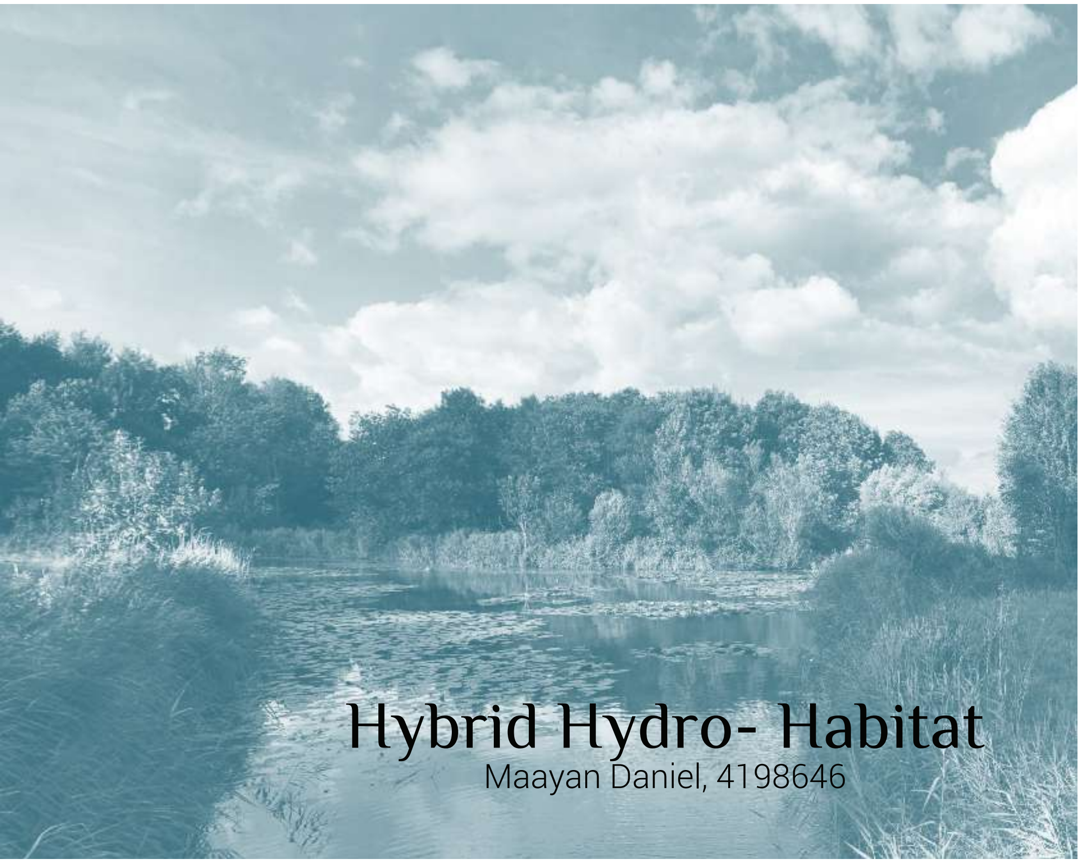

Hybrid Hydro- Habitat

Maayan Daniel, 4198646

COMPLEX PROJECTS - P5

Hybrid Hydro- Habitat

Maayan Daniel

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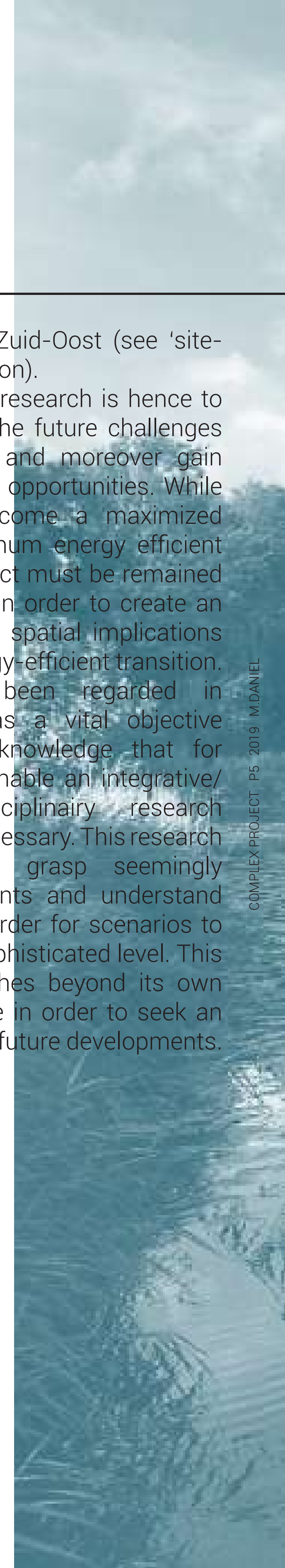
I. Introduction

Climate Change is an evident issue in the current state of the world. Moreover, as the world is urbanising rapidly complex challenges come into play into the construction of the build-environment. This quest has been answered with the introduction of the term 'Smart City', aiming towards a strategic plan for the city's development based on detected data.
The municipality of Amsterdam has therefore comeforth with an interesting request for architecture students of the Technical University of Delft within the studio of Complex Projects to investigate the future challanges of Amsterdam through scenario-research and hence come up with proposed spatial and/or architectural configurations within the year 2050.
Three themes were to be addressed: energy, mobility and health, from which each student had to pick one theme as a focus of their research. Although these areas overlap when regarding specific spatial consequences or solutions the theme energy has been taken as the main focus of this project and its related research.
This report hence reveals a scenario-research, site-research and spatial-research within the scope of the theme energy, whereas the second report (see Hybrid Hydro-Habitat- Design)follows this research up with answering the retrieved conclusions of the research with a spatial configuration and an architectural project.
The location: Amsterdam Zuid-Oost, had been given as a main focus area from which an excact site had been chosen by means of scientific reasoning within the area of Amsterdam Zuid-Oost (see 'site-choice: Bullewijk Station).
The objective of this research is hence to develop an idea on the future challenges of the urban fabric and moreover gain knowledge on spatial opportunities. While this project has become a maximized strategy for an optimum energy efficient urban fabric the project must be remained understood as such in order to create an understanding of the spatial implications of a sustainable energy-efficient transition.
Sustainability has been regarded in this report hence as a vital objective encompassing the knowledge that for projects to be sustainable an integrative/ mutli-factor/multi-disciplinairy research approach must be necessary. This research therefore seeks to grasp seemingly unrelated developments and understand their relationship in order for scenarios to be developed on a sophisticated level. This research hence reaches beyond its own domain of knowledge in order to seek an optimum solution for future developments.



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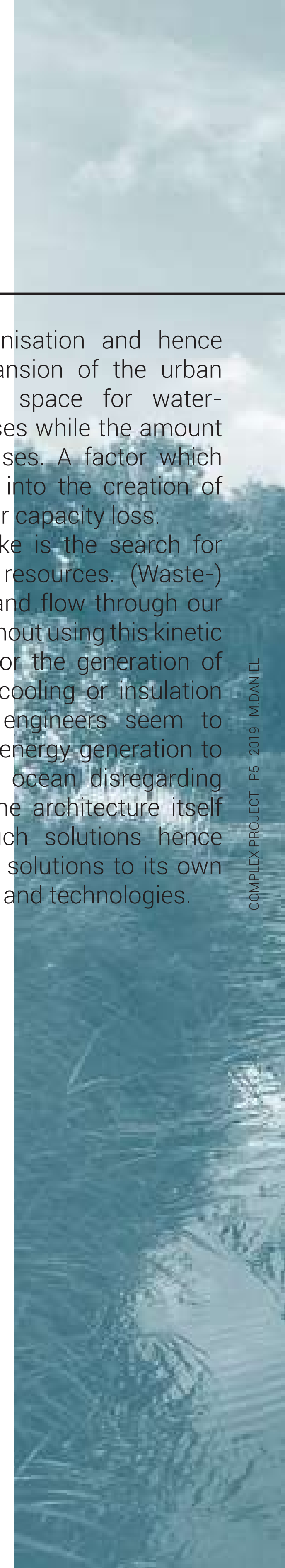
II. Problem Statement

Cimate Change and Urbanisation are a matter of fact. A myriad of problems and hence complex challanges arise for the built environment due to these phenomena. Different domains, such as sustainable energy-production, water-management and mobility however currently seem to be all addressed on a different level of expertise and scale, resulting into the loss of opportunities for flows and structures to intertwine and cooperate.
This can be illustrated by the following example regarding the opportunities for energy-production, water-management and the build environment to intertwine. As the world needs to deal with an increase in flood risk the issue on flood protection becomes more significantly crucial. An **intelligent water network** is hence crucial for the preservation of safety and health. Due to urbanisation and hence densification or expansion of the urban areas, the available space for water-management decreases while the amount of paved area increases. A factor which consequently results into the creation of heat islands and water capacity loss.
Another issue at stake is the search for carbon zero energy resources. (Waste-) Water seems to fall and flow through our build environment without using this kinetic or chemical energy for the generation of electricity or for the cooling or insulation of buildings. Many engineers seem to confine solutions for energy generation to the riversides or the ocean disregarding the opportunity for the architecture itself to accommodate such solutions hence merely restricting the solutions to its own domain of knowledge and technologies.



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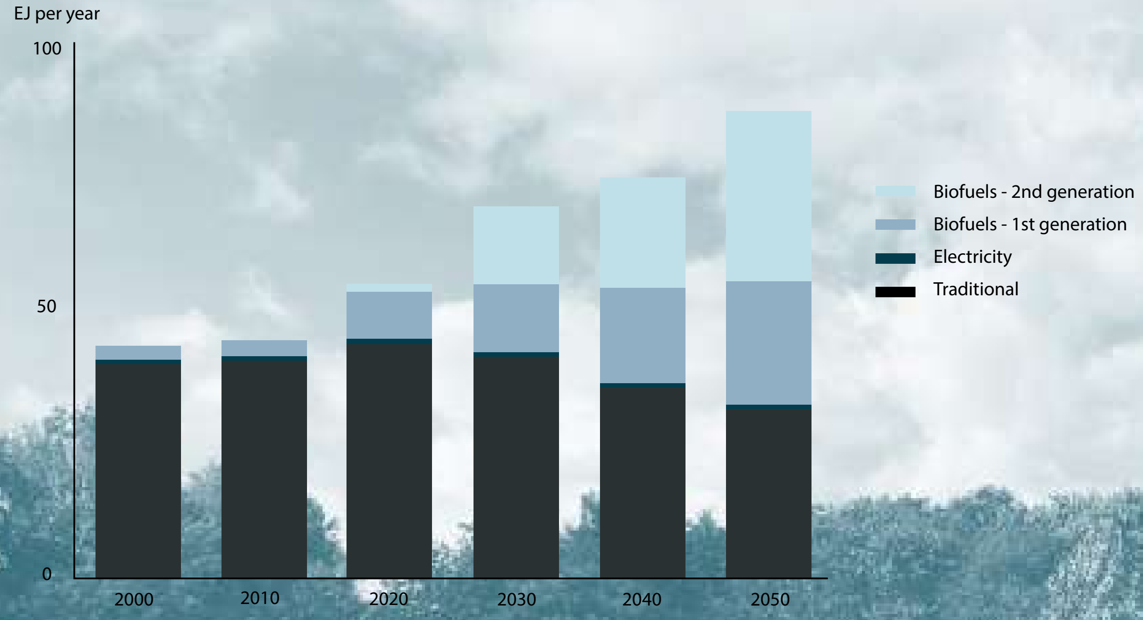
Percentage of energy production from renewable resources
Source: EIA - International Energy Statistics

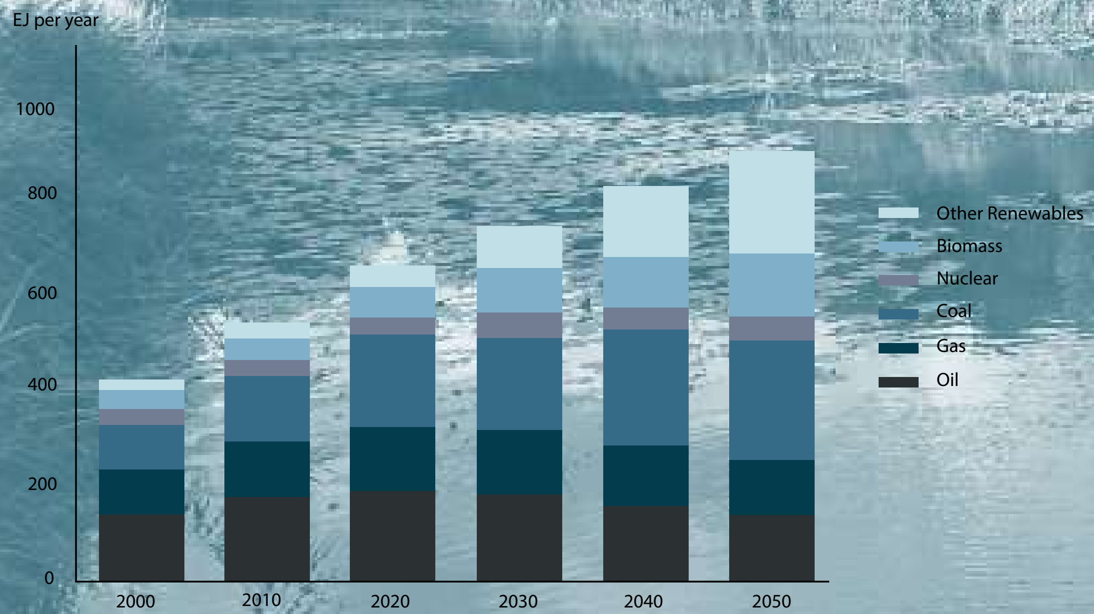
Energy Perspective

As the world seems to reach an ultimatum regarding the fact that the supply of fossil fuels is finite, it will need to face a transformation of vast proportions. During the Epoch of the Oil, the relationship between politics and urban development was clearly visible. Oil seemed to define the country's future and hence had an immense impact on the urban landscape.
Combining this notion with the fact that increased urbanisation is a matter of fact resource efficiency becomes increasingly important . The use of resources might hence alter in the nearby future since alternative renewable energy sources will be our only rescue . Talking about merely decades, this could have rapid and vast implications on the urban landscape as it already has had in the previous decades regarding the impact of oil.

The matter becomes even more problematic if we tie it on a global level to the increase of population and the transition towards a prosperity in certain countries (such as China and India). This due to the fact that history has shown that as people become richer they use more energy . Taking this matter to the level of an increase of automatized 'human' activities and dependence on technical devices such as smart phones the question arises if the energy use will increase due to technological innovation . This matter has been addressed by P. Mills who states the following:
"The information economy is a blue whale economy with its energy uses mostly out of sight. Based on a mid-range estimate,



Energy consumption from biomass (2000 - 2050)



Energy consumption by energysource (2000 - 2050)

the world's Information Communications Technologies (ICT) ecosystem uses about 1,500 TWh of electricity annually, equal to all the electric generation of Japan and Germany combined as much electricity as was used for global illumination in 1985. The ICT ecosystem now approaches 10% of world electricity generation. Or in other energy terms–the zettabyte era already uses about 50% more energy than global aviation (Mills, 2013, p. 3)"

Both regarding the quest of increased energy use due to globalisation (aviation), automation and urbanisation and the demand for zero CO2 emission resources due to climatic concerns the pressure on the construction of renewable energy resource systems becomes immense. Energy smart grids are therefore highly needed due to the differentiation between periods of energy demand and consumption.

The challenges previously addressed on both water and energy require an investment of immense value. The question which than logically arises is; who is going to pay; and is this an investment with direct economic yield? Sadly enough the national focus on maintaining economic growth leaves the climate change agenda largely disregarded, according to Shell (Shell International B.V., 2008). However as the demand for energy supply increases the emerging economic pressures make it even more difficult for politicians to act until they are forced to. As Shell states: "Nobody is prepared to risk being the first to act (Shell International B.V., 2008, p. 21)."

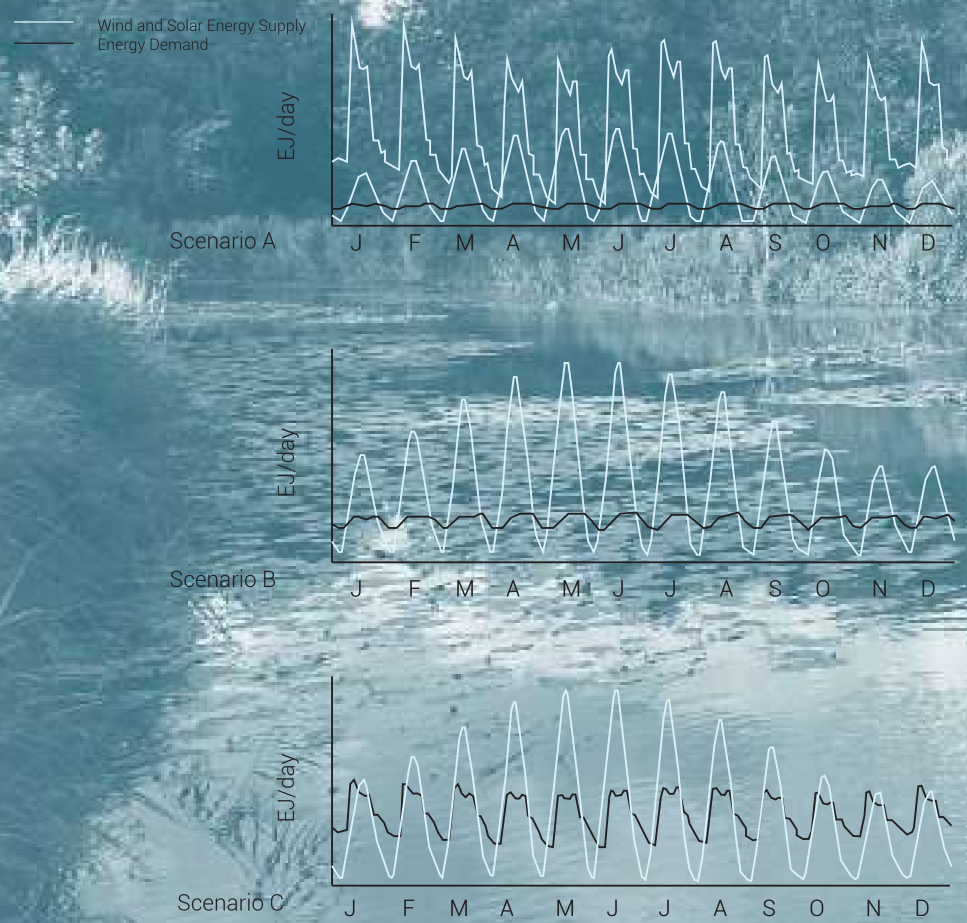
The concern for economic yield within the 'renewables' is therefore of high importance in order for this development to shift from non-renewables to renewables. Although a decrease of energy costs has been detected within technologies such as solar panels and windmills, the cost

Table I. Summary of energy storage demands in demand scenarios I, II, and III, based on the model deschribed and GEA prognosis for average renewable energy generation in 2030 and 2050.

	Short term storage demand 10^2 EJ/day		Long term, seasonal, storage demand, EJ	
Demand Scenario	2030	2050	2030	2050
I	2-8	5-9	16.5	108
II	2-9	3-20	10.7	27.5
III	1.5-8	1-14	10.8	29.2

Energy Storage Demand in 2030 and 2050

Source: F.M. Mulder (2014)



Predicted Intermittency Graph

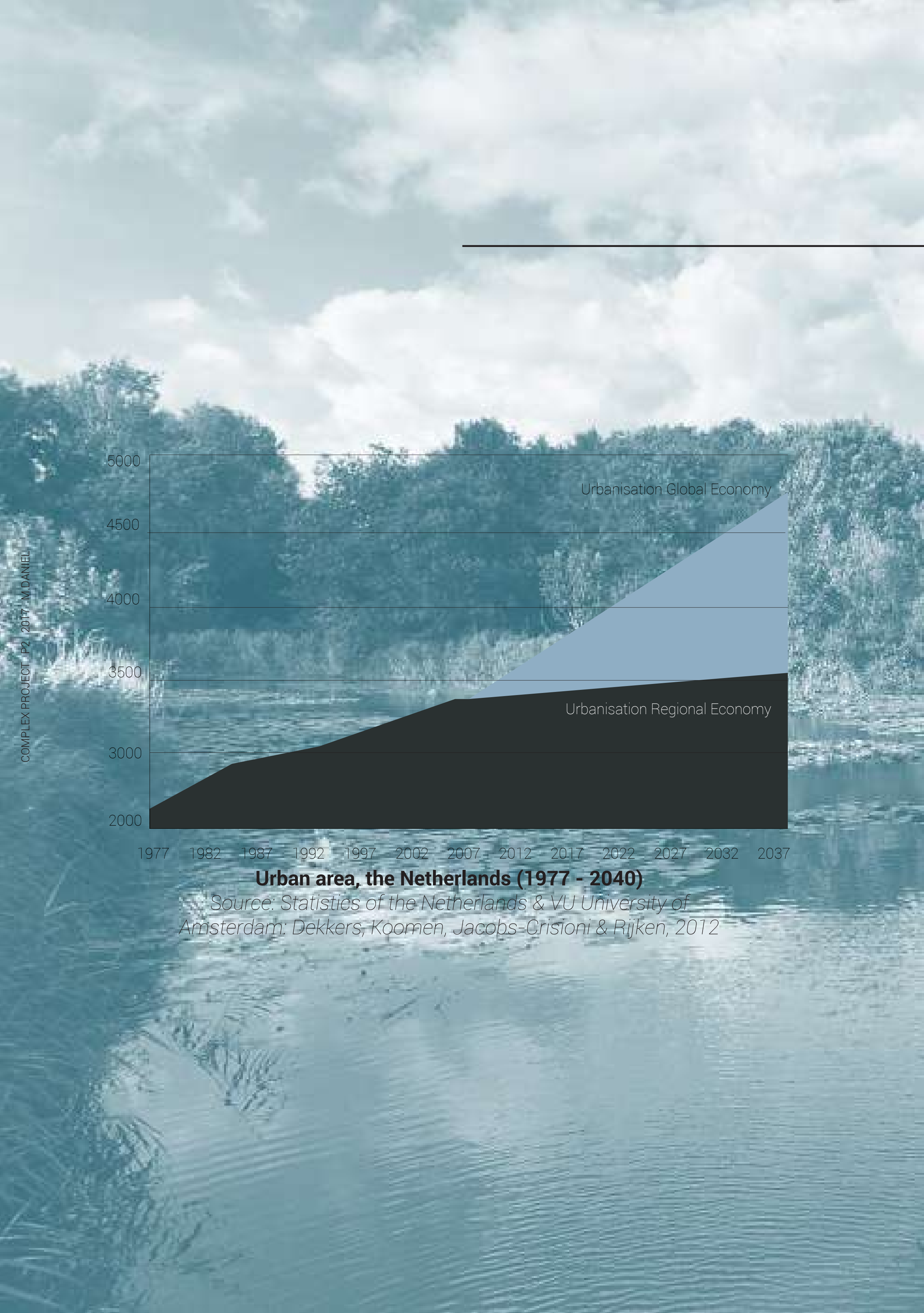
Source: F.M. Mulder (2014)

challenges remain in the net energy, their intermittency, and their capital intensity (Timmons, Harris & Roach, 2014)

Firstly the net energy, which is expressed as a ratio of energy available for final consumption divided by the energy required to produce it.
A large net energy ratio therefore means the energy generated is relatively high opposed to the energy needed for this generation. As can be seen in the table renewable energy sources generally have a lower net energy ratio opposed to fossil fuels like oil and coal. As the authors of 'the economics of renewable energy state: "Though there is a large quantity of solar radiation falling on the earth every day, it is dissipated over the whole earth's surface, and collecting such dispersed energy is costly (Timmons, Harris & Roach, 2014, p.20)" From all the renewables Hydropower however surpasses this notion according to Hall (Timmons, Harris & Roach, 2014).

Secondly an intermittency between energy produced and demanded within certain 'renewable' energy technologies constitute into a large economic burden. Energy source diversity is therefore an approach to meet and correct this intermittency. Infrastructure to store and connect different sources is therefore additionally the cost which remains. Hydro-energy can once more play a role in this matter (Timmons, Harris & Roach, 2014).

At last the capital intensity, or the capital investment needed for a certain energy generation system (Timmons, Harris & Roach, 2014). As stated previously the demand for storage capacity due to the intermittency between renewable resources is high. The first incentive might be the introduction of large (traditional) batteries within the built environment. When relating this however to the risk of flooding and therefore the risk of damage to the system this would imply elevated storage batteries. A system which however requires more construction than maybe needed since water batteries might be an alternative (Hydrogen, water) .

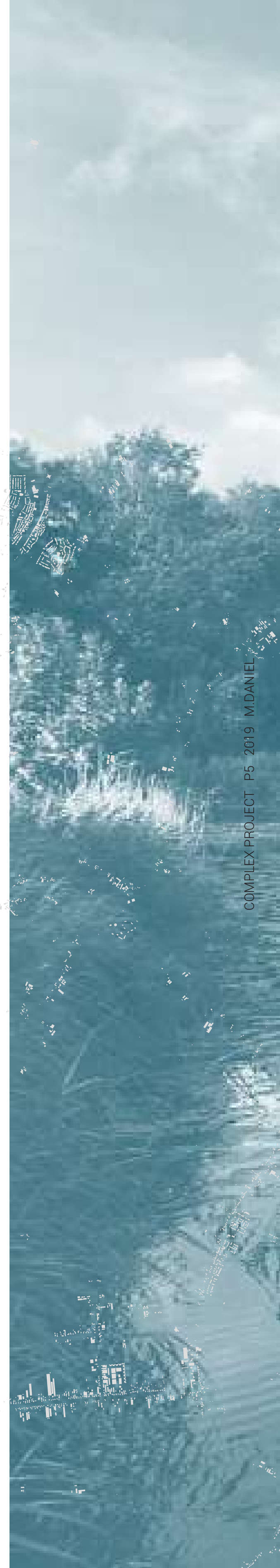


Urban area, the Netherlands (1977 - 2040)
Source: Statistics of the Netherlands & VU University of Amsterdam: Dekkers, Koomen, Jacobs-Crisioni & Rijken, 2012

Urbanisation Perspective

According to the VU University and the 'CBS' (Central Office of Statistics) Urbanisation will be a matter of fact whether based on the so-called 'Global Economy' scenario or the 'Regional Community' scenario. These two scenarios represent very different future outlooks for the Netherlands with regard to demographics, economy, land use and spatial planning and can be distinguished as follows:
"The Global Economy scenario shows a substantial population growth (up to 20 million inhabitants in 2040), a high economic growth and an expansion of the EU towards the east. A free trade agreement is operational without political integration and no initiatives for international co-operation are being taken with regard to environmental issues. In the Regional Communities scenario the population remains more or less stable (16 million in 2040), with a modest economic growth and a higher unemployment rate. Since the population in the Randstad area is still growing, this means a population decrease in certain peripheral areas. In terms of land use this effect hardly shows since the household size continues to decrease and it is not likely that houses will be demolished on a large scale. Next to that, trade barriers are implemented and taxes are levied in order to protect the environment; environmental policy receives a lot of attention and public awareness of the environment grows. These two scenarios thus describe very different future outlooks for the Netherlands with regard to demographics, economy, land use and spatial planning (Dekkers, Koomen, Jacobs-Crisioni & Rijken, 2012)."
According to this very same study conducted by the VU University of Amsterdam when regarding the Global Economy scenario a lot of urbanisation takes places near highway entries accredited by Dekkers, Koomen, Jacobs-Crisioni and Rijken to the accessibility of cars(Dekkers, Koomen, Jacobs-Crisioni & Rijken, 2012).
Furthermore, the municipality of Amsterdam aims towards an economically strong and sustainable arranged city. One of it's objectives is hence an intensified use of the current city in which simultaneously open areas of green landscape remain conserved. This will lead to a considerable increase of the number of dwellings accompanied with it's needed facilities, an intensified use of working spaces and a bigger mix of living and working. This hence requires an exta investement in the public spaces, and a more efficiently structured energy and transport network(municipality of Amsterdam, 2011)..
Thus, condensation is considered an important task for the city. Highrise is hence regarded as an adequate tool. Depending on the position of the highrise this tool can contribute to the quality of the city as a metropolitan city (municipality of Amsterdam, 2011).
The idea of positioning the highrise along the main infrastructural lines such as the a10 and along the railway tracks, mainly around the train/metro-stations, complies with the previously presented idea of the VU University to built mainly along the infrastructure. This way the green areas remain intact.

Urbanisation GE Scenario



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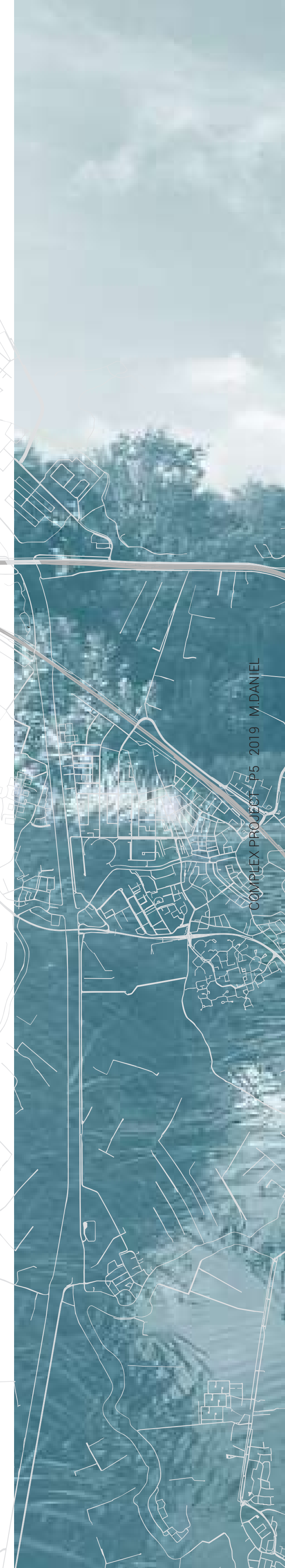
Current Position Highrise Amsterdam



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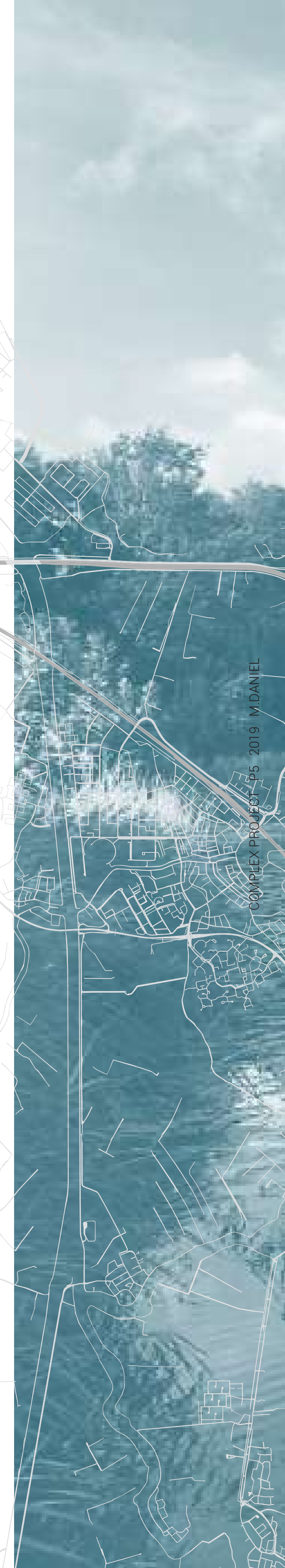
Intensification (Highrise) along Infrastructure (2020-2050)



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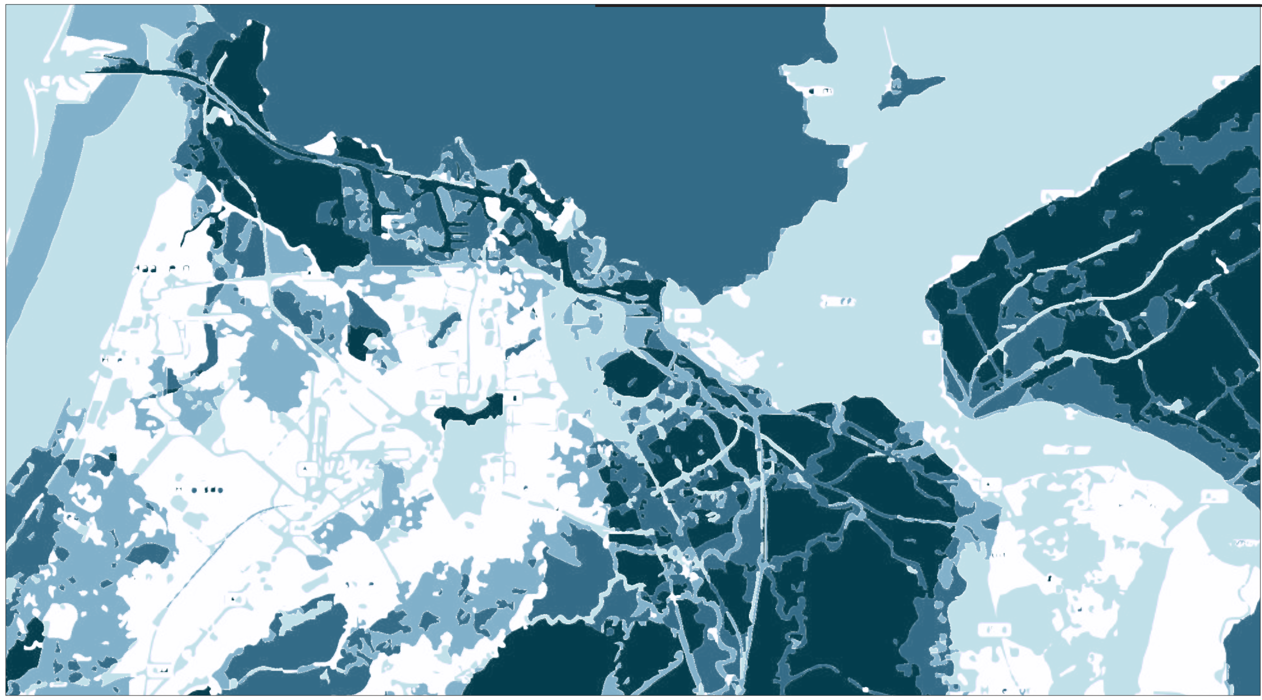


Floodrisk Amsterdam and Surroundings

"Some of the major hydrological effects of urbanization are: (1) increased water demand, often exceeding the available natural resources; (2) increased wastewater, burdening rivers and lakes and endangering the ecology; (3) increased peak flow; (4) reduced infiltration and (5) reduced groundwater recharge, increased use of groundwater, and diminishing base flow of streams (Mukherjee, 2016)."

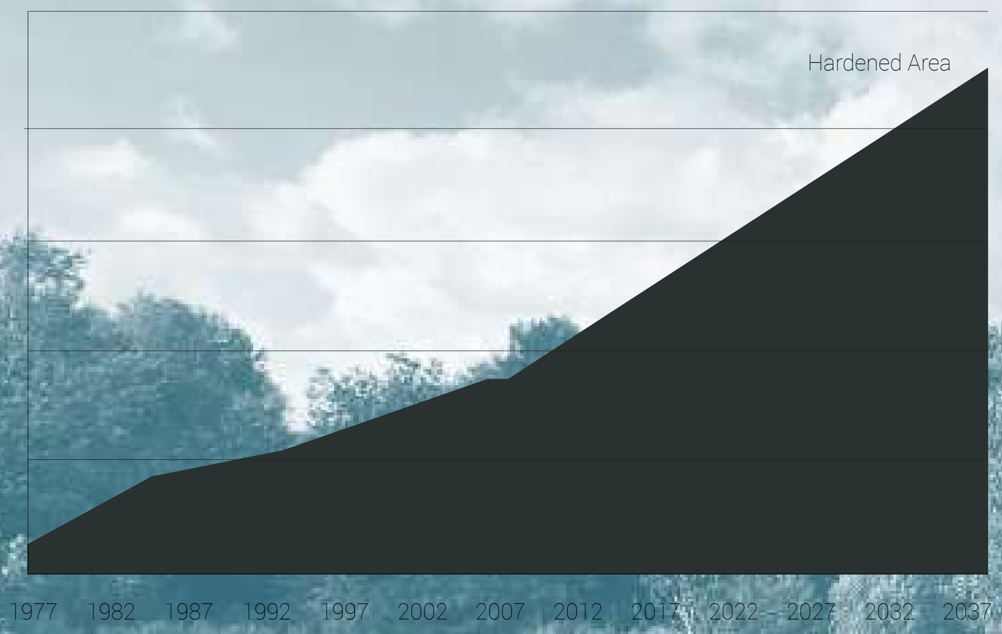
Environmental Perspective

As previously addressed flood risk is an issue at stake when regarding the future of the Netherlands. Though one might think that the water-management of Amsterdam and the rest of Holland could be defined as relatively sophisticated on the level of flood prevention due to a vast amount of gained knowledge in history on water management the actual risk has not yet diminished and will grow due to Climate Change. According to dr. Maessen the awareness and feeling of urgency to prevent such risks has decreased due to the fact that there is on average merely one flooding in each generation (Meassen, 2013). The last floods however dated from the year 1953, 1984, 1993 and 1995. Each flooding in the past induced a certain measure such as the drainage of the lake 'Haarlemmermeer', the reclamation of land in the than still to be defined as the see; the 'Zuiderzee' and the introduction of 'Delta Works' to secure safety for the provinces; 'Zeeland', 'West-Brabant' and 'Zuid-Holland' (Maessen, 2013). Every measure has however always been introduced after a flood hazard. And as dr. Maessen states: "The economic weight of water-safety is inconceivably big in the 'Randstad'*. If the water protection system will fail there will be no possibility to secure everybody. Thousands of people will drown. The economic damage will rise into billions (translated) (Maessen,2013)"

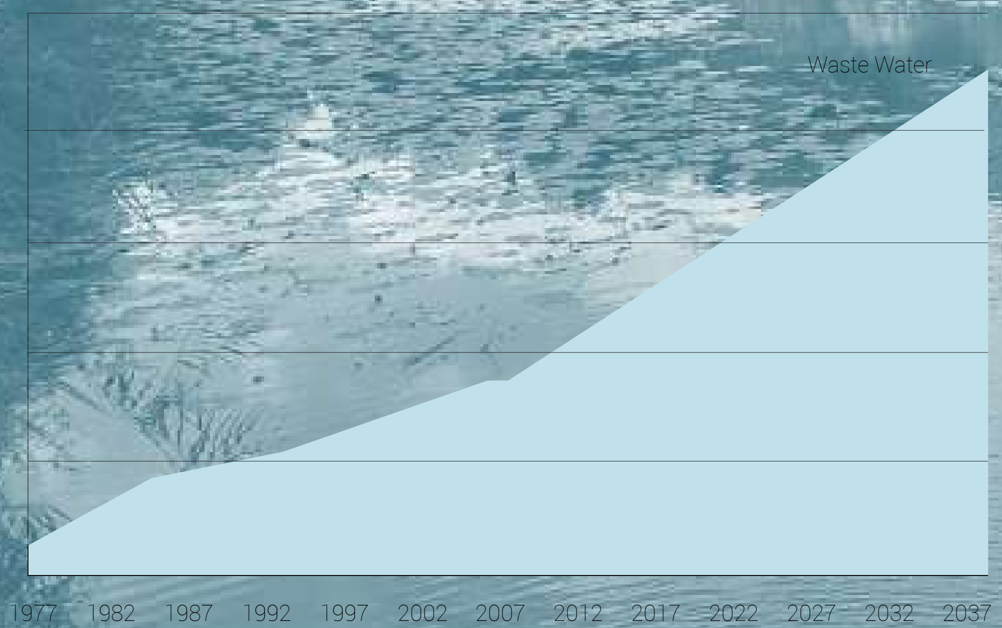
There are according to dr. Maessen three factors which influence the augmenting flood risk:

1. The soil of the Netherlands is tilting: on the west side of the imaginative line between 'Emmen' and 'Bergen op Zoom' the soil level is descending whereas on the east side the soil rises. A large piece of the Randstad, which is already below sea-level, will continue descending at a rate of ten to sixty centimetres within 30 years (2050) (Maessen, 2013). This is not merely an effect of natural subsidence of the Netherlands but also a result of urbanisation and intensive agriculture (van der Ven, p. 178 dutch water cities)
2. Due to Climate Change the rate of severe rainfall will increase in Europe. This will apply mostly to cities, as they tend to have higher temperature than the countryside according to van der Ven (p. van der Ven, 2009).
3. Due to Climate Change the sea level will rise. This requests a drastic enforcement of sea-dykes which will protect the low-land in which the Randstad resides.

However, it's not merely these factors which aid to the augmentation of water risk but moreover the expected prospect of urban intensification (gemeente Amsterdam, 2011). It is mostly in cities that the surplus of water cannot easily be filtered due to the large-scale building over the last fifty years which result into a high risk of flooding in such urban areas according to van der Ven (van der Ven, 2009). It is the increased amount of hardened area which lead to a higher burden on the surface water- and/or sewage-system since the ability for water infiltration through the soil will decrease. The current guideline for the amount of surface water needed is therefore 10 %.



Hardened area, the Netherlands (1977 - 2040)



Waste water, the Netherlands (1977 -2040)

The waterprotection in the 'Randstad' lies currently in the hands of 'Rijkswaterstaat' and six water conservancies. The conservancies pump the water out of the low laying areas into the 'boezem'; a connected series of lakes, ditches and rivers which serve as a receptacle.
There is currently no policy in the Netherlands for crucial institutions like hosptials and energy plants to be place on elevated planes. Some institutions have however come up with their own measures such as the Amsterdam internet exchange. Instead of introducing such measures within jurisdiction the water administrators try to make the whole area water proof. The safety is organised in such a way that the 'Randstad' retains a higher flood protection level than the rest of Holland. The dykes, weirs and pumping stations are designed in such a way that there is a flood chance of 1:10 000 (year). In other area of Holland the norm resides to for example 1:4000 (in the 'Betuwe').
The water conservacies call for attention for climate change in order to invoke action. If we do not do anything we will have 71 billion euro of damage due to flooding and draught. According to van der Ven we need to act together with the state, the governments, the inhabitants and the companies. Moreover, there are extra measurements needed. The creation of hardened area results into an increased presure on the surface water areas and on the sewage system, due tot the fact that the rainwater drainage will be less guaranteed by infiltration in the soil. The increase of the pressure should be compensated by the initiator. The urban areas should therefore encompass at least 10 % of surface water.
"The economic weight of water-safety is inconceivably big in the 'Randstad'*. If the water protection system will fail there will be no possibility to secure everybody. Thousands of people will drown. The economic damage will rise into billions.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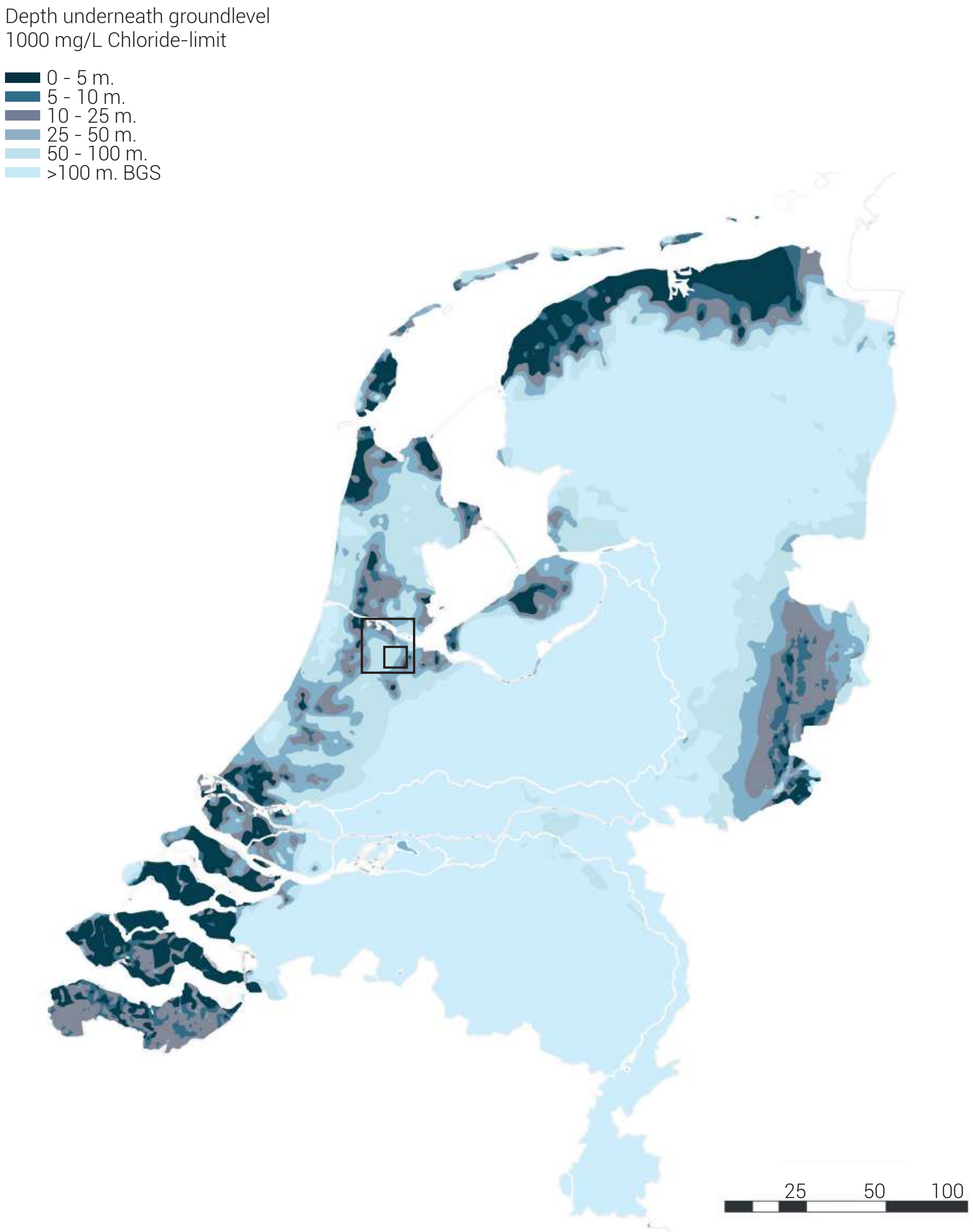

Current Availability of Salt Groundwater, 2018
Source: Deltares (2018)

Salinization

Salinization of the groundwater is a matter of fact and receives increasing attention in the Netherlands (de Boer, H & Radersma, S., 2011). This has various potential consequences on for example our fresh drinking water supply, agriculture and nature. Action is therefore required in order for these potential problems to be tackled. Different processes affect salt water intrusion in coastal aquifers (Center for Climate Adaptation, 2019):

- sea level rise (Post (2005), in: Van Dijk et al. (2009);
- over-exploitation of drinking water reservoirs to keep up with the increasing demand for domestic water (Post (2005), in: Van Dijk et al. (2009), Abd-Elhamid and Javadi (2008), in: Van Dijk et al. (2009));
- land subsidence (Oude Essink (2001b), in: Van Dijk et al. (2009));
- change in river discharge (Oude Essink (2008), in: Van Dijk et al. (2009));
- change in precipitation / evaporation ratio (Oude Essink (2007), in: Van Dijk et al. (2009));
- environmental conditions in the Holocene (Post (2005), in: Van Dijk et al. (2009),Oude Essink (2001b), in: Van Dijk et al. (2009));
- disruption of the natural hydrological system like the upstream intake of water from rivers, which reduces their discharge. This can lead to upstream migration of seawater in the river mouth, and shoreline retreat due to the reduction of the sediment load to the coastal zone (Post (2005), in: Van Dijk et al. (2009));
- the number and depth of ditches and the amount of water pumped from ditches, since the seepage flux is proportional to the difference between sea level and ditch water level (Maas

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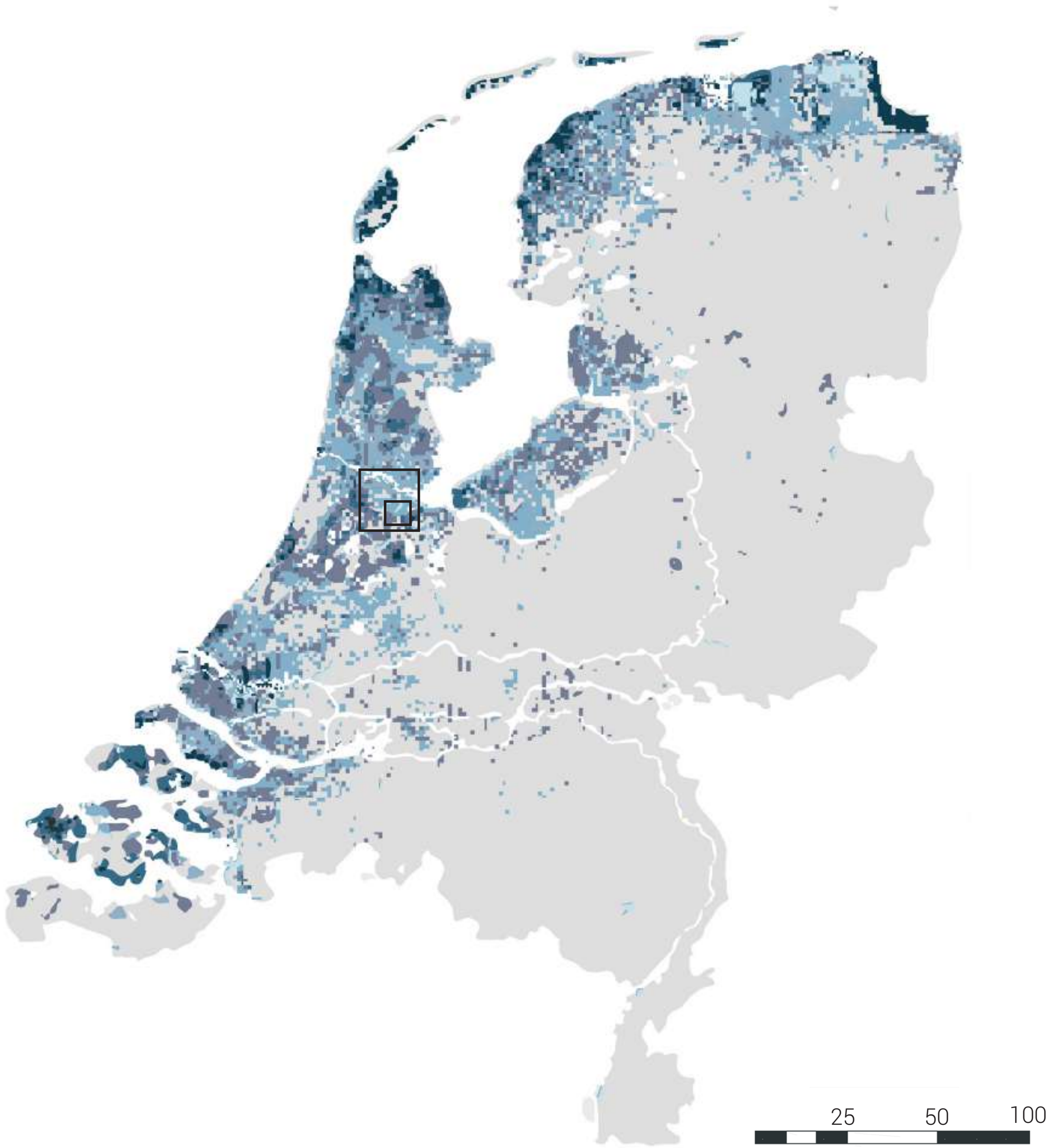
Difference in mg Cl/litre

- Strong Salinization (> 3000)
- Salinization (1000 - 3000)
- Light salinization (100 - 1000)
- No change expected (0)
- Light freshening (-1000 - -100)
- Freshening (-1000 - -3000)
- Strong Freshening (>-3000)



Freshening/Salinization 2050
Source: Deltares (2009/2010)

(2007), in: Van Dijk et al. (2009)).

On the left a map is shown of the actual predicted difference in the amount of Chloride/litre. This difference hence reveals the intensity of salinization in the Netherlands.

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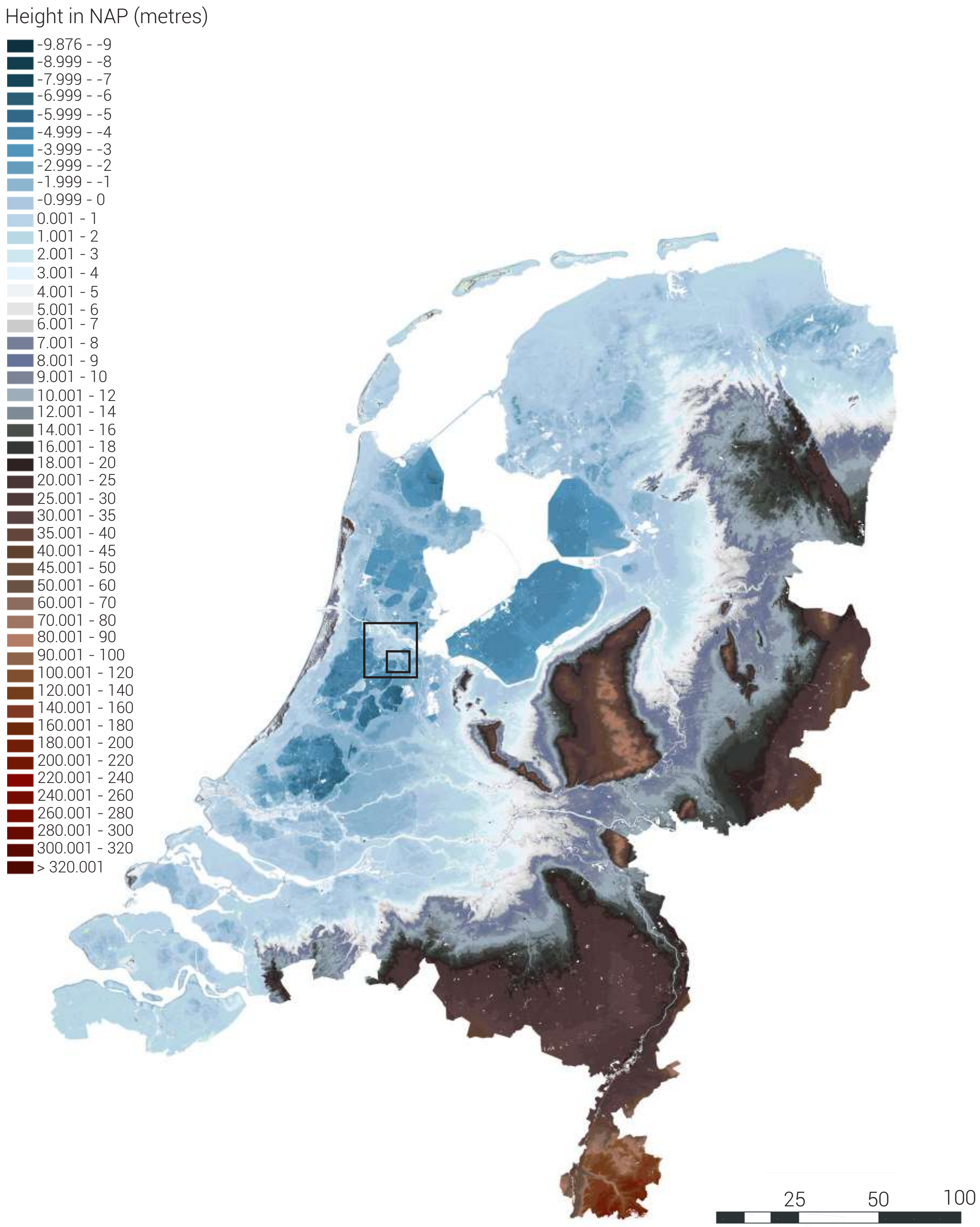

Height Map
Source: AHN (2018)

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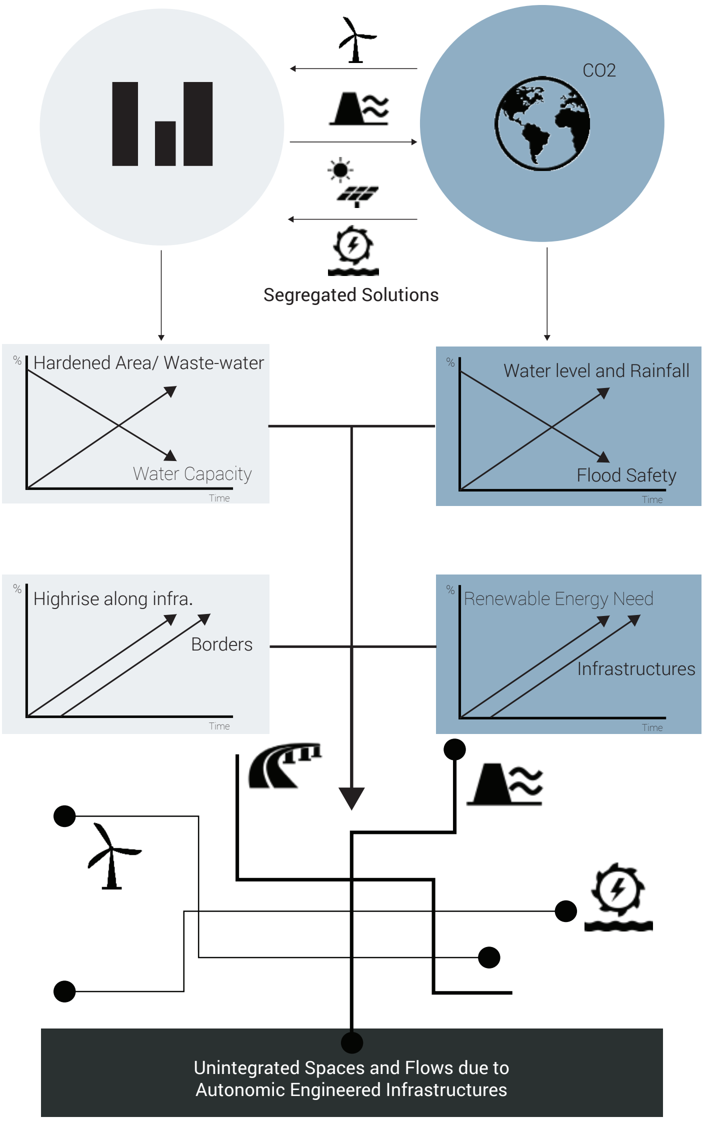
Summarized Problem Statement



Summarized Problem Statement

Cimate Change and Urbanisation

are a matter of fact. A myriad of problems and hence complex challanges arise for the built environment due to these phenomena. Different domains, such as sustainable energy-production, water-management and mobility however currently seem to be all addressed on a different level of expertise and scale, resulting into the loss of opportunities for flows and structures to intertwine and cooperate.
This can be illustrated by the following example regarding the opportunities for energy-production, water-management and the build environment to intertwine. As the world needs to deal with an increase in flood risk the issue on flood protection becomes more significantly crucial. An **intelligent water network** is hence crucial for the preservation of safety and health. Due to urbanisation and hence densification or expansion of the urban areas, the available space for water-management decreases while the amount of paved area increases. A factor which consequently results into the creation of heat islands and water capacity loss.
Another issue at stake is the search for carbon zero energy resources. (Waste-) Water seems to fall and flow through our build environment without using this kinetic or chemical energy for the generation of electricity or for the cooling or insulation of buildings. Many engineers seem to confine solutions for water generation to the riversides or the ocean disregarding the opportunity for the architecture itself to accommodate such solutions hence

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III. Research Question

How can architectural/spatial qualitative elements contribute to an integral energy system?

1. Why is the **current system** un-integral?

2. How can(waste) **water contribute to energy-efficiency**?

3. What are it's **spatial implications**?

4. How can **architecture/the built environment** accomodate and contribute to such a system?

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"Bundling energy and water services can contribute to a future of reduced operating costs and safer, healthier buildings (Isaacson, Gudell, Miller, Wiese, Wilson. & Center of Neighbourhood Technology, 2014)" .

II. Hypothesis

The problem statement previously addressed revealed probable scenarios or developments of urbanisation, water management and energy management with spatially problematic or conflicting outcomes. While we need more energy storage space for water sensitive electricity storage another need encompasses an increased amount of water storage resulting from the increase of urbanisation and hence an increase of the amount of hardened area and wastewater. Two seemingly conflicting matters (water management and energy management) which are maybe in some way complimentary to one another when we regard the disregarded aspect of water's lost energy when flowing, through and underneath the urban fabric. The hypothesis illustrated on the next page hence reveals an opportunity for the built environment to capture and store the energy and water integratively instead of losing water's energy and reproducing water and energy all together again.

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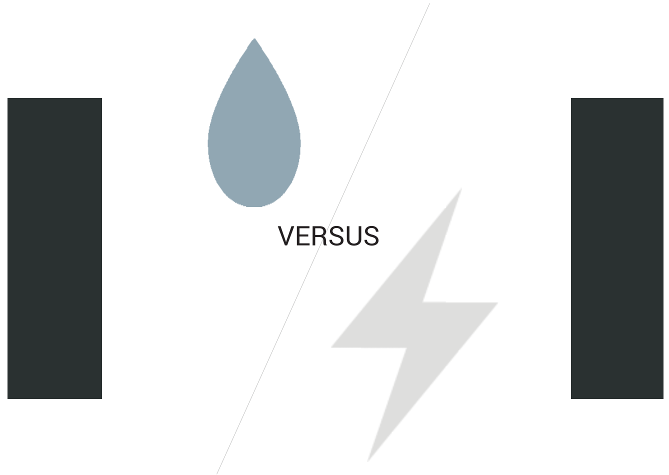
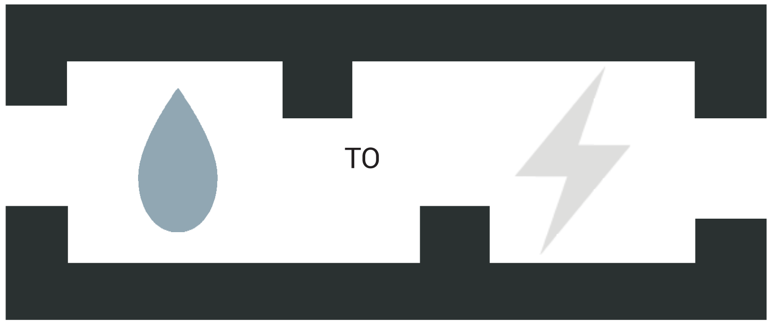
from; Reproducing & Losing



to; Capture & Store Integratively



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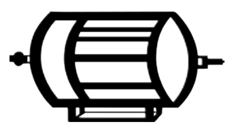
Waterstructure 1570

V. Research Seminar

1. Why is the current system un-integral?

Amsterdam is a city known for its authentic canal structure. A structure engrained within the material culture of the Dutch.
The ingenious structure could be considered highly integrative due to the fact that it both tackled the quests of health (sewage), water protection (drainage), transport (boats) and financial capacity.[1] Integrative approaches, however, seem to have been lost within the construction of the Dutch built environment. With the increase of technical possibilities within the era of industrialisation the need for integrative approaches was lost since the practical resources and capabilities (economic, oil, machinery etc.) seemed infinite.
This need has however returned with the prospect of a costly transition towards renewable energy production and the increasing amount of economic loss by weather hazards due to the phenomenon called 'Climate Change' (See appendix for thorough explanation).[2-3-4]
Illustratively, regarding the situation of Amsterdam, the flow of water entering the built environment might increase in the coming years due to the sea level rise and more frequent and heavier rainfall. Urbanisation and its related issue of increased hardened areas are an additional factor which contributes to the problems of water safety and water quality in the built environment.[5] An integrative approach for energy efficiency and flood protection is hence highly needed.

Until the present day this question seems to have been untouched or answered on the base of isolated domains missing the opportunity for energy efficient measures to comply with water efficient or flood protective measures. A phenomenon which



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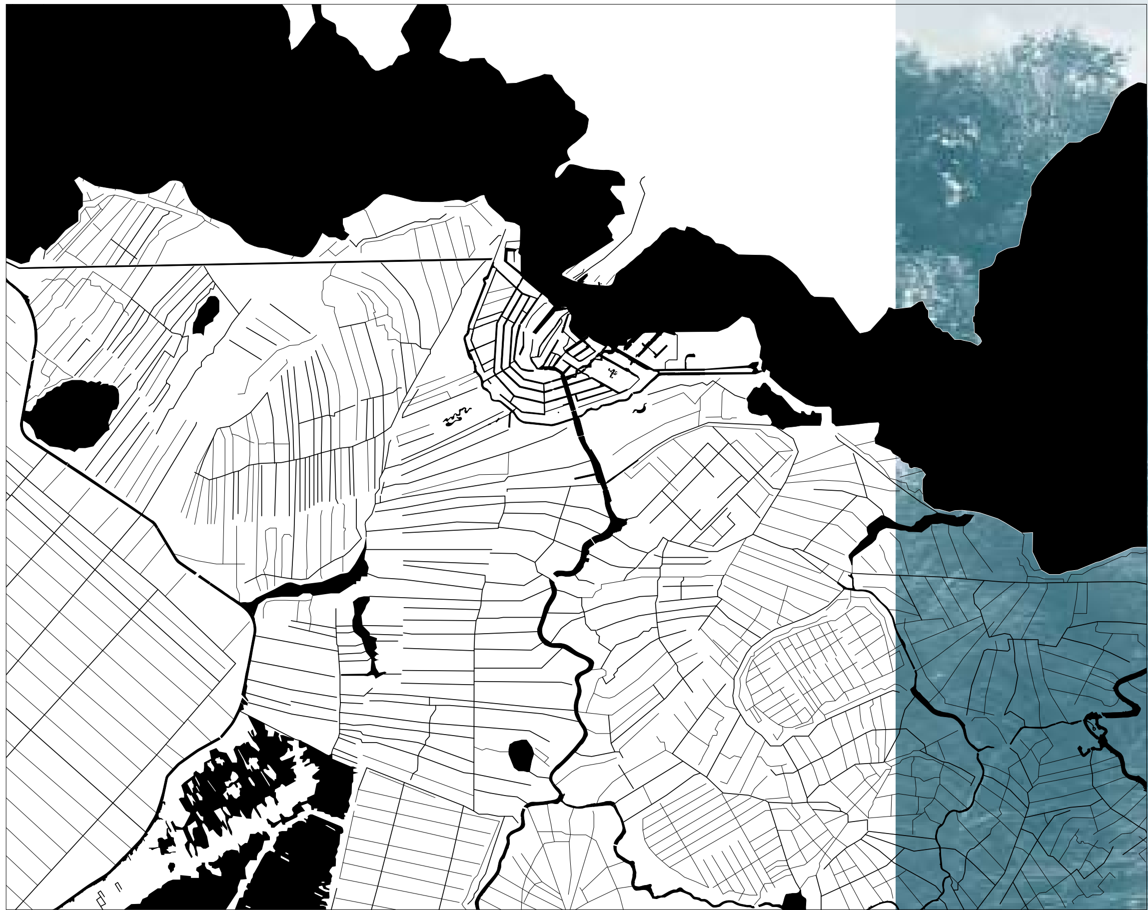
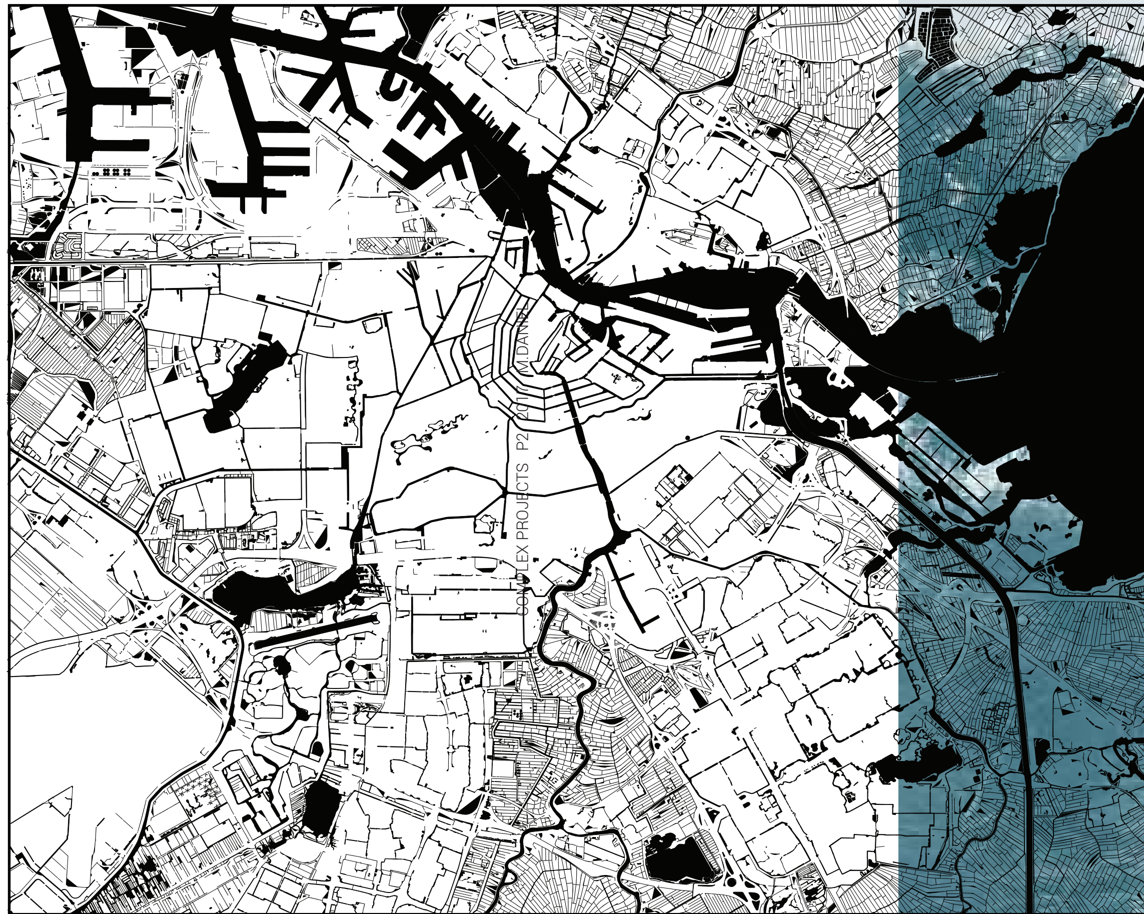
Waterstructure 1630



Waterstructure 1855

Waterstructure 1877



Waterstructure Now

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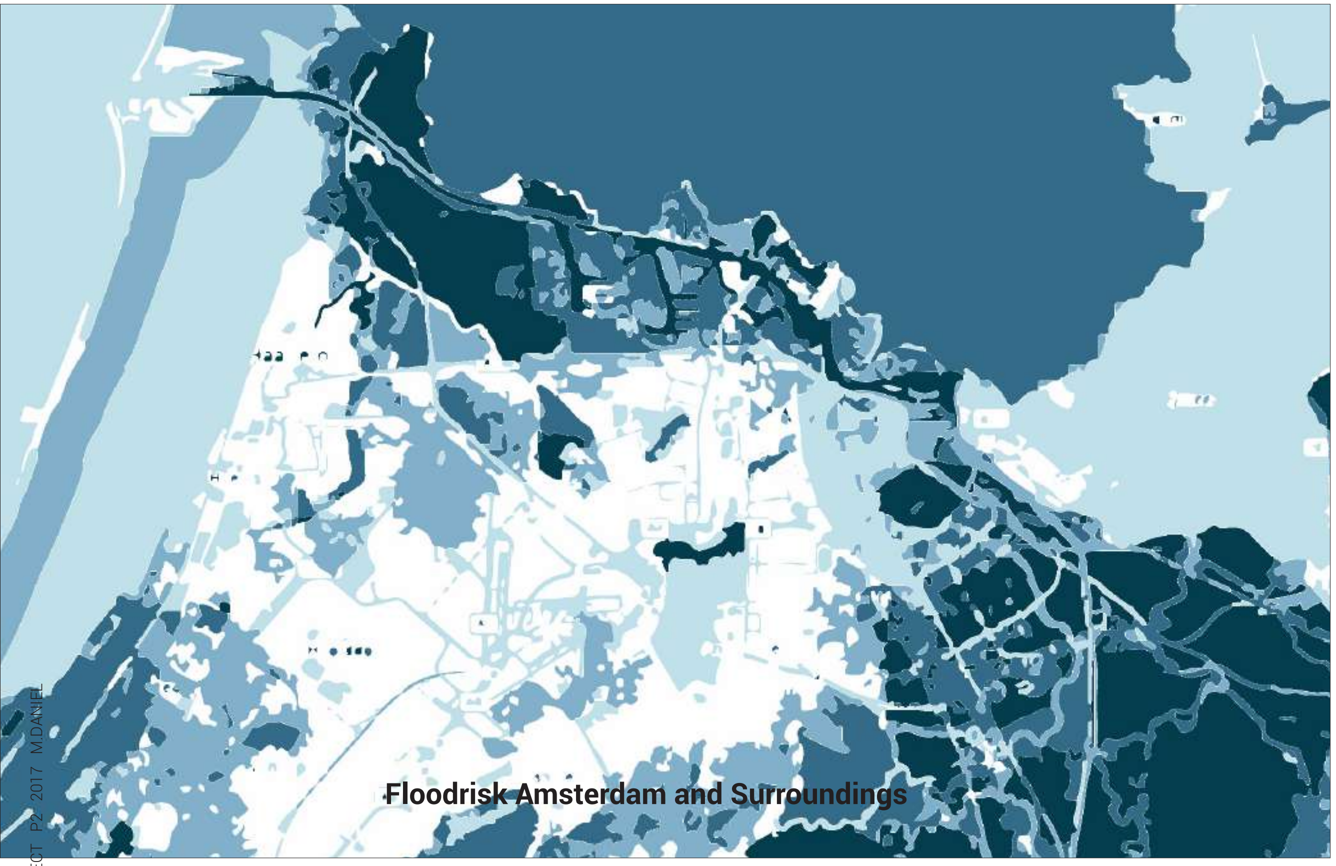

Floodrisk Amsterdam and Surroundings

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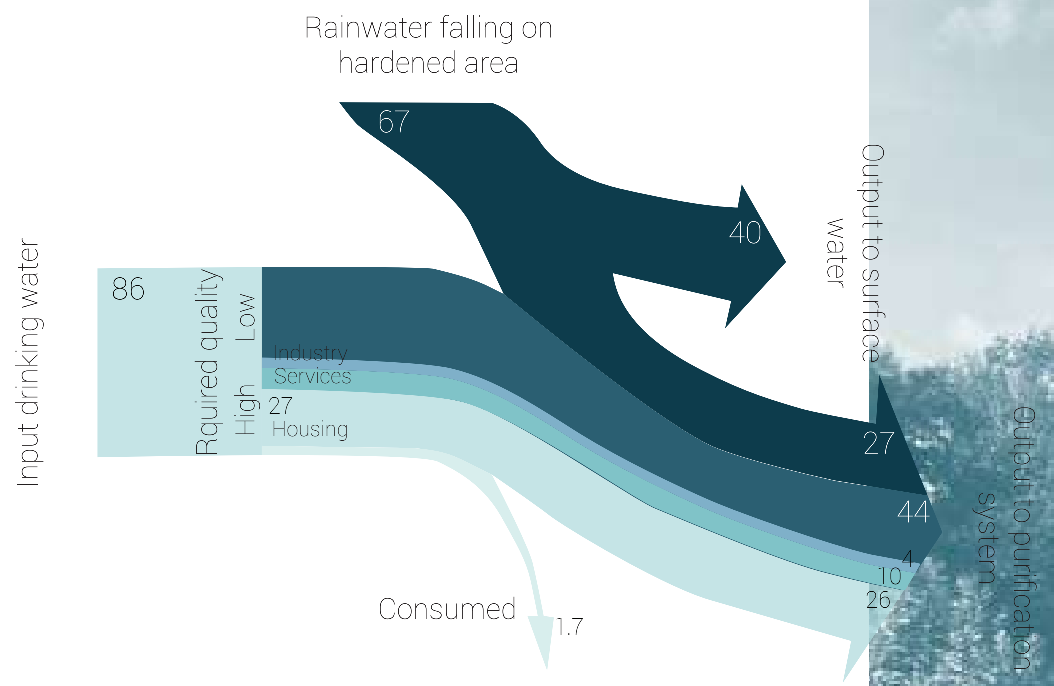
“The refinement of technology in the last decades of the twentieth century makes it possible not only to maintain that which is threatened, but also to **take in an increasingly vulnerable place in the game between water and land** (Hooimeijer, 2011) .”



Current Water Flow Amsterdam

can be illustrated accordingly:
Drinking water flows abundantly through the built environment. Following a planned course which encompasses an initial step of abstraction, following up with the transport towards the consumer and ultimately reaching the purification system, missing however the opportunity for its embodied energy to be reused or reduced. One could think of the reduction of purification energy consumption, the reuse of waste water heat etc. Hence an energy and water efficient approach which could issue an immense rate of energy saving and simultaneously contribute to the water management quest. One should therefore ask oneself if the current drinking and waste water flow could be optimized in terms of energetic losses.
When regarding both the opportunities for waste water energy extraction and the problems of water capacity one might state that it would only be a logical extrapolation that water needs to be regarded as an opportunity instead of a problem or threat. As Yatish T. Shah states:

“While the world is craving for more sources of energy and fuels, one source of energy that is most abundant and environmentally acceptable is water. Water in all its forms (i.e., subcritical, supercritical, steam, heavy water) is the most important solvent in the development of new “energy economy.”[6]

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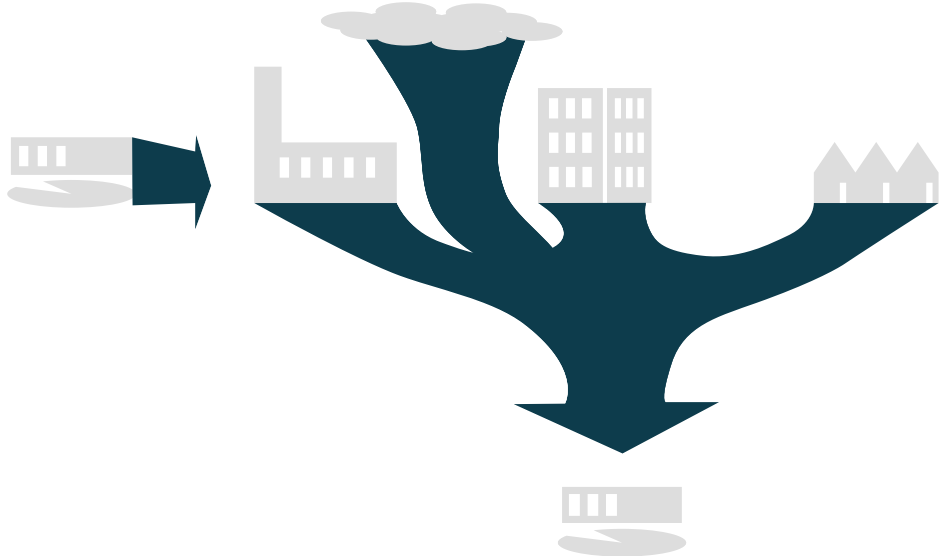
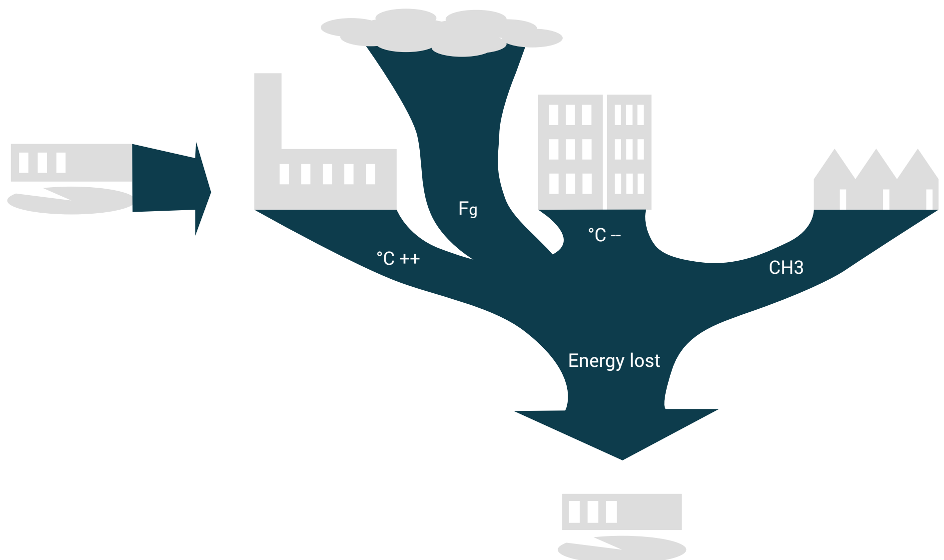


Water Flow and Waste Water Overload



Water Flow and its Lost Embodied Energy

Current Drinking Water System in Amsterdam

Waternet, is a public company responsible for the abstraction, distribution, collection and purification of Amsterdam's drinking water. The daily demand of drinking water in Amsterdam is currently easily met due to the abstraction of naturally and artificially filtered dune, river and lake water reaching the homes of 922,000 inhabitants.[8] After the clean drinking water has reached the homes, the industry or other services, the waste water will be returned to Waternet which then purifies the waste water in order to be able to return it to the surface water. This sophisticated system thanks its origin from the beginning of the 20st century when an underground sewage system was created in the Amsterdam on the base of hygienic reasons and technological possibilities.[9] This led to the disappearance of several waterways in the city of Amsterdam and hence to an increase of hardened area. The lock at the mount of the IJ inlet and the enclosure dam which were built in respectively 1872 and 1932 however ensured water safety in Amsterdam which made this disappearance of waterways acceptable in terms of flood control.[10]
However, the large-scale building over the last fifty years resulted into an increase of flood risk especially in the since then newly constructed areas where water capacity was not ensured by the means of canals.[11] The introduction of the so-called 'seperated' sewage system therefore came into play which ensured a decreased amount of pressure on the waste water purification plant and hence the sewage system during rainy periods. The system constitutes of the fact that the rainwater will be separated from the wastewater and directed directly towards surface water, preventing the rainwater to be contaminated unnecessarily. A system which was introduced in 1930 and currently encompasses 60

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“Bundling energy and water services can contribute to a future of reduced operating costs and safer, healthier buildings (Isaacson, M., Gudell,, J.D., Miller, J., Wiese, J., Wilson, R. & Center of Neighbourhood Technology, 2014)” .

percent of the total sewage network in Amsterdam.[12-13]

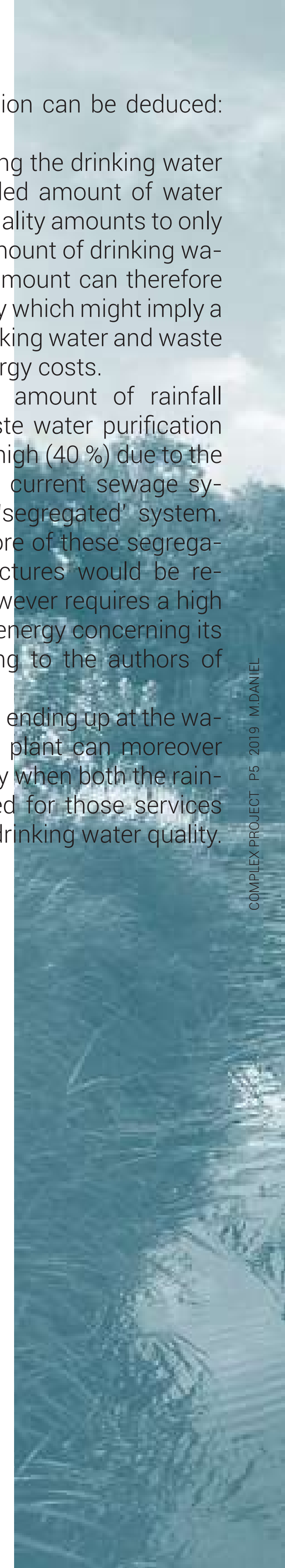
When regarding the prospect of urban intensification and an increase of rainfall the risk of flooding however will persist and even increase.[14] According to the authors of the Atlas of Dutch Water Cities the guideline for the amount of surface area should be 10 procent.[15] The question therefore arises in what way the water flow which enters the built environment could be reduced or in what way the water could be retained in order to reduce the pressure on existent water structures and the sewage system.

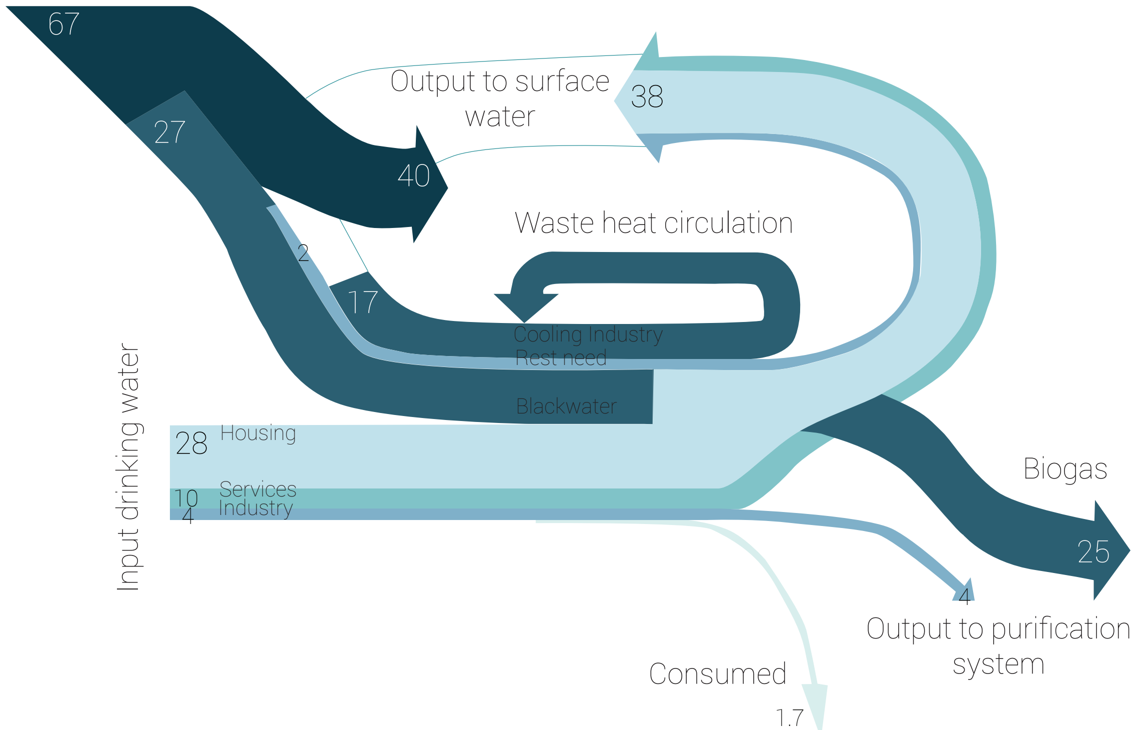
When relating this notion to the aspect of energy efficiency the previously addressed quest of wasted water and its embodied wasted energy comes into play. Since the water flow should be reduced in regard of flood protection which implies that we should search for reduction of waste water production in order to reduce the pressure on the sewage system and the waste water purification plant, the quest of energy efficiency automatically becomes an issue at stake. This due to the fact that our drinking embodies a certain amount of energy which could then be simultaneously reduced. The aim of wastewater in that way synchronizes with that of a search for energy efficiency since a certain amount of energy is needed to purify water and since waste water heat could be reused.

When regarding the current situation of Amsterdam's drinking water consumption and its related wasted water one could state that the amount of drinking water could be reduced immensely regarding the fact that certain services do not require high quality drinking water and can be replaced by rainwater or naturally purified rainwater. The following diagram shows the current drinking and waste water flow in Amsterdam from which the following conclusion can be deduced:

- When regarding the drinking water input the actual needed amount of water with drinking water quality amounts to only 50 % of the current amount of drinking water production. This amount can therefore be reduced immensely which might imply a huge reduction of drinking water and waste water purification energy costs.
- Secondly, the amount of rainfall ending up at the waste water purification plant is still relatively high (40 %) due to the fact that 40 % of the current sewage system is a so-called ‘segregated’ system. An introduction of more of these segregated sewage infrastructures would be recommended. This however requires a high amount of costs and energy concerning its construction according to the authors of ‘Water and Energy’.16

The amount of rainfall ending up at the waste water purification plant can moreover be reduced immensely when both the rainfall is used and stored for those services which do not require drinking water quality.





Maximised Solutions

V. Research Seminar

2. How could (waste-) water contribute to energy-efficiency?

Maximized Strategy for Amsterdam's Water System

When applying the previously presented solution to the case of Amsterdam on a maximized level the following flow diagram will be applicable.
The flow diagram encompasses the following previously presented solutions:
1. Reducing the amount of drinking water production and waste water discharge by using rainwater for those services which do not require drinking water quality in order to reduce the energy costs required to purify and transport the water.
2. Segregating the black water (toilet waste water) from the other waste water in order to optimize biogas production and hence being able to generate electricity.
3. Reusing the heat from the cooling water from the industry in other functions following a sequence of Industry, offices, and ultimately homes.[20]
When regarding the presented maximisation of the previously presented solutions the following quantitative and qualitative conclusions can be deduced.
1 a. (Water-reduction) As previously stated, merely 50 percent of the current drinking water supply needs to be actual drinking water from which most drinking water is needed for homes. The reduction of drinking water consumption and waste water discharge is fairly effective with the following system of flows. Only the highly contaminated drinking water needs to send towards the waste water purification

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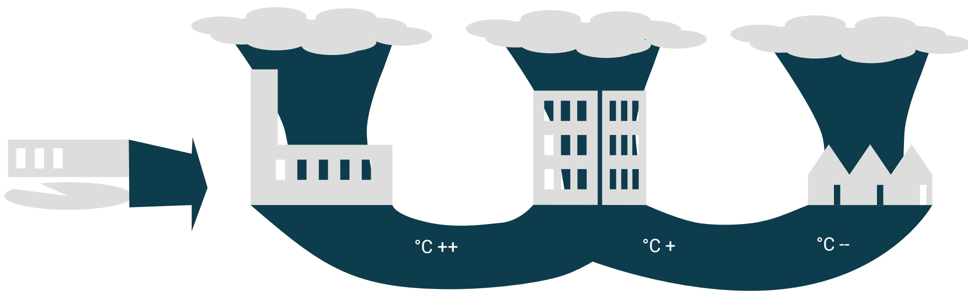
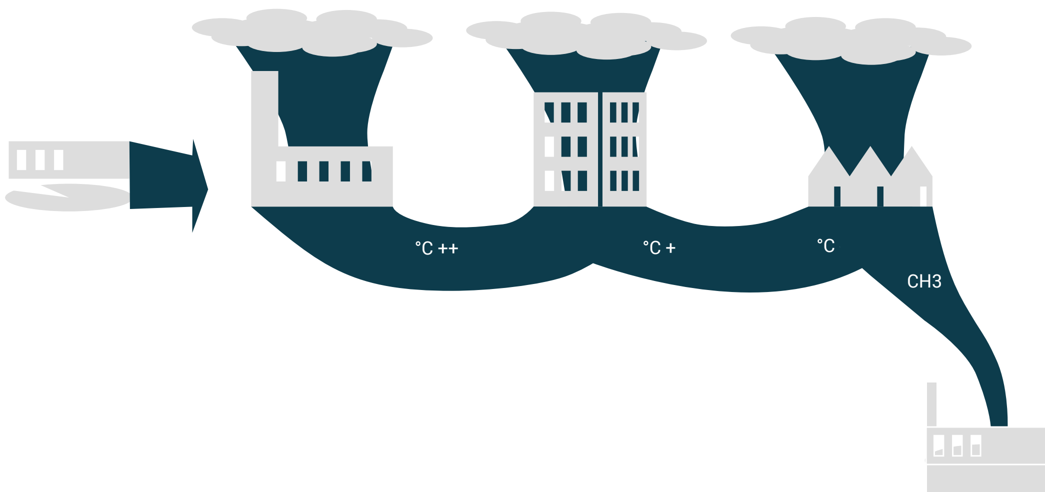


Reuse Waste Water Heat (Closed Circulation)

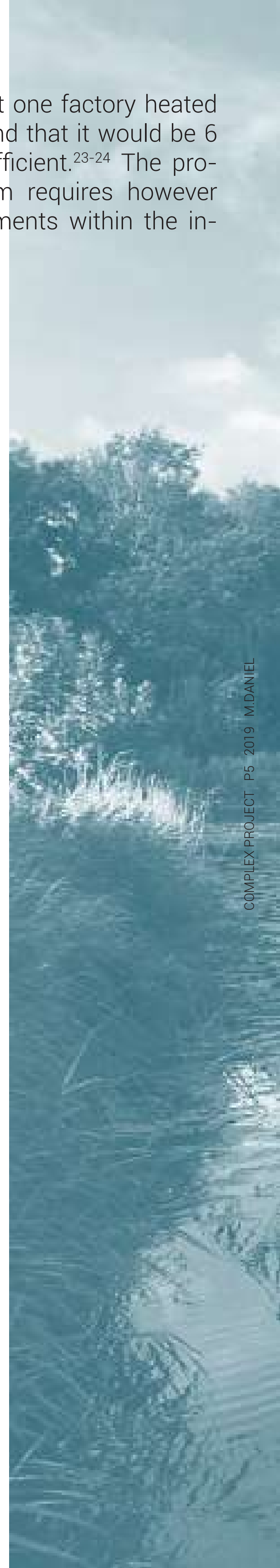


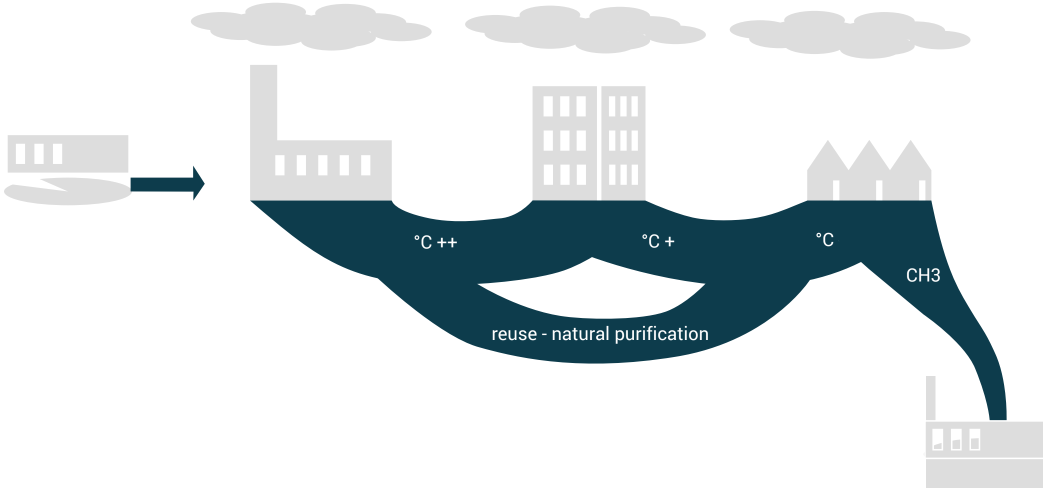
Biogas from Black Water

system which amounts to merely 4 million m3 per year (see diagram).
1 b. (Energy-reduction) Although the energy used for purification and transport is in this way decreased by almost 80 % the energetic costs of purification and transport are relatively low when applying it to the amount per person. The reduction will amount to merely 12 W per person per year. An amount which resembles merely 2% of the yearly household energy consumption.[21]

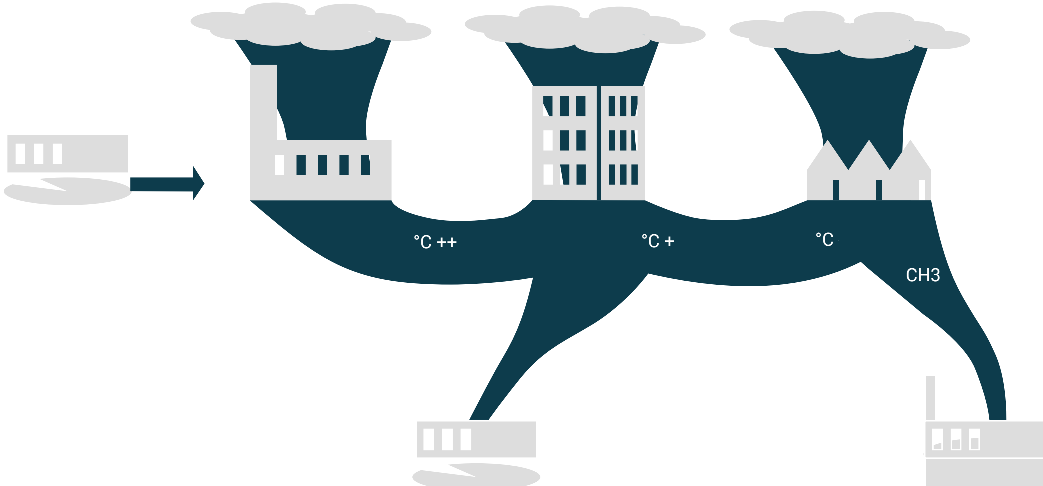
2 a. (Water-reduction) By using rainwater to flush toilets and segregating the blackwater (toilet waste water) from the other waste water both the amount of drinking water consumption and waste water discharge to the central purification system is decreased.
2 b. (Energy-reduction) The (estimated) amount of black water from both companies and homes results into an opportunity to generate maximum of 43 000 homes and a minimum of 20 000 homes.
The system however requires a huge amount of black water storage space since the biogas needs to be developed over a certain period of time.

3. a. (Water-reduction) The other amount of contaminated water is trapped within a closed circulation of heating homes and cooling industry and therefore does not necessarily need purification (by heat recovery). The pH-value of this water however needs to be controlled and monitored by the industry itself in order to prevent corrosion within the piping system.[22]
3. b. (Energy-reduction) When all industry currently present in Amsterdam would connect to a grid of waste water heat reuse the system would be able to heat 3 million households (estimated calculations). This estimation could be considered feasible when comparing it to other sources which for example state that one factory heated 56 000 households and that it would be 6 times more energy-efficient.[23-24] The proposed circular system requires however huge financial investments within the infrastructure.





Natural purification & Reuse in times of draught

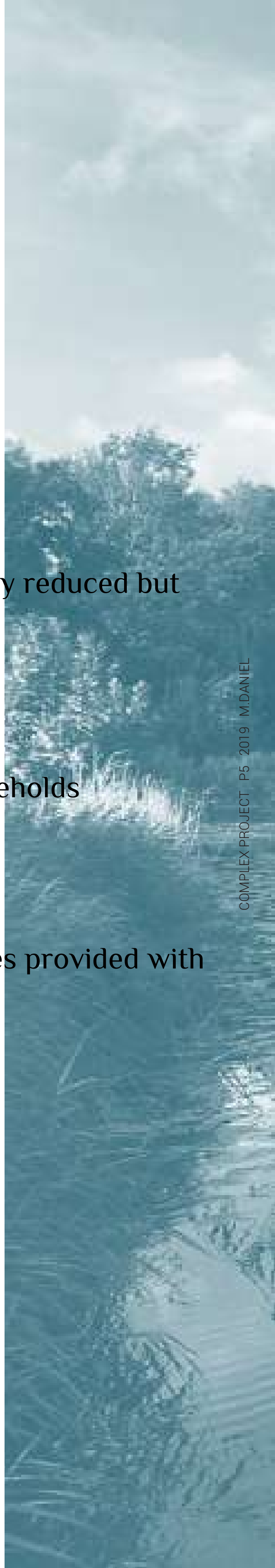


Leading to a smaller out- and input

1. Water purification energy consumption is immensely reduced but leads to only 12 W/pp/year reduction.

2. Waste water heat: heating of 2 million households

3. Black water; biogas- between 20.000 - 40.000 houses provided with energy - Amsterdam South East



V. Research Seminar

2. How could (waste-) water contribute to energy-efficiency?

Blue Energy

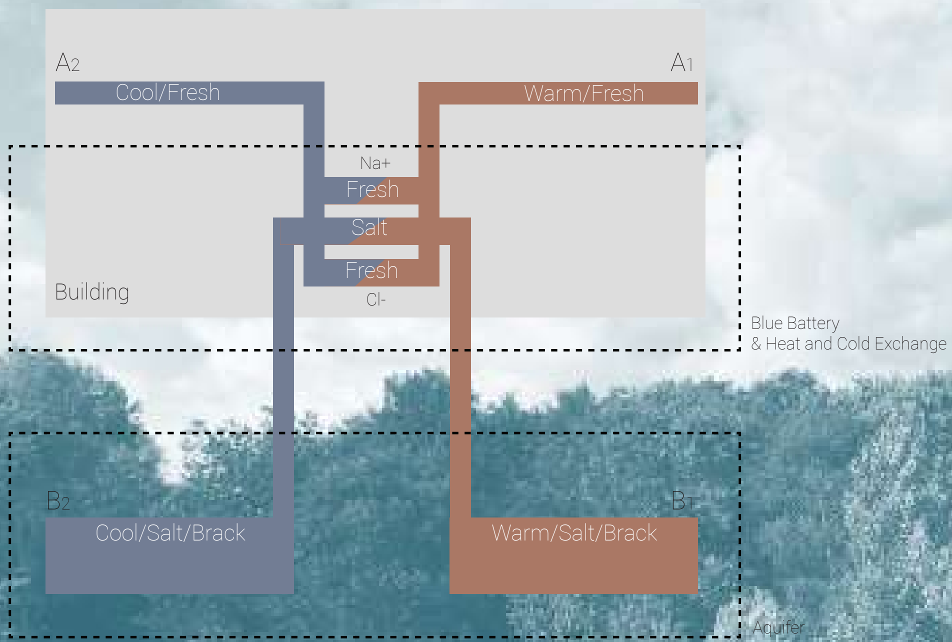
In the previous paragraphs water has been revealed as an energy carrier of heat/cold, methane (biogas), or even kinetic energy (gravitational energy), but the idea of water as a source for salinity gradient power (or 'blue energy') has yet been untouched and is according to Kuleszo, Kroeze, Post and Fekete (2010) a relatively unknown option.
The salient gradient power in rivers draining into oceans had been first identified as a potential source of renewable energy in 1954 by a British engineer named R E Pattle (Keszo, Kroeze, Post, Fekete, 2010 & Ball 2015). It wasn't however until an Israeli scientist named Sydney Lobe in the 1970s suggested to use the method in what he called 'an osmotic power plant' when the initial idea of Pattle was utilized (Keszo, Kroeze, Post, Fekete, 2010 & Ball 2015).
Currently, however, the term: Blue Energy, encompasses three different methods of generating electricity by the salinity gradient power.
The first method, Pressure Retarde Osmosis (PRO) is based on osmosis. When a salt water flow and a fresh water flow are seperated by a specific mambrane which allows merely the water and not the salt to flow from one side of the membrane to the other a pressure is created which can be utilized as a source of energy when the water is flowed through a turbine to generate power (Wikipedia, n.d. & Wulff, 2017).
The second method utilizes the process called 'Reverse Electro Dialyses' (RED) (Wikipedia, n.d.) . Hereby salt water is flowing in between a pair of one type of ion-exchange mebrane which allows positively charged ions to pass (Na+) and one type of ion-exchange which allows only negatively charged ions to pass (Cl-). The opposing transport of the positively and negatively charged ions creates positively and negatively charged poles, similar to a battery, hence generating electricity (electrochemical cell) (Redstack, n.d.).
Finally, the third method called TRAB or thermally regenerative ammonia-based battery derives power from the formation of metal ammine complexes, which are produced by adding ammonia to the anolyte, but not to the catholyte. Ammonia concentration differences between anolyte and catholyte than generate a chemical potential, which can be released as electrical current (Zhang, Liu, Yang and Logan, 2015 & Pen State University, n.d.).
Scientists, firms and institution are currently working hard in order to reach a higher power rate for the blue-energy battery. And when we combine this knowledge with the fact that the area of Amsterdam Zuid Oost undergoes a development of salinization regarding the ground water, an interesting solution for both matters: the salinization and the need for a renewable energy resource arises. One might want to use this salinized groundwater to generate energy by means of the blue energy method called RED. This method however seems to in-effective since the salt-concentration (also identified with the cl-concentration) is too

Principle 1 (Source: Personal Extrapolation from sources such as: Aquabattery B.V.*)

Blue Battery

Charging: Brack water becomes Salt by using electricity to regenerate the salt from the Na+ and Cl- ions.

Discharging: Fresh water becomes positive or negative loaded and Salt water becomes Brack.



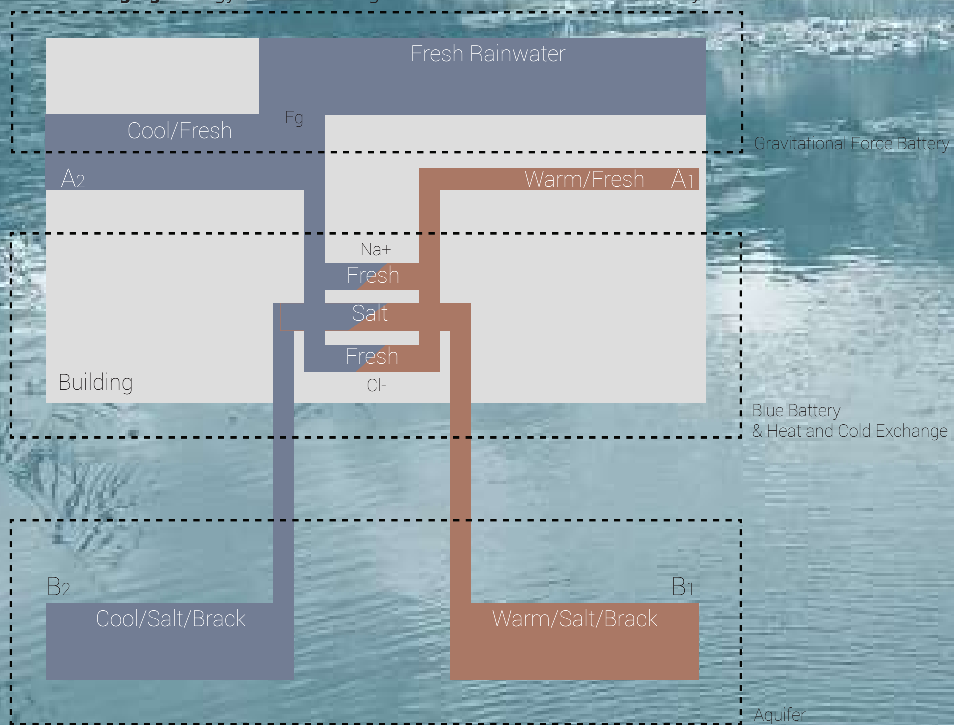
Principle 2 (Source: Personal Extrapolation from sources such as: Aquabattery B.V.*)

Blue Battery +

(Added) Gravitational Force Battery

Charging: Water is pumped upwards.

Discharging: Energy of water falling down is transferred into electricity.



low (see calculations). Hence an alternative use of the method will be presented: the renewable energy storage method in which the salt-water can be used as a renewable energy container: referred to in this report as a water-battery.

When using the blue energy method in combination with an aquifer as presented by the firm 'Aquabattery', excessive energy from other renewable energy sources could than be stored within the aquifer in the form of salt water and be extracted from the salt water when needed. Hence the seasonal imbalance between the demand of energy and the production of energy could than be restored by the use of this innovative seasonal storage method. The method can be explained as follows (see figure on the left): "The salt groundwater could be used within an aqcuifer system in order for the aqcuifer to not only serve as a a source for heat and cool water in order to heat or cool buildings but could simultaneously be used as a seasonal electricity storage of energy by converting excessive electricity into salt water. This salt water could than generate electricity by the use of an added blue energy system. This system enables the cool salt ground water to flow up to the building in the summer, cooling the building and meeting the fresh water stored within the building in order to generate electricity by using the method: Reverse Electro Dialysis. After which the water flows down to the aquifer again being less salty/brackish and warmed up by the heat within the building due to the summer climate. This flow can than be reversed in the winter when there is an overload of energy for example created by wind in relation to the demanded energy in the winter flowing the heated brackish water stored in the aquifer back into the building and retrieving it's saltness by using Electro Dialysis in it's unreversed manner. This can be done by using the overload of electricity from the wind in order for this electricity to be stored in the form of salt water again within the aquifer waiting for the summer again when this overload of energy is missing and needs to be extracted again by the Reverse Electro Dialysis/RED-method etc..

This approach of using water as an energy storing element could hence also be applied to a 'so-called' gravitational water battery. The second element of the proposed system hence encompasses this gravitational water battery and will store excessive renewable energy by pumping the water up in a built construction and to let the water flow down again, generating electricity by the use of watermills, when needed (see figure on the left).This method was estimated to be effective enough for the daily imballance between the demanded and the generated renewable energy to be restored (see calculation: appendix).

* **Aquabattery B.V.**: is currently developing the idea of the blue-battery in combination with an aquifer/geothermal heating. The integration of this idea within the built environment is currently under investigation by the firm in cooperation with 'Rijkwaterstaat' in the area of Flevoland. Other firms that are investigating the integration of blue energy within the built environment are: REDstack B.V., Enexis B.V., Alliander, Compass Infrastructuur Nederland (CIN) B.V. and Technolution B.V..

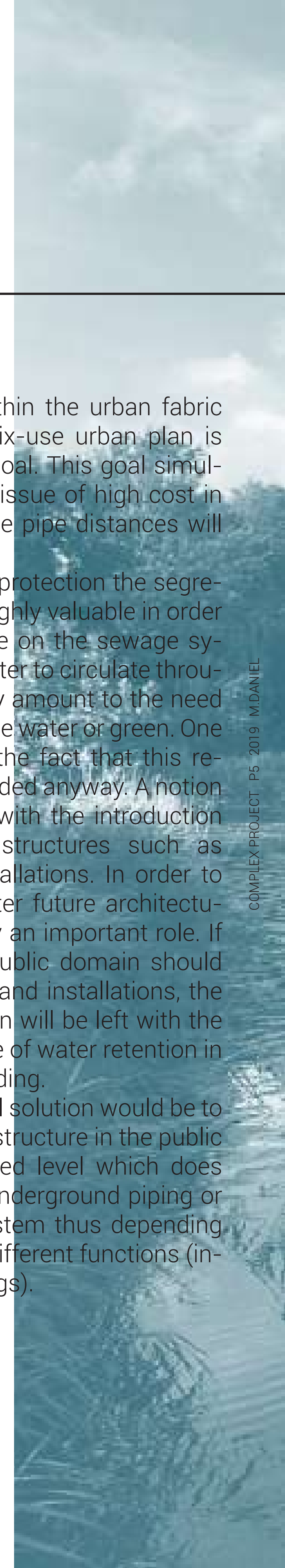
V. Research Seminar

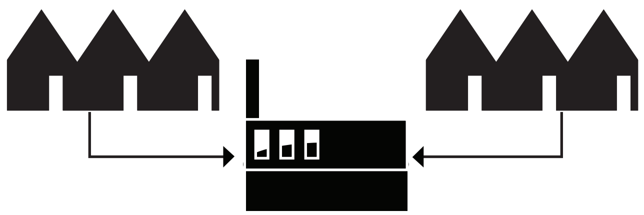
3. What are it's spatial implications?

Optimized Strategy for Amsterdam's Water System

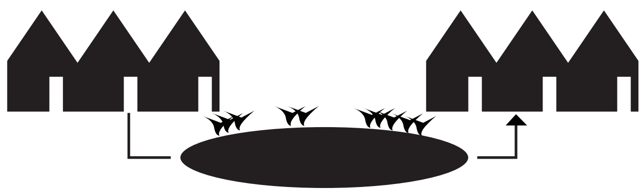
The previously established conclusions will be evaluated in this chapter in order to ultimately generate an optimized strategy for Amsterdam's Water System.
Both the bio-gas solution and the reuse of industrial heat turned out be highly effective in terms of energy. Its financial costs, which are due to the construction of massive infrastructure fairly high, could however be put into a positive perspective.
When regarding the introduction of biogas installations, the decentralisation of energy generation could amount to a high rate of job creation within the urban fabric and moreover make the system more resilient for flood damage. When keeping the biogas installations on a low human scale the spatial impact can be reduced, preventing both a monopoly of huge energy generation companies and providing an opportunity for inhabitants to earn their money within proximity. Storage of both electricity is less needed than other renewable resources since the input is relatively constant. In order however to be flood resilient storage is recommended, reducing the impact of failure.[25] Water-batteries could than come into play since the environmental (pollution) impact of flooding is minimal (for more information see appendix).

The low-scale factor also applies for the heat exchange circulation. In order to reduce heat loss a high proximity between different functions within the urban fabric is highly valued. A mix-use urban plan is therefore an optimal goal. This goal simultaneously tackles the issue of high cost in infrastructure since the pipe distances will then be reduced.
When regarding flood protection the segregated system is still highly valuable in order to reduce the pressure on the sewage system. Allowing greywater to circulate through the area would only amount to the need of more area for surface water or green. One could however issue the fact that this retention capacity is needed anyway. A notion which would conflict with the introduction of underground infrastructures such as pipes and biogas installations. In order to compensate this matter future architecture could therefore play an important role. If one issues that the public domain should be reserved for pipes and installations, the private building domain will be left with the task to tackle the issue of water retention in or underneath the building.
Another morphological solution would be to reintroduce big water structure in the public domain on a structured level which does not conflict with the underground piping or biogas installation system thus depending on the positioning of different functions (industry, offices, dwellings).



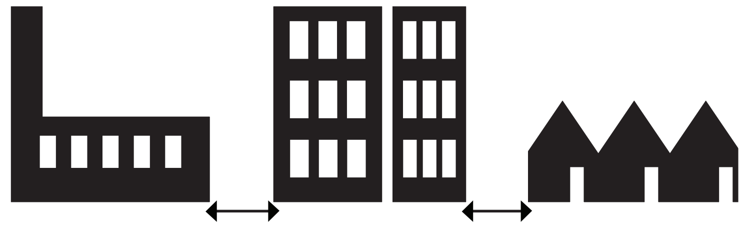


Decentralised - Energy Generation & Energy Storage

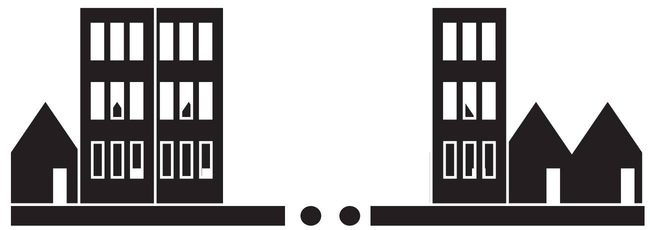


Decentralised Natural Purification

Hydro- Power - Relief/Height Difference



Close proximity different functions/ Mix-use



High Density => Water in/underneath the building

Low Density => Water Channels

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Rijkswaterstaat, Terneuzen, the Netherlands

Case Studies

3. What are it's spatial implications?

Rijkswaterstaat

The building is of naturally ventilated. Fresh air flows through wind pressure-dependent lattice in the façade through the interior to the atrium and from there, using the natural pull through the chimney outwards.

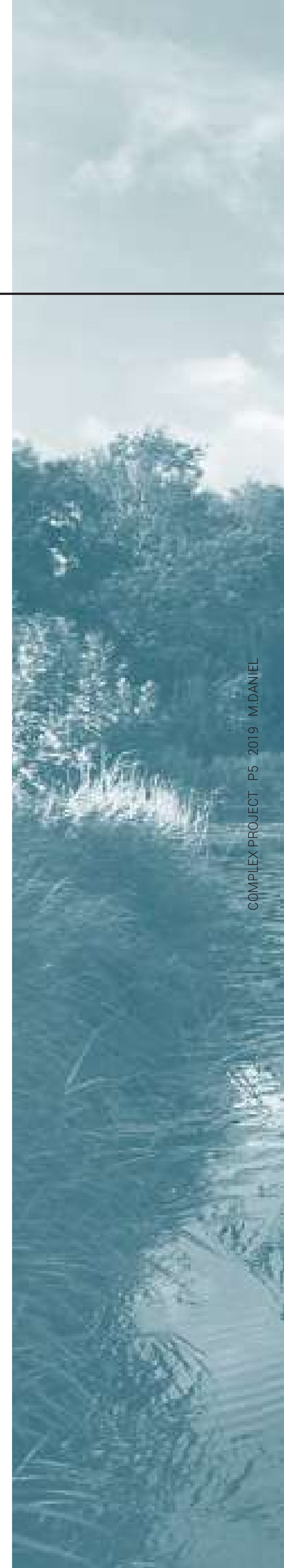
A heat pump extracting water from the channel water provides for the heating of the building through floor and wall heating. Solar panels are installed above the glass hood of the atrium. The panels with solar cells also function as a sunshade. Daylight attendance was optimized by simulations. Due to the permanent blinds and the optimization of the mass in the building, building cooling could be avoided. Solar panels provide hot tap water.

The building has its own wastewater treatment; All waste water is purified in the helophyte filter and the purified water is used to flush the toilets. By applying a mos-sedum roof and minimizing the hardened surface all rainwater is buffered or infiltrated. A sewage connection was not needed (Atelier Groenblauw, n.d.)


Hydroelectric Powerstation by Becker Architects, Kempton Germany

Hydroelectric Powerstation

On the left banks of the river Iller a new, hi-ghly efficient hydro – electric powerstation substituted an older powerstation from the Fifties by now supporting approximately 3000 households with 10,5 million kilowatt – hours of environmentally friendly power per year. The system augments the flow of the river below it to generate enough power to feed 3,000 homes with a total 10.5 million kilowatt—hours of electricity (The coolist, n.d.). Specialised engineering consultants had nearly finished planning the project, until the authorising agen-cy demanded a design, that would fit in a subtly manner into the listed building ensemble of a former spinnery / weavery and the natural space of the Iller.
The starting point of the design considera-tions was the symbolic representation of the water dynamics, which change from a calm state at the water inlet to the chur-ning and pitching of the water near to the turbines, before subsequently returning to a calm state after the electricity generation (Archdaily, n.d.)



Hammarby Sjöstad, Sweden

Hammarby Sjöstad

The idea of extracting energy from waste water and reducing the amount of wasted drinking water has been applied within the architectural realm. The following project will therefore reveal the possibilities and potentials of using and reducing waste water for energy and environmental purposes and the spatial implications of such solutions.

Hammarby Sjöstad, Stockholm, Sweden
Hammarby Sjöstad used to have a reputation for being a run-down, polluted and unsafe industrial and residential. Hammarby Sjöstad has however been transformed into one of Stockholm's most pleasant residential districts and one of the world's most successful urban renewal districts. In 2016, the second and final phase of the building activities has been completed resulting into an area which accommodates 25 000 people and offer work for 10 000 people.17

Hammarby Sjöstad is highly sustainable on the level of various domains. When regarding its wastewater strategy Hammarby Sjöstad could be considered a model example of efficient energy reuse. First of all, wastewater is treated locally. The sludge produced by the waste water treatment process is recycled and used for fertilising farmland and forestry land. Furthermore the waste releases biogas during processing. This biogas is ultimately used as a fuel for vehicles such as buses, taxis and waste collection trucks and to heat 1000 homes in the area.18

A second waste water strategy is the extraction of heat from the treated water in the treatment plant, which is then used for district heating. With a range in temperature between 10°C and 20°C over the whole year, the wastewater is highly suitable for both heat and cold extraction which results in the fact that in summer the cold water can be used for cooling and in winter the warm water can be used for heating.19

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I. Introduction

II. Problem Statement

III. Research Question(s)

IV. Hypothesis

V. Research: Seminar

VI. Research: Studio

VII. Initial/'P2'-Project Proposal

VIII. Conclusion

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VI. Research Studio

4. How can architecture/built environment accomodate and contribute to such an energy system?

Over the past few decades the highly integrative communal approach of the construction of the Dutch canal system seems to have been lost in the vocabulary of Amsterdam urban constructions. An approach which is currently however highly needed in order to tackle crucial future risks and assignments such as water risk and energy reduction. A search for bundling opportunities in one strategy is therefore highly recommended. A bundling which has great potential since the reuse of waste water streams and its embodied energy could reduce the incoming water flow. A strategy which had already been applied in Stockholm, Sweden.

Though the proposed reduction of the drinking water input did not have significant effects on the reduction of purification and transport energy costs (since these were already low), the inverse was the case: a reuse of waste water for energy purposes reduced the amount of input within the built environment.

This strategy encompasses both the issue of reuse waste heat from the industry and reusing black water (toilet water) for biogas generation. Both strategies however result into certain morphological implications such as: if certain areas need to be reserved for massive infrastructure, where could one still be able to create surface water area for flood protection. And a second implication included the proposal for decentralisation of both systems for optimal energy efficiency, job-creation, and resilience within the scope of flood-protection.

Strategies which hence imply a huge shift within the morphology and the program of the urban fabric. A shift which might however reintroduce the Dutch material culture and increase our awareness of energy and water use since the effects will be within our sight.

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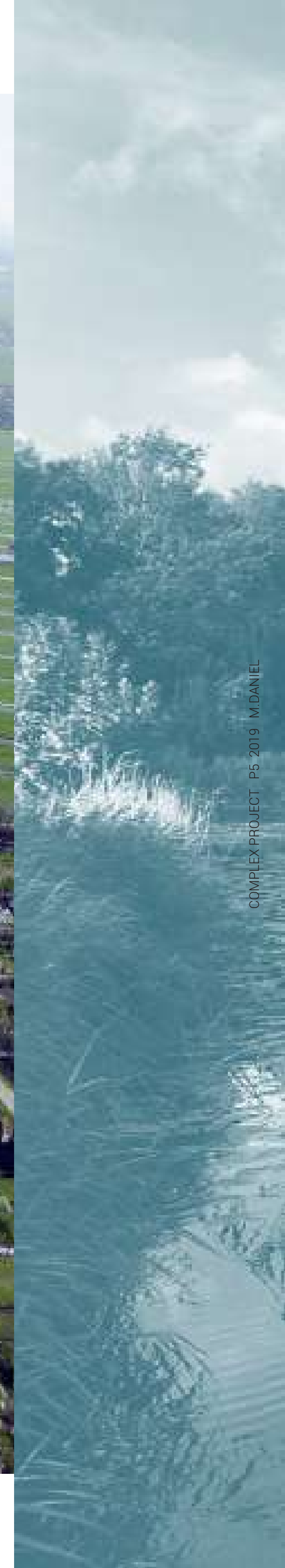

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Location Analyses

Amsterdam ZuidOost is situated on the border of urban constructions and the yet untouched 'natural' landscape of the polder. When putting this into the perspective of future developments the pressure on the reservations of such landscapes increases. The assignment lies in the fact how one preserves the landscape while simultaneously creating an healthy and livable environmet for the residents of Amsterdam ZuidOost.

When regarding the area two main factors become evidently visible. The high amount of surface water and the high amount of green compared to areas such as Amsterdam Central and Amstel. The water capacity for future scenario's is however not enough due to liquifaction and an increase of heavy rainfall due to climate change.

Moreover, an expected increase of hardened areas will increase the risk of flooding. A smart system is therefore required. Interestingly enough the are a consist of a windmill, a powerplant and a waterpurification installation as can be seen on the map below. A proposal in which such elements are included into an environmental clean ambition lies therefore within reach.

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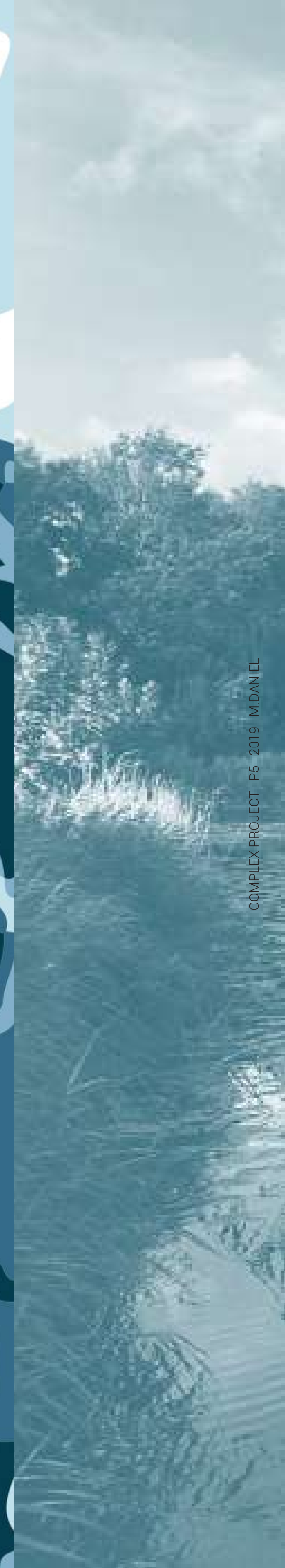
Floodrisk Amsterdam and Surroundings



Intensification along Infrastructure

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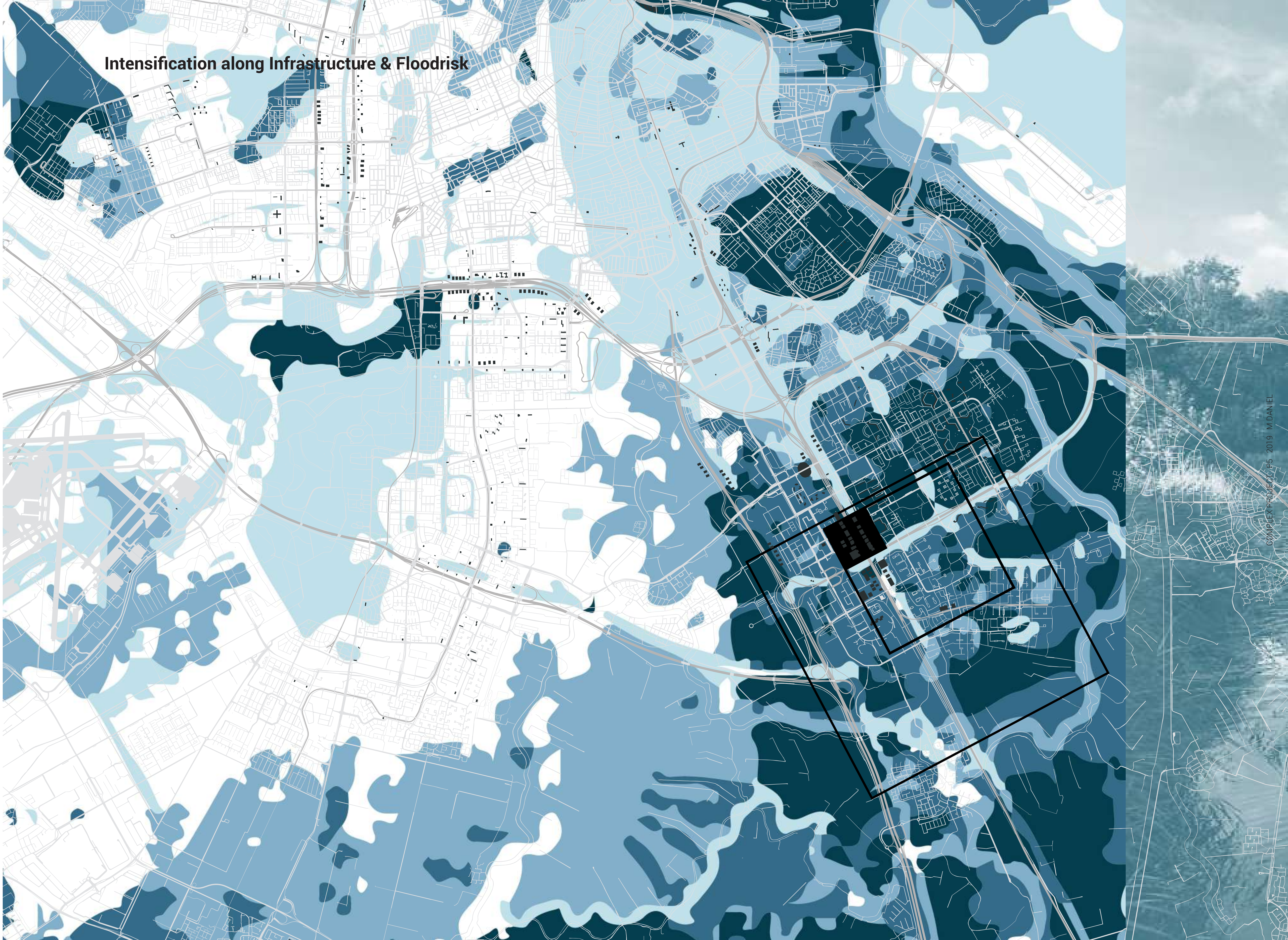
Intensification along Infrastructure & Floodrisk



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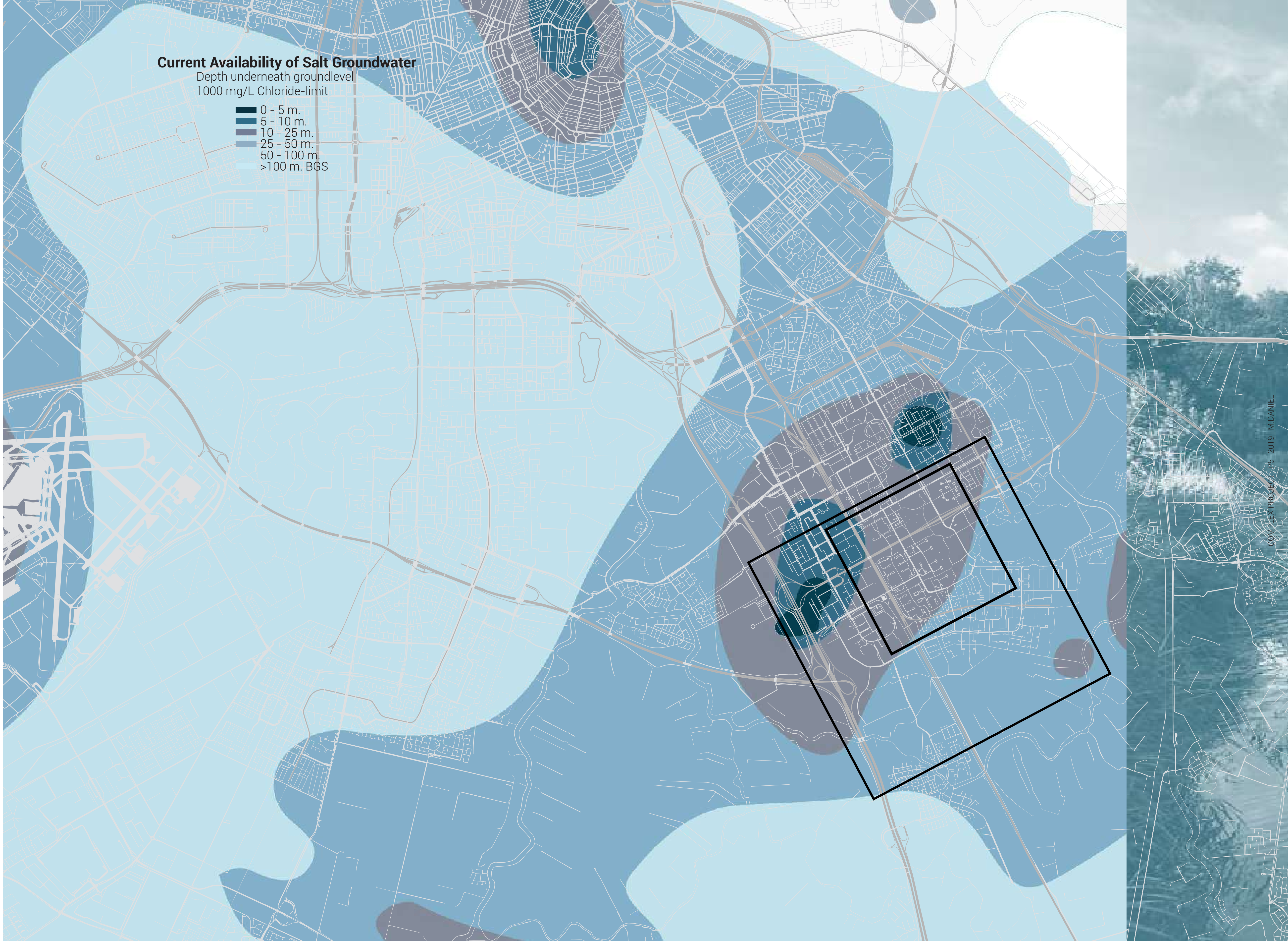
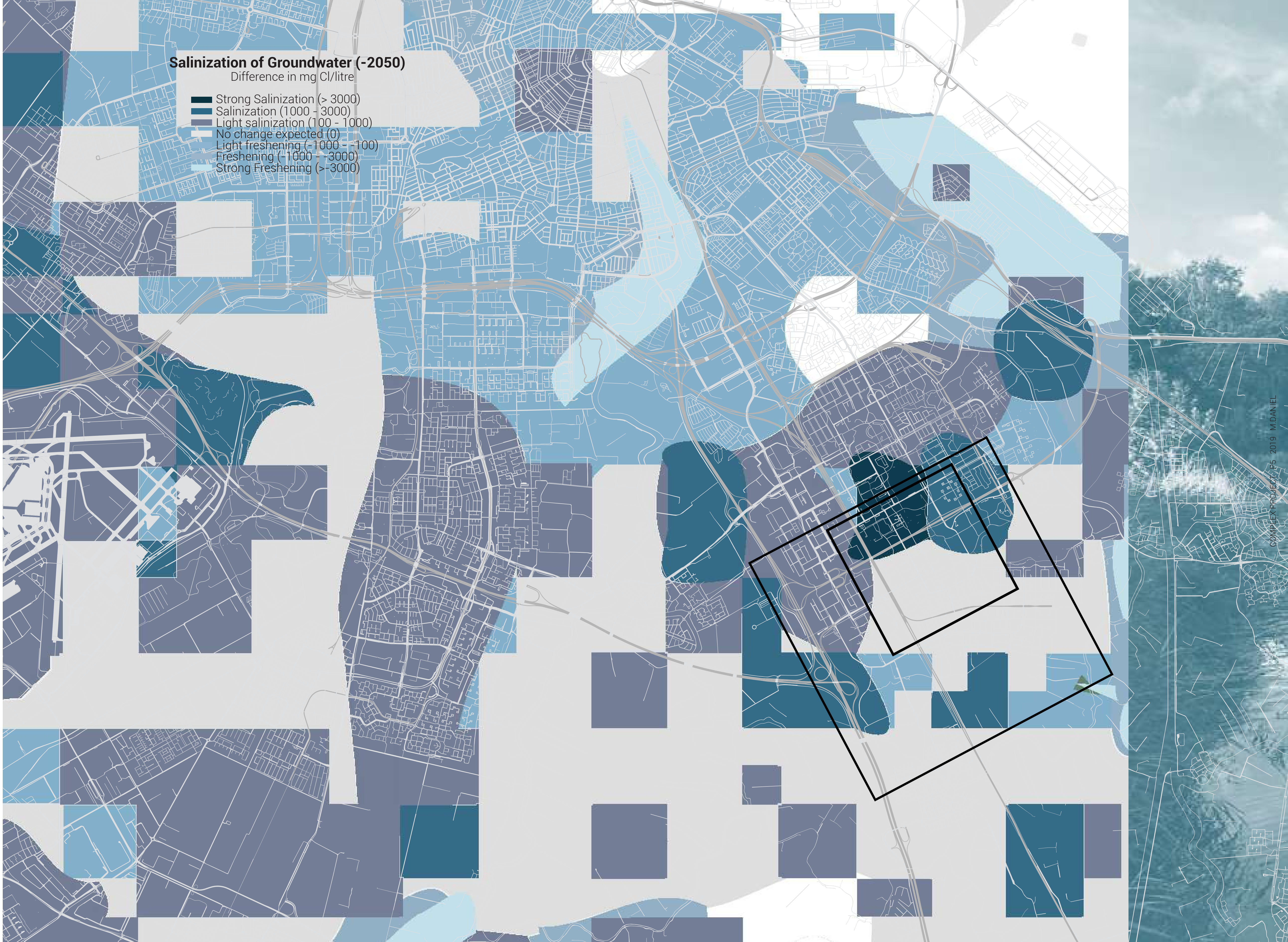


COMPLEX PROJECT P5 2019 M.DANIEL


Salinization of Groundwater (-2050)
Difference in mg Cl/litre
Strong Salinization (> 3000)
Salinization (1000 - 3000)
Light salinization (100 - 1000)
No change expected (0)
Light freshening (-1000 - -100)
Freshening (-1000 - -3000)
Strong Freshening (>-3000)

Intensification along Infrastructure

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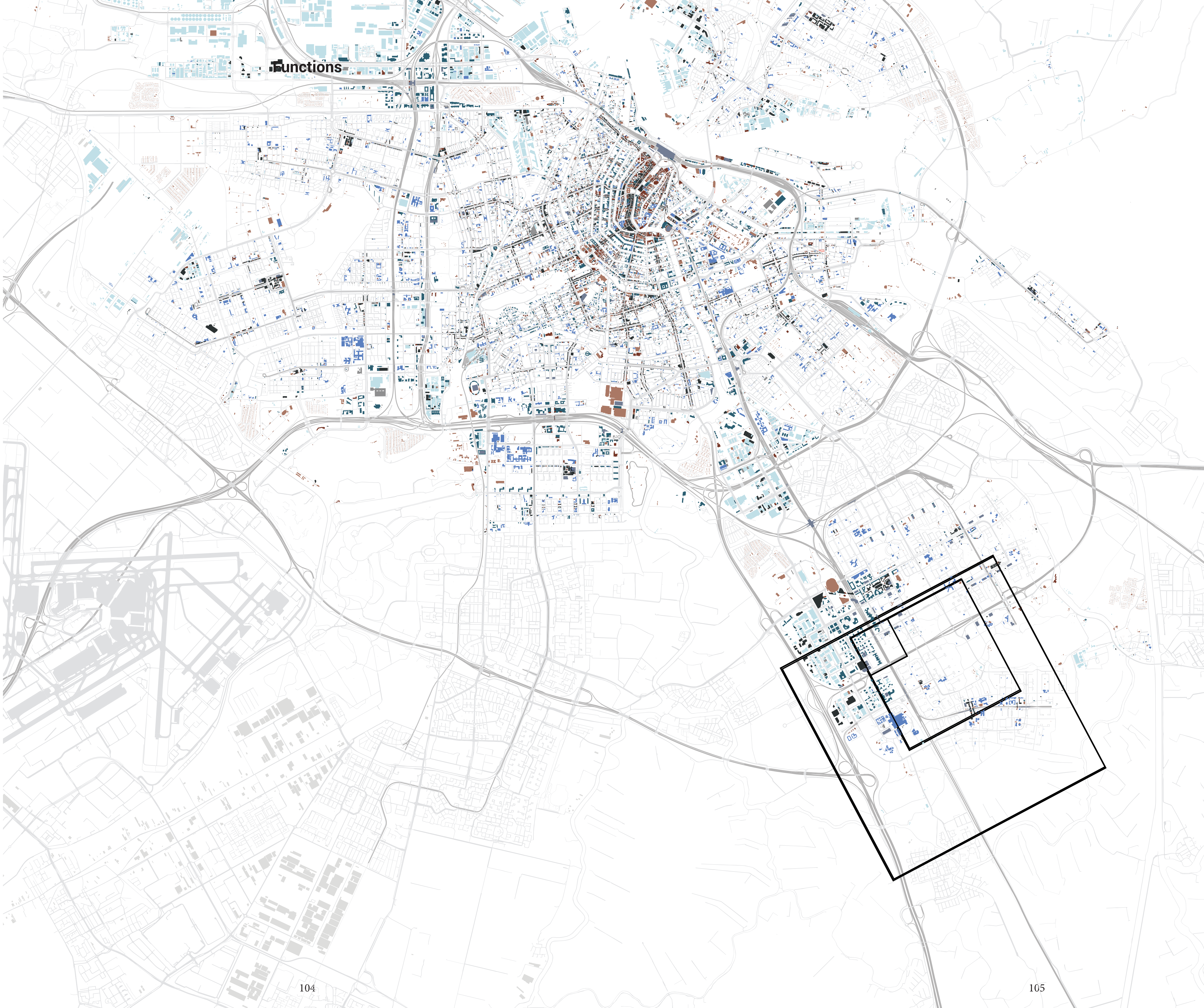
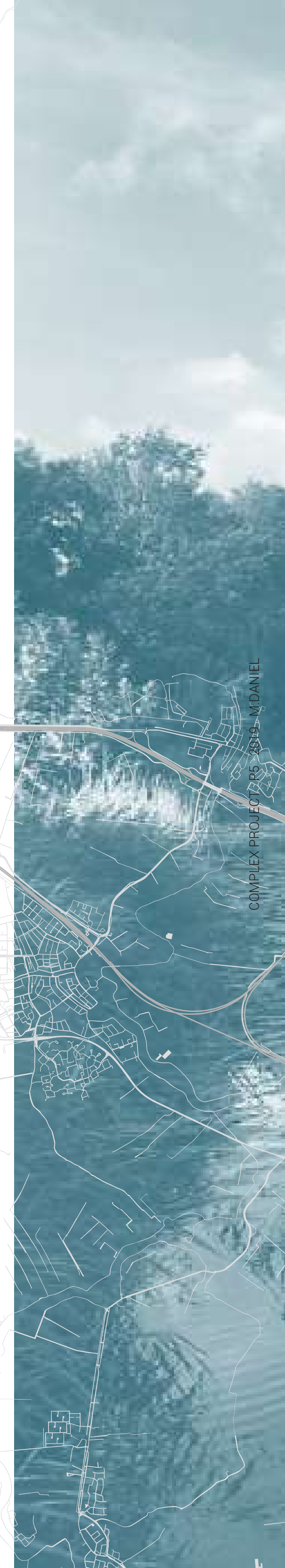
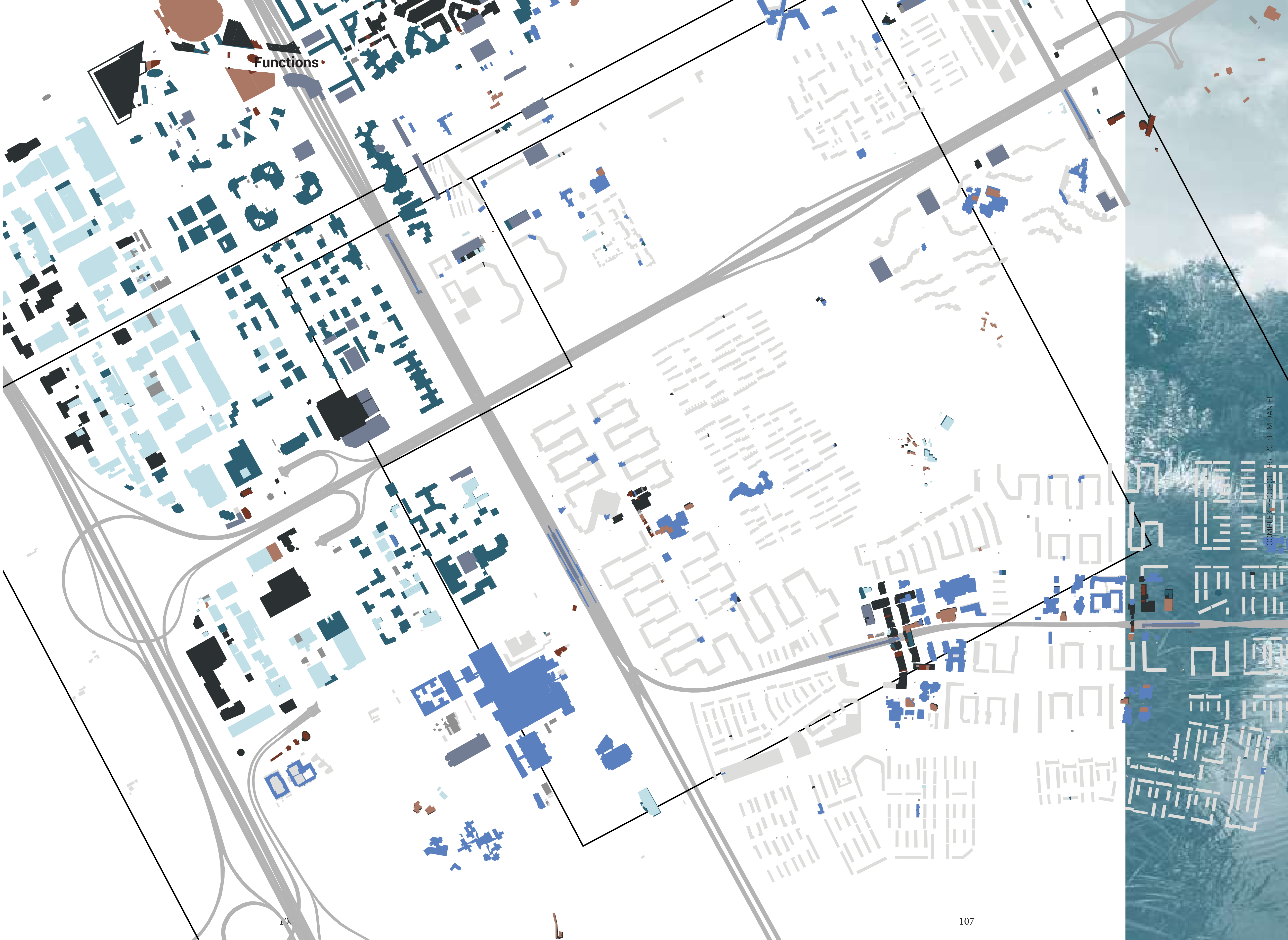




COMPLEX PROJECT P5 2019 M.DANIEL

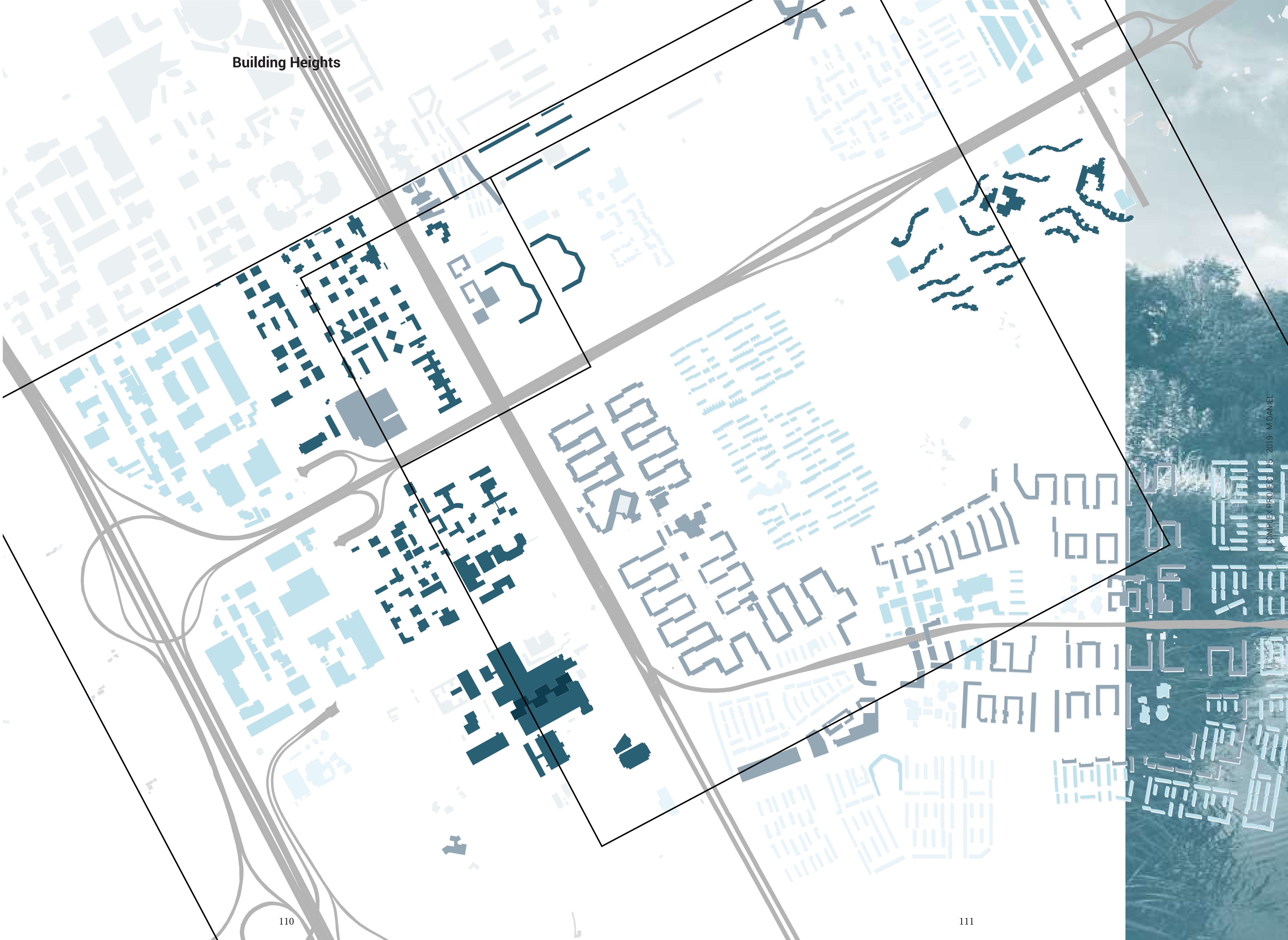
Functions



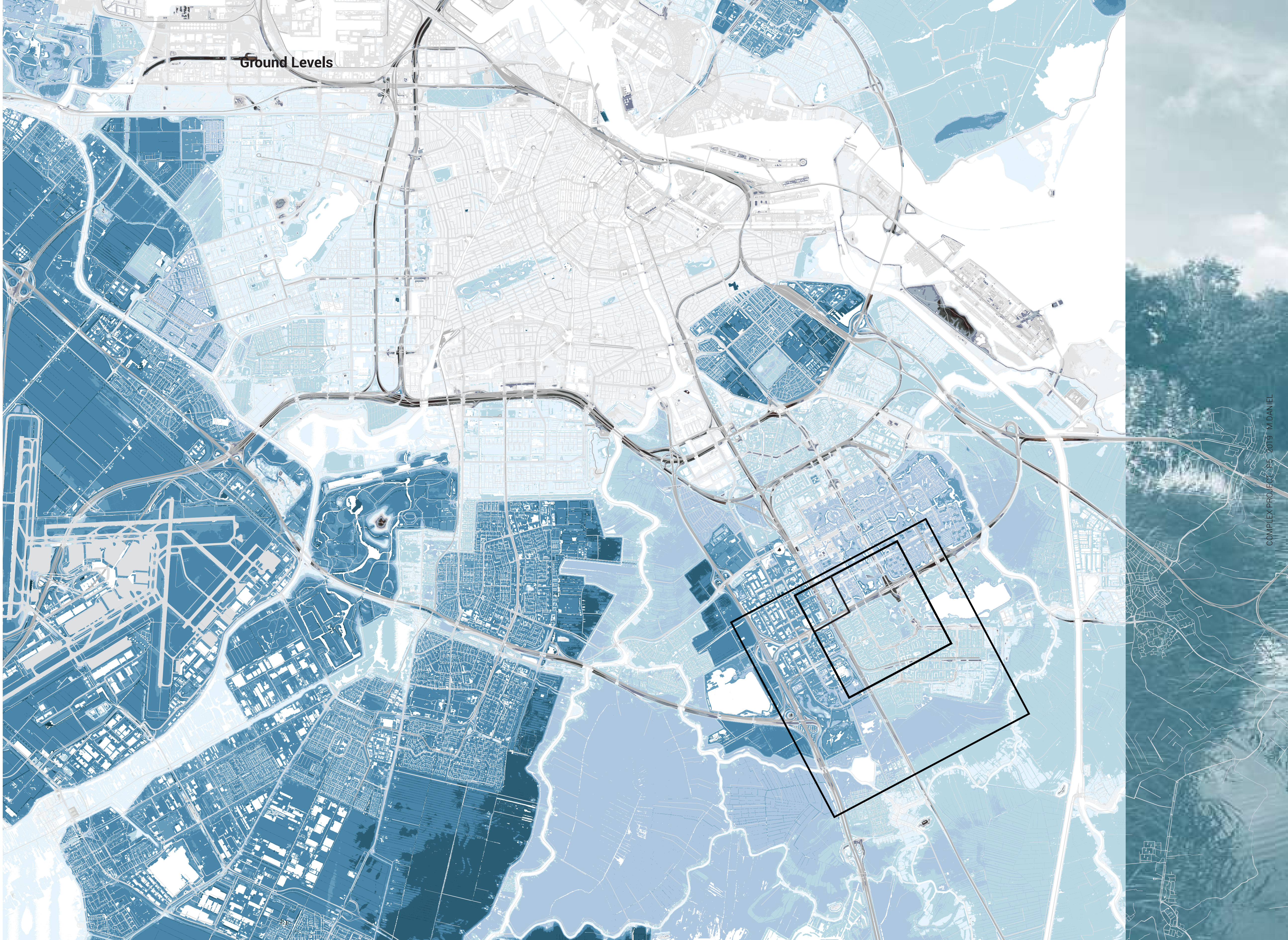
COMPLEX PROJECT P5 2019 M.DANIEL


Culture
Office
Industry
Living
Health

Building Heights



COMPLEX PROJECT P5 2019 M.DANIEL



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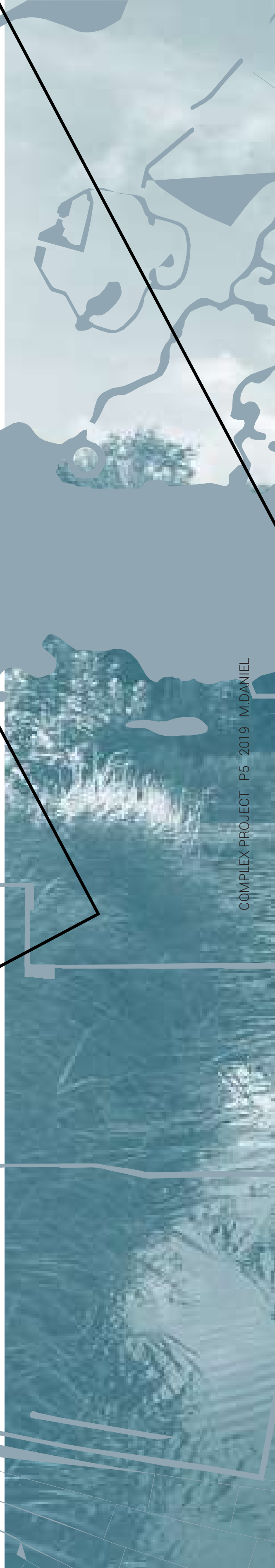
Waterstructure

COMPLEX PROJECT P5 2019 M.DANIEL

Waterstructure



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Social Demographics

Unemployment
12%
National
5,4%

Low Income
€ 22,8%

Higher Educated
40%
Amsterdam
Southeast
20%

Cultural diversity

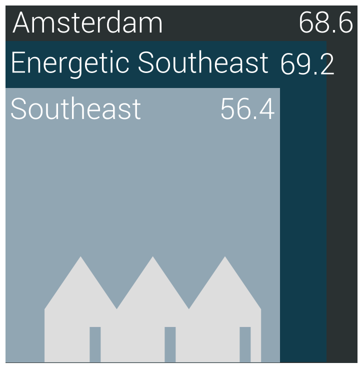
Surinam
Antilles
Ghana
Dutch
Others

x10= 85.000

5000 new dwellings in Amstel III

Amsterdam 207.000
Southeast 127.000
€ €

Office Vacancy
36%




Canal, Amsterdam


Boskoop, Netherlands

Typology Study

The Dutch Tradition of 'Waterscaping'

Water has played a crucial part in the Urban Fine Dutch Tradition. Chararcterizing Dutch watermanagement elements such as the canals and the ditches have all become an essential part of the Dutch landscape. As de Koning states:

The water is essential to the Dutch landscape; it shaped the Netherlands and gives identity and culture to the landscape. The moment the water system alters spatial planning new possibilities appear not only for the water system but also on life and use of the territory. It is inspiring and challenging to work with technical and natural conditions for the design of new living environments. (Robbert de Koning).

A statement which hence complies with the idea of reintroducing a well integrated waterstructure within the urban environment of Amsterdam Zuid Oost.

Adalay Stepwell (Adalaj, India)

Taj Mahal (Agra, India)

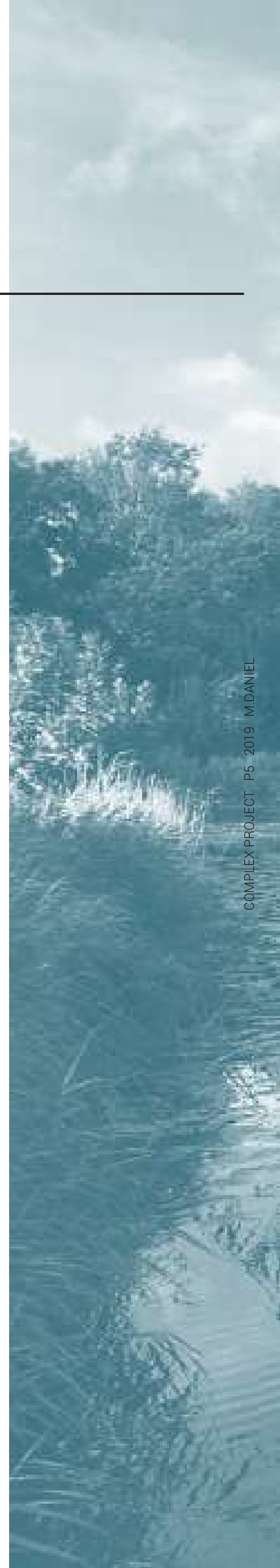
Typology Study

Water and Architecture Beyond Dutch History

When considering the fact that the inhabitants of Amsterdam Zuid Oost originate from a diverse range of foreign countries, a research on the foreign architectural approach should be conducted. An understanding which could lead to an architectural design which provokes a feeling of belonging due to the fact that it's architectural composition or materialisation ressembles their innate understanding of the relationship between architecture and water. An important idea when we take into account that some cultures might even embody an attitude of fear towards water due to it's identification with flooding. Moreover, an inclusion of foreign architectural languages regarding the use of water might lead to a feeling of inclusion and hence enforce a more open and inclusive society.

The first reference is the Adalaj Stepwell in Adalaj (India). This Stepwell provided drinking-, washing and bathing water in a semi-arid region. The structure is five stories-high and starts with an stairwell leading to a five stories deep circular well with square stepped floor which is covered with an octagonal planned roof. The structures on top of the stairwell consist of intricately carved large number of pillars and beams all made of sandstone. As can be scene in the picture this structures leads to an interesting play of light and allows the visitor to sit in the shade.

The Taj Mahal, situated in Agra (India) on




Sidi Harazem Thermal Bath (Morocco)


Kedareshwar Temple (Harishchandragad, India)

the other hand uses the water as a tool to create an extra symmetrical dimension, reflecting the symettrically designed mausoleum in the water.

The following project by the architect Jean François Zevaco in 1960, named the Sidi Harazem Thermal Bath (Morocco), showcases a marriage of nature, public space, and modern architecture (Aziza Chaouni, 2017). Being situated in an open, arid area, the circular form of the Thermal Bath reminds us of a natural pool which often ressembles this circularity.

The next architectural construction is the Kedareshwar Temple located in Harishchandragad (India) is situated in a cave. The presence of water throughout the whole year makes it a unique and intruiging composition. The stonish natural material is reflected in the water, reflecting the light and the natural cave / the architecture and hence creating a perception of a double floored construction. The robust stone materialisation used for the columns is evidently from the same material as the cave itself.

The fith reference project is a bathhouse in the city of Bath (Great Britain). This project originated from the Roman Era but has been redeveloped on several occassions (including the latest in the 19th century (1894-1897)). Previous to the construction of the bathhouse (before 70 A.D.) the site may have, according to archeological evidence, been used by Celts as a centre of workship towards the goddess of the springs; 'Sulis'. The current architectural composition however accomodated a space for social gathering and bathing and relates with it's architectural construction to the roman architectural style by the use of a neo-classical style. The use of ionic pillars in a structured collonade

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Bath-house (Bath, Great Britain)


Temple (Bali, Indonesia)

can therefore often been scene in bath-houses.

And the last project based in Bali once more reveals a use of stoney materials in different shapes and colours. A feature which repeats itself within the previous presented references which interestingly all fall into the cathagory of either religious, functional (bathing, drinking) and/or social entities. The resemblance of the nature either by using the same natural stoney materials (such as in the cave temple) or by using resembling shapes (such as the circular pool in morocco) is evident may it be situated in a desert or tropical area.

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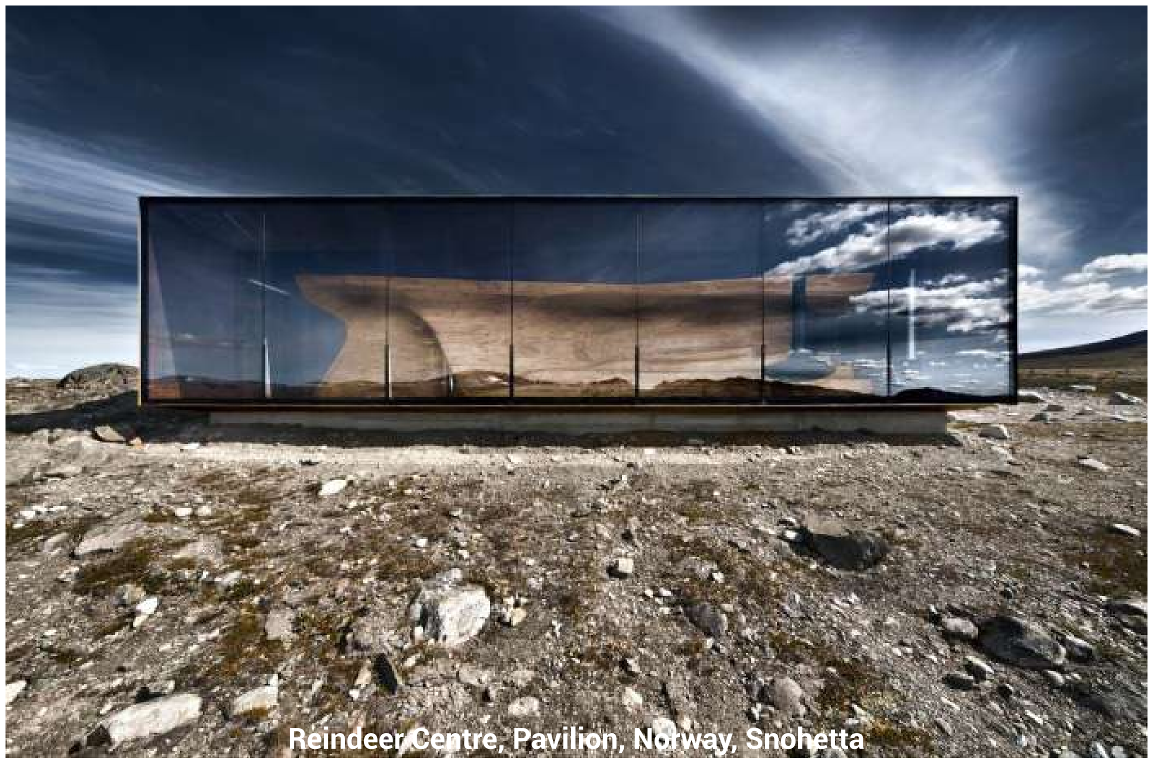
Ocean Space Centre, Norway, Snohetta



Reindeer Centre, Pavilion, Norway, Snohetta

Typology Study

Architectural References to the Concept

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Sayamaike museum, Japan, Tadao Ando

Contemporary art museum, Japan, Tadao Ando

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I. Introduction

II. Problem Statement

III. Research Question(s)

IV. Hypothesis

V. Research: Seminar

VI. Research: Studio

VII. Initial/'P2'-Project Proposal

VIII. Conclusion

VII . Project Proposal; City Scale

4. How can architecture/the built environment accomodate and contribute to such an energy system?

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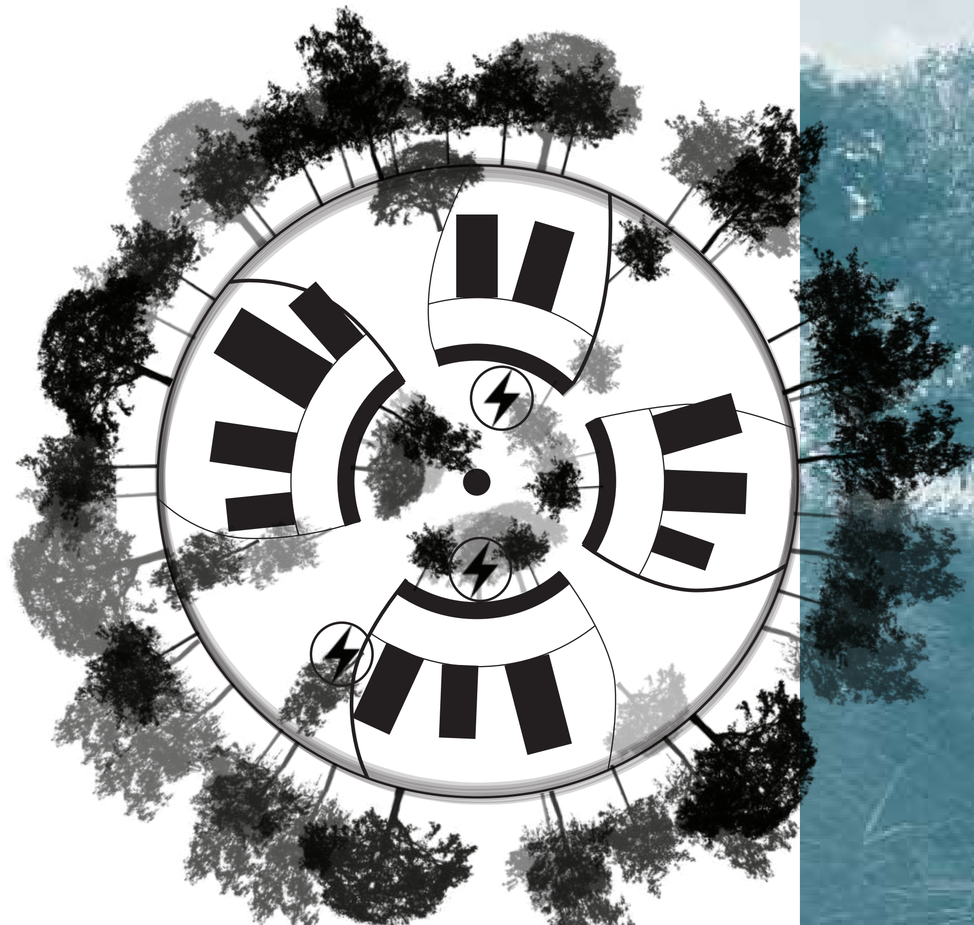
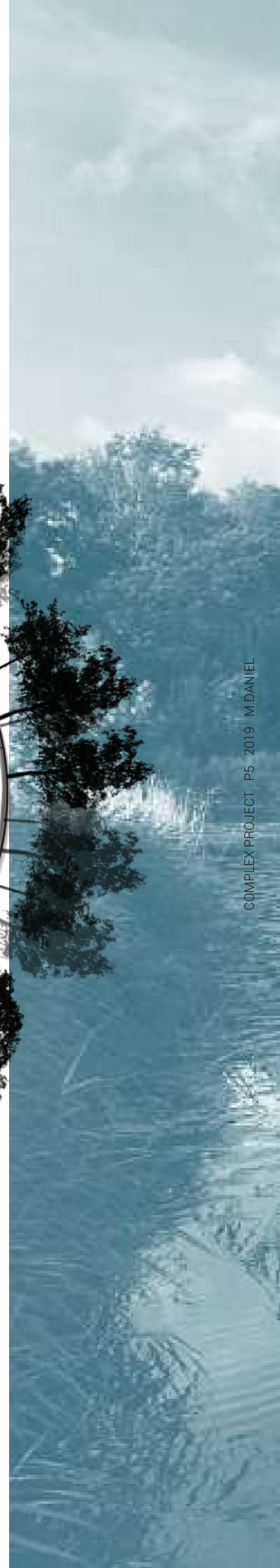
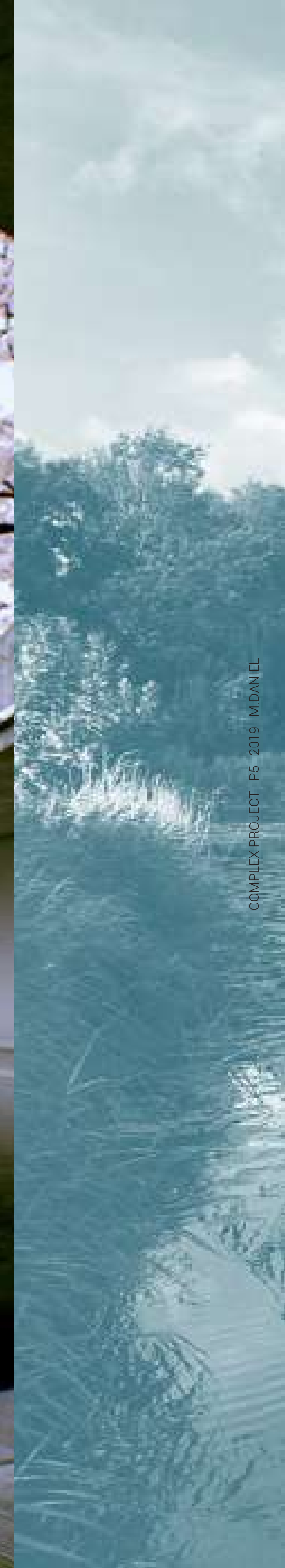
From the Boundary System



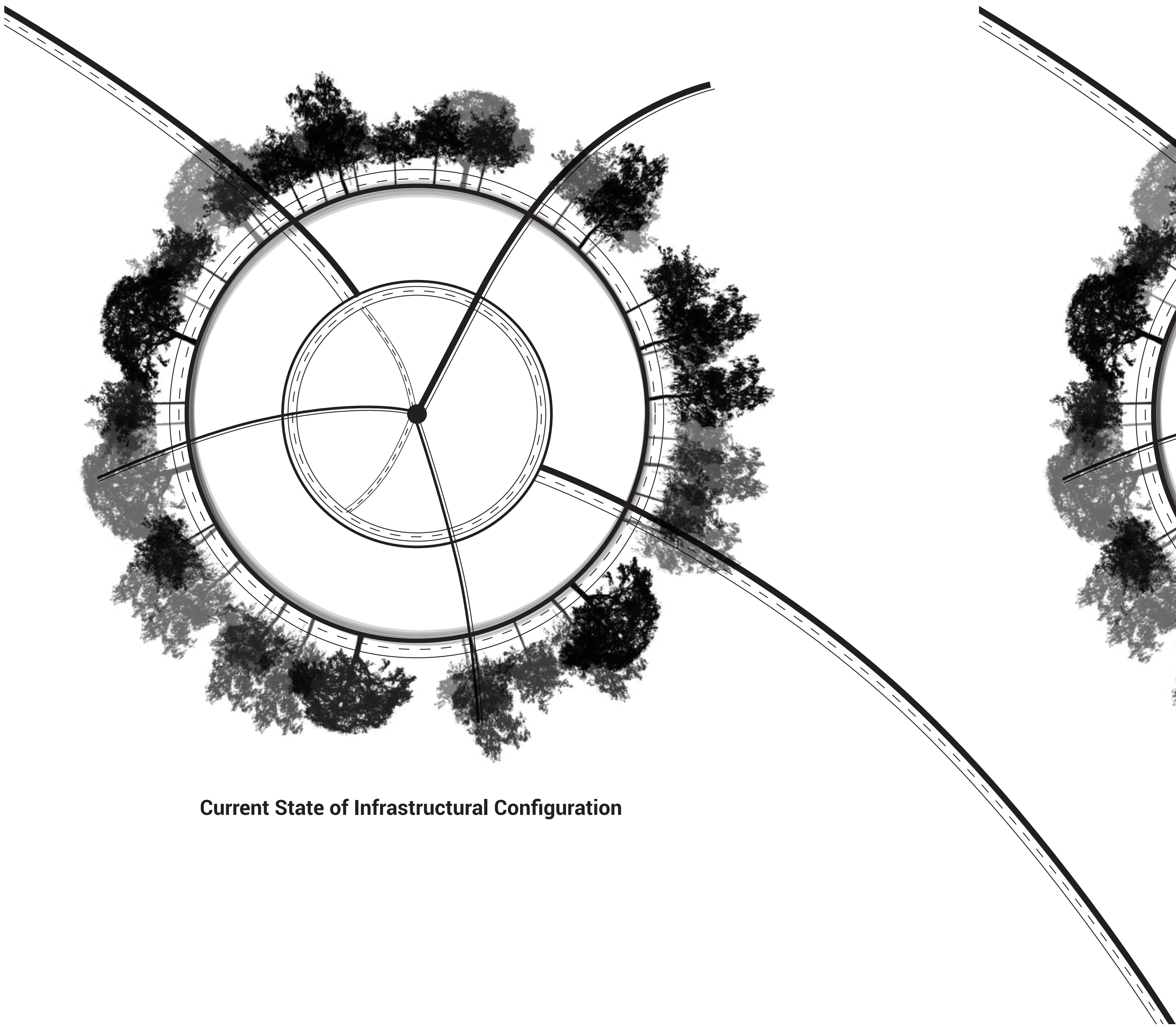
To the inverted and Open system



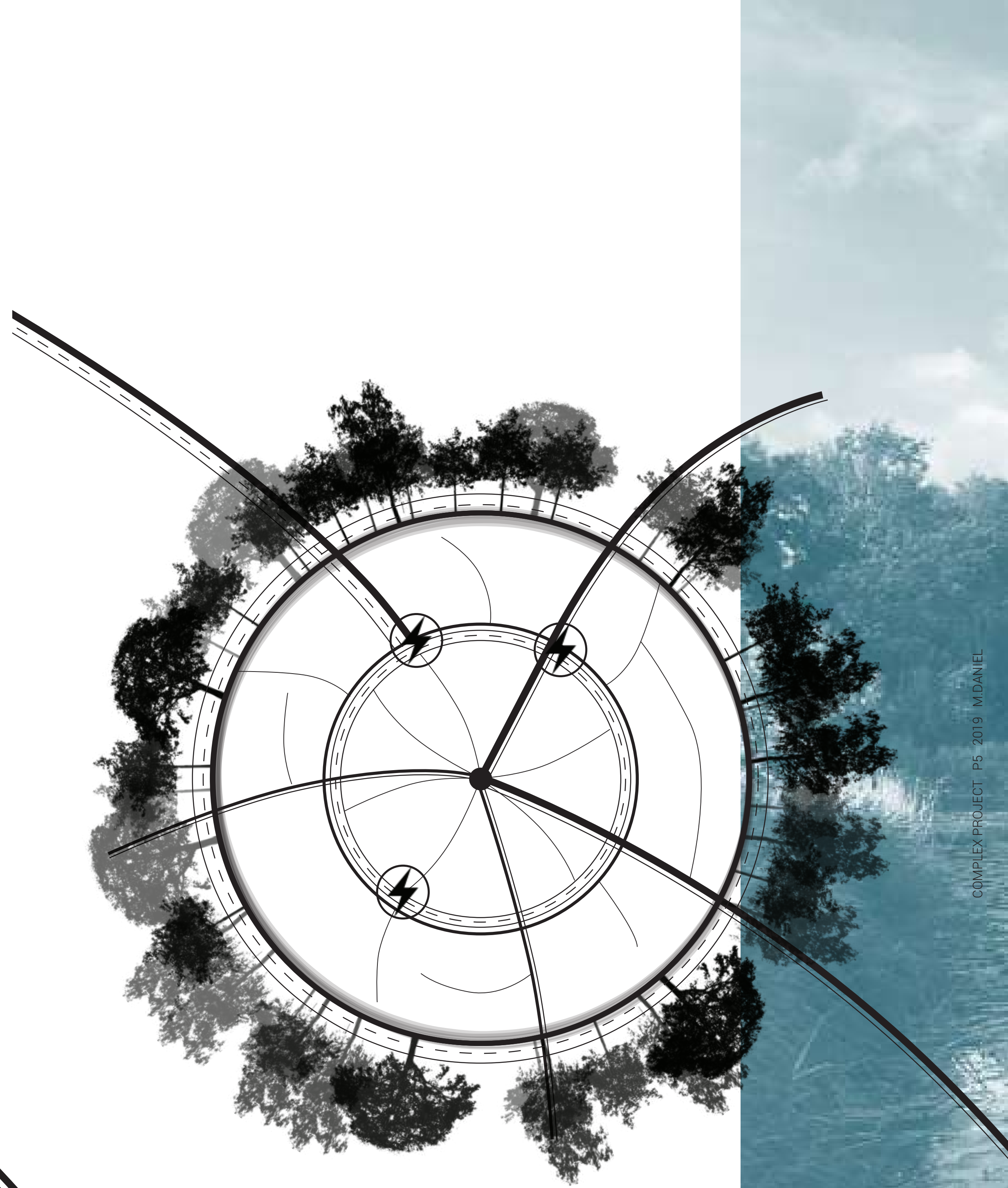
COMPLEX PROJECT P5 2019 M.DANIEL



COMPLEX PROJECT P5 2019 M.DANIEL

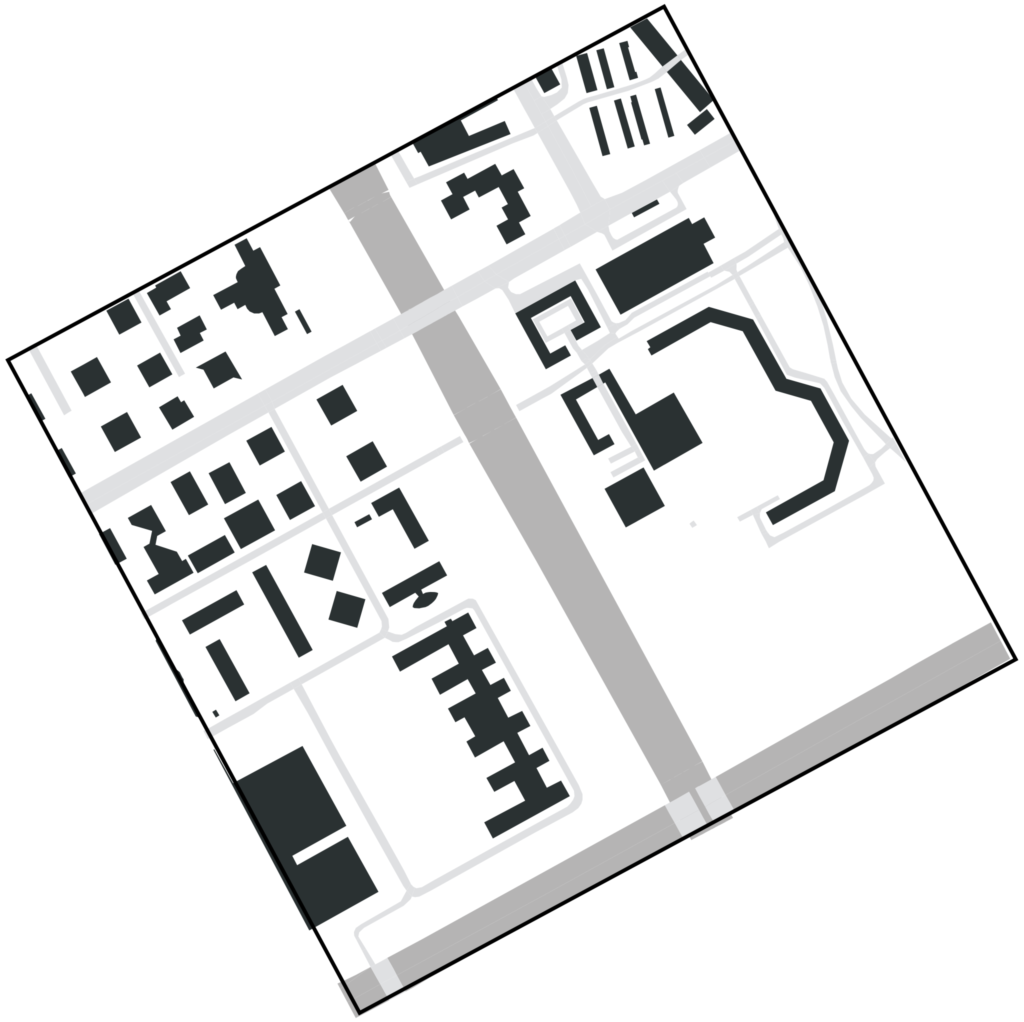


Current State of Infrastructural Configuration



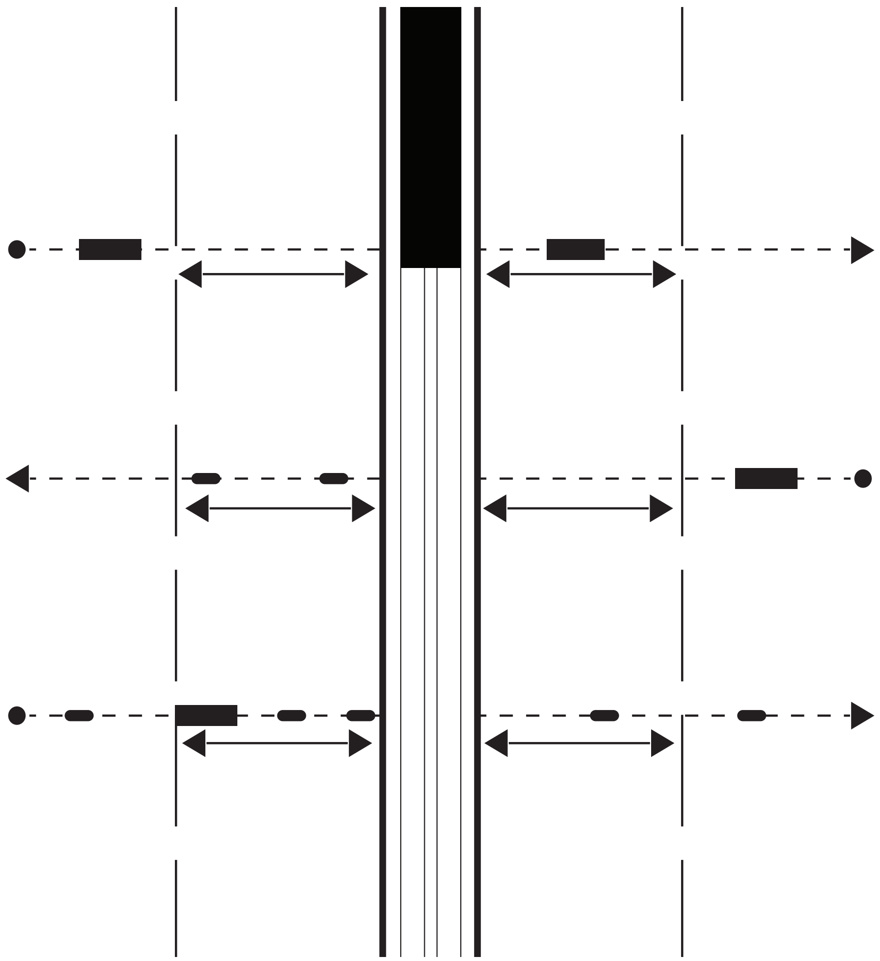
Future State of Infrastructural Configuration

Location

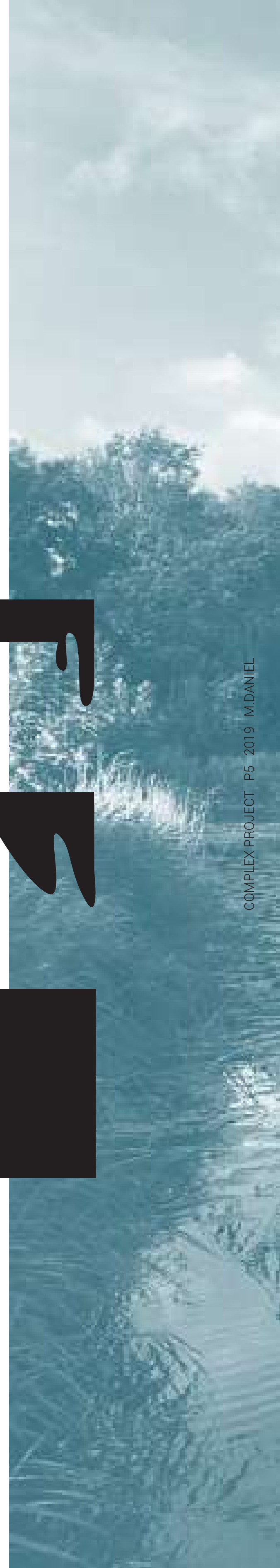


VII . Project Proposal; Local Scale

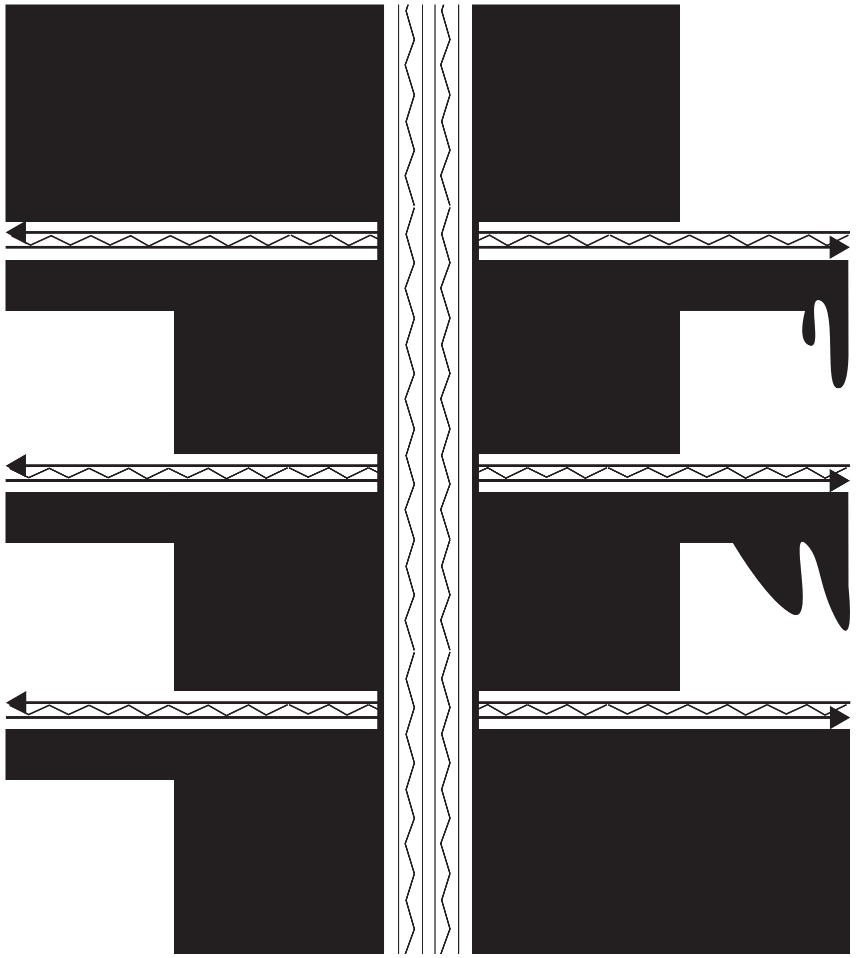
4. How can architecture/built environment accomodate and contribute to such an energy system?


Infrastructural Configuration


Water Storage Configuration



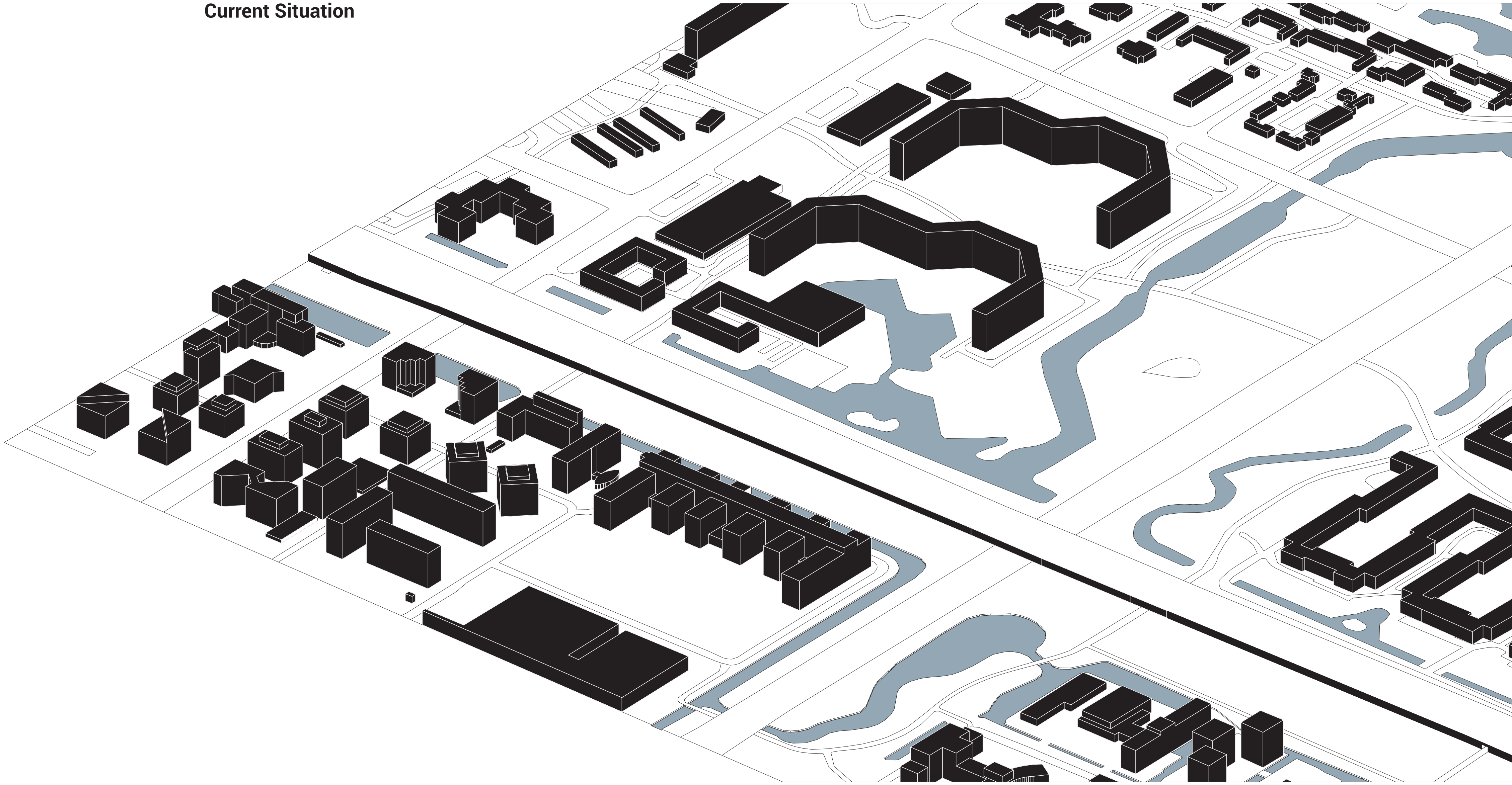
COMPLEX PROJECT P5 2019 M.DANIEL

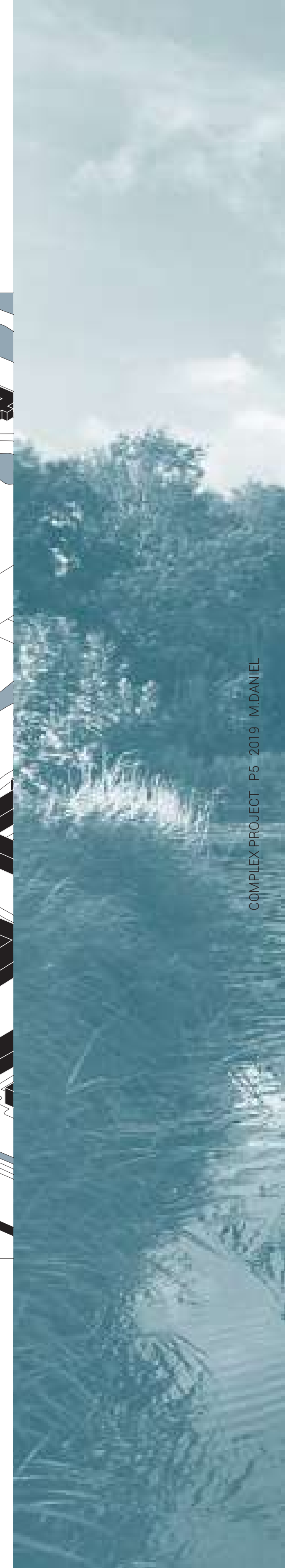


Energy Transfer and Storage Configuration

COMPLEX PROJECT P5 2019 M.DANIEL

Current Situation





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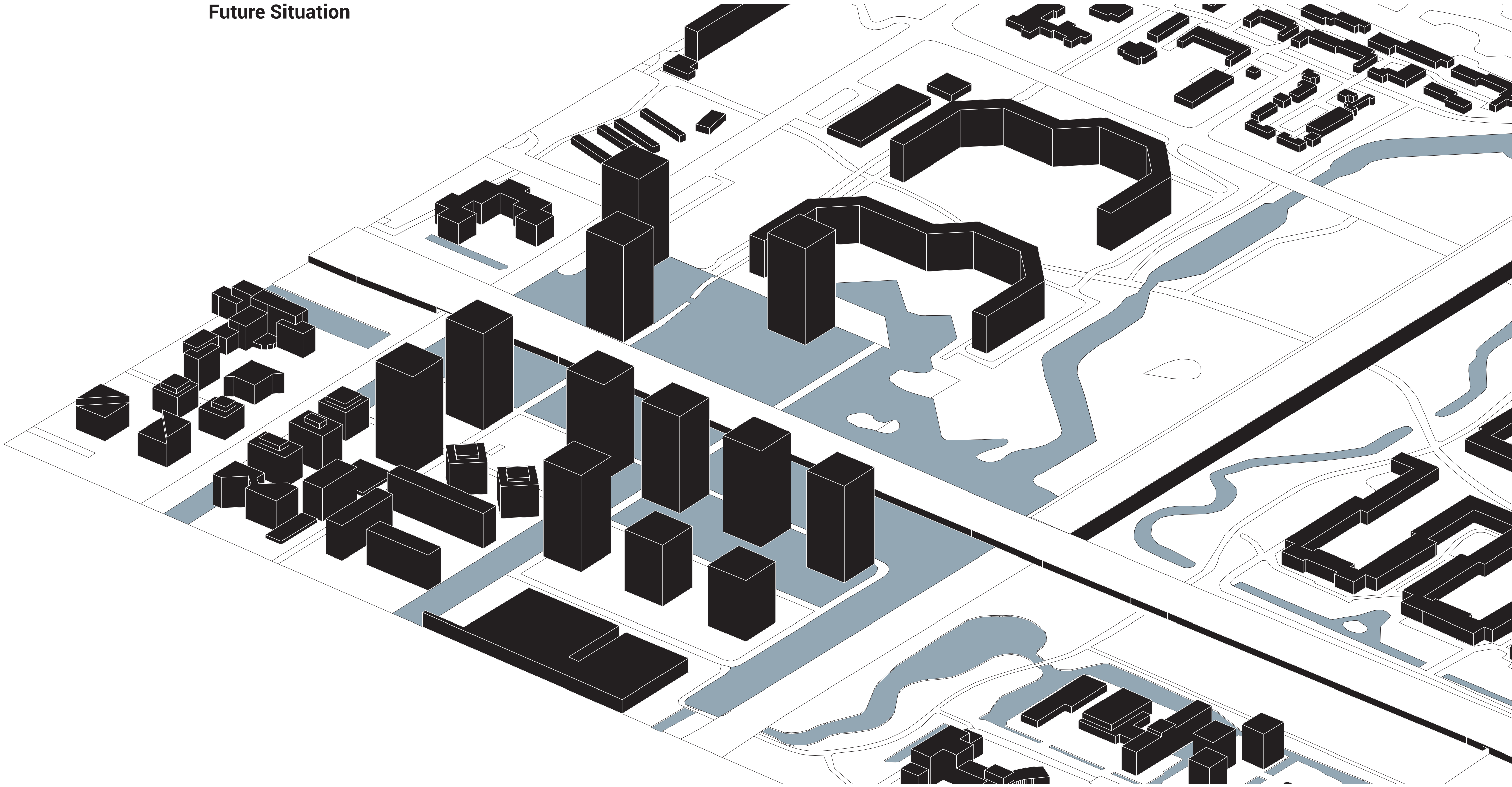
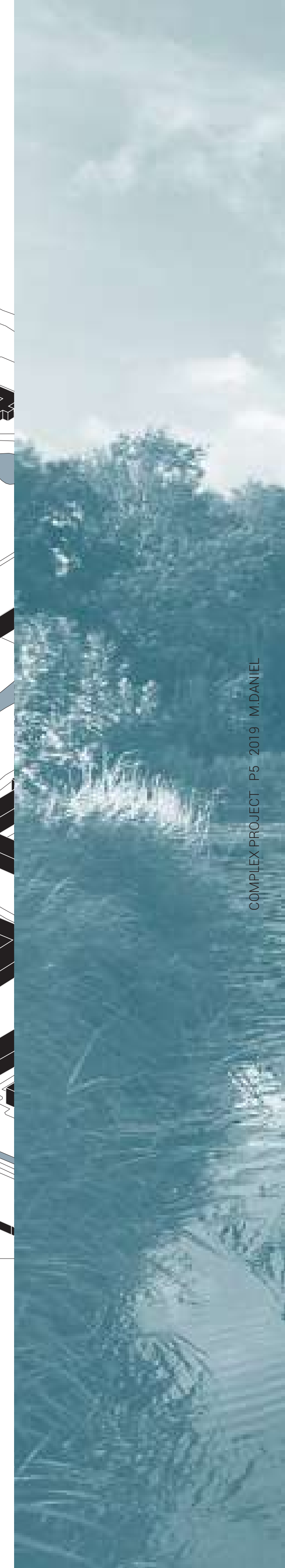
Future Situation



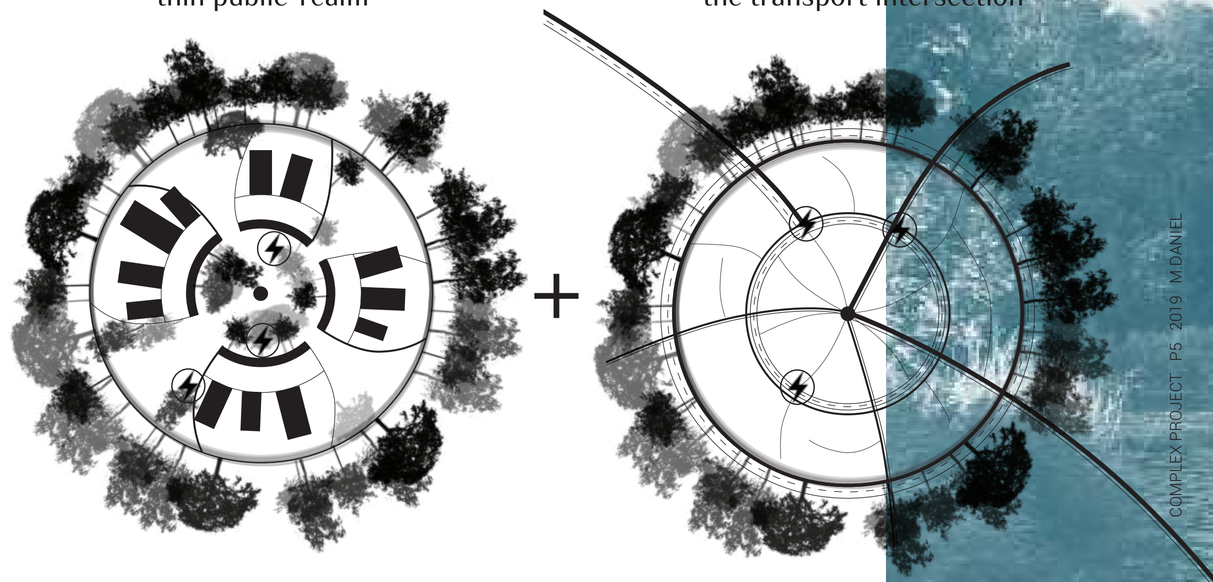


VII . Project Proposal; Building Scale

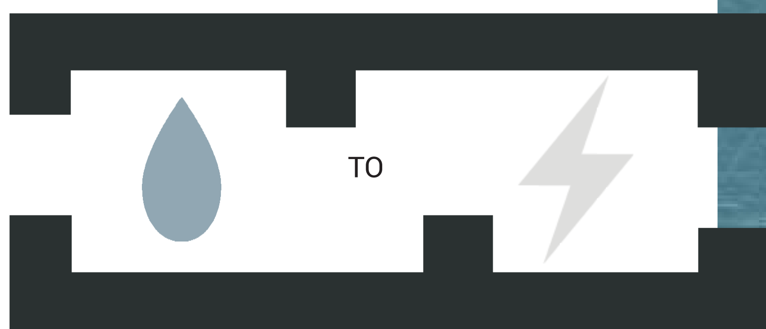
4. How can architecture/the built environment accomodate and contribute to such an energy system?

Energy generation/storage within public-realm

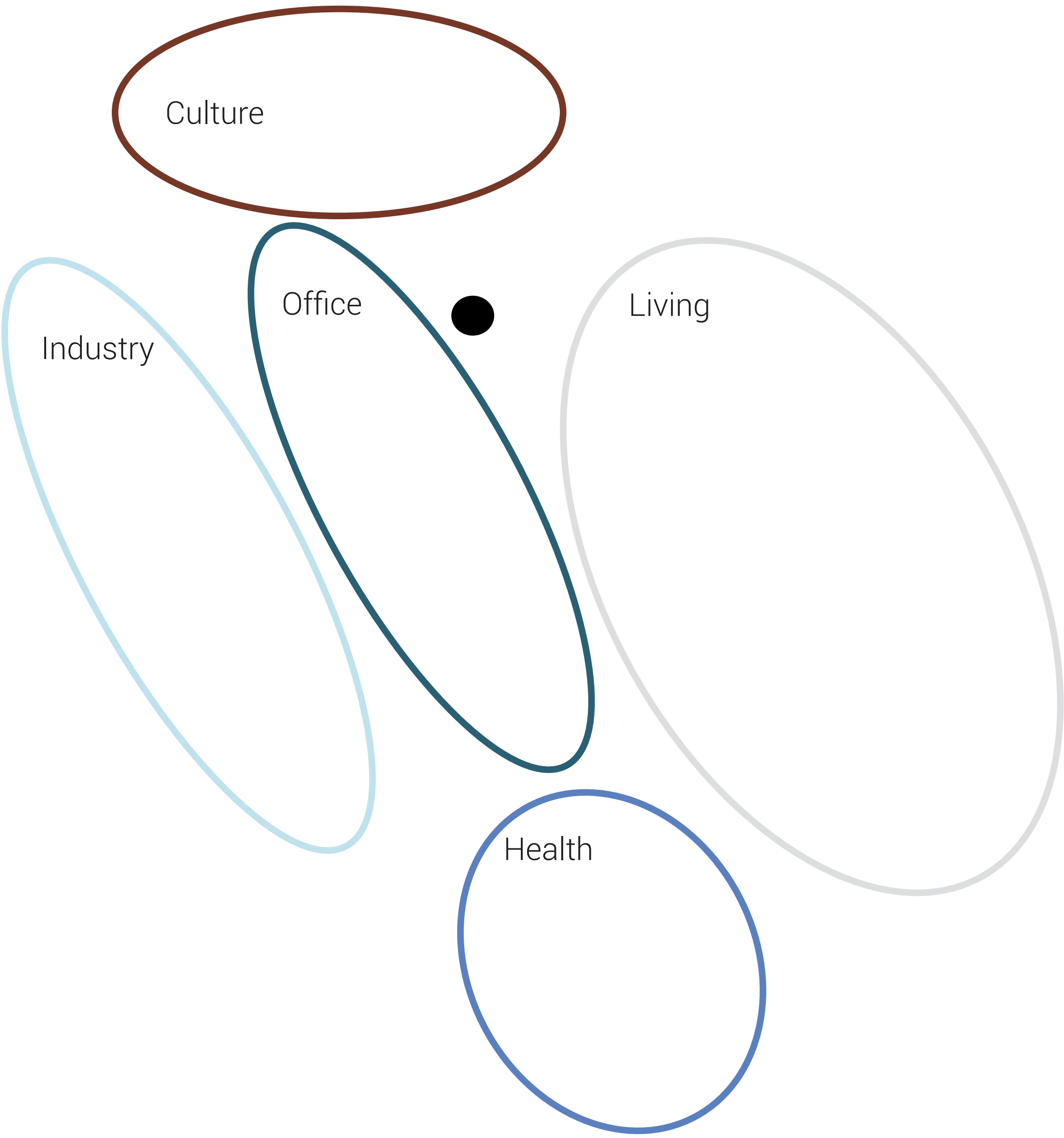
Energy generation/storage on the transport intersection



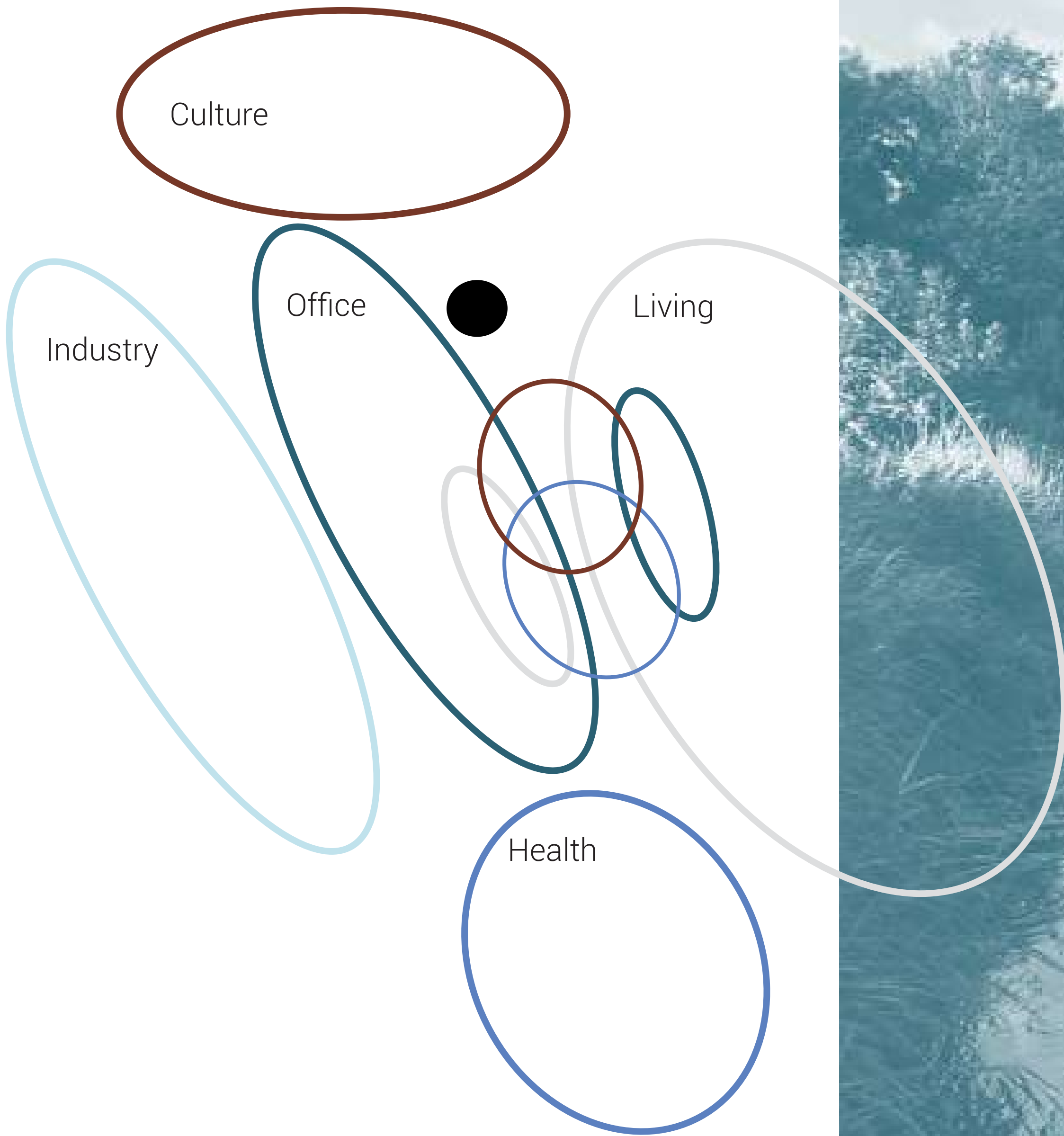
= The Battery



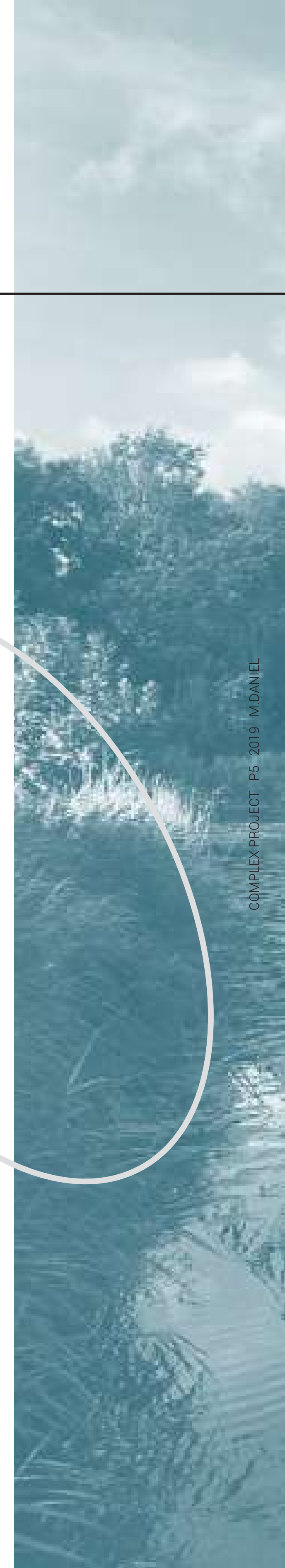
Program



Current Clusters



Proposed Intermingling



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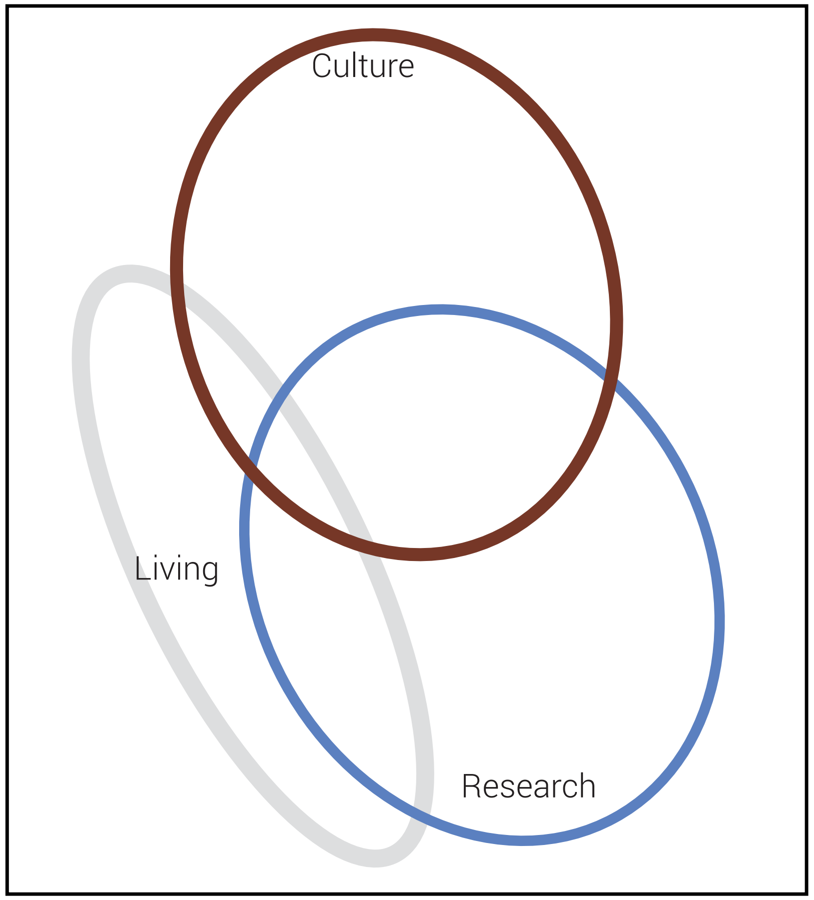
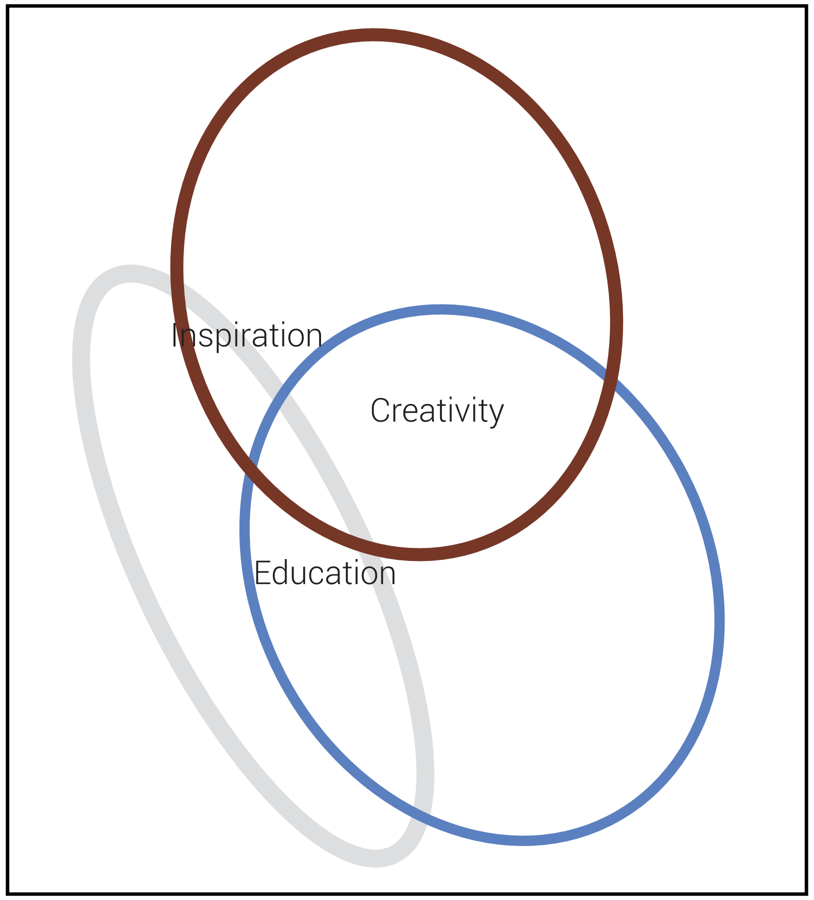


Culture, Research and Dwelling



Inspiration, Education & Creativity

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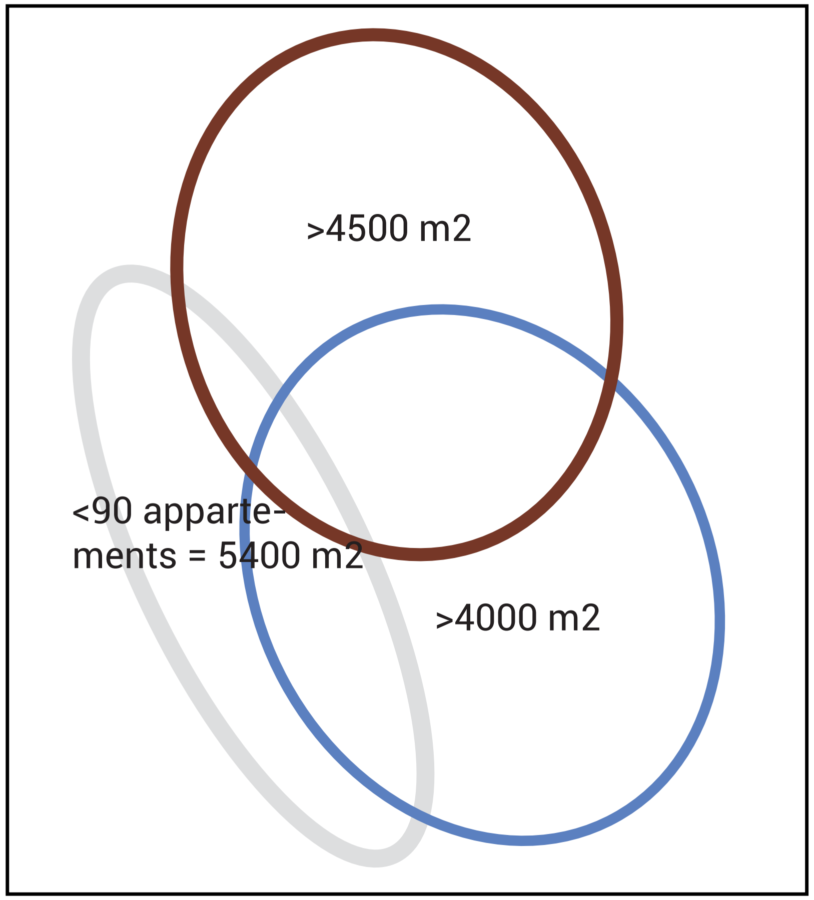


Approximated 'PvE'

Reference Massing

Wetsus Research Center
GEAR architects
Leeuwarden, NL

Surface: 4500 m2
Volume: 30 x 30 x 18 m

Culture Center
H.O.L.Y architecten, V. Yanovshtchinsky
Delft

Surface: 4000 m2
Volume: 30 x 55 x 12 m

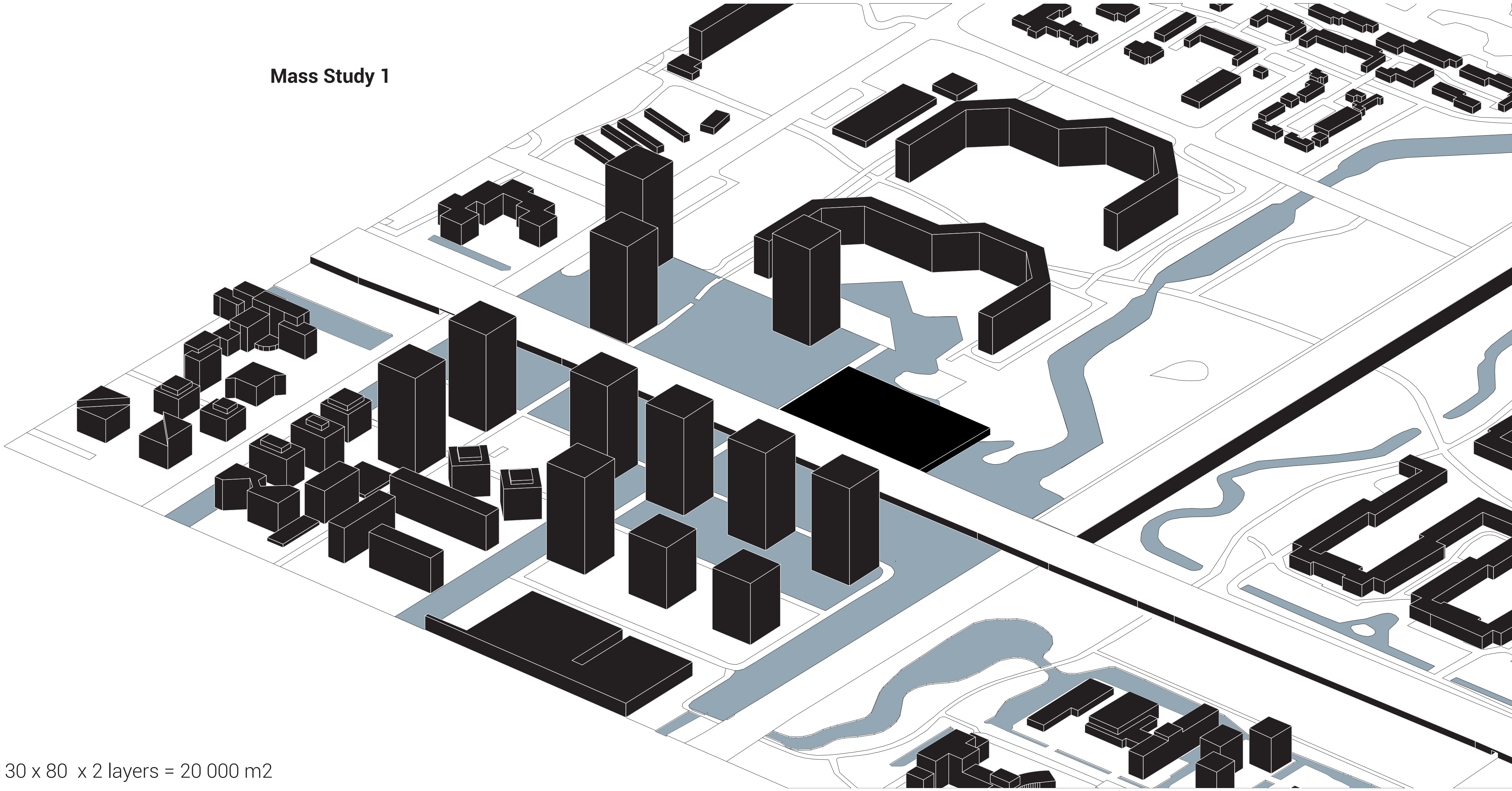
Mix Use ; Timmerhuis
OMA
Rotterdam

Appartements; 91

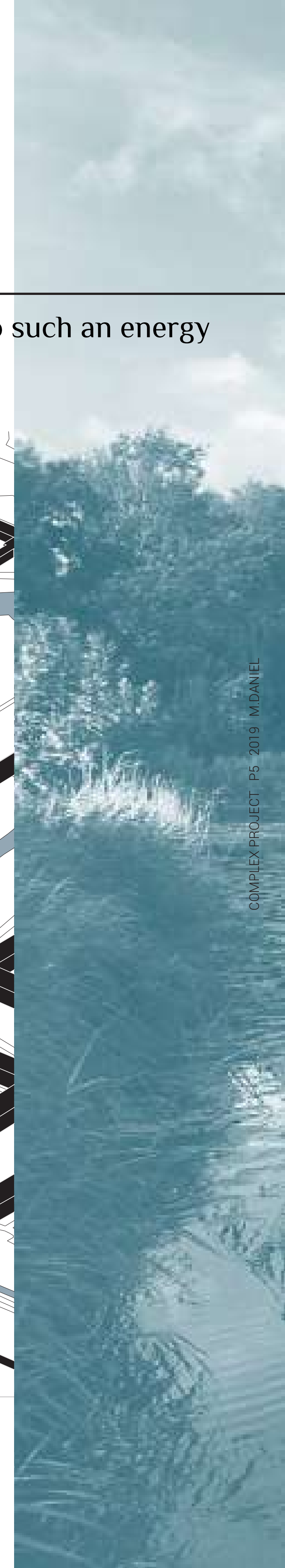
VII Project Proposal: Mass studies

4. How can architecture accomodate and contribute to such an energy system?

Mass Study 1



130 x 80 x 2 layers = 20 000 m2



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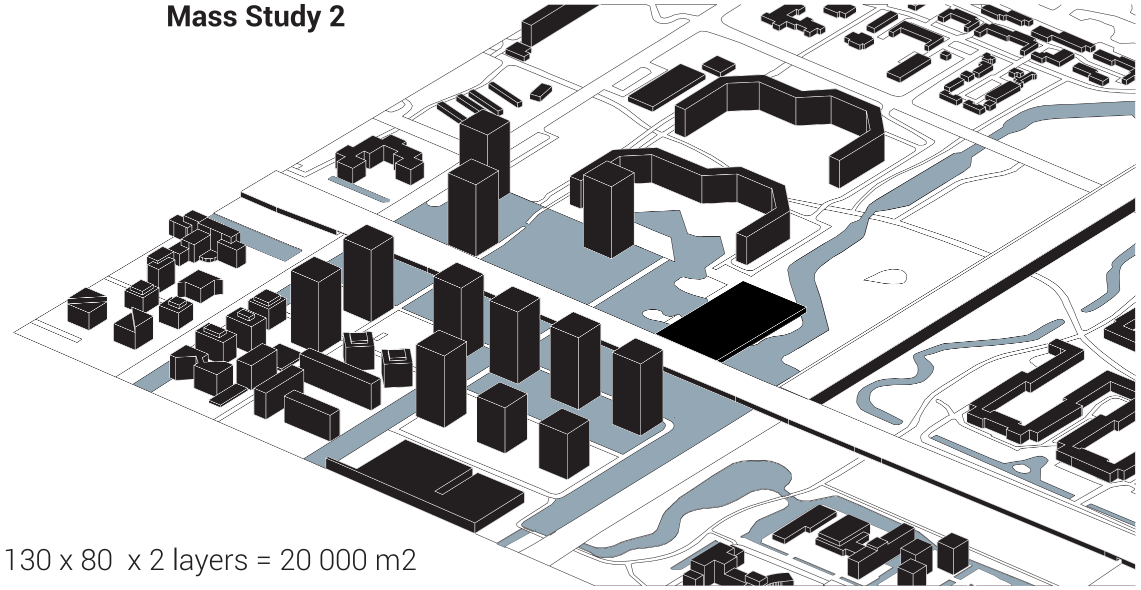
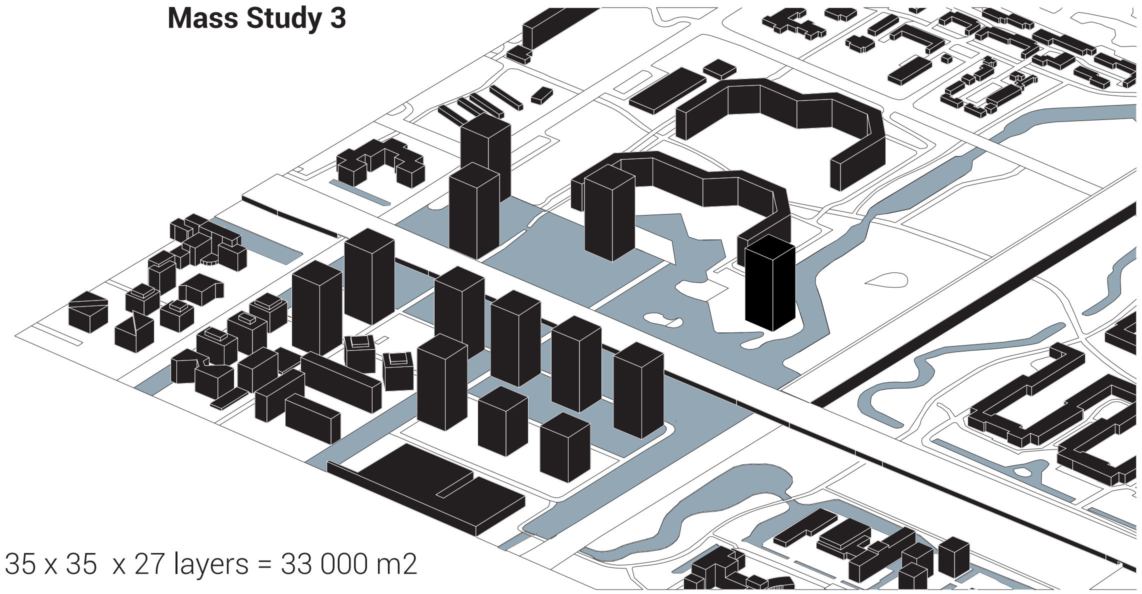
Mass Study 2

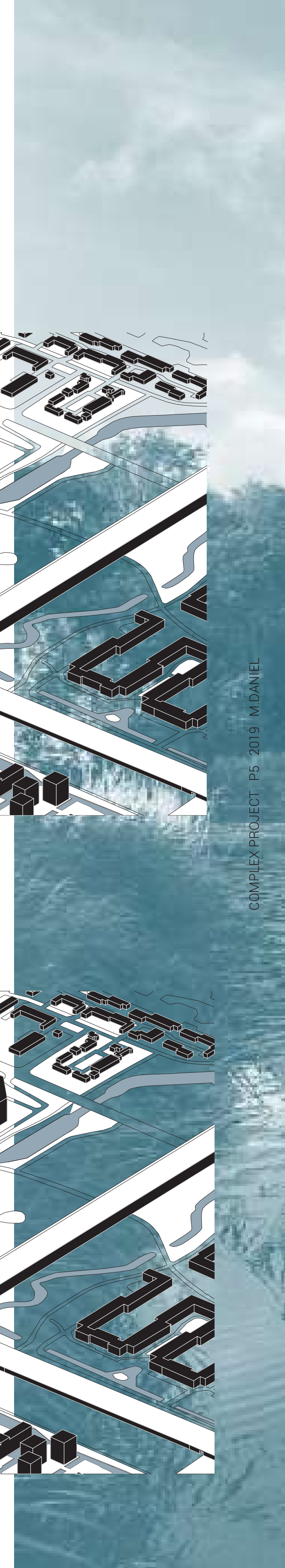


130 x 80 x 2 layers = 20 000 m2

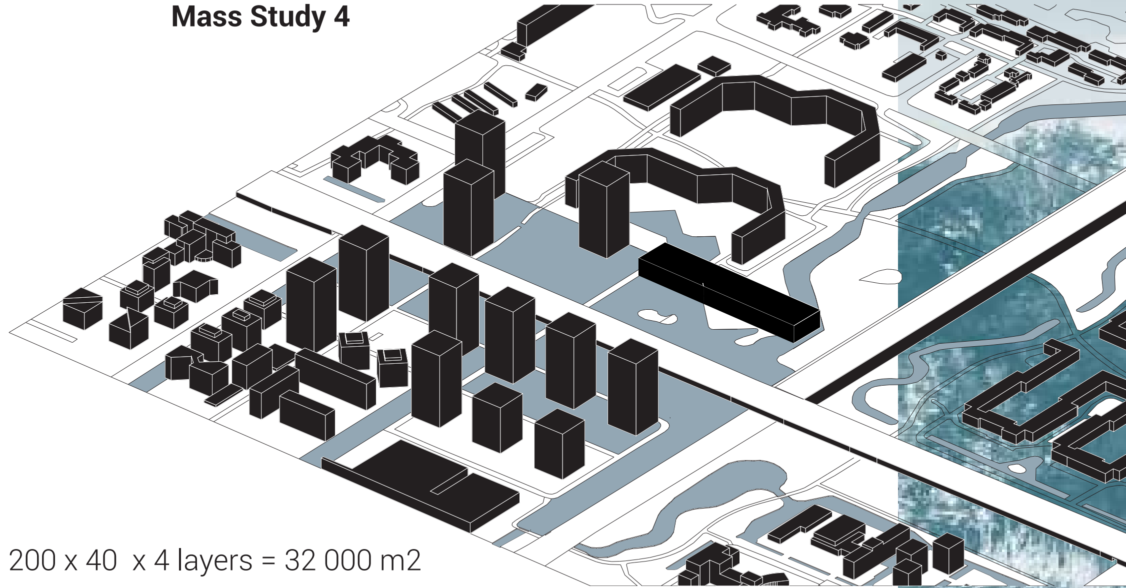
Mass Study 3



35 x 35 x 27 layers = 33 000 m2

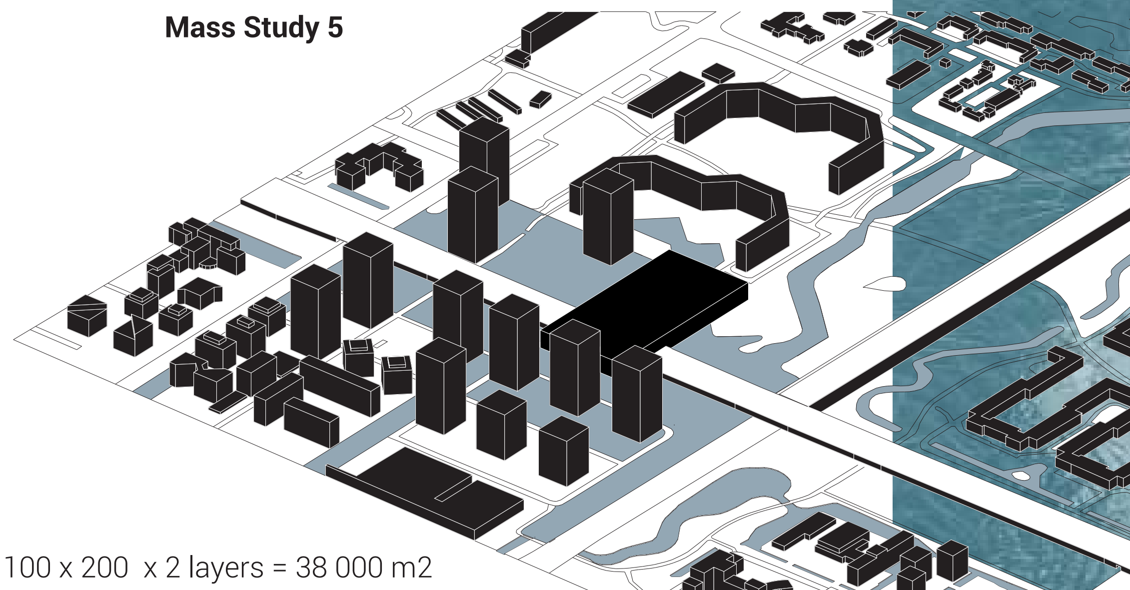


Mass Study 4



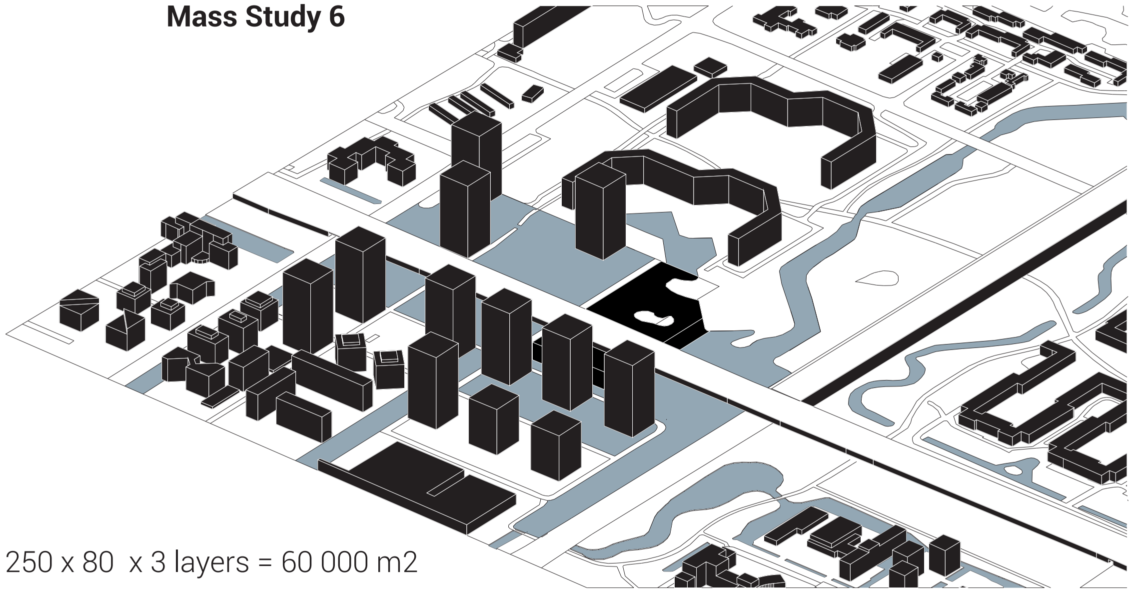
200 x 40 x 4 layers = 32 000 m2

Mass Study 5



100 x 200 x 2 layers = 38 000 m2

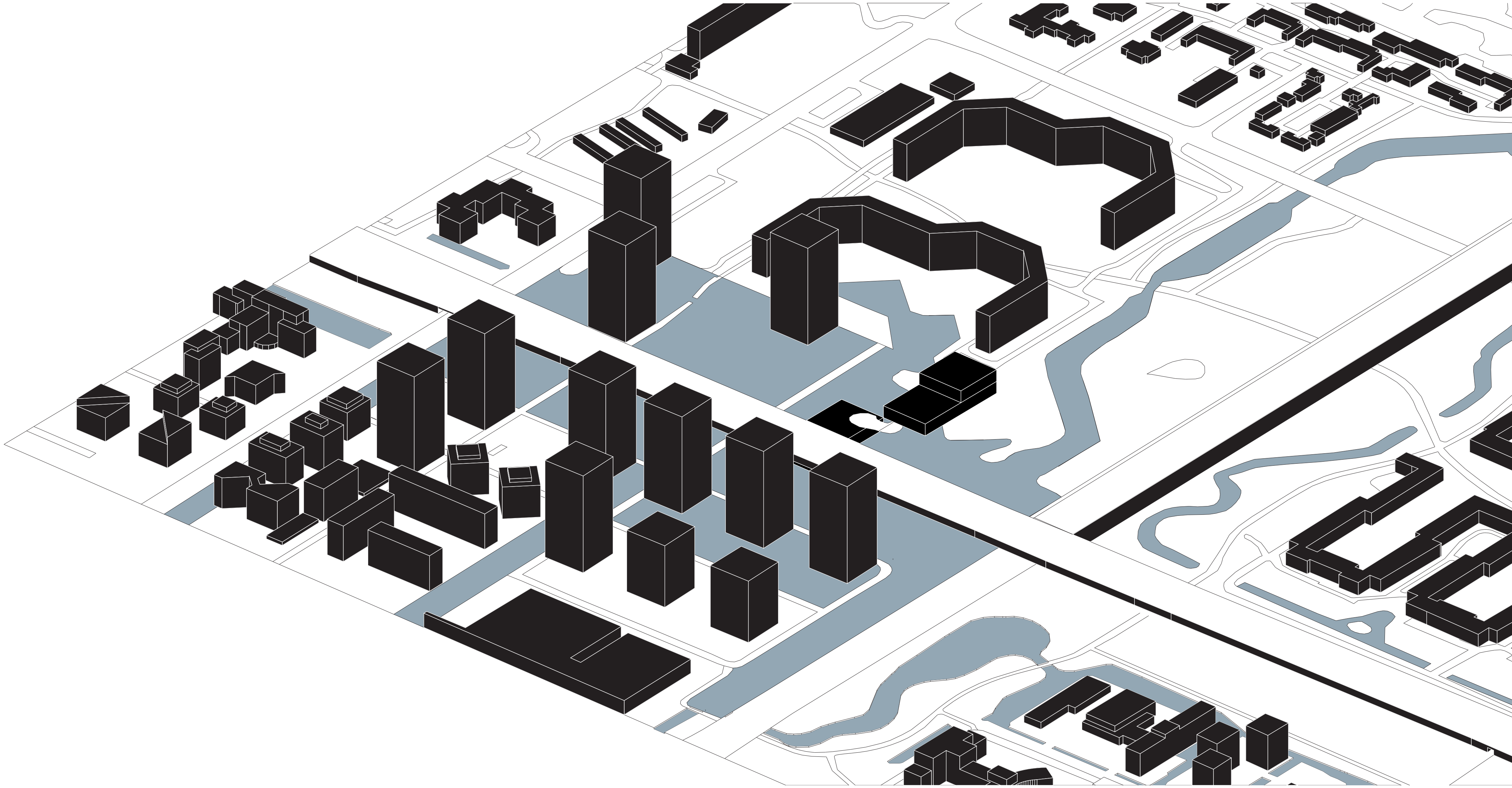
Mass Study 6

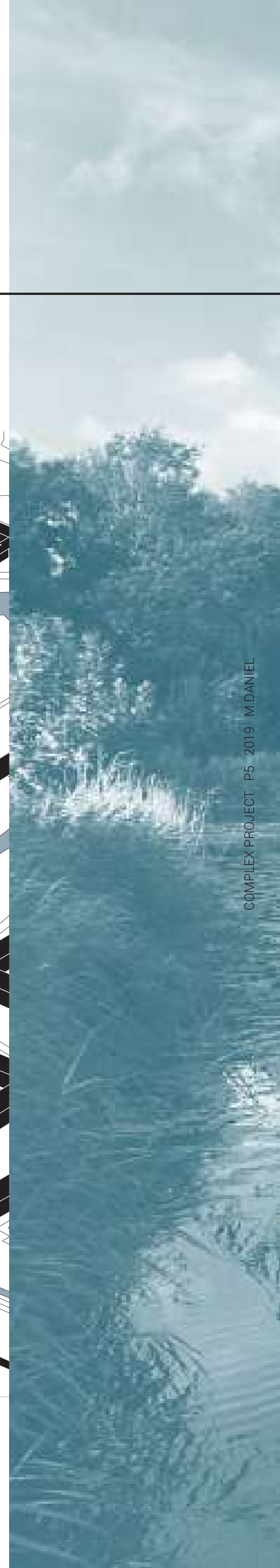


250 x 80 x 3 layers = 60 000 m2

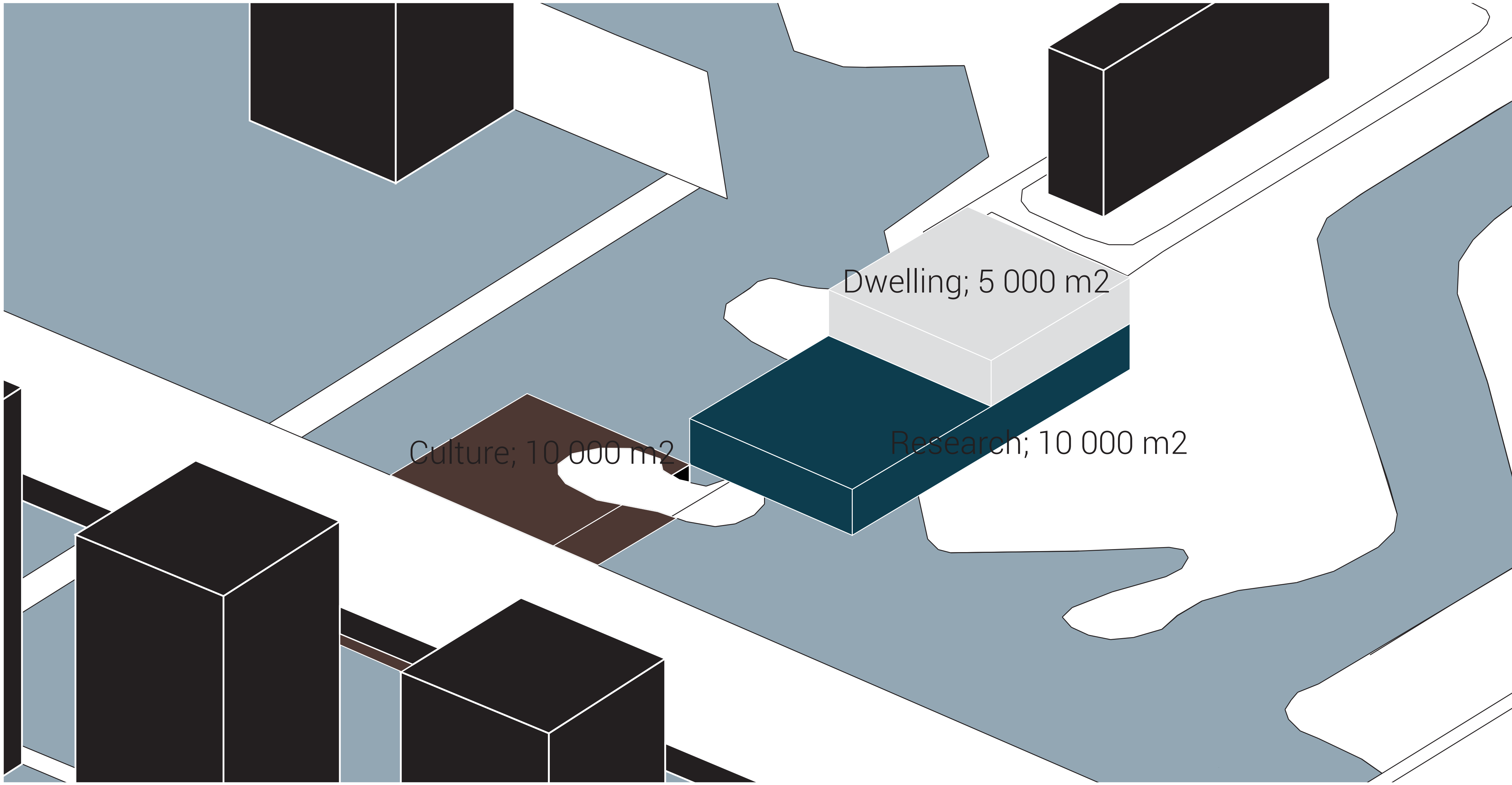
COMPLEX PROJECT P5 2019 M.DANIEL

VI . Initial/P2 Project Proposal

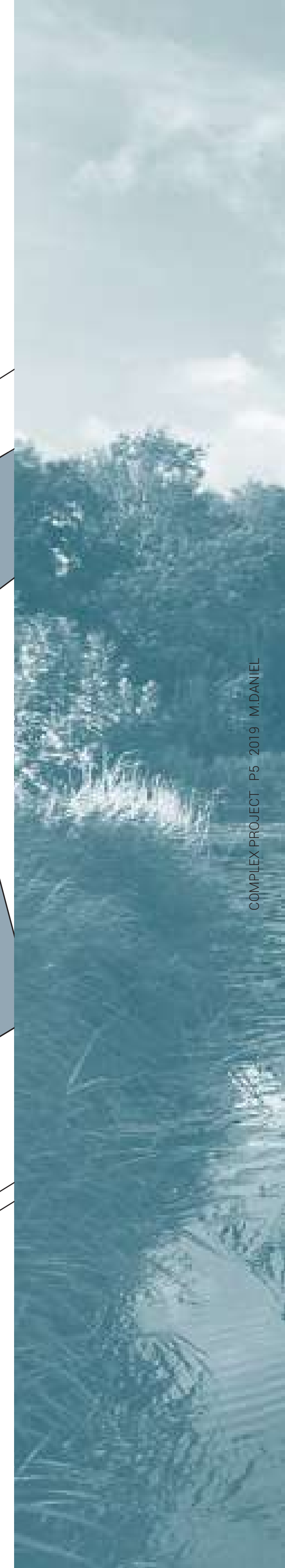




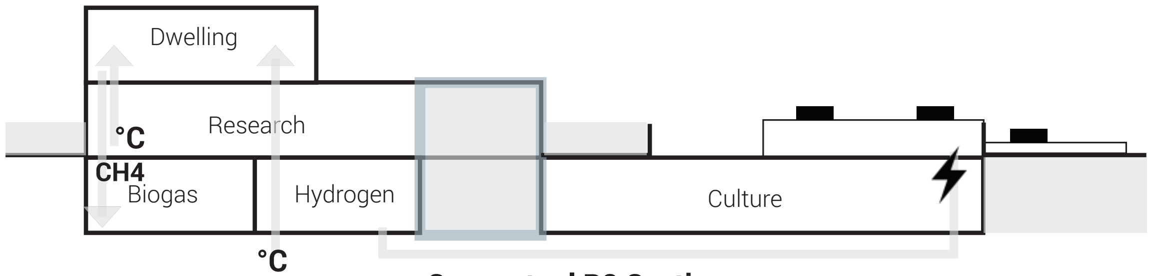
COMPLEX PROJECT P5 2019 M.DANIEL



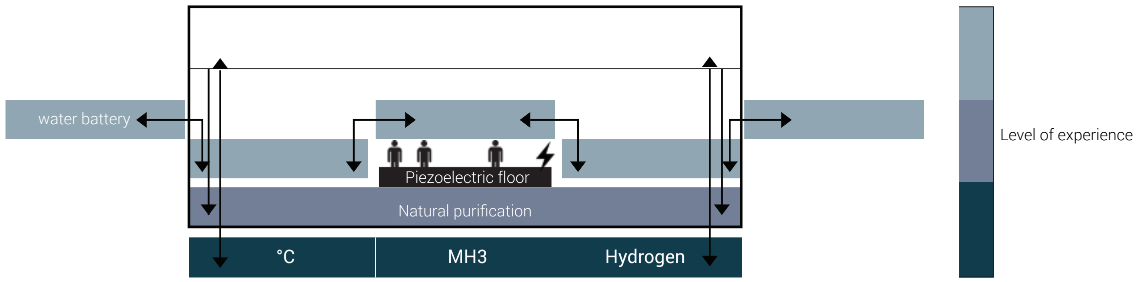
Program & Massing Proposal



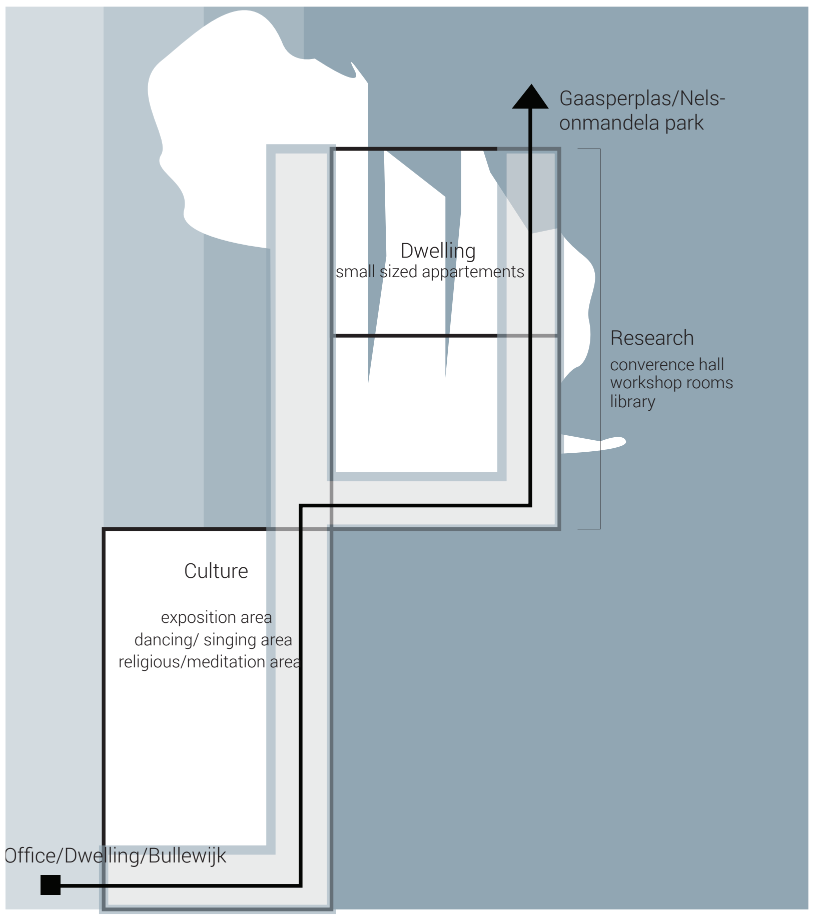
COMPLEX PROJECT P5 2019 M.DANIEL



Conceptual P2 Section



Conceptual Diagram Water exchange



Conceptual P2 Plan

I. Introduction

II. Problem Statement

III. Research Question(s)

IV. Hypothesis

V. Research: Seminar

VI. Research: Studio

VII. Initial/'P2'-Project Proposal

VIII. Conclusion

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"While the world is craving for more sources of energy and fuels, one source of energy that is most abundant and environmentally acceptable is water. Water in all its forms (i.e., subcritical, supercritical, steam, heavy water) is the most important solvent in the development of new "energy economy." (Shah, 2014)

VIII. Conclusion

The research conducted in this report had been aimed to answer the following question: **"How can architectural/ spatial qualitative elements contribute to an integral energy system?"** Several subquestions were created in order to be able to create a broad scope of knowledge on the matter and answer the question fully.
The first question: **"Why is the current system un-integral?**": had been answered by a thorough investigation by means of literature- and historic- research, revealing the fact that technological innovations within the previous era had made it possible for us to dwell in floodprone areas such as Amsterdam Zuid Oost. Resulting into the fact that it costs more energy for the water to flow through and out of the area than we currently generate by using it's potential energy.
This awareness has made it possible for us to come to the following question: **How can (waste) water contribute to energy-efficiency?** A question which had been created with the presumption that water might contribute as a spatial qualitative element itself- as it has already been part of the dutch traditional material culture- and hence if seen as an energy-providing spatial element instead of an energy-consuming spatial element, could possibly aid to an integrative energy system within the built environment. This question was answered encompassing the fact that neither the amount of energy needed for drinking water to run through the area nor the amount of energy needed for the waste water to be purified, could be considered as high. The amount of energy of the waste water which is currently lost is, however, relatively high. The waste water for the industry to cool down it's systems could heat up to 2 million households. Moreover 'black' waste water could provide energy for 20.000 to 40.000 households which is nearly equivalent to the amount of households in the area of Amsterdam Zuid-Oost (see calculations: appendix).
Since these waterflows however could, due to it's chemical impurity not be considered as potential visually pleasing architectural/spatial elements, two other waterenergy potentials had been regarded and investigated: First of all, the gravitational energy of water falling within the built environment which has currently been disregarded as a potential renewable energy resource. And secondly the chemical energy of salt or salinized ground water which could be coverted into electrical energy by using a 'Blue Energy'-method called: Reverse Electro Dialysis (See page 70-71).
After calculating the actual amount of generated electricity by these two forms of energy production methods, the methods could however not be considered as significant gamechangers within the field of renewable energy production methods (regarding the area of Amsterdam). After conducting some further research an alternative approach was however presented by the Dutch company: 'Aquabattery'. Instead of using the water as a renewable energy resource the water could be used as a renewable energy container- referred to in this report as a

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The water is essential to the Dutch landscape; it shaped the Netherlands and gives identity and culture to the landscape. The moment the water system alters spatial planning new possibilities appear not only for the water system but also on life and use of the territory. It is inspiring and challenging to work with technical and natural conditions for the design of new living environments. (Robbert de Koning, n.d.)

'water-battery'.

When using the blue energy method in combination with an aquifer as presented by the firm 'Aquabattery'*, excessive energy from other renewable energy sources could than be stored within the aquifer in the form of salt water and be extracted from the salt water when needed. Hence the seasonal imbalance between the demand of energy and the production of energy could than be restored by the use of this innovative seasonal storage method. The method can be explained as follows (see page 72-73): "*The salt groundwater could be used in within an aqcuifer system in order for the aqcuifer to not only serve as a a source for heat and cool water in order to heat or cool buildings but could simultaneously be used as a seasonal electricity storage of energy by converting excessive electricity into salt water. This salt water could than generate electricity by the use of an added blue energy system. This system enables the cool salt ground water to flow up to the building in the summer, cooling the building and meeting the fresh water stored within the building in order to generate electricity by using the method: Reverse Electro Dialysis. After which the water flows down to the aquifer again being less salty/brackish and warmed up by the heat within the building due to the summer climate. This flow can than be reversed in the winter when there is an overload of energy for example created by wind in relation to the demanded energy in the winter flowing the heated brackish water stored in the aquifer back into the building and retrieving it's saltness by using Electro Dialysis in it's unreversed manner. This can be done by using the overload of electricity from the wind in order for this electricity to be stored in the form of salt water again within the aquifer waiting for the summer again when this overload of energy is missing and needs to be extracted again by the Reverse Electro Dialysis/RED-method etc.*".

This approach of using water as an energy storing element could hence also be applied to a 'so-called' gravitational water battery. The second element of the proposed system hence encompasses this gravitational water battery and will store excessive renewable energy by pumping the water up in a built construction and to let the water flow down again, generating electricity by the use of watermills, when needed. This method was estimated to be effective enough for the daily imballance between the demanded and the generated renewable energy to be restored (see calculation: appendix) .

In order to be able to understand the impact on the built environment when considering the implementation of these water/energy measures the following question had to be answered: **"What are it's spatial implications?"**:

This was answered by means of both technological- and case-study research from which the following measures were distilled (see page 76-77): 1) decentralised energy storage, 2) decentralised natural purification of water (helofyte-filters), 3) constructed or existent relief/ height different (gravitational energy), 4) close proximity between different functions/mix-use (reuse- heat), 5)urban area/densely built areas: waterstorage in/around and underneath building, 6) low density: water canals.

These measures could hence be taken into account when designing the area of Amsterdam Zuid Oost for the year 2050. In order to further construct the spatial configuration of Amsterdam Zuid Oost further research was conducted specific to create an understanding about the situation of the location itself and to create an understanding of the relationship between architecture and water in general, answering the question: **How can architecture/the built environment accomodate and contribute to such an**

"**Bundling energy and water services can contribute to a future of reduced operating costs and safer, healthier buildings** (Isaacson, Gudell, Miller, Wiese, Wilson. & Center of Neighbourhood Technology, 2014)" .

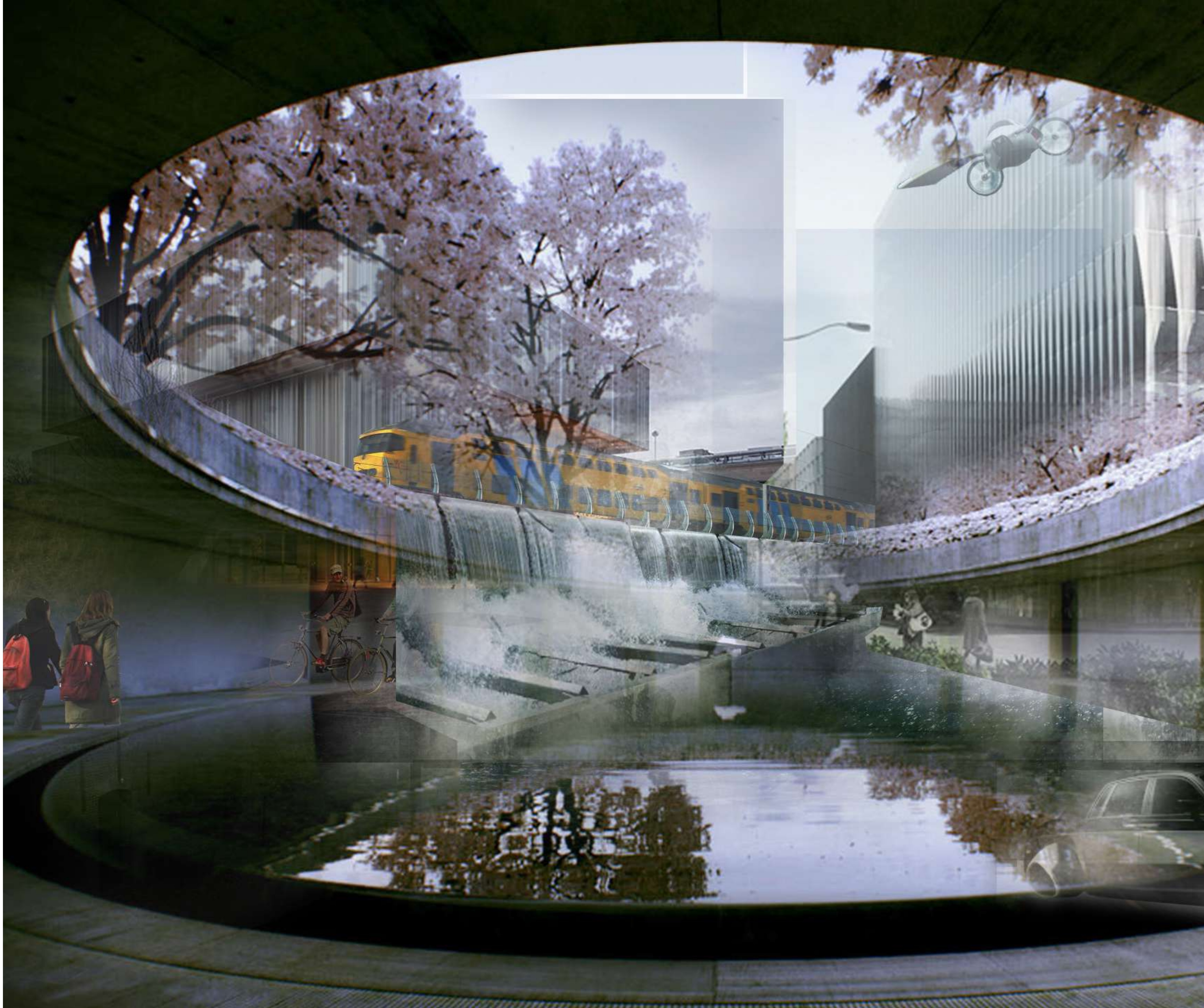
energy system?

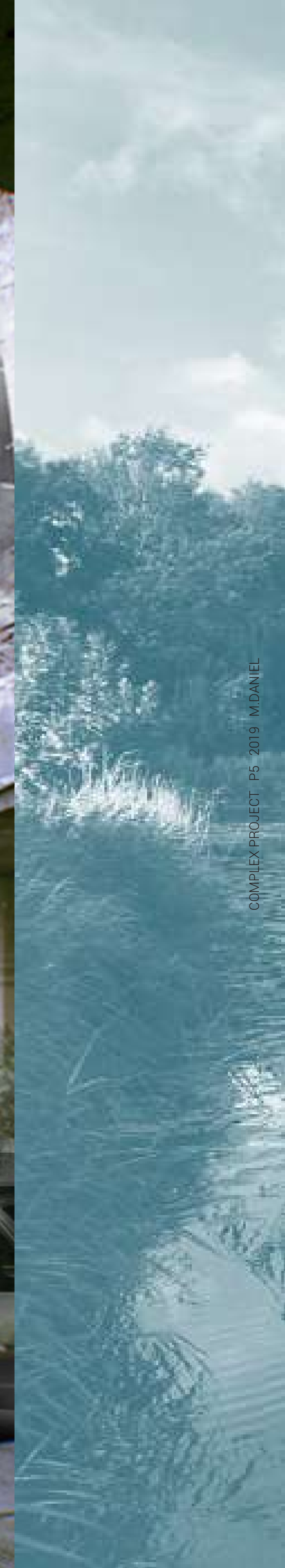
As could be derived from the site-specific scenario research the most fragile area to be considered in Amsterdam Zuid-Oost will be the area near 'Bullewijk' station. The rate of fragility is based on the fact that this area seems to both be prone to flooding on a relatively high risk rate and situated along the infrastructure where an urbanisation and hence increased amount of harderend area and waste-water has been predicted, increasing the risk of flooding to an even higher level.

When combining this with the relatively high rate of increased salinization of the groundwater towards 2050 in this very same area, an integral energy system by using both the gravitational waterbattery principal and the 'blue-energy/aquifer' principle could be considered to be suitable in this area. This could be further explained by the fact that the required height difference for the gravitational waterbattery could be realised by using the future constructed high-rise buildings and the height difference realised by the elevated park on top of the A9. Furthermore, the high salt rate of the groundwater could be utilized for the blue-energy storage method previously addressed. An interesting new spatial configuration will hence be introduced which allows the nature to flow into the future highly urbanised area of Bullewijk Station.

Moreover, since the area around Bullewijk Station can be considered highly segregated due to the infrastructural boundaries caused by the A9 and the railwaytrack, a reconnection of spaces need to take place by constructing connections between one side of the infrastructural boundary towards the otherside. This will than additionally aid to the interconnectivity between different functions and hence different kinds of people (officers, dwellers). The functions; Sports/culture, education and dwellings will therefore be an interesting mix to be accommodated in one building since different minds, cultures and activities will than gather together. Resulting in an opportunity for this gathering of differences to elicit creativity, innovation, and inspiration. Phenomena which could be considered of high value where relative poverty and jobless people are a matter of fact (Amsterdam Bijlmer). Hence when introducing a building where water moves constantly (water-battery) and people dance and sing songs from all over the world, a vibrant building will be inevitable.

* **Aquabattery B.V.**: is currently developing the idea of the blue-battery in combination with an aquifer/geothermal heating. The integration of this idea within the built environment is currently under investigation by the firm in cooperation with 'Rijkwaterstaat' in the area of Flevoland. Other firms that are investigating the integration of blue energy within the built environment are: REDstack B.V., Enexis B.V., Alliander, Compass Infrastructuur Nederland (CIN) B.V. and Technolution B.V..





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Bibliography

Aziza Chaouni, *Sidi Harazem Project receives Getty Foundation's Keeping It Modern Grant!* (2017) accessed 4 May, 2018 http://www.azizachaouniprojects.com/sidi-harazem-project-received-getty-foundations-keeping-it-modern-grant/

Ball, P., Blue energy: *How mixing water can create electricity.* (BBC, 2015) accessed May 4, 2018, http://www.bbc.com/future/story/20150610-blue-energy-how-mixing-water-can-create-electricity

Bollinger, L. A. & Dijkeman, G.P.J., *Evaluating infrastructure resilience to extreme weather – the case of the Dutch electricity transmission network.* (Delft: TU Delft, 2016), accessed May 10 2017, http://www.tbm.tudelft.nl/fileadmin/Faculteit/TBM/Onderzoek/EJTIR/Back_issues/16.1/2016_01a_07.pdf

de Brauw, H. Kluck, J., Stapel, W. & Tilma, M., *Water en Energie. Feiten over energieverbruik in het stedelijke waterbeheer* (Ede: Rioned, 2012), accessed May 12, 2017, http://www.verenigingvpb.nl/_images/ck_files/RIONED_Water_en_Energie_lr.pdf

de Boer, H & Radersma, S., *Verzilting in Nederland: oorzaken en perspectieven.* (Lelystad: Wageningen UR Livestock Research, 2011), accessed May 12, 2017, http://edepot.wur.nl/186856

Dekkers, J., Koomen, E., Jacobs-Crisioni, C. & Rijken, B., *Scenario-based projection of future land use in the Netherlands: A spatially-explicit knowledge base for the Knowledge for Climate programme* (Amsterdam: VU University Amsterdam, 2012) accessed 3 May, 2017, https://spinlab.vu.nl/wp-content/uploads/2016/09/SL-11_Scenario_based_projections_KvK8.pdf

Deltares (2018), *Beschikbaarheid zoet grondwater, verzilting.* (Den Haag: Ministerie van Binnenlandse Zaken, 2018) accessed May 10 2018, https://data.overheid.nl/data/dataset/beschikbaarheid-zoet-grondwater-verzilting/resource/810f9ac9-8989-478e-8c5c-b5adee65dde3

Gemeente Amsterdam, *Structuurvisie Amsterdam 2040; Economisch Sterk en Duurzaam* (Amsterdam: Gemeente Amsterdam, 2011), accessed May 15, 2017, from https://www.amsterdam.nl

Geudens, P.J.J.G., Vewin, *Dutch Drinking Water Statistics; The water cycle from source to tab.* (Rijswijk: Vewin, 2012), accessed May 10, 2017, http://www.vewin.nl/SiteCollectionDocuments/Publicaties/English%20_publications/Vewin_Dutch_Drinking_water_statistics_2012.pdf

Hettiarachchi, H & Ardakanian, R., *Environmental Resource Management and the Nexus Approach* (Germany: United Nations University, 2016)

Hooimeijer, F., Meijer, H. & Nienhuis, A., van der Ven., *Atlas of Dutch Water Cities* (Amsterdam: SUN, 2009), p.178

Hooimeijer, Fransje, *The tradition of making Polder Cities.* (Delft: TU Delft, 2011), 25, 50

Isaacson, M., Gudell,, J.D., Miller, J., Wiese, J., Wilson, R. & Center of Neighbourhood Technology. *Urban flooding and energy efficiency: Leveraging Community Action* (ACEEE, 2014), accessed, May 4, 2017, http://www.elevateenergy.org/wp/wp-content/uploads/Urban_Flooding_and_Energy_Efficiency1.pdf

Ittard, L., *Energy Conversion and Distribution*, Lecture, Urban Environments and Infrastructures from TU Delft, June, 11, 2017

Kristinsson J., van den Dobbelsteen, A. (2012). *Integrated Sustainable Design*

Kuleszo, J., Kroeze, C., Post, J. & Fekete, B., M., T*he potential of blue energy for reducing emissions of CO2 and non-CO2 greenhouse gases* (Journal of Integrative Environmental Sciences, 2010) accessed May 4, 2018, https://doi.org/10.1080/19438151003680850

Maessen, P. J. J., *De poldermetropool, wat iedereen moet weten over de randstad.* (Rotterdam: nai010 uitgevers, 2013)

Magara, Y., *Industrial Water* (Japan: Hokkaido University, n.d.), accessed May 11, 2017, http://www.eolss.net/Sample-Chapters/C07/E2-19-02-04.pdf

Mills, M. P., T*he Cloud Begins with Coal; Big Data, Big Networks, Big Infrastructure, and Big Power; An Overview of the Electricity Used by the Global Digital Ecosystem* (Digital Power Group, 2013) 3, accessed May 4, 2017, https://www.tech-pundit.com/wp-content/uploads/2013/07/Cloud_Begins_With_Coal.pdf?c761ac&c761ac

Mulder, F.M. (2014). *Implications of diurnal and seasonal variations in renewable energy generation for large scale energy storage.* (American Institute of Physics), accessed May 2018 , https://aip.scitation.org/doi/full/10.1063/1.4874845

Mukherjee et al., (2016). *Effect of Urbanisation on Flood*

Pen State University, *Energy from Water (n.d.),* accessed May 4, 2018, http://sites.psu.edu/energyfromwater/technologies/trab/

Potz, H. & Bleuzé, P. (2012). *Green-Blue Grids, manual for resilient cities*

Redstack, *Reverse Electro Dialysis* (n.d.), accessed May 4, 2018, https://www.redstack.nl/en/technology/reverse-electrodialysis-red

Shah, Y.T. *Water for energy and fuel production* (Boca Raton: CRC press, 2014)

Timmons, D., Harris, J., M. & Roach, B., *The Economics of Renewable Energy* (Medford: Tufts University, 2014), accessed May 5, 2017, http://www.ase.tufts.edu/gdae/education_materials/modules/RenewableEnergyEcon.pdf

Shell International B.V., *Shell energy scenarios, to 2050* (Shell International B.V., 2008), pp 21, accessed May 20, 2017 https://rjohnwilliams.files.wordpress.com/2016/02/shell-energy-scenarios2050.pdf

Van Dribbelen, C., Koeze, R. & Monchen, E., *Waterproof Amsterdam* (Amsterdam: Waternet, 2013), accessed, April10, 2017, https://www.amsterdam.nl/publish/pages/570156/planam-07-2013engwww_art_2.pdf

Van Hoogdalem, L. "*Geschiedenis van het riool in Amsterdam.",* last modified November 19, 2015, http://www.riool.amsterdam/geschiedenis-van-het-riool-in-amsterdam/

Vewin (2012). *Dutch Drinking Water Statistics; The water cycle from source to tab.* Retrieved 10-5-2017 from http://www.vewin.nl/SiteCollectionDocuments/Publicaties/English%20_publications/Vewin_Dutch_Drinking_water_statistics_2012.pdf

Visser & Smit-Hanab, *'De nieuwe warmteweg'*, accessed April 11, 2017, http://www.vshanab.nl/nl/projecten/detail/de-nieuwe-warmteweg-dnww

Waternet (2016). *Gemeentelijk Rioleringsplan Amsterdam 2016 – 2021. Stedelijk afvalwater, afvloeiend hemelwater en grondwater in Amsterdam.* Retrieved 05-05-2017 from https://www.waternet.nl/siteassets/ons-water/gemeentelijk-rioleringsplan-amsterdam-2016-2021.pdf

Wikipedia, *Blauwe Energie.* (n.d.), accessed May 4, 2018 https://nl.wikipedia.org/wiki/Blauwe_energie

Willson, W. Leipzig, T. & Griffiths Sattenspiel. *Burning our Rivers* (2012)

World Energy Council, *World Energy perspective; The road to resilience- managing and financing extreme weather risks* (London: World Energy Council, 2015), accessed April 11, 2017, http://www.mmc.com/content/dam/mmc-web/Files/20150921_Resilience_extreme_weather_PRINT.pdf

World Energy Council (2015). *World Energy perspective; The road to resilience- managing and financing extreme weather risks.* Retrieved 11-04-2017 from http://www.elevateenergy.org/wp/wp-content/uploads/Urban_Flooding_and_Energy_Efficiency1.pdf

Wulff, B., *Osmotic Power*. (Stanford University, 2017) accessed May 4, 2018 http://large.stanford.edu/courses/2017/ph240/wulff2/

Wylson, A., *Aquatecture: Architecture and water* (London: Architectural Press, 1986)

Younos, T. & Grady, C. A. (2013). *Climate Change and Water Resources*

Zhang, F., Lia, J., Yang, W., Logan, B., E., A *thermally regenerative ammonia-based battery for efficient harvesting of low-grade thermal energy as electrical power.* (Royal Society of Chemistry: Energy and Environmental Science, 2015, 8, 343) accessed May 4, 2018, https://www.engr.psu.edu/ce/enve/logan/publications/2015-Zhang-etal-EnergyEnvSci.pdf

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Appendix

Calculations Flow Diagram (page 53)

1st diagram
Water incoming flow of water
Rainfall mm per month
(62 + 73 + 73 + 63 + 24 + 105 + 83 + 30 + 81 + 45 + 104 + 57 + 86) / 12 = 67,75 mm p/m

yearly 2016> 856.7 mm normal > 848.7 mm
= 856.7 liter water per m2
> Amsterdam opp hardened area = 7919,20 surface roof area; 40 percent of hardened area
857.7 x 7919,20 ha (791 92 000 m2)= 67 922 978 400 liter per year on hardened terrain
total surface Amsterdam = 219, 94 km2 > 857.7 x 219 940 000 m2 == 188 642 538 000 liter total surface Amsterdam

Evaporation:
619,5 mm

Drinking Water Abstraction (Waternet)
Dunes – 12 million m3 per year = 12 000 000 000 liter and
49 million m3 river per year = 49 000 000 000
Surface – 25 million m3 per year = 25 000 000 000 liter
Drinking water production 86 000 000 000 liter -

living; drinking water use total: 120.1 x 922 000 x 365 = 40 417 253 000
drinked water per person is (amount of inhabitants to waternet) = 1,8 l per day = :
1,8 per inhabitant which is 922 000 x 1,8 = 1659600 liters per day = 1659600 x 365 = 605 754 000 liter in total per year
but all drinking water needed services (showering,washing, food peperation and drinking)
81,1 liter per person per day
which means 81,1 x 922 000 x 365 = 27 292 583 000 percentage of output = 25 % more or less since the is not in rhyme with another source.

agriculture consumption Amsterdam – since the percentage of agriculture is around 11 procent and that in Holland is about 50 procent we will convert the number of all dutch agriculture water into that of Amsterdam.
agriculture consumption holland: 47 million m3 – 47 000 000 000 liter
amount of square meters Amsterdam – 219. 94 km2 - agriculture = 0,11 x 219,94 x 100 = 2419.34
amount of square meters Netherlands – 41 543 km2 - agriculture = 0,5 x 41 543 x 100 = 2077150
> ratio = 2419.34/2077150 = 0.00116 > 0.11%
0.00116 x 47 000 000 000 = 54 742 786.99

total input = 67 922 978 400 + 12 000 000 000 + 25 000 000 000 + 49 000 000 000= 153 922 978 400
percentage each:
rain= 44,1 percentage = 44 %
dunes = 7,8 percentage= 8 %
dunes river = 31,8 percentage = 32 %
surface = 16,2 percentage = 16 %

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Output water
rainwater to sewage - 40 percent of 67 922 978 400 = 27 169 913 600
rainwater to surface - 60 percent of 67 922 978 400 = 40 753 870 400

no this is for the whole of the netherlands
consumption living : 788 million m3 – 788 000 000 000 litre
consumption industrial: 184 million m3 – 184 000 000 000 litre
consumption services: 115 million m3 – 115 000 000 000 litre
consumption agriculture: 47 million m3 – 47 000 000 000 litre
total 1093 000 000 000 litre

but output sewage total netherlands: 1818 million m3

this minus the rainwater and the drinking water = 1093 000 000 000 litre - 40 417 253 000 - 67 922 978 400 = 984 659 768 600
input around 92 000 000 000 (average of two sources) litre – rest households* and industry etc. ; *

* 43,7 litre per day per person rest household > 43,7 x 922 000 x 365 = 14 706 361 000 >
** 1093 000 000 000 - 27 292 583 000 = 1065 707 417 000 – sorry does not apply

second diagram
amount of black water – 33.7 litres per person per day
33.7 x 922 000 x 365= 11 341 061 000 litres
+ black water from services> estimated percentage of black water – 10% = 146 153 846 200 litres/year x 0.10 = 14 615 384 620

amount of rainwater falling on roof
> Amsterdam opp hardened area = 7919,20 ha = 791 92 000 m2
surface roof area; 40 percent of hardened area
31676800 surface area roof
31676800 x (rainwater) 856.7 = 27 137 514 560

amount of water needed to cool down in industry -
energy supply and waste management
72 procent is cooling for products
and 17 procent is cleaning and product treatment

Estimated industrial water:
we assume that the ratio between industry and services in Amsterdam is nearly complying with the industry working and living ratio in the Netherlands.
consumption industrial: 184 million m3 – 184 000 000 000 litre
consumption services: 115 million m3 – 115 000 000 000 litre

Services ratio
115/ (184+ 115) = 0.385

so since the total consumption of drinkingwater for services and industry = 86 000 000 000 – 40 400 000 000 (living consumption) litres per year = 38 000 000 000.
Services consumption is around 146 153 846 200 litres/year. From which an estimated 67 % (just like with housing) should be drinking water. So 97 923 076 950 000 litres drinking water

amount of industrial water which should be drinking water:
an assumption is made that cooling water could be abstracted from rainwater or naturally purified surface water.
the amount of cooling water in product industry = 72 procent
and the cleaning and product treatment should be with drinking water – 17 procent

0.615 x 38 000 000 000 = industrial use = 23 370 000 000 > 0.17 x 23 370 000 000 = 3 972 900 000

23 370 000 000 x 0.72 = 168 264 000 000 for cooling purposes

amount of highly contaminated industrial water is probably within the 17 procent. So ¬the

Consumed energy – 2016 - waterpurification
- andere source

RwZi : 7,5 – 0,8 = 211,05 Mj/y pp = 6.7 watt/pp
Transport: 4,1 – 1,2 = 91,35 Mj/ y pp = 2.9 watt /pp
Drinkingwater: 8,5 – 0,2 = 261,45 Mj/ y pp = 8.3 watt/pp
42/86 = 0.488 ratio of proposed situation/ current situation; drinking water generation energy consumption; reduction of 51%
which means that only the following amount of energy is needed; 0.488 x 261.45 = 127.684 MJ/y pp a reduction of > 261.45 – 127.684 = 133.766 Mj/y pp
4.233 W pp reduction

4/111 = 0.036 ratio of proposed situation/ current situation; RwZi energy consumption reduction of 96 %;
which means that only the following amount of energy is needed; 0.036 x 211.05 = 7.5978 Mj/y pp
a reduction of> 203.4522 Mj/y pp
7.968 W pp reduction

However => biogas >
25 000 000 000 litres black water/ 365/ 33.7 = > 2 032 438 people
the production of black water and organic kitchen waste is
100g BOD per person per day results in 35L methane per person per day (Zeeman, Grietje 2006). 2 million x 35 L > 70 million methane per day in Amsterdam

Each cubic meter (m3) of biogas contains the equivalent of 6 kWh of calorific energy.

6 x 70 000 = 420 000 kWh in Amsterdam

An average household consumes 3.500 kilowatthour (kWh) per year (per 2,2 persons)
4,4 kWh per day per person

420 000 /4.4 = 95 000 people

average of 2.2 people per household > 95 /2.2 = 43 000 homes. Max. 20 000 homes min.

which encompasses nearly whole the area of Amsterdam South East.

Dwelling extraction of heat of Industry > litres of heat per household - 90 – 160 litres per day = 32850- 58400 litres per year
litres of cooling needed for industry is – 170 000 000 000 litres per year.
since this will be transferred to hot water > 170 000 000 000 / 58400 = 2 910 959 households

as another source stated 6 x more energy efficient

or 56 000 dwellings with one factory

Adding up the reduced energy implications -

fsi amsterdam

4,3 bvo/219 km2
7919,20 ha
https://www.ois.amsterdam.nl/pdf/2015%20jaarboek%20amsterdam%20in%20cijfers.pdf

rain – 31 W per 185 m2
https://www.homepower.com/articles/microhydro-power/design-installation/microhydro-myths-misconceptions

Calculation Dimensions and Power Water Battery (page 72)

Introduction
The 'Water Battery' is initially composed out of different components. Each component is both tested on its effectiveness and researched on its required dimensions by means of the following calculations. The following components are distinguished:

- Gravitational Water Battery
- The Aquifer/Geothermal Storage
- 'Blue Energy' Battery
- Piezoelectric Energy
- Human Energy

Reflection on Seminar Research:
As the previous seminar research gave us the idea that both biogas and industrial waste water are enormous sources of energy the idea of storing all the biogas in one building was regarded highly unsafe in a highly urban environment. It is therefore proposed to do this either in a factory outside of the city or individually per household.
The idea of using industrial waste water has however been regarded highly attractive in regard of both safety and effectiveness.
The issue of heating our homes will be probably tackled. Wind and solar for electricity generation. But water as a battery.

"On the renewable side, solar and wind power do not have this character at all; energy output simply cannot be increased on demand. Hydropower may be regulated to accommodate demand, if reservoirs are adequate (and adequately replenished by rainfall). Biomass is similar to fossil fuels, available to burn on demand. Geothermal energy is the most constant of the renewable energy source sand can be started and stopped on demand. Most renewable energy portfolios will include some sources that are not available on demand, and thus most regions will have to confront energy-source intermittency."

Intermittency Storage Demand

The intermittency storage demand is therefore highly dependent on the hourly electricity demand and the hourly wind and solar electricity generation.
The following diagrams show an estimated amount of electricity storage needed in the year 2050.

Three different scenarios were distinguished from which 2 evidently different—
1. Electricity demand increased merely on the base of more energy usage.
2/3. Electricity demand increased more since we started to replace conventional oil user products into electricity products. >a scenario which is more favourable and reliable according to Mulder, since the electricity stored in the summer than wouldn't be higher than that which is needed in the winter.
Hence an approximated number of 0.2 EJ/day short term and 30 EJ=8333TW h per season long term storage by 2050 worldwide was distilled from Mulder's calculation (Mulder, 2014) , , .

0.2 EJ/day short term = 8 kWh installed short term storage capacity per person
30 EJ=8333TW h per season long term storage by 2050 worldwide (7x109 inhabitants and 91.25 days per season.) = 30 EJ / (7x109) / 91.25 = 47 x 106 Joule per day per person = 13 kWh installed storage long term per person.

Hence, in total an amount of 13+8 = 21 kWh per person per day
*To put this number into perspective one needs to realise that an average household consumes 3 500 kilowatthour (kWh) per year (per 2.2 persons)
That means; 3 500 / 365 / 2,2 = 4.4 kWh per day per person.

Gravitational Water Battery

First of all an indication of the effectiveness of a gravitational water battery will be exposed by simply calculating the considering the power generated by water falling from a building of 40 meter in height when regarding a constant flow of 80 m3/sec.
Equation:
$P = \eta . \rho . Q . g . h$

[W] = [x] . [kg/m3] . [m3/sec] . [9.81] . [m]

$\eta = 0.85$
$\rho = 1000$ kg/m3
Q = 80 m3/sec.
g = 9.81
h = 40

Example 1: With a building of 40 metres high and a flow rate of 80 m3/sec. 26.7 MW of electricity will be generated.
>
0.85 x 1000 x 80 x 9.81 x 40 = 26 683 200 W = +/- 26.7 MW per turbine.
*Converting this to an amount in kWh;
E(kWh) = P(W) × t(hr) / 1000

26.7 MW= 26.7 x106 W

> When considering the approximated 21 kWh storage needed per person per day. This amounts to (21 / 24(h. per day)) x 1000 = 875 Watts per person of storage needed.

This means that this one turbine when continuously flowing will be able to return the stored power for 26 683 200 / 875 = 30

495 people

When once again considering the amount of inhabitants in Amsterdam South East (83 743) a amount of 83 743 / 30 495 = +/- 3 turbines (2.746) need to continuously flow in order to be able to return the stored power.

In order for the turbines to continuously flow a certain amount of water will be needed. My hypothesis is that this continuous flow requires an immense amount of water. But let's first calculate it:
a given 80 m3/sec (Q) .
3600 x 24 x 365 = 31 536 000 seconds in a year.
80 x 31 536 000 = 2 522 880 000 m3 needed for one turbine = 3√ 2 522 880 000 = a capacity of 1361.34 meter x 1361.43 meter x 1361.43 meter of water.
for just one turbine- imagine three turbines.

Hence the speed of water or the amount of water flowing through the/multiple turbines needs to be increased. So Q needs to be increased. The height of 40 meter is for now kept at a constant value since this might be a good mean value for the building's height in the concerning area.

Thus, we will take a Q which might also be more architecturally preferable since the water flow would then be made bigger and more exposable.

equation flow rate:
qm= ρVA = c
[kg/s] = [kg/m3].[m/s].[m2]

However one might also start with an unknown speed . Hereby you will end up with an amount in kwh. Hence the potential energy will be calculated from the water storage. The calculation will be as follows:

P = η . ρ . Q . g . h

[W] = [x] . [kg/m3] . [m3/sec] . [9.81] . [m]

Refiguring the equation:

0.80 x 1000 x m3 x 9.81 x 40 = Ws

Example 2:
When considering a storage capacity of 100 m x 60 m x 3 m= 18000 m3

0.80 x 1000 x 18000 x 9.81 x 40 = 5 650 560 000 Ws
= 1569.6 kWh
If we now compare this value with the needed value of 21 kWh per day we will consider that the storage of water of 18000 m3 will be emptied within 3 hours.

P x t = E

So,
1569.6 x 24 / 21 x 3 = amount of people provided with storage

Intermezzo

In the previous two examples the fact that the long term storage can not be divided into storage in days since this storage must not be returned to the electricity net within one day but within a season.
The previous calculations hence give a wrong idea of the needed capacity.
We should therefore reconsider again the given fact that:

The short term storage then corresponds to about 0.7% of the seasonal storage, and on average +/-8 kWh installed storage capacity per person on an earth.

The storage capacity must hence be bigger than 21 kWh. > 8 kWh / 0.007 = 2571.4kWh per season/person.

* Check> 30 EJ = 8333 TW h (also given by Mulder)
8333 1012W h / 7 x 109 = 1190428.571 Wh = 1190.4 kWh> Not corresponding
* Double Check> 27.5 EJ = 7 638 888 888 888. 9 kWh
7 638 888 888 888. 9 kWh/ 7 x 109 = 1091.26 kWh> Not corresponding either

But we take hence the number which is most reliable due to its amount of recurrence in the article.

Hence the number 1190.4 kWh is taken as approximated value for long-term (seasonal) energy storage per person. (and 8 kWh per day)

Hence for the total needed potential energy capacity for the battery a total amount of 1190.4 + 8 = 1198.4 kWh should be considered.

Building Storage Typologies and Impact
Now considering different volumes for the water capacity:

Example I
building 40 meter mean height – 20x20x18 (high building; hb) + 6 x 40 x 20 (low building; lb) + 200 x 100 x 3 (surface water; sw) = 7200 + 4800 + 60 000 = 72000 m3
The impact on energy when relating it to the height in a simple ratio to ratio equation (highly approximated values in order to give an design indication):

(7200 x 40) + (4800 x 6) + (60 000 x 3) = 496800
impact hb : impact lb : impact sw

0.58 : 0.06 : 0.36

The impact of a high building is hence fairly high compared to the impact of a low building.

This previous building calculation gives us an idea of the impact of the chosen typological water storage. In order for the calculation to be more realistic – we will take a mean height of ((40 x 0.58)+(0.06 x 6)+(0.36x3)= 24.64 = +/- 25meter since the water storage might be distributed in this ratio in the urban plan.
When the design will turn out differently the numbers will of course be adjusted, for now however these numbers are taken as a base (72000 m3; Volume and 25 m. Height)

An example calculation has been performed in excel (see table next page)
The numbers are still a little disappointing. A volume of 96000m3/0.05 hours will provide only for 3104 people. Hence a maximised design calculation will be done for a maximised design typology.

Example II
hb: 30x30x30 (x5)
lb: 100 x 60 x 18
sw: 400 x 400 x 3 +

723 000 m3

medium height:
(30x30x5x60) + (100x 60x10) + (400x400x3) = 810 000
* total area = 170500
810 000/170500 = 4 m. average height.
When however maximising this value to an amount of 24 meters – going partially underground.

Table I: Gravitational Power of Waterbattery

η (%)	ρ (kg/m3)	V (m3)	g (m/s2)	h (m)	Energy (Ws)	Energy (kWh)
0.8	1000	72000	9.81	10	5650560000	1570.9
0.8	1000	112000	9.81	11	9668736000	2687.9
0.8	1000	152000	9.81	12	14314752000	3979.5
0.8	1000	192000	9.81	13	19588608000	5445.6
0.8	1000	232000	9.81	14	25490304000	7086.3
0.8	1000	272000	9.81	15	32019840000	8901.5
0.8	1000	312000	9.81	16	39177216000	10891.3
0.8	1000	352000	9.81	17	46962432000	13055.6
0.8	1000	392000	9.81	18	55375488000	15394.4
0.8	1000	432000	9.81	19	64416384000	17907.8
0.8	1000	472000	9.81	20	74085120000	20595.7
0.8	1000	512000	9.81	21	84381696000	23458.1
0.8	1000	552000	9.81	22	95306112000	26495.1
0.8	1000	592000	9.81	23	106858368000	29706.6
0.8	1000	632000	9.81	24	119038464000	33092.7
0.8	1000	672000	9.81	25	131846400000	36653.3
0.8	1000	712000	9.81	26	145282176000	40388.4
0.8	1000	752000	9.81	27	159345792000	44298.1

Table II: Amount of People provided with Storage

Energy (kWh)	Amount of People provided with Short and Long term Electricity Storage	Amount of People provided with Short term Electricity Storage
1570.9	1	196
2687.9	2	336
3979.5	3	497
5445.6	5	681
7086.3	6	886
8901.5	7	1113
10891.3	9	1361
13055.7	11	1632
15394.4	13	1924
17907.8	15	2238
20595.7	17	2574
23458.1	20	2932
26495.1	22	3312
29706.6	25	3712
33092.7	28	4137
36653.3	31	4582
40388.4	34	5049
44298.1	37	5537

Conclusion

From the calculations can be derived that the gravitational waterbattery can only provide enough energy for short term electricity storage for Amsterdam South East.

In order for the long- term energy to be stored the Blue Energy will be evaluated.

Aquifer
Het warme water wordt via de productieput omhoog gepompt uit de
aquifer, doorloopt vervolgens de warmtewisselaar en wordt na het afstaan van de warmte via een
injectieput weer teruggepompt.
Het terugpompen van het afgekoelde water is noodzakelijk omdat het formatiewater in het algemeen een
hoog zoutgehalte heeft en lozing aan het oppervlak niet wordt toegestaan.
Bij de ondiepe aquifers kan een goede put 50 tot 100 m3 water per uur leveren. Voor een hoger debiet
moeten er extra doubletten geboord worden. Bij putten naar diepe aquifers lopen de debieten uiteen van
100 tot 200 m3 per uur.

Bij de aanleg van een geothermisch doublet komt eerst de keuze en aanleg van een boorlocatie plus
benodigde infrastructuur aan bod, gevolgd door de constructie van een boorplatform waarop de
boorinstallatie kan worden geplaatst.
Daarna start het boren van twee gedevieerde putten. De putten worden verbuisd (casing) om instorten van
de boorgatwand te voorkomen. Tussen buizen en gesteente wordt een cement slurry geïnjecteerd, die
uithardt. De verbuizing geschiedt telescopisch in twee of drie diameters. Vanaf de top van het reservoir
worden de putten niet meer verbuisd. Beide boorgaten worden vervolgens over de gehele reservoirlengte
uitgeruimd, voorzien van een gravel pack en afgewerkt met een filterscherm. In de verbuizing wordt een
productiebuis (liner) neergelaten. Deze kan aan de binnenzijde voorzien zijn van een kunststof coating om
corrosie te voorkomen.
Vervolgens wordt een elektrische onderwaterpomp neergelaten in de productieput, die zo'n 3-5 jaar
meegaat.

Blue Energy Battery
From
800 m3 /s over one year gives a 1900 MW
https://refman.energytransitionmodel.com/publications/.../downloa...

THANK YOU
Maayan Daniel