Graduation Report

Building Technologies for Climate Change Adaptation

Case study Rotterdam Rijnhaven

Smart **Urban** Design
Form Follows **Sun** &
Floating **Water** Homes

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Building Technology

01.22.2015

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2nd: Dr. Craig Lee Martin (Sustainable Design)

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Acknowledgement

First of all, I would like to thank my mentors: Ir. J. van der Voort and Dr. C. L. Martin.

Jan van der Voort has been very helpful from the beginning to find the right information and literature. In the early phase of my research I was welcome at the library of his own architectural office. Here I found a lot of information about how to build on water and got inspired. I want to thank him for this warm welcome and all his useful tips and advice during my whole graduation study period.

Craig Martin had exactly the open-minded and futuristic view I was looking for to reflect my own ideas with. His future perspectives and sustainability approach, not only on buildings but also on the way of life, was of great value in my project.

Both mentors gave me valuable input and feedback for my research, each from their own points of view, to get the best out of this project, even when this implied intense discussions. After all I am thankful for these moments, because they improved the process and eventually the product.

I would also like to thank Duzan Doepel who gave me the opportunity to work on a real urban project for my case study on the Rijnhaven. For more than two months I felt more then welcome at DoepelStrijkers architecten office in Rotterdam. The products we made were very useful for the both of us. I feel lucky for this unique possibility and the urban plan I could use as realistic starting point for my MSc research.

Therefore, I would like to thank all at DoepelStrijkers architecten who I have been in contact with. I have been able to talk and discuss with them about the urban plan and exchange ideas. All showed their interest and support in this research, which gave me extra motivation.

Especially, I would like to thank Chris Zevenbergen, Professor of Flood Resilience of Urban Systems, working at Clean Tech Delta and at UNESCO-IHE. He has provided me with a lot of information about the harbors of Rotterdam. He also brought me in contact with Duzan Doepel where I got the opportunity to work on an urban plan during my internship.

Additionally, I would like to thank Lex Keuning, Associate Professor at the TU Delft faculty of maritime engineering (3ME) for his valuable advice on the stability and hydrostatics of my design, who concluded that the floating house is extremely stable and easily meets the safety requirements of obliquity.

One other company I would like to mention and thank is ABC Arkebouw in Urk. Mr. Willem Visser working for ABC provided me with very useful feedback on the specification of the floating concrete box they make as a company.

Finally, I would like to thank my parents for their financial and moral support throughout my whole study period.

Preface/Motivation

Many countries like the Netherlands, are dealing with the major problem of a higher water level than the ground level. This means technology is needed to make living possible. Building against the principles of nature goes along with lots of complications and risks. Floating construction, which can be an answer to this problem, is still under development. Although the technique is already available, there are not yet a lot of floating buildings in practice.

Floating development is a growing market, because there is a great need to become climate adaptive. Flood risk is a huge problem, not only in Western countries, but especially in much more poor countries like India, Bangladesh and China. Before implementing those plans at a larger scale, it seem wise to explore it first at a much smaller scale within a well known environment and context.

The floating housing business is coming up but research shows that it is not the technology why it has not been taken to the next level. So what is it? Why is it not coming off the ground (yet)? In my research I found that the benefits of floating development is not clear to all parties. They are still questioning the safety, feasibility, costs and social aspects. It will be of great importance to convince them on all aspects.

Designing energy-efficient houses floating in the middle of the city should convince all parties of its potential success. Briefly stated: the owners have lower energy bills, the municipality becomes climate adaptive, and the city obtains world leader fame, which can cause tourism and media attention.

This is why I want to graduate on this topic. I see lots of potential in floating housing development and have personal fascination in finding innovative solutions for complex urban situations.

Table of Content

01

Fig. 1

(http://www.rssefsun.com/wp-content/uploads/2009/12/global-warning.jpg)

Introduction

Oude-Tonge, Netherlands, Jan 1953

Bosten, USA, June 2008

Bangkok, Thailand, July 2011

01.Introduction

Fig. 1.2.1

Water-noodsramp in Netherlands in 1953.The dikes collapsed and many people died. (http://upload.wikimedia.org/wikipedia/commons/8/82/Waters-noodramp_1953.jpg

Fig. 1.2.2

Bosten recently hit by floods. (http://cache.boston.com/universal/site_graphics/blogs/bigpicture/iowa_06_17/iowa7.jpg)

Fig. 1.2.3

Bangkok totally flood in 2011(http://en.wikipedia.org/wiki/2011_Thailand_floods#mediaviewer /File:Helicopter_survey_of_flooding_in_suburban_Greater_Bangkok,_22_October_2011.jpg)

1.1 Building Technology track

This report contains the graduation research results of me, Loran Mynett, student of the Faculty of Architecture at the TU Delft. The master track I followed during my graduation was "Building Technology" which mainly focuses on the technical aspects of a design.

Climate-, construction- and facade design are the three graduation options within the Building Technology track and one of them should be chosen for further elaboration. Although a good integration of those three is essential for a good design, I chose to follow the climate design track, but addressed the other aspects in my design as well.

A building technology student is required to focus on innovative technical solutions where technical aspects are well elaborated. After all, the student becomes a climate-, construction- or facade designer instead of an architect. But with a BSc in architecture, I developed the basic skills of understanding the architect as well as the engineer.

The architectural side will attend the urban context and formulate a problem statement, while the engineering side will attend the context of technical innovations supported by the rationality of the engineer. A personal fascination is added in both contexts.

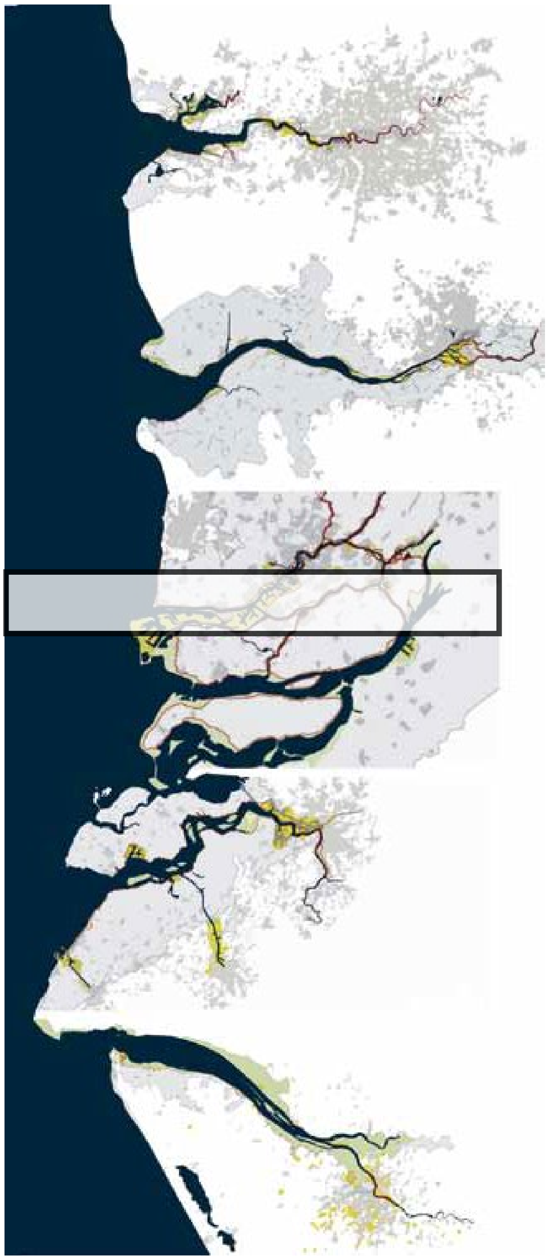
1.2 Problem statement

Climate change forces reconsidering the way we live nowadays. How we use the planet as an inexhaustible source, how we irreversibly destroy parts of nature and how we try to safely build homes on the same planet. Areas at or below sea level that are not protected by dikes are flood prone and need more attention to become flood resilient.

For harbor cities those areas are often located near the center of the city where the old city harbors are located which provides an appealing location for new buildings. Although building outside dikes brings a complex situation with lots of needs and requirements to be analyzed from all different angles that have to be made clearly visible and taken care of before such development can take place.

A problem that is already been taken care of is the area enclosed by the dike. The dikes of the Netherlands are known to be the safest dikes of the world. There is actually not so much to be concerned about if we are talking about the area enclosed by the dikes. There is only one problem: if somewhere the dike breaks and there are no compartments, then everything will be flooded.

The area outside the dike is not protected against extreme conditions and will flood over a period of time. Rotterdam wants to use these old harbor locations for new development, and a better results will be achieved if there is a possibility to build on water in an adaptive way. Cities or countries that can deal with the problems of flooding and develop buildings that are climate adaptive to deal with water fluctuations and rising water levels, have a global potential.




2008 - 2030
1960 - 1970
1400 - 1800
1906 - 1922
1929 - 1949
1800 - 1900
1970 - 2008
1948 - 1957
1934 - 1946
42 kilometers

Fig. 1.4.1

Harboars located nearby the sea and are expanding towards the sea. (Hoogheemraadschap van Delfland)

Fig. 1.4.2

The Harbour of Rotterdam showing the expanding over the years. (http://www.heavylift-news.com/shipping/offshore-projects--choose-port-of-rotterdam-)

1.3 Relevance

First, the social relevance of this research lies in improving the livability of old harbors in cities where industry disappears and flood risks are possible. In our current building development we see that buildings can float, go with the water in a dynamic landscape, and find more possibilities to become water adaptive. Also, the density of our cities is getting higher due to higher ground prices and the amount of free land to build on is getting less. Moreover, the more ground is paved or hardened, the bigger becomes the water drainage problem in the city.
Water needs space – if that is not available, problems arise. Building water provides space for both water and buildings.

The city landscape undergoes a transformation of hardening. This has consequences for the rainwater drainage system: less green means less delay for draining the water. This results in an obstruction because the drainage systems cannot handle al the water at the same time, which can give lots of troubles on the long term. To prevent this from happening, green has to be implemented in the city, for example on the roofs to slow down the water and provide a more gradual de-watering. But a much better solution can be found in increasing the space for water in the city

The harbors of Rotterdam located nearby the heart of the city provide a great location for residential development, but first care has to be taken of the water fluctuations. Outside the dikes, the water is free to go and is liable to flooding. To use this space effectively, one has to build in a climate adaptive way. If this can be achieved, Rotterdam can proudly say to be the first water adaptive city in the world and can become the world leader in floating development.

1.4 Research questions

The overarching research question in this study is:

"How can we transform old harbors with high flood risk into a climate adaptive urban design with energy efficient housing?"

Sub research questions are:

"What are the complexities for the case study Rijnhaven?"

"How can these be addressed in a sustainable way?"

"What does this imply for the predesign?"

"What are the design considerations?"

"How can the sun influence the design to become as energy-efficient as possible?"

"How can buildings be made climate adaptive?"

02

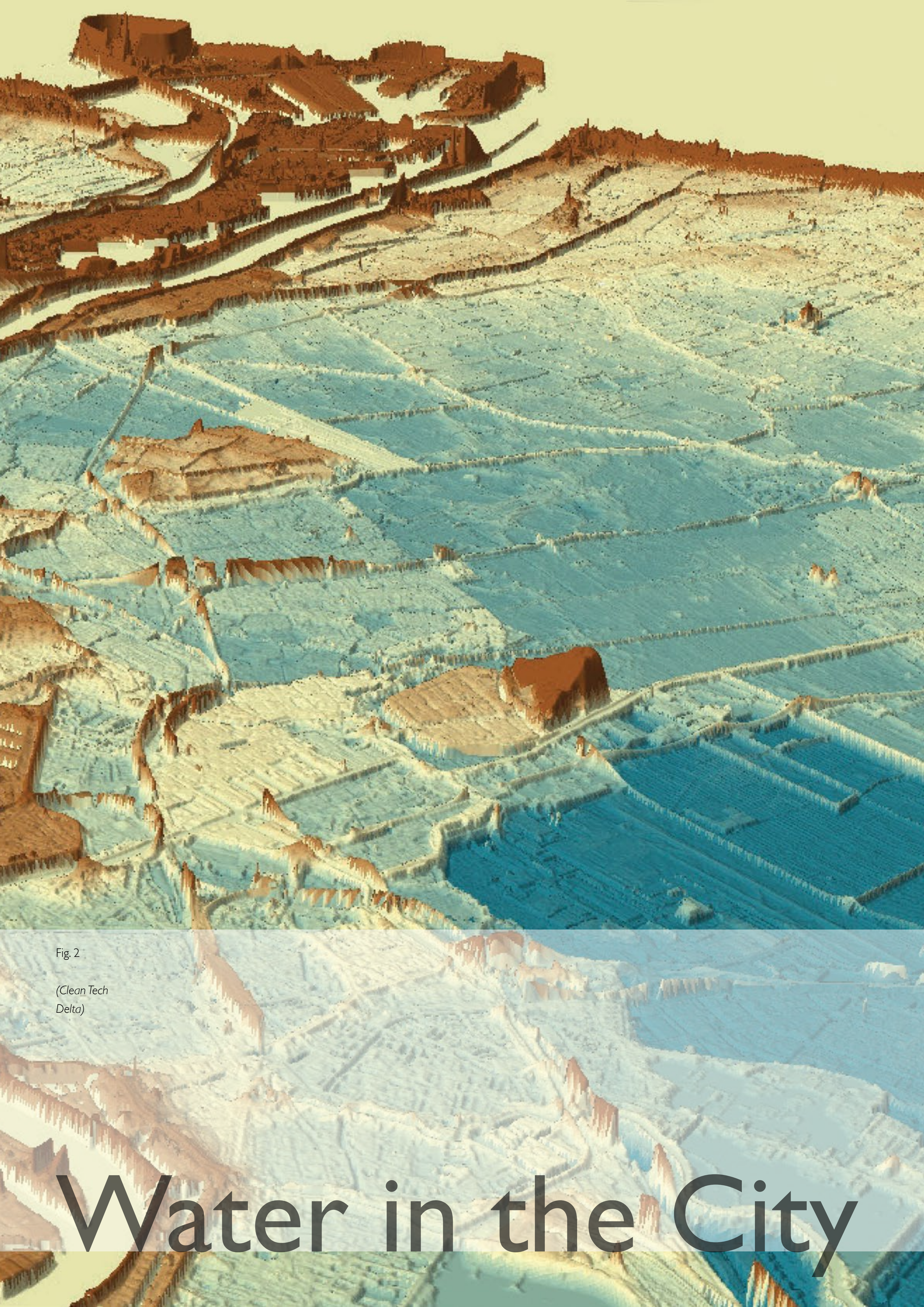
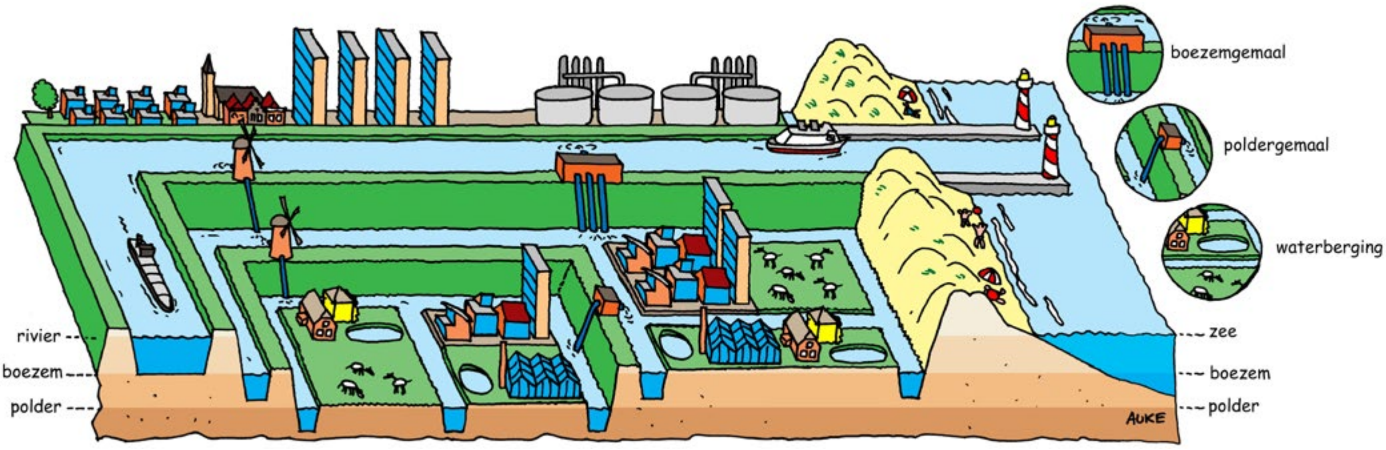


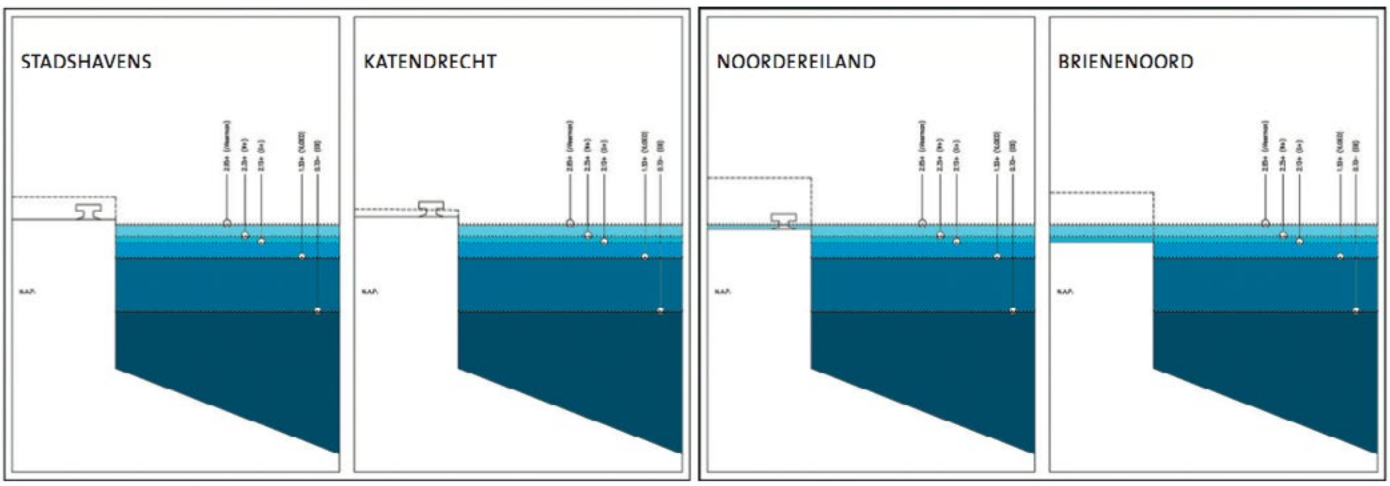
Fig. 2

(Clean Tech Delta)

Water in the City


boezemgemaal
poldergemaal
waterberging
rivier
boezem
polder
zee
boezem
polder
AUKE


Flooding event
(recurrence in years)
100
1,000
10,000
50,000


STADSHAVENS
KATENDRECHT
NOORDEREILAND
BRIENENOORD

02. Water in the City

Fig. 2.1.1

The extremely complex waterregulation system of holland (Hoogheemraadschap van Delfland)

Fig. 2.1.2

Map is trying to illustrate the flooding events recurrences in years (Rotterdam adaptive)

Fig. 2.1.3

A vertical drawing which indicates the flooding at different water levels. (Rotterdamse Stadshavens)

2.1 Purpose change

Water in the city is a hot topic that started in 2000 with a first 'water plan' made by and for the city of Rotterdam. This plan has been enlarged to futuristic city visions, received interests from different parties and developed into a drive to become the world leader on floating development. Water in the city can be experienced as good or bad. "Nowadays water in the city is seen as an opportunity", says John Jacobs, senior counselor in the Rotterdam climate proof development.

Originally the purpose of water in the city was not only to have dry feet, but most of all to be used for traffic and trading aspects. This is why there are beautiful big houses next to the water in big cities. Between the 15th and 19th century most of the cities developed by means of the construction of water structures. Soon it became that clear it was not that easy to regulate the water in a controlled way.

Since the second half of the 19th century the relationship between water and the city had a drastic change. Clean drinking water was supplied with pipes, dirty water was drained by a sewage system, rainwater had its own drainage system and trading was done more and more over land, especially because of the upcoming trains and cars.

Nowadays the purpose of water in the city has changed again. Not so long ago they tried to put all the water systems as much as possible out of sight, just pretending it had never been there and nobody is using it or suffers from it, but now water comes more and more back in sight. The three main factors leading to this change are:

1. Revaluation
2. Climate change
3. Social changes

2.2 Multifunctional water

There are five different kinds of water that occur in the city; drinking-, sewage-, ground-, surface-, and rain water. Each water flow needs a certain amount of space or storage and this influences the urban design. To design the water and include it into the design process, one needs to find a way that provides grip on the design aspects of it. This can be achieved by determining a certain hierarchy. In this hierarchy the people who design with water have some handle to form it into the design.

The hierarchy often is
1. safety first
2. pass the water on
3. water flows from clean to dirty
4. make water fun
5. build in a water aware way

The vertical drawing of a plan has more information and gives more views about the consequences and form than a horizontal plan can tell. However in practice you see almost only maps on which have been put lots of effort and time into and there is barely a cross section of the area. Although this is the only drawing where you can see the dynamic aspects of water fluctuations in certain areas.

There are different aspects that can be clearly seen in a cross section:
a. Normal water fluctuations
b. Waves and wind actions
c. Variation in level under normative conditions (1/10 – 1/100 year)
d. Variation in level under extreme conditions (1/1250 – 1/10,000 year)

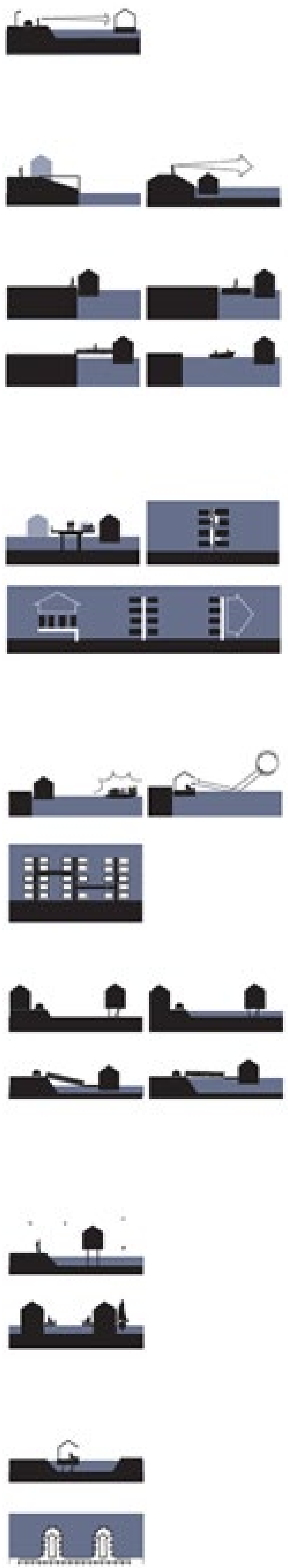


Fig. 2.3.1

Illustrations of different basic principles when building on water.
(Amphibios housing)

2.3 Urban basic principles

Water-based living is different from living on land at every level of planning. Designs can only be successful if all aspects are taken into account. The most significant urban principles are routing, privacy, positioning and water level.

Routing

Normal streets have no dead ends and provide routing for anyone. Jetties give, just like streets with dead ends, no reason for people to enter which automatically transforms this space to semi-private. Cross-connections or public functions can be used for lifting the barrier to set foot on the jetty

Privacy

In water housing designs water is mostly labeled as public. Which can give problems if the view is shared with private and public spaces. This means that from the public area one can easily watch the private living space. Distance is one of the options to avoid this problem. Also placing obstacles in the water can be used as a barrier.

Positioning

The relationship between a house and the bank of the water can be categorized into three groups: (i) the house partly on land; (ii) the house on a bank at the edge of land and water; and (iii) the house in the water. A small space between land and property in combination with a clear view on the water around the house is sufficient enough for the house to be perceived as a water house. When the distance increases it becomes clear it is a full water house so the water experience increases.

Water level

Fluctuations in water level can have a major impact on how water houses relate to the water. When the water level is constant, the building can be placed close to the water, making it a safe and above all aesthetic environmental feature. When the water level fluctuates, special measures need to be taken.


ROTTERDAM.


HISTORISCH BEELD RIJNHAVEN

Fig. 2.3.1

Old map of Rotterdam where water was used for trading aspects.

Fig. 2.3.2

Historical view of the Rijnhaven (Drijvend Ontwikkelen)

Fig. 2.3.3

Historical view of the Wilhelminapier (Drijvend Ontwikkelen)

Fig. 2.3.4

Historical view of the harbor industrial area (Drijvend Ontwikkelen)

Fig. 2.3.5

Historical view of Katendrecht (Drijvend Ontwikkelen)

2.4 Revaluation

In the beginning of the '90s a transformation started in abandoned old harbors, from empty spaces to beautiful waterfronts. People have a preference for water, which opens a market for new residences in old harbors.

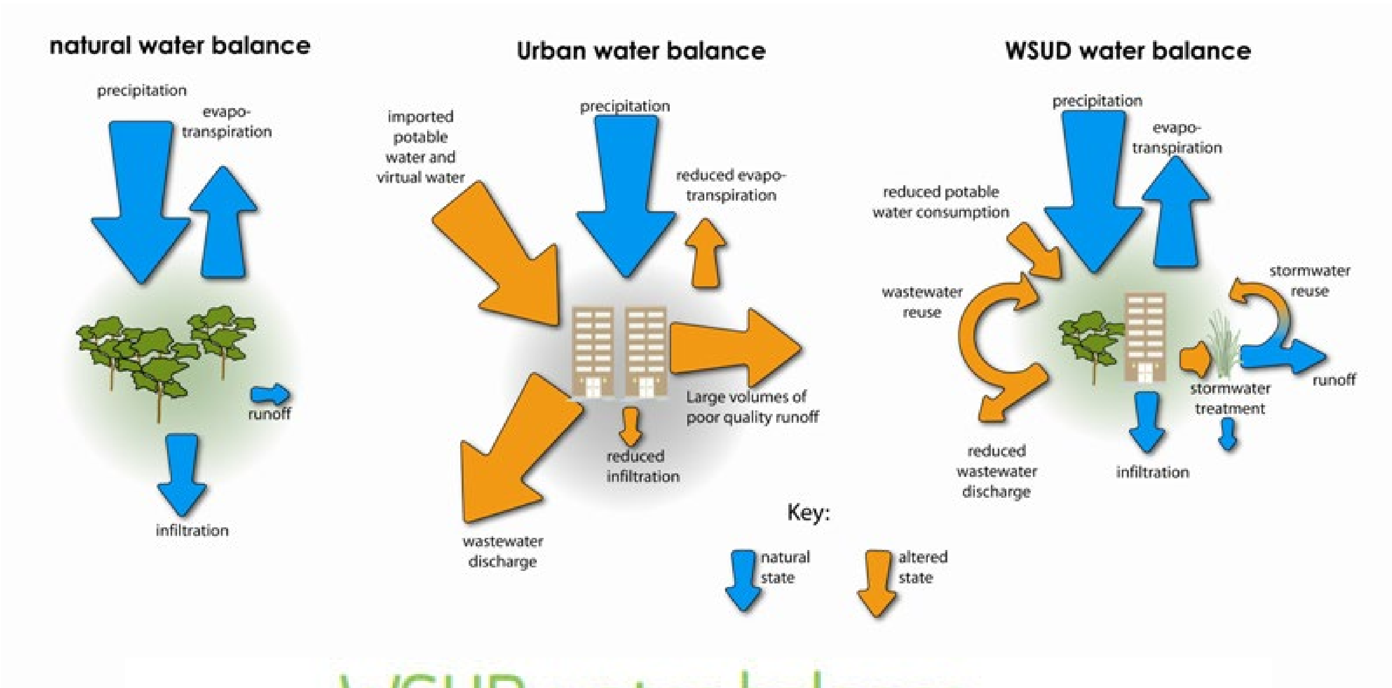
The cultural revaluation of waterfronts was already taking place from around the '70s as resistance against the monotonic urban design from the years before. Water lost its utilitarian role and was being used in a way to add identity to the city.

Water in the urban center brings back the characteristic look of how it was in the first place. The present use of it in an urban design is mainly to support for esthetical reasons.

Not only climate change forces the city to adapt to water, but nowadays the old historical view of the city filled with water is hot in real estate development. Most of the cities exist because there was water in the first place, used for trading.

Back in the '60s when the car industry came up, most of the canals were filled to build new roads. If old canals are excavated again, this is because of esthetic reasons instead of practical or functional reasons.

Social changes caused the faith in the government are becoming less. The market on the other hand is getting more powerful and wants to determine the place and function of water as well. This changes the responsibility and a shift to 'the one who pays determines'. Partly because of the financial crises we deal with nowadays, there is a lack of courage to spend money on innovative projects, certainly when changes are aesthetic.


natural water balance
precipitation
evapo-transpiration
runoff
infiltration
Urban water balance
imported potable water and virtual water
precipitation
reduced evapo-transpiration
Large volumes of poor quality runoff
reduced infiltration
wastewater discharge
WSUD water balance
precipitation
evapo-transpiration
reduced potable water consumption
wastewater reuse
stormwater reuse
runoff
stormwater treatment
infiltration
reduced wastewater discharge
Key:
natural state
altered state

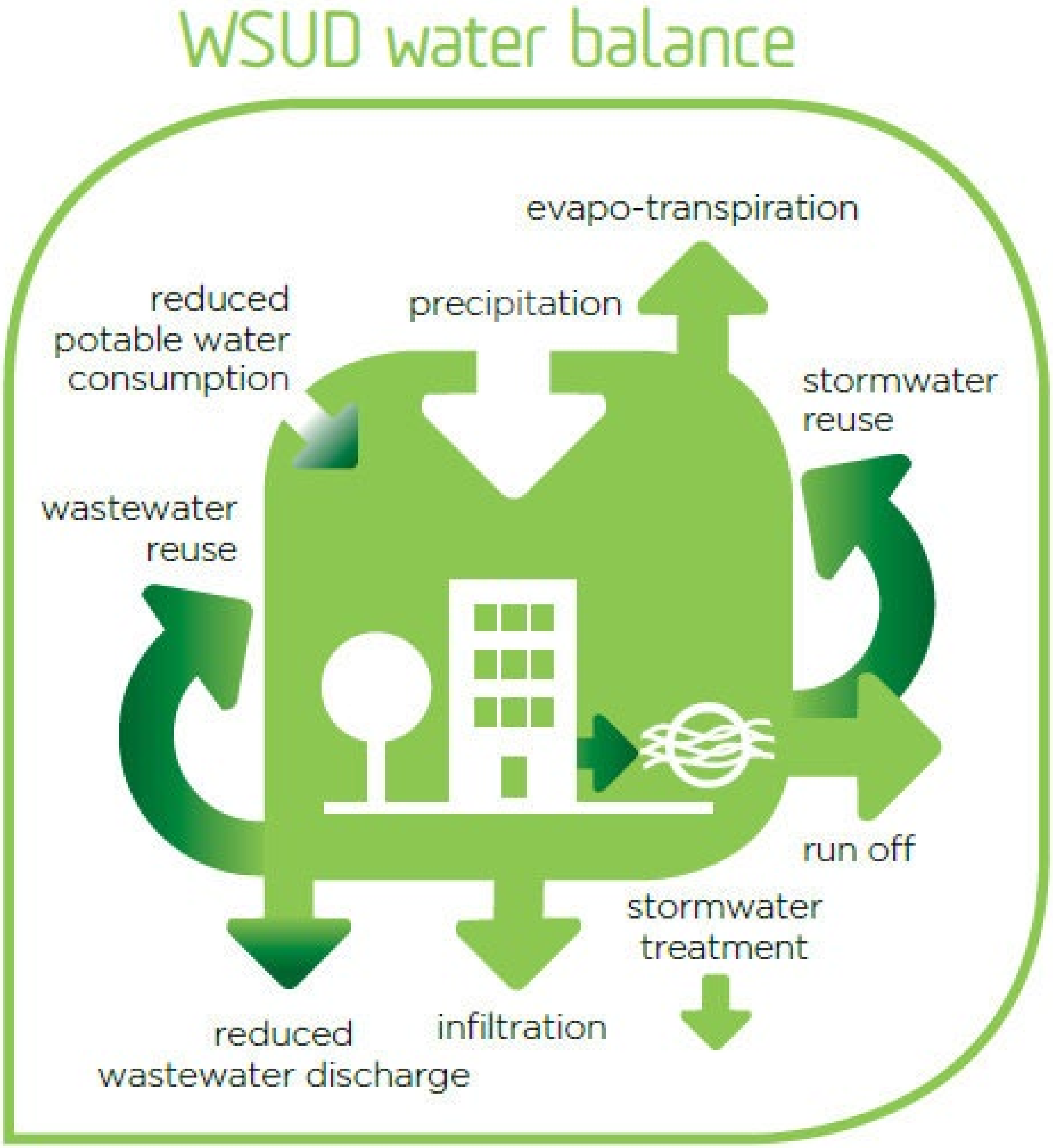

WSUD water balance
evapo-transpiration
reduced potable water consumption
precipitation
stormwater reuse
wastewater reuse
run off
stormwater treatment
reduced wastewater discharge
infiltration

Fig. 2.5.1

Illustration of the water cycles in a natural, urban and WSUD way. (WSUD)

Fig. 2.5.2

The WSUD water balance illustrated/ Arrows going back stands for reuse, down are going into the ground and up into the air.(WSUD)

2.5 Water Sensitive Urban Design

WSUD is a land planning and engineering design approach that integrates the urban water cycle, including stormwater, groundwater and wastewater management and water supply, into the urban design to minimise environmental degradation and improve aesthetic and recreational appeal

Principles

- Protecting and enhancing creeks, rivers and wetlands within urban environments;

- Protecting and improving the water quality of water draining from urban environments into creeks, rivers and wetlands;

- Restoring the urban water balance by maximising the reuse of stormwater, recycled water and grey water;

- Conserving water resources through reuse and system efficiency.

Objectives

- Reducing potable water demand through demand and supply side water management;

- Incorporating the use of water efficient appliances and fittings;

- Adopting a fit-for-purpose approach to the use of potential alternative sources of water such as rainwater;

- Minimising wastewater generation and treatment of wastewater to a standard suitable for effluent reuse and/or release to receiving waters;

- Treating stormwater to meet water quality objectives for reuse and/or discharge by capturing sediments, pollution and nutrients through the retention and slow release of stormwater;

- Improving waterway health through restoring or preserving the natural hydrological regime of catchments through treatment and reuse technologies;

- Improving aesthetics and the connection with water for urban inhabitants.

Techniques

- The use of water-efficient appliances to reduce potable water use;

- Greywater reuse as an alternate source of water to conserve potable supplies;

- Detention, rather than rapid conveyance, of stormwater;

- Reuse, storage and infiltration of stormwater, instead of drainage system augmentation;

- Use of vegetation for stormwater filtering purposes;

- Water efficient landscaping to reduce potable water consumption;

- Protection of water-related environmental, recreational and cultural values by minimising the ecological footprint of a project associated with providing supply, wastewater and stormwater services.


DRIJVENDE STAD, ROYAL HASKONING DELTACOMPETITION, DELTASYNC

Fig. 2.6

Futuristic plan of Royal Haskon-ing, winner in 2006 (Drijvend Ontwikkelen)

2.6 Innovative

Climate adaptive living is the solution to the risk of flooding. Floating houses are an adaptive way to deal with climate change. Especially countries that deal with floods can save a lot of money that damage can give. From an economical perspective it is interesting for countries with higher flood risks like China, India or Bangladesh.

Developing floating houses inside a dike ring has little to do with water safety. The only thing achieved here is the area for water storage and the multiple land use, which is a good thing.

Although living on water was much appreciated in Lelystad, they had to re-make the water first, and then build on top of it. Apparently water is just as feasible as land, to make the Netherlands.

Rutger de Graaf, co-founder of DeltaSync is convinced our future is on the water. In 2006 he won the Royal Haskoning Award with his futuristic plan of a floating city for 20.000 people on the IJmeer as location.

Floating development goes further than only providing residential areas. "Currently we are working on a mobile utility unit. If there is no more navel cord necessary to the main land, cities can be completely autonomous, which is the beginning of a floating self-sufficient city."

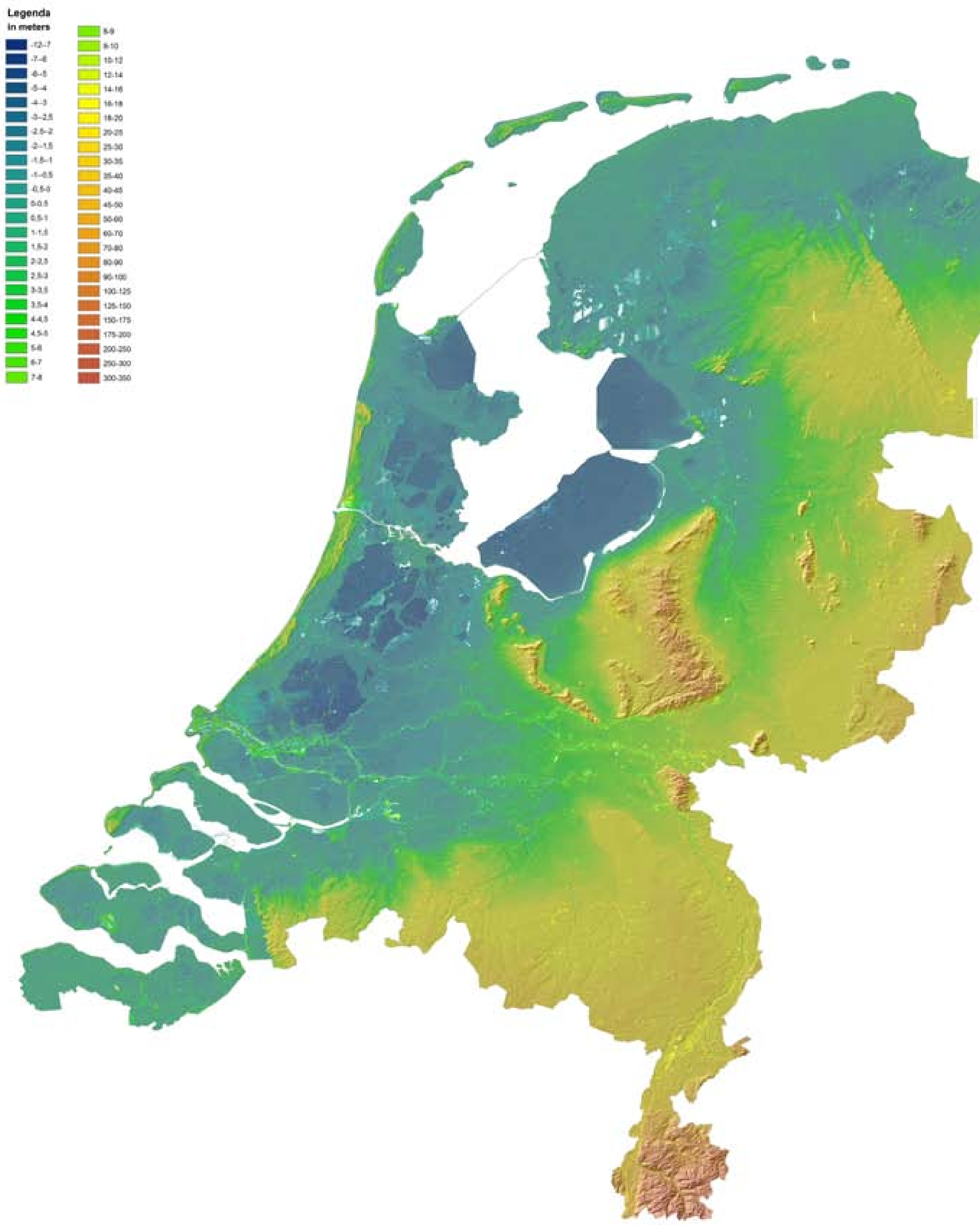
City apps are the future according to Koen Olthuis, founder of waterstudios.nl. Different parts can be moved elsewhere if they are no longer needed on a certain spot. Shipping houses, agriculture, infrastructure or power plants make them more sustainable.

03

Fig. 3

(Rotterdam Climate Adaptice)

Stakeholder views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in meters
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-6–-5
-5–-4
-4–-3
-3–-2,5
-2,5–-2
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-1,5–-1
-1–-0,5
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0-0,5
0,5-1
1-1,5
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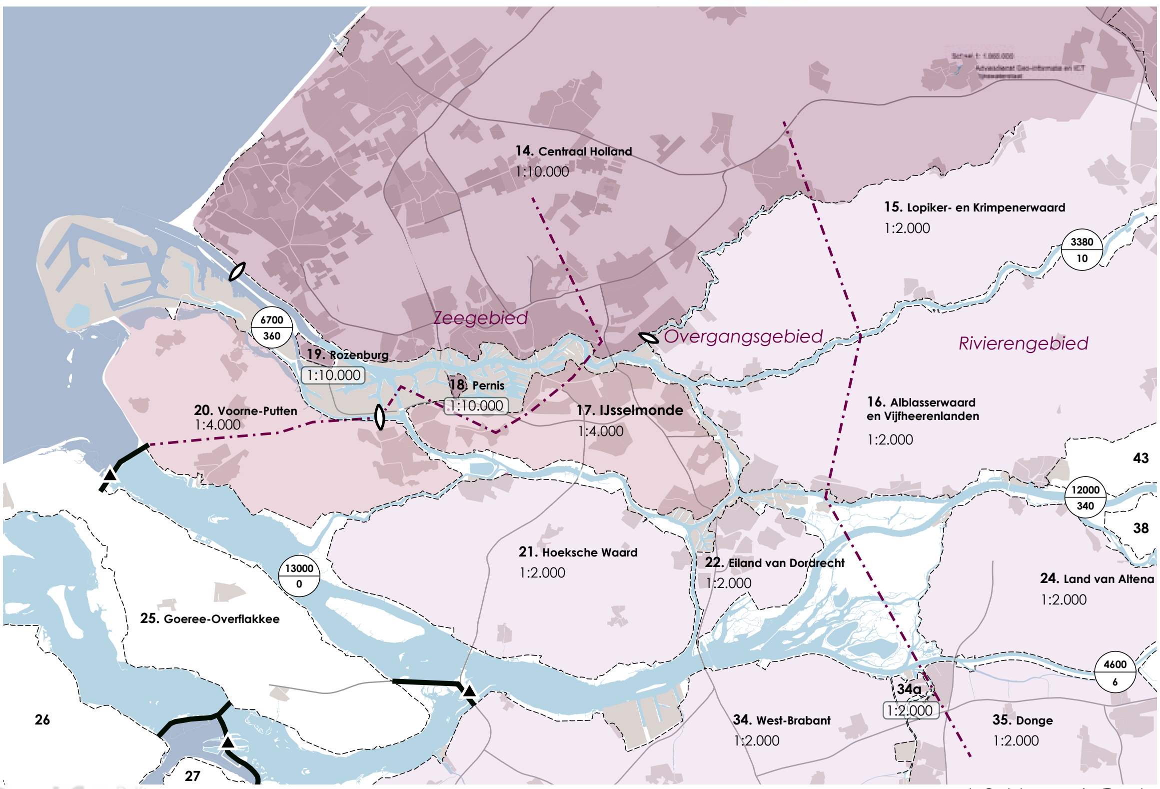
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15. Lopiker- en Krimpenerwaard
1:2.000
3380
10
6700
360
Zeegebied
Overgangsgebied
Rivierengebied
19. Rozenburg
1:10.000
18. Pernis
1:10.000
20. Voorne-Putten
1:4.000
17. IJsselmonde
1:4.000
16. Alblasserwaard
en Vijfheerenlanden
1:2.000
43
12000
340
38
13000
0
21. Hoeksche Waard
1:2.000
22. Eiland van Dordrecht
1:2.000
24. Land van Altena
1:2.000
25. Goeree-Overflakkee
4600
6
34a
1:2.000
26
34. West-Brabant
1:2.000
35. Donge
1:2.000
27

03.Stakeholder views

Fig. 3.1.1

Depthcard of the Netherlands. Clearly shows two third part of the country is originally under sea level. (Rijksoverheid Illustration)

Fig. 3.1.2

The Randstad with the flood risk departed in different divisions (Rijksoverheid Illustration)

3.1 Consciousness

The Dutch people feel very safe about their living conditions and the chance there will be a flood. This is the outcome of research done in 2010 by Altera of Wageningen University. Although 87% feels safe, feelings are mostly based on ignorance. Some 68% underestimates what the water level will be like in case of flooding, and more than 25% thinks their house can not be flooded. Fortunately 56% admits not to be prepared well if there will be a flood, while 76% thinks waterlogging and flooding will appear more and more.

It is more than logic people are not well prepared for flooding if they never experienced a flood in real life. Until the dikes flood, it is very hard for a layman to say how safe we are for floods. It is all managed by the government, which is why people don't feel responsible themselves. This is in huge contrast with for example the United States, where people are prepared to recover as soon as possible after a flood.

The world risk report of the United Nations concluded that Holland is first of all European countries concerning the risk of a natural disaster. The question if Holland is safe is not easy to answer. Two third of the population lives below sea level. Even if the safety requirements are from almost 50 years ago, they are still very high, the highest of the world, which is why we are relatively more safe than other countries.

We do have really safe dike systems, with a safety factor of 1/10,000 years for sea dikes, but if they brake, there is not always a second compartment. There is a law that prescribes that all dikes and dams have to be tested every five years, but this generally does not happen. There is money coming in on a regular basis for maintenance, but the costs are 2,5 times more expensive than the incoming amount and therefore there is a shortage. Although we have a well working network of infrastructure and communication, the most concentrated populated country of Europe does not have a national evacuation plan.

3.2 Water lives

There are four types of ways to live on the water, which can be coupled to four location typologies.

1) Free living on high pile houses to deal with fluctuations; in particular in "flood plane" locations, with appreciation for nature and preference for detached houses to maximize nature experience. No preference for floating or pile houses. This group is often modern orientated and focused on the material and view of the house.

2) Free living with on low pile houses and fluctuations: in particular in polder locations. This group likes to have a small closed community like a village which provides a certain comfort, safety, shared and supervised public spaces.

3) Urban living: in urban water zones as location. Mainly young people between 18 and 34 year, earning 2,5 times the average with a desire to live in an urban context with lots of facilities and a large living area with an exclusive character.

4) Active water living; a recreation area full of water as a location. Extremely exclusive is what this group is looking for with a well-regulated accessibility where they can make a lot of fun and enjoy the water every day in an active way.


floating quarter
show city
floating city
enjoy work
enjoy work

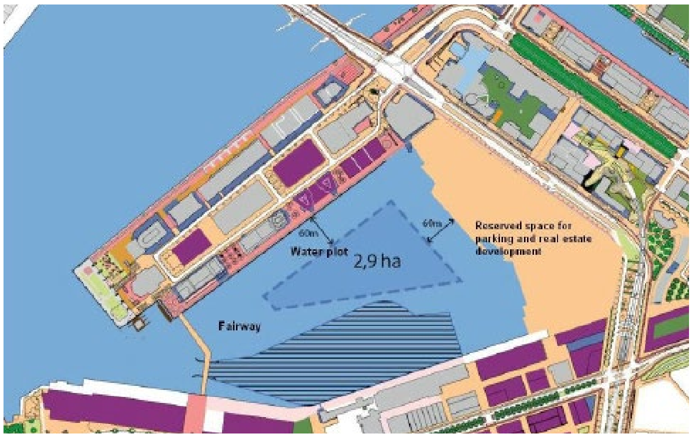

Water plot
2,9 ha
Reserved space for parking and real estate development
Fairway

Fig. 3.3.1

Futuristic impression of the Wilhelmina pier of rotterdam. (Rotterdam climate proof)

Fig. 3.3.2

Schematic illustrated where the potentials are of the stadshavens Rotterdam (Drijvend Ontwikkelen)

Fig. 3.3.3

Program of rotterdam filled in the rijnhaven (Drijvend Ontwikkelen)

3.3 Vision Rotterdam

Since 2010, Rotterdam continues to work on climate proofing the city. The plans are predominantly aimed at the realization of additional water storage, such as green roofs and water plazas.

It is not yet clear exactly what the impact of climate change on Rotterdam will be, which is why Rotterdam will need to invest in further research. At the same time, as a result of the combination of implementation and research, Rotterdam is successfully branded as an innovative water management and climate city.

In the period between 2011 and 2014, Rotterdam has proceeded along the same line, continuing to emphasize the implementation and realization of innovative projects in the city. In doing so, it took into account the results of research focused on the themes of flood risks, scenarios for flood management and accessibility of the city and port, optimization of the urban water system, adaptive building, and the urban climate.

New delta plans for Rotterdam will secure Rotterdam's position as a leading city in the area of intelligent water management and in the direction and coordination of the efforts to climate proof a delta city. Also the spatial plans will be climate proof as of 2012, and other climate adaptation themes will by then have been adequately embedded and incorporated in standing policy and planning procedures.

Even more than before, the emphasis will be on the economic spin-off as a result of the image Rotterdam has built up as an innovative water management and climate adaptation city.

The international collaboration with other delta cities is definitely gaining momentum. The Rotterdam approach plays an important role in the demand and supply concerning water management and delta technology. This will lead to growth for the regional and national water sector.

An important milestone in 2012 was the opening of the national water center in Rotterdam, concurrently with the nationwide Dutch Delta Design event to position the Netherlands even stronger as the water nation all over the world. Rotterdam will take up a central position in this respect. For this reason, both the start and the conclusion of this Dutch Delta Design process event will take place in Rotterdam. This way, Rotterdam demonstrates that climate change offers opportunities for an attractive and economically strong city (from "Rotterdam Climate Adaptation").

Fig. 3.4.1

Futuristic impression of the Wilhelmina pier of rotterdam. (Rotterdam climate proof)

Fig. 3.4.2

Schematic illustrated where the potentials are of the stadshavens Rotterdam (Drijvend Ontwikkelen)

Fig. 3.4.3

Program of rotterdam filled in the rijnhaven (Drijvend Ontwikkelen)

3.4 Potentials

Water is associated with peace, calmness and free sight, which can be seen as qualities. It creates a shelter of personal space around the house and increases the feeling of privacy. The movability of the residents are an advantage because it gives them the flexibility to change location on the long term, simply by shipping the house to an other place. It is also possible to share utilities with other cities, so it does not have to be built separately in each city. In spite of the fact there are a lot more plans for amphibious houses than actually realized, this is a growing market and will grow further until the water and housing problems are resolved in urban areas.

Water adaptation is necessary to regulate all the water in the right directions. A huge different can already be achieved when all the roofs are green. 'Water squares' are an innovative solution for water storage in the city. The enormous amount of water falling down when there is heavy rainfall will temporarily be collected and then gradually released into the drainage system. Besides these water squares for water adaptation, there are several experiments going on for water storage; "de trapdijk" to gain more space with a dike, "dakpark" which combines shops, dike and a park, "City water lounge Rotterdam" and "climate square". "All these may cost a lot but we have to spend money on water anyway, so why not making nice public spaces at the same time" (Florian Boer).

The Netherlands has always dominated the landscape. It decided where developments took place using dikes, pumps and polders. Helped by new techniques we were getting better in dictating the landscape. It will always be an artificial, high maintenance country, but where there are many strict safety rules, new plans are forming a new way of living, closer to nature. A floating high-tech city which goes up and down with the tide but still maintains a comfortable and familiar look.

3.5 Considerations

"You cannot fight water, you have to learn how to live with it", states minister Sybilla Dekker. Her department has arranged a competition for engineers, urban planners and architects to design living accommodation, glasshouses, parking lots and factories that would float and could grow into "waterproof" towns.

Origin

The origin of floating houses can be found in converted ships. After a lot of development and transformation floating houses still have one big difference compared to houses on the mainland. The floating part, also called the substructure, can be made traditionally of concrete, or of foam or even plastics.

Complications

The complications of water like variable water level, tilt, fluctuations and noise which can travel over water without being interrupted, has to be taken into account when designing floating buildings.

Real estate or property

The difference whether a floating house is real estate or property is considerable for both the government as well as for the inhabitant. Requirements, taxes and mortgage applications are different. Another important choice is related to the law, because if the house is able to move, it is movable property and if it is fixed it is real estate.

04

Fig. 4

(Bing Maps)

MACRO

Urban Design

Rijnhaven Rotterdam, Netherlands, 2013

Stadshavens Rotterdam, Netherlands, Bird's eye view

04.Urban Design

Fig. 4.1.1

Top view of the location zoomed in three parts. (Google Maps)

Fig. 4.1.2

Bird's eye view of the casus Rijnhaven Rotteram (Bing Maps)

Introduction

In this design there is a strong integration between the urban plan, architectural desing, and building technology, since those three components are closely linked to each other in this particular case. Starting from the macro scale and pragmatically zooming in on building details at the micro scale, the cohesion between these scales is a major consideration in this design.

4.1 Case study

The new harbor activities of Rotterdam are moving towards the sea (Maasvlakte-2), leaving a lot of possibilities for new developments with the space that will open up. The whole area is more than 1600 ha. (16.000.000 m2) which is the equivalent of 3200 football fields. The Rijnhaven comprises 21 ha thereof.

The Rijnhaven area is located next to the Wilhelmina pier where also Hotel New York is located as well as the Montevideo building and the headquarters of the Port of Rotterdam. Other famous eye catchers are the Erasmus Bridge that connects the south of Rotterdam with downtown. The whole new part of Rotterdam called "Kop van Zuid" is outside the sea protection dike. This includes the Old harbors as well as the Maas-, Waal-, Eem-, and Merwede-Vier harbors. All these harbors are bundled under the name "Stadshavens" of Rotterdam.

This area will be Rotterdam's most important urban expansion with 13.000 new dwellings of which 5.000 will be floating. Floating housing is seen by some as a niche market (e.g. Roland Goetgeluk, researcher at ABF, who is specialized in real-estate housing). Residences on piles or floating homes are not only something for watersport lovers, although big market development is not (yet) responding to such opportunities.

According to John Jacobs this is the wrong way to look at the situation: "skyscrapers are a niche market as well, because they facilitate only a few percent of the population but are still characteristic for the City. And this is what city development is all about in the end. With floating development, Rotterdam has the possibility to distinguish itself from the rest of the world.


BAYARDS
solutions in aluminium


In de Dokhaven wordt gerealiseerd:
AQUA DOCK
Ontwikkelende partners
Gemeente Rotterdam
Mede mogelijk gemaakt door
RDM CAMPUS
Clean Tech Delta
Informatie
www.rdmcampus.nl/aquadock
Participanten
BAYARDS
BELADON
VALORISATIEPROGRAMMA
JULES DOCK
ook dit is
Stadshavens
Rotterdam
WWW.BORDBUSTERS.NL

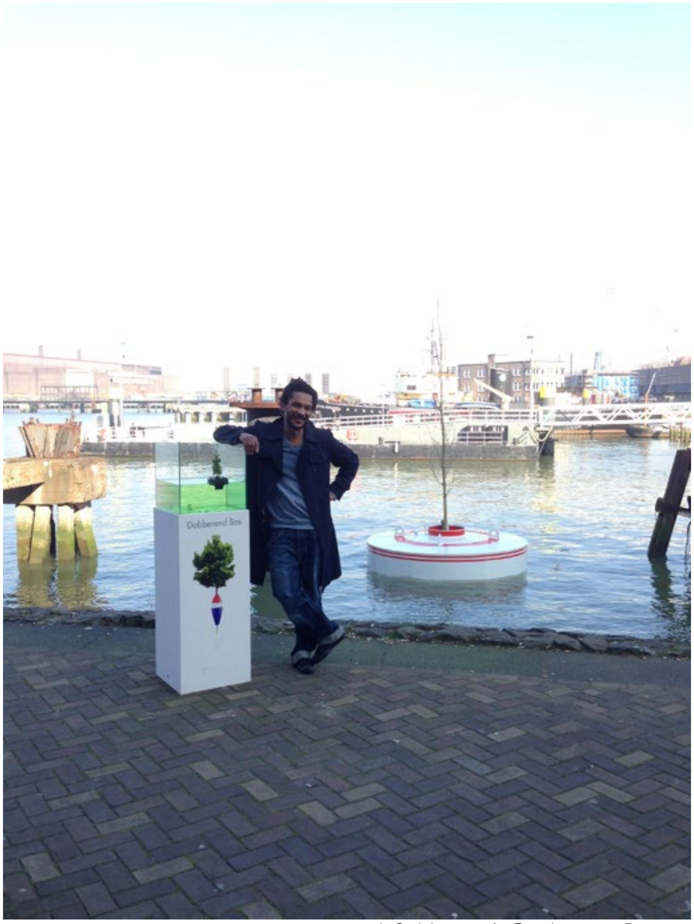


Fig. 4.2.1

(Own Photo)

Fig. 4.2.2

(Own Photo)

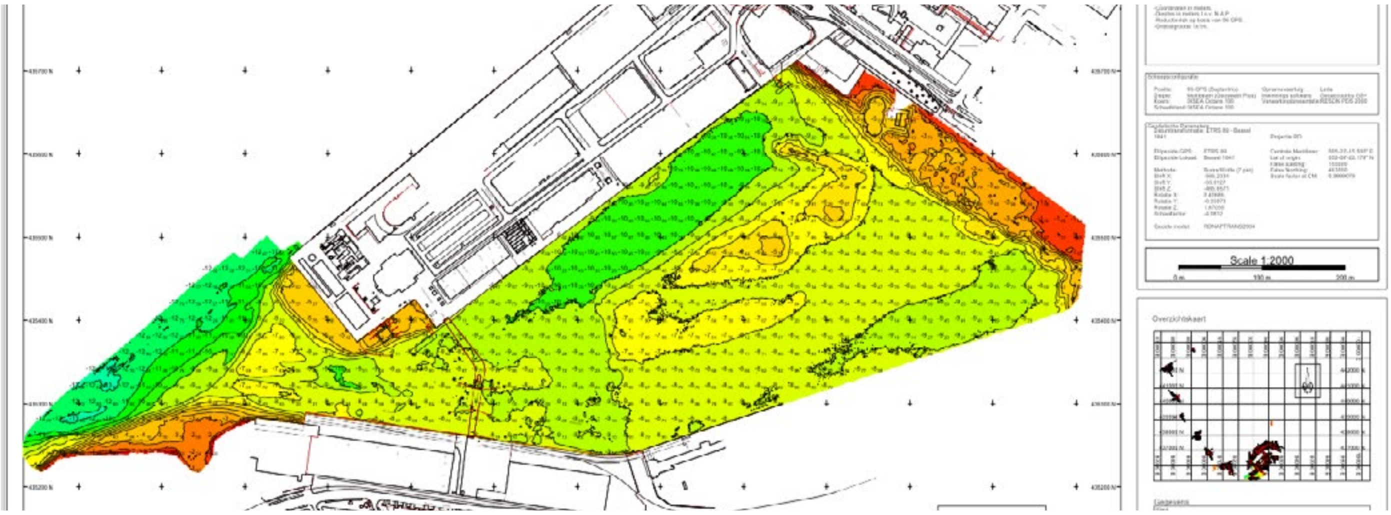
Fig. 4.2.3

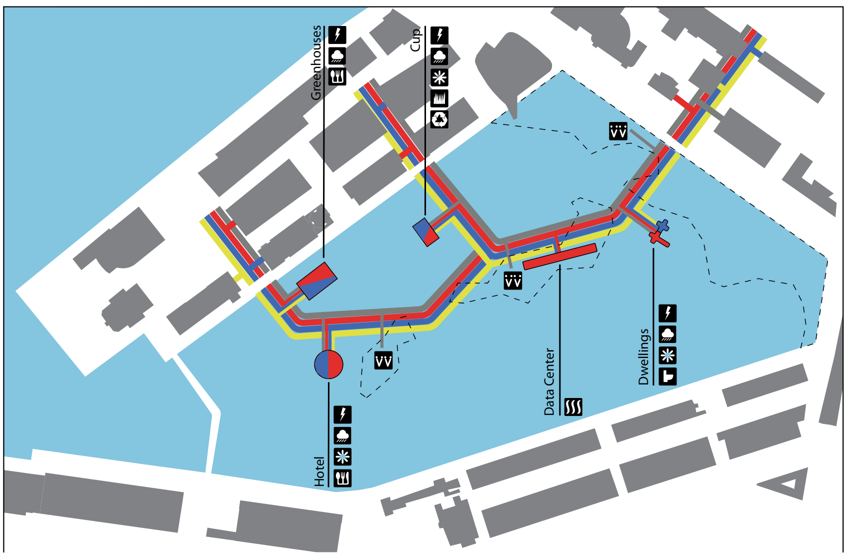
(Own Photo)

4.2 Aquadocks

Amphibious or floating development includes not only floating buildings, also infrastructure and green are important parts of the urban plan which should float. When attending the grand openings of Aquadocks, a project in Rotterdam where they brainstorm, design and gather companies to develop in the future in a floating way.

During this opening I met Tanja Kuiken working at Bayards, a company working on floating infrastructure, with allready a finished prototype. I also met Jorge s student of the Amsterdam Art Academy who was the creater of the floating tree. A tree placed in a big old see buoy could be a solution to make a tree float and is now tested on sea sickness.





Energy	Biobased materials
Knowledge	City bank materials
Recycle	Unemployed people
Wind energie	Solar energy
Roof Water	Rain water reuse
Water fluctuations	Income
Construction	Experienced people
Facades	Flush the toilets
Reed beds	Food

Fig. 4.3.1

Depthmap of the Rijnhaven. Green indicates deeper. (Gemeente Rotterdam)

Fig. 4.3.2

Smart grid of the urban plan, made in coop-eration with DoepeStri-jkers. (Own Ill.)

Fig. 4.3.3

Section of the urban plan made in coop-eration with Doepelstrijk-ers archi-tects. (Own Ill.)

4.3 Internship at Doepelstrijkers

During my internship at DoepelStrijkers architects I contributed to developing an overall plan and looked at particular sections and impressions. The main idea for the Rijnhaven was to create two islands where the harbor was less steep (see color map). Taking note of the natural deepness of the harbor and lifting the parts that were less steep, the natural surface was to be brought above sea level. The islands and the park at the side would be made of extraordinary large flexible GEO-tubes filled with bio trash with a 3 meter wide diameter. With these tubes it will be relative easy to fast create land in the deep Rijnhaven.

In the middle of the Rijnhaven, on the biggest island, a data center is planned which will provide a lot of energy.This data center is placed underground and releases a lot of heat. Using the water of the Rijnhaven to cool this data center and taking the energy out of the warm water will provide an enormous amount of energy that can be used by other buildings or other developments. In this way the area will be self-sufficient and energy-waste and water-circles will be closed. Closing these circles is of great importance in this plan and is very much aligned with the concepts of urban design for the future.

The jetties will provide arteries to the objects or buildings along the jetty. Adding a new component to the plan will change the flows. For example, an urban district needs energy and potable water but can give bio waste materials and collected rainwater in return. Those exchanges contribute to a diversity of the plan.

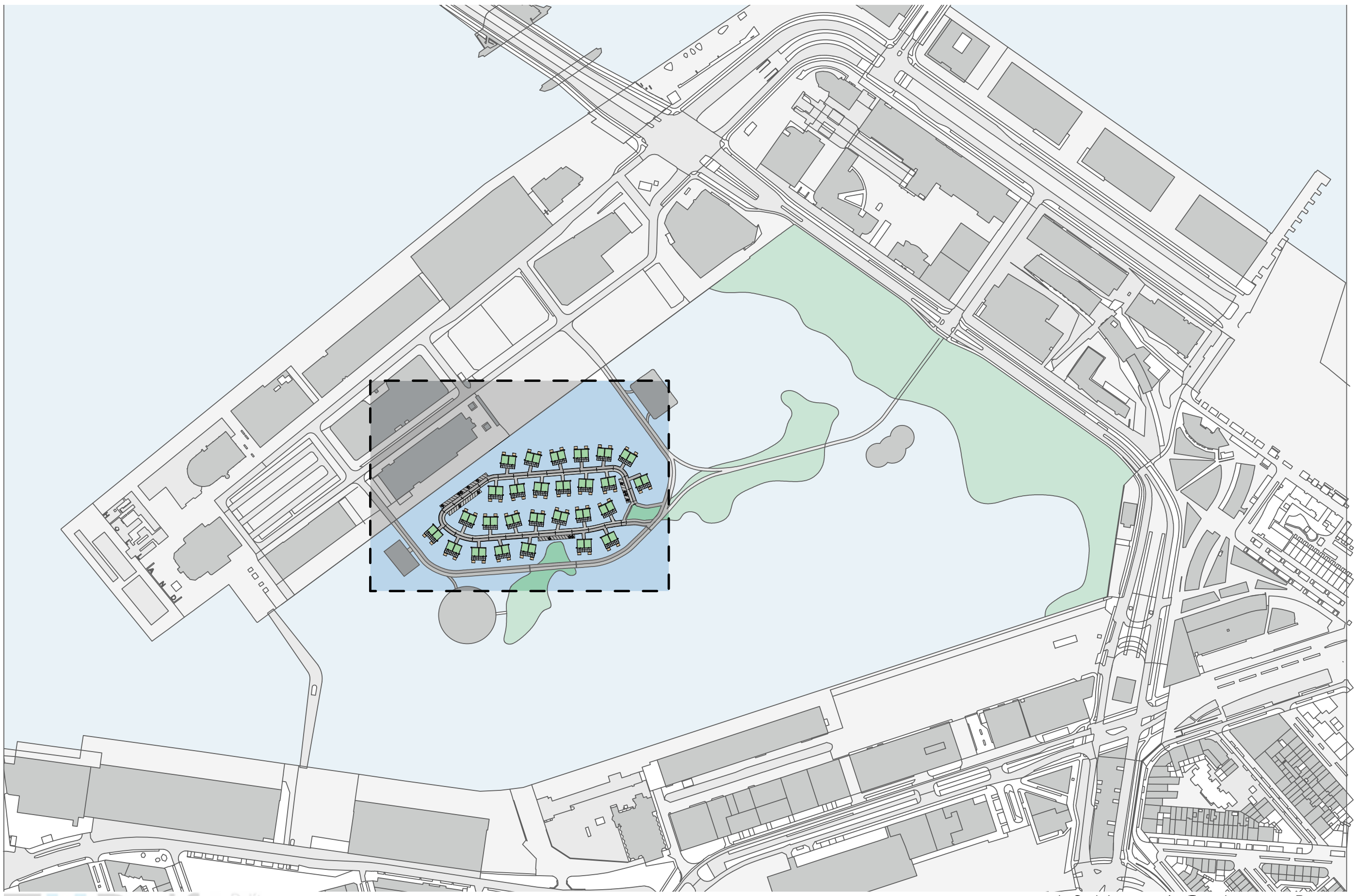


Fig. 4.4.1

Top view of the urban plan made in cooperation with Doepelstrijkers architects. (Own Ill.)

Fig. 4.4.2

Top view of the urban plan (Own Ill.)

4.4 Urban plan

My two months internship at DoepelStrijkers ended when the plan was officially handed in and presented to the municipality of Rotterdam. The agreement was that I worked on the plan without zooming in on a specific area, only to create and develop an urban plan with some different sketches and impressions.

These formed the starting point for my Master of Science research. I had already identified a suitable location (Rijnhaven) and now I also have interpretations of the context in which to design fifty floating houses as agreed after identifying my scientific research scope.

Where I would plan my floating houses was not a difficult choice. On the south side industrial activities are still in progress which use the water as a transport medium and produce noise and odor – this makes the whole south side of the plan not suitable for a new living area.

The north side is adjacent to the Wilhelmina pier, the east side is adjacent to the new park and the west side is a rather small area that misses good connections with the preliminary urban plan. Therefore the zone in the middle at the north side, surrounded by the plan and the islands, would suit as the best option and is also the deepest part of the plan (see selection location in the overall plan).

Fig. 4.5.1

Top view of the urban plan made in cooperation with Doepelstrijkers architects. (Own Ill.)

4.5 Urban principles

From the urbanism point of view, the surroundings of a new plan are most important aspects. Taking good notice of the things that are available on sight can improve the efficiency of the plan considerably. Another benefit of a good urban plan is the life-time. If the plan is flexible to social and technical changes and adaptive to changing circumstances, the life-time will increase which contributes to a sustainable city. When designing the urban plan there were three aspects to classify and prioritize before I could start designing: (i) the jetty-house ratio, (ii) the fire safety and (iii) the parking facilities.

Optimizing jetty-house ratio

Because jetties are relatively expensive this was the first priority to explore: minimizing the number of jetties while on the other hand maximizing the number of houses. Finding an optimum between those two, keeping in mind to retain the fire safety gave the following urban plan. The jetties should be oriented more or less east-west, because the houses would be oriented north-south. Because the drop shadow of the house would be around 15 meters and given the dimensions of the area, two rows were considered to be the most efficient. To avoid dead ends and a two-way road with a turning point at the end, a circular approach was chosen as the best option.

Fire safety

Not only buildings have strict requirements when it comes to fire safety, also an urban plan needs a fire safety plan which includes there are always two ways to escape. When developing housing on water this brings more complicated situations than on land. Connecting the two jetties would create the fire safety for the plan. If there is a fire, people have two ways to escape. Flashover will probably not appear because the houses are at a distance between each of at least 7 meters. The jetties are not designed for big fire trucks since the corners are too sharp to turn, but their water hoses can be connected to a pumping system which provides extinguishing points all around the urban plan. Alternatives to provide fire safety to the plan were (a) fire partitions (which would jeopardize visual esthetics), or (b) escape bridges to the quay (which would be extremely costly).

Fig. 4.5.3

Top view of the urban plan made in cooperation with Doepelstrijkers architects. (Own Ill.)

4.5 Urban principles

Parking

Parking was one of the most important items to take care of in a preliminary stage. Cars need a serious solution and can not be placed somewhere on the quay outside the designed area. This gives three options: (a) a parking place next to the house, (b) on the jetty or (c) on the quay (which requires expanding the design area).

Before solving the parking problem I made a really clear future vision, a vision how it should be, goals to aim at, a sustainable city with low energy requirements. After this I looked at the parking problem and implemented it into my plan. Normally there should be 1.6 parking spots per house. This number is increasing over the past decades and is only getting more and more.

The use of cars is contradictory to a sustainable vision. Besides, the location is down town in Rotterdam, one of the biggest cities of the Netherlands and parking spots are very scarce. This makes it not realistic to hold on to the 1.6 parking spots per house. In 2050 people are sharing cars and the number of parking spots per house will be less by then. From this point of view there is no need to develop an urban plan with so many parking spots. That is why in this design every house has only 1 parking place, so there is no need to share cars and space is kept to the minimum.

The parts where no houses can be placed are perfect to station cars. In this way the cars are situated nearby the houses, but not in front of the house where people are forced to look at cars when looking outside the window. A solution was found in the urban design as implemented in the plan, and not shifted away.

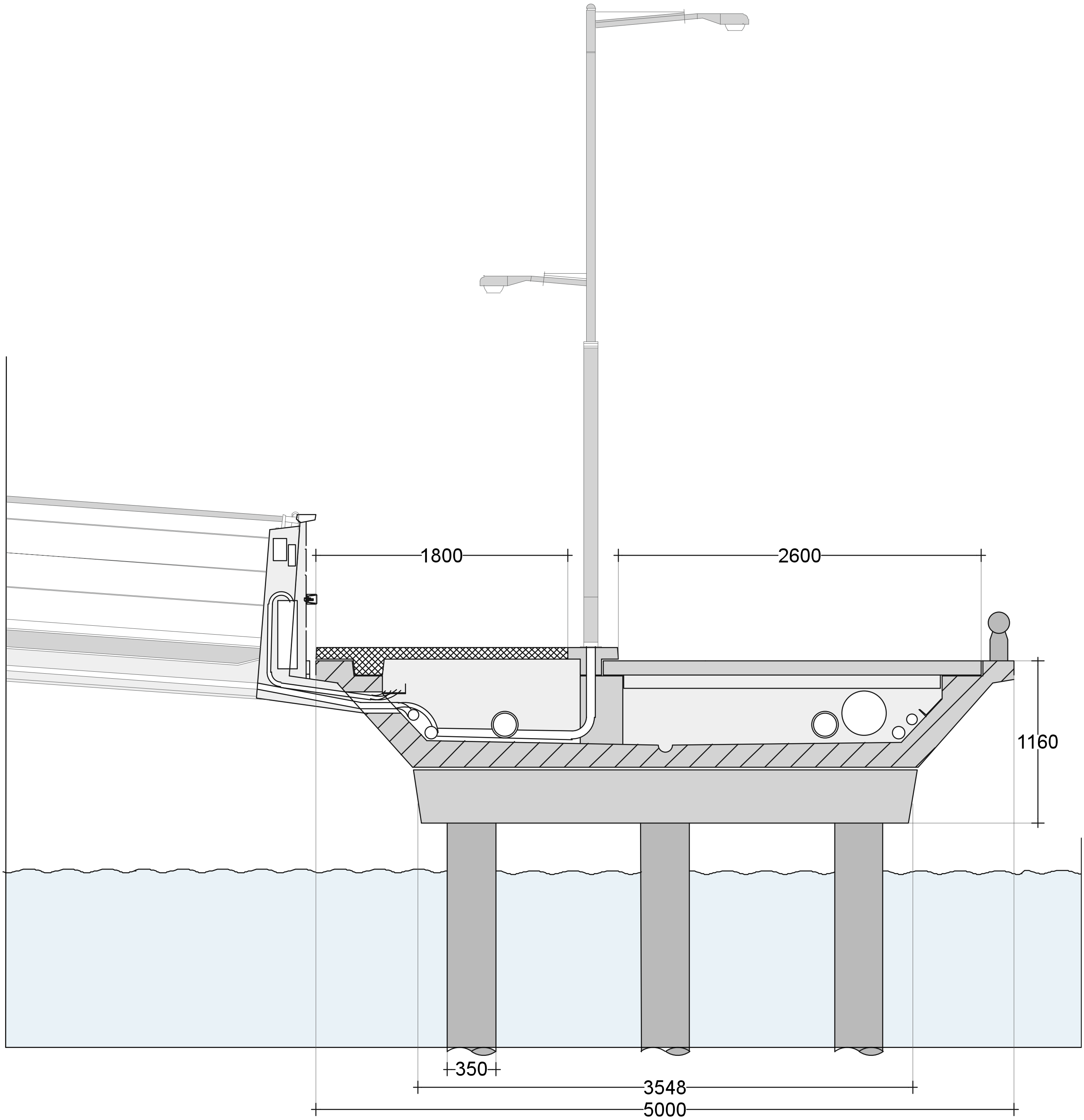

1800
2600
1160
350
3548
5000

Fig. 4.6

Section of the Jetty with measurements. (Own Ill.)

4.6 Jetty design

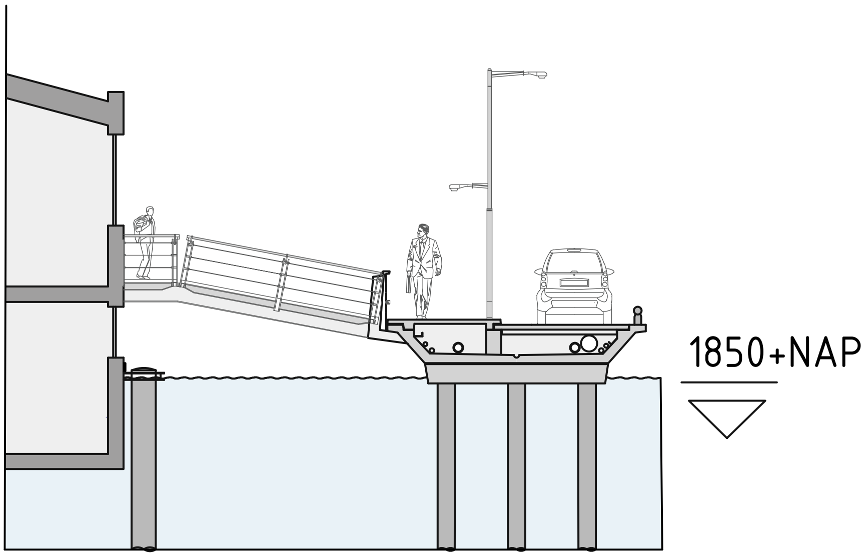
Jetties are public spaces just like a street, which ensures a certain level of design. Besides the pure functional aspect of making the residences attainable, there is also the need of fire safety and pedestrian friendliness.

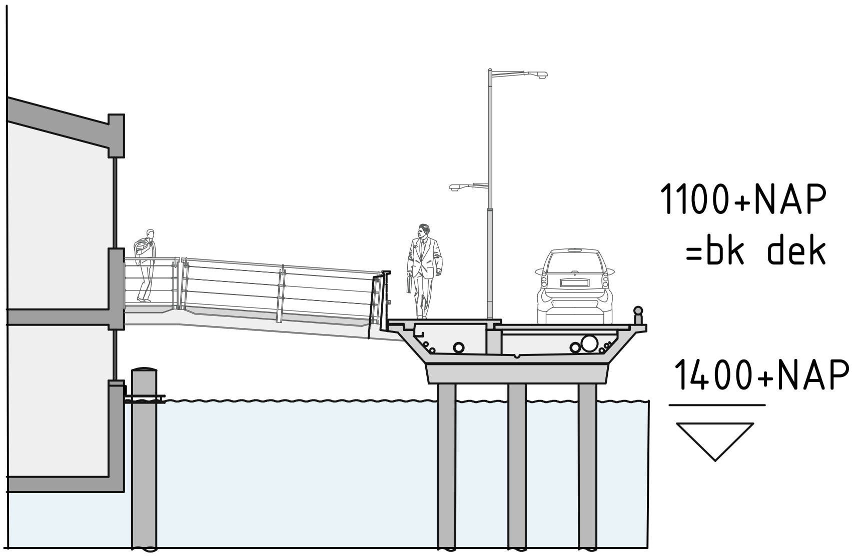
The residences need all utilities (water, gas, electricity) for normal living. These can be combined with the jetties but what this will look like is essential for the neighborhood. The architect Villanova designed the water area in IJburg taking many aspects into account: stairs and railings with pipes and cables all bundled out of sight. Lighting is integrated into the railing so one can still see where to go at night without disturbing the sky full of stars.

Railing is a must to ensure the safety of playing kids. They are made out of aluminum, which is light and strong, and gives it an industrial look. Fire-safety and emergency situations impose a lot of requirements on the jetties, which have to be wide enough and always have two possible escape exits. If the jetty is not floating, some distance has to be covered between the jetty and the house. Building regulations determine the maximum angle that is allowed in terms of safety regulations.

The jetty is one of the most expensive parts of the plan. To lower the cost, minimizing the length and width is necessary. The jetty should hold the weight of a small car, approximately around 1100 kg. The cars can only drive in one direction which makes the jetty less wide and allow them to be less strong . To provide adequate room for the pedestrian area or in case something unexpected happens, the walking part was made quite wide, which brings the total width of the jetty to 4,5 meters. The low car guardrail is to stimulate low speed traffic. At the pedestrian side there is a normal height guardrail including a car-proof protection part in the lower part of the rail.

The jetty is designed in such a way that it can hold and include all utility facilities. All pipes are covered with sand for insulation and protection reasons.


1850+NAP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1400+NAP

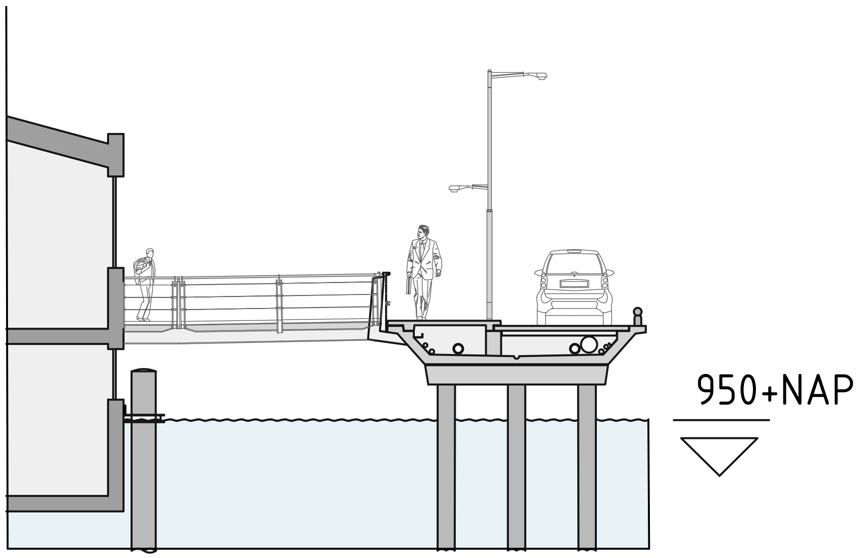

950+NAP

Fig. 4.7

Section of the water fluctuations relatice to the Nederlands Amsterdam Pijl (NAP) (Own Ill.)

4.7 Water level fluctuations

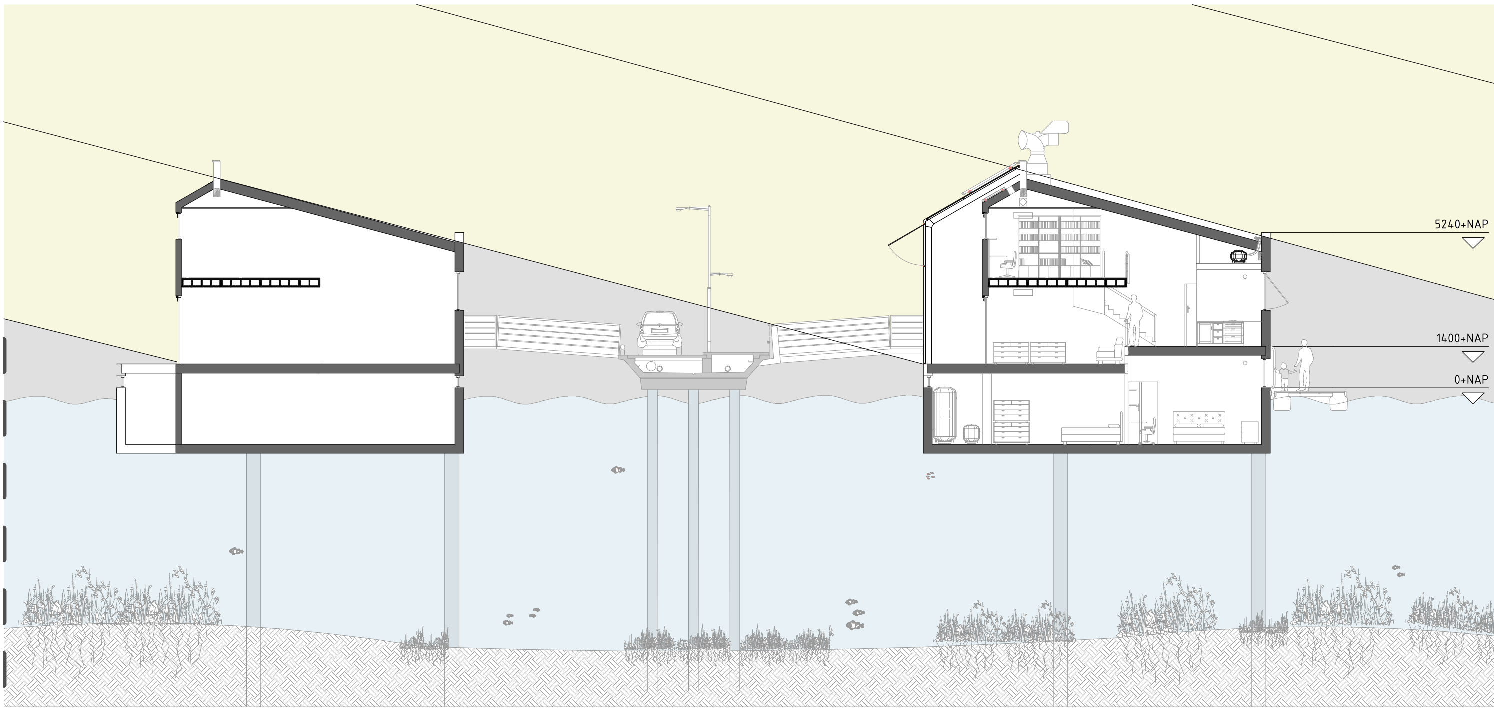
Water supply systems are dynamic which is why every regular design choice has to be taken into account. In case of floating houses, water level fluctuations are really important when it comes to the connection between the floating houses and the fixed jetty. The water levels inside the housing area fluctuate between maximal 200 mm up and 200 mm down during the year. To account for more extreme fluctuations that may happen once in a hundred years, the design fluctuations were set at 450 mm (both up and down). Although these fluctuations may not be overly large, these are numbers architects have to take into account when designing floating buildings.

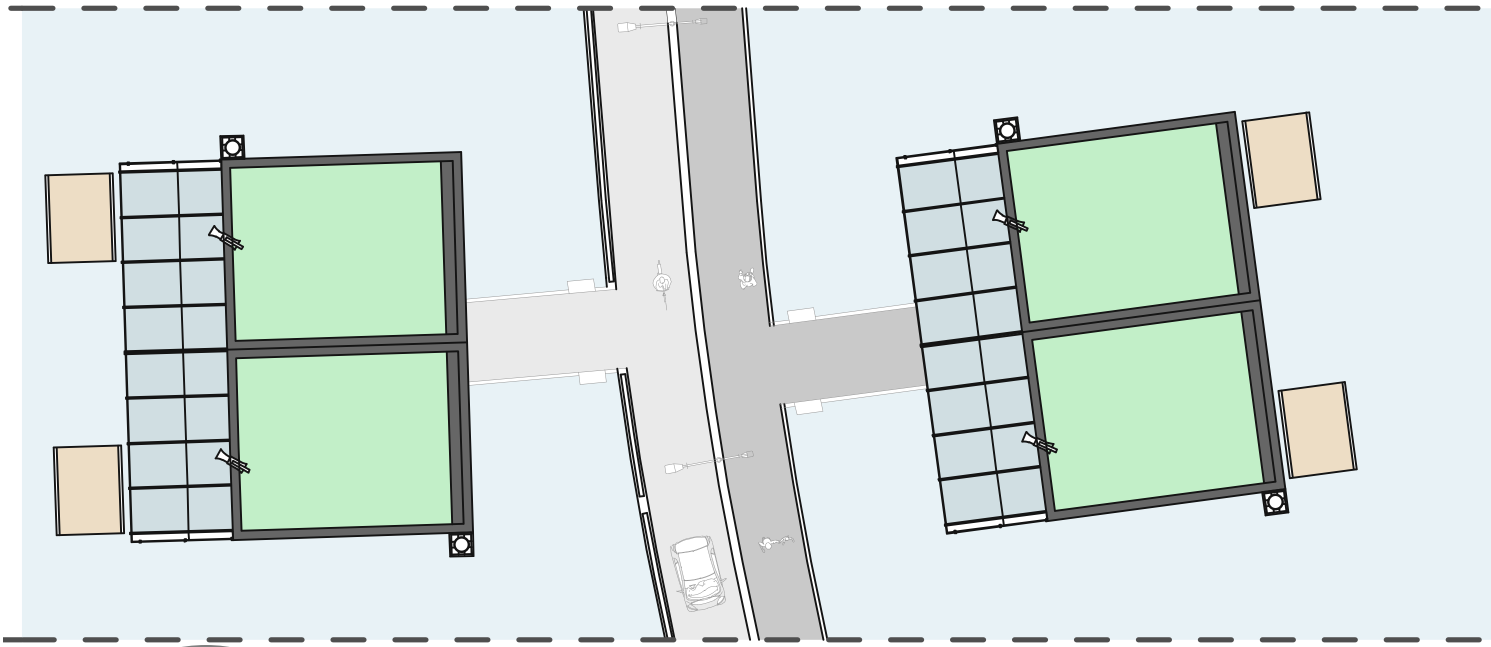
Two pivots and an adjustable gangway are foreseen to bridge the difference between the lowest position when the gangway is flat and the highest position when the water is at its highest point.

The utilities (electricity, potable water and sewage system) are designed to enter the house underneath the gangway. This requires adjustable length for cables and pipes. For any gas connection this is problematic, therefore the floating houses are designed not to use gas, but use electricity for heating and cooking. A gas connection would not be an informed choice anyway, since it makes the house dependent on external supplies, which goes against the self-generating energy concept.

Conclusion

The main goal at the macro scale was to create an urban design with an optimum number of houses in the area, taking into account that the number of jetties should be reduced to a minimum, combined with the required fire-safety protocol of two ways to escape and adequate parking places for small cars. This plan brings all those aspects together and provides a realistic basis for the architectural design at the meso scale.





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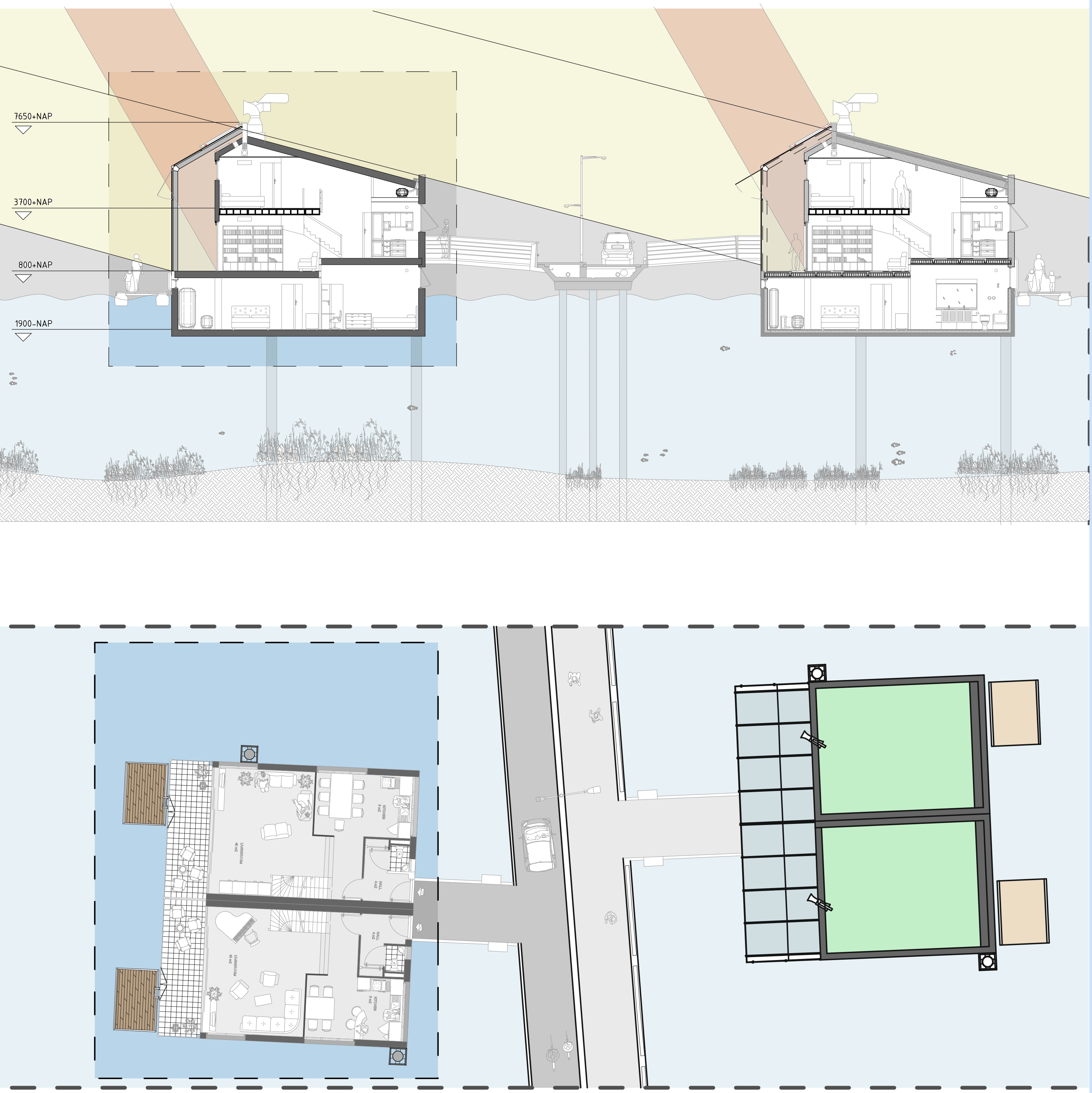
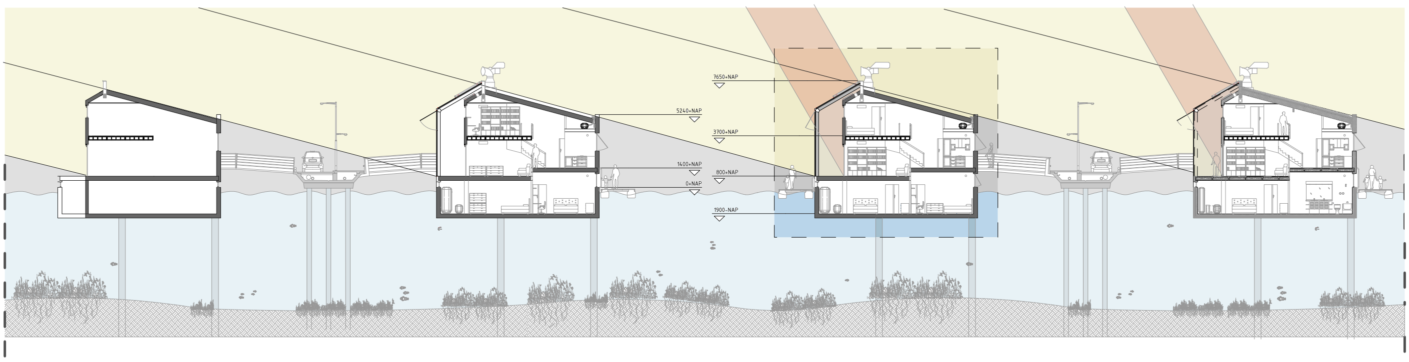


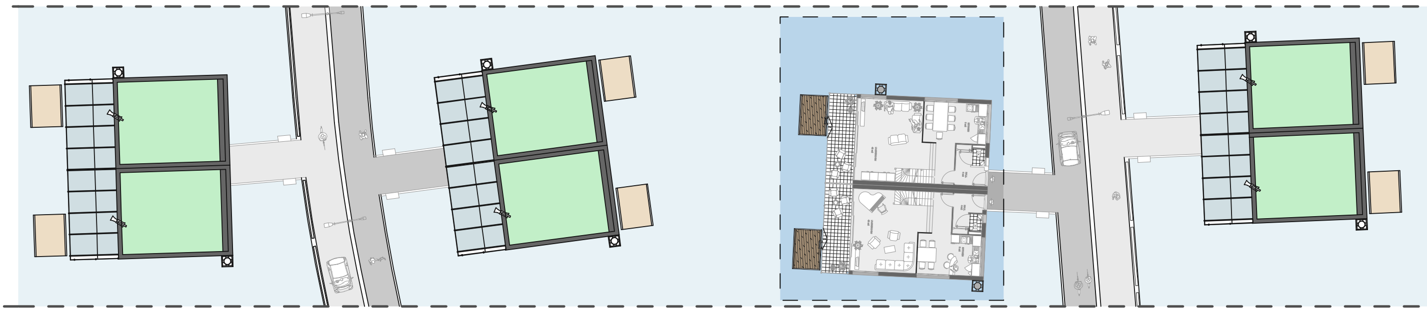
MESO

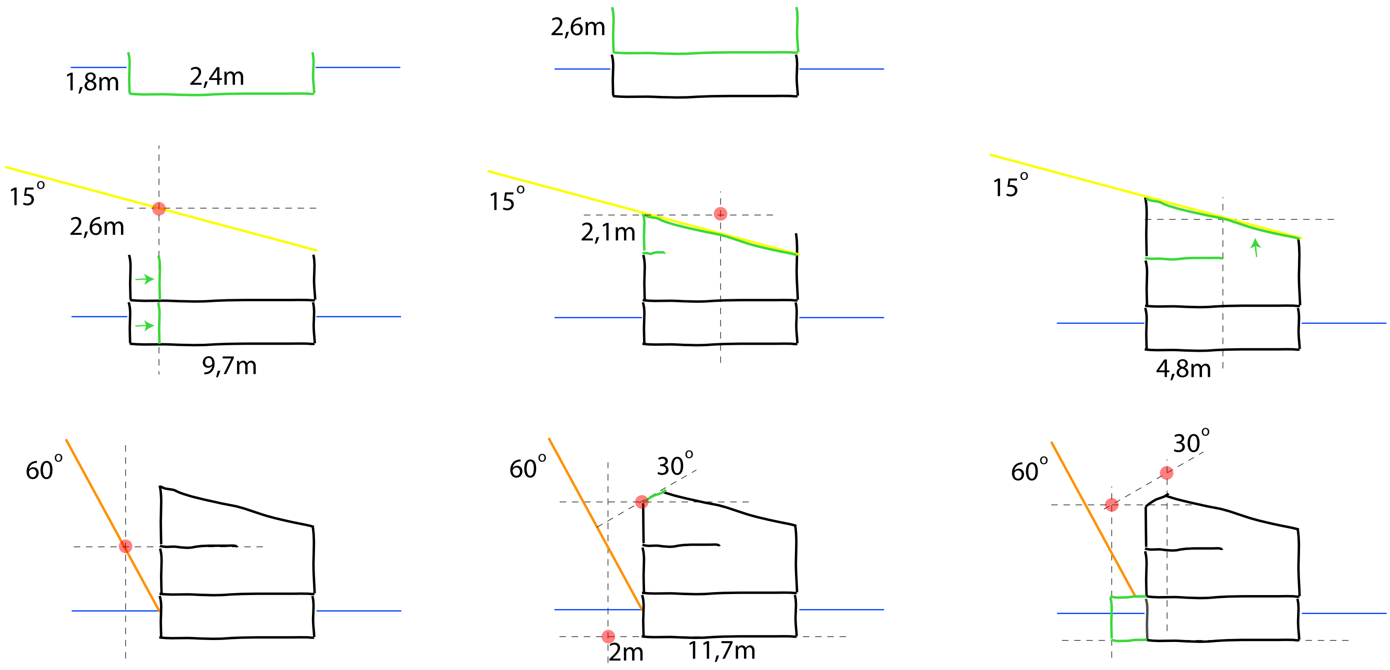
Fig. 5

(Own Ill.)

Climate Design






1,8m
2,4m
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15°
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9,7m
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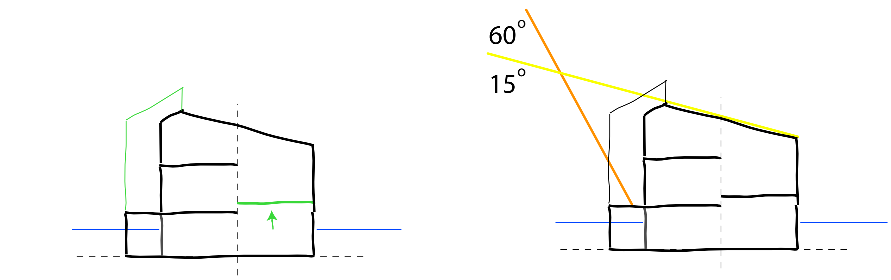
60°
30°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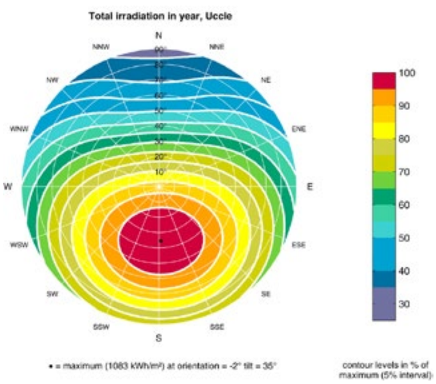
Total irradiation in year, Uccle
N
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30

05.Climate Design

Fig. 5.1.1

Section urban plan where the four houses are shown. The creation is shown in the 4 different dwellings, each dwelling shown a different aspect how the dwelling is formed.

Fig. 5.1.2

A solar indication map where the most sun comes in a year and under which angle. (http://alt-e.nl/pagina30.html)

Fig. 5.1.3

The four steps sketched to illustrate the design considerations. (Own Ill.)

Introduction

At the meso scale the building has direct connections with the urban plan on the one hand and the engineering details on the other. The shape of the building is designed for climatological reasons and the south-north orientation creates a dichotomy in the building. The south side is to gain solar energy and the north side to collect rainwater while the indoor climate can be controlled using a thick pack of insulation. All these aspects will be explained in detail in this chapter.

5.1 Form follows sun

The final form of each house was created in four steps; the design considerations are explained step by step hereafter.

1) The width of each house is determined by the width of the narrowest canal on the route from the building site in Urk till the final location, the Rijnhaven. This is 7,0 meter which is why I took a width of 6,5 meter including facade and construction for this house which results in a 6 meters netto width. Making the houses 2,5 stores high will give the amount of square meters corresponding to two-under-one-roof houses (140-180 m2).

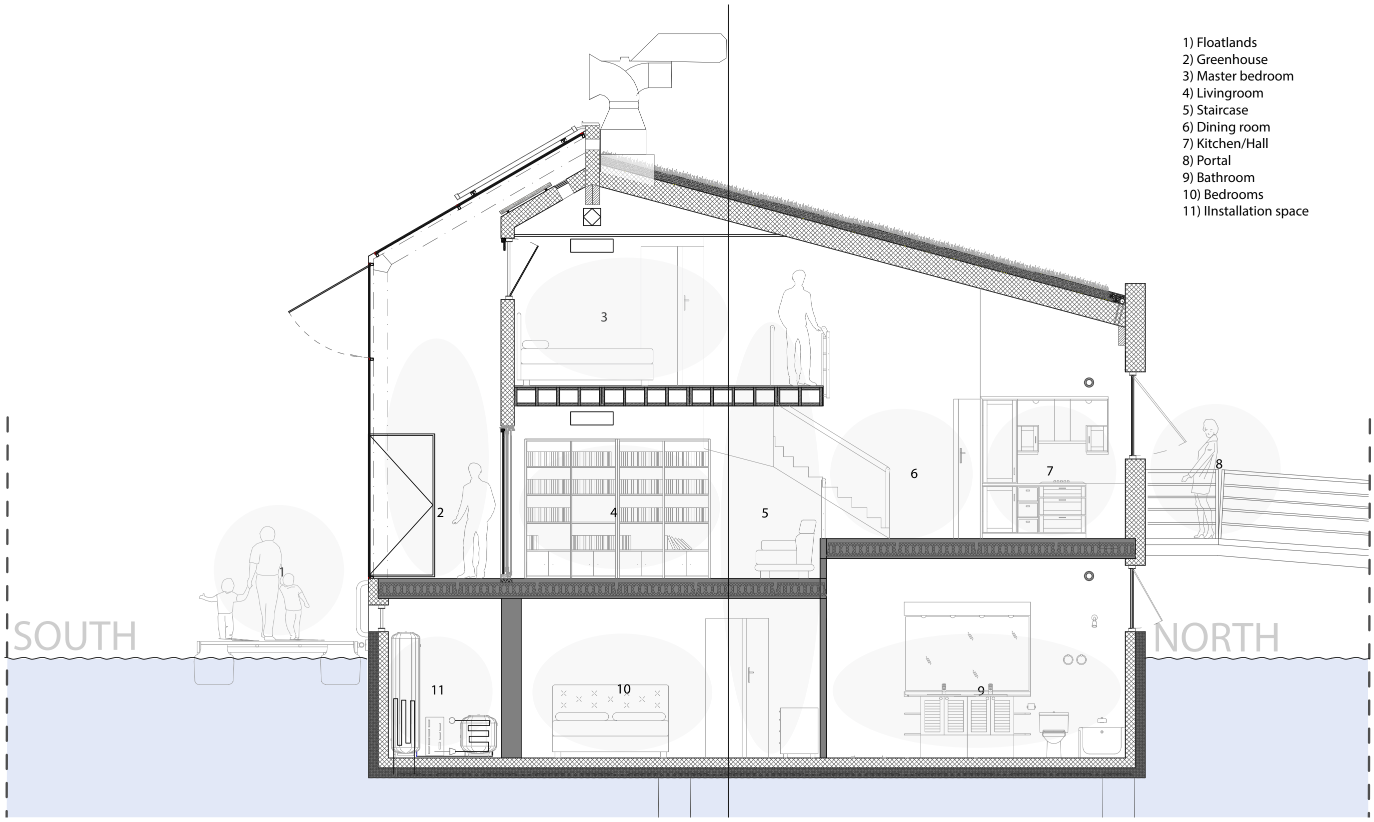
2) For the length of the house the angle of the winter sun is used to shape the roof. Using this angle will reduce the length of the shadow of the building so the next building can be built as close as possible to the other buildings. At the +1 floor I decide to put the roof at a 2,1 meter height. This brings the two rooms visually closer together and also contributes to a less far shadow in winter.

3) The summer sun comes in at a 60-degree angle which is not desired. To protect the house from the heat of the summer sun, a glasshouse is placed at the south side of the building. This zone helps regulating the climate comfort inside the building.

To optimize the energy gain from the sun using PV cells, the angle is of great importance. Creating a south facade perpendicular to the sun ensures that the PV panels can put flat on the facade and still have the perfect angle towards the sun.

4) The concrete foundation box has a draft of 1,5 meter. With a passage height of 2,4 meter in the basement and a 30 cm free space above the water level, there would only be 60 cm left for he assemble windows. This small stroke does not give a pleasant feel in all rooms. Therefore I lifted the floor at the north side of the building by 60 cm to provide a double length of the windows. As can be seen in the section, the room above this part of the building had already a higher roof because of the mezzanine of the building.

After those design considerations the house reached its final form. Instead of designing a building and trying to make it sustainable and energy efficient afterwards, a much better result can be reached when working the other way around: using the angles of the sun to create the south facade and roof, results in technically supported choices.


1) Floatlands
2) Greenhouse
3) Master bedroom
4) Livingroom
5) Staircase
6) Dining room
7) Kitchen/Hall
8) Portal
9) Bathroom
10) Bedrooms
11) IInstallation space
SOUTH
NORTH

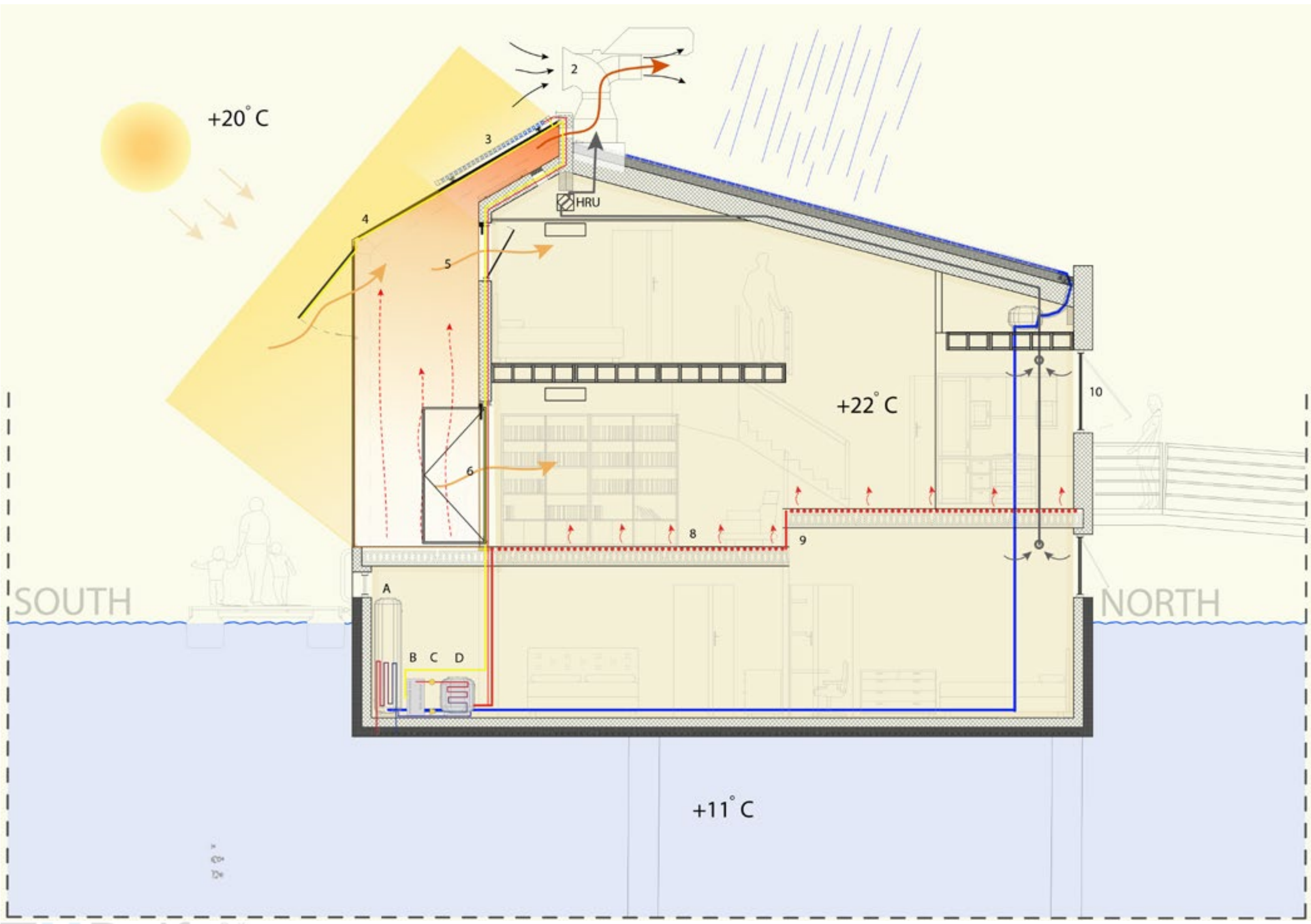

+20° C
HRU
+22° C
SOUTH
NORTH
A
B C D
+11° C

Fig. 5.2

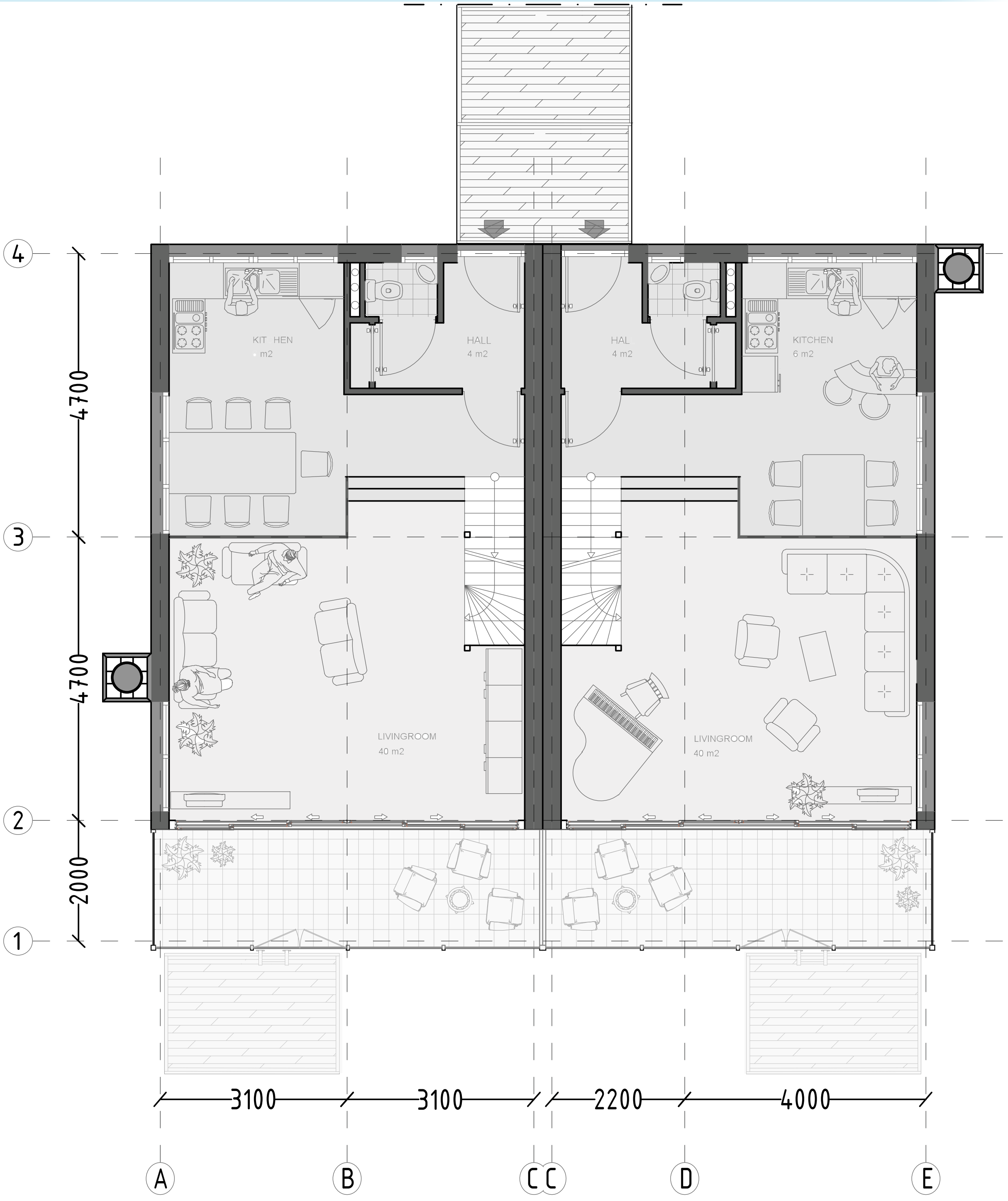
A Section of the dwelling with all the zones indicated. (Own Ill.)

5.2 Section dwelling

The basement is mostly under the water level and has a small stroke where windows can be placed to provide incoming daylight. Daylight is here less needed because this zone is mostly used in the evening and night but to increase the quality of the basement area an improvement has been made. At the north side of the house the floor has been lifted up which creates a small different in heights. This results in the possibility of putting much higher windows in the basement, which gives a much more spacious and wider feeling (see figure 'lifted floor'). Because of this the floor above will have a little less high roof but it had already a higher roof because of the vide.

The mezzanine provides not only space but also light. Because the rooms are in contact with each other since they do not have partition walls, light can reflect deep into the house (see figure 'winter light into the house').

One big advantage of floating houses is the reflecting characteristic of water. The amount of diffuse light because of the reflection is not only more, the incoming angle is also different. It bounces from the water to the roof, which results in a much brighter effect. Incoming light from the south can deeply penetrate the house without barely being interrupted.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m2
HALL
4 m2
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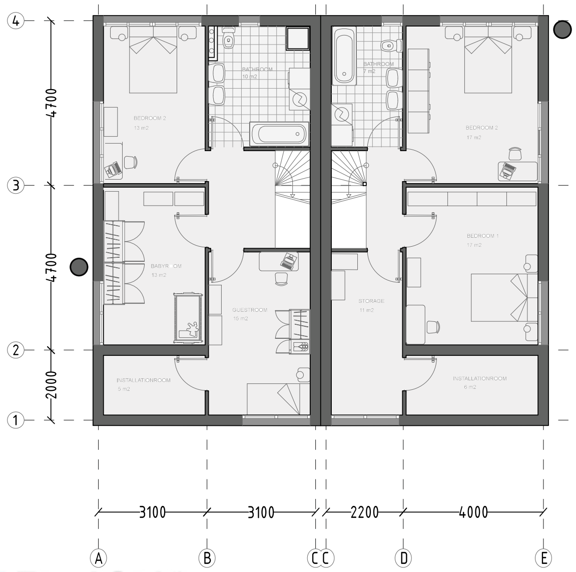
6 m2
LIVINGROOM
40 m2
LIVINGROOM
40 m2
4700
4700
2000
4
3
2
1
3100
3100
2200
4000
A
B
C C
D
E


4700
4700
2000
3100
3100
2200
4000
A
B
C C
D
E

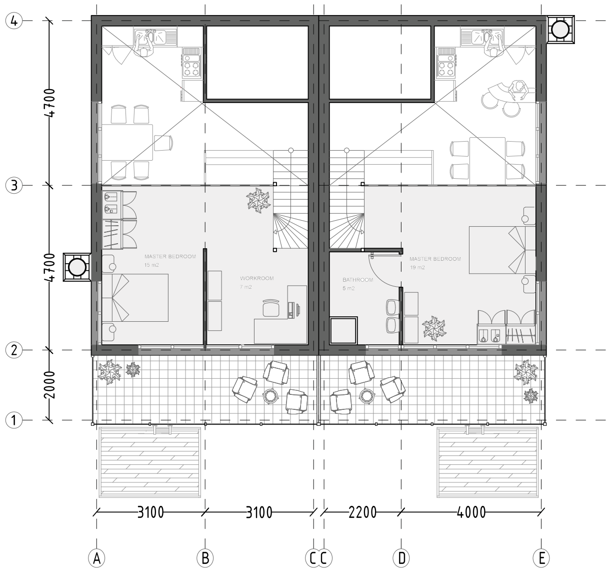

4700
4700
2000
3100
3100
2200
4000
A
B
C C
D
E

Fig. 5.3

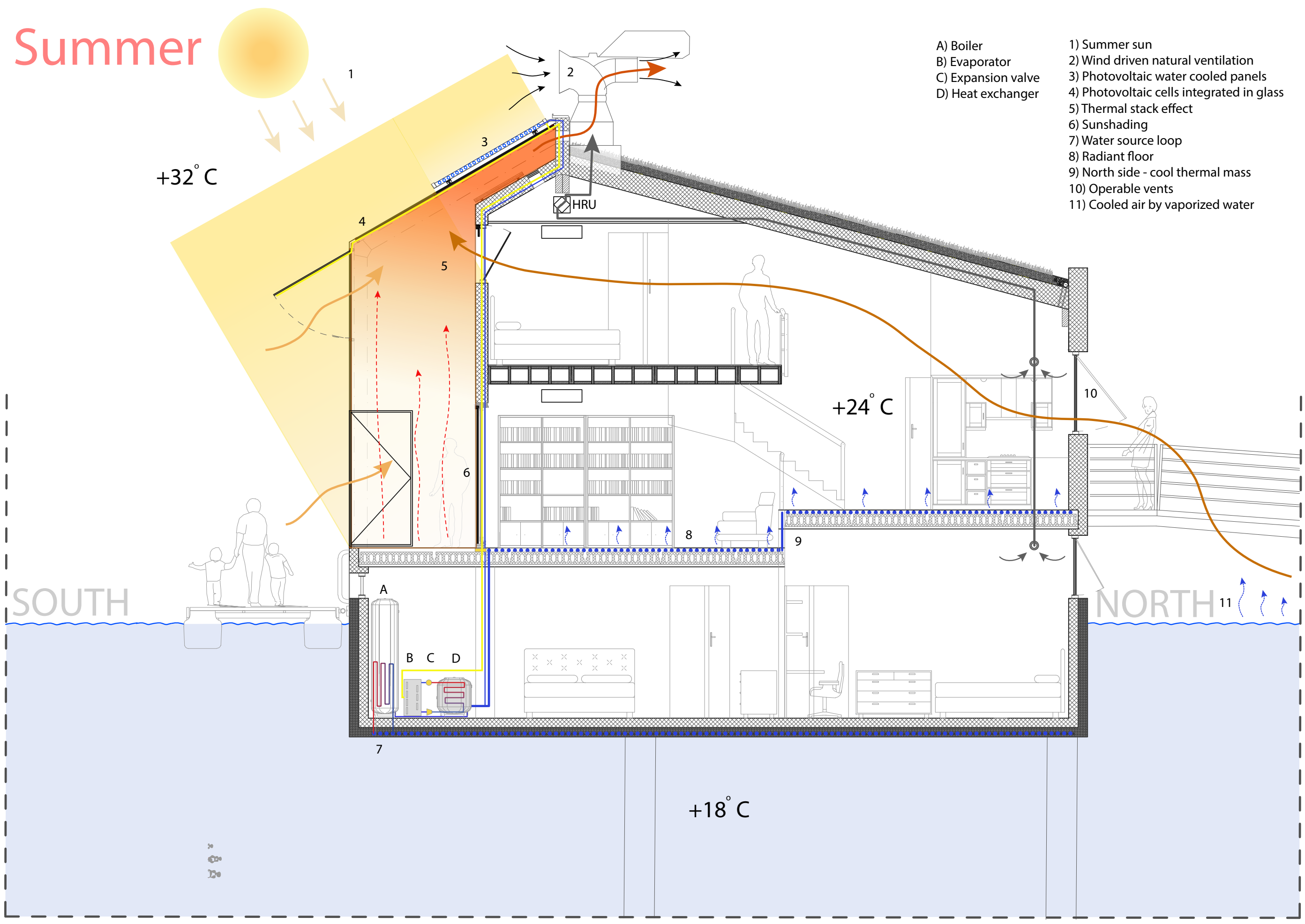
The floor plans of the dwelling with the grid underneath. (Own Ill.)

5.3 Floor plans

Taking into consideration that the house is orientated towards the south and one enters at the north side, already introduces in a preliminary design some zones in the house. Achieving a simple design based on logical decisions was the main goal. The vertical shaft is at the side where the house is bundled with the other house, which leaves less room for the hall, but more square meters for rooms or other spaces.

The roof angle (as explained in the previous chapter) determines where the vide will be. The extra floor is half of the other floor areas, so in total there are two and a half floors. In the top part the master bedroom is situated which has great view over the water and a direct connection with the living area and kitchen.

The ground floor is around 1 meter above the water level and is connected with the jetty on one side and the glasshouse with float lands on the other side. Here you find the kitchen diner area, living area and the glasshouse from north to south. In the basement you find all the bedrooms, storage place and installation room, which is relative large because of all the climate facilities.



Summer
1
2
3
4
5
6
7
8
9
10
11
+32° C
+24° C
+18° C
HRU
A
B
C
D
SOUTH
NORTH
A) Boiler
B) Evaporator
C) Expansion valve
D) Heat exchanger
1) Summer sun
2) Wind driven natural ventilation
3) Photovoltaic water cooled panels
4) Photovoltaic cells integrated in glass
5) Thermal stack effect
6) Sunshading
7) Water source loop
8) Radiant floor
9) North side - cool thermal mass
10) Operable vents
11) Cooled air by vaporized water

Fig. 5.4

Winter situation illustrated with all the climate aspects. (Own Ill.)

5.4 Summer situation

In summer the sun can be quite strong. To keep the heat of the sun outside the house as much as possible, direct sunlight should be blocked. The external sun shading on the ground floor ensures no heat is entering the house. On the mezzanine the PVT panels are even blocking incoming sunlight completely when it is summer.

The glasshouse heats up very fast. By opening the operable vents of the southern facade completely, the warm air will rise and the heat will leave the glasshouse at the top through a wind cowl. This wind cowl provides a wind driven natural ventilation system.

This stack effect also sucks air from the south side out of the house. Relatively cool air cooled by vaporization of the open water comes in from the north side, which results in a low-north to high-south air flow.

The northern side protects the house with the extra isolation layer and with the green roof. The green roof leads to gradual discharge of rainwater and has a lower surface temperature. Besides, it compensates the lack of green in the city and helps purifying fine dust.

The thermal mass with northerly orientation can be used for constant cooling throughout the day. The water under the house will be used to cool this floor. Getting rid of the heat by using the water brings a great solution to reach a comfortable indoor climate in summer.

The thirty square meter PV cells with southern orientation harvest the energy of the sun. This is 20% of the gross floor area, which is more than enough to make a house self-sufficient according to the 2014 energy manual of the ministry.

Winter

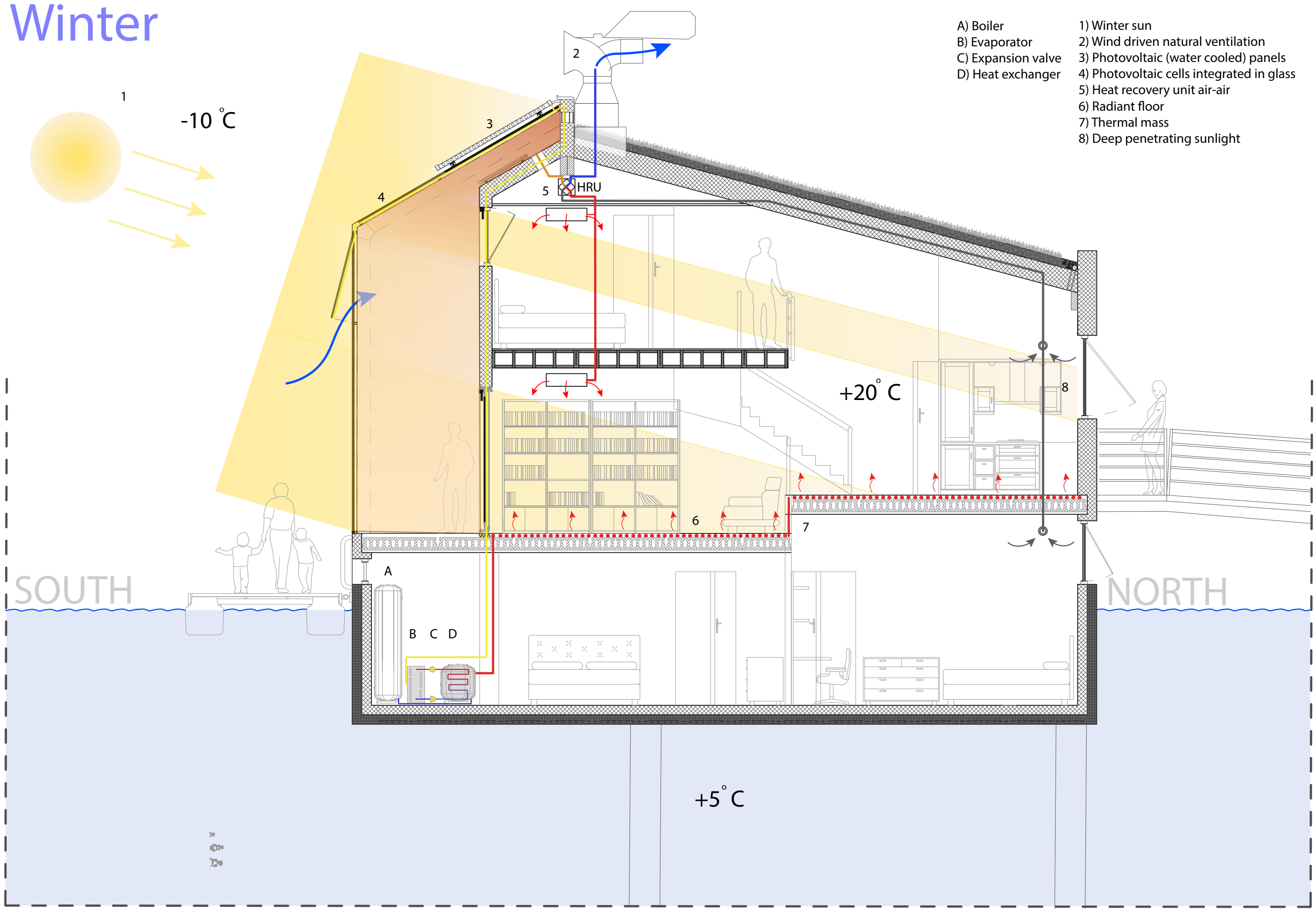

1
-10 °C
2
3
4
5
HRU
A) Boiler
B) Evaporator
C) Expansion valve
D) Heat exchanger
1) Winter sun
2) Wind driven natural ventilation
3) Photovoltaic (water cooled) panels
4) Photovoltaic cells integrated in glass
5) Heat recovery unit air-air
6) Radiant floor
7) Thermal mass
8) Deep penetrating sunlight
+20° C
8
6
7
A
SOUTH
NORTH
B C D
+5° C

Fig. 5.5

Summer situation illustrated with all the climate aspects. (Own Ill.)

5.5 Winter situation

In winter the sun is the heat source to bring warmth to the house. The almost perfectly south facing contributes enormous to this aspect. Facade openings are made in a way that the sunlight and warmth can penetrate deep into the house. Between 10:00 and 17:00 the thermal mass heats up and the warmth will gradually heat the room during the evening. The morning is the most difficult time for the house to reach a comfortable temperature by itself, and some additional heating may be needed then.

The air in the glasshouse will warm up and gather in the top of the building. The fresh preheated air is used by the ventilation system. It goes through a heat recovery unit what brings the temperature to the demanded level. In this way the heat loss will be reduced and relative cold used air will leave the building.

One of the main energy sources can be found in the integrated PV cells in the glass of the glasshouse. Slightly opening the window for incoming fresh air will provide a perpendicular angle towards the sun optimizing the energy gain, although it should be taken into account that the solar power is relative weak in winter in comparison with the summer. Besides, there are days in winter when the sun is barely shining. In this case no energy can be supplied to the heat pump to warm the water.

When there is no solar energy the water can be used as an energy source as well. The difference between the water temperature and the air temperature can be used as a catalyst for the heat pump. Energy will be withdrawn from the water to the heat pump which heats a 300 liters water tank to 55 °C. This heated water can be used for heating the thermal floor and as warm tap water.

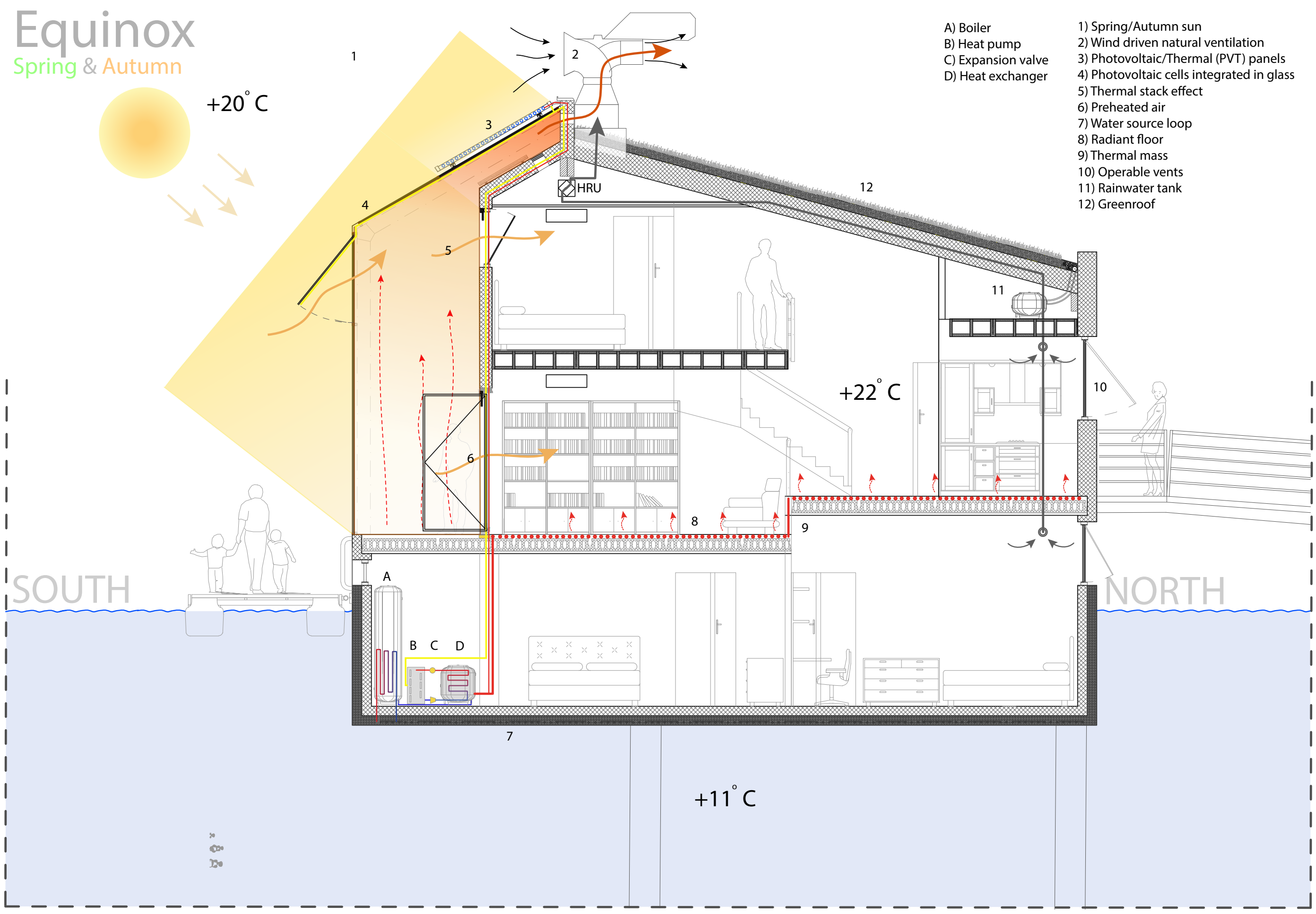

Equinox
Spring & Autumn
+20° C
1
2
3
4
5
6
7
8
9
10
11
12
HRU
+22° C
+11° C
A
B C D
SOUTH
NORTH
A) Boiler
B) Heat pump
C) Expansion valve
D) Heat exchanger
1) Spring/Autumn sun
2) Wind driven natural ventilation
3) Photovoltaic/Thermal (PVT) panels
4) Photovoltaic cells integrated in glass
5) Thermal stack effect
6) Preheated air
7) Water source loop
8) Radiant floor
9) Thermal mass
10) Operable vents
11) Rainwater tank
12) Greenroof

Fig. 5.6

Climate section how the dwelling regulates the climate during the seasons between summer and winter. (Own Ill.)

5.6 Equinox

During spring and autumn, also known as the mild and wet seasons in the Netherlands, the house is on its best in terms of energy efficiency. When opening the doors and windows, passive heating is enabled. Preheated air coming from the glasshouse can enter the house right away at the south side, while extraction takes place at the north side of the house.

The glasshouse is a nice place to enjoy the evening sun and relax after a long day at work in a comfortable temperature. This makes the outdoor glasshouse an extension of the house. Energy efficient applications like these can be seen as devices for the inhabitants. Smart climate designs can score high in tests on calculating efficiency, although a smart user who knows how the system works and understands which steps need to be taken to make this an energy efficient house, is another thing.

Energy efficient behavior is another graduation topic where big steps forward can be taken, like switching all devices completely off when no one is home, heating the house not during the whole night but just before you wake up and ventilate the house at the right amount and at the right time of the day, are all human behavior aspects which will reduce energy waste significantly.

The water-collecting feature uses gutters that are connected to a 1,200 liters storage tank. But before it goes right away into the big storage tank, it goes through a much smaller tank of 120 liters. This water will be used directly to flush the toilets. Placing energy-efficient toilets using only 3 liters per flush makes this tank provide 40 flushes. The smaller tank is placed right under the roof and above the toilets. In this case adding pressure on the water pipes is unnecessary.

Fig. 5.7

The city of the sun, designed by ashok bhalotra, urban planner and architect. (Google earth)

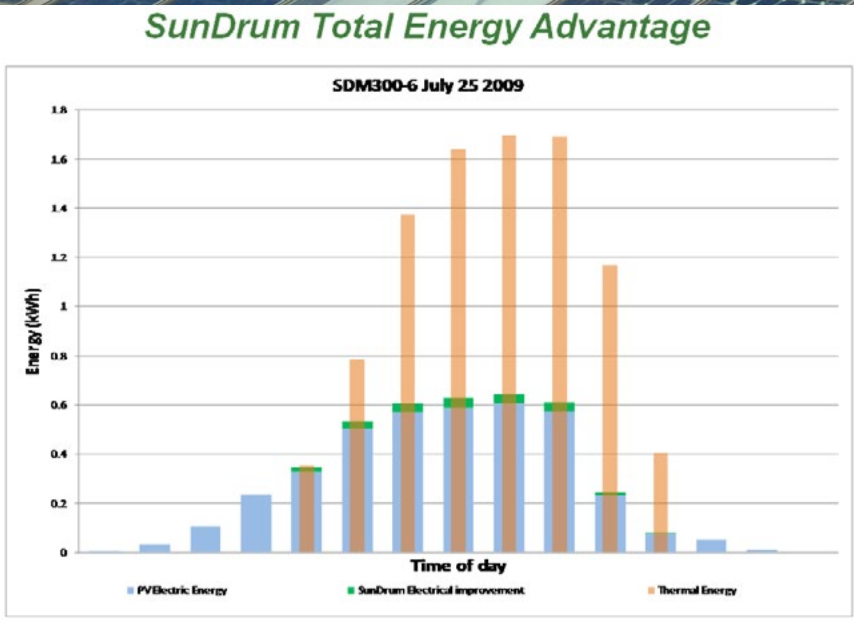
5.7 Solar cities

The City of the Sun in Heerhugowaard was the first city fully designed to the sun. In the urban plan the south-north orientation was already determined, so architects could more easily make the step towards gaining solar energy.

This urban plan was already developed and designed in the '90s. In 2009 the city was officially opened and in March 2014 I visited the city by joining a excursion organized by the Urban Flood Resilience chair group of UNESCO-IHE. During the excursion we walked through the whole city and it was remarkable to note that nothing seemed to be different in comparison with any ordinary city, which leads to the conclusion orientation does not have to influence the urban environment, although the orientation greatly contributes to the energy efficiency.

The City of the Sun has its roots in the water of the lake that surrounded it originally. The urbanism thoughts were to restore this lake and build a city in the middle of it. The urban plan was free from orientation. That's why the whole square is orientated to the south. In this way urban design considerations can improve the architectural design.

Orientation is crucial in order of optimize the energy efficiency and was the number one aspect I wanted to achieve in my own design for the Rotterdam Rijnhaven.


SunDrum Total Energy Advantage
SDM300-6 July 25 2009
Energy (kWh)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Time of day
PV Electric Energy
SunDrum Electrical improvement
Thermal Energy

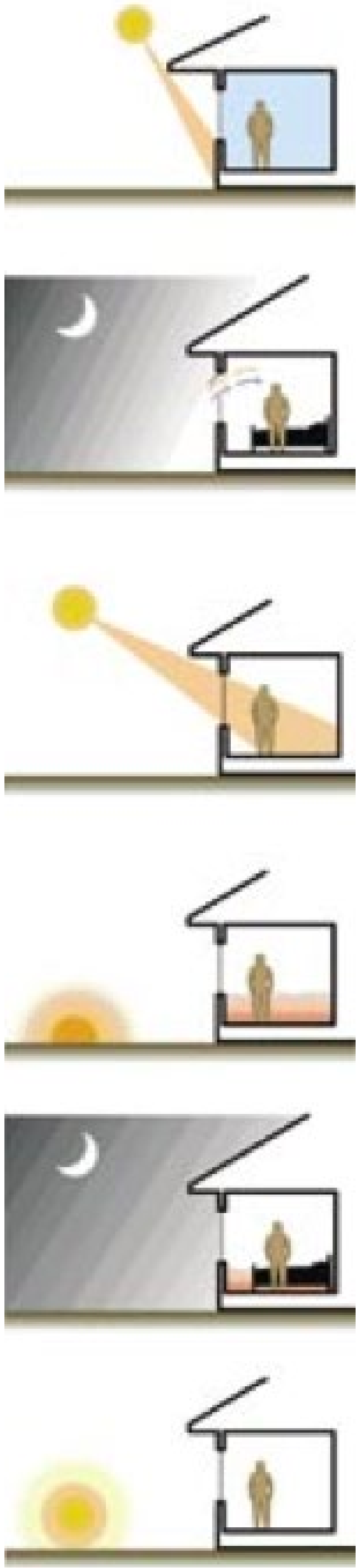


Fig. 5.8.1

Wind cowls on de BedZED dwellings in London. (BedZED, UK)

Fig. 5.8.2

Graph including the amount of energy in comparison to a normal PV panel. (Sumdrum, 2006)

Fig. 5.8.3

A PVT panel before it is mounted to the roof (Sumdrum, 2007)

Fig. 5.8.4

Day and night situations (warmteaccumulatie-thermische massa)

5.8 Climate regulators

PVT Panels

In the sustainable energy industry, it is commonly known that solar water heating offers a quicker payback period and a higher return on investment than photovoltaic. This is because solar radiation already contains a large amount of heat, so using the heat directly is more efficient than converting it to 'high-grade' energy like electricity. Your mileage may vary, but on average a solar water heating system will pay for itself in about 4-7 years, where a photovoltaic system could take 10-20 years.

But the reason electricity is considered 'high-grade' energy is that it is more versatile. Heating water is great, but it is only one job. Converting sunlight to heat and electricity, and doing both efficiently would be a double-win. since it also leads to a short payback period.

As can be seen from the chart on the other page, a PVT panel produces only a modest increase in electricity production, but nearly triples the total usable energy that the system produces, bringing the total efficiency of the system to around 70% without increasing its overall footprint.

A PVT system includes a solar thermal collector that mounts underneath a photovoltaic panel. A typical PV cell has an efficiency of ony 15% under ideal conditions. When a PV panel heats up, as dark objects facing direct sunlight tend to do, its efficiency and lifespan will both decrease. Remove some of that heat and the panel will achieve closer to its ideal efficiency and be less prone to heat-related failures.

PVT panels are 22oC cooler than standard PV panels. These are results of tests for a normal roof situation. In this case the temperature will be much higher at the top of the house, which would will the efficiency of a normal PV panel even more, which is why PVT panels were chosen here.

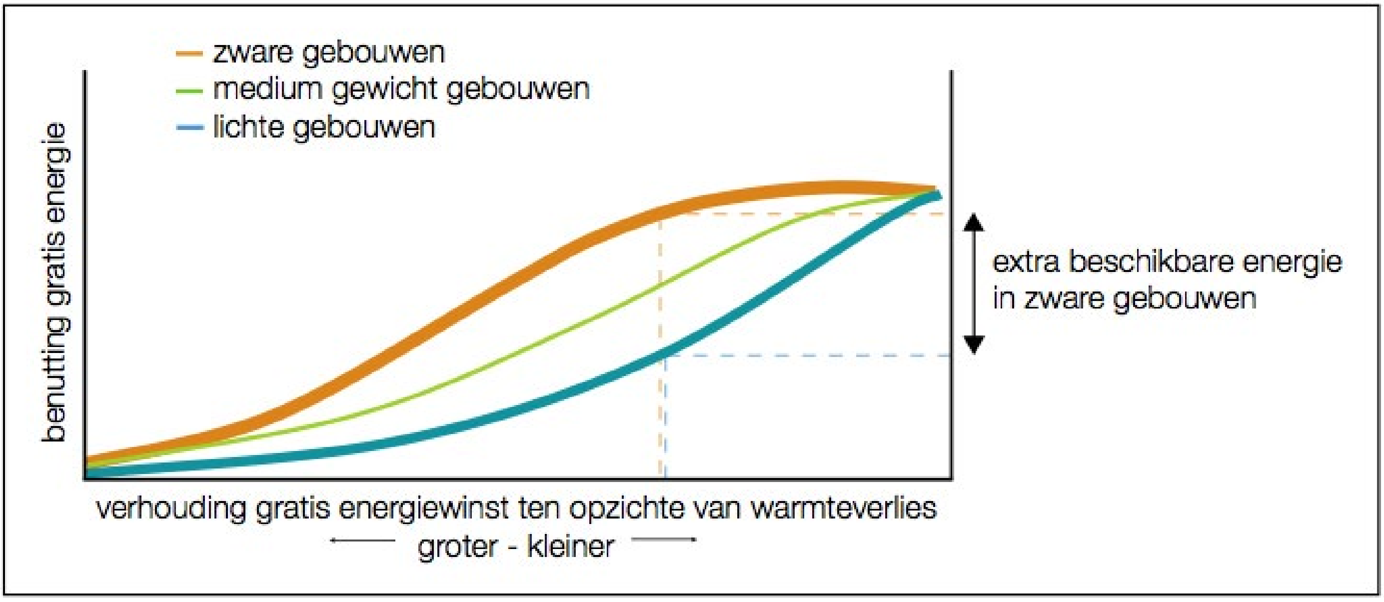
Wind Cowls

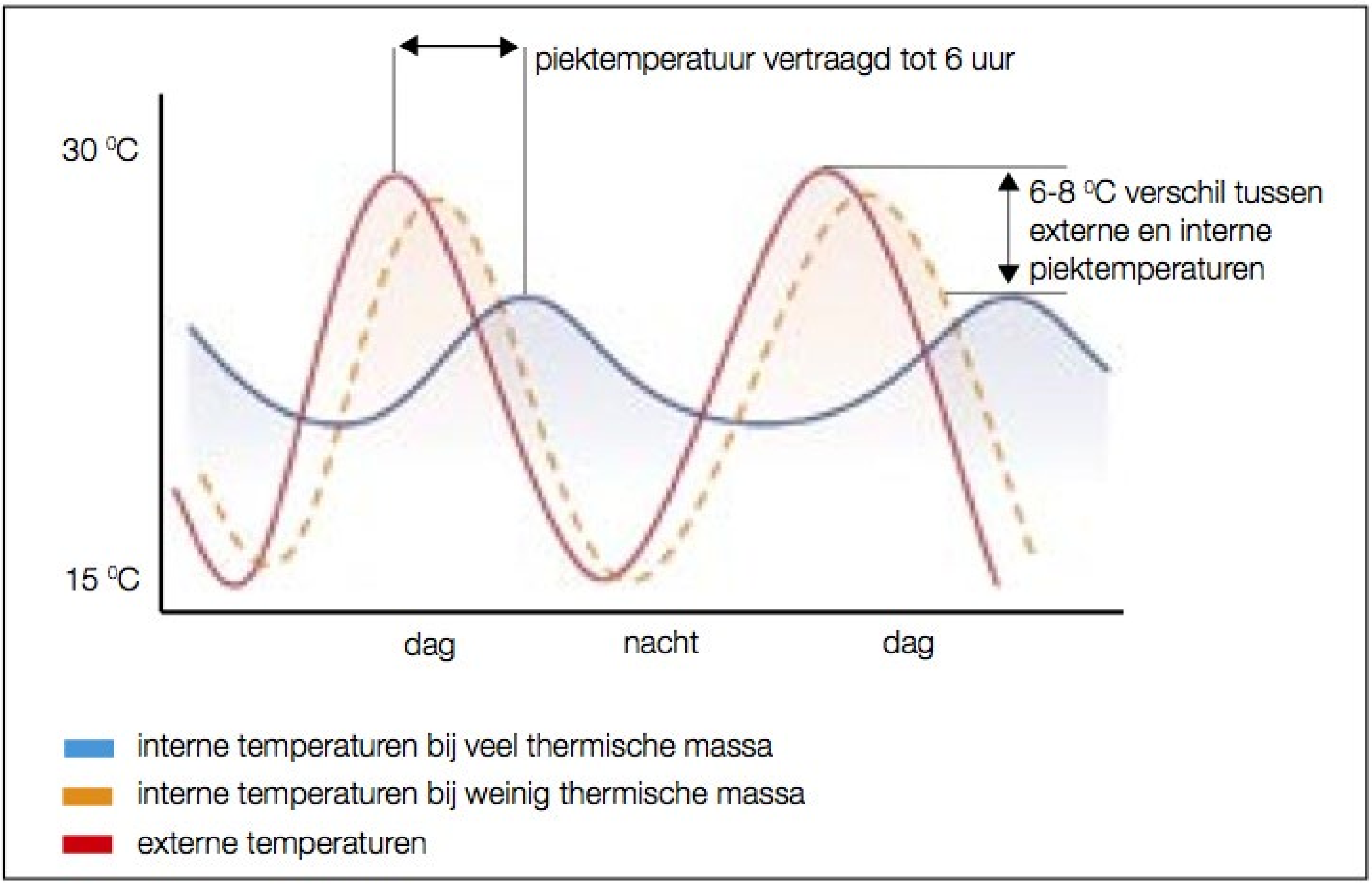
The distinctive BedZED wind cowls I used in my design for providing ventilation inside the homes while minimizing heat loss, were used here as well. They will contribute to the natural wind driven ventilation. The natural stack effect that will occur during summer will achieve even better results, leading to a better ventilated glasshouse.

Night situations

During the night there is no sun so the house can not use the energy of the sun for regulating the inside temperature. In the summer the absence of the sun gives the opportunity to loose heat. By opening the windows during the night, the thermal mass cools down significant and can absorb heat during the day again.

In the winter the sun is used in a passive way to heat up the thermal mass. When the sun has shine the whole day on the thermal mass, the thermal mass radiates heat during the evening what contributes to the comfortable inside climate. In the morning the whole house is cold and the thermal mass is not yet heated by the sun. This moment of the day is the most difficult for the house to get to a comfortable temperature without using a lot of energy.





cascovariant	ruimteverwarming		oververhitting*
	vraag (GJ/jr)	piek (kW)	aantal uren > 25 °C
beton	1,1	0,6	18
beton met hsb binnenspouwblad	1,1	0,5	20
houtskeletbouw	1,1	- 0,6	97
kalkzandsteen	1,1	0,5	22

Fig. 5.8.4

Influence of themal mass on comfort (Thermal mass for housding, the Concrete Centre, UK)

Fig. 5.8.5

Tabel of number of hours exceeding the indoor temperature per year for three a casco variants. (Passiefhuis in Nederland, 2006)

Fig. 5.8.6

Number of overheating hours a year with different types of constructions. (Passiefhuis in Nederland, 2006)

5.8 Climate regulators

Thermal mass

The temperature in the house is constantly changing. Large differences between seasons but also smaller ones between day and night have an influence on the indoor climate. Almost the complete house is made of timber frame. Although I have chosen a thick (200mm) layer of insulation, keeping the warmth or cold inside is nearly impossible without a source where the heat can be stored: a thermal mass.

Thermal mass reduces extreme temperatures and reduces the number of overheating hours by 80%. In summer thermal mass stores cold, even longer when the mass is situated at the north side of the building.

Adding a thermal mass floor on the timber frame should be done in the right way. The east and west sides of the house are loadbearing. To find the right floor I compared different floors:

- wooden beams (30 kg/m2)
- concrete hollow core slab (382 kg/m2)
- wooden hollow core slab (59 kg/m2)
- steel plate concrete floor (283 kg/m2)
- bubble deck floor (470 kg/m2)

Because I am looking for mass, the two wooden floors are not suitable. A bubble deck floor is the heaviest but also the thickest. Remain the hollow core slab and steel plate floor.

I have chosen the hollow core slab floors to span the floor in one direction. In retrospect it might make more sense to use a floor that uses all sides for loadbearing, because all sides can be used as loadbearing walls. On the other hand, hollow core slabs are relative cheap and easy to assemble.

Conclusions

*Regulating the in-house climate to a comfortable and satisfying level is the main reason why we build homes at all. Creating the perfect temperature and humidity costs energy when the surrounding conditions deviate a lot. These houses are designed in a way to optimize the energy demand and minimize the heat loss with the sun as most important factor. Gaining solar power from the south facade, collecting rainwater from the roof and applying a thick pack of insulation to prevent heat loss are well known sustainable ways that are commonly applied to existing buildings. Designing with those well known aspects in an early stage literally forms the house. The famous sentence '**form follows function**' can be paraphrased into 'form follows sun' to create a house that is as energy efficient as possible.*

06

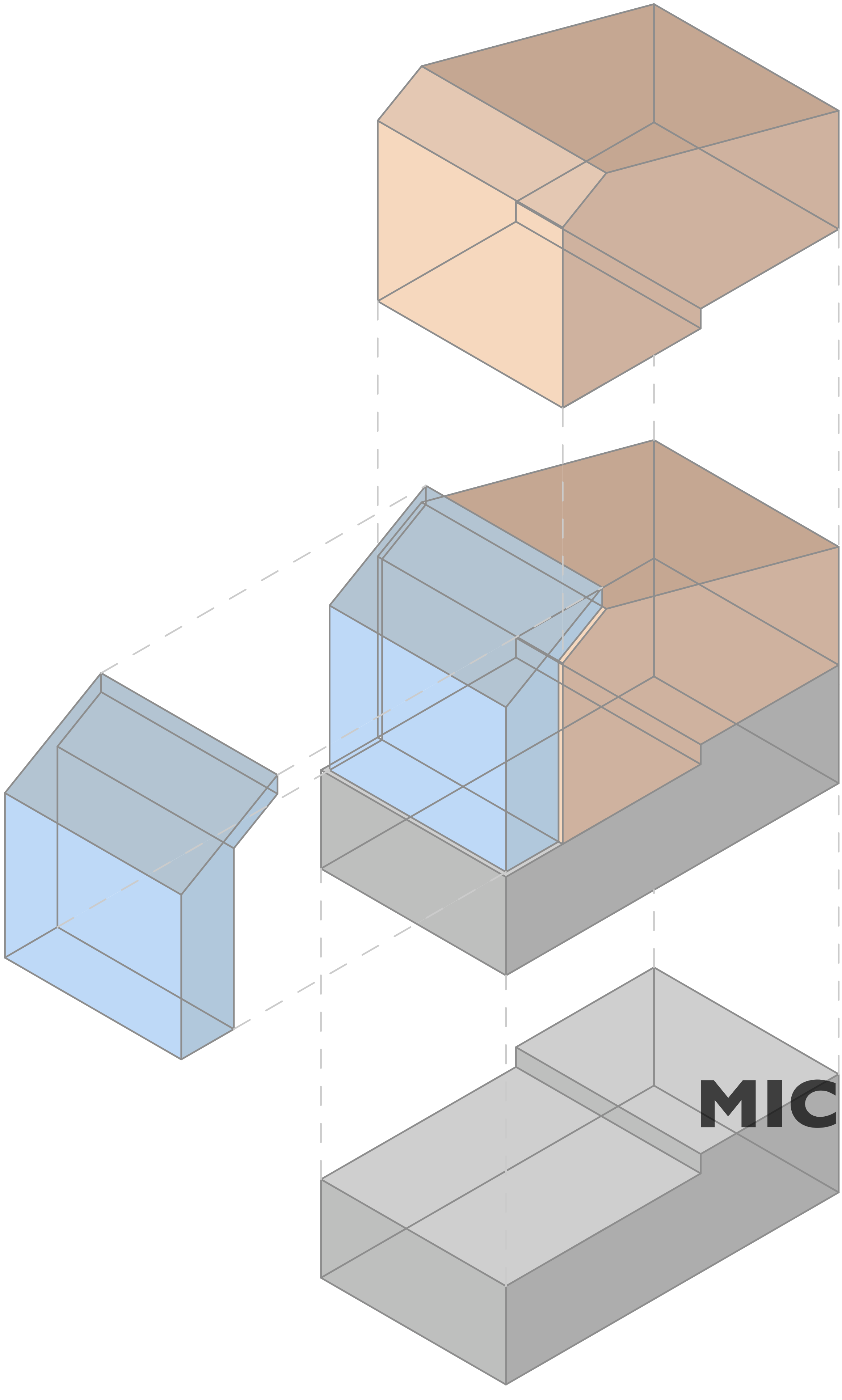
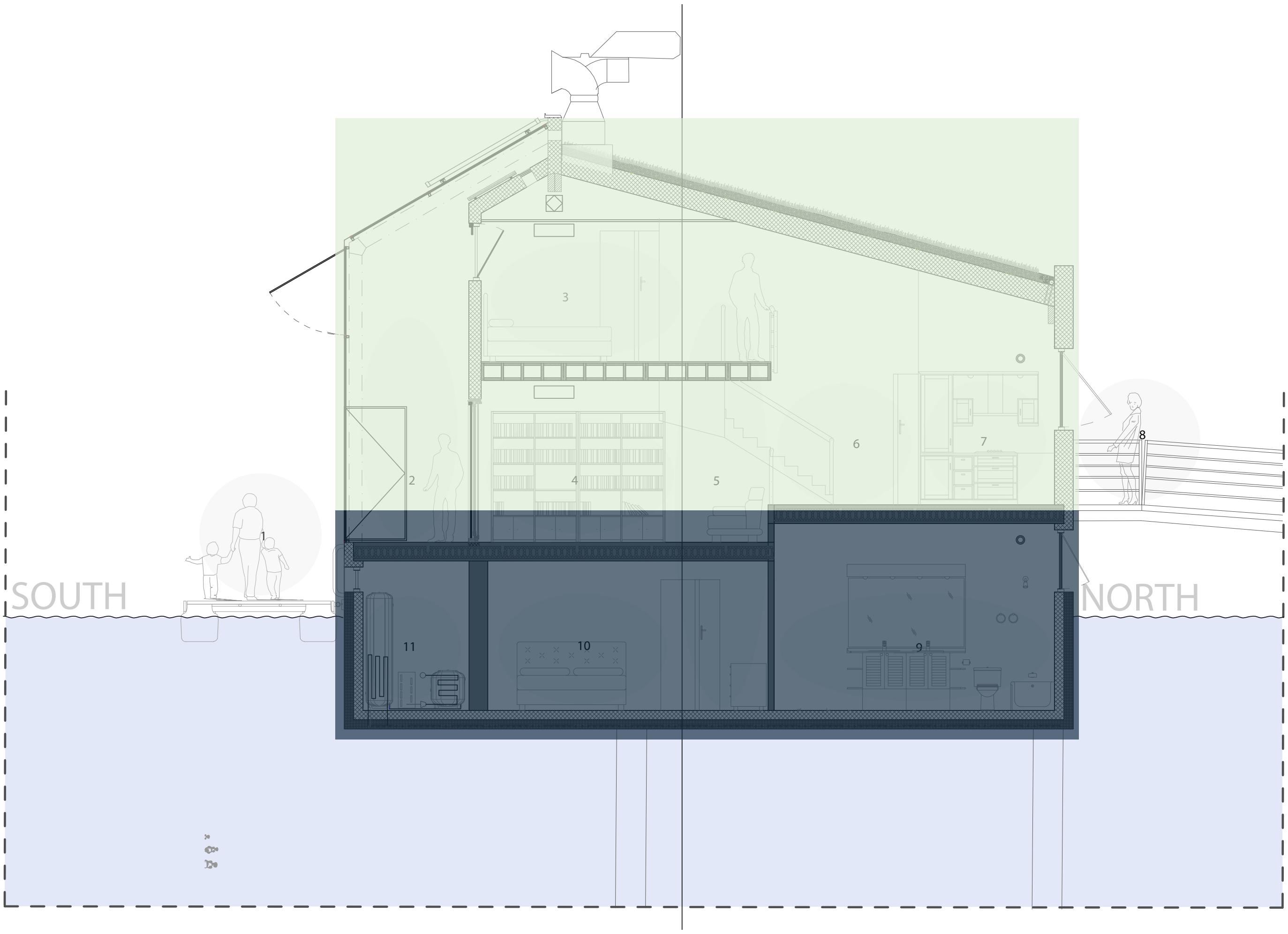


Fig. 5

(Own Ill.)

MICRO

Construction Design


SOUTH
NORTH
1
2
3
4
5
6
7
8
9
10
11

06.Construction Design

Fig. 6.1

Section of the dwelling illustrated the heavy and the light part. (Own Ill.)

Introduction

Although most of the design decisions seem quite logic, for some aspects or parts an explanation is required to fully understand how these principles are achieved in detail. A plan may contain great ideas but translating these into a final design where all the components are connected to each other is ultimately necessary in order to achieve a successful design.

6.1 Buoyancy

The concrete box floats by itself, even when it is loaded with a timber frame house on top and filled with interior. This can be easily explained by the law of Archimedes which indicates that 'the upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially submerged, is equal to the weight of the fluid that the body displaces'.

To ensure that the concrete box is watertight it is made in one time so there will emerge no cracks or crevices. To prevent the concrete box will be filled with water when the house is under extreme (external) load, 300 mm above the water level has to remain free to guarantee a certain level of buoyancy safety.

Ensuring the safety when the house is under extreme load like a thick pack of snow on the roof or during a party when a lot of people are on one side of the house at the same time, is the most important consideration of a floating building. Hence reference was sought at the Ship Hydromechanics Laboratory of the Maritime Engineering faculty (3ME) at TUDelft.

6.2 Stability

Stability is not provided by the piles where the house is attached to. Those piles are primarily for anchoring reasons, keeping the house stable in the horizontal directions, and are not dimensioned to absorb forces in the vertical direction what theoretically could result in the possibility of a crooked house. In order to make a floating building stable there are three aspects to consider:

1. Lowering the center of gravity
2. Enlarging the surface
3. Enlarging the weight

The concrete box is the heavy part of the building what enlarges the weight. The center of gravity has been lowered because of the use of a light timber frame on top of the concrete base. Enlarging the surface has been reached by connecting two houses to each other what brings the total to a very stable floating house.

The obliquity of the house has to be less then 2 % for a comfortable living environment but because for this house all three stability factors were taken into account, the house will be experienced as very stable with virtually no misalignment.

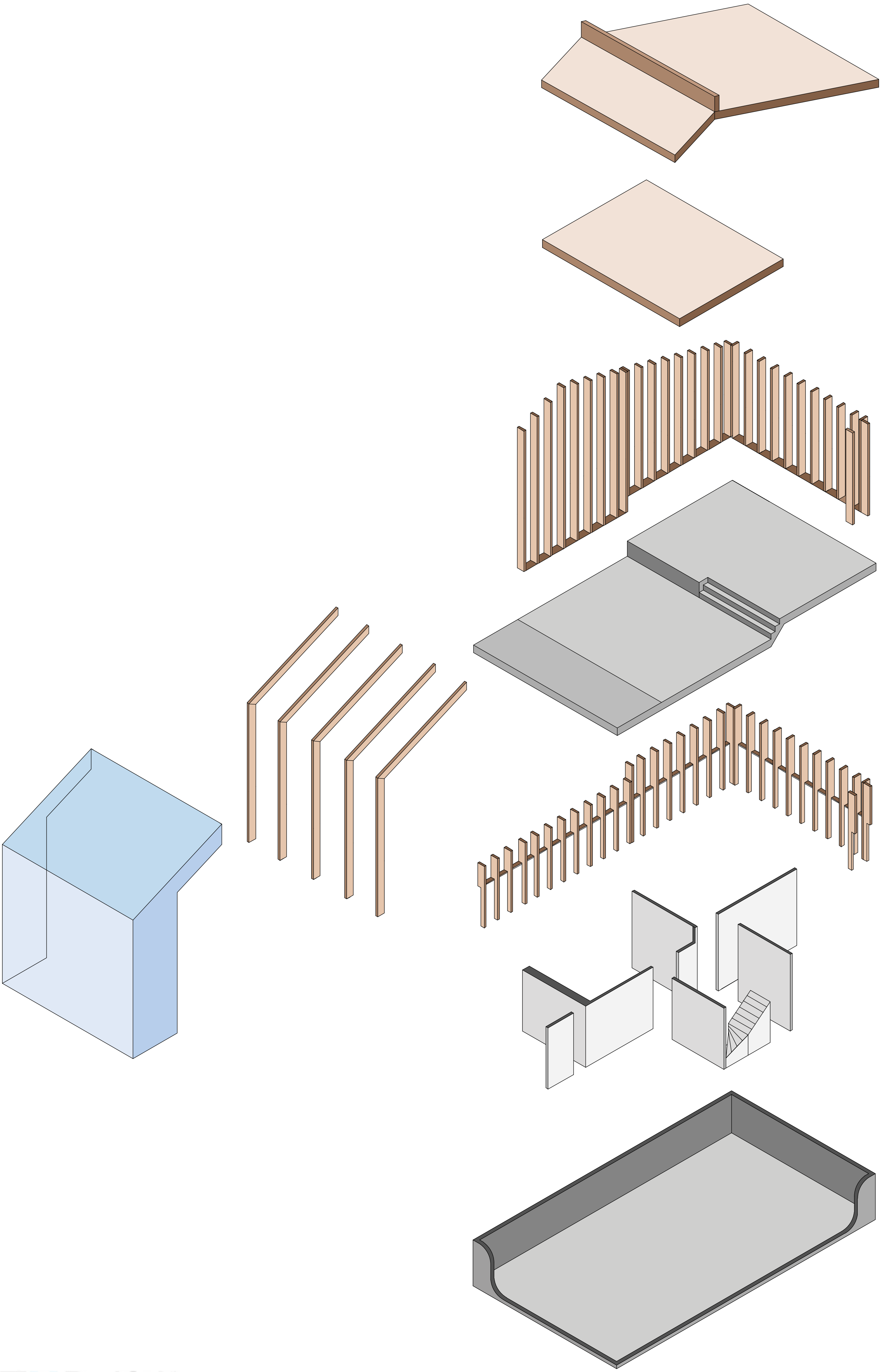


Fig. 6.3.1

An primitive axonometry of the three elements coming together. (Own Ill.)

Fig. 6.3.2

A axonometry over the Z axis to show how the components come together. (Own Ill.)

6.3 Building process

The design is made out of three components. The concrete box serving as the floating base part, the timber frame built as light as possible in order to ensure the low center of gravity and the glasshouse functioning as a climate buffer zone.

These elements are well known in building industry, so nothing new so far, but combining those three into one design working together to become a climate adaptive energy efficient and sustainable design is where the innovation comes in.

The building process is not that complicated and is envisaged to take place at a construction site in Urk that is specialized in this building technology. All building phases can be done right after each other and only one company is building it what reduces the costs and decreases the production time.

Concrete box

To ensure the building is waterproof and keeps floating, the concrete has to be poured in one go. Only then there are no cracks or crevices. After the concrete box is finished the timber frame will be placed partly starting from the bottom and partly from the edge of the concrete box. Because there will be a heavy thermal mass floor on top of the timber frame besides the continuation of the timber frame to the next floor, the timber frame is extra thick in the lower part of the house.

Timberframe

After the connection of the timber frame with the concrete, the house is completely built out of wood. The mezzanine and roof are from Lichnatur, a company who makes prefab wooden hollow core slabs, ideal to build light. Those elements span the 6,5 meter in one time so there are no beams needed to hand over the forces to the load bearing walls. In the ridge of the roof are two wooden beams. Those beams carry the roof curb where also the wooden beams are attached to carry the glasshouse. The timber frame is 184 mm thick and filled with insulation. This thick pack of insulation contributes to reduce the overall heat loss of the building.

Glasshouse

The glasshouse is overarching the complete South facade. The total amount of glass is around the 80 m2. This glass can't carry it's own weight, therefore wooden beams are placed, standing 1,5 m apart, who are loadbearing and can carry the glass. The glasshouse has to be air tight in the top. This is the place where all heated air is collected. A leak would be decisive for the design and the functioning of the glasshouse.

On the sides and at the bottom is an other story. First of all the air in the lower part of the glasshouse is not that much warmer than the air on the other side of the glass. Secondly, the air will be used at the top for the stack effect principle in summer, and for heat recovery in winter, resulting in a pressurized bottom of the glasshouse. This can be compensated by opening for example a vent.

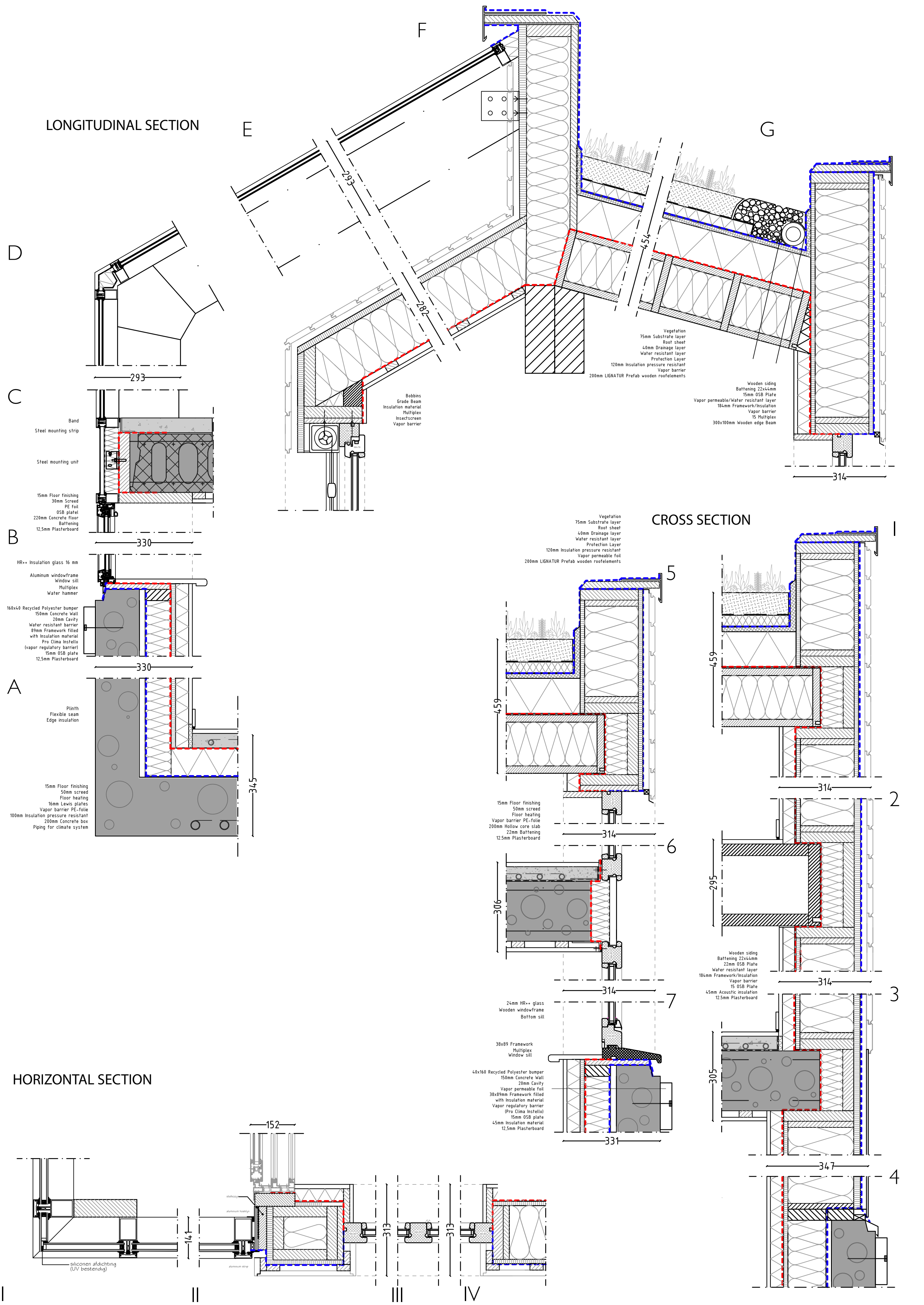

LONGITUDINAL SECTION
D
293
C
Band
Steel mounting strip
Steel mounting unit
15mm Floor finishing
30mm Screed
PE foil
OSB platel
220mm Concrete floor
Battening
12,5mm Plasterboard
B
330
HR++ Insulation glass 16 mm
Aluminum windowframe
Window sill
Multiplex
Water hammer
160x40 Recycled Polyester bumper
150mm Concrete Wall
20mm Cavity
Water resistant barrier
89mm Framework filled
with Insulation material
Pro Clima Instello
(vapor regulatory barrier)
15mm OSB plate
12,5mm Plasterboard
330
A
Plinth
Flexible seam
Edge insulation
15mm Floor finishing
50mm screed
Floor heating
16mm Lewis plates
Vapor barrier PE-folie
100mm Insulation pressure resistant
200mm Concrete box
Piping for climate system
345
E
F
G
293
282
454
Bobbins
Grade Beam
Insulation material
Multiplex
Insectscreen
Vapor barrier
Vegetation
75mm Substrate layer
Root sheet
40mm Drainage layer
Water resistant layer
Protection Layer
120mm Insulation pressure resistant
Vapor barrier
200mm LIGNATUR Prefab wooden roofelements
Wooden siding
Battening 22x44mm
15mm OSB Plate
Vapor permeable/Water resistant layer
184mm Framework/Insulation
Vapor barrier
15 Multiplex
300x100mm Wooden edge Beam
314
CROSS SECTION
Vegetation
75mm Substrate layer
Root sheet
40mm Drainage layer
Water resistant layer
Protection Layer
120mm Insulation pressure resistant
Vapor permeable foil
200mm LIGNATUR Prefab wooden roofelements
5
459
15mm Floor finishing
50mm screed
Floor heating
Vapor barrier PE-folie
200mm Hollow core slab
22mm Battening
12.5mm Plasterboard
314
6
306
314
7
24mm HR++ glass
Wooden windowframe
Bottom sill
38x89 Framework
Multiplex
Window sill
40x160 Recycled Polyester bumper
150mm Concrete Wall
20mm Cavity
Vapor permeable foil
38x89mm Framework filled
with Insulation material
Vapor regulatory barrier
(Pro Clima Instello)
15mm OSB plate
45mm Insulation material
12,5mm Plasterboard
331
I
459
314
2
295
Wooden siding
Battening 22x44mm
22mm OSB Plate
Water resistant layer
184mm Framework/Insulation
Vapor barrier
15 OSB Plate
45mm Acoustic insulation
12.5mm Plasterboard
314
3
305
347
4
HORIZONTAL SECTION
152
141
313
313
siliconen afdichting
(UV bestendig)
I
II
III
IV

Fig. 6.4.1

Longitudinal, cross and horizontal section of the building With all details corresponding to the letter or numbers. (Own Ill.)

Fig. 6.4.2

Schematic illustrated where the section is taken. (Own Ill.)

6.4 Detailing

Longitudional section

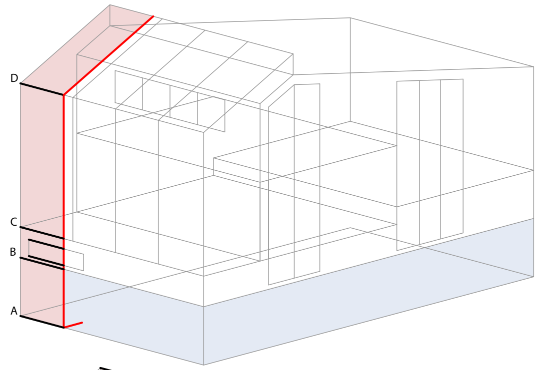
In the longitudinal section (A–G) we clearly see the meeting between the floating concrete box, the timber frame, and the glasshouse. Note that the wooden beams carry the curtain wall. In the rafters they come together with the timber frame so the forces can flow directly into the bearing walls. The water resistant layer is not needed in the inner part of the South facade.

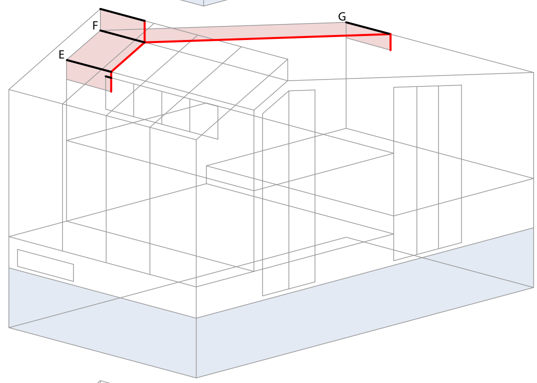
Cross section

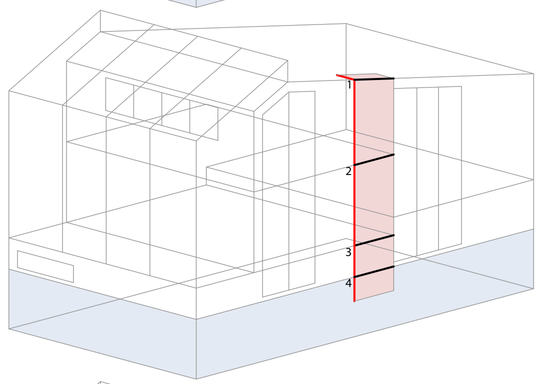
The cross sections (1–7) have been taken where the wall meets all 3 different floors; roof, mezzanine and the thermal mass floor. The roof and mezzanine are prefabricated wooden elements that can easily span up to 12 meters. The 6,2 meter in this house is therefore no problem. For the roof a less thick Lichnatur 200mm floor is chosen with insulation. This is because there is no need to walk on the roof and the extra insulation is always welcome in case of reducing heat loss. The mezzanine floor is 280mm without insulation. These prefabricated wooden floor or roof elements are easy to assemble and contribute to a lightweight structure.

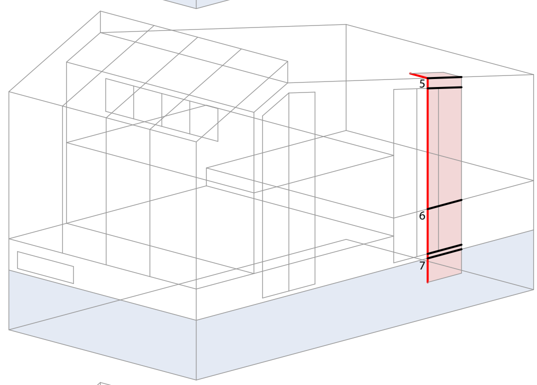
Horizontal section

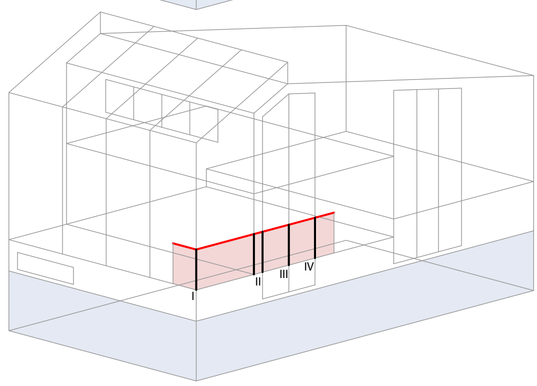
If we take a look at the horizontal section (I–IV) we see the facade opening or windows are laid back a little as well as the glasshouse. For the windows this is to provide the cohesion between the two elements, but for the glasshouse it is to make sure the glasshouses are not hitting or scratching each other when the two houses will be connected to each other.











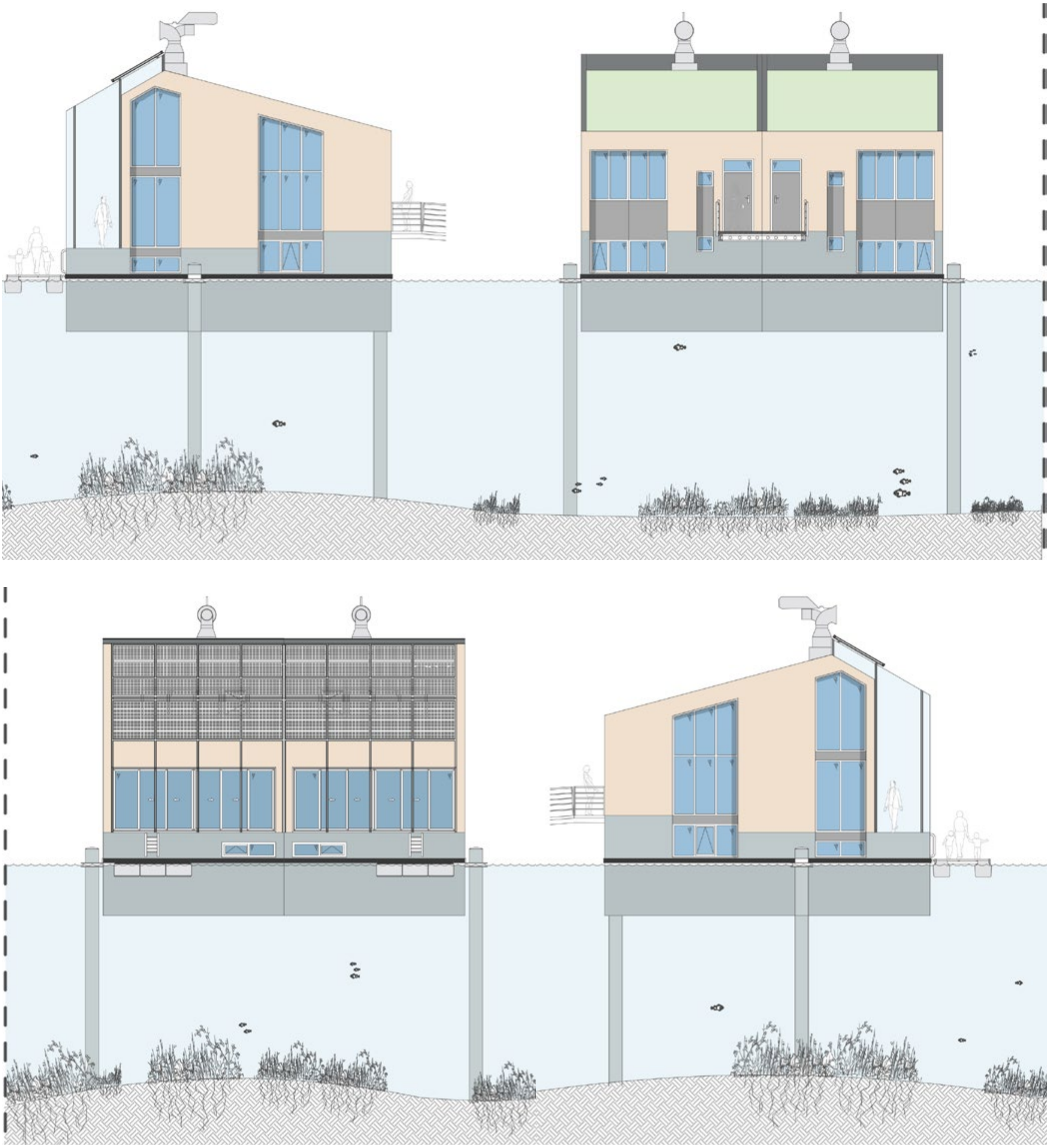


Fig. 6.5

The four elavations of the dwelling. (Own Ill.)

6.5 Elavations

A normal house has 5 facades. North, West, South, East and the roof. In this design the facades differ from each other because they have different purposes or functions. Each facade will be explained separately.

When the houses are entering the urban plan they will be connected to each other to increase their stability and decrease fluctuations what results in a facade with no openings. This side of the house, the West or East side, is the constructive facade. It has only the aim of connecting the houses to each other. The whole facade has no openings, which improves the Rc value. To make the connection watertight or let it open is a questionable point. In this elaboration the space in between, around 8 cm, is left open.

The roof has a 15-degree angle and is used to collect water. The roof consist of a green roof which brings many advantages. It is not only better for the durability of the roof; it also contributes to filtering fine dust out of the air and gradually discharge the rainwater. Compensating the lack of green down town is not even mentioned.

The North facade has the main function to connect the house with the jetty and the utilities of the mainland. The entrance is on the side of the house located next to the neighbors so the walkway to the jetty can be made out of one to have minimal width.

The side of the building as well as the North side has esthetical intentions. The concrete box makes this house float. Therefore the transition from concrete to wood is an important aspect what has been emphasized here in the external view. The windows in those two facades are deeper and are not disturbed when a change of floors occurs.

The facade opening continues what visually contributes to the transition between the two elements, concrete and timber frame.

The South facade has primarily climate considerations and is there to optimize the climate aspects of the building. The top part of the vertical glass is has integrated PV cells, while the lower part has no PV cells so that the horizontal view wont be disturbed. The inclined portion of the roof is partly filled with the same integrated PV cells but has on the top PVT panels that are not translucent.

The inner facade on the ground floor has large sliding doors almost completely out of glass to allow the winter sun to heat up the thermal mass. The windows on the mezzanine are there for other intentions than the windows on the North and side facade. Those windows are important for airflow reasons. The operable vents contribute to the stack effect in summer and let preheated air in during the equinox.


Urk
Amsterdam
Utrecht
Rotterdam

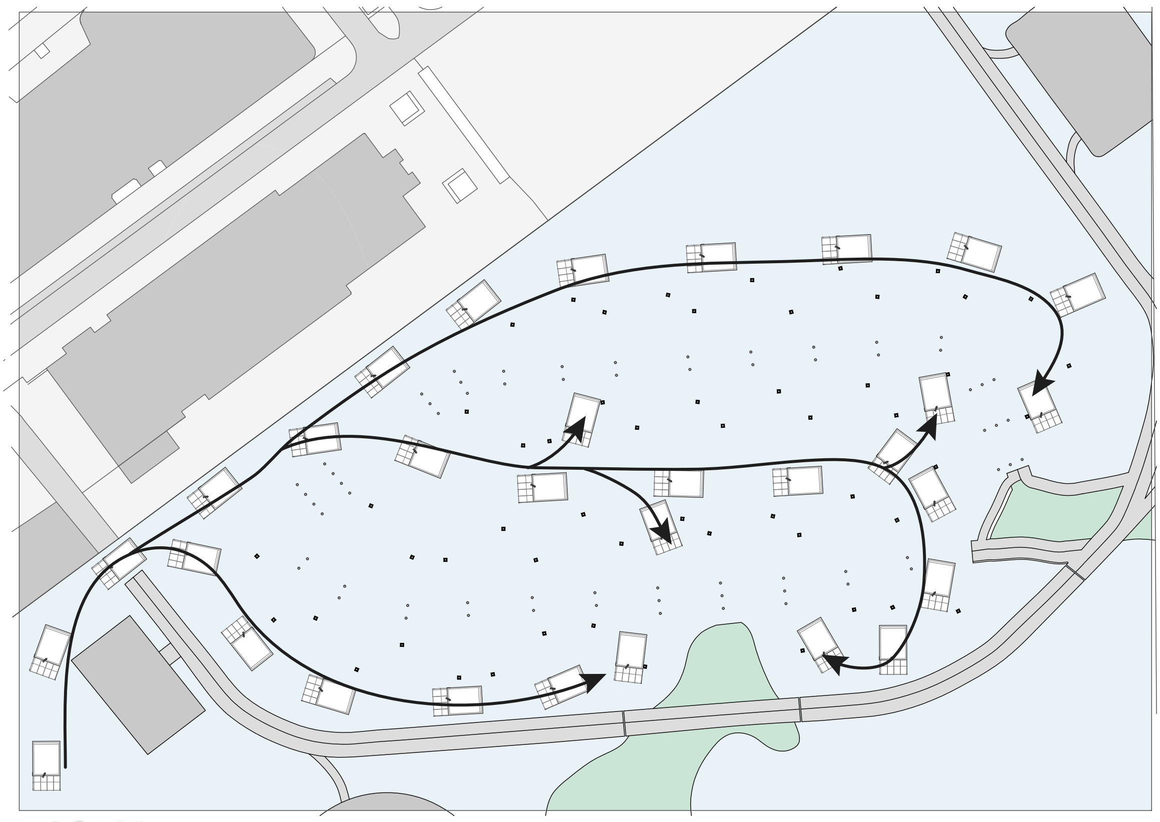


Fig. 6.6.1

Route over water from Urk where the engine house is located till the final destination in the Rijnhaven of Rotterdam. (Google Earth)

Fig. 6.6.2

After the floating dwellings have been transported they need to be put on their place really carefully with all the piles and in a certain order. (Own Ill.)

6.6 Transport

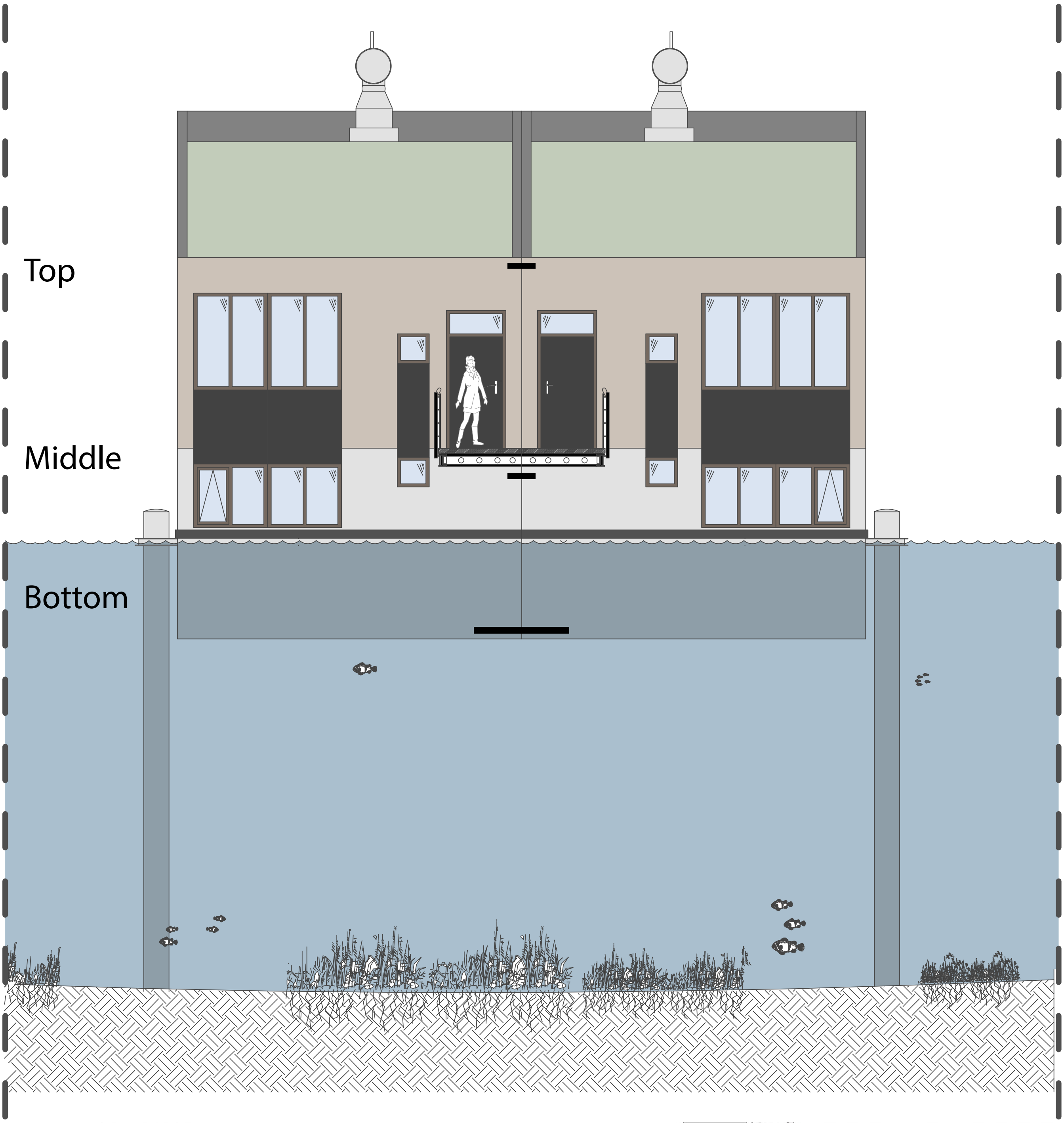
The whole building will be constructed and brought to water in a construction hall. The company who can do this and have done almost the same task for floating houses in IJburg in Amsterdam, is ABC Arkenbouw located in Urk. From there the houses will be transported over water to the Rijnhaven in Rotterdam. In total a journey of 160 km.

This journey will take more than a day because transport over water is not the same as over land. One of the reasons why the speed is limited is to prevent splashing of the water while sailing and the other one is the stopping distance.

Transporting the house over land is also an option but has to be proceeded very carefully. Additional difficulties are that a heavy crane is needed to put the house into the water.

The plan includes 54 houses and each one of them has to travel all the way from Urk to Rotterdam. Financial reasons will determine which transport possibility will be chosen. Nevertheless will it be a challenging project to transport all of the houses to the final location without damaging one of them, worth around 600.000 euro each.

But there is an other option which can reduce the transport costs significant. The old harbours of Rotterdam has planty of space for building the houses on sight. In the Eemhaven for example are many empty old engine houses which can be used. In that case the transportation is only a couple houndreds of meters in stead of houndreds of kilometers.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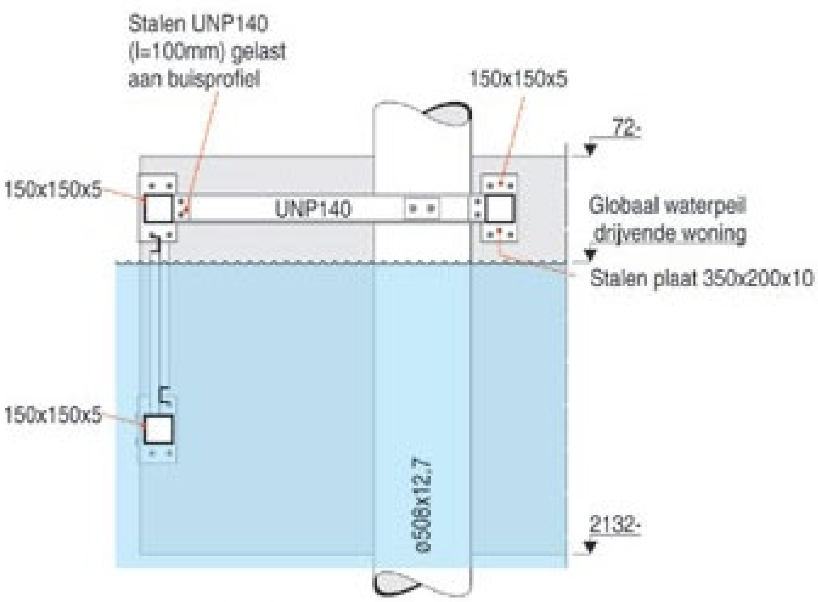
Middle
Bottom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aan buisprofiel
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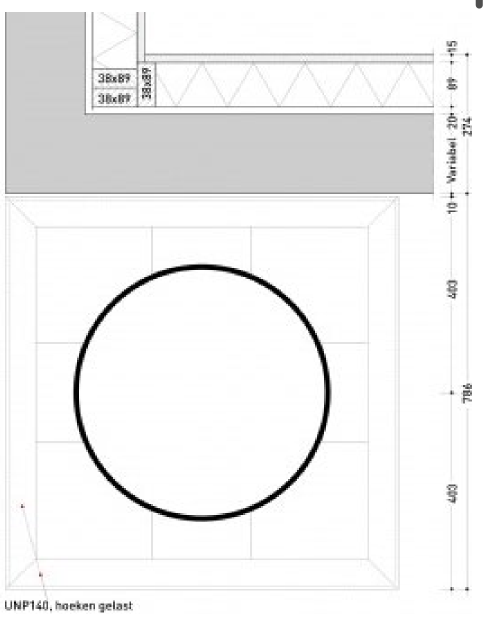
ø508x12.7
2132


38x89
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15
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UNP140, hoeken gelast

Fig. 6.7.1

Three constructive attachments who will be done on sight. In the bottom is the largest one tha provides the stability. The one in the middle and top are to prevent friction and scraping. (Own Ill.)

Fig. 6.7.2

The margins can be to much in practice to make it fit right away. This rail can be add to make it fit on sight. (Own Ill.)

Fig. 6.7.3

Top view of the attachment form concrete box to pile holder. (Own Ill.)

6.7 Anchoring

After the floating houses arrive in the Rijnhaven they have to be anchored carefully on their place. Floating the houses into their positions according to the urban plan has to be done in a certain order to make sure there is enough space.

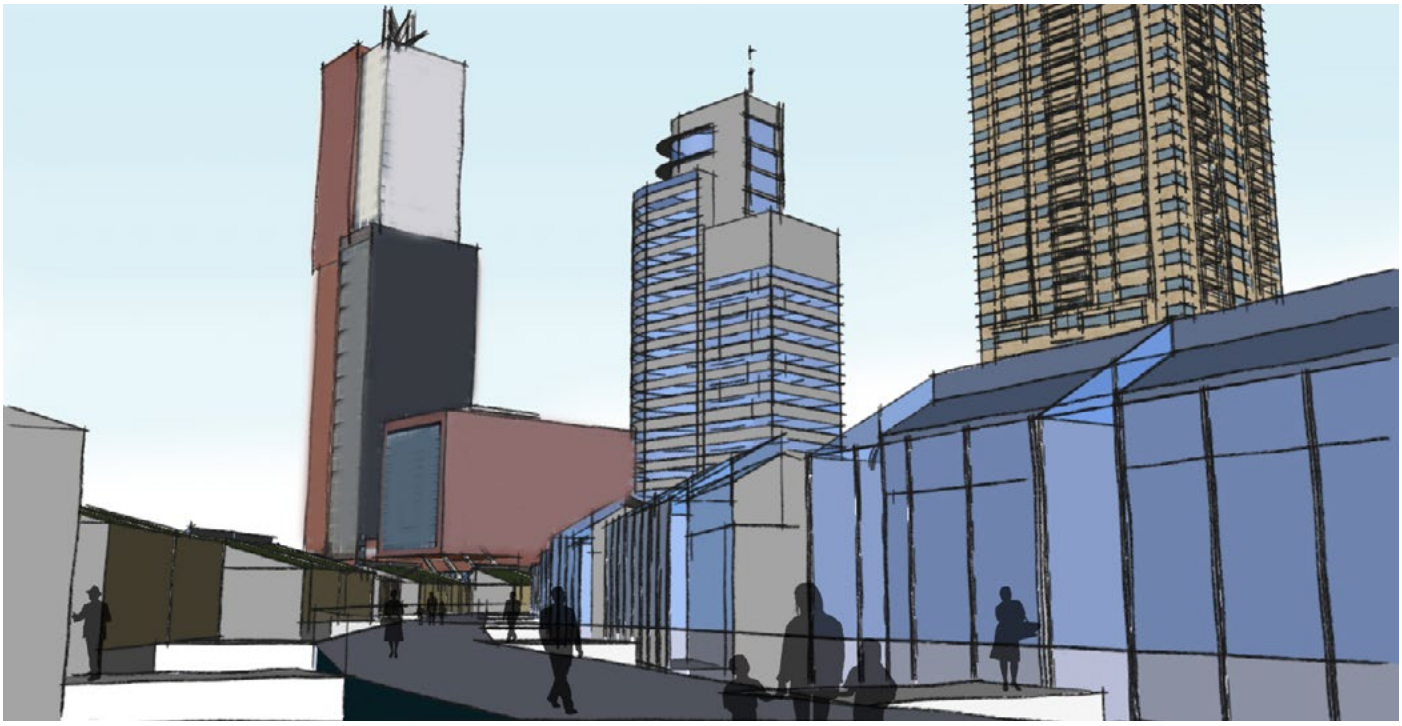
This process takes place after the jetties are in place, except for the houses at the most Southern part. The two houses are connected to each other to increase their stability and decrease fluctuations. This will be done at three places: at the top, middle and bottom. These connections will be carried out on site.

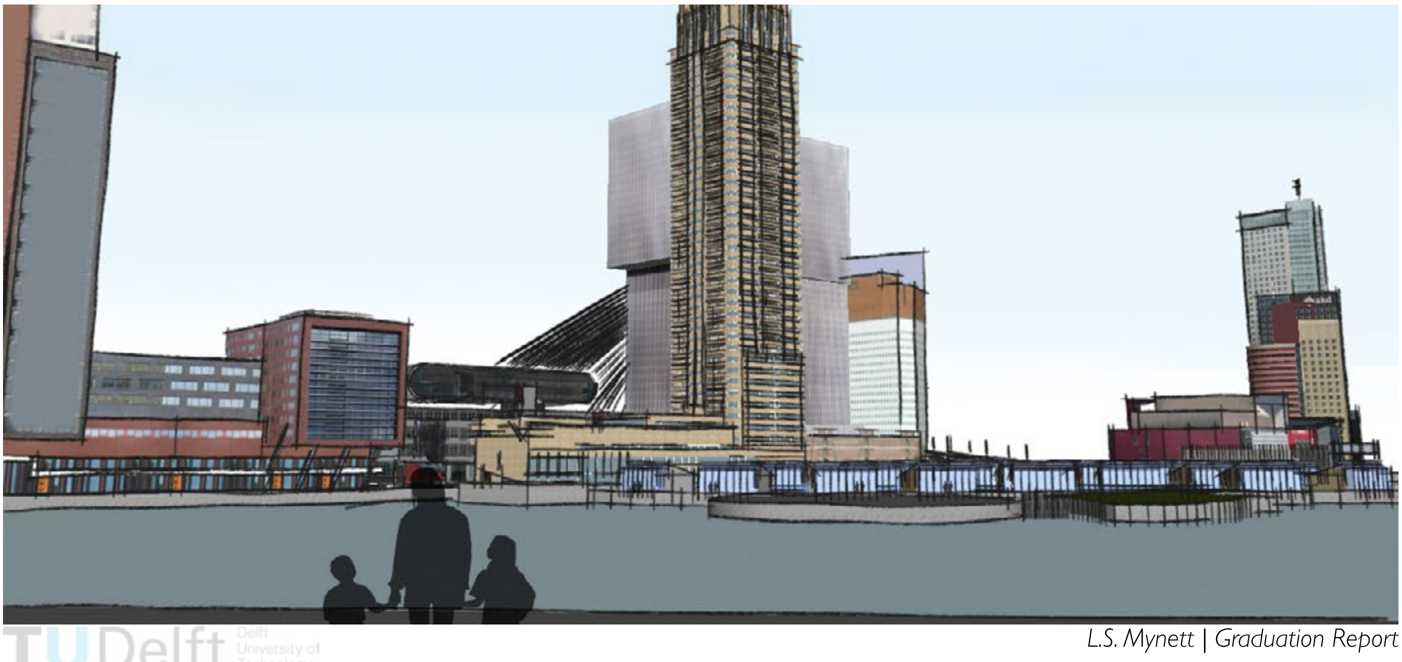
When connected the houses function as one and can only move vertically along the piles. There are two piles the two homes will be anchored to. The position of the piles are in the extension of each other and has only the function of holding the homes on their place. Sliding in the vertical direction is possible. There are rubbers placed to prevent shocks when the houses are wobbling.

It is practically impossible for the house to get disconnected from the piles, because under normal circumstances the fluctuations will not be more than 20 cm. This is why there is always a piece of the pile in sight from an external view, but they are positioned in a way you don't notice when you are inside.

Conclusions

At the micro scale all the elements and components come together. Each separate element is well known in the building technology world. Floating concrete boxes, glasshouses and houses made of timber frames are not innovative by themselves. But putting those three elements together, the cohesion between those three and the way they work together to reach their main goal 'a climate adaptive, energy efficient and sustainable urban house' – that is innovative indeed!





Impressions

Fig. 7.1.1

Sketchy impression of the urban plan from the top of the Montevideo building on the corner of the Wilhelminapier *(Own Ill.)*

Fig. 7.1.2

Sketchy impression from the jetty with the floating houses on both sides of the jetty. *(Own Ill.)*

Fig. 7.1.3

Sketchy impression from Katendrecht on the urban plan. *(Own Ill.)*

The urban plan does not solve a housing problem, but it does contribute to the floating development plans. There are three impressions, (a) of the roof from the Montevideo building located on the end of the Wilhelminapier, (b) on the jetty of the urban plan with on both sides houses and the last one (c) from the opposite side of the Wilhelminapier, Katendrecht.

Conclusions

If we look at the energy consumption of a household we see transport is number one. Open areas in a downtown area are not easy to find, which explains the long travel distance people make. Old harbors are located in the center of a city on the other hand are mostly wasteland. The reason is that the area has a high flood risk because it is located outside the dike. To develop housing in such areas they need to be built in a climate adaptive way that overcomes the problem of flooding.

Urban

The urban plan had a few criteria that were taken into account. Minimizing the size of jetties, maximizing the number of houses, creating parking places and making the plan fire proof were the main points. Fitting as many houses as possible in the plan would make the financial aspects more convincing. Ensuring the fire safety of the plan means there are always two ways to escape, hence the circular infrastructure. This plan brings all aspects together to provide a stable and realistic base for the architectural design at the meso scale.

Climate

The house is using the sun and the water to regulate the indoor climate during all seasons. There are active and passive energy systems integrated in the design. The active energy system are PV cells integrated in glass, PVT panels, heat recovery units, floor heating/cooling, rainwater collectors and in the bottom of the concrete box is a system of pipes positioned to transfer heat and cold with the ambient water.

The passive energy systems contributed to the shape and orientation of the design. Thermal mass on the North side for cooling during summer, thermal mass on the South side for absorbing deep penetrating sunlight during winter, wind cowls, thick insulation and good crack sealing are the main passive aspects. The green roofs lead to a gradual discharge of rainwater, provide better isolation, increase rooftop protection durability, provide compensation for lack of green in cities and help purify from fine dust. Another great passive aspect is the incoming light which is reflected from the water to the ceiling what gives a beautiful visual experience.

Construction

The homes are composed of 3 elements:
- The concrete box functions as the floating part
- The timber frame lowers the center of gravity
- The glasshouse is used for regulating the climate

These three elements together lead to an architecturally, technically and aesthetically interesting design. The elaboration of the details proved that the design could be constructed flawlessly.

The homes are designed as two-under-one-roofs. After being transported independently to their location they will be connected to increase the stability and decrease the obliquity.

The main goal "Designing a climate adaptive, energy efficient and sustainable house" has been achieved because of the good integration between the macro, meso and micro scale in this design.

Recommendations

After finishing my graduation project I would like to suggest some improvements what can bring this design to a higher level. 'Time is relative' is an old saying of Albert Einstein, but during a project there is always a deadline and time becomes automatically less relative, what results in a certain level of elaboration. Assuring all the different aspects and scales are elaborated to the same level is most important. But if there would have been more time, there were certainly some aspects that could have received more attention. Therefore I present you my recommendations.

Macro

At the macro scale there are infrastructure, parking places and good accessibility of the houses but one thing is mising. Urban plans need public space. People shouldn't be isolated in their homes. Feeling free to leave your house and meet people in public spaces like parks, or squares are essential to making a urban plan succeed.

Green can be found on the islands and the Rijnhaven-park situated parallel to the whole length of the road. But this public space is nearby the urban plan and not integrated. Elaborating the urban plan on a macro scale could increase perception or experience of the neighborhood. People who would like to fish on the side of the jetty or kids who always love the play a little soccer for example have to find their own spot now. Creating an urban plan that can be built, is safe, has all the technical aspects, and fulfills the requirements is one, but integrating those requirements into an appreciated urban plan is another.

Meso

The house is formed to optimize the indoor climate what is clearly explained in chapter five. Form follows sun is the formula that is applied to form the house. Although the simplicity of the design is also the key to success, the design how it is drawn now could be elaborated even further. Half of the houses of the plan do have the entrance on the other side of the building. The jetty is used like a corridor to reduce the amount of needed jetty. The principle of the other house is the same but the floor plans will be definitely different, as well as the place of entering the house. More likely is to enter the house from the side to enlarge the private feeling of the glasshouse.

But also the house I designed could be seen as a preliminary design. In my opinion it is completely finished but the heat mass is relative simple and a challenge could be found in giving the house a more complex mass for further improving the climate aspect. Although the houses are connected to each other what make them certainly different from each other, one has a West and the other an East facade. Also this aspect could be elaborated to achieve more diversity. To summarize the different buildings according to the 'Form follows Sun' in this plan there are 4 types: South-East, South-West, North-East and North-West. Making a distinction between those types could optimize the design even further, if it is done correctly.

Micro

On micro scale this is one of the many elaborations and interpretations of the concept. The concept is to clearly show the house consists of three different elements.: the floating concrete box, the light timber frame construction on top, and the climate regulator zone fully made out of glass. Those three elements have a diversity of materials. Wood for example is a product with many different colors, ways to attach and structures. Choosing a different type of wood completely changes the external view of the house. With this aspect there are endless numbers of possible combinations to further diversify.

Reflection

Motivation

This graduation project started with my interest in developing housing on water. Before I started my graduation project I went with the Building Technology S.W.A.T. Studio on an excursion to Sarajevo in Bosnia-Herzegovina. The only water problem we found was the sewage system, which flew right through the city. The whole country is around 500 meters above sea-level what explains why there is no flood risk for example. Back in the Netherlands I was deeply interest in water development and floodrisk areas. Two third of the world is water with everywhere flood risks as a result. The flood issues in Asia and parts of the United States are enormous but before failing in an attempt to improve the world I realized I should start small.

Problem Statement

The Netherlands, also two third under water if there were no dikes and pumps, is also dealing with water issues. The dikes prevent us from flooding. Pumping water upwards give us dry soil where we can build on inside the dikes. Outside the dike on the other hand, it is not safe to build, because there is no control of the water-level. Therefore it is impossible to insure a building. Building in a climate adaptive way where houses rise together with the water, for example by floating, can provide opportunities.

After talking to lots of different people I came in contact with Prof. Chris Zevenbergen who introduced me to the "Kaviaar aan de Maas" group a group of people working together to design an urban plan for the Rijnhaven in Rotterdam. The Rijnhaven became my case study. One of the participants was ir. Duzan Doepel who offered me an internship at his office DoepelStrijkers architecten. In cooperation with them I helped developing the urban plan for the Rijnhaven, which I used as the starting point for my MSc research.

Research Question

My main research question reads:
"How can we transform old harbors with high flood risks into a climate adaptive urban design with energy efficient houses?"
Sub research questions are:
"What are the complexities for the case study Rijnhaven?"
"How can these be addressed in a sustainable way?"
"What does this imply for the predesign?"
"What are the design considerations?"
"How can the sun influence the design to become as energy-efficient as possible?"
"How can buildings become climate adaptive?"

Research & Design

In my research I read a lot about floating houses, floating development and urban plans including a lot about water. There are many reports written about being a climate adaptive city: Rotterdam Climate Adaptation, Rotterdam Climate Proof, Floating Development, Waterplan, Ready for high water, Advice Deltacommision Waterdistrict, Structural Vision, Delta Innovations, Creating on the Edge, Rijn-Maas harbor Future Vision, just to name a few related to Rotterdam.

After reading them I came to the conclusion that Rotterdam cannot wait to become climate adaptive. The city cannot wait to become water proof, the first water proof city of the world. Being world leading on such major issue is a driver for Rotterdam.

But what stops them from doing it, why don't they start building on water (yet) and start using all this free space with floating developments? Money is the answer. Not all the parties are completely convinced and these days investments in projects which have never been done before is considered too big a risk, especially for developing at the large scale like

Rotterdam would like to see. Learning from these visions and with all the knowledge of floating buildings I started sketching and came up with a preliminary design. All the complexities of a normal house put into an urban plan that contains a lot of water and only a small number of jetties ensured, I had to consult not only the literature but also companies like ABC Arkenbouw quite a few times.

Theme & Studio

The studio building technology lets you quite free in finding a topic that fits you best. In comparison to my fellow students my graduation project is completely different, although my final design is in my interpretation really a building technology subject. After my preliminary research but before my actual design (around the P2 period) I had quite a difficult time. Thanks to the feedback received during my P2 evaluation ("you need to make things more concrete for yourself or else you can never take this graduation to a higher level"), I found the way forward.

If I were in the Urbanism master track course I had elaborated the urban plan into a system with maybe phases of how old harbors could operate again. Or an approach to restructure these parts of the city and connect them back to the living areas. But all of these elaborations do not meet building technology requirements, which was the master track which of my first choice.

In order to connect the floating development theme with the master track building technology, I designed a floating district that can be plugged into the urban plan I had helped develop during my internship. Having the main theme of connecting energy, water and waste flows to create a closed circle led to a floating energy efficient plan located in the Rijnhaven, which gives a great impulse to the urban plan.

Studio Approach & Chosen Method

In the S.W.A.T. Studio we worked al lot with the macro-meso-micro principle. Zooming through a plan or design treating all different scales contributes to the integration of the design with the context. Pragmatically working gives the design all the content it needs. I found out this approach was really working for me to keep the overview in the project. I know I can easily loose myself in perfecting a detail or less important part of the design, and it is good to know your own weak sides so you can prepare and prevent yourself doing it.

I applied the macro scale for the urban design. After macro I found the meso scale in my house design and lastly the micro scale in the details. All scales affect each other and the macro-meso-micro approach helps integrating these scales.

Design & Social Context

My problem statement names 'developing outside the dike'. Old harbors that are loosing their industrial function become empty areas that are desperately in need of a new function to prevent the quality of the areas to decrease and become unsafe and plagued with criminality.

Developing these old harbors, which created the city in the first place, would resurrect the areas and bring revaluation to the city. Social control will rise when people live there and criminality will eventually be pushed out of the area.

The Wilhelminapier is leading this future image and I think this project is a great way to achieve this perspective and contributes to making this restructuring a success.

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2nd: Dr. Craig Lee Martin (Sustainable Design)

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