities, economic zones and networks. They can be rather complex but there are few tools to describe them.

First of all we can say that they are defined by the agglomerations of elements: buildings, public spaces, streets and landscape. Buildings articulate the space by the creation of street walls around the city; Public spaces are responsible for the improvement of the city's quality of life, are meeting point and leisure areas, they can differ from big central squares to small neighborhoods' parks. Streets work as connectors and are defined by their size and purpose, they illustrate the city's transport network and are considered one of the main characteristic used to delineate a urban fabric; Landscape refers to all areas involving the presence of nature elements, either with green or water. To consider a city as such, all these components need to be present and work together.
Moreover, a city is divided in different zones according to the type of use they host (city center, residential district, business district etc.). The way these different sectors are placed defines the land use layout, which is normally called zoning. There are three basic models of zoning: the concentric model also called Burgess Model, the Sector model or Hoyt model, and the multiple nuclei model by C. Harris and E. Ullman. According to the concentric model,

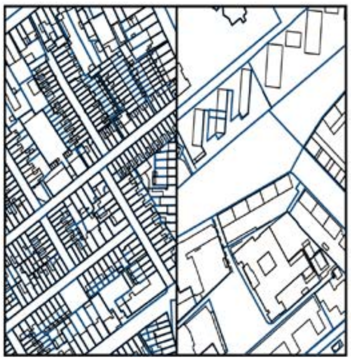

Buildings


Public Spaces


Landscape


Streets and Networks


Zoning


Density

HIghlights from the city of Delft

the city develops around the central business district in concentric rings. In the Hoyt model the city develops its sectors along major transportation. The last model, recognizes the presence of more than one business district or city Centre, saying that there are multiple nuclei in the city will different districts developing on them. Density is defined by the concentration of people or elements in a given area; within a city usually varies according to the districts. To conclude, networks play an important tool when defining urban development; it mainly regards the study the distance, connections, reaching velocity of city nodes and what is in between them.

However, what happens to all these element in a floating urban development?
When building on water, there are other parameters that must be taken into account, like the basic principles of floating construction or the preservation of the marine environment.

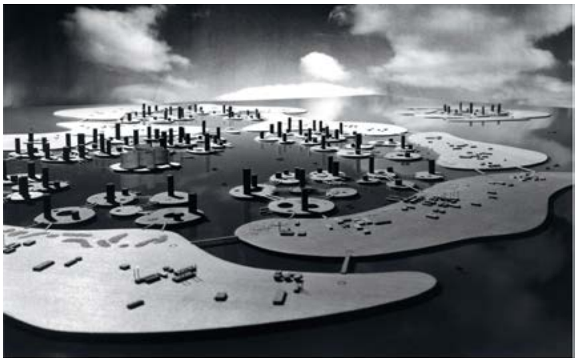
In the next pages, three reference examples are described and analyzed, to understand better how a floating community could be developed and to form the starting point for the dynamic city object of study. These examples are the Marine cities by Kiyonori Kikutake, the DeltaSync design for The Seasteading institute's floating city, and the thesis reseach on platforms structural feasibility by Kevin Ko.

Marine cities by Kiyonori Kikutake

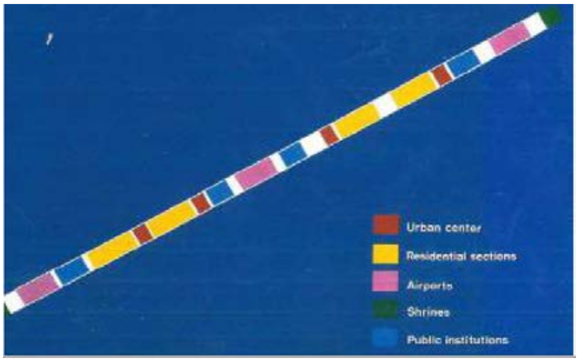
More than fifty years ago, Kiyonori Kikutake was the first to design cities that would be placed on water. He proposed his design for a "Marine city" in 1959 and then spread the concept through the Metabolism group manifesto in 1960. At that time, his designs weren't discussed seriously, but they constituted an influential approach for current designers. Kitkutake proposals include two basic designs: a concentric mega structure on city scale, and a linear mega structure on a national scale.

In the 1963's design, he places six big island for industrial facilities, which embrace smaller island with residential facilities. The smaller islands are connected through bridges to create different city block, which are themselves connected to each industrial island and, where each of them is characterized by a central island with administrational function. In terms of urban plan this can be considered as a multi nuclei model. Looking at the platforms they have the advantage of protecting the residential buildings through the big islands around. It is not clear if the choice was merely a spatial design or took into account the dynamic natural environment, but looking at the design it can be a model aware of the boundary conditions related to building on water.

The linear city design is considered his most radical design. It comprises 400 km of a linear city-nation between Osaka and the island of Kyushu. The aim of this structure was to take off pressure from the densely populated coastal areas. One advantage on the layout is the simplicity with which the pieces of the structure can be moved in different locations. Not only, as it also facilitated transport creating one big network line, such that a magnet train could travel through the entire city within one hour only. There are no specific given information about the technology for the construction of such structure, although it can be hypothetically be built with the connection of multiple platforms.
Must be said that a linear platform connection of such dimension would not structurally a good option for building on sea. In Kikutake's design the scale is very big and the city is probably made out of hexagonal or triangular platforms (according to his sketches), both of which cases guarantee a structurally stable mega platform. But, in the case



1963 design
Source: http://polinice.org/2016/04/05/kiyonori-kikutake-between-land-and-sea/

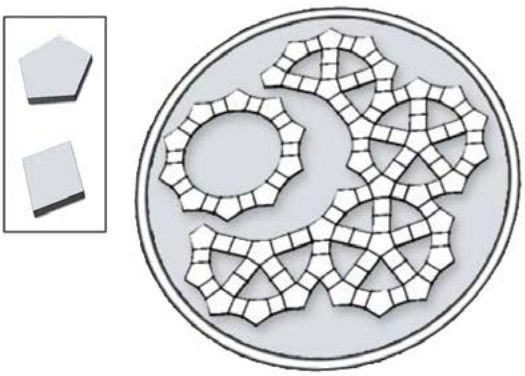


Linear city-nation
Source: K. Olthuis, D. Keining, ***Float! Building on water to combat urban congestion and climate change,*** Frame,Netherlands 2010

of a smaller scale design, linear platforms connected together might get into stability risk. In fact, in such layout a small degree movement on one side of the structure can become a high degree movement on the other side, with an effect similar to what happens on a whip takes place.

DeltaSync design for The Seasteading institute's floating city

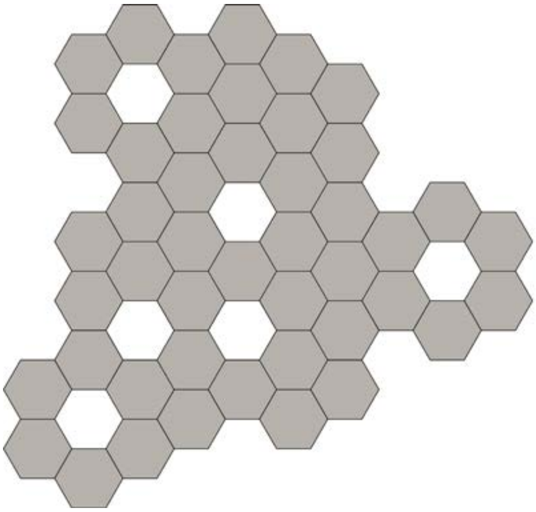
The Seasteading Institute aims to build the first floating establishment, with considerable autonomy. The design has been commissioned to DeltaSync, a design, research and consultancy firm, which designed a realistic project made out of connected concrete platforms to form a cluster structure. The design considered movability of platforms, city relocation, financial aspects, sea keeping and more. All platforms have either a pentagon or squared shape. These two shapes allow together to create circular clusters with different curvatures. The aim of Delta Sync is to give enough freedom but to guarantee dimensional stability when creating the entire cluster. The proposal comes with linear disposition of housing units, offices, hotels, terraced houses and villas, although no information are given on the building materials.

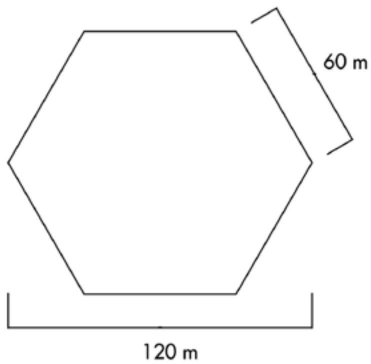


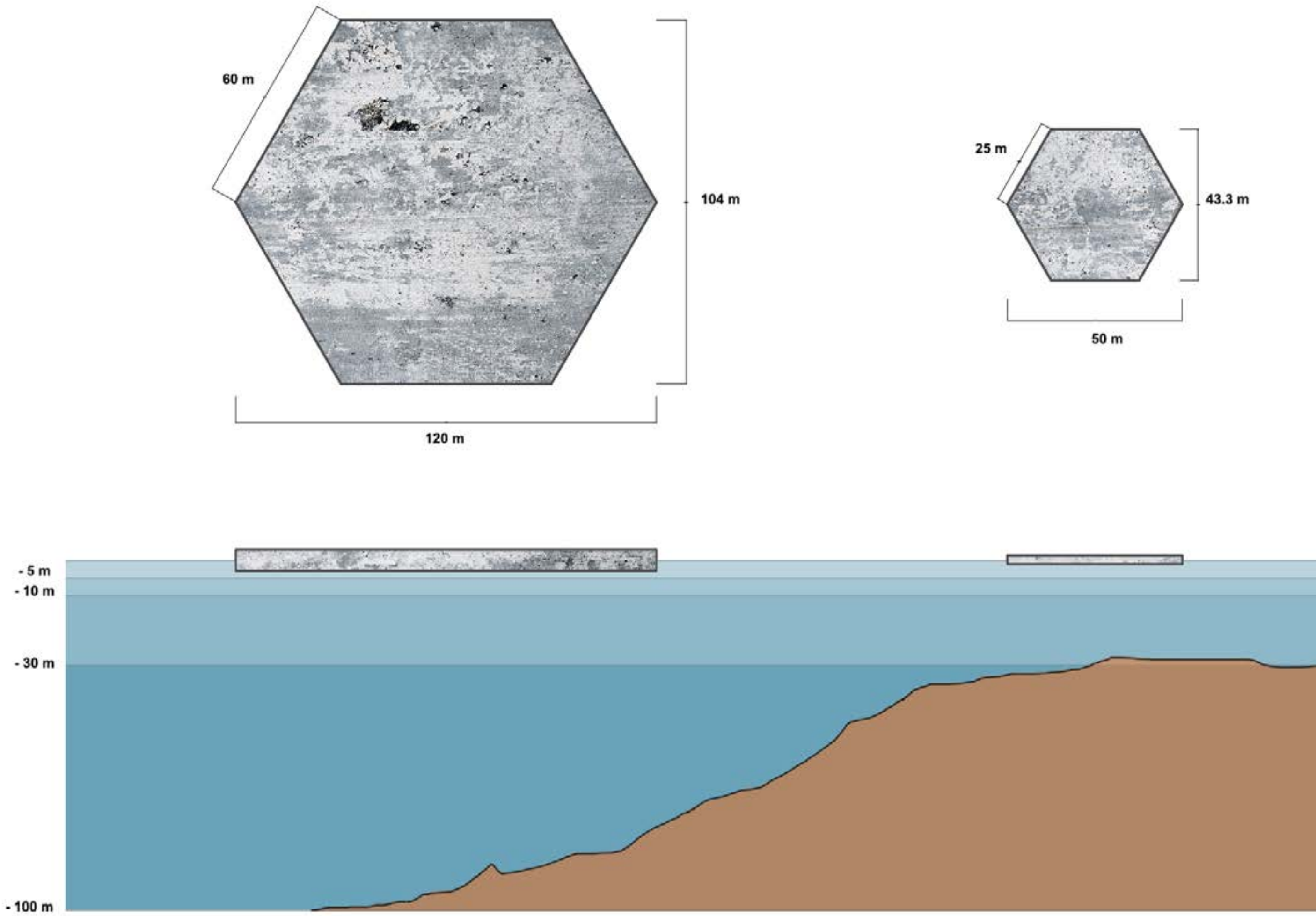
Source: Steasetading floating city report

Kevin Ko’s research on platforms structural feasibility

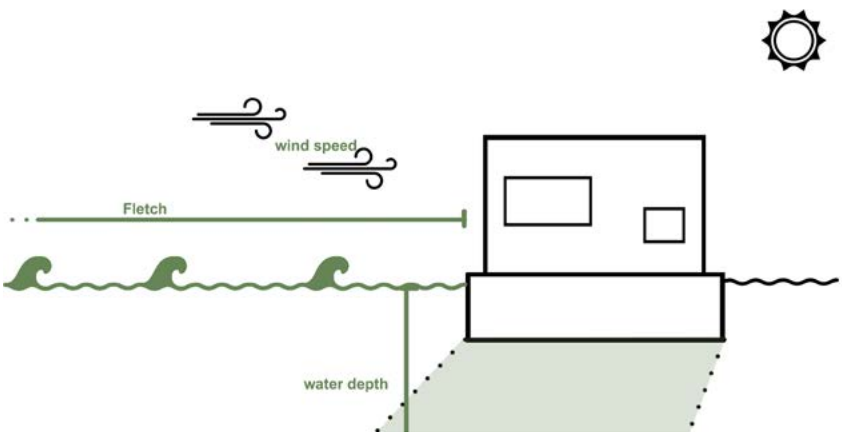
In 2015 Kevin Ko in collaboration with DeltaSync, studied the structural feasibility of large concrete floating platforms for his civil engineering master thesis. His studies place a city in an open sea situation, with latter boundary conditions. He could develop a series of conclusions among which he considers hexagonal platforms and rigid connection as the most suitable options when constructing a floating city.
According to him, the use of square and pentagon do not allow as many configurations as expected, when designed on scale. A rectangular shape configuration is considered the simplest but also the one that needs the most number of connection. A cross-shaped is instead very prone to pitching and rolling. The hexagonal shape is for him the most stable structurally and as well as the one that allows more possible configurations. His final design for a single platform is a hexagon of 60 m side and a thickness of 6 m. The thickness of the platform is calculated for low rise buildings of 12 m and high rise buildings of 50 m set in the central area of the platform.
Kevin Ko’s research was a useful tool to understand floating platforms configurations and behavior, and has been taken into account as a starting point for the platform development.



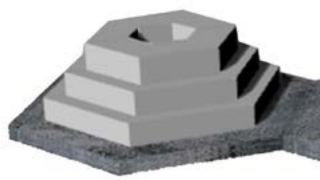




Plaform size possibilities.

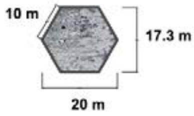


Boundary Conditions

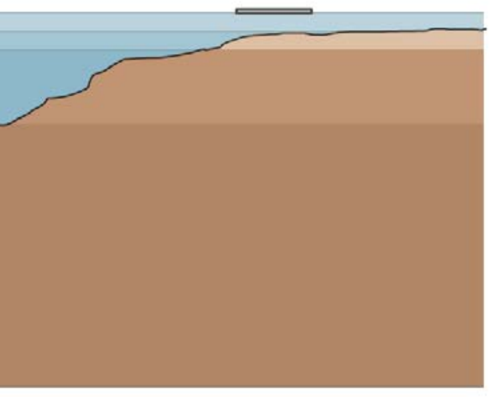


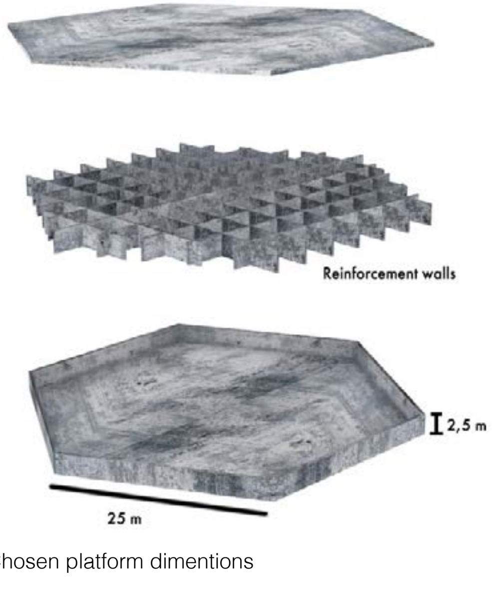
Buildings heights

Platform size and shape

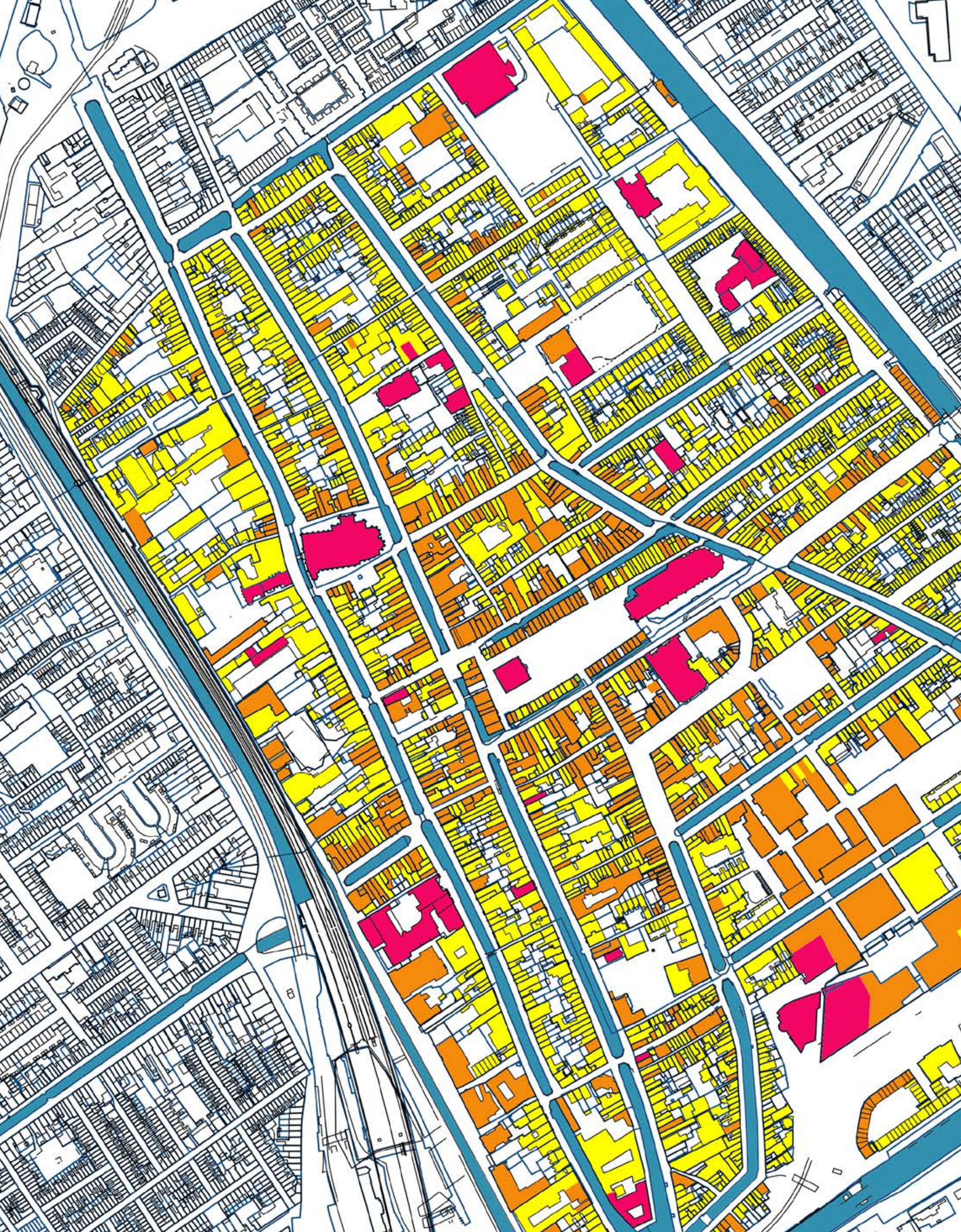


To define the shape and size of the floating platforms, Kevin Ko's research has been taken as a starting point. From the use of a hexagonal shape, it was then necessary to define the size. Ko's structural calculation are referred to a buoyant body of more than 100 m diameter and height of 6 m (first platform on the left), which could be considered too large for this study. In the location of this research, waters are rather shallow (20-30 m), consequently, it is more appropriate to decrease the size to around half of Ko's platform. This is due to a number of reasons: firstly, there is the need to allow light get under the platform, to guarantee health of the natural and marine environment; secondly a smaller size would facilitate the urban flexibility which is normally promoted by floating cities enthusiasts, for instance by using each platform for one building typology; to conclude, a smaller platform would also need a thinner thickness, which matches the water shallowness. The platform thickness will also depend on the building's height and weight, which brought to the decision of not exceeding a height of four floor for the buildings; this will also facilitate the design as higher construction will need to be more carefully designed structurally to withstand the open sea strong winds. As a generalization, the thumb rule of having a thickness of 1/6 of the longer side can be used. This brings to a thickness of 2.5 m for a platform of 25 m side. Based on the preliminary research, and the reference examples, platforms are made out of concrete, with a reinforcing wall system.





Chosen platform dimentions



The city's size

In the chapter "Building on water" and in the previous pages some basic principles for floating construction have been analyzed. But to conduct our analysis we need the city to have a set of requirement and a certain number of inhabitants. To facilitate the research process, the city of Delft has been taken as example and as starting point, adapting its square meters to a floating environment.

In the map aside have been highlighted the different building uses in the center of the city. The mixed use buildings refer to housing blocks in which in 90% of the cases the ground floor is assigned to commercial use or leisure (restaurants, bars, etc..) and the top floor to dwellings.

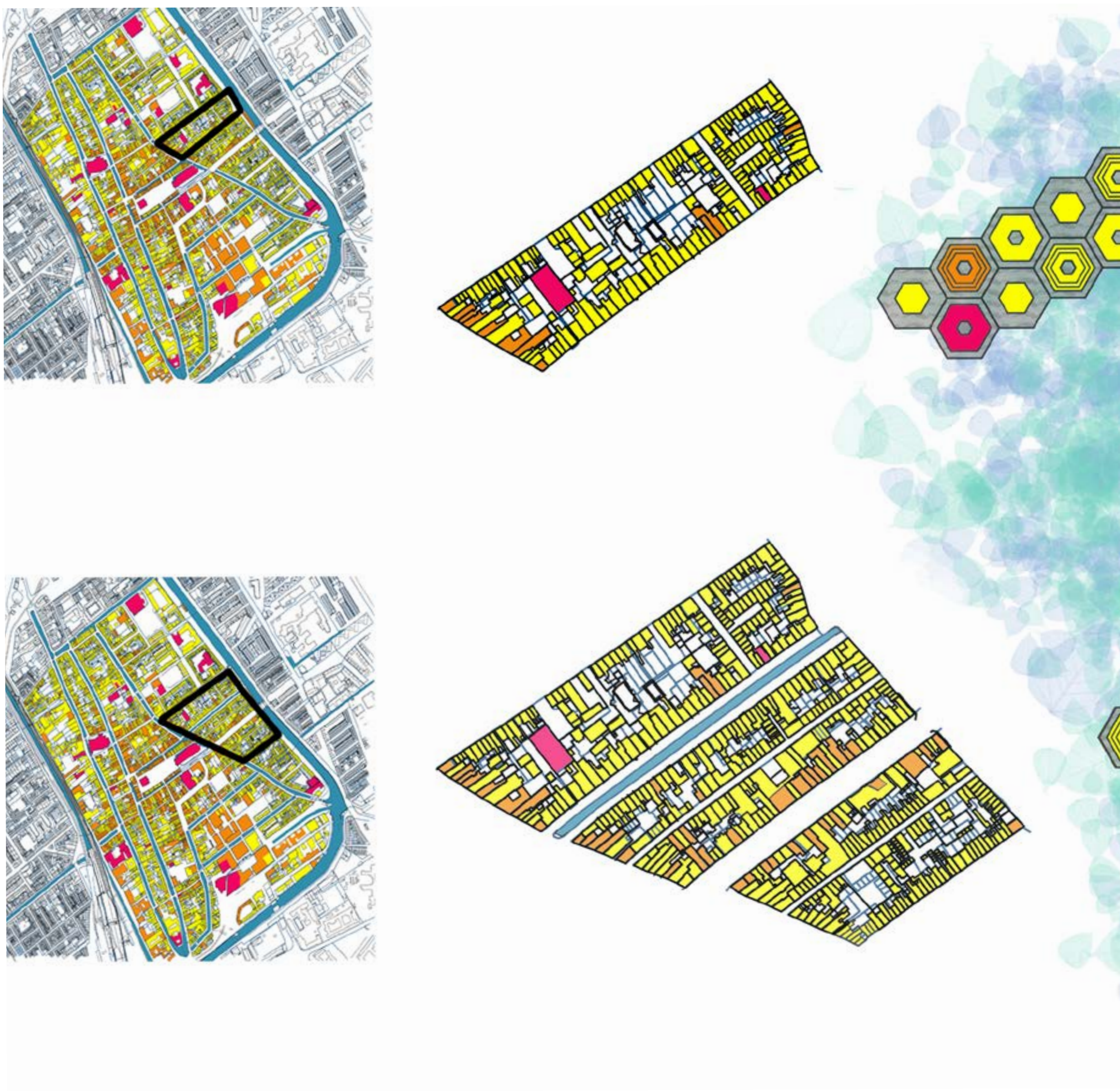
As can be seen from the map, public buildings are spread creating different zone of interest Commercial, bars and restaurants spread as well although they slightly fade while leaving the center to make space for mostly residential neighborhoods. In fact the situation as represented continues for one extra km, after that there are mostly dwelling, one commercial zone in the south west direction, and the university campus. In general however, we can say that the city center as quite a spread use of land with a high percentage of dwellings.

Aim of the next pages is to translate a portion of the city into a floating city, and understand the differences and challenges that this would involve.

Canals
Public Buildings
Mix use
Dwellings

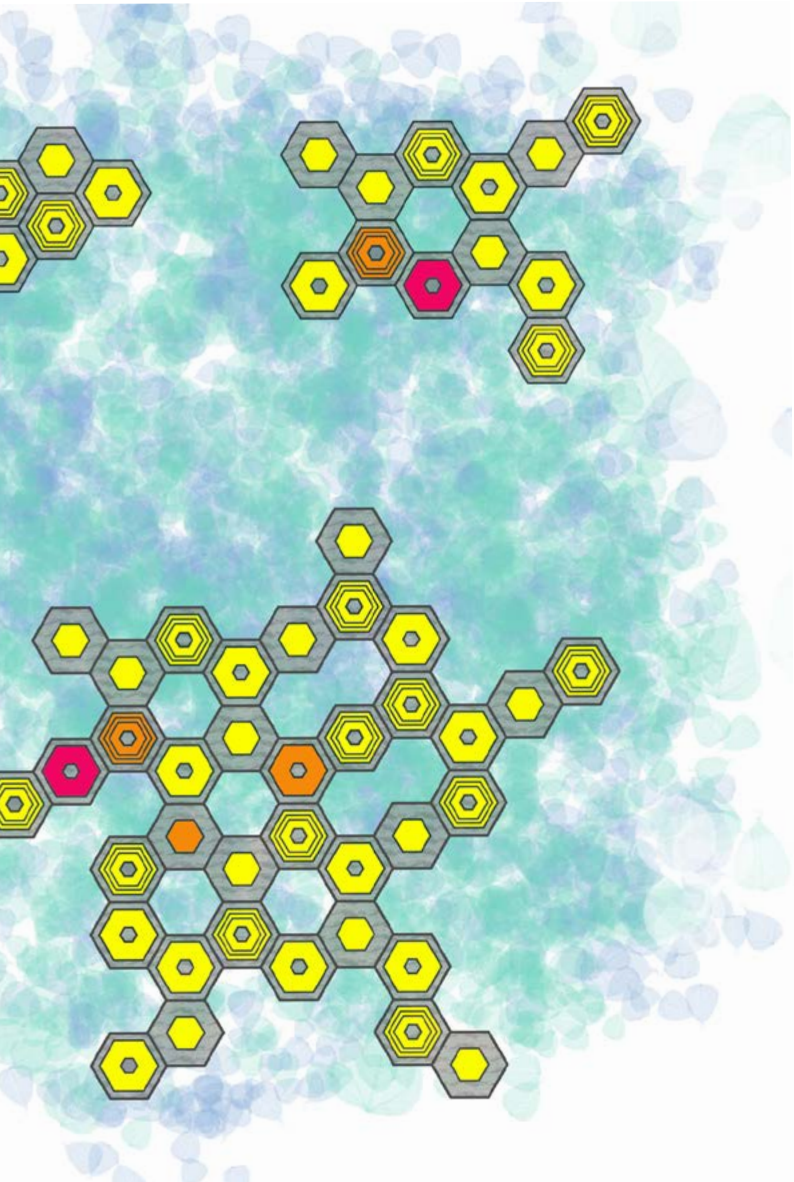
Scale 1:5000

0 100 300 m



Platform configuration and moorings

In the illustration above, square meters of some neighborhoods of the city center are translated into the platform design. The square meters of the buildings are those of the simplified buildings volumes calculated in the energy chapter. Platforms need to be connected in a way that they can allow light to pass throw, but also to form a cluster for stability. As can be seen above, each platform contains a building typology and an area around it for pedestrian and bicycle transit. Such configuration and platform connection, would need several cable moorings distributed in the cluster, but would also represent less movability of the platforms; in fact, to move a platform in the middle of the cluster, several other platforms would need to be moved and disconnected.

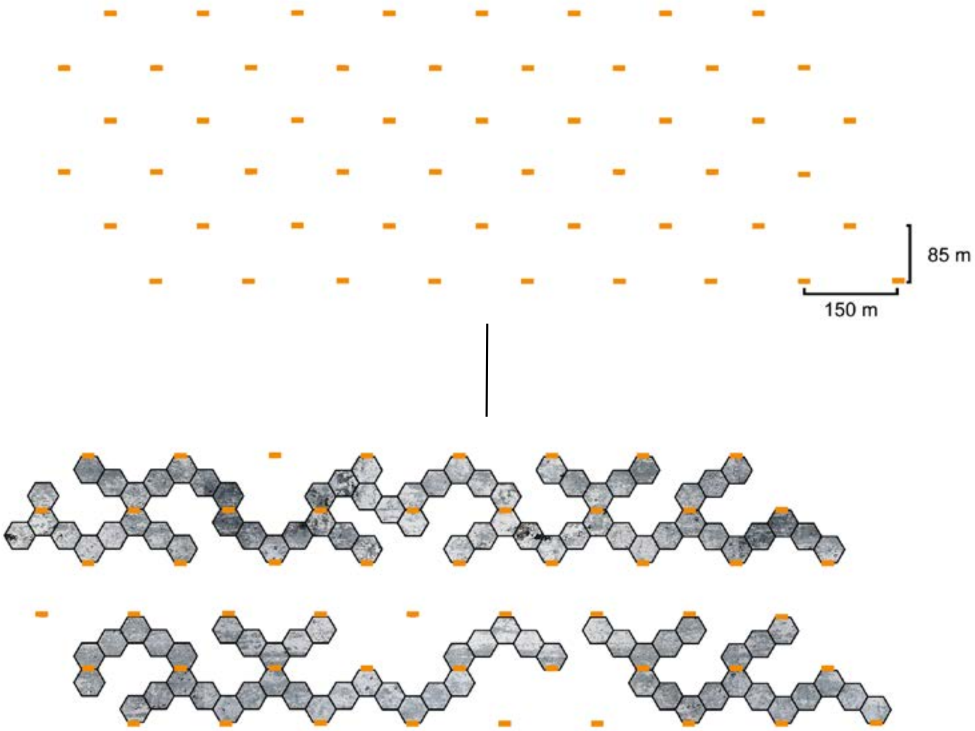


Square meters of neighborhoods translated into platforms.

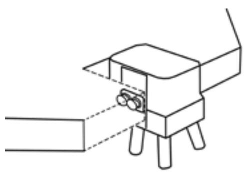
Scale 1:5000

Moreover, in the location of interest, tides are present with a height difference between 1.5 to 2 meters, which means that a mooring typology which allows full vertical displacement would be preferred. Considering the environment condition and the desire of full movability, fixed mooring such as piles and dolphin can substitute the cable mooring, with a consequent different city configuration. Such moorings can be placed on the opposite corners of two or three platforms, which will then be connected to one another by fixed connections, as this will make the platform work as one. Using this method, the movability of each platform is simplified, and vertical displacement is allowed minimizing horizontal movement, but higher resources are required to build the mooring.

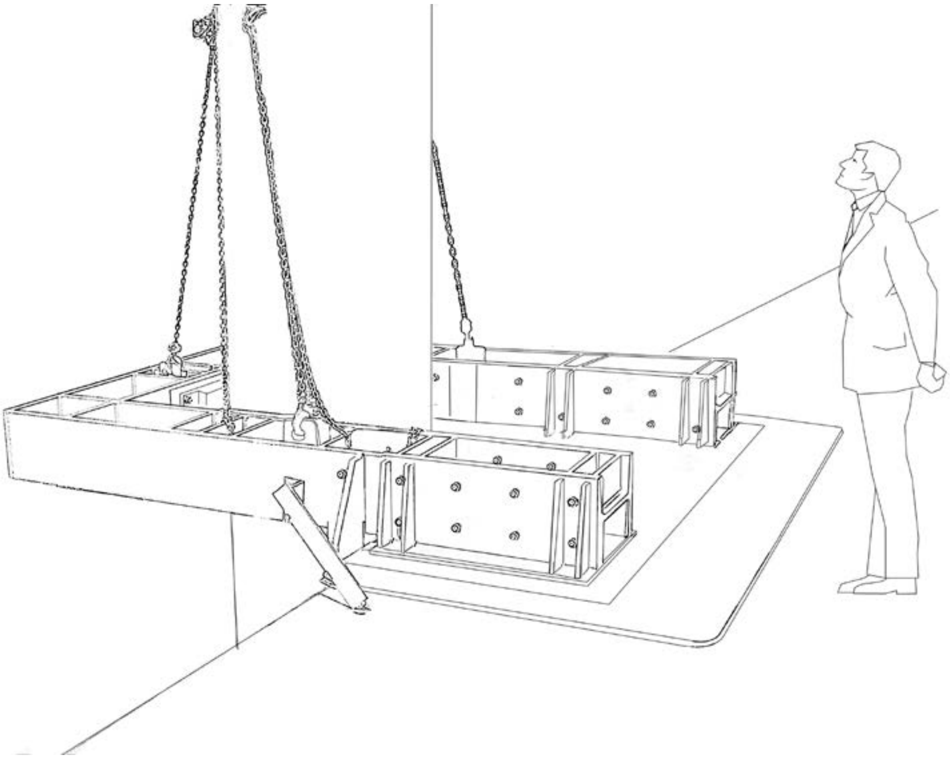
The option with two platforms between two moorings would offer more stability than three platforms connected in between, but would also require a higher number of fixed moorings for the same quantity of platforms. Considering the increased amount of resources needed to build fixed moorings, the option with three platform per two moorings is considered.
Platform can be placed and moved around the moorings, and the city's configuration will change according to the city's needs.

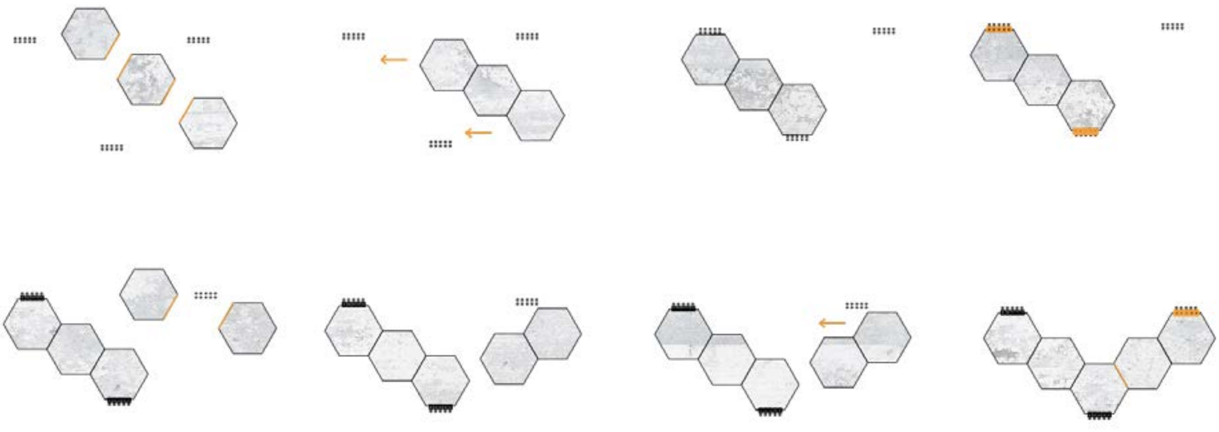


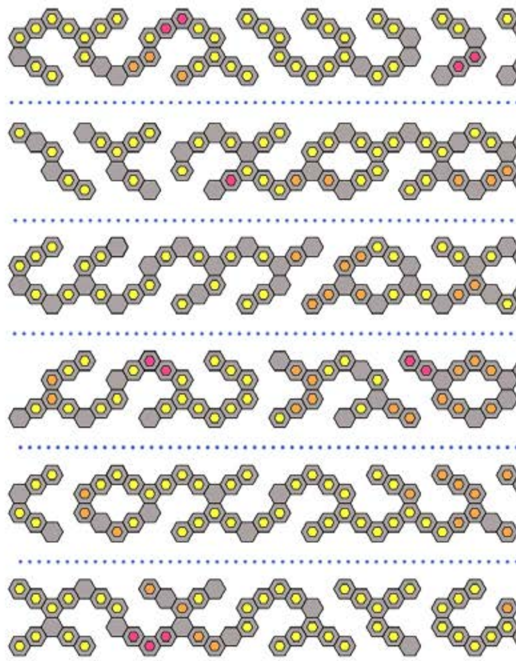
When choosing the mooring specifically, we can see that a fixed mooring might involve modification in the platform shape to work; that would be the case with the dolphin method as showed below.


Dolphin mooring

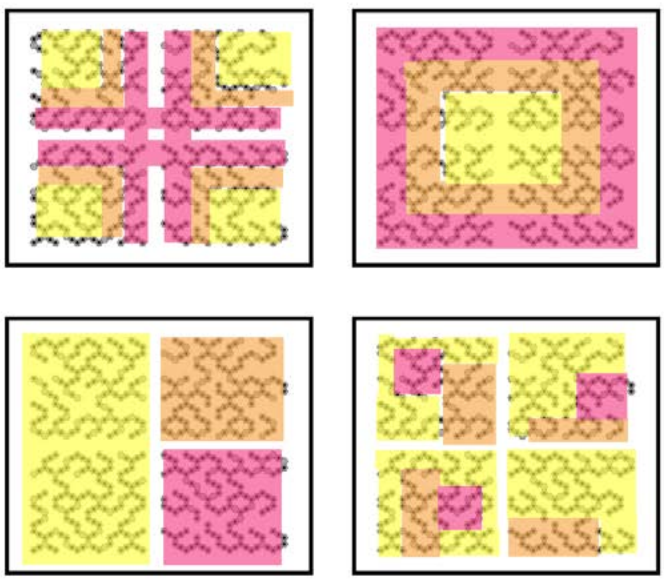
As we want the platforms to behave equally when changing location, another method which allows the platform to maintain their shape and orientation would need to be used. A pile system constitutes a better option as the connection platform-mooring can be separated from both as shown below. The platforms can then be first connected to one another, moved in position between moorings, and then be connected to the mooring. The piles will need to be more than one to guarantee the stability of the platforms, which will mean again a higher amount of resources, in terms of materials and construction.



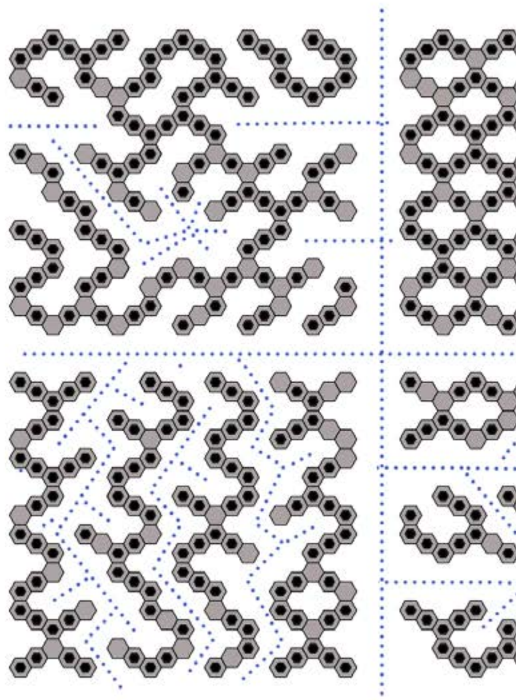




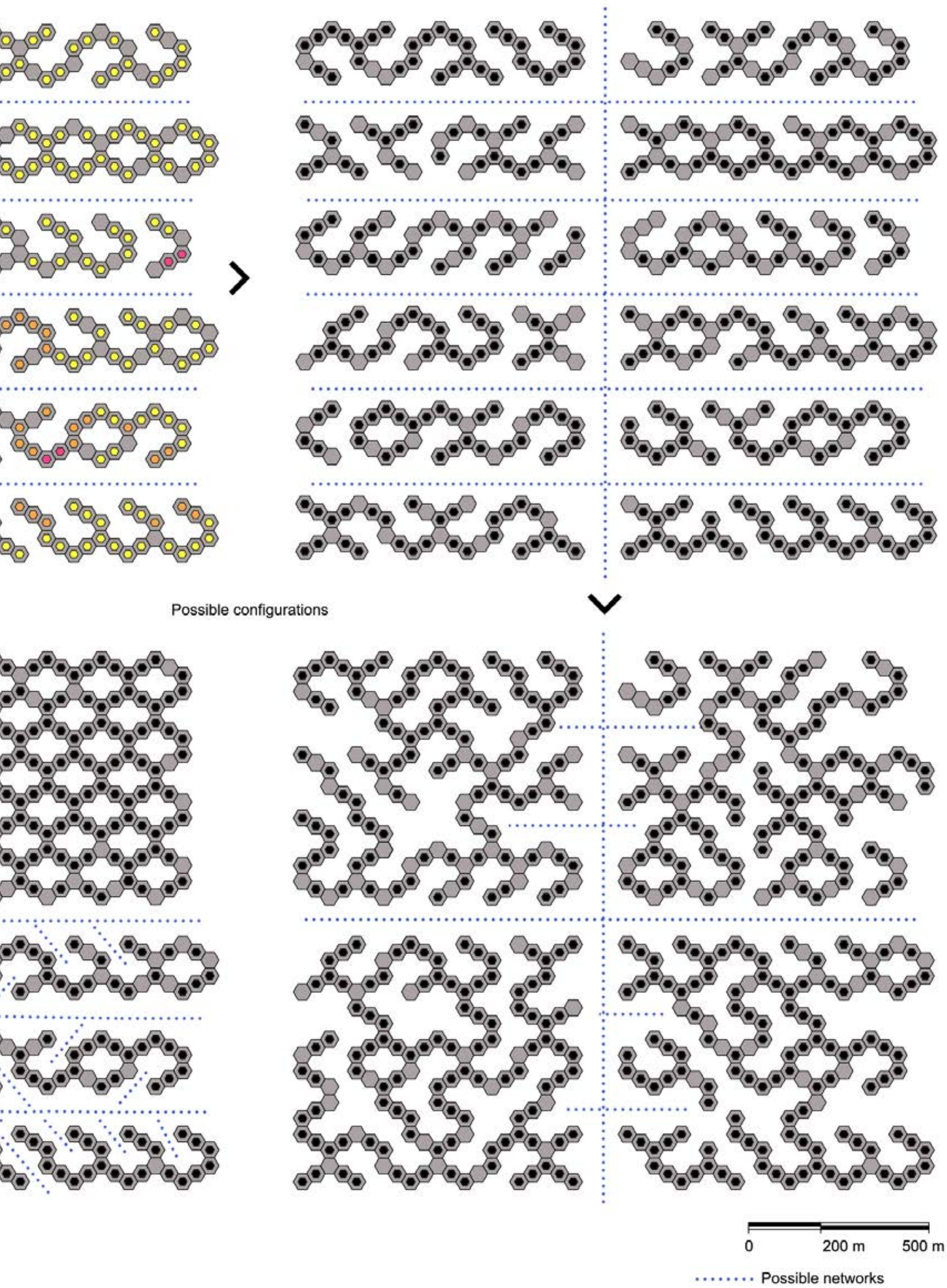
Zone models



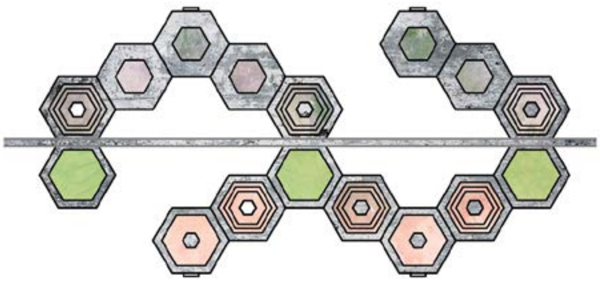
City zoning can change over time



Configuration can be a reflection of neighborhood typology

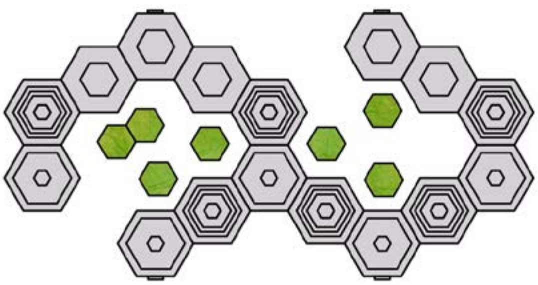

Possible configurations
0
200 m
500 m
Possible networks

Using this system, the city’s configuration will change according to need, it can be more or less dense and form different networks around the moorings for water transit. The negative aspect is that pedestrian and bicycle transit are not efficient, as they are set in the perimeter of each platform around the buildings. It will be necessary then, if this system is used, to implement the traffic network by the addition of perpendicular floating streets when a shorter distance is need between two or more points of interest.

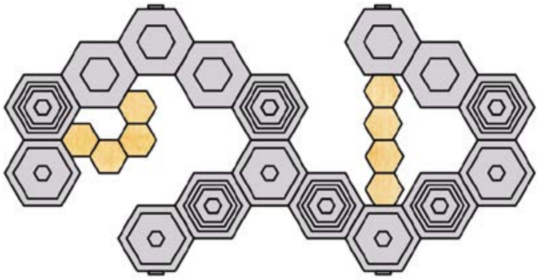


Landscape and public spaces

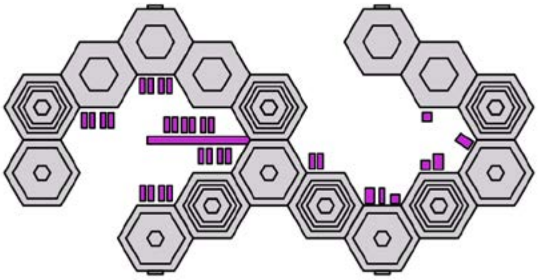
As the system creates a lot of empty space in between connected platforms, it is opportune to use the formed bay for other functions, like green, public spaces or even smaller floating dwellings. This way the bigger platforms with the urban components can be calculated structurally to work together and with the mooring, independently from less heavy constructions as public squares and parks. Moreover the bay formed by the platforms, will further protect from wave and wind action what is positioned in between, creating a favorable location for small floating elements like single family houses.



Green



Public Spaces



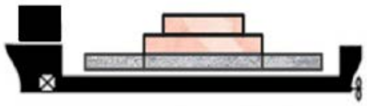
Floating houses

Movability

Platform can be transported in different ways. Making the platforms self-propelled is not considered as an advantage as it is expected that the platform will need to change location after multiple years, in the order of at least fifty or more. It is more suitable then to use boats which can easily tow the platforms. Semisubmersible ships can be considered when the platforms are moved from inland to the city's location, but they are not strictly necessary.

Self propelled

Towed by ship



Semi submersible ship

ENERGY

INTRODUCTION

This chapter aims to define the operational energy need and energy supply of the floating city, given sustainable and energy efficient buildings. Since the energy need will be outlined by the building's properties, such as façade's resistance or heating devices, it was necessary to establish a set of requirement prior to the design, in such a way to permit efficient construction options. At this point, is known that different building typologies will require different characteristics, with the possible change of the architecture's envelope, structure or systems. Considering the large amount of possibilities, the detailed research on energy need has been applied only on the residential typology.
The first part of this chapter describes how the characteristics for efficient residential buildings have been defined by the use of the software Uniec 2.2. Subsequently, the energy supply is discussed, to understand the effectiveness of sustainable energy production means in the open water scenario.
More specifically, the research approach starts by simplifying the city into building pixels per each floating platform (determined in the previous chapter). The idea is to determine a series of basic building units that could have the lowest energy need without the use of external energy devices, and see with them which is the total energy need, on average. By doing this it will be afterwards possible to analyze quantitatively how many devices for sustainable energy production are needed, the area they will cover and how much they can be included in the floating city's architectural design. In this way it will be possible to understand what are the pros and cons in building an energy self-sustained floating city.
This chapter is related only to the pixels energy need, few variation are taken into account, compared and used to set an average for the entire city's energy need.

ENERGY NEED AND THE USE OF UNIEC 2.2

Uniec 2.2 is a package which allows to make EPC (Energy Performance certificate) calculations, Energy labels and Energy Index calculations for Residential buildings.
Within the program a set of information about the building are inserted, regarding the residential typology, layout, envelope characteristics, orientation, size, and heating, water and ventilation systems, with the possibility to add PV panels. After defining few basic volume for the pixel, all the values have been changed to find the most optimal solution, with some that remained fixed from the beginning. Below and in the next pages are listed the main options offered by the program, a description of the considerations made to set default choices, and conclusions on the software results.

DWELLING TYPOLOGY

The program offers the chance to calculate raw houses, corner houses, semidetached, detached houses and apartment buildings. One negative aspect in the choice was that only in the apartment category more than one housing unit could have been set. In the other cases, the house is considered as a private property with only one housing unit. The problem could partly be solved by considering more than one heated zones per each housing unit.
For the pixel design semidetached and detached houses have not been calculated nor taken into account. There are already enough examples of sustainable floating single housing units as well as almost inexistent examples of

bigger scale building that could suit the floating city development throw the floating platform defined previously. The building pixels have a maximum of four floor, they have a minimum distance of 5 meters from the perimeter of the platform, are compact and are defined around the center of the platform for stability; these choices have been made consistently to the notions acquired in the preliminary research and conclusions made in the 'building on water' chapter.

INTERNAL HEAT CAPACITY ACCORDING TO BUILDING LAYER

The program offers four options: traditional construction, mixed heavy construction, mixed light construction and full timber construction. Below are the relative reference values:

- Traditional construction:
Inner cavity leaf> 100 kg / m2
House separating wall> 100 kg / m2
Floor> 100 kg / m2

- Mixed heavy construction:
Inner cavity leaf ≤ 100 kg / m2
House separating wall> 100 kg / m2
Floor> 100 kg / m2
Lofts with a roof boarding capacity of ≤ 100 kg / m2 and a house separating wall and floor> 100 kg / m2 also fall into this category.

- Mixed light construction:
Inner cavity leaf ≤ 100 kg / m2
House separating wall ≤ 100 kg / m2 (or no residential wall)
Floor> 100 kg / m2
Attics with a roof boarding ≤ 100 kg / m2 and no dwelling-separating wall but with a floor> 100 kg / m2 also fall into this category.

- Full timber frame construction:
Inner cavity leaf ≤ 100 kg / m2w
House separating wall ≤ 100 kg / m2 (or no residential wall)
Floor ≤ 100 kg / m2

The program also notes that the mass of constructions that are shielded by internal insulation may not be taken into account when determining the mass.
As the building will be floating I excluded traditional construction and mixed heavy construction considering only the mixed light and timber framed option, equally stated in the next chapter on building construction. By changing the two the difference is minimal allowing me to consider both as suitable options.

INFILTRATION AND ARCHITECTURE

Referring to roof and facade type, among the options are considered standard facade, double skin facade with interrupted gap or continuous double skin facade. As I consider the city made of different architectural choices, and conclusions on construction and material choices are made in the next chapter, I manually applied the minimum values for the external envelope resistance required by the Dutch law as follow:

Floors: 3.50 m2K/W
Facade: 4.50 m2K/W
Roof: 6.00 m2K/W

By increasing such values, there are not noticeable changes in the overall energy demand. This values are therefore the base of the following calculations.

HEATING SYSTEM

It is possible to choose one of the following heating systems:

- Individual heating system - Boiler
- Electric heat- pump
- Electric heat pump that complies with table 14.14 (WP approval)
- Micro CHP
- Local and central electric heating
- Directly fired air heater
- Local gas or oil heating-steam boiler
- External heat supply

All of them are compered to choose the optimal one. External heat supply is not considered in the comparison, although the value has been given for general knowledge. First calculations are made for a 50-50 glass wall ratio on both south and north facade, such percentage is chosen as arbitrary starting point, only to concentrate on the heating system. Same goes for the external heat supply for water heating and natural ventilation, both arbitrary in this phase. What can be seen from the table on the next page is that the basic energy need for such a volume is 76,8 KWh/m^2, and this remains unvaried , contrary to the primary energy use, which changes according to the energy system used. The basic energy need will in fact vary according to the glass window percentage and other envelope’s characteristics. We could say that the total energy need of the building is given by the sum of the energy need determined by passive and active characteristics, where the passive refer to the construction choices, and the active to the adopted energy system. This is the reason for which the volume’s glass/wall percentage is arbitrarily chosen.
For the table below can be seen that the most effective solution is given by the use of an electric heat pump, which is in fact considered one of the best solution for heating and cooling.
Heat pumps work by using a small amount of electrical energy to move heat from different places with different temperatures. In other words, if it is for instance an air heat pump, when outside is cold, it will move heat from the outside to the inside, making the outside cooler and the inside warmer; in the same way, during summer, it will take

heat from the inside to the outside of the building, making the inside cooler, and the outside warmer. Electric heat pump can work air to air, using underground or water. All three work with the same mechanism, moving heat rather than producing it, although geothermal and water source heat pumps are considered more effective. In the calculations below, the electrical heat pump throw water source as been considered, since the open sea environment. Moreover heating and cooling are spread throw the floor, because this was the option that saved more energy.

It is very important in the case of a water heat pump that the extraction must take place where the water doesn't freeze and it is not disturbed by the life in the bottom water. The applicability of the resource depends on: Availability, both geographically and in time; the size and complexity of the installation for making the source usable; the investment costs and the costs for maintenance and operation (Vadevecum, 2017).

Heating System	Energy needs [kWh / m²}	Primary energy use [kWh / m²]	TOT Energy kWh / m²]	Heating %	EPC
Individual heating system outside EPC boundary	76.8	118.2	195.0	47%	0.791
Micro CHP	76.8	113.1	189.9	48%	0.760
Electric heat- pump	76.8	92.9	169.7	34%	0.639
Local and central electric heating	76.8	194.5	271.3	66%	1.252
Directly fired air heater	76.8	115.1	191.9	46%	0.773
Local gas or oil heating-steem boile	76.8	140.4	217.2	55%	0.926
External heat supply	76.8	111.9	188.7	44%	0.754

Table containing results for each heating system

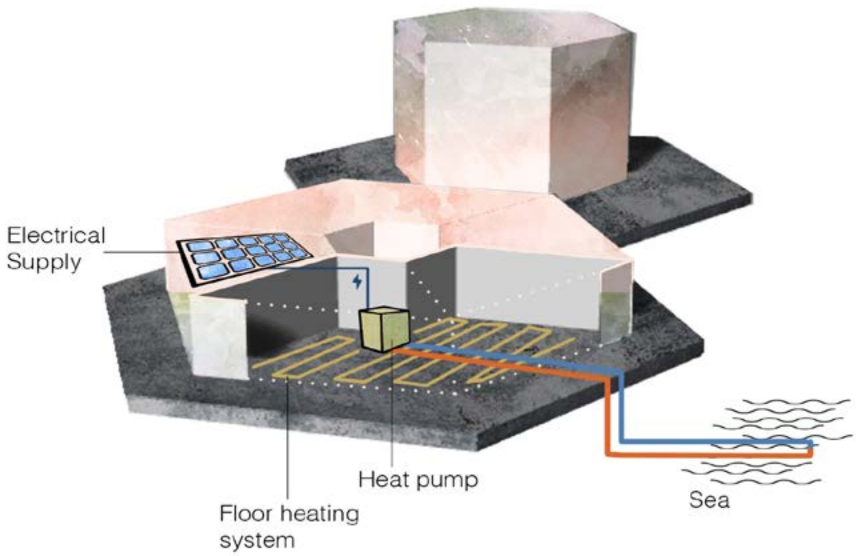


Illustration of electric heat pump mechanism in the floating pixel

WATER HEATING SYSTEM

The program offers a choice among the following:
- HR Boiler
- Heat pump boiler
- External heat supply

As for the heating system, the external heat supply is not considered. The same consideration on basic energy need and primary energy use apply here as well.
In this case, although both HR boiler and external heat supply provide a lesser energy consumption, the heat pump boiler has been chosen as the option to adopt. This is due to, firstly, the desire to avoid the use of fossil fuels, and secondly, to keep the energy production as linked to the pixel as possible, without considering an external supply.

Water heating system	Primary energy use [kWh / m²]	TOT Energy kWh / m²]	Hot water %	Heating %	EPC
External heat supply	92.9	169.7	32%	34%	0.639
HR Boiler	88.0	164.8	29%	36%	0.609
Heat pump boiler	97.3	174.1	33%	35%	0.665

WINDOWS AND WALL RATIO

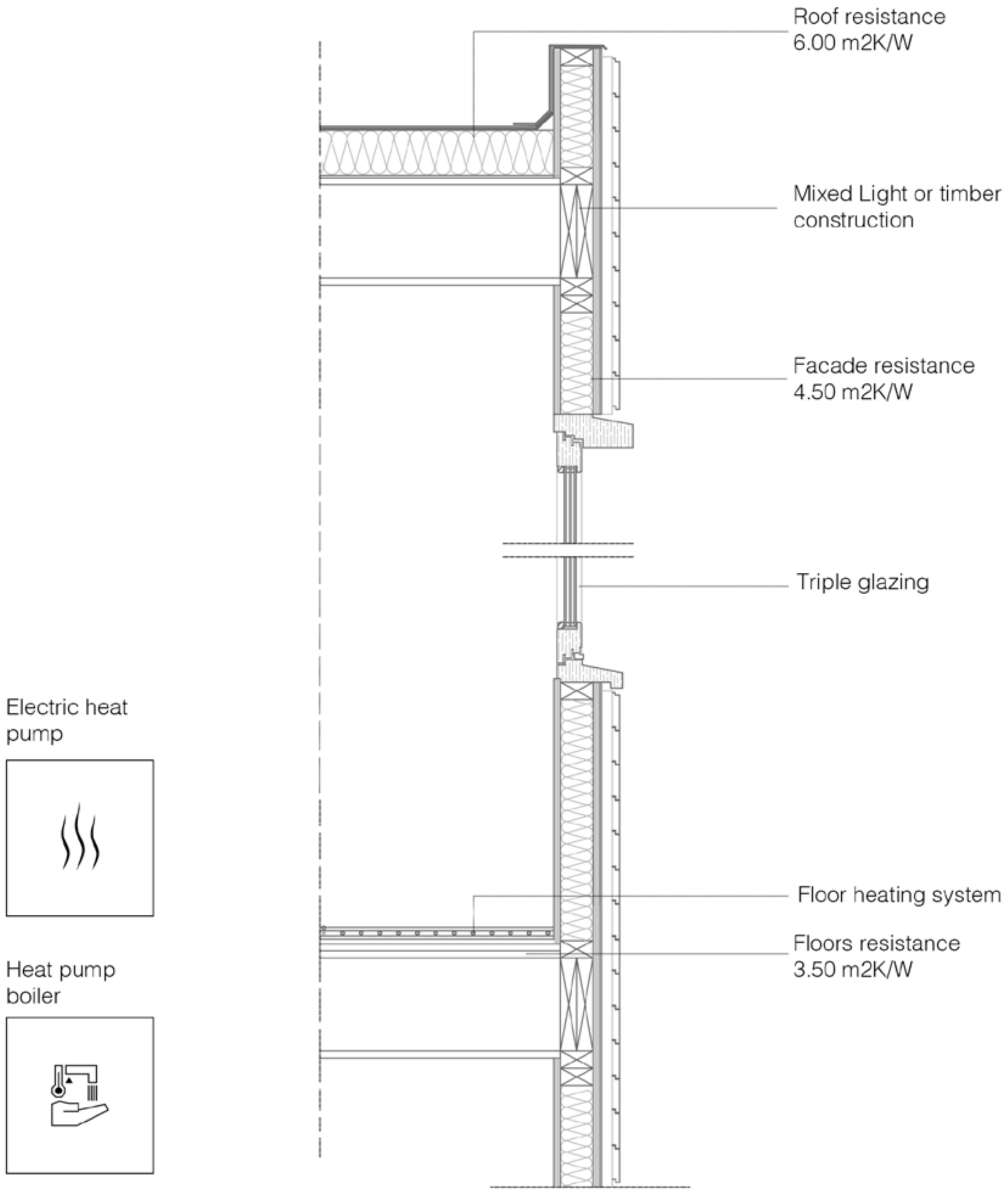
The window-wall ratio will change considerably the energy demand of the building. Because we are working on a simplified version of the pixels, calculating all the different options with changing percentage in the four orientation (south, north, west and east) for all the possible volumes, was believed unnecessary for this first phase of the study. It was then considered appropriate to primarily determine an acceptable average working ratio which was chosen with such glazing percentage: 50% south, 40% east and west, and 30% north. This will be used to calculate a higher number of different volumes by the end of this section. Must be noted that this is a simplification needed to reach a first set of conclusions on the energy need of the pixels. In a real scenario such percentages can be optimized according to the architectural design. For the glass I applied the transmittance value (U value) of triple glazing equal to 0.70 W/m2K, as it is the most energy effective option.

VENTILATION

Here different options are available, although, since we are using a heat pump boiler, the exhausting air will have to pass throw this mechanical system. The incoming air was considered instead available throw natural ventilation. There is therefore a combined system with natural incoming air and mechanically exhausting air throw the heat pump boiler.

TO SUM UP

After a first use of the software certain characteristics of building pixels have been defined to be the optimal ones. These are summed up in the image below, and will be part of all residential pixels object of study



Scale 1:20

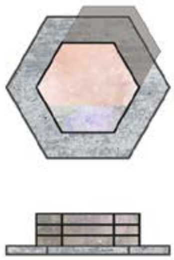
595,4 m2
7 units
26.617 kWh
3802 kWh per unit

847.2 m2
11 units
40.826 kWh
3711 kWh per unit

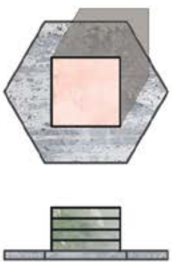
1190.8 m2
15 units
54.474 kWh
3631 kWh per unit

1694 m2
22 units
78.020 kWh
3546 kWh per unit

1786 m2
23 units
81.610 kWh
3548 kWh per unit



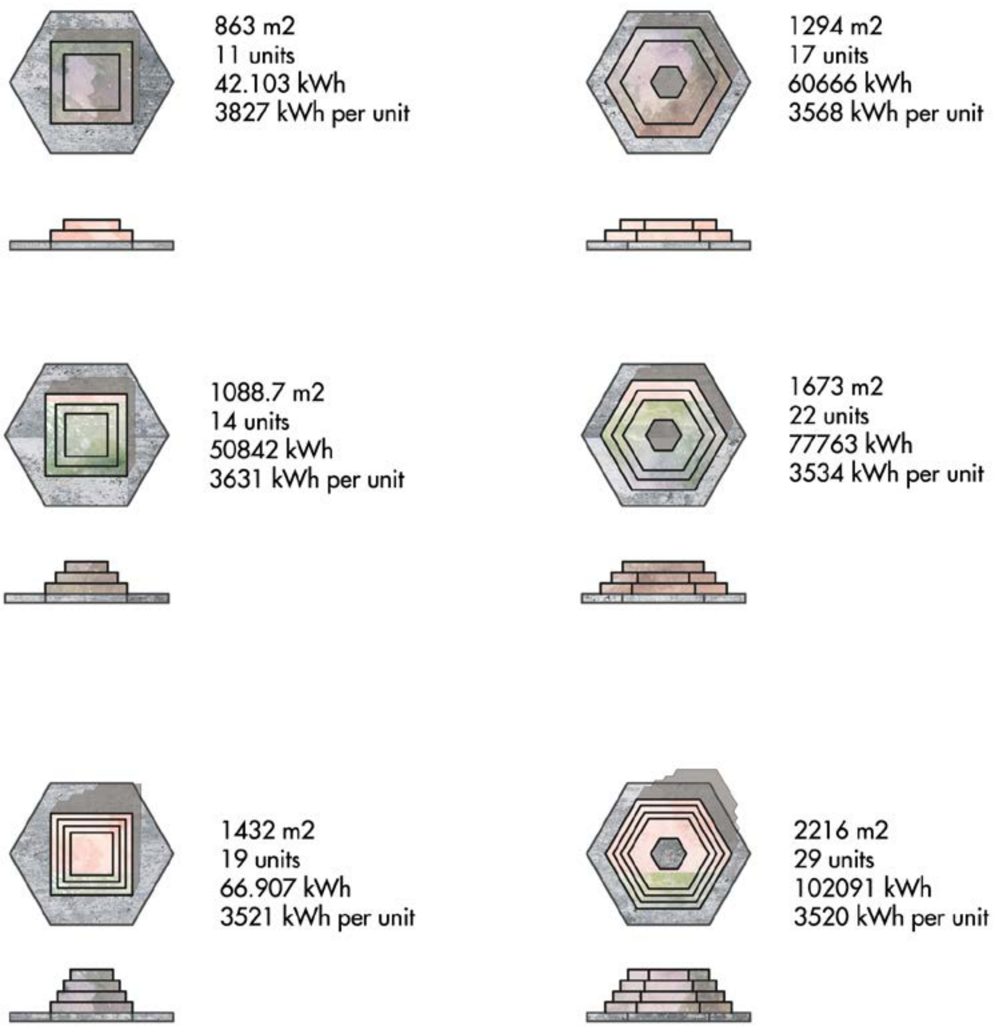
973.8 m2
13 units
46.857 kWh
3604 kWh per unit



1664 m2
22 units
76.954 kWh
3498 kWh per unit

1504 m2
20 units
53.786 kWh
2689 kWh per unit

Energy calculations per pixel



CALCULATIONS AND RESULTS

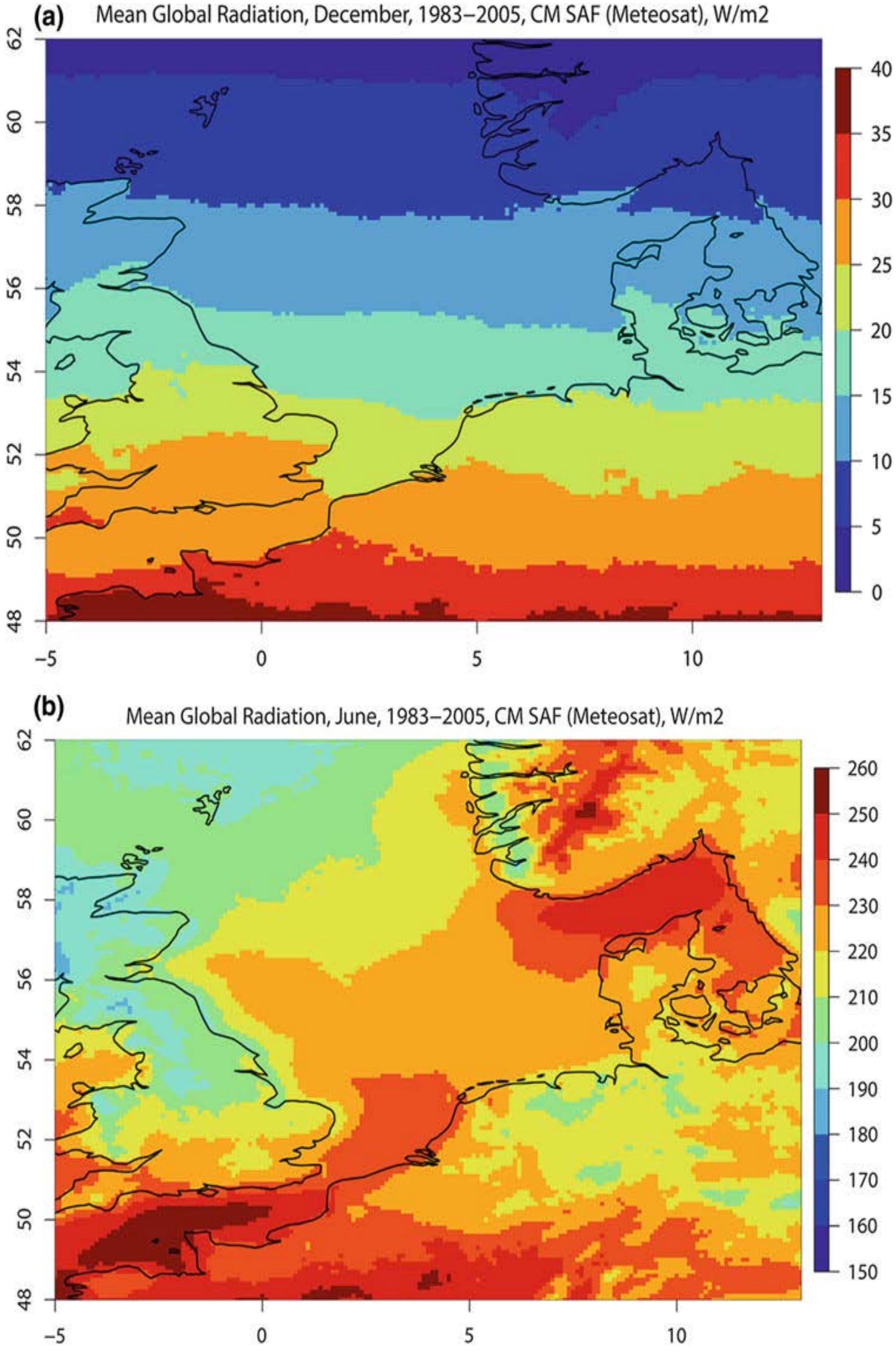
After defining the optimal characteristics to lower the energy need, calculations on different volumes have been made to understand until which point the parameters defined previously are applicable, and to see if any of the volume has a better performance. The pixels on the left, are simplified versions of possible buildings that vary from one to four floors height. Floor areas vary from a minimum of 595 m2 to a maximum of 2216 m2, for a number of housing units that vary from 7 to 29, considering housing units from 50 to 100 square meters. By calculating the average energy need per each housing unit, it was possible to see that all volumes differ from 200 to 1000 kWh per year difference, which is around 2.73 Kw/h on average per day. Moreover if we calculate the mean energy demand per day we can see that it varies from a minimum of 7.36 kW/h to a maximum of 10 kW/h, which, considering that on average a household needs 30 kW/h per day, is a reduction of at least 1/ 3 compared to a normal housing units. By these we can conclude that, by the use of the parameters defined in the previous pages, even by changing the building's volume, the average energy need remains almost unvaried and still at least one third of energy need for average households, which determines a relatively good energy saving.
To conclude, we can also see that the higher the number of housing units per each building the lower the energy demand and that the less compact the building the higher the energy need.

SUSTAINABLE ENERGY SUPPLY

There are five different forms of sustainable energy supply that can be considered in the sea environment: solar, wind, currents, tides and wave energy. In the next pages some consideration will be made on the applicability and integration of these sources with the with the urban pixels

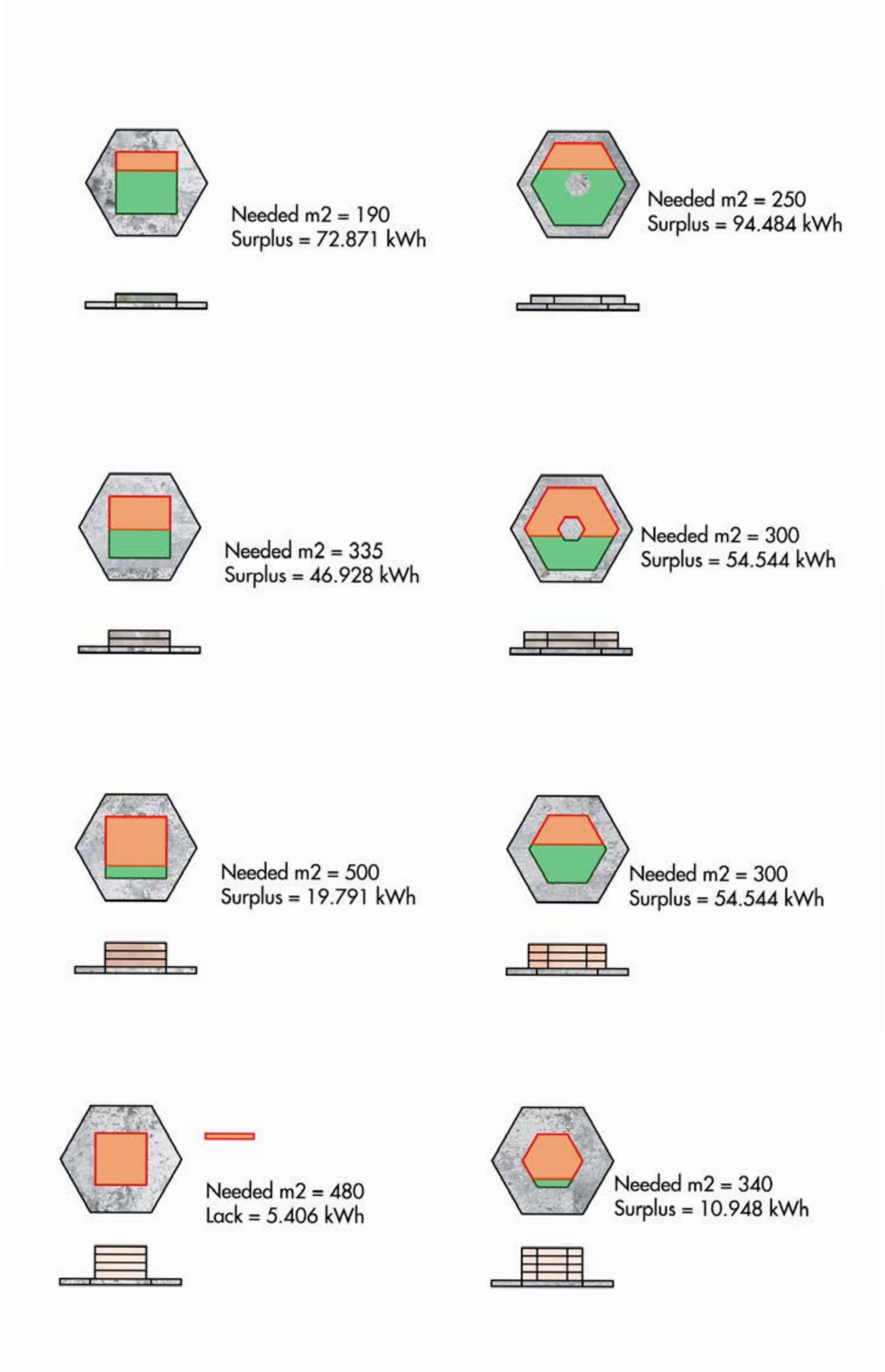
PV PANELS

The use of Photovoltaic panels, not only can be very fruitful in the warm seasons but can also be applied to the building pixels more easily than any of the other energy supply systems, on the roof or on the façade, on the floating platform and with the possibility of placing panels themselves directly on the water by making them floating. Example of floating solar power plants already exist and in a way are considered more efficient as the ambient temperature of water is relatively low. To understand quantitatively the use of PV panels for the floating city, calculations have been made in relation to the simplified building pixels discussed before; to calculate the square meter surface of panel needed per pixel, Uniec 2.2 has been used, as the program offers the possibility to calculate the amount of PV needed to make the pixel solar self-sufficient. The panels are considered horizontal with an efficiency of 200 Wp/m2. If the panels where inclined for optimal results, the amount of them would be minor although the square meter wouldn't change as much because of the distance necessary in between panels to avoid their own shade, if placed on the roof. The reason to keep them horizontally is to visually translate how much space they will require and how they can be integrated, in a case of less efficiency. In fact, facade and floating platform could also be used. The visual representation is then indicative of a negative scenario, with improvement possible according to design. Looking at the visual representation, it is possible to see that the amount of pv lacking for some of the pixels could be easily set on the facade of the pixel itself (drawings are on scale). The efficiency will be slightly different as the angle changes, but from horizontal to vertical the difference is not excessive. The best solution would be to have an inclined facade with the PV set on it, in a way that the pixel volumes have more like a pyramid shape with a greater surface used. It is also possible to see the the amount of pv, in such scenario, would eventually cover the majority of the south facade, with consequences on the architectural outcome of a design.
Another important fact to consider is that on warm seasons, the location presents a higher solar radiation than in inland territory, as can be seen on the image aside. As Uniec 2.2 calculates for an inland water location, the effectiveness of the PV is actually improved compared to the calculations. In general we can say that PV panels can be an effective solution and can be integrated in the design. Moreover, some of them even present a surplus of energy per year which could eventually be used by other pixels.

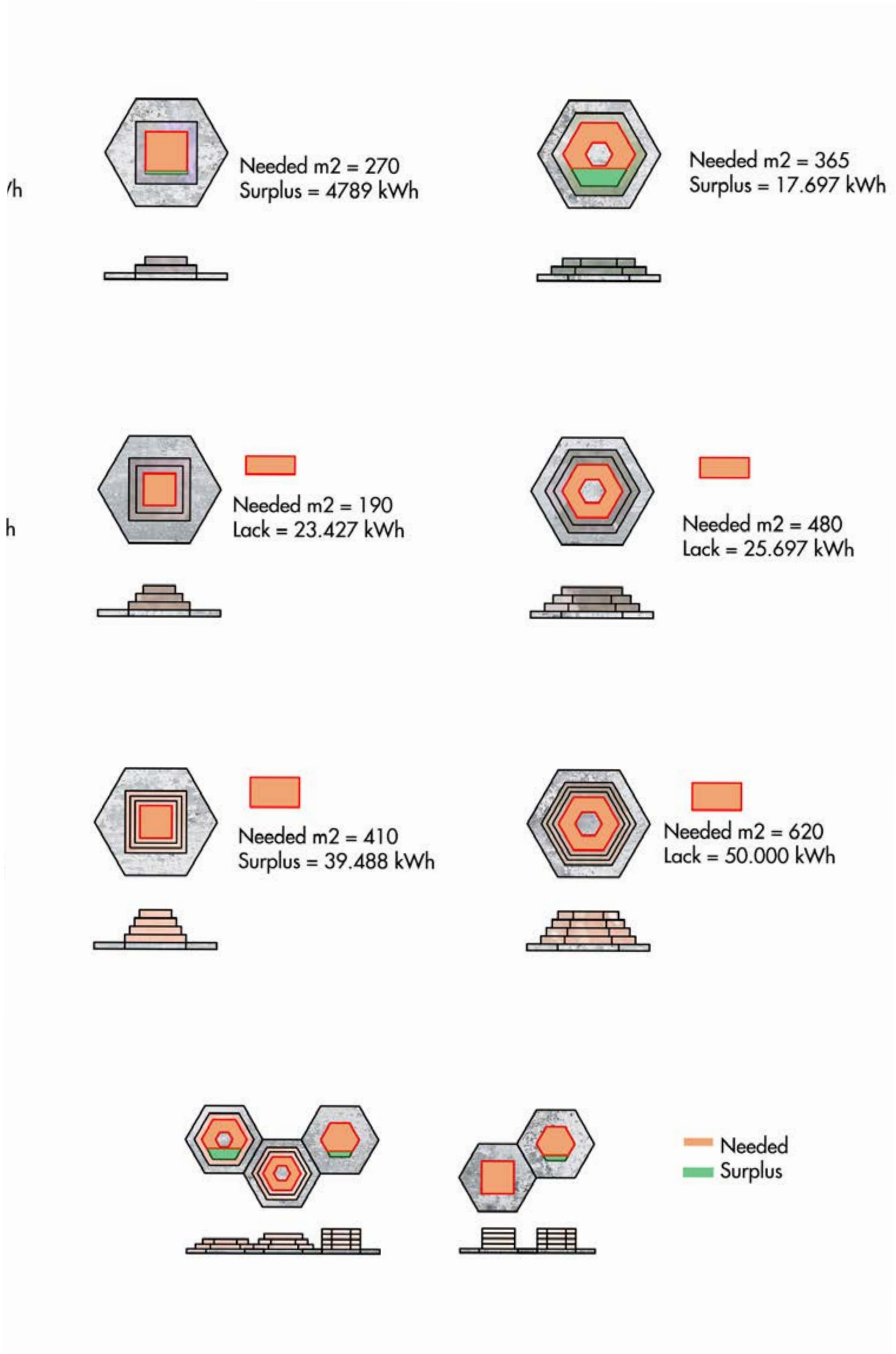


(a)
Mean Global Radiation, December, 1983–2005, CM SAF (Meteosat), W/m2
62
60
58
56
54
52
50
48
–5
0
5
10
40
35
30
25
20
15
10
5
0
(b)
Mean Global Radiation, June, 1983–2005, CM SAF (Meteosat), W/m2
62
60
58
56
54
52
50
48
–5
0
5
10
260
250
240
230
220
210
200
190
180
170
160
150

ENERGY



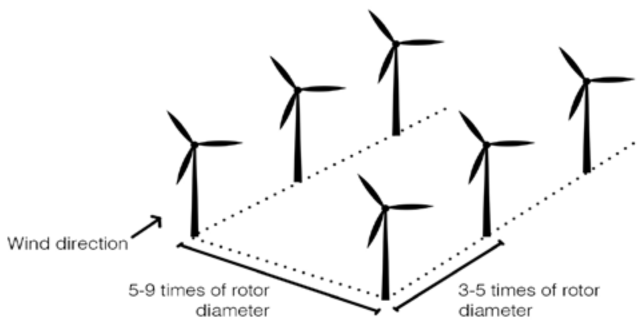
PV panels area



Needed m2 = 270
Surplus = 4789 kWh
Needed m2 = 365
Surplus = 17.697 kWh
Needed m2 = 190
Lack = 23.427 kWh
Needed m2 = 480
Lack = 25.697 kWh
Needed m2 = 410
Surplus = 39.488 kWh
Needed m2 = 620
Lack = 50.000 kWh
Needed
Surplus

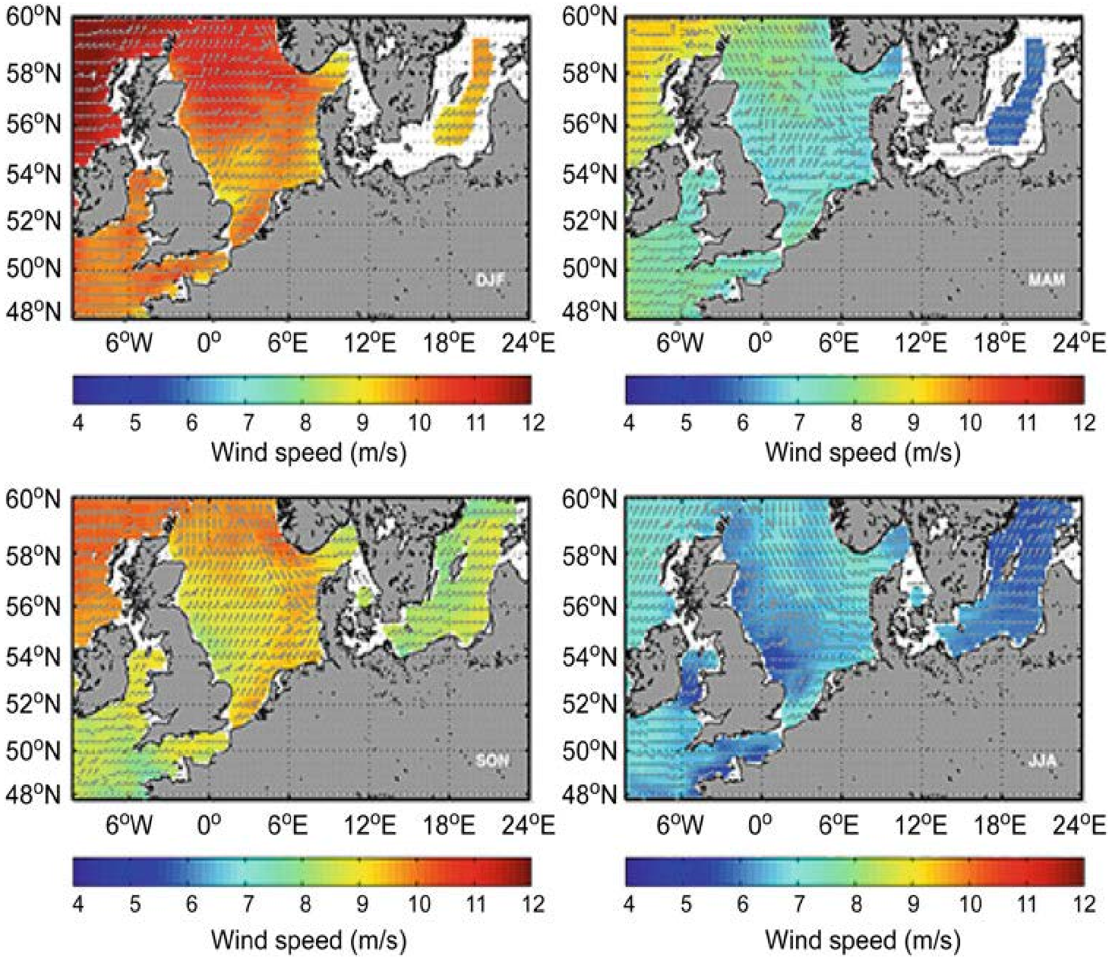
WIND TURBINES

Wind constitutes an indubitable energy potential for the location of interest, especially in the cold seasons, which could very well compensate the minus efficiency of the PV panels in that particular part of the year. Wind turbine are in fact source of undesirable noise for urban environment, in the order of 35 to 43 dB of sound pressure, in fact it has been found that 10 to 20% of residents are annoyed and 6 % very annoyed by it[1]. This means that placing wind turbines in proximity to the building pixels would be adverse to acoustic comfort of the inhabitants. This problem could be partly solved by the use of small and possibly silent turbines which can be placed at smaller distance compared to normal wind turbines. According to some studies even one of the quietest turbines cannot bring down the noise level when in function but the noise of these type of turbines can dissipate quickly by increasing the distance from the turbines, with possibly a minimum of 30 m[2]. In a way this means that small turbine could still be placed on adjacent platform to the building's one, yet the amount of turbines would be minimal considering not only the distance to the dwellings but also the distance in between the turbines themselves. Besides, the level of pressure increases by the increment of wind speed, which in a way makes the turbines more undesirable near residential building in the North Sea more than inland. Moreover determining the noise due to wind turbine can be very complex as the surroundings play a role by absorbing or reflecting the sound in different directions. For instance, grass, trees and humidity can absorb the noise, whether rocks, waters or buildings can enhance it. All this bring to the conclusion that small turbines could be used near the dwellings with certain precautions, yet the acoustic comfort cannot be guaranteed 100% and specific and more detailed studies are required to understand the noise behavior of a small turbine in the particular environment of study. Nevertheless, some calculations for the amount of energy supply of small turbines has been calculated in relation to the building pixels to understand their potential. This calculations have been done for a 10 kW small turbine which can produce around 16.000 kw/h per year on ideal conditions. The illustration simply shows how much of the total energy need per year of the pixel, can be produced by one 10kW turbine, which is in general the maximum numer of turbines that can be set near the building to avoid excessive noise.This simple illustration is just indicative, as to calculate the real energy supply the capacity factor of the turbine, which varies with the wind speed and over a period of time, needs to be known.



1 Karl Bolin, Infrasound and low frequency noise from wind turbines: exposure and health effects, Enviromental research letters, 2011

2 Ernest V.F Hodgson, residential wind turbines and noise emissions, Contemporary project in appropriate technology, North Carolina University



Wind average speed distribution according to season (m/s), and prevalent wind directions.

Source: M. Quante and F. Colijn, *North Sea Climate Change Assesment.*

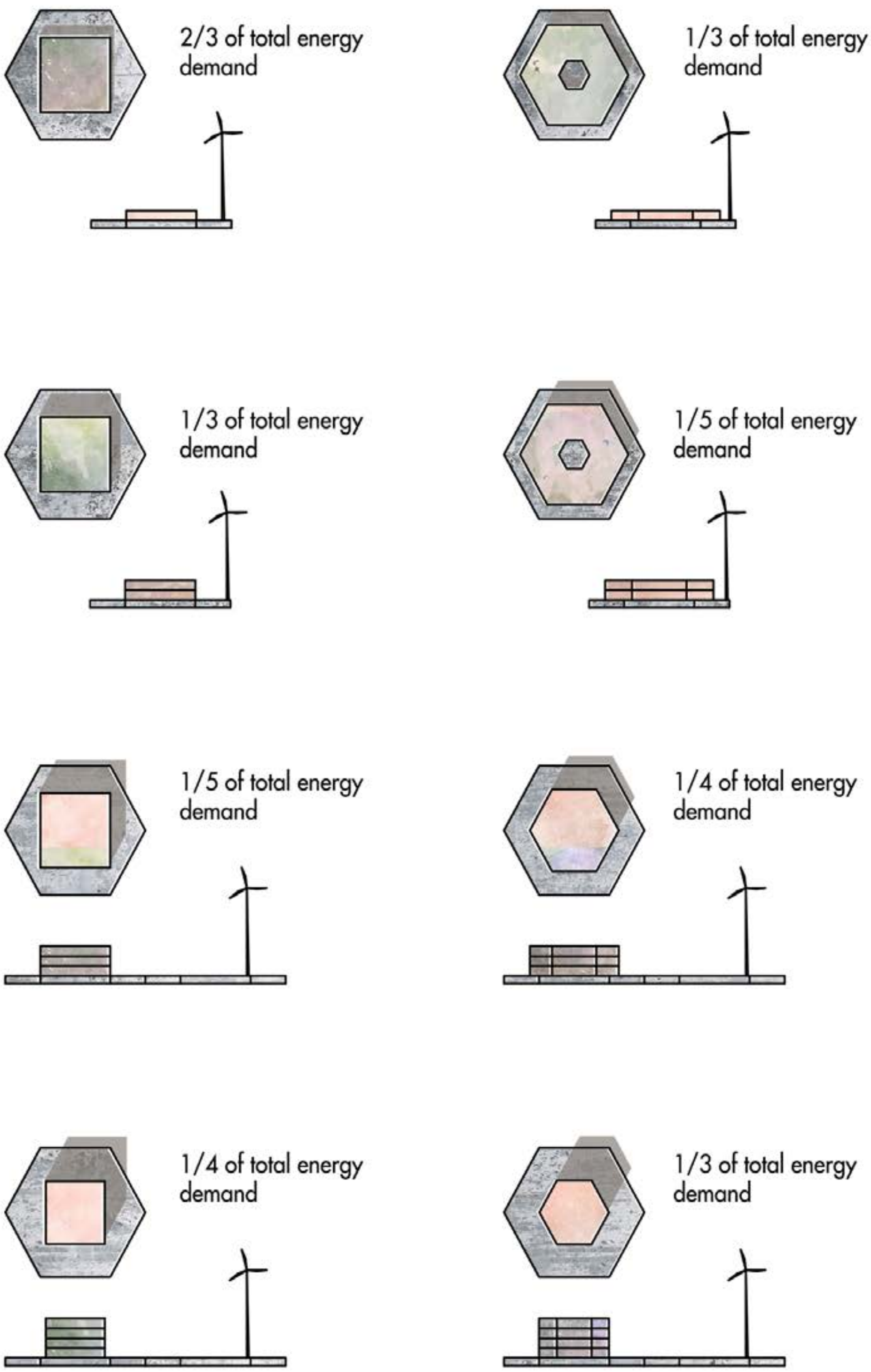
As small wind turbines are preferrably not applicable, some calculations have been made for bigger turbines to set outside the city, to have an idea on how many turbines would be necessary. This has been done considering the wind speed according to months as shown on the map above, and considering the formula below to calculate the the energy supply for an entire year.

turbine power × 365 days × 24 hours × capacity factor(%) = ...kWh per year[1]

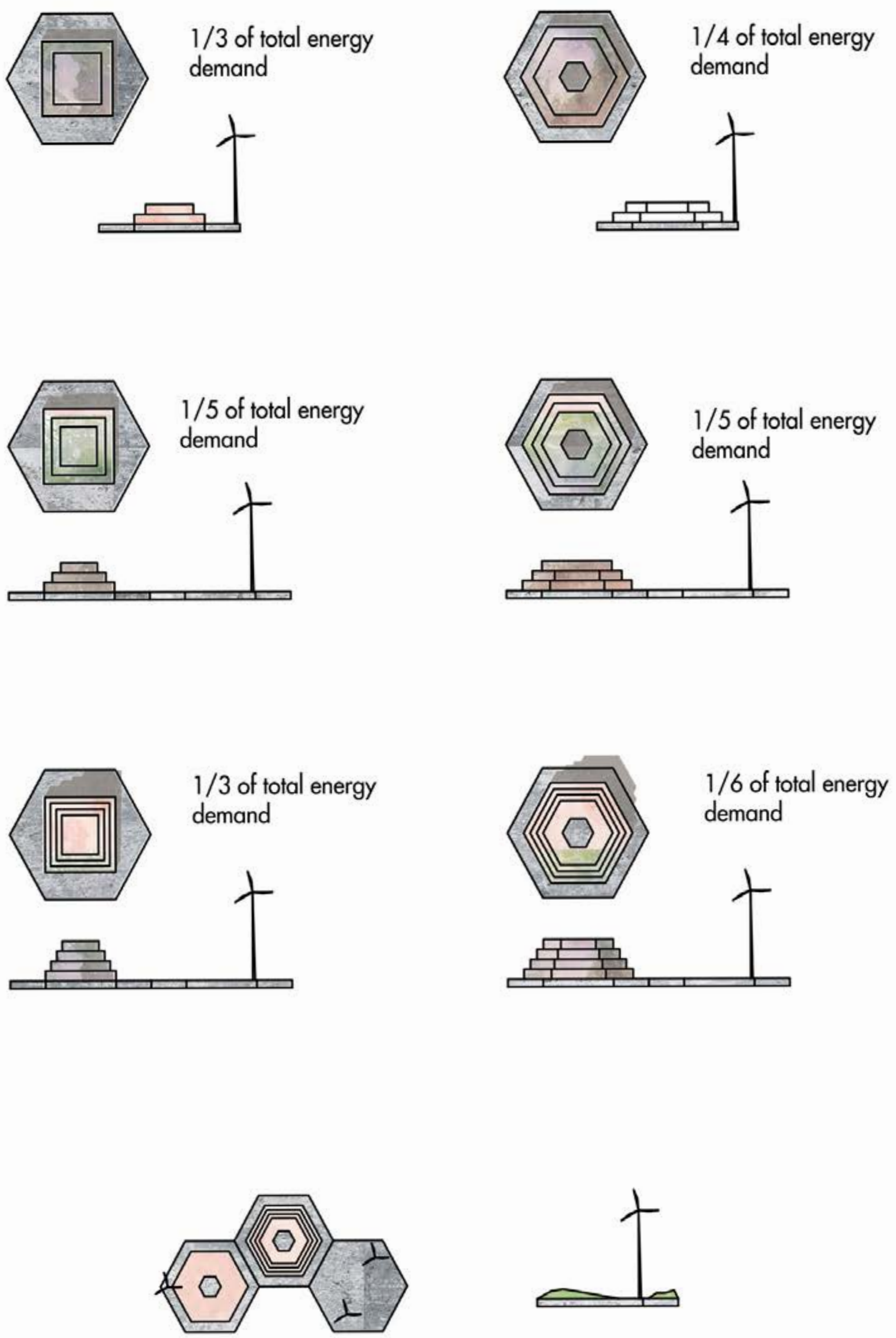
The capacity factor considered is of 25%, as an average factor, and a 35% considering the better results of off-shores wind turbines. Again, this calculations are indicative, the energy factor will change by changing the location of the city as well. The idea is to see in average conditions how the city will provide energy for itself and how it will look like. The wind turbine considered is a the E53/800 model for 800 kW, with its relative data according to wind speed[2]

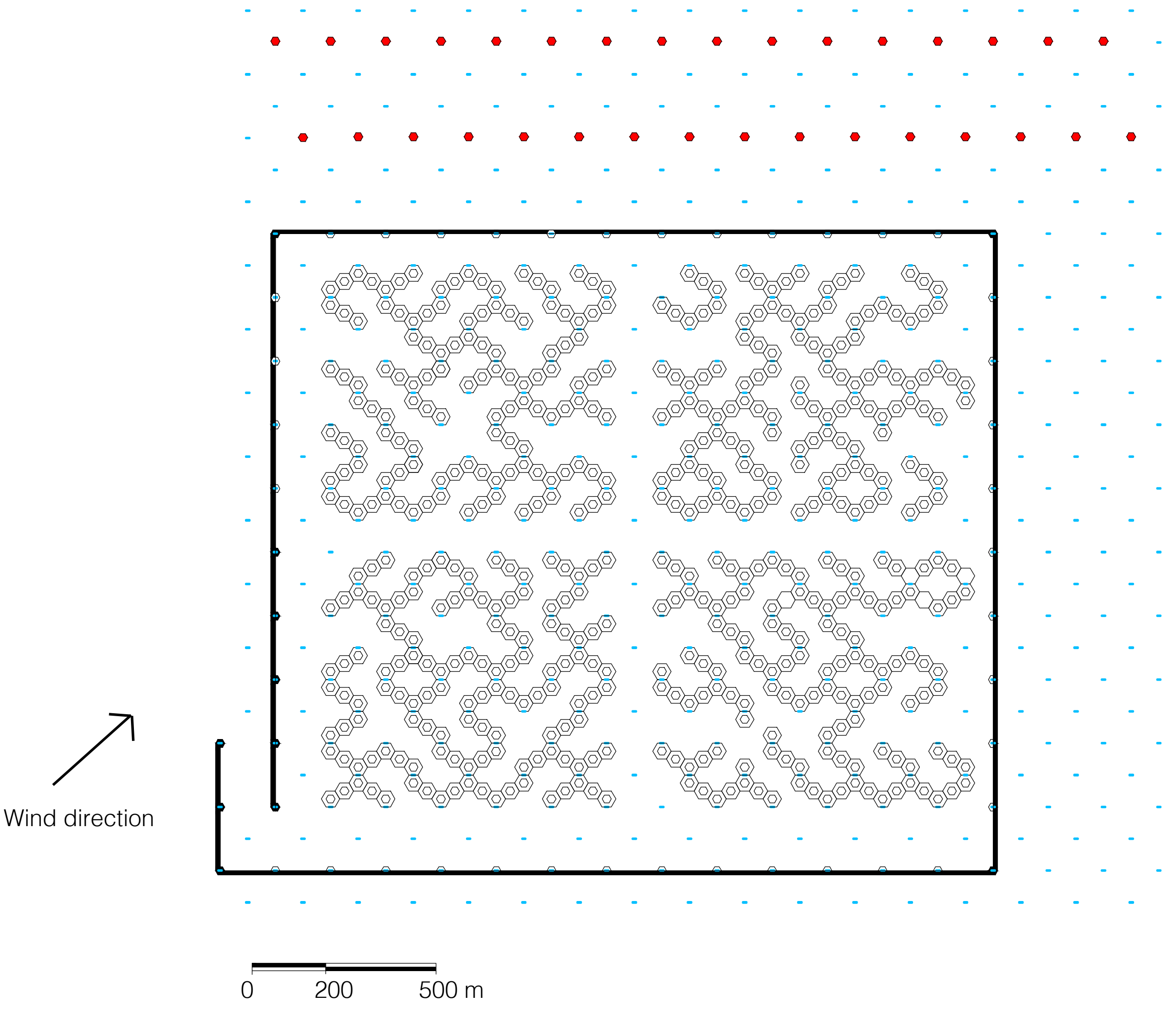
1 From: https://www.wind-watch.org/faq-output.php

2 Turbine's data at : https://www.thewindpower.net/turbine_en_4_enercon_e53-800.php



Amount of energy demand supplied by 10 KW wind turbine per pixel pe year


1/3 of total energy demand
1/4 of total energy demand
1/5 of total energy demand
1/5 of total energy demand
1/3 of total energy demand
1/6 of total energy demand



- Turbines will need to be placed at least 300 m from dwelling
- The scheme shows the minimal distance required among turbines of this size
- For 500 pixels the amount of turbines varies between 30 and 35.

Full capacity per Months:

DJF 10m/s = 516 kW
516 x 90 x 24 = 1114560 kWh

MAM 7.5 m/s = 234 kW
234 x 92 x 24 =516672 kWh

SON 9.5 m/s = 456 kW
456 x91 x 24 = 995904 kWh

JJA 7 m/s =184 kW
184 x 92 x 24 = 406272 kWh

Full capacity all year:
1114560 + 516672 + 995904 + 406272 = 3033408 kWh

With 25% capacity factor
3033408 x 25% = 758352 kWh per year
Enough to supply 10 to 15 pixels.

With 35% capacity factor
3033408 x 35% = 1061692.8 kWh per year
Enough to supply 15 to 20 pixels.

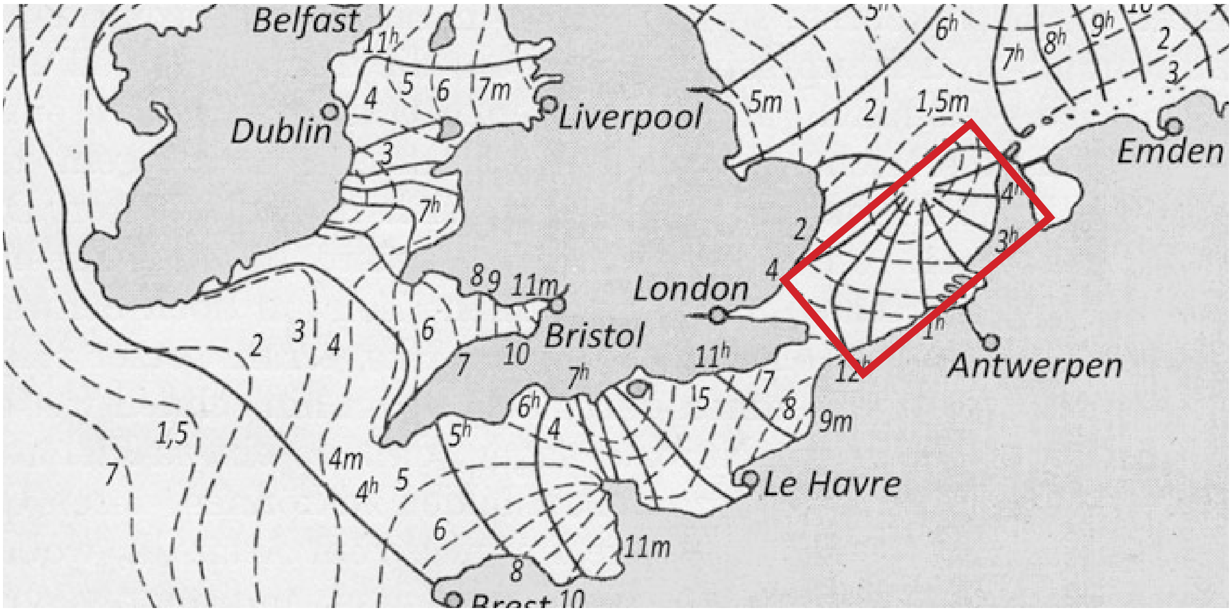
A portion of the city with the energy need of the building 1000 pixels will need aproximately 65 to 92 turbines of 800 kW according to the capacity factor. Bigger turbines will decrease their amount for equal energy need but increase the distance required.

TIDES

Tides are in in the order of 2 meters average height difference to a maximum of 4 meters height difference in the south of the Netherlands coast. To be effective in an energy point of view, tides need to have a minimum of 5 meters height difference. But this is not the main problem when considering tides for energy production in the location of interest. To produce energy throw tides a dam system is needed, which, if built in in the middle of the sea, will require a set of walls all around the perimeter of the city that can create a water level difference. This would require an incredible amount of material and energy resources, besides constructing walls around the city would even block its growth and flexibility. Dams for energy production throw tides are in fact built near the cost creating lagoons. This is not the case for the floating city object of study.

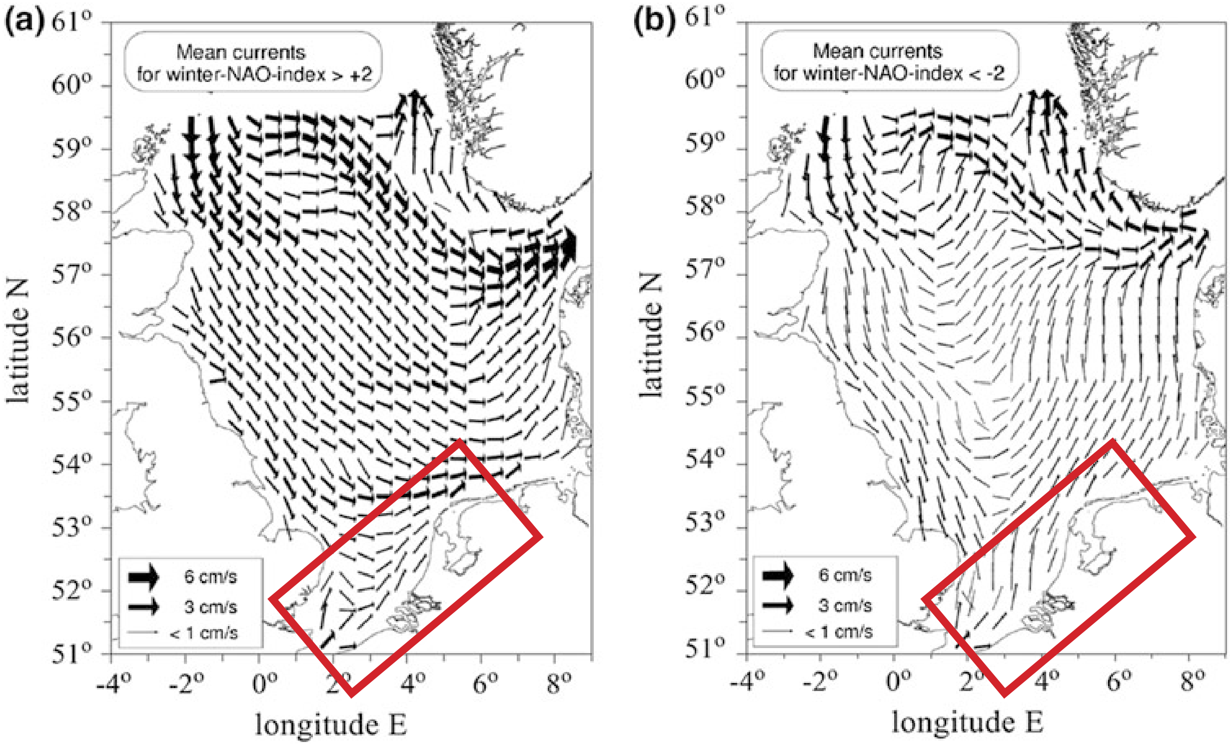
CURRENTS

In the location of study currents are minimal with a speed between 1 to 3 c/s. When currents are considered for energy production far higher speed are needed, in fact ocean currents are considered as an optimal source as they can reach 19 km/h, which is 500 times more than the speed of the Netherlands coast current speed.



Tides height

Source: M. Quante and F. Colijn, *North Sea Climate Change Assesment.*



Currents speed

Source: M. Quante and F. Colijn, *North Sea Climate Change Assesment.*

WAVES

To quantify the energy potential of waves many parameters need to be evaluated, such as wave height, length, frequency, and wave direction, all in different time of the year. To evaluate the potential of the location the data below based on scatter diagrams of measurement taken in location have been considered.

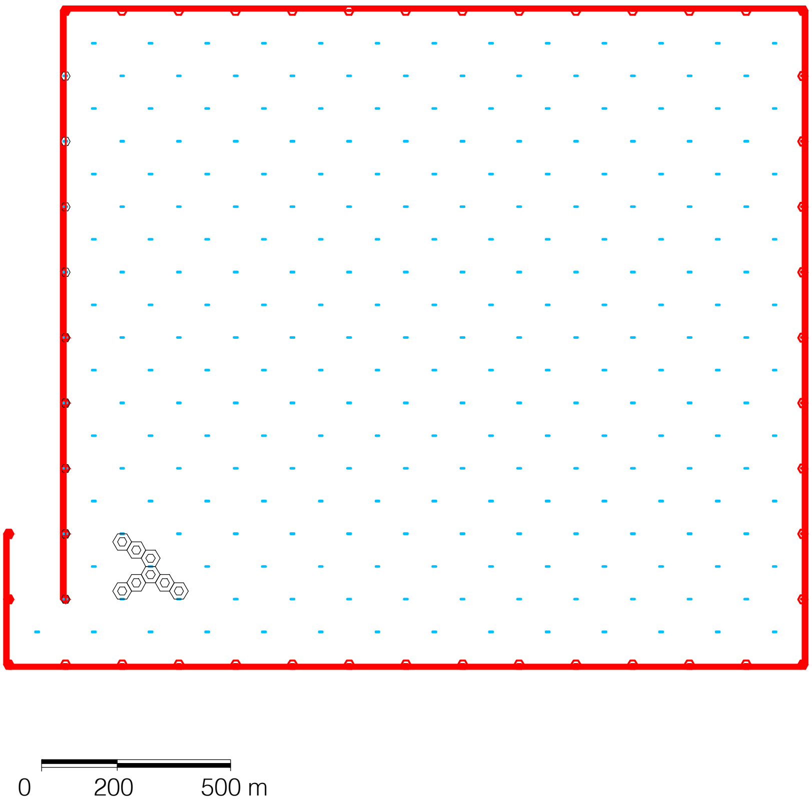
N°	Location	Research on which data are based	Average annual available wave power [kW/m]	Mean water depth [m]	Shortest distance to shore [km]
The Dutch Continental Shelf					
7	**Eierlandse Gat**	**Physical measurements (1979-2002)** (2)	**9.86**	**26**	**31**
8	Euro platform	Physical measurements (1979-2002) (2)	7.04	32	36
9	K13a platform	Physical measurements (1979-2002) (2)	10.80	30	88
10	Lichteiland Goeroe	Physical measurements (1979-2002) (2)	6.13	21	15
11	Noordwijk Meetpost	Physical measurements (1979-2002) (2)	5.42	18	7.5
12	Schiermonnikoog N.	Physical measurements (1979-2002) (2)	7.44	19	16
13	Schouwenbank	Physical measurements (1979-2002) (2)	5.57	20	20
14	IJmuiden Munitie Stortplaats	Physical measurements (1979-2002) (2)	8.68	21	32

Average annual wave power

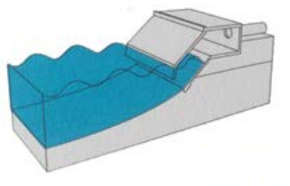
Source:C. Beels,J.C.C. Henriques, J. De Rouck, M.T. Pontes, G. De Backer,H. Verhaeghe1, *Wave energy resource in the North Sea*,

As can be seen from the map, number 14 and 11 could be considered for the location of interest. Their average annual available wave power is respectively 8. 68 and 5.42 kw/m. If we apply such value on the perimeter of the city as it is (ca 7 km) we can see that we have a total average wave power of 60760 kW for location 14, and a total of 37940 kW for location 11, which translate respectively to 1458240 kWh and 910560 kWh, enough to provide for 15 to 20 pixel in the first case, and 8 to 13 pixel in the second case. Such results are quite small considering the large amount of meters (7 km minimum) in which wave power generator should be set. The illustration on the next page shows approximately how this translates specially.
Moreover, according to the device applied, the efficiency could further decrease; for instance the use of floating OWC (oscillating wave column) or the taperin channel, is lower than when they are fixed.
It is then not opportune to install such extensive km of energy supply systems for such a small result. This result could in fact be substituted by the size of one floating platform of PV panels.

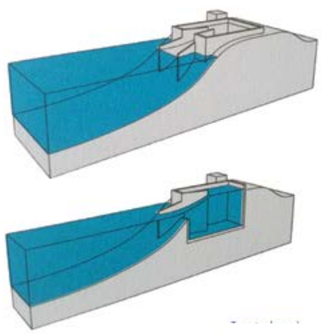
WAVES



Pixel that can be provided annually by wave energy, using the entire perimeter of the city.



OWC- Oscillatind water column

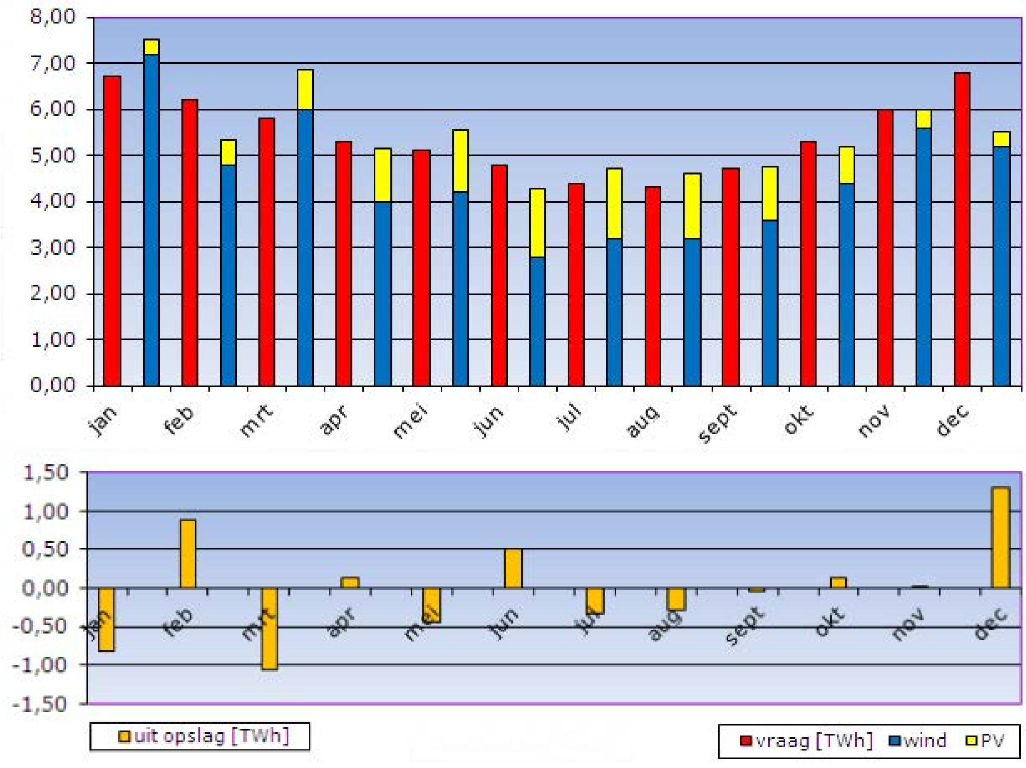


Taperin channel

Examples of wave energy systems
Source: K. Olthuis, D. Keining, ***Float! Building on water to combat urban congestion and climate change,*** Frame,Netherlands 2010

MONTHLY ENERGY SUPPLY

We have seen that solar and wind energy can be both valuable supplies, they can also work well together as one is more suitable for one part of the year and vice versa. They both have been calculated to supply energy for the entire year but it is known that for parts of the year none of the two supplies can provide energy to the city, for lack of sun and wind at the same time. The graph below shows the monthly yields of favorable combination of energy from wind turbines (70%) and PV cells (30%) to cover the annual Dutch electricity demand. As can be seen, with such combinations there will still be a need for energy storage. This for the months of February, April, June and December, in the order of 1/6 to 1/5 of the energy demand.



Source: Leo Gommans, gebiedsgerichte energetische systeemoptimalisatie, doctoral thesis, 2012, p. 221

But there will also be an energy surplus, in the graph in the months of January, March, May, July, August and September.
Now, we have seen before that seasonal efficiency of solar and wind in the sea is improved in the sea than the one inland and this could decrease the energy lack in the winter with the use of turbines and in summer with the use of PV panels. But there will still be a seasonal lack and surplus which needs to be taken into account.

The surplus energy could be stored by batteries to overcome the seasonal lack. The problem with batteries is that they are more suitable for a day/night storage rather than a seasonal one. Moreover, their lifespan decreases as they are charged and discharged, and this slowly reduces their capacity to store energy. They can last between 5 to 15 years and they also require a lot of maintenance. It is clear that another option for seasonal storage is required.

Another possibility would be to store energy in the form of hydrogen. The energy would than repurposed with the use of fuel cells. The problem with this mechanism is that only 40% of the initial energy surplus used to extract hydrogen from water, is then available after the use of fuel cells. 60% of the energy surplus is lost in the process. If we consider the table in the previous page we can apply the monthly proportions of energy demand and supply on our case, is we consider only wind turbine power for the cold season for example, we will have

Energy demand December for 1000 pixel in proportion with the graph = 7351598.2 kWh
Energy supply December 65 wind turbines of 800 W in proportion with the graph = 7064013.7 kWh
Lack of energy = 287584.5 kWh

Energy demand January for 1000 pixel in proportion with the graph = 7245053 kWh
Energy supply January 65 wind turbines of 800 W in proportion with the graph = 9645095.6 kWh
Surplus energy = 1207027 kWh
Usable energy stored for another month = 1207027 x 40%= 482810 kWh

Energy demand February for 1000 pixel in proportion with the graph= 6499238 kWh
Energy supply February of 65 wind turbines in proportion with the graph = 6384781.6 kWh
Lack energy = 114456 kWh

Without considering the PV influence the usable surplus energy with hydrogen fuel cells is 482810 KW/h in January, and the lack of energy is in total 402040 kWh. We can then say that with hydrogen fuel cell it is possible to overcome the biggest lacks in February and December show in the graph by the use of one month surplus energy. In the same way the March energy surplus can overcome the June lack. Of course this is indicative and made with simple proportions on existing data, but we could say that the city could be energy self-sufficient with the seasonal storage of hydrogen.
The problem is, if it can be considered a problem, that there will still be a surplus of energy, not only with the wind turbines but also with the use of PV panels. It would be opportune then to connect the city to an existing energy grid that could use its surplus of energy. Near the location there are some wind turbine power plants which are connected already to the inland and that can be connected to the floating city.

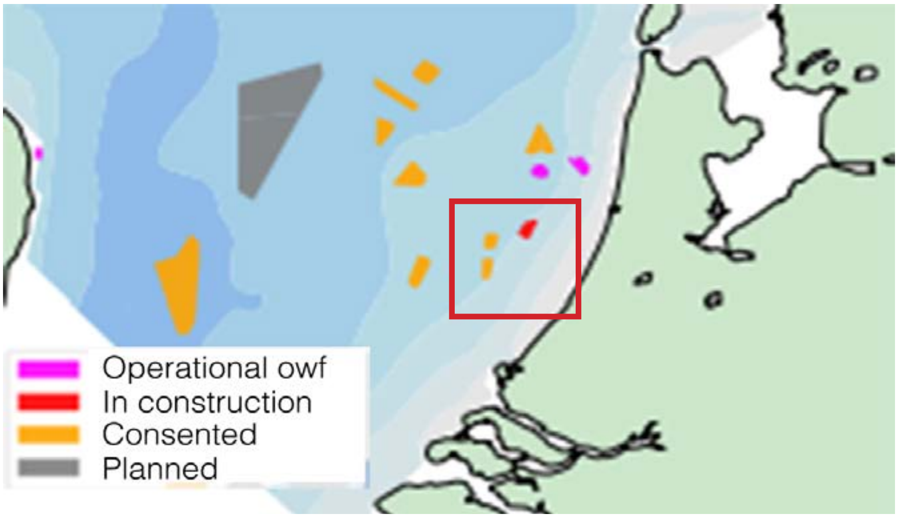
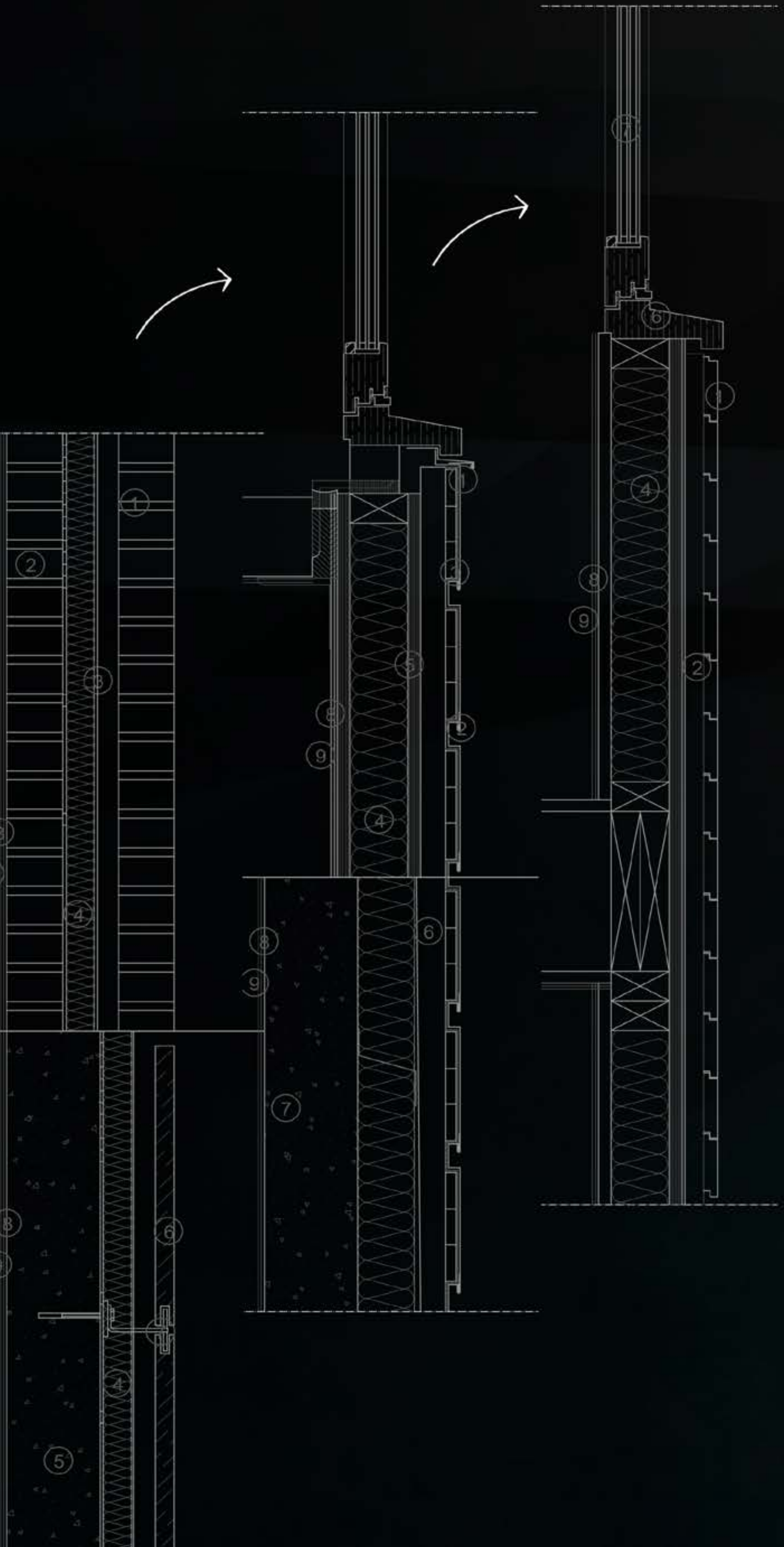


Image showing operational and in construction OWF. The floating city can take place in the consented areas shown in yellow.

RELIABILITY OF THE MODEL

We have seen that the simplified model could be energetically self-sufficient although there are some restriction on the calculations. The software Uniec 2.2 calculates the energy demand for settlement in inland water. Some variations are possible considering that in the open sea temperatures and RH are more drastic. Therefore the model could be considered indicative but not 100% reliable.

Moreover, there will be an added energy demand from the desalinization plants around the city and the energy demand will require an added number of turbines and PV to keep it self-sufficient. This will have further consequences on the visual aspect of the city, which will be full of energy devices, form the pixel scale to the city scale..



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BUILDING CONSTRUCTION
In Marine environment

BUILDING MATERIALS IN MARINE ATMOSPHERE

As mentioned in the floating urbanism chapter, there are few parameters which need to be taken into account when building on water. An important one, especially for the chosen location, is material behavior and resistance in marine atmosphere, as the presence of water and chloride in the air reduces their life span inducing additional corrosive effects. Corrosion does change according to the material typology, and is determined by many factors, most of which are normally monitored for inland cities' atmosphere air quality, such as solar radiation, temperature, relative humidity, rainfall degree and wind direction and speed. In marine atmosphere two other factors should be consider: buildings' time of wetness (TOW) and the surface contamination of corrosive agents, in this case chlorides.
Rainwater is not necessarily corrosive, and it can be very helpful in marine environment, washing away chlorides particles present on the building's surface, although dew and condensation due to high humidity levels should always be avoided. Corrosion activity can double with every increase of 10 degree temperature, moreover condensation may occur on the surface when a lag of temperature change happens between the material surface and the outside air inducing corrosion through the moisture film developed on the surface. Temperature correlation is important on regard of the climate of the location in which the building is going to be set.
Many studies have been conducted on the corrosion rate of different materials, although most of them are laboratory tests, which predictions for real case scenarios cannot be 100% reliable as they are conducted with cycles of wet and dry speeded by high degree temperatures. Additionally, example and data on coastal building's material are based on construction within a certain distance from the coast, on the contrary of the graduation project study which sets the buildings in direct contact with the marine environment, the most corrosive, compared to rural and industrial.
To understand better the consequences of the locations characteristics on building materials and make construction choices which can be suitable for the design, the behavior of different materials in regards to salt attack is explained in the following pages. At the end of it some comparisons are made in regards to durability, maintenance, weight and price, to find the most suitable for a floating city.

METALS

Metals are considered by far the most susceptible in marine environment. Their corrosive nature does not put them in the podium of the best materials to construct by the sea, in a first thought. Nevertheless some of them, like Steel and aluminum, are actually often used in naval and offshore engineering, due to their lightness and their strength against the mechanical and structural stresses.
In the case of metals, corrosion happens especially when the surface is wet because an invisible thin layer electrolyte is created on the surfaces which contains a high concentration of corrosive contaminants, and on which the atmospheric corrosion proceeds by anodic and cathodic reactions. To resist this effect, some metals are able to create an oxide layer which then protects them from corrosion agents.

Steels

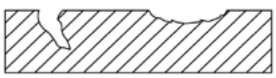
If we look at ship construction we will see that weathering steel with addition of corrosion resistant alloys are not commonly used due to their higher costs in the beginning phase of the production; what is used instead are mid steels with a high quantity of manganese and carbon, which are well protected with additive coatings. In our case the best option looks at stainless steel in which the chromium content makes it corrosion resistant, the more chromium content the more durable, even to Chloride attack, and with less maintenance. Weathering steels could also be made with the addition of Cupper or Nickel which allow the material to create a protective layer as in with the stainless steel. Durability of any weathering steel will depend on the added alloy content, it is necessary then to choose the right percentage to guarantee an optimal solution.

Titanium

Titanium could be the best material choice among all metals, as presents the same strength of steel but with 60% less of its density and incredible corrosion resistance due to its capacity to create oxide film on its surface. Such layer is more resistant than the one in stainless steel, especially with crevice and pitting corrosion, which are predominant with salt water. It can become vulnerable, but only on very high temperatures in the order of 110 degree Celsius. Moreover, as it is an element itself, it doesn't need to be mixed with other alloys to gather its positive properties. It has been an expensive material for long, used in aerospace and chemical industry only, but its price has recently dropped in a way that is being considered for offshore engineering as well.

Copper, Aluminum and Zinc

All free grant their resistance to the capacity of creating a protective film which makes them more durable. Such film is created at speed rate that is higher in the sea environment than inland.
Copper is an excellent corrosion resistant material, as well as environmentally friendly, by being 100% recyclable. Its resistance can be decreased when paired with other alloys, in that case the durability will depend on which alloy and which percentage. Unfortunately it's behavior in saltwater decreases considerably its durability, making it the least suitable for marine environment.
Aluminum resistance on salt environment will depend on the metals to which is paired with as well. Among the aluminum alloys, those that are more resistant in unpolluted salt water, are those which do not contain Copper (1)
Zinc is stronger than Copper and Aluminum, and is corrosion rate is 10 times lower than that of steel for any atmospheric environment[1], one of the reasons it is used for the creation of galvanized steel. Its durability is strictly related to time of wetness and presence of pollutants in the air, for this reason it is not one of the best solution in a location of very high humidity and severe rainfalls.



Pitting and crevice corrosion

1 Revie, R.Winston, Uhlig's Corrosion hanbook (3rd edition), John Wiley & Sons, 2011

METALS	Weathering Steel	Titanium	Copper	Aluminium	Zinc
Weight (kg/dm3)	7.8-7.9	4.5	8.93	2.7-2.75	7.1
Life span (years)	30-100	100+	60-100	25-50	100
Life span marine environment	30-80+	90+	>10	15-25	50
Mantainance	minimal	minimal	minimal	minimal	minimal
Embodied energy	***	***	***	***	***
λ value [W/mK]	50.2	22	385	205	116
Recyclable	Yes	Yes	Yes	Yes	Yes
Coating	Yes	no	no	yes	no
Price	***	***	***	***	**
Other uses	Supporting structures	Aerospace, mediacal implants, construc-tions etc..	Electrical equipment roofing, cookware	Cars, kitch-enware, computers ...	Automo-biles,cos-metics ,cladding...

Table of most weather resistant metals and their characteristics.
Lifespan in marine environment is assumed according to literature study and should be considered indicative but not precise. Titanium can be considered the most suitable material both for supporting structure and for facade cladding, for lightness, strength, low mantainance and lower thermal transmittance, unfortunately with a high price.

PLASTICS

There three commonly used plastics for building construction. GRP (glass reinforced polyester) or fiberglass, polycarbonate and UPVC or PVC-u.

Fiberglass is the strongest among all plastics, and considered by few better than painted aluminum and steel structures in terms of durability[1]. It can be opaque or transparent and it is commonly used for small boats which, in a way could put the material among the preferable for marine environment. What is not known is that despite its strength and lightness it is not immune to maintenance. Moreover it is susceptible to UV light, heat and moisture.

Polycarbonate is light, transparent, has good insulation value and is sometimes preferred to glass for its strength. It yet a material with low durability, inflammable, scratches easily, and with a very high thermal expansion, in the order of 20% more than glass. On one hand is the preferable glass substitute when transparency is needed, on the other hand its many negative characteristics make it even more unsuitable for the design objectives.

1 Andrew Watts, Modern construction envelope, , SpringerWienNewYork, Austria 2011,

PVC-u is an unplasticised PVC with very low thermal conductivity, more than aluminum, and good strength. It is mainly used in plastic based window frames and weatherboarding, and can be colored.

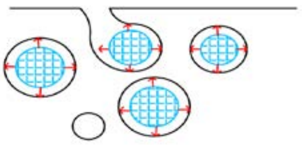
So we can already see that fiberglass and PVC-u are already preferable to the use of polycarbonate. The problem stands in determining their behavior in the marine environment. When it comes to polymers, the study can be very complex due to the large amount of chemical presents. Moreover study on durability are very recent and it is difficult to make assumption for this particular scenario (2). What can be said is that in general, polymers can be subjected to the colonization of natural microorganisms, like fungi or bacteria, which actually puts them in need of a protective coatings and maintenance as other possible materials as well.

POLYMERS	GRP	Polycarbonate	PVC-u
Weight (kg/m3)	3.9	ca	ca
Life span	50	5-15	10-50
Life span marine environment	40-50	2-10	40
Mantainance	minimal	yes	minimal
Embodied energy	***	***	**
λ value [W/(mK)]	0.04	0.19	0.19
Coating	yes	yes	yes
Recyclable	yes	yes	yes
Price	***	**	**
Other uses	Aeroplanes, electronic components, automotives, sporting equip-ment....	Glass substitute when higher resistance re-quired, lenses, facade	Pipes, window frames

Table of most used polymers in facades and window framing.
Lifespan in marine environment is assumed according to literature study and should be considered indicative but not precise. Both fiberglass and PVC-u are suitable options, for lightness, resistance, low mantainance and durability. The first can be considered mostly for facade components, the second for both facade and window frames.

CERAMIC MATERIALS AND MANSORY WALL

The durability of ceramic material in relation to marine environment is directly correlated to their porosity and pore size. This is due to salt crystallization, and the crystals pressure on the microstructure of the porous material in cycles of wet and dry. When the salts deposited in the pores get hydrated, it subjects the material to a micro pressure which can decrease its modulus of elasticity, moreover studies have shown that NaCl has the higher crystallization pressure compared to other salts. Moreover, when bricks are used and Chloride is present, stresses are created due to differences in thermal expansion; in fact while chloride expands, bricks shrink, and the degree in which they do so is even enhanced by the presence of Chloride itself[1].
There is a first phase of salt deposition in which there are no traceable consequences, until a point called damage onset is reach. Of course, such point will be reach in a shorter time in marine environment than inland, and will depend on the specific material characteristics, but in general we can say that salt corrosion will not affect the building for a certain amount of time and then will decrease its structural stability, at least in masonry wall.
Yet masonry wall or stone cladding will not be considered for floating architecture, as their weight goes against the basic floating principles which must be followed to grant stability in the water environment. Ceramic material could however be considered for external pavement, their placement on the bottom of construction could in fact make good use of their higher weight for stability.



Micropressure by salt crystals when hydrated in wet and dry cycles

MASONRY	Bricks	Concrete	Limestone
Weight (kg/m3)	1922	2400-3000	1760
Life span	100+	100+	50-100
Life span marine environment	80 or less	100+ (with the right mixture)	40-80 or less
Mantainance	no	50	no
Embodied energy	*	****	*
λ value [W/(mK)]	0.6/0.11	0.8	1.26/1.23
Coating	no	no	no
Recyclable	Depends	Depends	depends
Price	*	**	**
Other uses	building material	building material	building material

Table of commonly used masonry wall materials.
Lifespan in marine environment is assumed according to literature study and should be considered indicative but not precise. Concrete is considered suitable only for the floating platform but not for the building's construction, due to it's weight.

1 B.H. Abu Bakar, M.H. Van Ibrahim, M.A Megat Johary, A review: Durability of Fired clay Brick Masonry Wall due to Salt attack, International Journal of integrated Engineering (Issue on Civil and Environmental Engineering),

WOODS

Wood has been for thousands of years, the preferable material used in ship construction, mostly for his buoyancy, availability and ease in manufacturing. Yet when adopted in marine environment has to be chosen carefully to avoid deterioration, due to salt, microorganism and water. One positive thing about the marine environment, is that brown-rot fungi and white-rot fungi do not present a thread when high salt percentage is present in the environment, although must be taken into account that other possible microorganism present in the North Sea might attack and start a decay process on wood. Salt does affect wood in a similar way as it does on masonry material; in cycles of wet and dry, salt crystals pressure the wood fibers moving them apart in a process called salt kill or salt defibration. Another type of decay that can occur in particularly wet conditions and in wet and dry alternating settings is called soft-rot decay and causes the outside surface softening of the wood when wet, opposing to the internal subsurface which remains intact.

To avoid salt and water deterioration the best approach consists in choosing naturally decay resistant woods, such has redwood, cedar, old-growth cypress and white oak, or pressure treated woods which are preserved by the use of chemicals. Must be taken into account that such chemicals cannot be waterborne preservative but rather oily ones like Pentachlorophenol, Naphthenate and the most used, Creosote.

Defibration by salt crystallisation

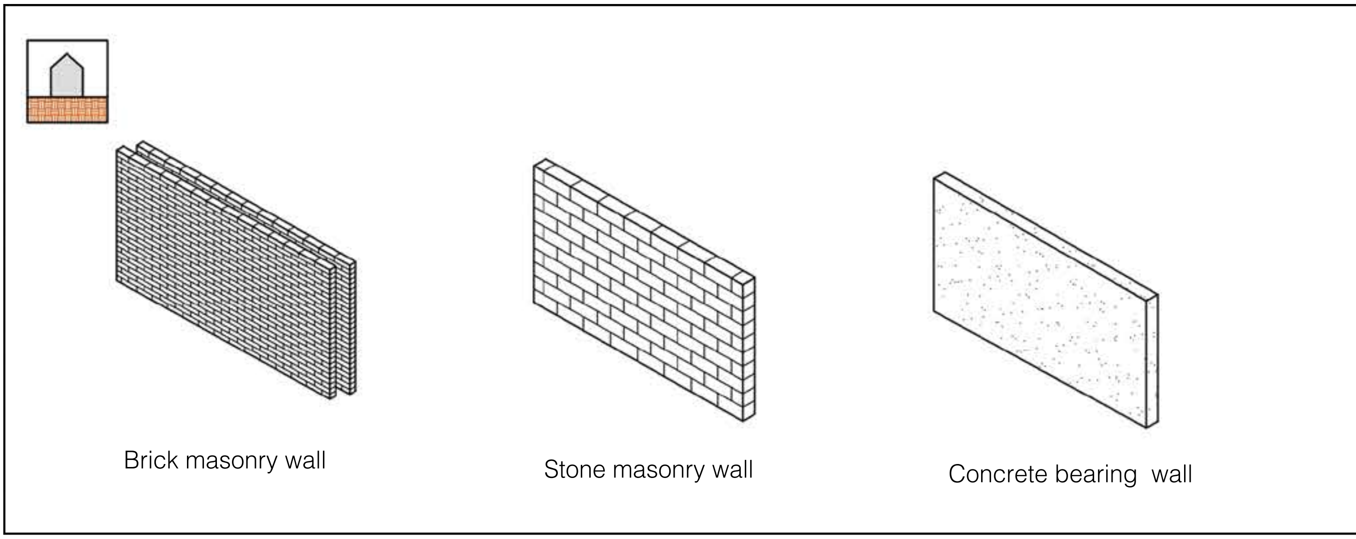
WOOD	White Oak	Old grown Cypress	Plywood
Weight (kg/m3)	730	510	600
Life span	40-50	40-50	25 ca
Life span marine environment	40-50	40-50	25 ca
Mantainance (years)	1-2	1-2	no
Embodied energy	*	*	*
Coating	yes	yes	yes
λ value [W/(mK)]	0.17		0.13
Recyclable	depends	depends	yes
Price	*/**	*/**	*/**
Other Uses	Various	various	various

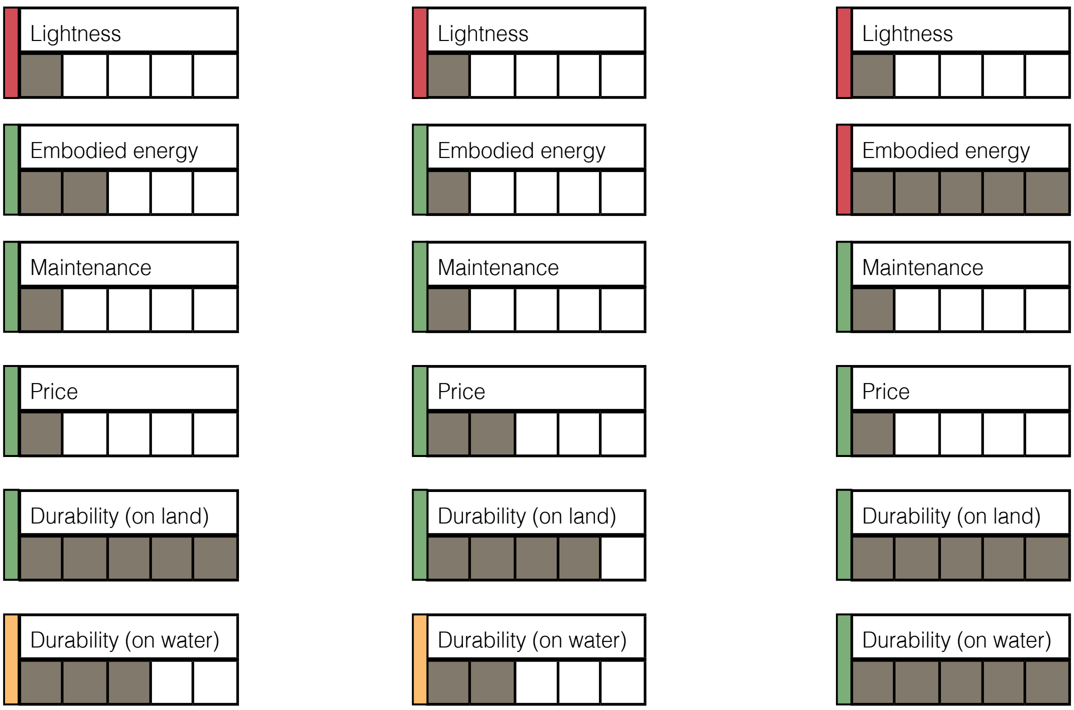
Table of three naturally decay resistant woods

Lifespan in marine environment is assumed identical due to the constant maintenance they would need. They are all considerate suitable material for building construction as long as maintenance is possible.

BUILDING ON LAND AND BUILDING ON WATER IN COMPARISON

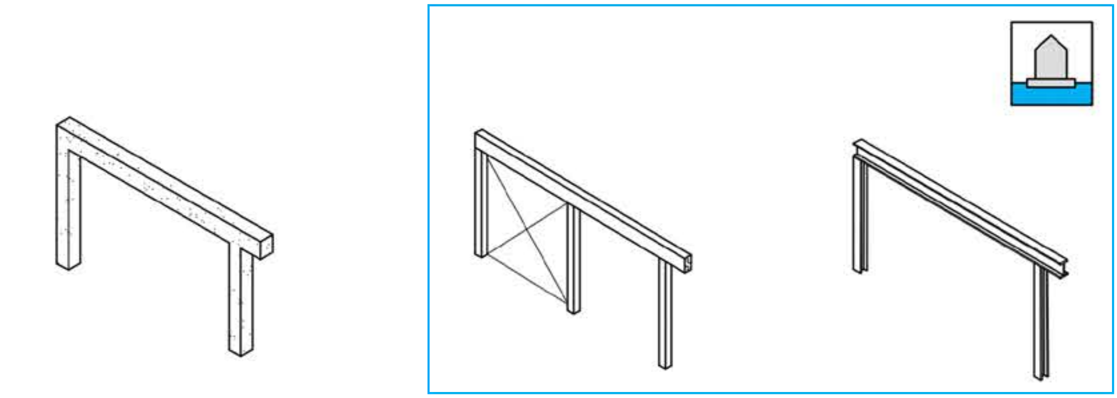
After an overview on material behavior to salt attack and few of their properties, some considerations should be done on the use of these materials in relation to building construction. This paragraph aims to underline the most suitable construction choices for the marine environment, with a comparison between land and salt water. The purpose is to define if and in which degree, water architecture could be a good substitute to land construction.



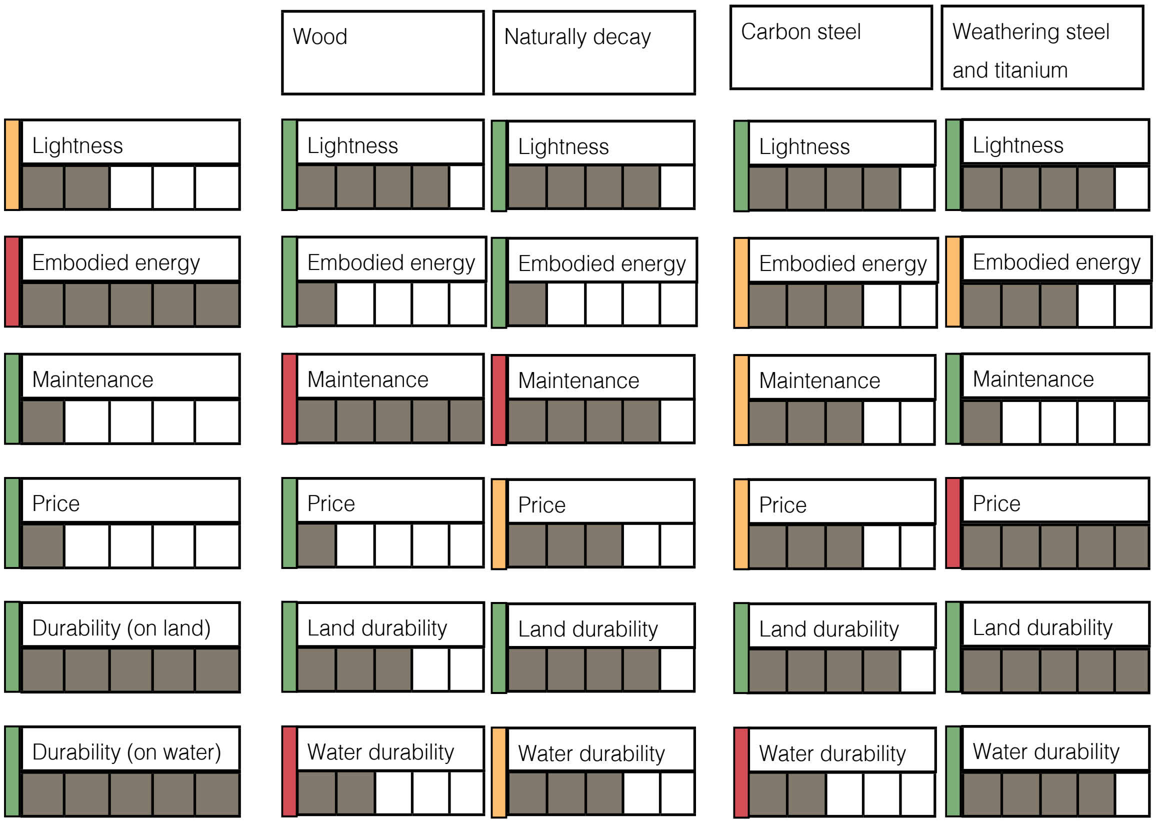


Supporting structure

As mentioned before, lightness is very important for floating construction, consequently masonry walls and concrete supporting structure should be avoided, using lighter structural material as wood and steel. Besides this first reduction, a wood or steel frame should be able to withstand the marine environment, for which choosing a naturally decay wood and weathering steel constitutes a favorable choice to decrease maintenance and increase durability, but at a higher price. Titanium would make the best choice in terms of durability, lightness and maintenance, but



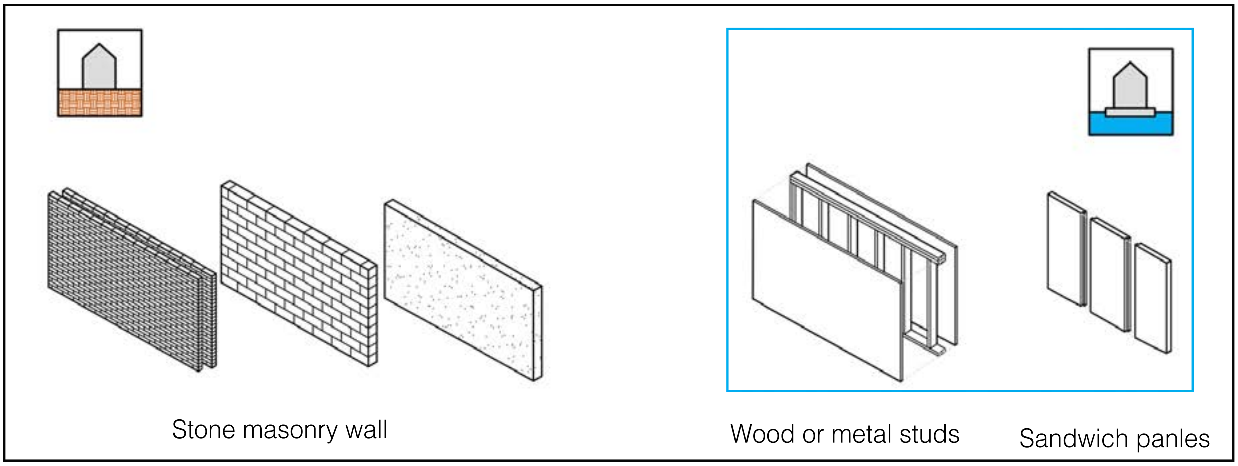
Concrete frame structure — Timber frame structure — Steel frame structure

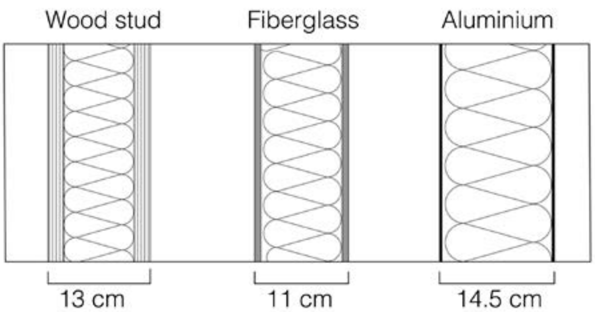


would also signify an incredibly high priced building. If the structure is not exposed to the external environment and well protected by other construction components, normal wood and structural steel could be used. In general we can say that we have, two options, one less expensive, with less embodied energy and more maintenance, and the other which is more expensive but requires less preservation.

Walls

Without considering masonry wall and concrete walls, walls in a floating structure could be made out of wood or metal studs, or sandwich panels. It is important to have a minimal thermal resistance value that can simulate the thicker wall counterpart which cannot be used. In the energy chapter, a minimal Resistance of 4.5 m2K/W has been set to minimize the energy need of the building. This translates to slightly different insulation thicknesses according to the material used as shown below





Thickness has been defined with arbitrary rse and rsi values, and without considering cladding, which would eventually decrease the thickness more. In terms of material durability to external factors, the consideration previously made on salt resistance and the considerations on the cladding paragraph can be taken into account.

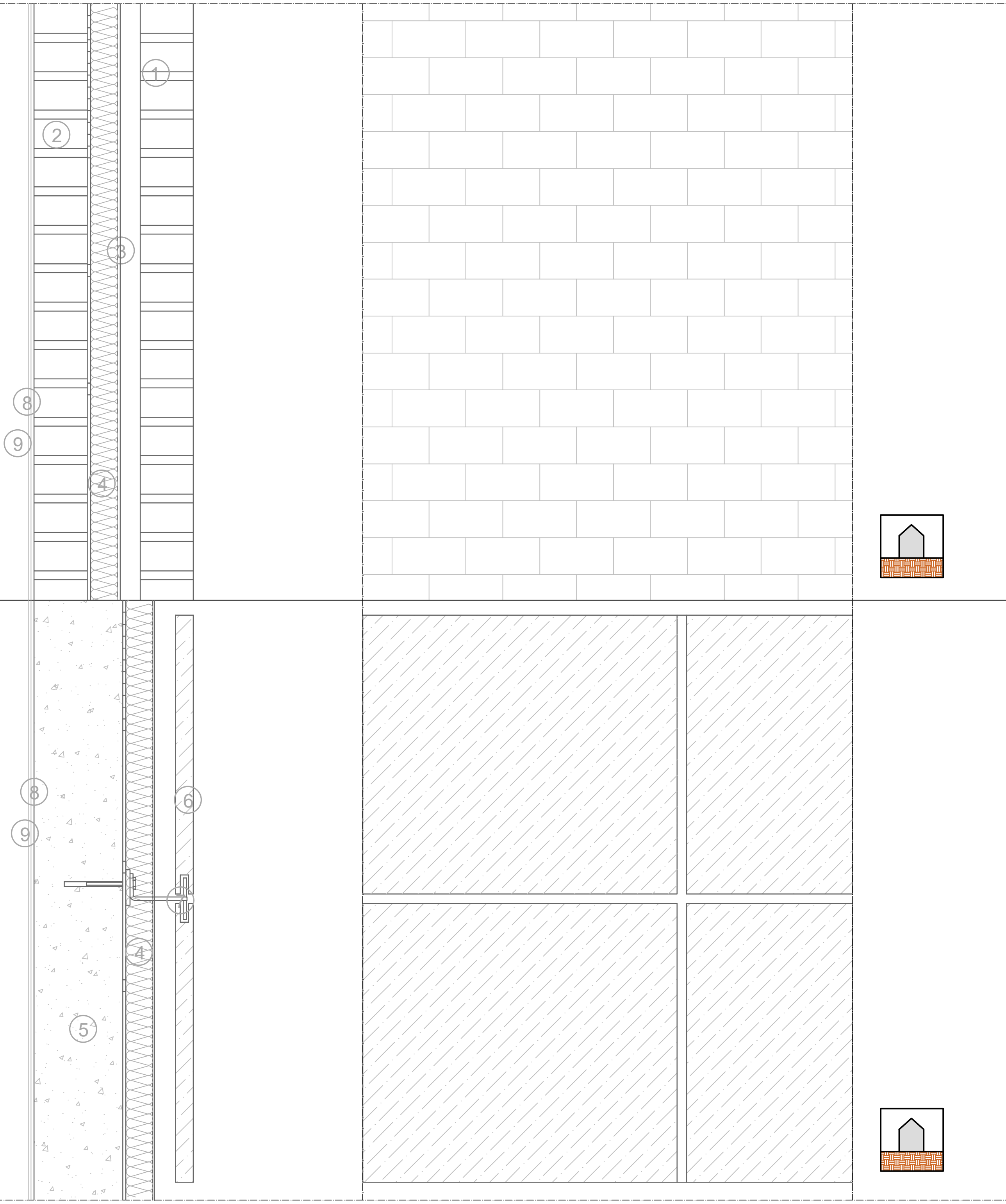
Facade and cladding

This is the component which has to be the most environment resistant part of the building. In the next pages some facade typologies are shown to compare their behavior between land and sea. It is important to remember that facades do also have to deal with other external factors. The table on the side shows them for different materials.

In general, considering the material tables at the beginning of this chapter as well, we could say that:

- All passive metals work well against salt except Copper
- Wood works against salt if it is naturally decay resistant type
- Plywood is not appropriate for external cladding use
- Polyesters resins and unplasticized polymers resist better UV (fiberglass and PVC-u)
- The right metals and polymers need minimal maintenance
- Wood in external cladding needs constant maintenance
- Polymers and metals are more expensive and have higher embodied energy
- Wood is cheaper and has less embodied energy
- Wood and polymers have a thermal conductivity value considerably lower than metals

MATERIAL	DEGRADATION TYPE	EXTERNAL FACTORS							
		Temperature	Condensation	RH	TOW	Bio Agents	Pollution	UV	Salt
METALS	Corrosion	±	±	+	+	no	+	-	±
BRICKS	Weathering/Salt attack	-	±	+	+	-	±	-	+
CONCRETE	Salt attack , freeze/thaw	-	-	-	+	no	+	-	±
STONE	Salt attack, chemical dissolution	-	-	-	±	±	+	-	+
GLASS		+	-	-	-	no	±	±	-
TIMBER	Fungal attack, termits, defibration	-	-	±	+	+	-	±	-
TIMBER COMPOSITES	Adhesive failure	+	-	+	+	-	-	-	no
PLASTICS	Photo - oxidation	+	-	-	±	?	+	+	-
POLYESTER RESINS	Yellowing	+	-	-	±	?	no	+	-



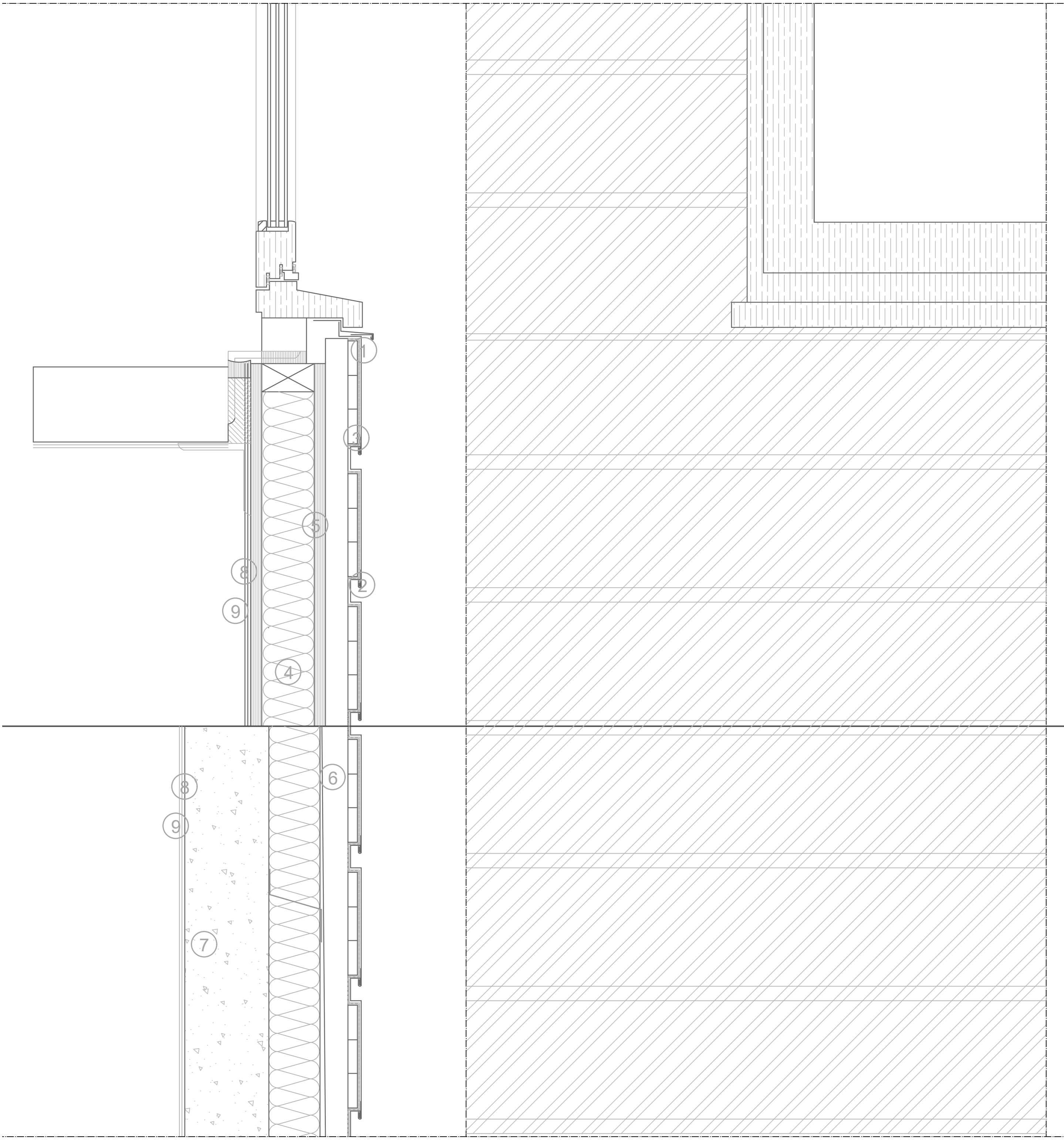
Masonry wall (top) and concrete wall with stone cladding (bottom)

Scale 1:20

1. Outer brick skin
2. Inner brick skin
3. Waterproof membrane
4. Thermal insulation in cavity
5. Backing wall- Concrete
6. Stone panel
7. Stainless steel fixing
8. Vapor barrier
9. Internal finish

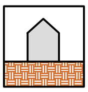
Ceramic materials and concrete

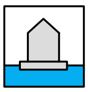
Bricks, despite durability, is not applicable to case study. Ceramic materials could be used for external pavement to lower the center of gravity but they remain an undesirable option and concrete remains the best solution for the platform only, because of its weight.

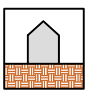


Example of metal cladding on different supporting structures. Scale 1:20

1. Metal recessed sheets
2. Standing seam joints
3. Waterproof membrane
4. Thermal Insulation
5. Backing wall: timber/metal frame with plywood facing
6. Fixing battents
7. Backing wall concrete
8. Vapor barrier
9. Internal finish

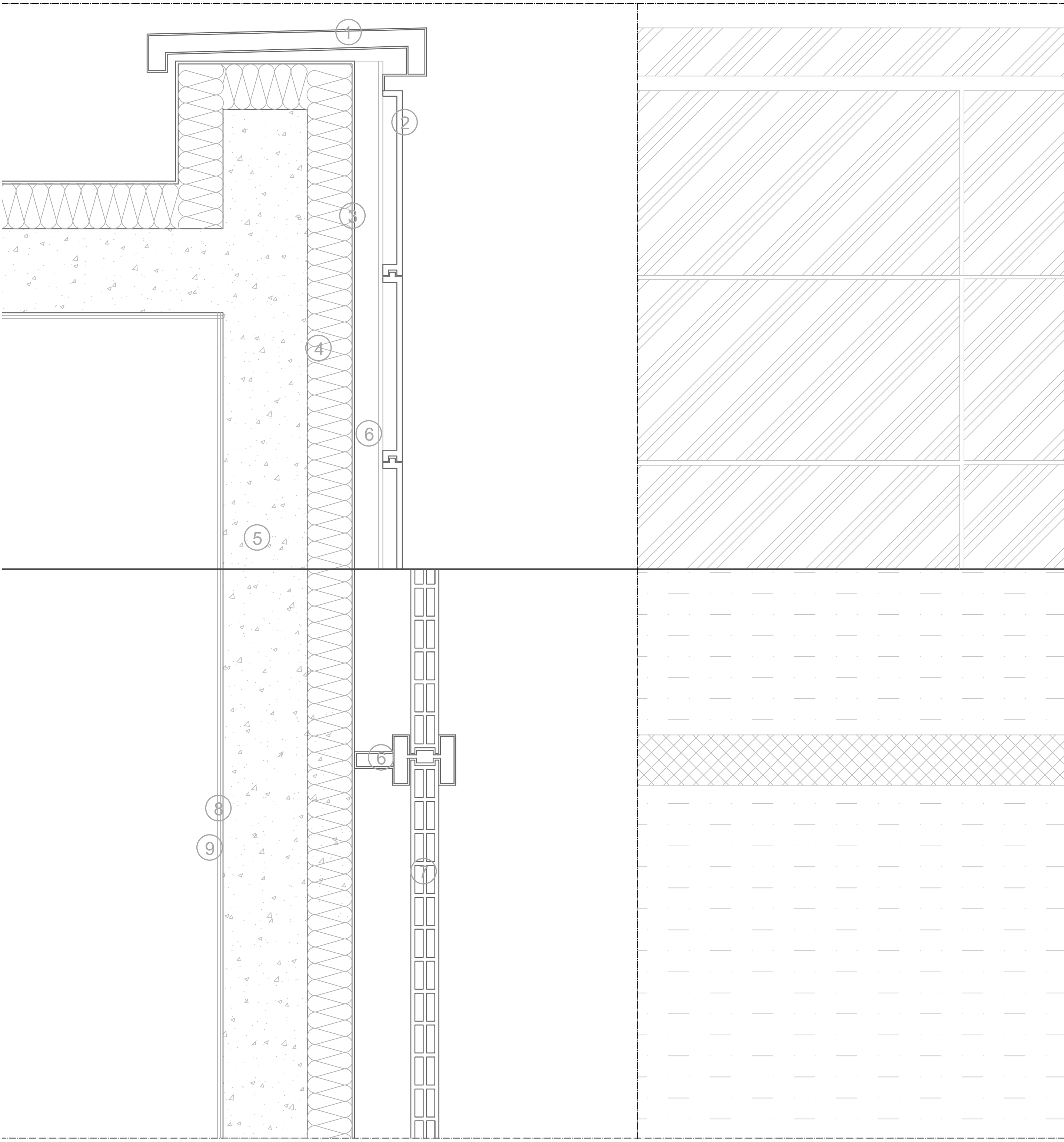




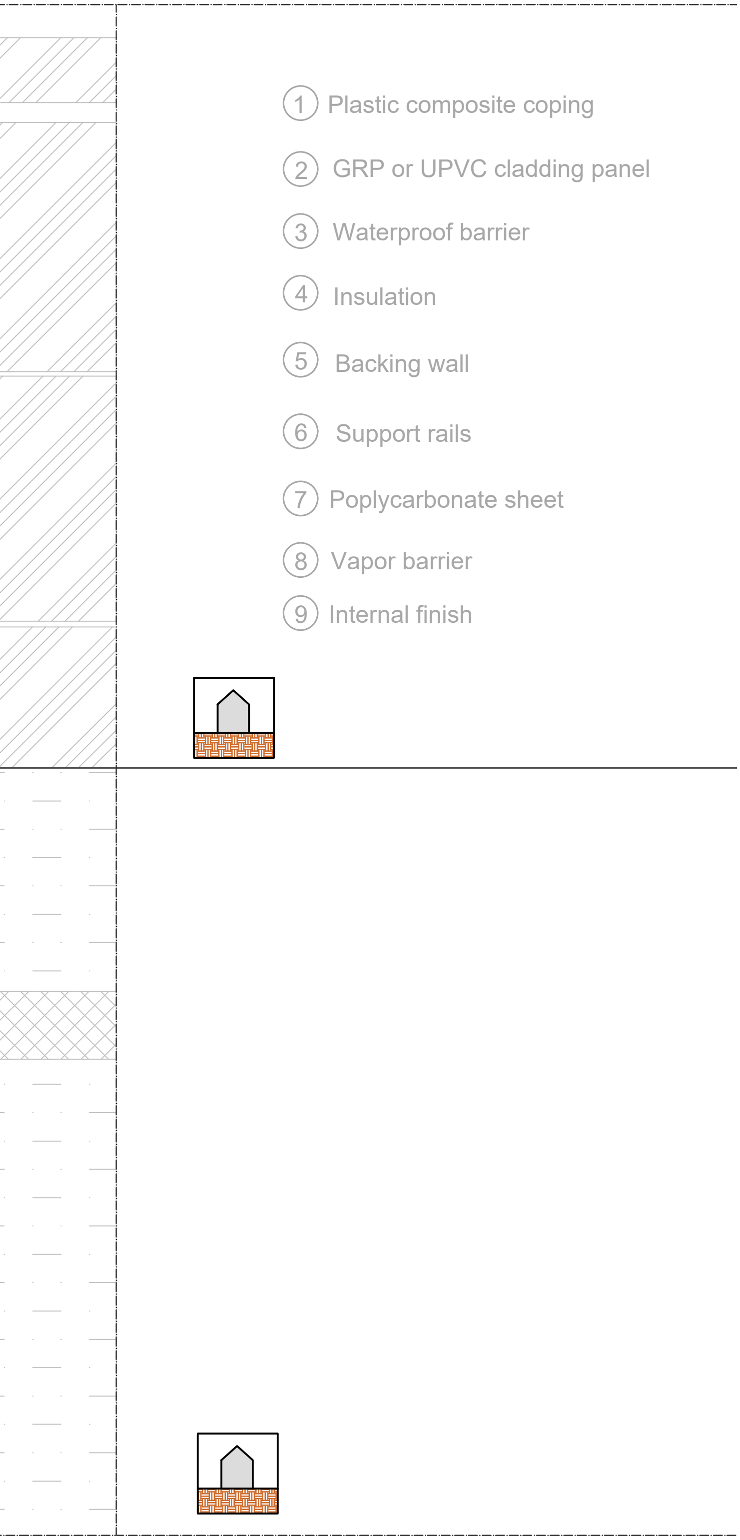


Metal cladding

Can be used only with passive metals resistant to salt. Weathering steel, aluminum and titanium are the possible options for the sea environment

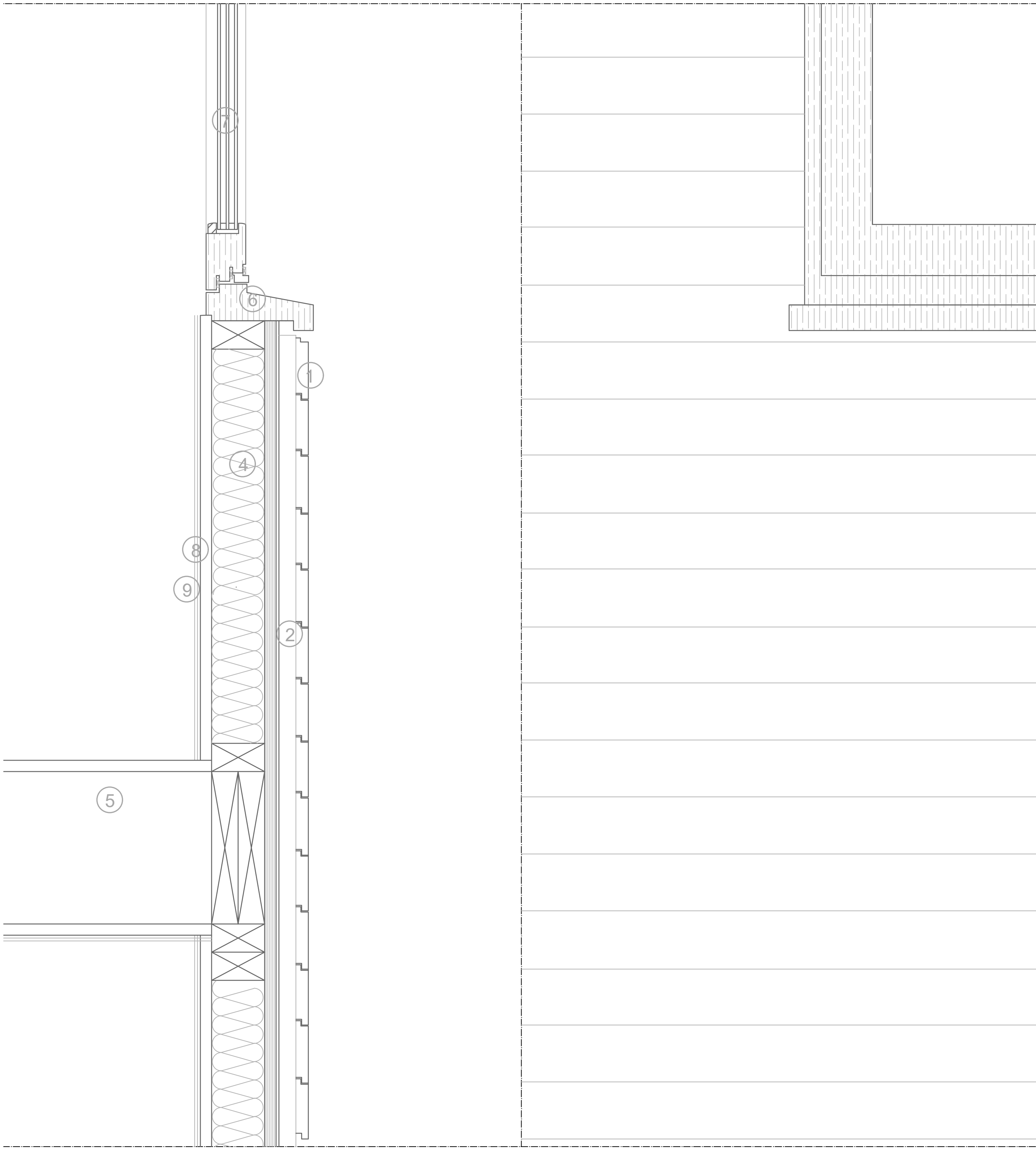


Example of plastic cladding, Fiberglass or PVC-u panels on the top, and polycarbonate on the bottom. Scale 1:20

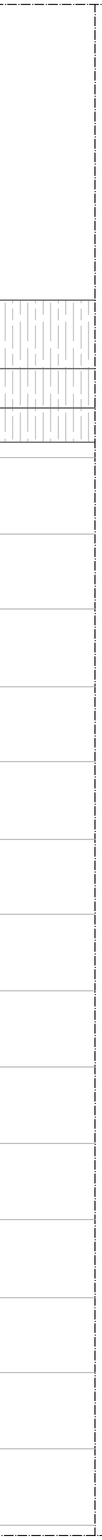


COMPOSITES

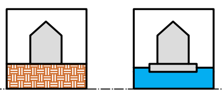
In the sea environment, fiberglass can be used forcladding panels and PVC-u for both panels and window frames. Polycarbonate would not have a durable behaviour. Notice that the first example despite the right cladding would not work for the heavy supporting structure.



Example of wood structure and cladding. Scale 1:20



1. Timber boards
2. Timber studs
3. Breather membrane
4. Thermal Insulation within timber frame
5. Wood floor
6. Wood window frame
7. Triple glass
8. Vapor barrier
9. Internal finish



Wood

Only naturally decay resistance woods can be used at sea, and they will still require a lot of mantainance compared to an inland situation

Conclusions

The positive aspect about floatinng construction, are the movability of the entire construction or parts of it. Buildings can be constructed in protected environment fastening the construction process and then towned to location, or part of the building can be directly brought on location with more ease then in an inland city, as the sea offers more space for trasportations.
The problem is that open sea environment construction offers much lesser options than inland construction. Materials have to be light and durable, and the possible choices either require a lot of mantainance or are hihgtly expensive with higher embodied energy. Moreover, materials must be chosen according to the design, if the floating platform allows maintenance wood can be used as cladding, otherwise passive metals, fiberglass and PVC-u, should be used. It is important to notice that in the location radiation is stronger than inland (in warm season), therefore plastic materials can have a decreased durability not only because of the salt but because of their an increment of UV radiation.

A REFLECTION

URBAN FLEXIBILITY AND CONSTRUCTION

Having flexible urban components can be very useful when the city grows, to maintain the function of a building or improve the city zoning or networks when they are not functional. By trying to develop a small town of flexible floating components, it was possible to see that such flexibility is not granted by the simplicity of water movability. In fact, urban flexibility will depend on the platform dimension, on the platform's shape, mooring typology and density of the city in relation to the preservation of the marine environment. A floating city will have a spread configuration, and will need fixed units (the mooring) to maintain the platform fixed in relation to the other platforms and external climate conditions. This comes with a set of material and energy resources which are not usually contemplated when talking about the positive aspects of a movable component.
Furthermore, the most important reason to build flexible urban components, is to have a construction which can fulfill its entire technical lifespan regardless the location in which it is set. We have seen by the study of material durability that their lifespan will in fact decrease when set in the open sea environment, but also that to maintain the longer lifespan possible, construction will require a high amount of maintenance and be very expensive
A flexible building, to be 100% flexible, will also need to consider other parameter, such as the water density and the external climate condition. A building designed for inland water might not be usable at sea, either because its structure and materials are not suitable for the marine environment or its shape will not resist the stronger winds of the open Sea. When changing its location the mooring typology and space available might also change its orientation, and if it was not designed to work well in all directions, this would have consequences on its climate behavior.

ENERGY

We have seen that building energy self-sufficient floating cities is possible. There is although an amount of energy loss due to the process of energy storing itself, which is quite considerable; 60% of the energy surplus. Moreover, we have seen that the city will need to have a connection to an existing OWF to transmit its energy surplus to the existent grid connected to land, which would question the need to build more than 65 wind turbines near the city. Considering the large number of turbines, they could be built directly as an addition to the existing OWF, which would then provide for both the floating city and inland cities.
Another consideration to make, is the high maintenance that the turbines will require, and the space need to store the hydrogen. More concrete platforms will need to be built just for the hydrogen air compressed containers.
For the location of interest water does not provide enough energy as it could have been expected. Wind and solar remain the main energy provider. The amount needed though is considerable and that would affect the look of the city with PV panels on all facades and a wind farm in the background.
As the sea does provide a large amount of space, having a an external supply made out of solar and wind supply could be applied instead; this could improve the look of the city, but also increase the need of maintenance for the energy network to connect the supply to the city.

CONCLUSIONS

As for now, urban flexibility makes more sense for small floating components anchored to inland territory facing waters. Dynamic geography of autonomous floating cities it is not worth the amount of resources which requires

and also it is not applicable to its fullest. Floating cities will need to have a number fixed components which can then work with movable ones. The movable ones are also supposed to last more than an inland construction, and with the available materials such durability is not necessarily granted.
The natural environment can give a positive outcome in the energy production, but the natural resources used will depend on the location of the city, and will have consequences on the architectural design.

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LECTURES

- Erik van den Eijnden, Tidal Bridge, Monday 23 April 2018

APPENDIX

Uniec[2.2] STUDIEBEREKENING

- Pixel 1a
onbekend

0,26

Algemene gegevens

projectomschrijving	*Pixel 1a*
variant	*onbekend*
straat / huisnummer / toevoeging	*23, Binnenwatersloot*
postcode / plaats	*2611BJ Delft*
eigendom	*Koop*
bouwjaar	*2018*
renovatiejaar	
categorie	*Energieprestatie Woningbouw*
woningtype	*appartementengebouw*
aantal woningbouw-eenheden in berekening	*7*
gebruiksfunctie	*woonfunctie - drijvend bouwwerk - nieuwe ligplaats*
datum	*28-05-2018*
opmerkingen	

Indeling gebouw

Eigenschappen rekenzones

type rekenzone	omschrijving	interne warmtecapaciteit	Ag [m²]	aantal wb-eenheden
verwarmde zone	1a	gemengd licht	595,40	7

Interne warmtecapaciteit volgens bijlage H *nee*

Infiltratie

meetwaarde voor infiltratie $q_{v;10;spec}$	*ja*
lengte van het gebouw	*25,00 m*
breedte van het gebouw	*25,00 m*
hoogte van het gebouw	*3,50 m*

Eigenschappen infiltratie

rekenzone	positie	dak en/of geveltype	$q_{v;10;spec}$ [dm³/s per m²]
1a	geheel gebouw	standaard geveltype	0,42 (meetwaarde)

Open verbrandingstoestellen

Het gebouw bevat geen open verbrandingstoestellen.

Bouwkundige transmissiegegevens

Transmissiegegevens rekenzone 1a

onstructie	A [m²]	R_c [m²K/W]	U [W/m²K]	g_{gl} [-]	zonwering	beschaduwing	toelichting
acade zuid - buitenlucht, Z - 87,5 m² - 90°							
acade	43,75	4,50				minimale belem.	
vindows zuid	43,75		0,70	0,60	nee	constante overstek 0,5 ≤ ho < 1,0	
acade noord - buitenlucht, N - 87,5 m² - 90°							
acade	35,00	4,50				minimale belem.	
vindow noord	52,50		0,70	0,60	nee	minimale belem.	
Roof - buitenlucht, HOR, dak - 625,0 m² - 0°							
oors	625,00	4,00				minimale belem.	
Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3) - 595,0 m²							
oors	595,00	4,00					
acade west - buitenlucht, O - 87,5 m² - 90°							
acade	17,50	4,50				minimale belem.	
vindows zuid	70,00		0,70	0,60	nee	minimale belem.	
acade east - buitenlucht, W - 87,5 m² - 90°							
acade	17,50	4,50				minimale belem.	
vindows zuid	70,00		0,70	0,60	nee	minimale belem.	

e lineaire warmteverliezen zijn berekend volgens de forfaitaire methode uit hoofdstuk 13 van NEN 1068.

Overige kenmerken vloerconstructies (inclusief eventuele kruipruimten en onverwarmde kelders)

loor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3)

oogte bovenkant vloer boven maaiveld (h)	*0,20 m*
mtrek van het vloerveld (P)	*8,00 m*
rootste dikte v.d. gevels/wanden ter hoogte v.d. vloer ($d_{bw;v}$)	*0,30 m*

/erwarmingsystemen

erwarming

pwekking

ype opwekker	*elektrische warmtepomp*
ron warmtepomp	*bodem*
ntwerpaanvoertemperatuur	*θsup ≤ 30°*
ermogen warmtepomp	*3,50 kW*
-factor warmtepomp	*4,24*
antal opwekkers	*7*
ype bijverwarming	*elektrisch element*
ijstooktoestel geïntegreerd	*ja*
ansmissieverlies verwarmingssysteem - januari (H_T)	*485 W/K*
armtebehoefte verwarmingssysteem ($Q_{H;nd;an}$)	*23.112 MJ*
oeveelheid energie t.b.v. verwarming per toestel ($Q_{H;dis;nren;an}$)	*3.302 MJ*
pwekkingsrendement - warmtepomp ($\eta_{H;gen}$)	*4,150*
pwekkingsrendement - bijverwarming ($\eta_{H;gen}$)	*1,000*

Regeneratie

zonne-energiesysteem voor regeneratie	*nee*

Kenmerken afgiftesysteem verwarming

Type warmteafgifte (in woonkamer)					
type warmteafgifte	positie	hoogte	R	$\theta_{em;avg}$	$\eta_{H;em}$
vloer- en/of wandverwarming en/of betonkernactivering	buitenvloer of buitenwand	< 8 m	≥ 2,5 m²K/W	n.v.t.	1,00

regeling warmteafgifte aanwezig	*ja*
afgifterendement ($\eta_{H;em}$)	*1,000*

Kenmerken distributiesysteem verwarming

buffervat buiten verwarmde ruimte aanwezig	*nee*
verwarmingsleidingen in onverwarmde ruimten en/of kruipruimte	*nee*
distributierendement ($\eta_{H;dis}$)	*1,000*

Hulpenergie verwarming

hoofdcirculatiepomp aanwezig	*nee*
aanvullende circulatiepomp aanwezig	*nee*

Aangesloten rekenzones

1a

Warmtapwatersystemen

verwarming/warmtapwater 2

Opwekking

type opwekker	*warmtepompboiler*
toepassingsklasse (CW-klasse)	*4 (CW 4)*
toestel	*Duurzame Techniek - Dimplex LBW 300 en LBW 300 LW*
aantal toestellen	*7*
hoeveelheid energie t.b.v. warmtapwater per toestel ($Q_{W;dis;nren;an}$)	*8.841 MJ*
opwekkingsrendement warmtapwater - WBP ($\eta_{W;gen}$)	*2,950*

Kenmerken tapwatersysteem

aantal woningbouw-eenheden aangesloten op systeem	*7*
warmtapwatersysteem ten behoeve van	*keuken en badruimte*
gemiddelde leidinglengte naar badruimte	*forfaitair*
gemiddelde leidinglengte naar aanrecht	*forfaitair*
inwendige diameter leiding naar aanrecht	*≤ 10 mm*
afgifterendement warmtapwater ($\eta_{W;em}$)	*0,742*

Douchewarmteterugwinning

douchewarmteterugwinning	*nee*

Zonneboiler

zonneboiler	*nee*

Ventilatie

ventilatie 1

Ventilatiesysteem

ventilatiesysteem	*A. natuurlijke toe- en afvoer*
systeemvariant	*A1 standaard*
luchtvolumestroomfactor voor warmte- en koudebehoefte (f_{sys})	*1,24*
correctiefactor regelsysteem voor warmte- en koudebehoefte (f_{reg})	*1,00*

Kenmerken ventilatiesysteem

werkelijk geïnstalleerde ventilatiecapaciteit bekend	*nee*
luchtdichtheidsklasse ventilatiekanalen	*onbekend*

Passieve koeling

max. benutting geïnstal. ventilatiecapaciteit voor koudebehoefte	*ja*
max. benutting geïnstal. spuicapaciteit voor koudebehoefte	*ja*

Aangesloten rekenzones

1a

Koeling

koeling 1

Kenmerken opwekker

type opwekker	*warmtepomp*
toestel / leverancier	*Itho Daalderop WPU 3 (ook bij verwarming kiezen)*
aantal toestellen	*7*
koudebehoefte koelsysteem ($Q_{C;nd}$)	*49.119 MJ*
opwekkingsrendement ($\eta_{C;gen}$)	*64,000*
distributierendement ($\eta_{C;dis}$)	*1,00*

Aangesloten rekenzones

1a

Zonnestroom

solar

piekvermogen (Wp) per m²	*200 Wp/m² bepaald volgens NEN-EN-IEC 60904-1*

Zonnestroom eigenschappen				
ventilatie	A_{PV} [m²]	oriëntatie	helling [°]	beschaduwing

Resultaten

Jaarlijkse hoeveelheid primaire energie voor de energiefunctie		
verwarming (excl. hulpenergie)	$E_{H;P}$	14.257 MJ
hulpenergie		5.651 MJ
warmtapwater (excl. hulpenergie)	$E_{W;P}$	53.708 MJ
hulpenergie		0 MJ
koeling (excl. hulpenergie)	$E_{C;P}$	1.96[illegible] MJ
hulpenergie		0 MJ
zomercomfort	$E_{SC;P}$	[illegible] MJ
ventilatoren	$E_{V;P}$	0 MJ
verlichting	$E_{L;P}$	[illegible]7.43[illegible] MJ
geëxporteerde elektriciteit	$E_{P;exp;el}$	0 MJ
op eigen perceel opgewekte & verbruikte elektriciteit	$E_{P;pr;us;el}$	0 MJ
in het gebied opgewekte elektriciteit	$E_{P;pr;dei;el}$	0 MJ

Oppervlakten		
totale gebruiksoppervlakte	$A_{g;tot}$	595,40 m²
totale verliesoppervlakte	A_{ls}	1.391,50 m²

Elektriciteitsgebruik	
gebouwgebonden installaties	11.178 kWh
niet-gebouwgebonden apparatuur (stelpost)	16.690 kWh
op eigen perceel opgewekte & verbruikte elektriciteit	0 kWh
geëxporteerde electriciteit	0 kWh
TOTAAL	27.868 kWh

CO_2-emissie		
CO_2-emissie	m_{co2}	6.314 kg

Energieprestatie		
specifieke energieprestatie	EP	173 MJ/m²
karakteristiek energiegebruik	E_{Ptot}	103.017 MJ
toelaatbaar karakteristiek energiegebruik	$E_{P;adm;tot;nb}$	160.975 MJ
energieprestatiecoëfficiënt	EPC	0,256 -
energieprestatiecoëfficiënt	EPC	0,26 -

BENG indicatoren	
energiebehoefte	33,7 kWh/m²
primair energiegebruik	35,3 kWh/m²
aandeel hernieuwbare energie	19 %

Uniec 2.2 is gebaseerd op NEN7120;2011 “Energieprestatie van gebouwen” (inclusief het Nader Voorschrift) en NEN 8088-1 “Ventilatie en luchtdoorlatendheid van gebouwen” inclusief alle wettelijk van kracht zijnde correctiebladen.

Alle bovenstaande energiegebruiken zijn genormeerde energiegebruiken gebaseerd op een standaard klimaatjaar en een standaard gebruikersgedrag. Het werkelijke energiegebruik zal afwijken van het genormeerde energiegebruik. Aan de berekende energiegebruiken kunnen geen rechten ontleend worden.

Uniec[2.2] STUDIEBEREKENING

- Pixel 1b
onbekend 0,28

Algemene gegevens

projectomschrijving	*Pixel 1b*
variant	*onbekend*
straat / huisnummer / toevoeging	*23, Binnenwatersloot*
postcode / plaats	*2611BJ Delft*
eigendom	*Koop*
bouwjaar	*2018*
renovatiejaar	
categorie	*Energieprestatie Woningbouw*
woningtype	*apparteme[illegible]nter gebouw*
aantal woningbouw-eenheden in berekening	*15*
gebruiksfunctie	*woonfunctie - drijvend bouwwerk - nieuwe ligplaats*
datum	*28-05-2018*
opmerkingen	

Indeling gebouw

Eigenschappen rekenzones				
type rekenzone	omschrijving	interne warmtecapaciteit	Ag [m²]	aantal wb-eenheden
verwarmde zone	1b	gem[illegible]d licht	1.190,80	15

Interne warmtecapaciteit volgens bijlage H *nee*

Infiltratie

meetwaarde voor infiltratie $q_{v;10;spec}$	*ja*
lengte van het gebouw	*25,00 m*
breedte van het gebouw	*25,00 m*
hoogte van het gebouw	*7,00 m*

Eigenschappen infiltratie			
rekenzone	[illegible]itie	dak en/of geveltype	$q_{v;10;spec}$ [dm³/s per m²]
1b	geheel gebouw	standaard geveltype	0,42 (meetwaarde)

Open verbrandingstoestellen

Het gebouw bevat geen open verbrandingstoestellen.

Bouwkundige transmissiegegevens

Transmissiegegevens rekenzone 1b

constructie	A [m²]	R_c [m²K/W]	U [W/m²K]	g_{gl} [-]	zonwering	beschaduwing	toelichting
Facade zuid - buitenlucht, Z - 175,0 m² - 90°							
facade	87,50	4,50				minimale belem.	
windows zuid	87,50		0,70	0,60	nee	constante overstek 0,5 ≤ ho < 1,0	
Facade noord - buitenlucht, N - 175,0 m² - 90°							
facade	122,50	4,50				minimale belem.	
window noord	52,50		0,70	0,60	nee	minimale belem.	
Roof - buitenlucht, HOR, dak - 625,0 m² - 0°							
roof	625,00	6,00				minimale belem.	
Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3) - 595,0 m²							
floors	595,00	4,00					
Facade west - buitenlucht, O - 175,0 m² - 90°							
facade	105,00	4,50				minimale belem.	
windows zuid	70,00		0,70	0,60	nee	minimale belem.	
Facade east - buitenlucht, W - 175,0 m² - 90°							
facade	105,00	4,50				minimale belem.	
windows zuid	70,00		0,70	0,60	nee	minimale belem.	

De lineaire warmteverliezen zijn berekend volgens de forfaitaire methode uit hoofdstuk 13 van NEN 1068.

Overige kenmerken vloerconstructies (inclusief evt. kruipruimten en onverwarmde kelders)

Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3)

hoogte bovenkant vloer boven maaiveld (h)	*0,20 m*
omtrek van het vloerveld (P)	*8,00 m*
grootste dikte v.d. gevels/wanden ter hoogte v.d. vloer ($d_{bw;v}$)	*0,30 m*

Verwarmingsystemen

verwarming

Opwekking

type opwekker	*elektrische warmtepomp*
bron warmtepomp	*bodem*
ontwerpaanvoertemperatuur	*θsup ≤ 30°*
vermogen warmtepomp	*3,50 kW*
β-factor warmtepomp	*16,55*
aantal opwekkers	*15*
type bijverwarming	*elektrisch element*
bijstooktoestel geïntegreerd	*ja*
transmissieverlies verwarmingssysteem - januari (H_T)	*599 W/K*
warmtebehoefte verwarmingssysteem ($Q_{H;nd;an}$)	*12.691 MJ*
hoeveelheid energie t.b.v. verwarming per toestel ($Q_{H;dis;nren;an}$)	*846 MJ*
opwekkingsrendement - warmtepomp ($\eta_{H;gen}$)	*4,150*
opwekkingsrendement - bijverwarming ($\eta_{H;gen}$)	*1,000*

Regeneratie

zonne-energiesysteem voor regeneratie	*nee*

Kenmerken afgiftesysteem verwarming

Type warmteafgifte (in woonkamer)					
type warmteafgifte	positie	hoogte	R	$\theta_{em;avg}$	$\eta_{H;em}$
vloer- en/of wandverwarming en/of betonkernactivering	buitenvloer of buitenwand	< 8 m	≥ 2,5 m²K/W	n.v.t.	1,00

regeling warmteafgifte aanwezig	*ja*
afgifterendement ($\eta_{H;em}$)	*1,000*

Kenmerken distributiesysteem verwarming

buffervat buiten verwarmde ruimte aanwezig	*nee*
verwarmingsleidingen in onverwarmde ruimten en/of kruipruimte	*nee*
distributierendement ($\eta_{H;dis}$)	*1,000*

Hulpenergie verwarming

hoofdcirculatiepomp aanwezig	*nee*
aanvullende circulatiepomp aanwezig	*nee*

Aangesloten rekenzones

1b

Warmtapwatersystemen

verwarming/warmtapwater 2

Opwekking

type opwekker	*warmtepompboiler*
toepassingsklasse (CW-klasse)	*4 (CW 4)*
toestel	*Duurzame Techniek - Dimplex LBW 300 en LBW 300 LW*
aantal toestellen	*15*
hoeveelheid energie t.b.v. warmtapwater per toestel ($Q_{W;dis;nren;an}$)	*8.606 MJ*
opwekkingsrendement warmtapwater - WBP ($\eta_{W;gen}$)	*2,800*

Kenmerken tapwatersysteem

aantal woningbouw-eenheden aangesloten op systeem	*15*
warmtapwatersysteem ten behoeve van	*keuken en badruimte*
gemiddelde leidinglengte naar badruimte	*forfaitair*
gemiddelde leidinglengte naar aanrecht	*forfaitair*
inwendige diameter leiding naar aanrecht	*≤ 10 mm*
afgifterendement warmtapwater ($\eta_{W;em}$)	*0,742*

Douchewarmteterugwinning

douchewarmteterugwinning	*nee*

Zonneboiler

zonneboiler	*nee*

Ventilatie

ventilatie 1

Ventilatiesysteem

ventilatiesysteem	*A. natuurlijke toe- en afvoe*
systeemvariant	*A1 standaard*
luchtvolumestroomfactor voor warmte- en koudebehoefte (f_{sys})	*1,24*
correctiefactor regelsysteem voor warmte- en koudebehoefte (f_{reg})	*1,00*

Kenmerken ventilatiesysteem

werkelijk geïnstalleerde ventilatiecapaciteit bekend	*nee*
luchtdichtheidsklasse ventilatiekanalen	*onbekend*

Passieve koeling

max. benutting geïnstal. ventilatiecapaciteit voor koudebehoefte	*ja*
max. benutting geïnstal. spuicapaciteit voor koudebehoefte	[illegible]

Aangesloten rekenzones

1b

Koeling

koeling 1

Kenmerken opwekker

type opwekker	*warmtepomp*
toestel / leverancier	*Itho Daalderop WPU 3 (ook bij verwarming kiezen)*
aantal toestellen	*7*
koudebehoefte koelsysteem ($Q_{C;nd}$)	*38.920 MJ*
opwekkingsrendement ($\eta_{C;gen}$)	*64,000*
distributierendement ($\eta_{C;dis}$)	*1,00*

Aangesloten rekenzones

1b

Zonnestroom

solar

piekvermogen (Wp) per m²	*200 Wp/m² bepaald volgens NEN-EN-IEC 60904-1*

Zonnestroom eigenschappen				
ventilatie	A_{PV} [m²]	oriëntatie	helling [°]	beschaduwing

Resultaten

Jaarlijkse hoeveelheid primaire energie voor de energiefunctie		
verwarming (excl. hulpenergie)	$E_{H;P}$	7.829 MJ
hulpenergie		12.110 MJ
warmtapwater (excl. hulpenergie)	$E_{W;P}$	118.027 MJ
hulpenergie		0 MJ
koeling (excl. hulpenergie)	$E_{C;P}$	1.55[illegible] MJ
hulpenergie		0 MJ
zomercomfort	$E_{SC;P}$	[illegible] MJ
ventilatoren	$E_{V;P}$	0 MJ
verlichting	$E_{L;P}$	[illegible]4.87[illegible] MJ
geëxporteerde elektriciteit	$E_{P;exp;el}$	0 MJ
op eigen perceel opgewekte & verbruikte elektriciteit	$E_{P;pr;us;el}$	0 MJ
in het gebied opgewekte elektriciteit	$E_{P;pr;dei;el}$	0 MJ

Oppervlakten		
totale gebruiksoppervlakte	$A_{g;tot}$	1.190,80 m²
totale verliesoppervlakte	A_{ls}	1.741,50 m²

Elektriciteitsgebruik	
gebouwgebonden installaties	21.093 kWh
niet-gebouwgebonden apparatuur (stelpost)	33.381 kWh
op eigen perceel opgewekte & verbruikte elektriciteit	0 kWh
geëxporteerde electriciteit	0 kWh
TOTAAL	54.474 kWh

CO_2-emissie		
CO_2-emissie	m_{co2}	11.914 kg

Energieprestatie		
specifieke energieprestatie	EP	163 MJ/m²
karakteristiek energiegebruik	E_{Ptot}	194.394 MJ
toelaatbaar karakteristiek energiegebruik	$E_{P;adm;tot;nb}$	286.957 MJ
energieprestatiecoëfficiënt	EPC	0,271 -
energieprestatiecoëfficiënt	EPC	0,28 -

BENG indicatoren	
energiebehoefte	12,0 kWh/m²
primair energiegebruik	32,5 kWh/m²
aandeel hernieuwbare energie	6 %

Uniec 2.2 is gebaseerd op NEN7120;2011 “Energieprestatie van gebouwen” (inclusief het Nader Voorschrift) en NEN 8088-1 “Ventilatie en luchtdoorlatendheid van gebouwen” inclusief alle wettelijk van kracht zijnde correctiebladen.

Alle bovenstaande energiegebruiken zijn genormeerde energiegebruiken gebaseerd op een standaard klimaatjaar en een standaard gebruikersgedrag. Het werkelijke energiegebruik zal afwijken van het genormeerde energiegebruik. Aan de berekende energiegebruiken kunnen geen rechten ontleend worden.

Uniec[2.2]

STUDIEBEREKENING

- Pixel 1c
onbekend

0,29

Algemene gegevens

projectomschrijving	*Pixel 1c*
variant	*onbekend*
straat / huisnummer / toevoeging	*23, Binnenwatersloot*
postcode / plaats	*2611BJ Delft*
eigendom	*Koop*
bouwjaar	*2018*
renovatiejaar	
categorie	*Energieprestatie Woningbouw*
woningtype	*appartementen gebouw*
aantal woningbouw-eenheden in berekening	*23*
gebruiksfunctie	*woonfunctie - drijvend bouwwerk - nieuwe ligplaats*
datum	*28-05-2018*
opmerkingen	

Indeling gebouw

Eigenschappen rekenzones

type rekenzone	omschrijving	interne warmtecapaciteit	Ag [m²]	aantal wb-eenheden
verwarmde zone	1c	gemengd licht	1.786,20	23

Interne warmtecapaciteit volgens bijlage H *nee*

Infiltratie

meetwaarde voor infiltratie $q_{v;10;spec}$	*ja*
lengte van het gebouw	*25,00 m*
breedte van het gebouw	*25,00 m*
hoogte van het gebouw	*10,00 m*

Eigenschappen infiltratie

rekenzone	positie	dak en/of geveltype	$q_{v;10;spec}$ [dm³/s per m²]
1c	gehele gebouw	standaard geveltype	0,42 (meetwaarde)

Open verbrandingstoestellen

Het gebouw bevat geen open verbrandingstoestellen.

Bouwkundige transmissiegegevens

Transmissiegegevens rekenzone 1c

constructie	A [m²]	R_c [m²K/W]	U [W/m²K]	g_{gl} [-]	zonwering	beschaduwing	toelichting
Facade zuid - buitenlucht, Z - 250,0 m² - 90°							
facade	125,00	4,50				minimale belem.	
windows zuid	125,00		0,70	0,60	nee	constante overstek 0,5 ≤ ho < 1,0	
Facade noord - buitenlucht, N - 250,0 m² - 90°							
facade	175,00	4,50				minimale belem.	
window noord	75,00		0,70	0,60	nee	minimale belem.	
Roof - buitenlucht, HOR, dak - 625,0 m² - 0°							
roof	625,00	6,00				minimale belem.	
Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3) - 595,0 m²							
floors	595,00	4,00					
Facade west - buitenlucht, O - 250,0 m² - 90°							
facade	180,00	4,50				minimale belem.	
windows zuid	70,00		0,70	0,60	nee	minimale belem.	
Facade east - buitenlucht, W - 250,0 m² - 90°							
facade	180,00	4,50				minimale belem.	
windows zuid	70,00		0,70	0,60	nee	minimale belem.	

De lineaire warmteverliezen zijn berekend volgens de forfaitaire methode uit hoofdstuk 13 van NEN 1068.

Overige kenmerken vloerconstructies (inclusief e... kruipruimten en onverwarmde kelders)

Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3)

hoogte bovenkant vloer boven maaiveld (h)	*0,20 m*
omtrek van het vloerveld (P)	*100,00 m*
grootste dikte v.d. gevels/wanden ter hoogte v.d. vloer ($d_{bw;v}$)	*0,30 m*

Verwarmingsystemen

verwarming

Opwekking

type opwekker	*elektrische warmtepomp*
bron warmtepomp	*bodem*
ontwerpaanvoertemperatuur	*θsup ≤ 30°*
vermogen warmtepomp	*3,50 kW*
β-factor warmtepomp	*22,56*
aantal opwekkers	*23*
type bijverwarming	*elektrisch element*
bijstooktoestel geïntegreerd	*ja*
transmissieverlies verwarmingssysteem - januari (H_T)	*807 W/K*
warmtebehoefte verwarmingssysteem ($Q_{H;nd;an}$)	*14.272 MJ*
hoeveelheid energie t.b.v. verwarming per toestel ($Q_{H;dis;nren;an}$)	*621 MJ*
opwekkingsrendement - warmtepomp ($\eta_{H;gen}$)	*4,150*
opwekkingsrendement - bijverwarming ($\eta_{H;gen}$)	*1,000*

Regeneratie

zonne-energiesysteem voor regeneratie	*nee*

Kenmerken afgiftesysteem verwarming

Type warmteafgifte (in woonkamer)					
type warmteafgifte	positie	hoogte	R	$\theta_{em;avg}$	$\eta_{H;em}$
vloer- en/of wandverwarming en/of betonkernactivering	buitenvloer of buitenwand	< 8 m	≥ 2,5 m²K/W	n.v.t.	1,00

regeling warmteafgifte aanwezig	*ja*
afgifterendement ($\eta_{H;em}$)	*1,000*

Kenmerken distributiesysteem verwarming

buffervat buiten verwarmde ruimte aanwezig	*nee*
verwarmingsleidingen in onverwarmde ruimten en/of kruipruimte	*nee*
distributierendement ($\eta_{H;dis}$)	*1,000*

Hulpenergie verwarming

hoofdcirculatiepomp aanwezig	*nee*
aanvullende circulatiepomp aanwezig	*nee*

Aangesloten rekenzones

1c

Warmtapwatersystemen

verwarming/warmtapwater 2

Opwekking

type opwekker	*warmtepompboiler*
toepassingsklasse (CW-klasse)	*4 (CW 4)*
toestel	*Duurzame Techniek - Dimplex LBW 300 en LBW 300 LW*
aantal toestellen	*23*
hoeveelheid energie t.b.v. warmtapwater per toestel ($Q_{W;dis;nren;an}$)	*8.535 MJ*
opwekkingsrendement warmtapwater - WBP ($\eta_{W;gen}$)	*2,800*

Kenmerken tapwatersysteem

aantal woningbouw-eenheden aangesloten op systeem	*23*
warmtapwatersysteem ten behoeve van	*keuken en badruimte*
gemiddelde leidinglengte naar badruimte	*forfaitair*
gemiddelde leidinglengte naar aanrecht	*forfaitair*
inwendige diameter leiding naar aanrecht	*≤ 10 mm*
afgifterendement warmtapwater ($\eta_{W;em}$)	*0,742*

Douchewarmteterugwinning

douchewarmteterugwinning	*nee*

Zonneboiler

zonneboiler	*nee*

Ventilatie

ventilatie 1

Ventilatiesysteem

ventilatiesysteem	*A. natuurlijke toe- en afvoer*
systeemvariant	*A1 standaard*
luchtvolumestroomfactor voor warmte- en koudebehoefte (f_{sys})	*1,24*
correctiefactor regelsysteem voor warmte- en koudebehoefte (f_{reg})	*1,00*

Kenmerken ventilatiesysteem

werkelijk geïnstalleerde ventilatiecapaciteit bekend	*nee*
luchtdichtheidsklasse ventilatiekanalen	*onbekend*

Passieve koeling

max. benutting geïnstal. ventilatiecapaciteit voor koudebehoefte	*ja*
max. benutting geïnstal. spuicapaciteit voor koudebehoefte	[illegible]

Aangesloten rekenzones

1c

Koeling

koeling 1

Kenmerken opwekker

type opwekker	*warmtepomp*
toestel / leverancier	*Itho Daalderop WPU 3 (ook bij verwarming kiezen)*
aantal toestellen	*7*
koudebehoefte koelsysteem ($Q_{C;nd}$)	*37.988 MJ*
opwekkingsrendement ($\eta_{C;gen}$)	*64,000*
distributierendement ($\eta_{C;dis}$)	*1,00*

Aangesloten rekenzones

1c

Zonnestroom

solar

piekvermogen (Wp) per m²	*200 Wp/m² bepaald volgens NEN-EN-IEC 60904-1*

Zonnestroom eigenschappen				
ventilatie	A_{PV} [m²]	oriëntatie	helling [°]	beschaduwing

Resultaten

Jaarlijkse hoeveelheid primaire energie voor de energiefunctie		
verwarming (excl. hulpenergie)	$E_{H;P}$	8.804 MJ
hulpenergie		18.568 MJ
warmtapwater (excl. hulpenergie)	$E_{W;P}$	179.469 MJ
hulpenergie		0 MJ
koeling (excl. hulpenergie)	$E_{C;P}$	1.52[illegible] MJ
hulpenergie		0 MJ
zomercomfort	$E_{SC;P}$	[illegible] MJ
ventilatoren	$E_{V;P}$	0 MJ
verlichting	$E_{L;P}$	[illegible]2.30[illegible] MJ
geëxporteerde elektriciteit	$E_{P;exp;el}$	0 MJ
op eigen perceel opgewekte & verbruikte elektriciteit	$E_{P;pr;us;el}$	0 MJ
in het gebied opgewekte elektriciteit	$E_{P;pr;dei;el}$	0 MJ

Oppervlakten		
totale gebruiksoppervlakte	$A_{g;tot}$	1.786,20 m²
totale verliesoppervlakte	A_{ls}	2.041,50 m²

Elektriciteitsgebruik	
gebouwgebonden installaties	31.540 kWh
niet-gebouwgebonden apparatuur (stelpost)	50.071 kWh
op eigen perceel opgewekte & verbruikte elektriciteit	0 kWh
geëxporteerde electriciteit	0 kWh
TOTAAL	81.610 kWh

CO_2-emissie		
CO_2-emissie	m_{co2}	17.815 kg

Energieprestatie		
specifieke energieprestatie	EP	163 MJ/m²
karakteristiek energiegebruik	E_{Ptot}	290.668 MJ
toelaatbaar karakteristiek energiegebruik	$E_{P;adm;tot;nb}$	411.070 MJ
energieprestatiecoëfficiënt	EPC	0,283 -
energieprestatiecoëfficiënt	EPC	0,29 -

BENG indicatoren	
energiebehoefte	8,1 kWh/m²
primair energiegebruik	32,4 kWh/m²
aandeel hernieuwbare energie	5 %

Uniec 2.2 is gebaseerd op NEN7120;2011 “Energieprestatie van gebouwen” (inclusief het Nader Voorschrift) en NEN 8088-1 “Ventilatie en luchtdoorlatendheid van gebouwen” inclusief alle wettelijk van kracht zijnde correctiebladen.

Alle bovenstaande energiegebruiken zijn genormeerde energiegebruiken gebaseerd op een standaard klimaatjaar en een standaard gebruikersgedrag. Het werkelijke energiegebruik zal afwijken van het genormeerde energiegebruik. Aan de berekende energiegebruiken kunnen geen rechten ontleend worden.

Uniec 2.2 STUDIEBEREKENING

- Pixel 1d
onbekend
0,30

Algemene gegevens

projectomschrijving	*Pixel 1d*
variant	*onbekend*
straat / huisnummer / toevoeging	*23, Binnenwatersloot*
postcode / plaats	*2611BJ Delft*
eigendom	*Koop*
bouwjaar	*2018*
renovatiejaar	
categorie	*Energieprestatie Woningbouw*
woningtype	*appartementengebouw*
aantal woningbouw-eenheden in berekening	*22*
gebruiksfunctie	*woonfunctie - drijvend bouwwerk - nieuwe ligplaats*
datum	*28-05-2018*
opmerkingen	

Indeling gebouw

Eigenschappen rekenzones

type rekenzone	omschrijving	interne warmtecapaciteit	Ag [m²]	aantal wb-eenheden
verwarmde zone	1d	gemengd licht	1.664,00	22

Interne warmtecapaciteit volgens bijlage H *nee*

Infiltratie

meetwaarde voor infiltratie $q_{v;10;spec}$	*ja*
lengte van het gebouw	*25,00 m*
breedte van het gebouw	*25,00 m*
hoogte van het gebouw	*13,50 m*

Eigenschappen infiltratie

rekenzone	positie	dak en/of geveltype	$q_{v;10;spec}$ [dm³/s per m²]
1d	gehele gebouw	standaard geveltype	0,42 (meetwaarde)

Open verbrandingstoestellen

Het gebouw bevat geen open verbrandingstoestellen.

Bouwkundige transmissiegegevens

Transmissiegegevens rekenzone 1d

constructie	A [m²]	R_c [m²K/W]	U [W/m²K]	g_{gl} [-]	zonwering	beschaduwing	toelichting
Facade zuid - buitenlucht, Z - 283,0 m² - 90°							
facade	141,30	4,50				minimale belem.	
windows zuid	141,70		0,70	0,60	nee	constante overstek 0,5 ≤ ho < 1,0	
Facade noord - buitenlucht, N - 283,0 m² - 90°							
facade	198,10	4,50				minimale belem.	
window noord	84,90		0,70	0,60	nee	minimale belem.	
Roof - buitenlucht, HOR, dak - 441,0 m² - 0°							
roof	441,00	6,00				minimale belem.	
Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3) - 416,0 m²							
floors	416,00	4,00					
Facade west - buitenlucht, O - 283,0 m² - 90°							
facade	170,00	4,50				minimale belem.	
windows zuid	113,00		0,70	0,60	nee	minimale belem.	
Facade east - buitenlucht, W - 283,0 m² - 90°							
facade	170,00	4,50				minimale belem.	
windows zuid	113,00		0,70	0,60	nee	minimale belem.	

De lineaire warmteverliezen zijn berekend volgens de forfaitaire methode uit hoofdstuk 13 van NEN 1068.

Overige kenmerken vloerconstructies (inclusief evt. kruipruimten en onverwarmde kelders)

Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3)

hoogte bovenkant vloer boven maaiveld (h)	*0,20 m*
omtrek van het vloerveld (P)	*100,00 m*
grootste dikte v.d. gevels/wanden ter hoogte v.d. vloer ($d_{bw;v}$)	*0,30 m*

Verwarmingsystemen

verwarming

Opwekking

type opwekker	*elektrische warmtepomp*
bron warmtepomp	*bodem*
ontwerpaanvoertemperatuur	*θsup ≤ 30°*
vermogen warmtepomp	*3,50 kW*
β-factor warmtepomp	*21,27*
aantal opwekkers	*22*
type bijverwarming	*elektrisch element*
bijstooktoestel geïntegreerd	*ja*
transmissieverlies verwarmingssysteem - januari (H_T)	*840 W/K*
warmtebehoefte verwarmingssysteem ($Q_{H;nd;an}$)	*14.481 MJ*
hoeveelheid energie t.b.v. verwarming per toestel ($Q_{H;dis;nren;an}$)	*658 MJ*
opwekkingsrendement - warmtepomp ($\eta_{H;gen}$)	*4,150*
opwekkingsrendement - bijverwarming ($\eta_{H;gen}$)	*1,000*

Regeneratie

zonne-energiesysteem voor regeneratie	*nee*

Kenmerken afgiftesysteem verwarming

Type warmteafgifte (in woonkamer)					
type warmteafgifte	positie	hoogte	R	$\theta_{em;avg}$	$\eta_{H;em}$
vloer- en/of wandverwarming en/of betonkernactivering	buitenvloer of buitenwand	< 8 m	≥ 2,5 m²K/W	n.v.t.	1,00

regeling warmteafgifte aanwezig	*ja*
afgifterendement ($\eta_{H;em}$)	*1,000*

Kenmerken distributiesysteem verwarming

buffervat buiten verwarmde ruimte aanwezig	*nee*
verwarmingsleidingen in onverwarmde ruimten en/of kruipruimte	*nee*
distributierendement ($\eta_{H;dis}$)	*1,000*

Hulpenergie verwarming

hoofdcirculatiepomp aanwezig	*nee*
aanvullende circulatiepomp aanwezig	*nee*

Aangesloten rekenzones

1d

Warmtapwatersystemen

verwarming/warmtapwater 2

Opwekking

type opwekker	*warmtepompboiler*
toepassingsklasse (CW-klasse)	*4 (CW 4)*
toestel	*Duurzame Techniek - Dimplex LBW 300 en LBW 300 LW*
aantal toestellen	*22*
hoeveelheid energie t.b.v. warmtapwater per toestel ($Q_{W;dis;nren;an}$)	*8.450 MJ*
opwekkingsrendement warmtapwater - WBP ($\eta_{W;gen}$)	*2,750*

Kenmerken tapwatersysteem

aantal woningbouw-eenheden aangesloten op systeem	*22*
warmtapwatersysteem ten behoeve van	*keuken en badruimte*
gemiddelde leidinglengte naar badruimte	*forfaitair*
gemiddelde leidinglengte naar aanrecht	*forfaitair*
inwendige diameter leiding naar aanrecht	*≤ 10 mm*
afgifterendement warmtapwater ($\eta_{W;em}$)	*0,742*

Douchewarmteterugwinning

douchewarmteterugwinning	*nee*

Zonneboiler

zonneboiler	*nee*

Ventilatie

ventilatie 1

Ventilatiesysteem

ventilatiesysteem	*A. natuurlijke toe- en afvoe[illegible]*
systeemvariant	*A1 standaard*
luchtvolumestroomfactor voor warmte- en koudebehoefte (f_{sys})	*1,24*
correctiefactor regelsysteem voor warmte- en koudebehoefte (f_{reg})	*1,00*

Kenmerken ventilatiesysteem

werkelijk geïnstalleerde ventilatiecapaciteit bekend	*nee*
luchtdichtheidsklasse ventilatiekanalen	*onbek[illegible]d*

Passieve koeling

max. benutting geïnstal. ventilatiecapaciteit voor koudebehoefte	*ja*
max. benutting geïnstal. spuicapaciteit voor koudebehoefte	[illegible]

Aangesloten rekenzones

1d

Koeling

koeling 1

Kenmerken opwekker

type opwekker	*warmtepomp*
toestel / leverancier	*Itho Daalderop WPU 3 (ook bij verwarming kiezen)*
aantal toestellen	*7*
koudebehoefte koelsysteem ($Q_{C;nd}$)	*72.260 MJ*
opwekkingsrendement ($\eta_{C;gen}$)	*64,000*
distributierendement ($\eta_{C;dis}$)	*1,00*

Aangesloten rekenzo[illegible]s

1d

Zonnestroom

solar

piekvermogen (Wp) per m²	*200 Wp/m² bepaald volgens NEN-EN-IEC 60904-1*

Zonnestroom eigenschappen				
ventilatie	A_{PV} [m²]	oriëntatie	helling [°]	beschaduwing

Resultaten

Jaarlijkse hoeveelheid primaire energie voor de energiefunctie		
verwarming (excl. hulpenergie)	$E_{H;P}$	8.933 MJ
hulpenergie		17.761 MJ
warmtapwater (excl. hulpenergie)	$E_{W;P}$	173.066 MJ
hulpenergie		0 MJ
koeling (excl. hulpenergie)	$E_{C;P}$	2.89[illegible] MJ
hulpenergie		0 MJ
zomercomfort	$E_{SC;P}$	[illegible] MJ
ventilatoren	$E_{V;P}$	0 MJ
verlichting	$E_{L;P}$	[illegible]6.67[illegible] MJ
geëxporteerde elektriciteit	$E_{P;exp;el}$	0 MJ
op eigen perceel opgewekte & verbruikte elektriciteit	$E_{P;pr;us;el}$	0 MJ
in het gebied opgewekte elektriciteit	$E_{P;pr;dei;el}$	0 MJ

Oppervlakten		
totale gebruiksoppervlakte	$A_{g;tot}$	1.664,00 m²
totale verliesoppervlakte	A_{ls}	1.864,20 m²

Elektriciteitsgebruik	
gebouwgebonden installaties	30.309 kWh
niet-gebouwgebonden apparatuur (stelpost)	46.645 kWh
op eigen perceel opgewekte & verbruikte elektriciteit	0 kWh
geëxporteerde electriciteit	0 kWh
TOTAAL	76.954 kWh

CO_2-emissie		
CO_2-emissie	m_{co2}	17.120 kg

Energieprestatie		
specifieke energieprestatie	EP	168 MJ/m²
karakteristiek energiegebru[illegible]	E_{Ptot}	279.328 MJ
toelaatbaar karakteri[illegible] energ[illegible]ruik	$E_{P;adm;tot;nb}$	383.811 MJ
energieprestatiecoëffic[illegible]	EPC	0,292 -
energieprestatieco[illegible]fficiënt	EPC	0,30 -

BENG indicatoren	
energiebehoefte	14,5 kWh/m²
primair energiegebruik	33,8 kWh/m²
aandeel hernieuwbare energie	5 %

Uniec 2.2 is gebaseerd op NEN7120;2011 “Energieprestatie van gebouwen” (inclusief het Nader Voorschrift) en NEN 8088-1 “Ventilatie en luchtdoorlatendheid van gebouwen” inclusief alle wettelijk van kracht zijnde correctiebladen.

Alle bovenstaande energiegebruiken zijn genormeerde energiegebruiken gebaseerd op een standaard klimaatjaar en een standaard gebruikersgedrag. Het werkelijke energiegebruik zal afwijken van het genormeerde energiegebruik. Aan de berekende energiegebruiken kunnen geen rechten ontleend worden.

Uniec[2.2]

STUDIEBEREKENING

- Pixel 2a
onbekend

0,28

Algemene gegevens

projectomschrijving	*Pixel 2a*
variant	*onbekend*
straat / huisnummer / toevoeging	*23, Binnenwatersloot*
postcode / plaats	*2611BJ Delft*
eigendom	*Koop*
bouwjaar	*2018*
renovatiejaar	
categorie	*Energieprestatie Woningbouw*
woningtype	*appartementengebouw*
aantal woningbouw-eenheden in berekening	*11*
gebruiksfunctie	*woonfunctie - drijvend bouwwerk - nieuwe ligplaats*
datum	*28-05-2018*
opmerkingen	

Indeling gebouw

Eigenschappen rekenzones

type rekenzone	omschrijving	interne warmtecapaciteit	Ag [m²]	aantal wb-eenheden
verwarmde zone	2a	gemengd licht	847,20	11

Interne warmtecapaciteit volgens bijlage H *nee*

Infiltratie

meetwaarde voor infiltratie $q_{v;10;spec}$	*ja*
lengte van het gebouw	*38,63 m*
breedte van het gebouw	*33,45 m*
hoogte van het gebouw	*3,50 m*

Eigenschappen infiltratie

rekenzone	positie	dak en/of geveltype	$q_{v;10;spec}$ [dm³/s per m²]
2a	geheel gebouw	standaard geveltype	0,42 (meetwaarde)

Open verbrandingstoestellen

Het gebouw bevat geen open verbrandingstoestellen.

Bouwkundige transmissiegegevens

Transmissiegegevens rekenzone 2a

constructie	A [m²]	R_c [m²K/W]	U [W/m²K]	g_{gl} [-]	zonwering	beschaduwing	toelichting
Facade zuid - buitenlucht, Z - 67,5 m² - 90°							

Transmissiegegevens rekenzone 2a

constructie	A [m²]	R_c [m²K/W]	U [W/m²K]	g_{gl} [-]	zonwering	beschaduwing	toelichting
facade	33,80	4,50				minimale belem.	
windows zuid	33,70		0,70	0,60	nee	constante overstek 0,5 ≤ ho < 1,0	
Facade noord - buitenlucht, N - 67,5 m² - 90°							
facade	47,25	4,50				minimale belem.	
window noord	20,25		0,70	0,60	nee	minimale belem.	
Roof - buitenlucht, HOR, dak - 834,8 m² - 0°							
roof	834,80	6,00				minimale belem.	
Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3) - 847,2 m²							
floors	847,20	4,00					
Facade north est - buitenlucht, NO - 67,5 m² - 90°							
facade	54,10	4,50				minimale belem.	
window nord oost	13,40		0,70	0,60	nee	minimale belem.	
Facade north west - buitenlucht, NW - 67,5 m² - 90°							
facade	54,10	4,50				minimale belem.	
window noorrd west	13,40		0,70	0,60	nee	minimale belem.	
facade south est - buitenlucht, ZO - 67,5 m² - 90°							
floors	54,00	4,00				minimale belem.	
window south oost	13,50		0,70	0,60	nee	minimale belem.	
facade south west - buitenlucht, ZW - 67,5 m² - 90°							
floors	54,00	4,00				minimale belem.	
window south west	13,50		0,70	0,60	nee	minimale belem.	

De lineaire warmteverliezen zijn berekend volgens de forfaitaire methode uit hoofdstuk 13 van NEN 1068.

Overige kenmerken vloerconstructies (inclusief evt. kruipruimten en onverwarmde kelders)

Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3)

hoogte bovenkant vloer boven maaiveld (h)	*0,20 m*
omtrek van het vloerveld (P)	*115,80 m*
grootste dikte v.d. gevels/wanden ter hoogte v.d. bk vloer ($d_{bw;v}$)	*0,30 m*

Verwarmingsystemen

verwarming

Opwekking

type opwekker	*elektrische warmtepomp*
bron warmtepomp	*bodem*
ontwerpaanvoertemperatuur	*θsup ≤ 30°*
vermogen warmtepomp	*3,50 kW*
β-factor warmtepomp	*4,49*
aantal opwekkers	*11*
type bijverwarming	*elektrisch element*

bijstooktoestel geïntegreerd	*ja*
transmissieverlies verwarmingssysteem - januari (H_T)	*563 W/K*
warmtebehoefte verwarmingssysteem ($Q_{H;nd;an}$)	*34.326 MJ*
hoeveelheid energie t.b.v. verwarming per toestel ($Q_{H;dis;nren;an}$)	*3.121 MJ*
opwekkingsrendement - warmtepomp ($\eta_{H;gen}$)	*4,000*
opwekkingsrendement - bijverwarming ($\eta_{H;gen}$)	*1,000*

Regeneratie

zonne-energiesysteem voor regeneratie	*nee*

Kenmerken afgiftesysteem verwarming

Type warmteafgifte (in woonkamer)					
type warmteafgifte	positie	hoogte	R_c	$\theta_{em;avg}$	$\eta_{H;em}$
vloer- en/of wandverwarming en/of betonkernactivering	buitenvloer of buitenwand	< 8 m	≥ 2,5 m²K/W	n.v.t.	1,00

regeling warmteafgifte aanwezig	*ja*
afgifterendement ($\eta_{H;em}$)	*1,000*

Kenmerken distributiesysteem verwarming

buffervat buiten verwarmde ruimte aanwezig	*nee*
verwarmingsleidingen in onverwarmde ruimten en/of kruipruimte	*nee*
distributierendement ($\eta_{H;dis}$)	*1,000*

Hulpenergie verwarming

hoofdcirculatiepomp aanwezig	*nee*
aanvullende circulatiepomp aanwezig	*nee*

Aangesloten rekenzones

2a

Warmtapwatersystemen

verwarming/warmtapwater 2

Opwekking

type opwekker	*warmtepompboiler*
toepassingsklasse (CW-klasse)	*4 (CW 4)*
toestel	*Duurzame Techniek - Dimplex LBW 300 en LBW 300 LW*
aantal toestellen	*11*
hoeveelheid energie t.b.v. warmtapwater per toestel ($Q_{W;dis;nren;an}$)	*8.508 MJ*
opwekkingsrendement warmtapwater - WBP ($\eta_{W;gen}$)	*2,750*

Kenmerken tapwatersysteem

aantal woningbouw-eenheden aangesloten op systeem	*11*
warmtapwatersysteem ten behoeve van	*keuken en badruimte*
gemiddelde leidinglengte naar badruimte	*forfaitair*
gemiddelde leidinglengte naar aanrecht	*forfaitair*
inwendige diameter leiding naar aanrecht	*≤ 10 mm*

afgifterendement warmtapwater ($\eta_{W;em}$)	*0,742*

Douchewarmteterugwinning

douchewarmteterugwinning	*nee*

Zonneboiler

zonneboiler	*nee*

Ventilatie

ventilatie 1

Ventilatiesysteem

ventilatiesysteem	*A. natuurlijke toe- en afvoer*
systeemvariant	*A1 standaard*
luchtvolumestroomfactor voor warmte- en koudebehoefte (f_{sys})	*1,24*
correctiefactor regelsysteem voor warmte- en koudebehoefte (f_{reg})	*1,00*

Kenmerken ventilatiesysteem

werkelijk geïnstalleerde ventilatiecapaciteit bekend	*nee*
luchtdichtheidsklasse ventilatiekanalen	*onbekend*

Passieve koeling

max. benutting geïnstal. ventilatiecapaciteit voor koudebehoefte	*ja*
max. benutting geïnstal. spuicapaciteit voor koudebehoefte	*ja*

Aangesloten rekenzones

2a

Koeling

koeling 1

Kenmerken opwekker

type opwekker	*warmtepomp*
toestel / leverancier	*Itho Daalderop WPU 3 (ook bij verwarming kiezen)*
aantal toestellen	*11*
koudebehoefte koelsysteem ($Q_{C;nd}$)	*9.405 MJ*
opwekkingsrendement ($\eta_{C;gen}$)	*64,000*
distributierendement ($\eta_{C;dis}$)	*1,00*

Aangesloten rekenzones

2a

Zonnestroom

solar

piekvermogen (Wp) per m²	*200 Wp/m² bepaald volgens NEN-EN-IEC 60904-1*

Resultaten

Jaarlijkse hoeveelheid primaire energie voor de energiefunctie		
verwarming (excl. hulpenergie)	$E_{H;P}$	21.969 MJ
hulpenergie		8.881 MJ
warmtapwater (excl. hulpenergie)	$E_{W;P}$	87.120 MJ
hulpenergie		0 MJ
koeling (excl. hulpenergie)	$E_{C;P}$	37[illegible] MJ
hulpenergie		0 MJ
zomercomfort	$E_{SC;P}$	[illegible] MJ
ventilatoren	$E_{V;P}$	0 MJ
verlichting	$E_{L;P}$	[illegible]9.03[illegible] MJ
geëxporteerde elektriciteit	$E_{P;exp;el}$	0 MJ
op eigen perceel opgewekte & verbruikte elektriciteit	$E_{P;pr;us;el}$	0 MJ
in het gebied opgewekte elektriciteit	$E_{P;pr;dei;el}$	0 MJ

Oppervlakten		
totale gebruiksoppervlakte	$A_{g;tot}$	847,20 m²
totale verliesoppervlakte	A_{ls}	1.832,84 m²

Elektriciteitsgebruik	
gebouwgebonden installaties	17.077 kWh
niet-gebouwgebonden apparatuur (stelpost)	23.749 kWh
op eigen perceel opgewekte & verbruikte elektriciteit	0 kWh
geëxporteerde electriciteit	0 kWh
TOTAAL	40.826 kWh

CO_2-emissie		
CO_2-emissie	m_{co2}	9.646 kg

Energieprestatie		
specifieke energieprestatie	EP	186 MJ/m²
karakteristiek energiegebruik	E_{Ptot}	157.385 MJ
toelaatbaar karakteristiek energiegebruik	$E_{P;adm;tot;nb}$	227.666 MJ
energieprestatiecoëfficiënt	EPC	0,277 -
energieprestatiecoëfficiënt	EPC	0,28 -

BENG indicatoren	
energiebehoefte	14,3 kWh/m²
primair energiegebruik	38,8 kWh/m²
aandeel hernieuwbare energie	18 %

Uniec 2.2 is gebaseerd op NEN7120;2011 “Energieprestatie van gebouwen” (inclusief het Nader Voorschrift) en NEN 8088-1 “Ventilatie en luchtdoorlatendheid van gebouwen” inclusief alle wettelijk van kracht zijnde correctiebladen.

Alle bovenstaande energiegebruiken zijn genormeerde energiegebruiken gebaseerd op een standaard klimaatjaar en een standaard gebruikersgedrag. Het werkelijke energiegebruik zal afwijken van het genormeerde energiegebruik. Aan de berekende energiegebruiken kunnen geen rechten ontleend worden.

Uniec 2.2 STUDIEBEREKENING

- Pixel 2b
onbekend **0,29**

Algemene gegevens

projectomschrijving	*Pixel 2b*
variant	*onbekend*
straat / huisnummer / toevoeging	*23, Binnenwatersloot*
postcode / plaats	*2611BJ Delft*
eigendom	*Koop*
bouwjaar	*2018*
renovatiejaar	
categorie	*Energieprestatie Woningbouw*
woningtype	*appartementengebouw*
aantal woningbouw-eenheden in berekening	*22*
gebruiksfunctie	*woonfunctie - drijvend bouwwerk - nieuwe ligplaats*
datum	*28-05-2018*
opmerkingen	

Indeling gebouw

Eigenschappen rekenzones				
type rekenzone	omschrijving	interne warmtecapaciteit	Ag [m²]	aantal wb-eenheden
verwarmde zone	2b	gemengd licht	1.694,00	22

Interne warmtecapaciteit volgens bijlage H *nee*

Infiltratie

meetwaarde voor infiltratie $q_{v;10;spec}$	*ja*
lengte van het gebouw	*38,63 m*
breedte van het gebouw	*33,45 m*
hoogte van het gebouw	*7,00 m*

Eigenschappen infiltratie			
rekenzone	positie	dak en/of geveltype	$q_{v;10;spec}$ [dm³/s per m²]
2b	geheel gebouw	standaard geveltype	0,42 (meetwaarde)

Open verbrandingstoestellen

Het gebouw bevat geen open verbrandingstoestellen.

Bouwkundige transmissiegegevens

Transmissiegegevens rekenzone 2b

constructie	A [m²]	R_c [m²K/W]	U [W/m²K]	g_{gl} [-]	zonwering	beschaduwing	toelichting
Facade zuid - buitenlucht, Z - 127,4 m² - 90°							
facade	63,70	4,50				minimale belem.	
windows zuid	63,70		0,70	0,60	nee	constante overstek 0,5 ≤ ho < 1,0	
Facade noord - buitenlucht, N - 127,4 m² - 90°							
facade	89,20	4,50				minimale belem.	
window noord	38,20		0,70	0,60	nee	minimale belem.	
Roof - buitenlucht, HOR, dak - 834,8 m² - 0°							
roof	834,80	6,00				minimale belem.	
Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3) - 847,2 m²							
floors	847,20	4,00					
Facade north est - buitenlucht, NO - 127,4 m² - 90°							
facade	102,00	4,50				minimale belem.	
window nord oost	25,40		0,70	0,60	nee	minimale belem.	
Facade north west - buitenlucht, NW - 127,4 m² - 90°							
facade	102,00	4,50				minimale belem.	
window noorrd west	25,40		0,70	0,60	nee	minimale belem.	
facade south est - buitenlucht, ZO - 127,4 m² - 90°							
floors	102,00	4,00				minimale belem.	
window south oost	25,40		0,70	0,60	nee	minimale belem.	
facade south west - buitenlucht, ZW - 127,4 m² - 90°							
floors	102,00	4,00				minimale belem.	
window south west	25,40		0,70	0,60	nee	minimale belem.	

De lineaire warmteverliezen zijn berekend volgens de forfaitaire methode uit hoofdstuk 13 van NEN 1068.

Overige kenmerken vloerconstructies (inclusief evt. kruipruimten en onverwarmde kelders)

Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3)

hoogte bovenkant vloer boven maaiveld (h)	*0,20 m*
omtrek van het vloerveld (P)	*115,80 m*
grootste dikte v.d. gevels/wanden tot hoogte v.d. bk vloer ($d_{bw;v}$)	*0,30 m*

Verwarmingssystemen

verwarming

Opwekking

type opwekker	*elektrische warmtepomp*
bron warmtepomp	*bodem*
ontwerpaanvoertemperatuur	*θsup ≤ 30°*
vermogen warmtepomp	*3,50 kW*
β-factor warmtepomp	*17,75*
aantal opwekkers	*22*
type bijverwarming	*elektrisch element*

bijstooktoestel geïntegreerd	*ja*
transmissieverlies verwarmingssysteem - januari (H_T)	*742 W/K*
warmtebehoefte verwarmingssysteem ($Q_{H;nd;an}$)	*17.351 MJ*
hoeveelheid energie t.b.v. verwarming per toestel ($Q_{H;dis;nren;an}$)	*789 MJ*
opwekkingsrendement - warmtepomp ($\eta_{H;gen}$)	*4,150*
opwekkingsrendement - bijverwarming ($\eta_{H;gen}$)	*1,000*

Regeneratie

zonne-energiesysteem voor regeneratie	*nee*

Kenmerken afgiftesysteem verwarming

Type warmteafgifte (in woonkamer)					
type warmteafgifte	positie	hoogte	R_c	$\theta_{em;avg}$	$\eta_{H;em}$
vloer- en/of wandverwarming en/of betonkernactivering	buitenvloer of buitenwand	< 8 m	≥ 2,5 m²K/W	n.v.t.	1,00

regeling warmteafgifte aanwezig	*ja*
afgifterendement ($\eta_{H;em}$)	*1,000*

Kenmerken distributiesysteem verwarming

buffervat buiten verwarmde ruimte aanwezig	*nee*
verwarmingsleidingen in onverwarmde ruimten en/of kruipruimte	*nee*
distributierendement ($\eta_{H;dis}$)	*1,000*

Hulpenergie verwarming

hoofdcirculatiepomp aanwezig	*nee*
aanvullende circulatiepomp aanwezig	*nee*

Aangesloten rekenzones

2b

Warmtapwatersysteem

verwarming/warmtapwater 2

Opwekking

type opwekker	*warmtepompboiler*
toepassingsklasse (CW-klasse)	*4 (CW 4)*
toestel	*Duurzame Techniek - Dimplex LBW 300 en LBW 300 LW*
aantal toestellen	*22*
hoeveelheid energie t.b.v. warmtapwater per toestel ($Q_{W;dis;nren;an}$)	*8.507 MJ*
opwekkingsrendement warmtapwater - WBP ($\eta_{W;gen}$)	*2,750*

Kenmerken tapwatersysteem

aantal woningbouw-eenheden aangesloten op systeem	*22*
warmtapwatersysteem ten behoeve van	*keuken en badruimte*
gemiddelde leidinglengte naar badruimte	*forfaitair*
gemiddelde leidinglengte naar aanrecht	*forfaitair*
inwendige diameter leiding naar aanrecht	*≤ 10 mm*

afgifterendement warmtapwater ($\eta_{W;em}$)	*0,742*

Douchewarmteterugwinning

douchewarmteterugwinning	*nee*

Zonneboiler

zonneboiler	*nee*

Ventilatie

ventilatie 1

Ventilatiesysteem

ventilatiesysteem	*A. natuurlijke toe- en afvoer*
systeemvariant	*A1 standaard*
luchtvolumestroomfactor voor warmte- en koudebehoefte (f_{sys})	*1,24*
correctiefactor regelsysteem voor warmte- en koudebehoefte (f_{reg})	*1,00*

Kenmerken ventilatiesysteem

werkelijk geïnstalleerde ventilatiecapaciteit bekend	*nee*
luchtdichtheidsklasse ventilatiekanalen	*onbekend*

Passieve koeling

max. benutting geïnstal. ventilatiecapaciteit voor koudebehoefte	*ja*
max. benutting geïnstal. spuicapaciteit voor koudebehoefte	*ja*

Aangesloten rekenzones

2b

Koeling

koeling 1

Kenmerken opwekker

type opwekker	*warmtepomp*
toestel / leverancier	*Itho Daalderop WPU 3 (ook bij verwarming kiezen)*
aantal toestellen	*22*
koudebehoefte koelsysteem ($Q_{C;nd}$)	*16.366 MJ*
opwekkingsrendement ($\eta_{C;gen}$)	*64,000*
distributierendement ($\eta_{C;dis}$)	*1,00*

Aangesloten rekenzones

2b

Resultaten

Jaarlijkse hoeveelheid primaire energie voor de energiefunctie		
verwarming (excl. hulpenergie)	$E_{H;P}$	10.703 MJ
hulpenergie		17.761 MJ
warmtapwater (excl. hulpenergie)	$E_{W;P}$	174.225 MJ
hulpenergie		0 MJ
koeling (excl. hulpenergie)	$E_{C;P}$	65[illegible] MJ
hulpenergie		0 MJ
zomercomfort	$E_{SC;P}$	[illegible] MJ
ventilatoren	$E_{V;P}$	0 MJ
verlichting	$E_{L;P}$	[illegible]8.06[illegible] MJ
geëxporteerde elektriciteit	$E_{P;exp;el}$	0 MJ
op eigen perceel opgewekte & verbruikte elektriciteit	$E_{P;pr;us;el}$	0 MJ
in het gebied opgewekte elektriciteit	$E_{P;pr;dei;el}$	0 MJ

Oppervlakten		
totale gebruiksoppervlakte	$A_{g;tot}$	1.694,00 m²
totale verliesoppervlakte	A_{ls}	2.192,24 m²

Elektriciteitsgebruik	
gebouwgebonden installaties	30.534 kWh
niet-gebouwgebonden apparatuur (stelpost)	47.486 kWh
op eigen perceel opgewekte & verbruikte elektriciteit	0 kWh
geëxporteerde electriciteit	0 kWh
TOTAAL	78.020 kWh

CO_2-emissie		
CO_2-emissie	m_{co2}	17.247 kg

Energieprestatie		
specifieke energieprestatie	EP	166 MJ/m²
karakteristiek energiegebruik	E_{Ptot}	281.404 MJ
toelaatbaar karakteristiek energiegebruik	$E_{P;adm;tot;nb}$	400.171 MJ
energieprestatiecoëfficiënt	EPC	0,282 -
energieprestatiecoëfficiënt	EPC	0,29 -

BENG indicatoren	
energiebehoefte	5,5 kWh/m²
primair energiegebruik	33,3 kWh/m²
aandeel hernieuwbare energie	6 %

Uniec 2.2 is gebaseerd op NEN7120;2011 “Energieprestatie van gebouwen” (inclusief het Nader Voorschrift) en NEN 8088-1 “Ventilatie en luchtdoorlatendheid van gebouwen” inclusief alle wettelijk van kracht zijnde correctiebladen.

Alle bovenstaande energiegebruiken zijn genormeerde energiegebruiken gebaseerd op een standaard klimaatjaar en een standaard gebruikersgedrag. Het werkelijke energiegebruik zal afwijken van het genormeerde energiegebruik. Aan de berekende energiegebruiken kunnen geen rechten ontleend worden.

Uniec[2.2] STUDIEBEREKENING

- Pixel 2c
onbekend 0,28

Algemene gegevens

projectomschrijving	*Pixel 2c*
variant	*onbekend*
straat / huisnummer / toevoeging	*23, Binnenwatersloot*
postcode / plaats	*2611BJ Delft*
eigendom	*Koop*
bouwjaar	*2018*
renovatiejaar	
categorie	*Energieprestatie Woningbouw*
woningtype	*appartementengebouw*
aantal woningbouw-eenheden in berekening	*13*
gebruiksfunctie	*woonfunctie - drijvend bouwwerk - nieuwe ligplaats*
datum	*28-05-2018*
opmerkingen	

Indeling gebouw

Eigenschappen rekenzones

type rekenzone	omschrijving	interne warmtecapaciteit	Ag [m²]	aantal wb-eenheden
verwarmde zone	2c	gemengd licht	973,80	13

Interne warmtecapaciteit volgens bijlage H *nee*

Infiltratie

meetwaarde voor infiltratie $q_{v;10;spec}$	*ja*
lengte van het gebouw	*27,00 m*
breedte van het gebouw	*33,45 m*
hoogte van het gebouw	*10,00 m*

Eigenschappen infiltratie

rekenzone	positie	dak en/of geveltype	$q_{v;10;spec}$ [dm³/s per m²]
2c	geheel gebouw	standaard geveltype	0,42 (meetwaarde)

Open verbrandingstoestellen

Het gebouw bevat geen open verbrandingstoestellen.

Bouwkundige transmissiegegevens

Transmissiegegevens rekenzone 2c

constructie	A [m²]	R_c [m²K/W]	U [W/m²K]	g_{gl} [-]	zonwering	beschaduwing	toelichting
Facade zuid - buitenlucht, Z - 158,0 m² - 90°							
facade	79,00	4,50				minimale belem.	
windows zuid	79,00		0,70	0,60	nee	constante overstek 0,5 ≤ ho < 1,0	
Facade noord - buitenlucht, N - 158,0 m² - 90°							
facade	110,60	4,50				minimale belem.	
window noord	47,40		0,70	0,60	nee	minimale belem.	
Roof - buitenlucht, HOR, dak - 625,0 m² - 0°							
roof	625,00	6,00				minimale belem.	
Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3) - 624,0 m²							
floors	624,00	4,00					
Facade north est - buitenlucht, NO - 158,0 m² - 90°							
facade	126,40	4,50				minimale belem.	
window nord oost	31,60		0,70	0,60	nee	minimale belem.	
Facade north west - buitenlucht, NW - 158,0 m² - 90°							
facade	126,40	4,50				minimale belem.	
window noorrd west	31,60		0,70	0,60	nee	minimale belem.	
facade south est - buitenlucht, ZO - 158,0 m² - 90°							
floors	126,40	4,00				minimale belem.	
window south oost	31,60		0,70	0,60	nee	minimale belem.	
facade south west - buitenlucht, ZW - 158,0 m² - 90°							
floors	126,40	4,00				minimale belem.	
window south west	31,60		0,70	0,60	nee	minimale belem.	

De lineaire warmteverliezen zijn berekend volgens de forfaitaire methode uit hoofdstuk 13 van NEN 1068.

Overige kenmerken vloerconstructies (inclusief evt. kruipruimten en onverwarmde kelders)

Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3)

hoogte bovenkant vloer boven maaiveld (h)	*0,20 m*
omtrek van het vloerveld (P)	*94,80 m*
grootste dikte v.d. gevels/wanden t.h.v. hoogte v.d. bk vloer ($d_{bw;v}$)	*0,30 m*

Verwarmingssystemen

verwarming

Opwekking

type opwekker	*elektrische warmtepomp*
bron warmtepomp	*bodem*
ontwerpaanvoertemperatuur	*θsup ≤ 30°*
vermogen warmtepomp	*3,50 kW*
β-factor warmtepomp	*5,20*
aantal opwekkers	*13*
type bijverwarming	*elektrisch element*

bijstooktoestel geïntegreerd	*ja*
transmissieverlies verwarmingssysteem - januari (H_T)	*745 W/K*
warmtebehoefte verwarmingssysteem ($Q_{H;nd;an}$)	*35.005 MJ*
hoeveelheid energie t.b.v. verwarming per toestel ($Q_{H;dis;nren;an}$)	*2.693 MJ*
opwekkingsrendement - warmtepomp ($\eta_{H;gen}$)	*4,150*
opwekkingsrendement - bijverwarming ($\eta_{H;gen}$)	*1,000*

Regeneratie

zonne-energiesysteem voor regeneratie	*nee*

Kenmerken afgiftesysteem verwarming

Type warmteafgifte (in woonkamer)					
type warmteafgifte	positie	hoogte	R_c	$\theta_{em;avg}$	$\eta_{H;em}$
vloer- en/of wandverwarming en/of betonkernactivering	buitenvloer of buitenwand	< 8 m	≥ 2,5 m²K/W	n.v.t.	1,00

regeling warmteafgifte aanwezig	*ja*
afgifterendement ($\eta_{H;em}$)	*1,000*

Kenmerken distributiesysteem verwarming

buffervat buiten verwarmde ruimte aanwezig	*nee*
verwarmingsleidingen in onverwarmde ruimten en/of kruipruimte	*nee*
distributierendement ($\eta_{H;dis}$)	*1,000*

Hulpenergie verwarming

hoofdcirculatiepomp aanwezig	*nee*
aanvullende circulatiepomp aanwezig	*nee*

Aangesloten rekenzones

2c

Warmtapwatersysteem 1

verwarming/warmtapwater 2

Opwekking

type opwekker	*warmtepompboiler*
toepassingsklasse (CW-klasse)	*4 (CW 4)*
toestel	*Duurzame Techniek - Dimplex LBW 300 en LBW 300 LW*
aantal toestellen	*13*
hoeveelheid energie t.b.v. warmtapwater per toestel ($Q_{W;dis;nren;an}$)	*8.420 MJ*
opwekkingsrendement warmtapwater - WBP ($\eta_{W;gen}$)	*2,750*

Kenmerken tapwatersysteem

aantal woningbouw-eenheden aangesloten op systeem	*13*
warmtapwatersysteem ten behoeve van	*keuken en badruimte*
gemiddelde leidinglengte naar badruimte	*forfaitair*
gemiddelde leidinglengte naar aanrecht	*forfaitair*
inwendige diameter leiding naar aanrecht	*≤ 10 mm*

afgifterendement warmtapwater ($\eta_{W;em}$)	*0,742*

Douchewarmteterugwinning

douchewarmteterugwinning	*nee*

Zonneboiler

zonneboiler	*nee*

Ventilatie

ventilatie 1

Ventilatiesysteem

ventilatiesysteem	*A. natuurlijke toe- en afvoer*
systeemvariant	*A1 standaard*
luchtvolumestroomfactor voor warmte- en koudebehoefte (f_{sys})	*1,24*
correctiefactor regelsysteem voor warmte- en koudebehoefte (f_{reg})	*1,00*

Kenmerken ventilatiesysteem

werkelijk geïnstalleerde ventilatiecapaciteit bekend	*nee*
luchtdichtheidsklasse ventilatiekanalen	*onbekend*

Passieve koeling

max. benutting geïnstal. ventilatiecapaciteit voor koudebehoefte	*ja*
max. benutting geïnstal. spuicapaciteit voor koudebehoefte	*ja*

Aangesloten rekenzones

2c

Koeling

koeling 1

Kenmerken opwekker

type opwekker	*warmtepomp*
toestel / leverancier	*Itho Daalderop WPU 3 (ook bij verwarming kiezen)*
aantal toestellen	*13*
koudebehoefte koelsysteem ($Q_{C;nd}$)	*35.049 MJ*
opwekkingsrendement ($\eta_{C;gen}$)	*64,000*
distributierendement ($\eta_{C;dis}$)	*1,00*

Aangesloten rekenzones

2c

studentenlicentie

Resultaten

Jaarlijkse hoeveelheid primaire energie voor de energiefunctie		
verwarming (excl. hulpenergie)	$E_{H;P}$	21.593 MJ
hulpenergie		10.495 MJ
warmtapwater (excl. hulpenergie)	$E_{W;P}$	101.900 MJ
hulpenergie		0 MJ
koeling (excl. hulpenergie)	$E_{C;P}$	1.402 MJ
hulpenergie		0 MJ
zomercomfort	$E_{SC;P}$	[illegible] MJ
ventilatoren	$E_{V;P}$	0 MJ
verlichting	$E_{L;P}$	4.87[illegible] MJ
geëxporteerde elektriciteit	$E_{P;exp;el}$	0 MJ
op eigen perceel opgewekte & verbruikte elektriciteit	$E_{P;pr;us;el}$	0 MJ
in het gebied opgewekte elektriciteit	$E_{P;pr;dei;el}$	0 MJ

Oppervlakten		
totale gebruiksoppervlakte	$A_{g;tot}$	973,80 m²
totale verliesoppervlakte	A_{ls}	2.009,80 m²

Elektriciteitsgebruik	
gebouwgebonden installaties	19.560 kWh
niet-gebouwgebonden apparatuur (stelpost)	27.298 kWh
op eigen perceel opgewekte & verbruikte elektriciteit	0 kWh
geëxporteerde electriciteit	0 kWh
TOTAAL	46.857 kWh

CO_2-emissie		
CO_2-emissie	m_{co2}	11.048 kg

Energieprestatie		
specifieke energieprestatie	EP	185 MJ/m²
karakteristiek energiegebruik	E_{Ptot}	180.264 MJ
toelaatbaar karakteristiek energiegebruik	$E_{P;adm;tot;nb}$	259.473 MJ
energieprestatiecoëfficiënt	EPC	0,278 -
energieprestatiecoëfficiënt	EPC	0,28 -

BENG indicatoren	
energiebehoefte	20,0 kWh/m²
primair energiegebruik	38,6 kWh/m²
aandeel hernieuwbare energie	16 %

Uniec 2.2 is gebaseerd op NEN7120;2011 “Energieprestatie van gebouwen” (inclusief het Nader Voorschrift) en NEN 8088-1 “Ventilatie en luchtdoorlatendheid van gebouwen” inclusief alle wettelijk van kracht zijnde correctiebladen.

Alle bovenstaande energiegebruiken zijn genormeerde energiegebruiken gebaseerd op een standaard klimaatjaar en een standaard gebruikersgedrag. Het werkelijke energiegebruik zal afwijken van het genormeerde energiegebruik. Aan de berekende energiegebruiken kunnen geen rechten ontleend worden.

Uniec 2.2 STUDIEBEREKENING

- Pixel 2d
onbekend
0,33

Algemene gegevens

projectomschrijving	*Pixel 2d*
variant	*onbekend*
straat / huisnummer / toevoeging	*23, Binnenwatersloot*
postcode / plaats	*2611BJ Delft*
eigendom	*Koop*
bouwjaar	*2018*
renovatiejaar	
categorie	*Energieprestatie Woningbouw*
woningtype	*appartementengebouw*
aantal woningbouw-eenheden in berekening	*20*
gebruiksfunctie	*woonfunctie - drijvend bouwwerk - nieuwe ligplaats*
datum	*28-05-2018*
opmerkingen	

Indeling gebouw

Eigenschappen rekenzones

type rekenzone	omschrijving	interne warmtecapaciteit	Ag [m²]	aantal wb-eenheden
verwarmde zone	2d	gemengd licht	973,80	20

Interne warmtecapaciteit volgens bijlage H *nee*

Infiltratie

meetwaarde voor infiltratie $q_{v;10;spec}$	*ja*
lengte van het gebouw	*24,70 m*
breedte van het gebouw	*21,45 m*
hoogte van het gebouw	*13,50 m*

Eigenschappen infiltratie

rekenzone	positie	dak en/of geveltype	$q_{v;10;spec}$ [dm³/s per m²]
2d	gehele gebouw	standaard geveltype	0,42 (meetwaarde)

Open verbrandingstoestellen

Het gebouw bevat geen open verbrandingstoestellen.

Bouwkundige transmissiegegevens

Transmissiegegevens rekenzone 2d

studentenlicentie

constructie	A [m²]	R_c [m²K/W]	U [W/m²K]	g_{gl} [-]	zonwering	beschaduwing	toelichting
Facade zuid - buitenlucht, Z - 167,4 m² - 90°							
facade	83,70	4,50				minimale belem.	
windows zuid	83,70		0,70	0,60	nee	constante overstek 0,5 ≤ ho < 1,0	
Facade noord - buitenlucht, N - 167,4 m² - 90°							
facade	117,20	4,50				minimale belem.	
window noord	50,20		0,70	0,60	nee	minimale belem.	
Roof - buitenlucht, HOR, dak - 399,0 m² - 0°							
roof	399,00	6,00				minimale belem.	
Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3) - 376,0 m²							
floors	376,00	4,00					
Facade north est - buitenlucht, NO - 167,4 m² - 90°							
facade	133,92	4,50				minimale belem.	
window nord oost	33,48		0,70	0,60	nee	minimale belem.	
Facade north west - buitenlucht, NW - 167,4 m² - 90°							
facade	133,92	4,50				minimale belem.	
window noorrd west	33,48		0,70	0,60	nee	minimale belem.	
facade south est - buitenlucht, ZO - 167,4 m² - 90°							
floors	133,92	4,00				minimale belem.	
window south oost	33,48		0,70	0,60	nee	minimale belem.	
facade south west - buitenlucht, ZW - 167,4 m² - 90°							
floors	133,92	4,00				minimale belem.	
window south west	33,48		0,70	0,60	nee	minimale belem.	

De lineaire warmteverliezen zijn berekend volgens de forfaitaire methode uit hoofdstuk 13 van NEN 1068.

Overige kenmerken vloerconstructies (inclusief evt. kruipruimten en onverwarmde kelders)

Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3)

hoogte bovenkant vloer boven maaiveld (h)	*0,20 m*
omtrek van het vloerveld (P)	*74,40 m*
grootste dikte v.d. gevels/wanden t.h.v. hoogte v.d. bk vloer ($d_{bw;v}$)	*0,30 m*

Verwarmingsystemen

verwarming

Opwekking

type opwekker	*elektrische warmtepomp*
bron warmtepomp	*bodem*
ontwerpaanvoertemperatuur	*θsup ≤ 30°*
vermogen warmtepomp	*3,50 kW*
β-factor warmtepomp	*16,33*
aantal opwekkers	*20*
type bijverwarming	*elektrisch element*

bijstooktoestel geïntegreerd	*ja*
transmissieverlies verwarmingssysteem - januari (H_T)	*682 W/K*
warmtebehoefte verwarmingssysteem ($Q_{H;nd;an}$)	*17.148 MJ*
hoeveelheid energie t.b.v. verwarming per toestel ($Q_{H;dis;nren;an}$)	*857 MJ*
opwekkingsrendement - warmtepomp ($\eta_{H;gen}$)	*4,150*
opwekkingsrendement - bijverwarming ($\eta_{H;gen}$)	*1,000*

Regeneratie

zonne-energiesysteem voor regeneratie	*nee*

Kenmerken afgiftesysteem verwarming

Type warmteafgifte (in woonkamer)

type warmteafgifte	positie	hoogte	R_c	$\theta_{em;avg}$	$\eta_{H;em}$
vloer- en/of wandverwarming en/of betonkernactivering	buitenvloer of buitenwand	< 8 m	≥ 2,5 m²K/W	n.v.t.	1,00

regeling warmteafgifte aanwezig	*ja*
afgifterendement ($\eta_{H;em}$)	*1,000*

Kenmerken distributiesysteem verwarming

buffervat buiten verwarmde ruimte aanwezig	*nee*
verwarmingsleidingen in onverwarmde ruimten en/of kruipruimte	*nee*
distributierendement ($\eta_{H;dis}$)	*1,000*

Hulpenergie verwarming

hoofdcirculatiepomp aanwezig	*nee*
aanvullende circulatiepomp aanwezig	*nee*

Aangesloten rekenzones

2d

Warmtapwatersysteem

verwarming/warmtapwater 2

Opwekking

type opwekker	*warmtepompboiler*
toepassingsklasse (CW-klasse)	*4 (CW 4)*
toestel	*Duurzame Techniek - Dimplex LBW 300 en LBW 300 LW*
aantal toestellen	*20*
hoeveelheid energie t.b.v. warmtapwater per toestel ($Q_{W;dis;nren;an}$)	*7.332 MJ*
opwekkingsrendement warmtapwater - WBP ($\eta_{W;gen}$)	*2,200*

Kenmerken tapwatersysteem

aantal woningbouw-eenheden aangesloten op systeem	*20*
warmtapwatersysteem ten behoeve van	*keuken en badruimte*
gemiddelde leidinglengte naar badruimte	*forfaitair*
gemiddelde leidinglengte naar aanrecht	*forfaitair*
inwendige diameter leiding naar aanrecht	*≤ 10 mm*

afgifterendement warmtapwater ($\eta_{W;em}$)	*0,742*

Douchewarmteterugwinning

douchewarmteterugwinning	*nee*

Zonneboiler

zonneboiler	*nee*

Ventilatie

ventilatie 1

Ventilatiesysteem

ventilatiesysteem	*A. natuurlijke toe- en afvoer*
systeemvariant	*A1 standaard*
luchtvolumestroomfactor voor warmte- en koudebehoefte (f_{sys})	*1,24*
correctiefactor regelsysteem voor warmte- en koudebehoefte (f_{reg})	*1,00*

Kenmerken ventilatiesysteem

werkelijk geïnstalleerde ventilatiecapaciteit bekend	*nee*
luchtdichtheidsklasse ventilatiekanalen	*onbekend*

Passieve koeling

max. benutting geïnstal. ventilatiecapaciteit voor koudebehoefte	*ja*
max. benutting geïnstal. spuicapaciteit voor koudebehoefte	*ja*

Aangesloten rekenzones

2d

Koeling

koeling 1

Kenmerken opwekker

type opwekker	*warmtepomp*
toestel / leverancier	*Itho Daalderop WPU 3 (ook bij verwarming kiezen)*
aantal toestellen	*20*
koudebehoefte koelsysteem ($Q_{C;nd}$)	*47.015 MJ*
opwekkingsrendement ($\eta_{C;gen}$)	*64,000*
distributierendement ($\eta_{C;dis}$)	*1,00*

Aangesloten rekenzones

2d

Resultaten

Jaarlijkse hoeveelheid primaire energie voor de energiefunctie		
verwarming (excl. hulpenergie)	$E_{H;P}$	10.578 MJ
hulpenergie		16.146 MJ
warmtapwater (excl. hulpenergie)	$E_{W;P}$	170.642 MJ
hulpenergie		0 MJ
koeling (excl. hulpenergie)	$E_{C;P}$	1.88[illegible] MJ
hulpenergie		0 MJ
zomercomfort	$E_{SC;P}$	[illegible] MJ
ventilatoren	$E_{V;P}$	0 MJ
verlichting	$E_{L;P}$	[illegible]4.87[illegible] MJ
geëxporteerde elektriciteit	$E_{P;exp;el}$	0 MJ
op eigen perceel opgewekte & verbruikte elektriciteit	$E_{P;pr;us;el}$	0 MJ
in het gebied opgewekte elektriciteit	$E_{P;pr;dei;el}$	0 MJ

Oppervlakten		
totale gebruiksoppervlakte	$A_{g;tot}$	973,80 m²
totale verliesoppervlakte	A_{ls}	1.666,60 m²

Elektriciteitsgebruik	
gebouwgebonden installaties	26.489 kWh
niet-gebouwgebonden apparatuur (stelpost)	27.298 kWh
op eigen perceel opgewekte & verbruikte elektriciteit	0 kWh
geëxporteerde electriciteit	0 kWh
TOTAAL	53.786 kWh

CO_2-emissie		
CO_2-emissie	m_{co2}	14.962 kg

Energieprestatie		
specifieke energieprestatie	EP	251 MJ/m²
karakteristiek energiegebruik	E_{Ptot}	244.120 MJ
toelaatbaar karakteristiek energiegebruik	$E_{P;adm;tot;nb}$	302.486 MJ
energieprestatiecoëfficiënt	EPC	0,323 -
energieprestatiecoëfficiënt	EPC	0,33 -

BENG indicatoren	
energiebehoefte	18,3 kWh/m²
primair energiegebruik	56,8 kWh/m²
aandeel hernieuwbare energie	6 %

Uniec 2.2 is gebaseerd op NEN7120;2011 “Energieprestatie van gebouwen” (inclusief het Nader Voorschrift) en NEN 8088-1 “Ventilatie en luchtdoorlatendheid van gebouwen” inclusief alle wettelijk van kracht zijnde correctiebladen.

Alle bovenstaande energiegebruiken zijn genormeerde energiegebruiken gebaseerd op een standaard klimaatjaar en een standaard gebruikersgedrag. Het werkelijke energiegebruik zal afwijken van het genormeerde energiegebruik. Aan de berekende energiegebruiken kunnen geen rechten ontleend worden.

Uniec[2.2] STUDIEBEREKENING

- Pixel 3b
onbekend **0,28**

Algemene gegevens

projectomschrijving	*Pixel 3b*
variant	*onbekend*
straat / huisnummer / toevoeging	*23, Binnenwatersloot*
postcode / plaats	*2611BJ Delft*
eigendom	*Koop*
bouwjaar	*2018*
renovatiejaar	
categorie	*Energieprestatie Woningbouw*
woningtype	*appartementengebouw*
aantal woningbouw-eenheden in berekening	*14*
gebruiksfunctie	*woonfunctie - drijvend bouwwerk - nieuwe ligplaats*
datum	*28-05-2018*
opmerkingen	

Indeling gebouw

Eigenschappen rekenzones

type rekenzone	omschrijving	interne warmtecapaciteit	Ag [m²]	aantal wb-eenheden
verwarmde zone	3b	geheel licht	1.088,70	14

Interne warmtecapaciteit volgens bijlage H *nee*

Infiltratie

meetwaarde voor infiltratie $q_{v;10;spec}$	*ja*
lengte van het gebouw	*25,00 m*
breedte van het gebouw	*25,00 m*
hoogte van het gebouw	*10,50 m*

Eigenschappen infiltratie

rekenzone	positie	dak en/of geveltype	$q_{v;10;spec}$ [dm³/s per m²]
3b	geheel gebouw	standaard geveltype	0,42 (meetwaarde)

Open verbrandingstoestellen

Het gebouw bevat geen open verbrandingstoestellen.

Bouwkundige transmissiegegevens

Transmissiegegevens rekenzone 3b

constructie	A [m²]	R_c [m²K/W]	U [W/m²K]	g_{gl} [-]	zonwering	beschaduwing	toelichting
Facade zuid - buitenlucht, Z - 188,1 m² - 90°							
facade	94,10	4,50				minimale belem.	
windows zuid	94,00		0,70	0,60	nee	constante overstek 0,5 ≤ ho < 1,0	
Facade noord - buitenlucht, N - 188,1 m² - 90°							
facade	131,70	4,50				minimale belem.	
window noord	56,40		0,70	0,60	nee	minimale belem.	
Roof - buitenlucht, HOR, dak - 625,0 m² - 0°							
roof	625,00	6,00				minimale belem.	
Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3) - 595,0 m²							
floors	595,00	4,00					
Facade west - buitenlucht, O - 188,1 m² - 90°							
facade	112,90	4,50				minimale belem.	
windows zuid	75,20		0,70	0,60	nee	minimale belem.	
Facade east - buitenlucht, W - 188,1 m² - 90°							
facade	112,90	4,50				minimale belem.	
windows zuid	75,20		0,70	0,60	nee	minimale belem.	

De lineaire warmteverliezen zijn berekend volgens de forfaitaire methode uit hoofdstuk 13 van NEN 1068.

Overige kenmerken vloerconstructies (inclusief eventuele kruipruimten en onverwarmde kelders)

Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3)

hoogte bovenkant vloer boven maaiveld (h)	*0,20 m*
omtrek van het vloerveld (P)	*100,00 m*
grootste dikte v.d. gevels/wanden ter hoogte v.d. vloer ($d_{bw;v}$)	*0,30 m*

Verwarmingsystemen

verwarming

Opwekking

type opwekker	*elektrische warmtepomp*
bron warmtepomp	*bodem*
ontwerpaanvoertemperatuur	*θsup ≤ 30°*
vermogen warmtepomp	*3,50 kW*
β-factor warmtepomp	*8,24*
aantal opwekkers	*14*
type bijverwarming	*elektrisch element*
bijstooktoestel geïntegreerd	*ja*
transmissieverlies verwarmingssysteem - januari (H_T)	*698 W/K*
warmtebehoefte verwarmingssysteem ($Q_{H;nd;an}$)	*23.782 MJ*
hoeveelheid energie t.b.v. verwarming per toestel ($Q_{H;dis;nren;an}$)	*1.699 MJ*
opwekkingsrendement - warmtepomp ($\eta_{H;gen}$)	*4,150*
opwekkingsrendement - bijverwarming ($\eta_{H;gen}$)	*1,000*

Regeneratie

zonne-energiesysteem voor regeneratie	*nee*

Kenmerken afgiftesysteem verwarming

Type warmteafgifte (in woonkamer)					
type warmteafgifte	positie	hoogte	R	$\theta_{em;avg}$	$\eta_{H;em}$
vloer- en/of wandverwarming en/of betonkernactivering	buitenvloer of buitenwand	< 8 m	≥ 2,5 m²K/W	n.v.t.	1,00

regeling warmteafgifte aanwezig	*ja*
afgifterendement ($\eta_{H;em}$)	*1,000*

Kenmerken distributiesysteem verwarming

buffervat buiten verwarmde ruimte aanwezig	*nee*
verwarmingsleidingen in onverwarmde ruimten en/of kruipruimte	*nee*
distributierendement ($\eta_{H;dis}$)	*1,000*

Hulpenergie verwarming

hoofdcirculatiepomp aanwezig	*nee*
aanvullende circulatiepomp aanwezig	*nee*

Aangesloten rekenzones

3b

Warmtapwatersystemen

verwarming/warmtapwater 2

Opwekking

type opwekker	*warmtepompboiler*
toepassingsklasse (CW-klasse)	*4 (CW 4)*
toestel	*Duurzame Techniek - Dimplex LBW 300 en LBW 300 LW*
aantal toestellen	*14*
hoeveelheid energie t.b.v. warmtapwater per toestel ($Q_{W;dis;nren;an}$)	*8.539 MJ*
opwekkingsrendement warmtapwater - WBP ($\eta_{W;gen}$)	*2,800*

Kenmerken tapwatersysteem

aantal woningbouw-eenheden aangesloten op systeem	*14*
warmtapwatersysteem ten behoeve van	*keuken en badruimte*
gemiddelde leidinglengte naar badruimte	*forfaitair*
gemiddelde leidinglengte naar aanrecht	*forfaitair*
inwendige diameter leiding naar aanrecht	*≤ 10 mm*
afgifterendement warmtapwater ($\eta_{W;em}$)	*0,742*

Douchewarmteterugwinning

douchewarmteterugwinning	*nee*

Zonneboiler

zonneboiler	*nee*

Ventilatie

ventilatie 1

Ventilatiesysteem

ventilatiesysteem	*A. natuurlijke toe- en afvoer*
systeemvariant	*A1 standaard*
luchtvolumestroomfactor voor warmte- en koudebehoefte (f_{sys})	*1,24*
correctiefactor regelsysteem voor warmte- en koudebehoefte (f_{reg})	*1,00*

Kenmerken ventilatiesysteem

werkelijk geïnstalleerde ventilatiecapaciteit bekend	*nee*
luchtdichtheidsklasse ventilatiekanalen	*onbekend*

Passieve koeling

max. benutting geïnstal. ventilatiecapaciteit voor koudebehoefte	*ja*
max. benutting geïnstal. spuicapaciteit voor koudebehoefte	[illegible]

Aangesloten rekenzones

3b

Koeling

koeling 1

Kenmerken opwekker

type opwekker	*warmtepomp*
toestel / leverancier	*Itho Daalderop WPU 3 (ook bij verwarming kiezen)*
aantal toestellen	*11*
koudebehoefte koelsysteem ($Q_{C;nd}$)	*46.736 MJ*
opwekkingsrendement ($\eta_{C;gen}$)	*64,000*
distributierendement ($\eta_{C;dis}$)	*1,00*

Aangesloten rekenzones

3b

Zonnestroom

solar

piekvermogen (Wp) per m²	*200 Wp/m² bepaald volgens NEN-EN-IEC 60904-1*

Zonnestroom eigenschappen				
ventilatie	A_{PV} [m²]	oriëntatie	helling [°]	beschaduwing

Resultaten

Jaarlijkse hoeveelheid primaire energie voor de energiefunctie		
verwarming (excl. hulpenergie)	$E_{H;P}$	14.670 MJ
hulpenergie		11.303 MJ
warmtapwater (excl. hulpenergie)	$E_{W;P}$	109.297 MJ
hulpenergie		0 MJ
koeling (excl. hulpenergie)	$E_{C;P}$	1.86[illegible] MJ
hulpenergie		0 MJ
zomercomfort	$E_{SC;P}$	[illegible] MJ
ventilatoren	$E_{V;P}$	0 MJ
verlichting	$E_{L;P}$	[illegible]0.16[illegible] MJ
geëxporteerde elektriciteit	$E_{P;exp;el}$	0 MJ
op eigen perceel opgewekte & verbruikte elektriciteit	$E_{P;pr;us;el}$	0 MJ
in het gebied opgewekte elektriciteit	$E_{P;pr;dei;el}$	0 MJ

Oppervlakten		
totale gebruiksoppervlakte	$A_{g;tot}$	1.088,70 m²
totale verliesoppervlakte	A_{ls}	1.793,90 m²

Elektriciteitsgebruik	
gebouwgebonden installaties	20.324 kWh
niet-gebouwgebonden apparatuur (stelpost)	30.518 kWh
op eigen perceel opgewekte & verbruikte elektriciteit	0 kWh
geëxporteerde electriciteit	0 kWh
TOTAAL	50.842 kWh

CO_2-emissie		
CO_2-emissie	m_{co2}	11.480 kg

Energieprestatie		
specifieke energieprestatie	EP	172 MJ/m²
karakteristiek energiegebruik	E_{Ptot}	187.306 MJ
toelaatbaar karakteristiek energiegebruik	$E_{P;adm;tot;nb}$	271.031 MJ
energieprestatiecoëfficiënt	EPC	0,277 -
energieprestatiecoëfficiënt	EPC	0,28 -

BENG indicatoren	
energiebehoefte	18,0 kWh/m²
primair energiegebruik	35,0 kWh/m²
aandeel hernieuwbare energie	12 %

Uniec 2.2 is gebaseerd op NEN7120;2011 “Energieprestatie van gebouwen” (inclusief het Nader Voorschrift) en NEN 8088-1 “Ventilatie en luchtdoorlatendheid van gebouwen” inclusief alle wettelijk van kracht zijnde correctiebladen.

Alle bovenstaande energiegebruiken zijn genormeerde energiegebruiken gebaseerd op een standaard klimaatjaar en een standaard gebruikersgedrag. Het werkelijke energiegebruik zal afwijken van het genormeerde energiegebruik. Aan de berekende energiegebruiken kunnen geen rechten ontleend worden.

Uniec 2.2 STUDIEBEREKENING

- Pixel 3c
onbekend **0,29**

Algemene gegevens

projectomschrijving	*Pixel 3c*
variant	*onbekend*
straat / huisnummer / toevoeging	*23, Binnenwatersloot*
postcode / plaats	*2611BJ Delft*
eigendom	*Koop*
bouwjaar	*2018*
renovatiejaar	
categorie	*Energieprestatie Woningbouw*
woningtype	*appartementengebouw*
aantal woningbouw-eenheden in berekening	*19*
gebruiksfunctie	*woonfunctie - drijvend bouwwerk - nieuwe ligplaats*
datum	*28-05-2018*
opmerkingen	

Indeling gebouw

Eigenschappen rekenzones				
type rekenzone	omschrijving	interne warmtecapaciteit	Ag [m²]	aantal wb-eenheden
verwarmde zone	3c	gematigd licht	1.432,20	19

Interne warmtecapaciteit volgens bijlage H *nee*

Infiltratie

meetwaarde voor infiltratie $q_{v;10;spec}$	*ja*
lengte van het gebouw	*25,00 m*
breedte van het gebouw	*25,00 m*
hoogte van het gebouw	*13,50 m*

Eigenschappen infiltratie			
rekenzone	positie	dak en/of geveltype	$q_{v;10;spec}$ [dm³/s per m²]
3c	geheel gebouw	standaard geveltype	0,42 (meetwaarde)

Open verbrandingstoestellen

Het gebouw bevat geen open verbrandingstoestellen.

Bouwkundige transmissiegegevens

Transmissiegegevens rekenzone 3c

constructie	A [m²]	R_c [m²K/W]	U [W/m²K]	g_{gl} [-]	zonwering	beschaduwing	toelichting
Facade zuid - buitenlucht, Z - 251,0 m² - 90°							
facade	126,00	4,50				minimale belem.	
windows zuid	125,00		0,70	0,60	nee	constante overstek 0,5 ≤ ho < 1,0	
Facade noord - buitenlucht, N - 251,0 m² - 90°							
facade	175,70	4,50				minimale belem.	
window noord	75,30		0,70	0,60	nee	minimale belem.	
Roof - buitenlucht, HOR, dak - 625,0 m² - 0°							
roof	625,00	6,00				minimale belem.	
Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3) - 595,0 m²							
floors	595,00	4,00					
Facade west - buitenlucht, O - 251,0 m² - 90°							
facade	150,60	4,50				minimale belem.	
windows zuid	100,40		0,70	0,60	nee	minimale belem.	
Facade east - buitenlucht, W - 251,0 m² - 90°							
facade	150,60	4,50				minimale belem.	
windows zuid	100,40		0,70	0,60	nee	minimale belem.	

De lineaire warmteverliezen zijn berekend volgens de forfaitaire methode uit hoofdstuk 13 van NEN 1068.

Overige kenmerken vloerconstructies (inclusief eventuele kruipruimten en onverwarmde kelders)

Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3)

hoogte bovenkant vloer boven maaiveld (h)	*0,20 m*
omtrek van het vloerveld (P)	*100,00 m*
grootste dikte v.d. gevels/wanden ter hoogte v.d. vloer ($d_{bw;v}$)	*0,30 m*

Verwarmingsystemen

verwarming

Opwekking

type opwekker	*elektrische warmtepomp*
bron warmtepomp	*bodem*
ontwerpaanvoertemperatuur	*θsup ≤ 30°*
vermogen warmtepomp	*3,50 kW*
β-factor warmtepomp	*12,24*
aantal opwekkers	*19*
type bijverwarming	*elektrisch element*
bijstooktoestel geïntegreerd	*ja*
transmissieverlies verwarmingssysteem - januari (H_T)	*838 W/K*
warmtebehoefte verwarmingssysteem ($Q_{H;nd;an}$)	*21.737 MJ*
hoeveelheid energie t.b.v. verwarming per toestel ($Q_{H;dis;nren;an}$)	*1.144 MJ*
opwekkingsrendement - warmtepomp ($\eta_{H;gen}$)	*4,150*
opwekkingsrendement - bijverwarming ($\eta_{H;gen}$)	*1,000*

Regeneratie

zonne-energiesysteem voor regeneratie	*nee*

Kenmerken afgiftesysteem verwarming

Type warmteafgifte (in woonkamer)					
type warmteafgifte	positie	hoogte	R	$\theta_{em;avg}$	$\eta_{H;em}$
vloer- en/of wandverwarming en/of betonkernactivering	buitenvloer of buitenwand	< 8 m	≥ 2,5 m²K/W	n.v.t.	1,00

regeling warmteafgifte aanwezig	*ja*
afgifterendement ($\eta_{H;em}$)	*1,000*

Kenmerken distributiesysteem verwarming

buffervat buiten verwarmde ruimte aanwezig	*nee*
verwarmingsleidingen in onverwarmde ruimten en/of kruipruimte	*nee*
distributierendement ($\eta_{H;dis}$)	*1,000*

Hulpenergie verwarming

hoofdcirculatiepomp aanwezig	*nee*
aanvullende circulatiepomp aanwezig	*nee*

Aangesloten rekenzones

3c

Warmtapwatersystemen

verwarming/warmtapwater 2

Opwekking

type opwekker	*warmtepompboiler*
toepassingsklasse (CW-klasse)	*4 (CW 4)*
toestel	*Duurzame Techniek - Dimplex LBW 300 en LBW 300 LW*
aantal toestellen	*19*
hoeveelheid energie t.b.v. warmtapwater per toestel ($Q_{W;dis;nren;an}$)	*8.440 MJ*
opwekkingsrendement warmtapwater - WBP ($\eta_{W;gen}$)	*2,750*

Kenmerken tapwatersysteem

aantal woningbouw-eenheden aangesloten op systeem	*19*
warmtapwatersysteem ten behoeve van	*keuken en badruimte*
gemiddelde leidinglengte naar badruimte	*forfaitair*
gemiddelde leidinglengte naar aanrecht	*forfaitair*
inwendige diameter leiding naar aanrecht	*≤ 10 mm*
afgifterendement warmtapwater ($\eta_{W;em}$)	*0,742*

Douchewarmteterugwinning

douchewarmteterugwinning	*nee*

Zonneboiler

zonneboiler	*nee*

Ventilatie

ventilatie 1

Ventilatiesysteem

ventilatiesysteem	*A. natuurlijke toe- en afvoer*
systeemvariant	*A1 standaard*
luchtvolumestroomfactor voor warmte- en koudebehoefte (f_{sys})	*1,24*
correctiefactor regelsysteem voor warmte- en koudebehoefte (f_{reg})	*1,00*

Kenmerken ventilatiesysteem

werkelijk geïnstalleerde ventilatiecapaciteit bekend	*nee*
luchtdichtheidsklasse ventilatiekanalen	*onbekend*

Passieve koeling

max. benutting geïnstal. ventilatiecapaciteit voor koudebehoefte	*ja*
max. benutting geïnstal. spuicapaciteit voor koudebehoefte	[illegible]

Aangesloten rekenzones

3c

Koeling

koeling 1

Kenmerken opwekker

type opwekker	*warmtepomp*
toestel / leverancier	*Itho Daalderop WPU 3 (ook bij verwarming kiezen)*
aantal toestellen	*19*
koudebehoefte koelsysteem ($Q_{C;nd}$)	*64.778 MJ*
opwekkingsrendement ($\eta_{C;gen}$)	*64,000*
distributierendement ($\eta_{C;dis}$)	*1,00*

Aangesloten rekenzones

3c

Zonnestroom

solar

piekvermogen (Wp) per m²	*200 Wp/m² bepaald volgens NEN-EN-IEC 60904-1*

Zonnestroom eigenschappen				
ventilatie	A_{PV} [m²]	oriëntatie	helling [°]	beschaduwing

Resultaten

Jaarlijkse hoeveelheid primaire energie voor de energiefunctie		
verwarming (excl. hulpenergie)	$E_{H;P}$	13.409 MJ
hulpenergie		15.339 MJ
warmtapwater (excl. hulpenergie)	$E_{W;P}$	149.277 MJ
hulpenergie		0 MJ
koeling (excl. hulpenergie)	$E_{C;P}$	2.59[illegible] MJ
hulpenergie		0 MJ
zomercomfort	$E_{SC;P}$	[illegible] MJ
ventilatoren	$E_{V;P}$	0 MJ
verlichting	$E_{L;P}$	[illegible].99[illegible] MJ
geëxporteerde elektriciteit	$E_{P;exp;el}$	0 MJ
op eigen perceel opgewekte & verbruikte elektriciteit	$E_{P;pr;us;el}$	0 MJ
in het gebied opgewekte elektriciteit	$E_{P;pr;dei;el}$	0 MJ

Oppervlakten		
totale gebruiksoppervlakte	$A_{g;tot}$	1.432,20 m²
totale verliesoppervlakte	A_{ls}	2.045,50 m²

Elektriciteitsgebruik	
gebouwgebonden installaties	26.759 kWh
niet-gebouwgebonden apparatuur (stelpost)	40.147 kWh
op eigen perceel opgewekte & verbruikte elektriciteit	0 kWh
geëxporteerde electriciteit	0 kWh
TOTAAL	66.907 kWh

CO_2-emissie		
CO_2-emissie	m_{co2}	15.115 kg

Energieprestatie		
specifieke energieprestatie	EP	172 MJ/m²
karakteristiek energiegebruik	E_{Ptot}	246.612 MJ
toelaatbaar karakteristiek energiegebruik	$E_{P;adm;tot;nb}$	347.094 MJ
energieprestatiecoëfficiënt	EPC	0,285 -
energieprestatiecoëfficiënt	EPC	0,29 -

BENG indicatoren	
energiebehoefte	16,8 kWh/m²
primair energiegebruik	35,0 kWh/m²
aandeel hernieuwbare energie	8 %

Uniec 2.2 is gebaseerd op NEN7120;2011 “Energieprestatie van gebouwen” (inclusief het Nader Voorschrift) en NEN 8088-1 “Ventilatie en luchtdoorlatendheid van gebouwen” inclusief alle wettelijk van kracht zijnde correctiebladen.

Alle bovenstaande energiegebruiken zijn genormeerde energiegebruiken gebaseerd op een standaard klimaatjaar en een standaard gebruikersgedrag. Het werkelijke energiegebruik zal afwijken van het genormeerde energiegebruik. Aan de berekende energiegebruiken kunnen geen rechten ontleend worden.

Uniec$^{2.2}$ STUDIEBEREKENING

- Pixel 4a
onbekend **0,28**

Algemene gegevens

projectomschrijving	*Pixel 4a*
variant	*onbekend*
straat / huisnummer / toevoeging	*23, Binnenwatersloot*
postcode / plaats	*2611BJ Delft*
eigendom	*Koop*
bouwjaar	*2018*
renovatiejaar	
categorie	*Energieprestatie Woningbouw*
woningtype	*appartementengebouw*
aantal woningbouw-eenheden in berekening	*17*
gebruiksfunctie	*woonfunctie - drijvend bouwwerk - nieuwe ligplaats*
datum	*28-05-2018*
opmerkingen	

Indeling gebouw

Eigenschappen rekenzones

type rekenzone	omschrijving	interne warmtecapaciteit	Ag [m²]	aantal wb-eenheden
verwarmde zone	4a	gemiddeld licht	1.294,00	17

Interne warmtecapaciteit volgens bijlage H *nee*

Infiltratie

meetwaarde voor infiltratie $q_{v;10;spec}$	*ja*
lengte van het gebouw	*38,63 m*
breedte van het gebouw	*33,45 m*
hoogte van het gebouw	*7,00 m*

Eigenschappen infiltratie

rekenzone	positie	dak en/of geveltype	$q_{v;10;spec}$ [dm³/s per m²]
4a	geheel gebouw	standaard geveltype	0,42 (meetwaarde)

Open verbrandingstoestellen

Het gebouw bevat geen open verbrandingstoestellen.

Bouwkundige transmissiegegevens

Transmissiegegevens rekenzone 4a

constructie	A [m²]	R_c [m²K/W]	U [W/m²K]	g_{gl} [-]	zonwering	beschaduwing	toelichting
Facade zuid - buitenlucht, Z - 109,0 m² - 90°							

Transmissiegegevens rekenzone 4a

constructie	A [m²]	R_c [m²K/W]	U [W/m²K]	g_{gl} [-]	zonwering	beschaduwing	toelichting
facade	54,55	4,50				minimale belem.	
windows zuid	54,45		0,70	0,60	nee	constante overstek 0,5 ≤ ho < 1,0	
Facade noord - buitenlucht, N - 109,0 m² - 90°							
facade	76,30	4,50				minimale belem.	
window noord	32,70		0,70	0,60	nee	minimale belem.	
Roof - buitenlucht, HOR, dak - 890,7 m² - 0°							
roof	890,70	6,00				minimale belem.	
Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3) - 846,5 m²							
floors	846,50	4,00					
Facade north est - buitenlucht, NO - 109,0 m² - 90°							
facade	87,20	4,50				minimale belem.	
window nord oost	21,80		0,70	0,60	nee	minimale belem.	
Facade north west - buitenlucht, NW - 109,0 m² - 90°							
facade	87,20	4,50				minimale belem.	
window noorrd west	21,80		0,70	0,60	nee	minimale belem.	
facade south est - buitenlucht, ZO - 109,0 m² - 90°							
floors	87,20	4,00				minimale belem.	
window south oost	21,80		0,70	0,60	nee	minimale belem.	
facade south west - buitenlucht, ZW - 109,0 m² - 90°							
floors	87,20	4,00				minimale belem.	
window south west	21,80		0,70	0,60	nee	minimale belem.	

De lineaire warmteverliezen zijn berekend volgens de forfaitaire methode uit hoofdstuk 13 van NEN 1068.

Overige kenmerken vloerconstructies (inclusief evt. kruipruimten en onverwarmde kelders)

Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3)

hoogte bovenkant vloer boven maaiveld (h)	*0,20 m*
omtrek van het vloerveld (P)	*115,80 m*
grootste dikte v.d. gevels/wanden ter hoogte v.d. bk vloer ($d_{bw;v}$)	*0,30 m*

Verwarmingssystemen

verwarming

Opwekking

type opwekker	*elektrische warmtepomp*
bron warmtepomp	*bodem*
ontwerpaanvoertemperatuur	*θsup ≤ 30°*
vermogen warmtepomp	*3,50 kW*
β-factor warmtepomp	*8,74*
aantal opwekkers	*17*
type bijverwarming	*elektrisch element*

bijstooktoestel geïntegreerd	*ja*
transmissieverlies verwarmingssysteem - januari (H_T)	*706 W/K*
warmtebehoefte verwarmingssysteem ($Q_{H;nd;an}$)	*27.219 MJ*
hoeveelheid energie t.b.v. verwarming per toestel ($Q_{H;dis;nren;an}$)	*1.601 MJ*
opwekkingsrendement - warmtepomp ($\eta_{H;gen}$)	*4,150*
opwekkingsrendement - bijverwarming ($\eta_{H;gen}$)	*1,000*

Regeneratie

zonne-energiesysteem voor regeneratie	*nee*

Kenmerken afgiftesysteem verwarming

Type warmteafgifte (in woonkamer)					
type warmteafgifte	positie	lengte	R_c	$\theta_{em;avg}$	$\eta_{H;em}$
vloer- en/of wandverwarming en/of betonkernactivering	buitenvloer of buitenwand	< 8 m	≥ 2,5 m²K/W	n.v.t.	1,00

regeling warmteafgifte aanwezig	*ja*
afgifterendement ($\eta_{H;em}$)	*1,000*

Kenmerken distributiesysteem verwarming

buffervat buiten verwarmde ruimte aanwezig	*nee*
verwarmingsleidingen in onverwarmde ruimten en/of kruipruimte	*nee*
distributierendement ($\eta_{H;dis}$)	*1,000*

Hulpenergie verwarming

hoofdcirculatiepomp aanwezig	*nee*
aanvullende circulatiepomp aanwezig	*nee*

Aangesloten rekenzones

4a

Warmtapwatersystemen

verwarming/warmtapwater 2

Opwekking

type opwekker	*warmtepompboiler*
toepassingsklasse (CW-klasse)	*4 (CW 4)*
toestel	*Duurzame Techniek - Dimplex LBW 300 en LBW 300 LW*
aantal toestellen	*17*
hoeveelheid energie t.b.v. warmtapwater per toestel ($Q_{W;dis;nren;an}$)	*8.470 MJ*
opwekkingsrendement warmtapwater - WBP ($\eta_{W;gen}$)	*2,750*

Kenmerken tapwatersysteem

aantal woningbouw-eenheden aangesloten op systeem	*17*
warmtapwatersysteem ten behoeve van	*keuken en badruimte*
gemiddelde leidinglengte naar badruimte	*forfaitair*
gemiddelde leidinglengte naar aanrecht	*forfaitair*
inwendige diameter leiding naar aanrecht	*≤ 10 mm*

afgifterendement warmtapwater ($\eta_{W;em}$)	*0,742*

Douchewarmteterugwinning

douchewarmteterugwinning	*nee*

Zonneboiler

zonneboiler	*nee*

Ventilatie

ventilatie 1

Ventilatiesysteem

ventilatiesysteem	*A. natuurlijke toe- en afvoer*
systeemvariant	*A1 standaard*
luchtvolumestroomfactor voor warmte- en koudebehoefte (f_{sys})	*1,24*
correctiefactor regelsysteem voor warmte- en koudebehoefte (f_{reg})	*1,00*

Kenmerken ventilatiesysteem

werkelijk geïnstalleerde ventilatiecapaciteit bekend	*nee*
luchtdichtheidsklasse ventilatiekanalen	*onbekend*

Passieve koeling

max. benutting geïnstal. ventilatiecapaciteit voor koudebehoefte	*ja*
max. benutting geïnstal. spuicapaciteit voor koudebehoefte	*ja*

Aangesloten rekenzones

4a

Koeling

koeling 1

Kenmerken opwekker

type opwekker	*warmtepomp*
toestel / leverancier	*Itho Daalderop WPU 3 (ook bij verwarming kiezen)*
aantal toestellen	*17*
koudebehoefte koelsysteem ($Q_{C;nd}$)	*15.343 MJ*
opwekkingsrendement ($\eta_{C;gen}$)	*64,000*
distributierendement ($\eta_{C;dis}$)	*1,00*

Aangesloten rekenzones

4a

Zonnestroom

solar

piekvermogen (Wp) per m²	*200 Wp/m² bepaald volgens NEN-EN-IEC 60904-1*

Resultaten

Jaarlijkse hoeveelheid primaire energie voor de energiefunctie		
verwarming (excl. hulpenergie)	$E_{H;P}$	16.791 MJ
hulpenergie		13.724 MJ
warmtapwater (excl. hulpenergie)	$E_{W;P}$	134.049 MJ
hulpenergie		0 MJ
koeling (excl. hulpenergie)	$E_{C;P}$	61[illegible] MJ
hulpenergie		0 MJ
zomercomfort	$E_{SC;P}$	[illegible] MJ
ventilatoren	$E_{V;P}$	0 MJ
verlichting	$E_{L;P}$	[illegible]9.62[illegible] MJ
geëxporteerde elektriciteit	$E_{P;exp;el}$	0 MJ
op eigen perceel opgewekte & verbruikte elektriciteit	$E_{P;pr;us;el}$	0 MJ
in het gebied opgewekte elektriciteit	$E_{P;pr;dei;el}$	0 MJ

Oppervlakten		
totale gebruiksoppervlakte	$A_{g;tot}$	1.294,00 m²
totale verliesoppervlakte	A_{ls}	2.137,25 m²

Elektriciteitsgebruik	
gebouwgebonden installaties	24.393 kWh
niet-gebouwgebonden apparatuur (stelpost)	36.273 kWh
op eigen perceel opgewekte & verbruikte elektriciteit	0 kWh
geëxporteerde electriciteit	0 kWh
TOTAAL	60.666 kWh

CO_2-emissie		
CO_2-emissie	m_{co2}	13.778 kg

Energieprestatie		
specifieke energieprestatie	EP	174 MJ/m²
karakteristiek energiegebruik	E_{Ptot}	224.805 MJ
toelaatbaar karakteristiek energiegebruik	$E_{P;adm;tot;nb}$	323.755 MJ
energieprestatiecoëfficiënt	EPC	0,278 -
energieprestatiecoëfficiënt	EPC	0,28 -

BENG indicatoren	
energiebehoefte	9,1 kWh/m²
primair energiegebruik	35,5 kWh/m²
aandeel hernieuwbare energie	11 %

Uniec 2.2 is gebaseerd op NEN7120;2011 “Energieprestatie van gebouwen” (inclusief het Nader Voorschrift) en NEN 8088-1 “Ventilatie en luchtdoorlatendheid van gebouwen” inclusief alle wettelijk van kracht zijnde correctiebladen.

Alle bovenstaande energiegebruiken zijn genormeerde energiegebruiken gebaseerd op een standaard klimaatjaar en een standaard gebruikersgedrag. Het werkelijke energiegebruik zal afwijken van het genormeerde energiegebruik. Aan de berekende energiegebruiken kunnen geen rechten ontleend worden.

Uniec 2.2 STUDIEBEREKENING

- Pixel 4b
onbekend 0,29

Algemene gegevens

projectomschrijving	*Pixel 4b*
variant	*onbekend*
straat / huisnummer / toevoeging	*23, Binnenwatersloot*
postcode / plaats	*2611BJ Delft*
eigendom	*Koop*
bouwjaar	*2018*
renovatiejaar	
categorie	*Energieprestatie Woningbouw*
woningtype	*appartementengebouw*
aantal woningbouw-eenheden in berekening	*22*
gebruiksfunctie	*woonfunctie - drijvend bouwwerk - nieuwe ligplaats*
datum	*28-05-2018*
opmerkingen	

Indeling gebouw

Eigenschappen rekenzones				
type rekenzone	omschrijving	interne warmtecapaciteit	Ag [m²]	aantal wb-eenheden
verwarmde zone	4b	gemengd licht	1.673,00	22

Interne warmtecapaciteit volgens bijlage H *nee*

Infiltratie

meetwaarde voor infiltratie $q_{v;10;spec}$	*ja*
lengte van het gebouw	*38,63 m*
breedte van het gebouw	*33,45 m*
hoogte van het gebouw	*10,50 m*

Eigenschappen infiltratie			
rekenzone	positie	dak en/of geveltype	$q_{v;10;spec}$ [dm³/s per m²]
4b	geheel gebouw	standaard geveltype	0,42 (meetwaarde)

Open verbrandingstoestellen

Het gebouw bevat geen open verbrandingstoestellen.

Bouwkundige transmissiegegevens

Transmissiegegevens rekenzone 4b

constructie	A [m²]	R_c [m²K/W]	U [W/m²K]	g_{gl} [-]	zonwering	beschaduwing	toelichting
Facade zuid - buitenlucht, Z - 155,8 m² - 90°							
facade	77,86	4,50				minimale belem.	
windows zuid	77,90		0,70	0,60	nee	constante overstek 0,5 ≤ ho < 1,0	
Facade noord - buitenlucht, N - 155,8 m² - 90°							
facade	109,06	4,50				minimale belem.	
window noord	46,70		0,70	0,60	nee	minimale belem.	
Roof - buitenlucht, HOR, dak - 890,7 m² - 0°							
roof	890,70	6,00				minimale belem.	
Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3) - 846,5 m²							
floors	846,50	4,00					
Facade north est - buitenlucht, NO - 155,8 m² - 90°							
facade	124,61	4,50				minimale belem.	
window nord oost	31,15		0,70	0,60	nee	minimale belem.	
Facade north west - buitenlucht, NW - 155,8 m² - 90°							
facade	124,61	4,50				minimale belem.	
window noorrd west	31,15		0,70	0,60	nee	minimale belem.	
facade south est - buitenlucht, ZO - 155,8 m² - 90°							
floors	124,61	4,00				minimale belem.	
window south oost	31,15		0,70	0,60	nee	minimale belem.	
facade south west - buitenlucht, ZW - 155,8 m² - 90°							
floors	124,61	4,00				minimale belem.	
window south west	31,15		0,70	0,60	nee	minimale belem.	

De lineaire warmteverliezen zijn berekend volgens de forfaitaire methode uit hoofdstuk 13 van NEN 1068.

Overige kenmerken vloerconstructies (inclusief evt. kruipruimten en onverwarmde kelders)

Floor - vloer op/boven mv; boven grond/spouw (z ≤ 0,3)

hoogte bovenkant vloer boven maaiveld (h)	*0,20 m*
omtrek van het vloerveld (P)	*115,80 m*
grootste dikte v.d. gevels/wanden t.o.v. hoogte v.d. bk vloer ($d_{bw;v}$)	*0,30 m*

Verwarmingssystemen

verwarming

Opwekking

type opwekker	*elektrische warmtepomp*
bron warmtepomp	*bodem*
ontwerpaanvoertemperatuur	*θsup ≤ 30°*
vermogen warmtepomp	*3,50 kW*
β-factor warmtepomp	*12,45*
aantal opwekkers	*22*
type bijverwarming	*elektrisch element*

bijstooktoestel geïntegreerd	*ja*
transmissieverlies verwarmingssysteem - januari (H_T)	*846 W/K*
warmtebehoefte verwarmingssysteem ($Q_{H;nd;an}$)	*24.747 MJ*
hoeveelheid energie t.b.v. verwarming per toestel ($Q_{H;dis;nren;an}$)	*1.125 MJ*
opwekkingsrendement - warmtepomp ($\eta_{H;gen}$)	*4,150*
opwekkingsrendement - bijverwarming ($\eta_{H;gen}$)	*1,000*

Regeneratie

zonne-energiesysteem voor regeneratie	*nee*

Kenmerken afgiftesysteem verwarming

Type warmteafgifte (in woonkamer)

type warmteafgifte	positie	hoogte	R_c	$\theta_{em;avg}$	$\eta_{H;em}$
vloer- en/of wandverwarming en/of betonkernactivering	buitenvloer of buitenwand	< 8 m	≥ 2,5 m²K/W	n.v.t.	1,00

regeling warmteafgifte aanwezig	*ja*
afgifterendement ($\eta_{H;em}$)	*1,000*

Kenmerken distributiesysteem verwarming

buffervat buiten verwarmde ruimte aanwezig	*nee*
verwarmingsleidingen in onverwarmde ruimten en/of kruipruimte	*nee*
distributierendement ($\eta_{H;dis}$)	*1,000*

Hulpenergie verwarming

hoofdcirculatiepomp aanwezig	*nee*
aanvullende circulatiepomp aanwezig	*nee*

Aangesloten rekenzones

4b

Warmtapwatersystemen

verwarming/warmtapwater 2

Opwekking

type opwekker	*warmtepompboiler*
toepassingsklasse (CW-klasse)	*4 (CW 4)*
toestel	*Duurzame Techniek - Dimplex LBW 300 en LBW 300 LW*
aantal toestellen	*22*
hoeveelheid energie t.b.v. warmtapwater per toestel ($Q_{W;dis;nren;an}$)	*8.467 MJ*
opwekkingsrendement warmtapwater - WBP ($\eta_{W;gen}$)	*2,750*

Kenmerken tapwatersysteem

aantal woningbouw-eenheden aangesloten op systeem	*22*
warmtapwatersysteem ten behoeve van	*keuken en badruimte*
gemiddelde leidinglengte naar badruimte	*forfaitair*
gemiddelde leidinglengte naar aanrecht	*forfaitair*
inwendige diameter leiding naar aanrecht	*≤ 10 mm*

afgifterendement warmtapwater ($\eta_{W;em}$)	*0,742*

Douchewarmteterugwinning

douchewarmteterugwinning	*nee*

Zonneboiler

zonneboiler	*nee*

Ventilatie

ventilatie 1

Ventilatiesysteem

ventilatiesysteem	*A. natuurlijke toevoer en afvoer*
systeemvariant	*A1 standaard*
luchtvolumestroomfactor voor warmte- en koudebehoefte (f_{sys})	*1,24*
correctiefactor regelsysteem voor warmte- en koudebehoefte (f_{reg})	*1,00*

Kenmerken ventilatiesysteem

werkelijk geïnstalleerde ventilatiecapaciteit bekend	*nee*
luchtdichtheidsklasse ventilatiekanalen	*onbekend*

Passieve koeling

max. benutting geïnstal. ventilatiecapaciteit voor koudebehoefte	*ja*
max. benutting geïnstal. spuicapaciteit voor koudebehoefte	*ja*

Aangesloten rekenzones

4b

Koeling

koeling 1

Kenmerken opwekker

type opwekker	*warmtepomp*
toestel / leverancier	*Itho Daalderop WPU 3 (ook bij verwarming kiezen)*
aantal toestellen	*22*
koudebehoefte koelsysteem ($Q_{C;nd}$)	*23.049 MJ*
opwekkingsrendement ($\eta_{C;gen}$)	*64,000*
distributierendement ($\eta_{C;dis}$)	*1,00*

Aangesloten rekenzones

4b

Resultaten

Jaarlijkse hoeveelheid primaire energie voor de energiefunctie		
verwarming (excl. hulpenergie)	$E_{H;P}$	15.266 MJ
hulpenergie		17.761 MJ
warmtapwater (excl. hulpenergie)	$E_{W;P}$	173.414 MJ
hulpenergie		0 MJ
koeling (excl. hulpenergie)	$E_{C;P}$	92[illegible] MJ
hulpenergie		0 MJ
zomercomfort	$E_{SC;P}$	[illegible] MJ
ventilatoren	$E_{V;P}$	0 MJ
verlichting	$E_{L;P}$	[illegible]7.09[illegible] MJ
geëxporteerde elektriciteit	$E_{P;exp;el}$	0 MJ
op eigen perceel opgewekte & verbruikte elektriciteit	$E_{P;pr;us;el}$	0 MJ
in het gebied opgewekte elektriciteit	$E_{P;pr;dei;el}$	0 MJ

Oppervlakten		
totale gebruiksoppervlakte	$A_{g;tot}$	1.673,00 m²
totale verliesoppervlakte	A_{ls}	2.417,81 m²

Elektriciteitsgebruik	
gebouwgebonden installaties	30.865 kWh
niet-gebouwgebonden apparatuur (stelpost)	46.898 kWh
op eigen perceel opgewekte & verbruikte elektriciteit	0 kWh
geëxporteerde electriciteit	0 kWh
TOTAAL	77.763 kWh

CO_2-emissie		
CO_2-emissie	m_{co2}	17.434 kg

Energieprestatie		
specifieke energieprestatie	EP	170 MJ/m²
karakteristiek energiegebruik	E_{Ptot}	284.454 MJ
toelaatbaar karakteristiek energiegebruik	$E_{P;adm;tot;nb}$	405.743 MJ
energieprestatiecoëfficiënt	EPC	0,281 -
energieprestatiecoëfficiënt	EPC	0,29 -

BENG indicatoren	
energiebehoefte	7,9 kWh/m²
primair energiegebruik	34,4 kWh/m²
aandeel hernieuwbare energie	8 %

Uniec 2.2 is gebaseerd op NEN7120;2011 “Energieprestatie van gebouwen” (inclusief het Nader Voorschrift) en NEN 8088-1 “Ventilatie en luchtdoorlatendheid van gebouwen” inclusief alle wettelijk van kracht zijnde correctiebladen.

Alle bovenstaande energiegebruiken zijn genormeerde energiegebruiken gebaseerd op een standaard klimaatjaar en een standaard gebruikersgedrag. Het werkelijke energiegebruik zal afwijken van het genormeerde energiegebruik. Aan de berekende energiegebruiken kunnen geen rechten ontleend worden.