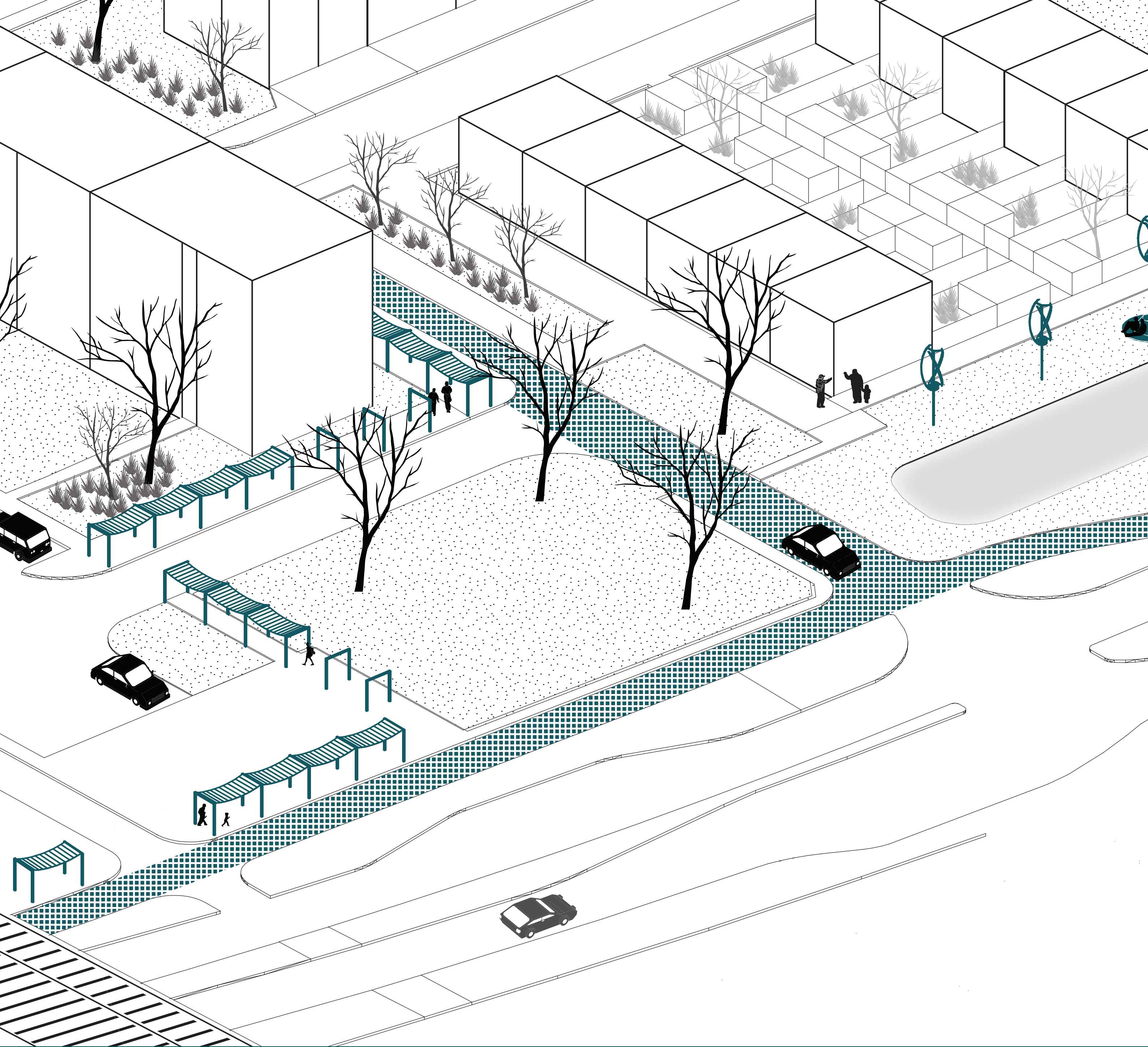

TOWARDS URBAN ENERGY TRANSITION:

HOW CLIMATE-RESPONSIVE AND ENERGY-ACTIVE URBAN DESIGN CAN FACILITATE THE TRANSITION

Angeliki Bazaiou

ABSTRACT

The subject of this graduation project is the energy transition within urban environments. This is pursued through, firstly, gaining an understanding of the fossil dependency and how this has affected our cities and practices. In order to overturn this effect and open the way for the urban energy transition, urban design needs to become more responsive to the climate in terms of buildings' energy use and to incorporate renewable energy technologies. In this direction climate-responsive and energy-active urban design is introduced as part of sustainable urban design, and the steps taken in the project contribute in its implementation within existing residential areas, and more specifically dutch post-war neighbourhoods. Because apart from facilitating the urban energy transition there is a need to sustain the rapidly growing urbanization rates in a different way than the one followed in the post-war era. The illusion of free space is no longer in place and densification needs to take place first and foremost in post-war neighbourhoods. Their open space and inherent unsustainability makes them an ideal case for climate-responsive and energy-active urban design to be applied. Therefore the knowledge gathered in this project in order to review the practice of urban design is combined with the morphological qualities of post-war neighbourhoods to provide with design solutions that act on three levels: lowering energy use, generating energy locally and offering the potential for densification. In the end the steps taken are combined in a design method that can contribute in developing climate-responsive and energy-active urban design.

"Towards urban energy transition: how climate-responsive and energy-active urban design can facilitate the transition"
P2 report
Delft, July 2018

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MSc thesis under Smart Cities and Urban Metabolism research group
Graduation studio 2017/2018

Delft University of Technology - Department of Urbanism

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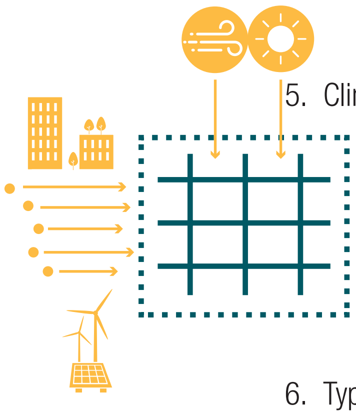

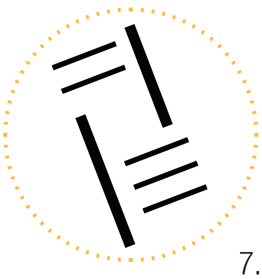

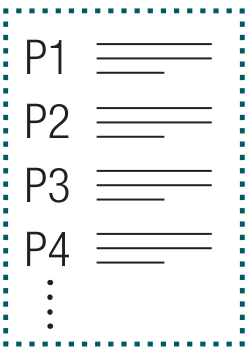

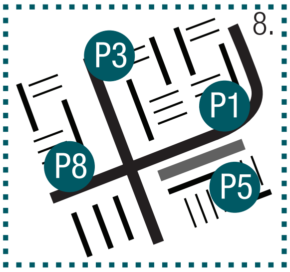
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1. INTRODUCTION

The present thesis explores the field of the *sustainable energy transition* outside of its technochratic domain and within the *urban environment*. The energy supply is more than a fuel that feeds our energy demands, it shapes our lifestyles, society and our cities. Similarly the energy transition is not simply a matter of technological progress, it is a matter of established economic and social structures, institutions, lifestyles, etc., which create a lock-in state that icreases the resistance towards the energy transition (Broto, 2017; Loorbach, 2014). There lies the aspiration of this project, *going beyond the energy transition as pursued so far*. Namely, by realizing that renewable technologies cannot single-handedly lead the transition, this project ideltifies elements of this lock-in state that have a spatial manifestation in the city and can be addressed by designers.

The identification led to two core problems which are closely interwoven and concern the urban environment. First is the *urban carbon lock-in*, which as will be further elaborated, can be seen in the urban morphology of modern cities and makes them resiliant to sustainability measures. This is the current state that was caused more than half a century ago by the domination of fossil fuels and the advances in technology and was spread partially due to modernism. The abundance of energy and the new means of spending it in the built environment led to a deliberation that now it can only be described as a diregard to climate and its influence on building's energy use. On this grounds the second core problem is also built, namely *the gap between urban design and engineering*. So part of this gap relates to the fact that years of fossil dependency have disconnected urban design from climate's influence. The other part is directly connected to the unexploited potential lying in energy generation within the urban environment by making use of the most recent and revolutionary renewable technologies. For both parts of the gap the engineering and technical knowledge exists but it remains largely unconnected to urban design. The gap is studied in the research paper and the results lead to the approach of the project. Namely, the revision of the built environment based on conservation and production of energy on the urban level.

Therefore after making this gap more explicit through literature review, the first step of the project is to gather the aforementioned engineering and technical knowledge and after relating it to the urban morphology, to present it in a focused and concentrated framework. This framework is presented in the *Energy & Climate Matrix*, it addresses both energy use and sustainable energy production and it is meant for urban designers. For this *climate-responsive and energy-active urban design* are proposed as tools for the urban designer. The second step is to actually identify in cities the spatial manifestation of the carbon lock-in. *Post-war neighbourhoods* are chosen as a typical example since they are clearly connected to that era and they were the most immense projects where the ideas of modernism took place. After gathering their most common morphological characteristics and comparing them with those of the Matrix, a set of design solutions are drafted. By formulating them into useful and repeatable solutions for the aforementioned typology a catalogue of *Design Patterns* is formulated. These patterns have - unavoidably - some local characteristics (due to climatic reliance) and their effectiveness as design solutions is being tested in *the Case study*. Final goal of this project is also to extract steps that can be followed by designers formulating a *Design method*. Namely, to organise a process that if followed can contribute to sustainability in terms of energy and - in the long run - to the urban energy transition.

"Smart systems are not only about new technologies and new designs,it's about creating a mental maps. Pushing people to think about the future instead of the past. That's the role of the designer: to be this hippie with a business plan, to ***come up with new dreams, but also with new proposals.****"*

Daan Roosegaarde, designer in Studio Roosegaarde

" We moderns still tend to take energy as a largely neutral aspect of social life. But the ***forms of energy we use, and how we use them, shape society through and through.****(...) Our expectations, our sensibilities, our habits, our ways of being in and moving across the world, how we imagine ourselves in relation to nature, as well as in relation to each other, these have all been sculpted by and in relation to the massively expanded energies of the fossil fuel era."*

Imre Szeman on Petrocultures, MIT Energy Initiative, October 24 (2017)

In Berlin, the German government is building a "House of the Future" in which citizens, architects and planners can experiment and explore the world of tomorrow. What is clear is that ***imagination and creativity are just as essential as efficient technologies*** *and generating capacity.*

Thus history and the arts must have a central part to play in how we imagine and plan our energy futures.

Professor Frank Trentmann and Rebecca Wright

"On the one hand there are best-practice models of development which focus on a one-size-fits-all solution without properconsideration of the implementation contexts. On the other, there are rich studies which immediately point towards the complexity and uniqueness of each urban area. Yet, in the context of an ***urban energy transition, one which engages with the global challenges of urbanisation and sustainable energy, we need tools to manage this complexity,*** *opening up spaces to learn from similarities and differences."*

V,C, Broto (Broto, 2017)

"...you are going to see a lot of people in the Netherlands wanting to have their own power plant. Why would they want to be stuck in getting electricity where they have to pay a big tax on it and then they have to rely on the price of oil and fossil fuels on real markets that shoot through the roof or nuclear power that is too expensive, ***when they can produce their own electricity?****.."*

Jeremy Rifkin, Tegenlich Talks

2. MOTIVATION

The initial motivation stemmed from the *potentials lying in the renewable resources and the related technologies* towards the much needed energy transition on a global scale. A number of facts such as fossil resources depletion, climate change, unhealthy urban environments, the rising global middle class, etc. have created this necessity and SET (Sustainable Energy Technology) is rapidly evolving towards making independency from fossil fuels possible. Indeed in countries like Germany energy produced from renewable sources is rising reaching 35% in the first half of 2017 (Wacket & Kirschbaum, 2017), however a significant part of this energy is generated via large scale plants (wind farms, solar parks, etc.). Most articles, papers, books or talks related to the energy transition state quite clearly that the energy transition will inevitably take place in the future (Wei, Cameron, Harris, Prattico, Scheerder, and Zhou, 2016; Roggema, 2009; Loorbach, 2007). The scale of this transition and the variety of its stake holders (governments, NGOs, energy companies, end users, etc.) as well as its strong linkage to economy, influence not only the speed in which it will take place but also the manner. *The manner of the transition* is my second and even more significant motivation. Looking for example into the transition towards the fossil-based (current) economy, created social and economic injustice. The fossil resources that were globally used, were controlled and distributed through a large scale and centralized system that created various issues. Observing the sustainable energy transition – as it is happening so far – one can see the same energy companies of the fossil economy investing in SET and building wind and solar parks.These observations led me to extrapolate that even though no one can predict the future equilibrium, it would be desirable to create the appropriate systems to go *beyond changing our energy resources*.

Discovering all these aspects has been an immensely interesting experience for me and it is something I continue to explore. All those ideas for decentralized energy systems and the potential contribution to the development of a more just system, triggered my interest in exploring how could that be possible in a neighbourhood and what in the end is the role of the local element. So, as already described the fields or disciplines that the energy transition connects to are so many that the question that came to me in the end was *"What is the role of urban design within this multifaceted transition?"*. Firstly the exploration of urban form in order to discover the traces of fossil dependency and then actually trying to imagine the future of the energy transition and how this new energy form could become evident in the future urban form, stirred my enthousiasm throughout the project. Therefore it became my ambition to explore how we can *revise our built environment and the practices of urban design in order to facilitate the energy transition within cities*

So the most important question is: *How can we design for the energy transition?* Similarly to water sensitive design, can we create energy sensitive design within urban environments? For that purpose design solutions and proposals that take into account engineering, technology and urban environments are necessary. Because as Daan Roosegaarde (designer in the Studio Roosegaarde) pointed out: "That's the role of the designer: (..), to come up with new dreams, but also with new proposals."

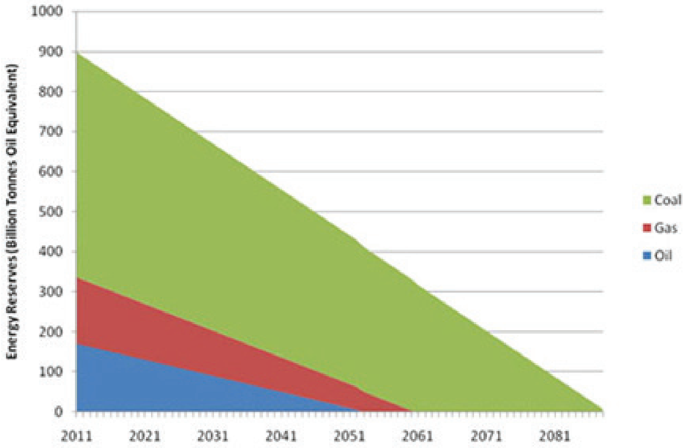
3

PROBLEM FIELD

3.1. URGENCY

Perhaps the earliest sign that fossil dependency would become a global issue was environmental pollution. Burning of fuels creates contamination to soil, water and air. It initiated as an important phenomenon from the industrial revolution but it grew substantially with the discovery of large oil and gas reserves. The exploitation of these reserves after some decades it turned environmental pollution to an actual crisis. This *environmental crisis* has been present for more than half a century – scientists have been studying global warming from the 60s – but only recently has it started becoming more and more apparent in our lives. Extreme weather phenomenon such as heat waves, coastal flooding, and severe droughts on some areas and extreme precipitation on others, are directly linked to climate change and they are influencing people's lives around the world. In the Netherlands, rising sea level and coastal flooding poses a grave threat for the whole country but also phenomenon such as supercells which in 2016 produced hailstones "the size of tennis balls" (dutchnews.nl) causing at the greenhouses of North Brabant alone, damages of millions of euros. At the same time the *fossil resources are facing depletion* (fig. 1) and the reserves are becoming smaller and less economically viable to extract (Murphy & Hall, 2011). In the Netherlands the natural gas field in Slochteren has almost depleted and the fracking technique that is used in order to extract more gas is causing the so-called "shallow gas quakes". Therefore it is widely acceptable that the *energy transition* towards renewable energy sources will inevitably occur (Rotmans et al., 2001; Loorbach, Van der Brugge and Taanman, 2008; Hocks, 2017; Kokhuis, 2017; Witte, 2017).

It is crucial, however to point out that the issue of the urgency is linked more closely than anything else to cities. As Petit (2017) emphatically highlights urbanization worldwide will reach 61% in 2035 and increase even further to 70% in 2050. At the same time, the global middle class that emerges in metropolitan areas has resulted in a significant increase in energy demands – in other words the "imperial mode of living" (Brand & Wissen, 2012). This lifestyle has been shaped by the abundance – until now – , ease of access and low prices of fossil resources (Van den Dobbelsteen, Broersma & Stremke, 2011). Therefore our current energy-spending trend – expressed in our lifestyle as well as in the spatial configuration of the urban environments – is considered unsustainable if we are to use 100% renewable energy (Van Timmeren & Henriquez, 2013). It becomes evident then that the urgency for energy transition has at its core, the *sustainable transition of our cities*.

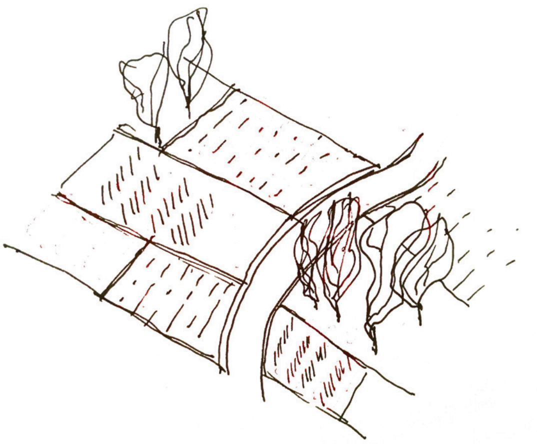


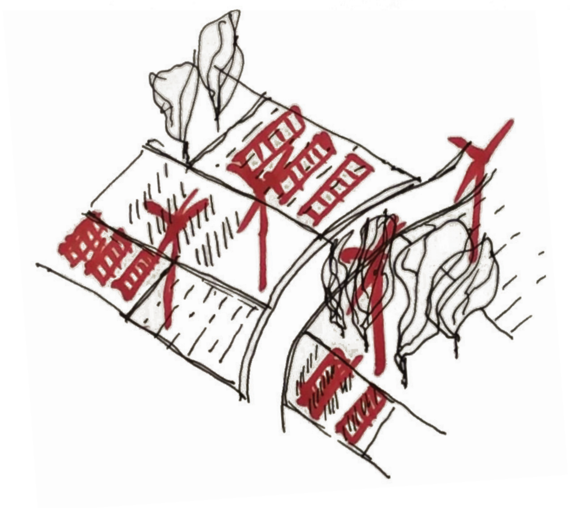
end of fossil fuels (source: www.ecotricity.co.uk)

Making the transition by:

1. *not changing our spending patterns,*
2. *only producing on a massive scale (wind/solar parks, etc.) and away from urban environments*

will occupy tremendous amounts of the already limited free space.





3.2. URBAN CARBON LOCK-IN

As it is going to be explained further on, the fossil era has affected both urban environments and users' behaviour and it has created unsustainable cities which are currently in a state of – as Broto (2017) describes it – carbon lock-in. The discovery of large fossil fuel reserves is a historical event which made socio-technical and socio-ecological systems to coevolve – development of institutions, economic interests, lifestyles and technological developments – in a deterministic pattern that created an inertia. The present in such cases remains within this inertia and whatever differentiates from the established systems meets resistance, for instance renewable energy and sustainable development. In other words, as Broto (2017: 757) describes it, "with the development of infrastructures, institutions and social habits, moving away from fossil fuels may prove an impossible enterprise, which is described as carbon lock-in". This state finds its spatial manifestation in the city in terms of urban obduracy, namely the resistance of the built environment to change following our current needs.

This lock-in state acquires action on specific aspects of cities and by specific actors. This project provides an overview of these aspects and actors, but it will focus on the urban morphology and on professionals of the built environment, in particular urban designers and engineers. The focus on those two types of professionals, is not intended to illustrate their individual duties. On the contrary it is intended to explore the gap between the two and then on which aspects of the urban context their collaboration can contribute in successfully overcoming our carbon lock-in.

Advertisement from the 50's, in small letters "at the turn of a tap, day or night, everyday and everywhere. Gas and only gas can meet your every hot water need – instantly, economically, endlessly – without waste, without work, without waiting!" (source: http://vintage-ads.livejournal.com/tag/baby)

Business

Shell creates green energy division to invest in wind power

Insiders say oil firm's New Energies renewables arm could grow very big, but not for a decade or more

Terry Macalister
Energy editor
@TerryMac999
Sun 15 May 2016
16.08 BST

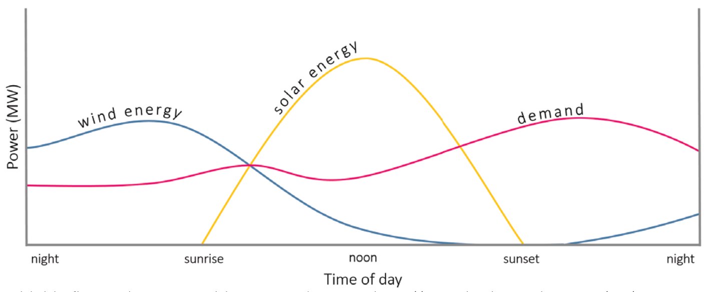
This article is 1 year old

1634 | 119

▲ A leading economist has warned oil firms such as Shell that they must change or face a 'brutal end' within 10 years. Photograph: Peter Dejong/AP

in small letters: "A leading economist has warned oil firms such as Shell that the must change or face a 'brutal end' within 10 years" (source:The Guardian)

Shell ad from 1941: "Fuel of the Future"; in comparison with the figure above one can see the change in future perspective of the same colossal company then and now (source: `https://io9.gizmodo.com/glorious-gasoline-ads-from-the-dieselpunk-days-1525811023



highly fluctuating renewable energy (source: http://www.hydrogenious.net/en/energy-storage/)

3.3. TECHNOLOGY: LIMITATIONS & POTENTIAL

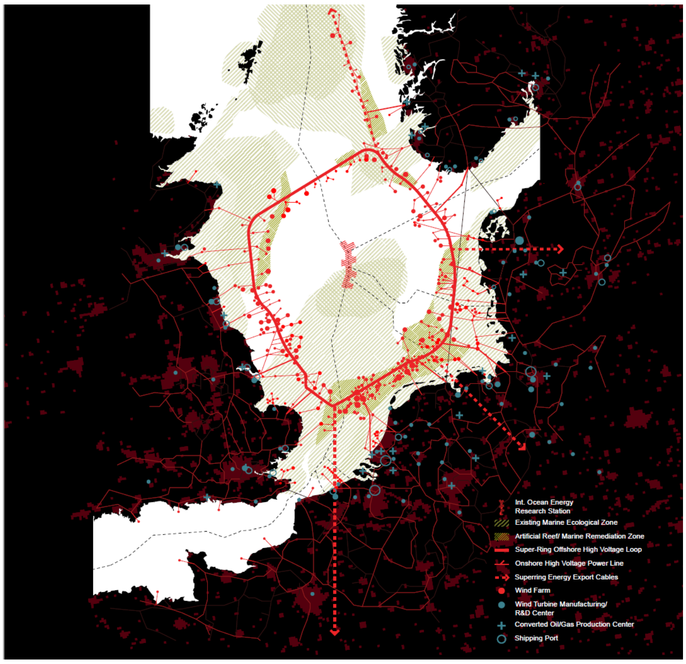
First there needs to be a thorough consideration of how the energy transition is pursued so far and of the role of renewable energy technologies. So the transition is currently being pursued mostly via wind farms in the sea, on the mountains and on agricultural land, and solar parks in the dessert or again on agricultural land. Meanwhile technological progress has allowed these technologies to become more efficient, less expensive and more adaptable, and their potential can be seen also in the fact that fossil giants (e.g. Shell or ExxonMobil) are investing in renewable energy. But also in literature (Berger, 2014) we can see that there is a popular *"misconception that dealing with the environment is merely an engineering problem to be overcome by technology"* as Carmona states (p.52, Carmona, 2009). The way they are currently applied though (like aforementioned), in oceans, desserts, forests, agricultural land, mountains or any other so-called free space, it occupies more and more of the available land. Thus if we are also to take into consideration the growing population, urbanization rates and our current spending patterns, the energy demand will grow exponentially in the future. Will we be able then to accommodate all our needs and our population in, for instance, 2050? So based on the most common definition of sustainable development , are the current practices sufficient to make a successful transition or the future generations will have to face similar issues?

Furthermore, solar parks or wind turbines in the ocean can provide with large amounts of energy but firstly new national electricity networks need to be made in order to adapt to the type of energy that for instance new types of wind turbines produce . As history has exhibited no matter how much technical knowledge it might exist, systems of this scale always meet (un) expected issues that because of the central control could black-out whole cities at times. Typical examples of such immense electricity shortages were those of the 20th century when our primary energy source was gas and oil. These disruptions were mostly caused by the exponential growth of energy demand and the complexity of the electricity network system, among others. As aforementioned these are still relevant in the energy source transition to come. Besides, fossil resources at least have a steady production rate, renewable sources on the other hand such as wind and sun have unstable production rates (fig. 2). This is also why ongoing research is focused on finding ways of successfully storing energy, but even in this front the obstacles seem to be hard to overcome. For instance, the energy produced by wind turbines can only be stored briefly and therefore many countries, such as Germany, use hydroelectric systems to store the energy. This system is appropriate for alpine regions which for the Netherlands, for example, is not possible.

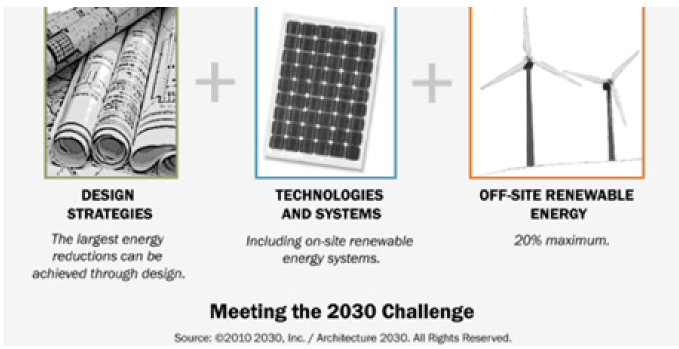
At the same time though, technology can have another side apart from large scale plants. Indeed there is huge potential in the use of renewables in a smaller scale and within cities. We can see that there are already applications of renewable technologies within the urban environment, from solar panels on roofs to small wind turbines on apartment blocks or non-residential buildings. Therefore, it is visible that these technologies have already penetrated the cities and designers are already engaged with incorporating them. Strengthening the intraurban presence of renewables is, firstly, desirable in terms of energy stability on a local scale and, secondly, possible since it lies on design solutions which can utilize the new technologies. However in order to actually take place in the optimum way there is a gap to be bridged between technology and design practices. Indeed in an interview (conducted by the author), Borris Hocks – urban designer and cofounding member of the Dutch office for spatial strategies "Posad", employed also in energy projects – stated that there is a need for developing a design language similar to the water-sensitive design language. Namely designers so far have been applying engineering solutions, by learning technical details and spatial restrictions, but there is a need for learning how to design with those technologies (Hocks, 2017). Similarly, organisations such as Architecture 2030 – established in 2002 by the architect Edward Mazria – consider the architects duty to provide innovative solutions for the built environment by creating strategies and making use of technologies (fig. 3). This is more than desireable since local intraurban energy production can stabilize the relationship between energy production and demand. It can provide a certain level of self-sufficiency on the neighbourhood level and engage users in the process.

Design solutions within cities are, undoubtedly, necessary in our trajectory to the urban energy transition, and so are wind farms and solar parks, but they are not sufficient (Janda, 2011). As aforementioned (see 3.3) if we are to take the future of cities into consideration, we need to go beyond energy production. We need to reinvent the way we perceive our urban environments and our relationship with energy holistically.

Mohammed bin Rashid Al Maktoum Solar Park in Dubai (source: First Solar)



Zeekracht: an energy productive ring of windmills in the North sea by OMA (source: OMA)



the pathway towards carbon neutral by 2030 as illustrated in the 2030 challenge (source: architecture2030.org)

3.4. TRACING THE GAP

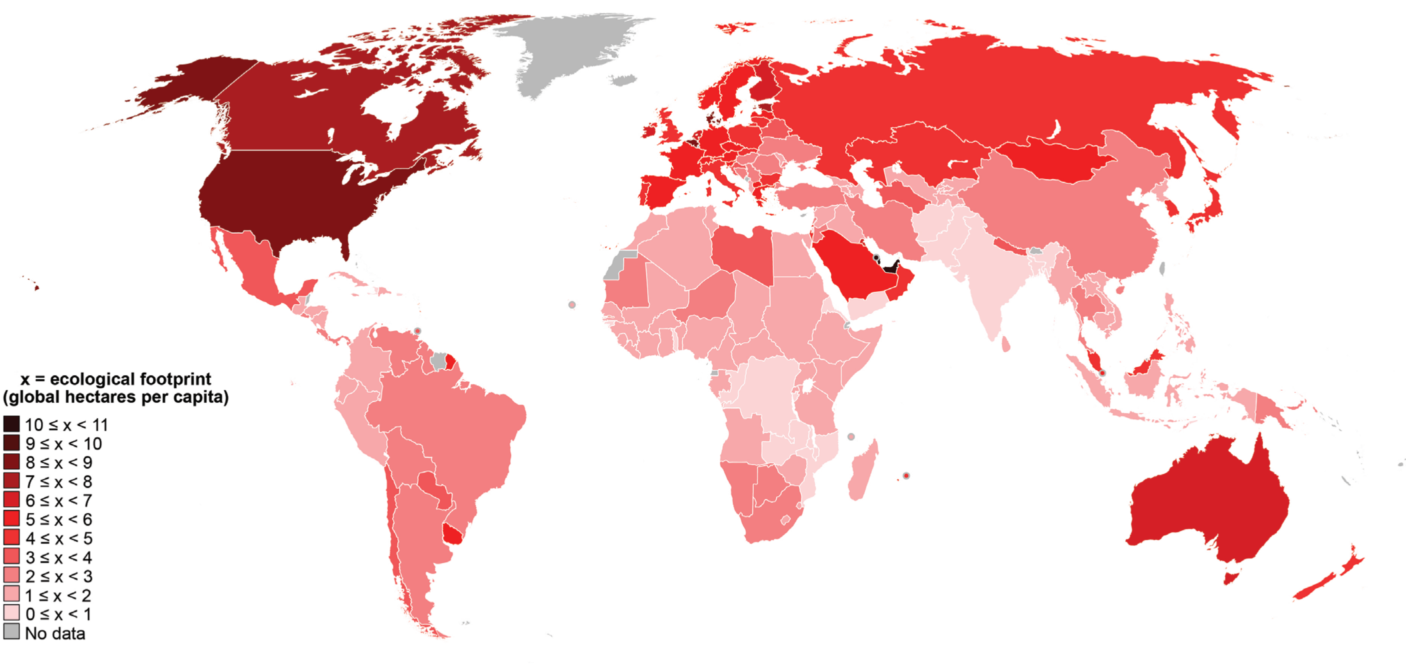
As it has been observed (Janda & Parag, 2013; Van Den Dobbelsteen et al., 2011), there is a gap between urban design and engineering in our trajectory towards the energy transition. Part of this gap has been already addressed in the previous sub-chapter (3.3), however an even bigger gap exists when it comes to the relation between climate and energy use. This sub-chapter explores the reason for its existence and the ways it can be addressed which are practiced in the main part of the project.

Droege (2006) in his book "The renewable city: a comprehensive guide to an urban revolution", studies the connection between cities and energy. Interestingly the particular subchapter of the book is entitled "Form follows fuel". In this subchapter, he describes how the coal influenced not only the expansion of cities but also their development along rail corridors due to the steam engine and how electricity (that stemmed from coal) transformed cities into "magic citadels of bright lights and motorised motion" (Droege, 2006: 131). Later on the oil and gas fully facilitated the growth of cities and served well in the steep housing demands of the post-war period. With oil and gas there is not even the need for proximity to the source as with coal. The extraction points are located far from cities and transportation services along with a large centralized distribution networks provide cities with 'invisible' energy (Hommels, 2005). Buildings, streets, transportation services, household devices were all built with dependence to this fuel system.

Therefore it is visible that the gap is not as simple as initially perceived. On the contrary it is deeply rooted into the urban form as it was shaped by the fossil era. Namely, the abundance of fossil resources and the invisibility of its source and access, have led urban development to become energy-costly. For instance the megastructures of the 70s that were made possible because of the development of central heating which gave people the opportunity to heat their houses or their water by the turn of a tap, and at the same time the materials used for their construction they provided no insulation. Or the post-war neighbourhoods which were built in the same form and with same materials in different countries with completely different climatic and local conditions (Olygay et al., 2015). This process has been ongoing for the last half century and more, leading to a generation not only of end users (Janda, 2011) but also professionals (architects, planners, engineers, etc.), which are alienated from climatic conditions and any awareness of how they are connected to energy use. This is also evident when looking into the ecological footprint per capita of each country (fig. 4). Western developed countries even though they possess the technological and economic means to reduce their ecological footprint, they seem to have the largest environmental impact and they also appear to be unaware of it (Carmona, 2009).

This is essentially the state of carbon lock-in that Broto (2017) analyses and it is manifested in various ways within the urban context. In this paper the focus of energy related unsustainability lies mostly on the built environment as one of the largest impact factors - users' behaviour is also taken into account but through the practice of urban design and how it can practically engage users. The built environment will be addressed as the ground of collaboration between urban designers and engineers. Perspectives on users' behaviour and its importance and potential will be briefly presented in the latter part of this paper.

In the built environment, existing knowledge is more limited and there are still key features that affect energy consumption which are mostly ignored by practitioners. For instance lack of



World map of countries by ecological footprint; data is given in global hectares per capita – data of 2016 (source: wikipedia) vegetation, concrete and asphalt have led to the urban heat island effect (Newman et al., 2017), which has affected even countries with cooler climates creating various issues including health problems. Furthermore there is a direct link between urban heat island and space heating requirements. But urban heat island is a phenomenon that becomes more evident in cities in particular periods and it is still less prominent in colder climates such as the dutch climate. As Owens (1987) describes in her article "The urban future: does energy really matter", the micro-climate and all elements of the built form – orientation, height and density of buildings, width of roads, vegetation, etc. – that affect it on a local level have an immense influence on the thermal comfort inside buildings and therefore on energy consumption. The root of this problem lies in fossil fuels as a cheap energy that shaped urban areas – built since the coal era and even more, later in the oil and gas era – ignorant to the local context (Droege, 2006). Namely, climate - weather conditions, sunlight, wind, etc. – orientation and materials, all of which were important before fossil fuels. Climatic distinctions that characterized urban settlements – such as bright colours or small windows for warm climates or dark colours and narrow streets for windy and cold climates – have been forsaken. And it is of course no coincidence that the two large urban growth periods – 19th and 20th century – took place hand in hand with this fuel system. But precisely this fact makes sustainability even harder to pursue due to rigid structures which are in place and thus hard to change. Therefore the challenge of our century is on one hand, as Droege states (1987: 131), "undoing the negative effects of almost three generations of planning priorities bred in an era that was gripped by great collective delusions about limitless growth". And on the other hand to solve this problem on the local context by producing climate- and energy-sensitive design solutions.

In brief, there is a paradox when it comes to technology and urban context. Technology seems – especially nowadays – to evolve rapidly. On the other hand, its spatial manifestation in the urban context – infrastructure, bridges, transportation facilities, etc. – is fixed, stable and obdurate (Hommels, 2005). This obduracy can be more easily perceived when considering a more specific example. To this direction we need to consider when the fossil era mostly influenced the built environment and the answer is during the post-war period. The cities were immensely expanded because of the baby-boom and new residential areas were constructed on the outskirts of the existing cities. This will be further explained in the next sub-chapter.

Greek islands: white walls, small windows and narrow streets. Photographer: Voula Papaïoannou

demographics showing post-war babyboom (source: commons.wikimedia.org)

3.5. POST-WAR NEIGHBOURHOODS AND DENSIFICATION

As aforementioned post-war residential areas have benn built in the peak of the fossil era and at the same time they constitute the biggest residential stock of the modern city. The fossil era and the energy abundance it offered affected the urban form of these neighbourhoods as it will be further addresed in the according chapter (Chapter 6). Apart from their importance in observing the urban obduracy, they pose great potential to address our current needs. Those needs are characterised by the rising urbanization rates and the limits of city chores in being densified. Indeed modern cities have densified to a maximum level – in their vast majority – and at the same time they have spread in expense of nature already a lot. In the post-war period when technology was advancing in various ways, industrialization and new materials allowed for whole residential areas to be built fast on the outskirts of the cities. Mobility was rising as well with the commercialization of private vehicles resulting in the famous now phenomenon of suburbia. Back then it seemed that with the help of technology growth wouldn't be a problem. Today, however we are facing a radically different reality; the limitless growth ideas belong to the past. Especially in the Netherlands where almost every parcel of land is characterized by a land use, densification seems inevitable.

Finding where and how to densify is of great importance. The centres of cities are already too densified and in many cities on a level that there are huge issues such as air pollution and floodings (lack of permeability), to name a few. If we go back to the description of the post-war period as the era of ideas of unlimited growth, we can already get a sense of the way the residential areas built back then had no spatial limits. Indeed post-war neighbourhoods – as it will be further explained in chapter 6 – were planned on the expense of nature. Of course this is something that on one hand can be explained by the principles of the modernism movement in architecture, and on the other exactly because of these principles it cannot be disregarded as something fundamentally wrong. Therefore when proposing to densify post-war neighbourhoods we should bear in mind that there is value in many of the spatial qualities they have.

So, without of course overruling the past, post-war neighbourhoods are considered a good starting ground for densification. The basic reasons for this are the following:

- sparse – space for densification
- monotonous – need to be restructured
- social mixing failed
- fastly decaying
- 36% of dutch housing stock
- existing plans for transformation

Table 1 The Dutch building stock in numbers (source:Platform31, 2013).

	Total residential stock	**Post-war residential stock (1946-1974)**	**Total apartment flats**	**Post-war apartment flats**	**Industrialised systems (all dwelling types**
no. dwellings	7300000	2600000	878000	381000	450000
% of the total stock in the NL		**36%**	**12%**	**5%**	**6%**

Source: "An integrated design process for a zero-energy refurbishment prototype for post-war residential buildings in the Netherlands", Konstantinou et al., 2015

"Stedelijke vernieuwing, rollen en samenwerken", source: 'Naoorlogse wijken, Anders kijken', Lydia Buist-Izelaar, 2014

3.6. PROBLEM STATEMENT

The urgency of the energy transition coupled with the current carbon lock-in create a complex situation which grows beyond the energy transition as pursued so far. This challenge requires to revise our current practices (gap) and the urban built environment (carbon lock-in) in order to also sustain the rising urbanization rates. Urbanization needs to be addressed differently than in the past. It needs a new approach that will make the new urban environments more climate-responsive and energy-active. At the same time no more 'free' land must be claimed in the process, existing urban areas need to be densified within this new approach.

4

FRAME. . . WORK

4.1 RESEARCH QUESTIONS

MAIN RESEARCH QUESTION

On our way to the urban energy transition, what are the spatial interventions needed in dutch post-war neighbourhoods that, based on principles of climate responsiveness and energy active design, can reduce building energy use and increase sustainable energy production?

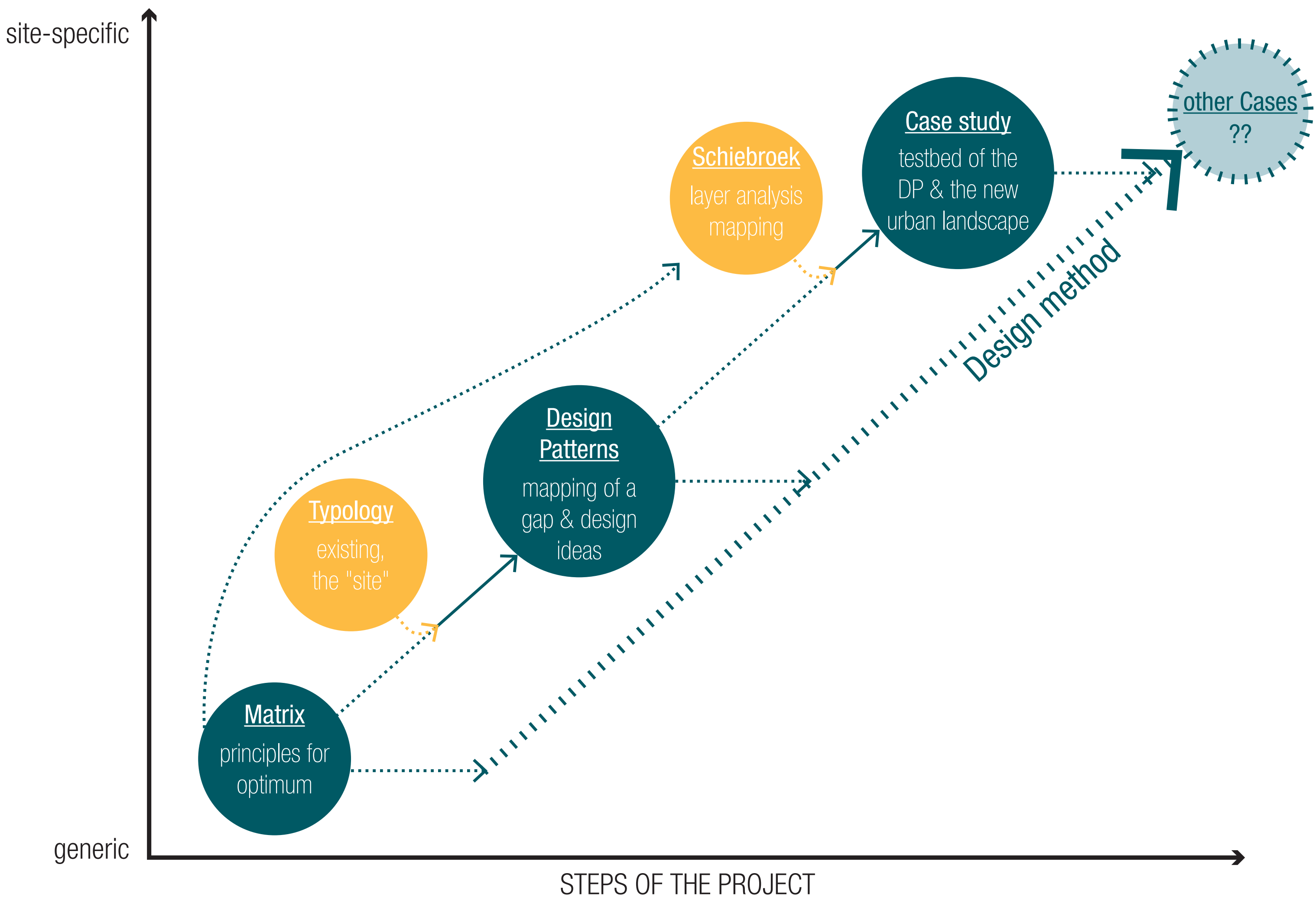
energy and climate Matrix

Typology of dutch post-war neighbourhoods

Design Patterns & Case study

SUB-RESEARCH QUESTIONS

- What characteristics/parameters of the urban form affect the micro-climate? → Literature review
- Which are the optimum characteristics of urban morphology for the Dutch climate? → energy & climate Matrix
- How can the optimum characteristics and renewable energy technologies be coupled and integrated into applicable urban design solutions? → Design patterns
- Which parameters should be considered and which steps should be followed in applying those design patterns in an existing post-war neighbourhood? → Case study
- Which are the elements, that can be effectively extracted from the overall process in order to contribute to climate-responsive and energy-active urban design? → Design method


site-specific
generic
STEPS OF THE PROJECT
Matrix
principles for optimum
Typology
existing, the "site"
Design Patterns
mapping of a gap & design ideas
Schiebroek
layer analysis mapping
Case study
testbed of the DP & the new urban landscape
other Cases
??
Design method

4.2 GOALS & FINAL PRODUCTS

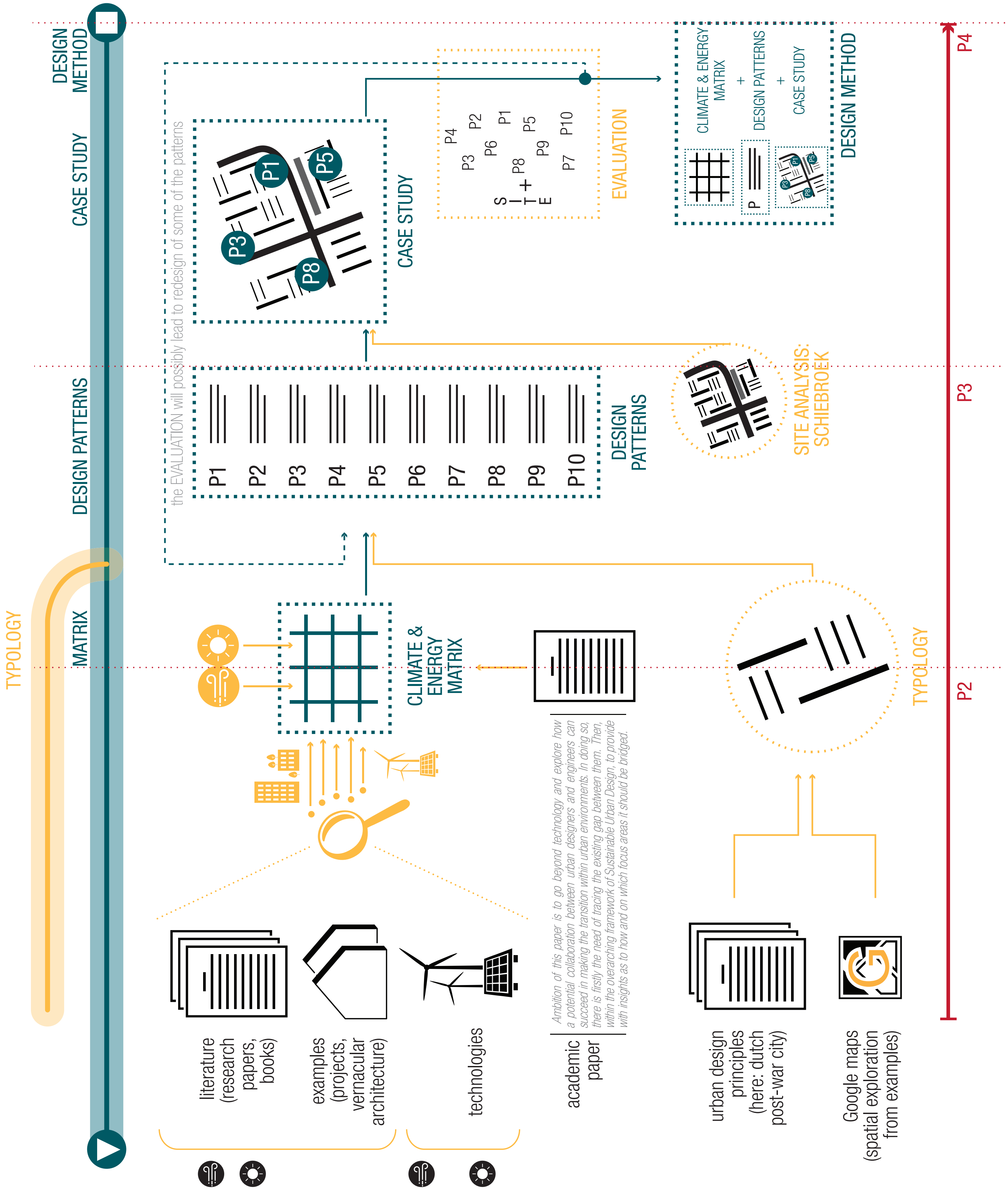
GOALS

The ultimate goal of the current graduation project is to explore the path towards the urban energy transition and offer actual design solutions as to how it can be pursued. The intention of the author, however is not only to incorporate renewables in the urban fabric. It is to look deeper into what the transition towards renewables implies on 3 different levels: technology, built environment and users. As it is aforementioned the type of energy used affects all different aspects of society so it grows beyond changing the energy source. Therefore, by creating a better understanding of our current practices - in building, designing, using energy, etc as influenced by the fossil economy - this project aspires to propose new practices. New practices are also seen as a way of densifying the existing urban fabric to respond to urbanization rates. Keeping as main focus urban porphology and design, those practices can be determined by applying climate-responsive and energy-active urban design.
However, given the fact that this fiels remains still more of an unexplored territory, there is a need for creative design solutions (patterns) as well as practical application that can show the applicability of those solutions in real space. Densifiaction.... Finally, in order to move towards the urban energy transition, the author aims to overcome the local context. Both by locating extractible characteristics within the design solutions, but most importantly by proposing steps and elements that should be taken into account when applying climate-responsive and energy-active urban design. This basically entails the afforementioned change in practices and a set of steps that practitioners can explore towards the transition.

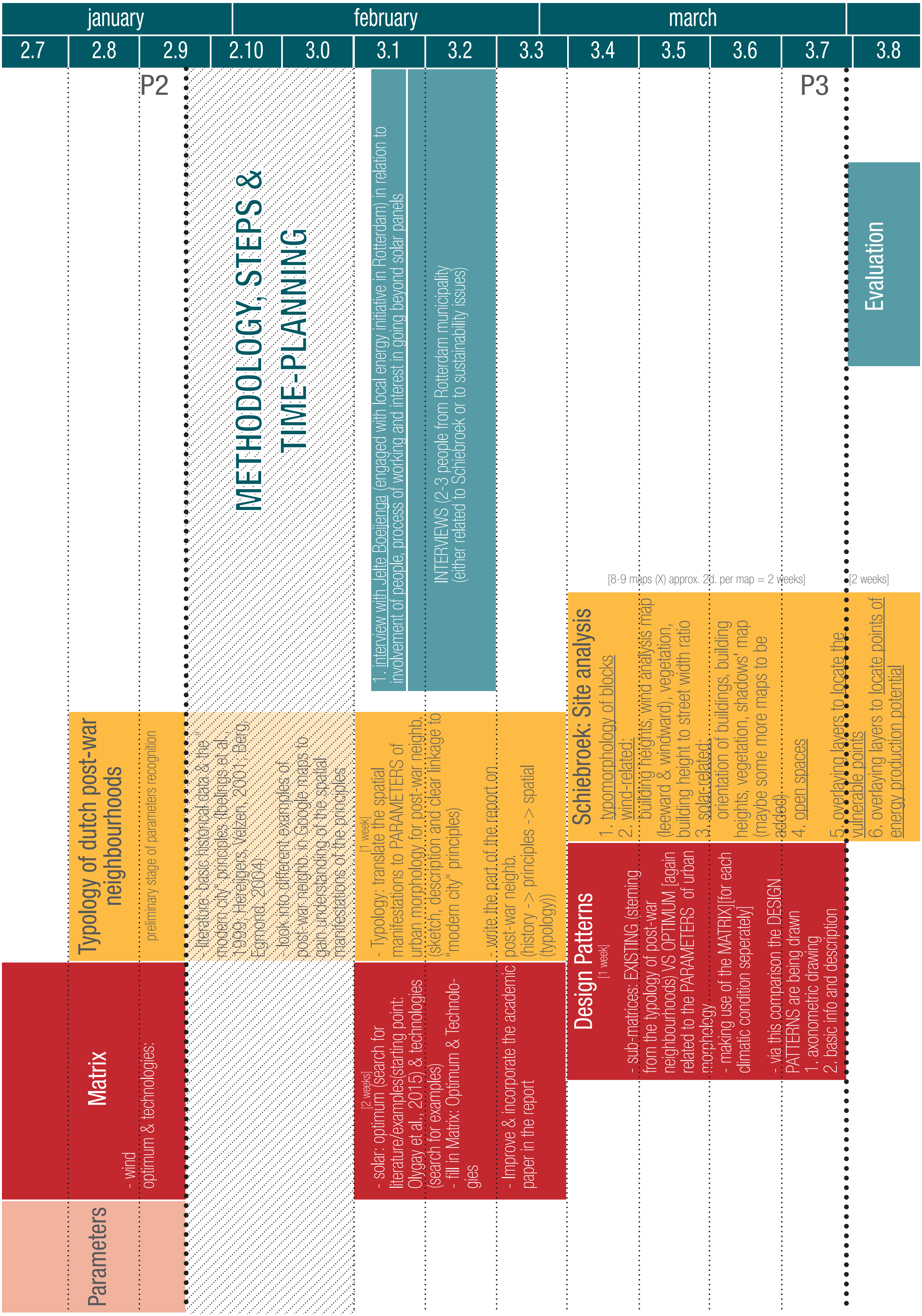
FINAL PRODUCTS

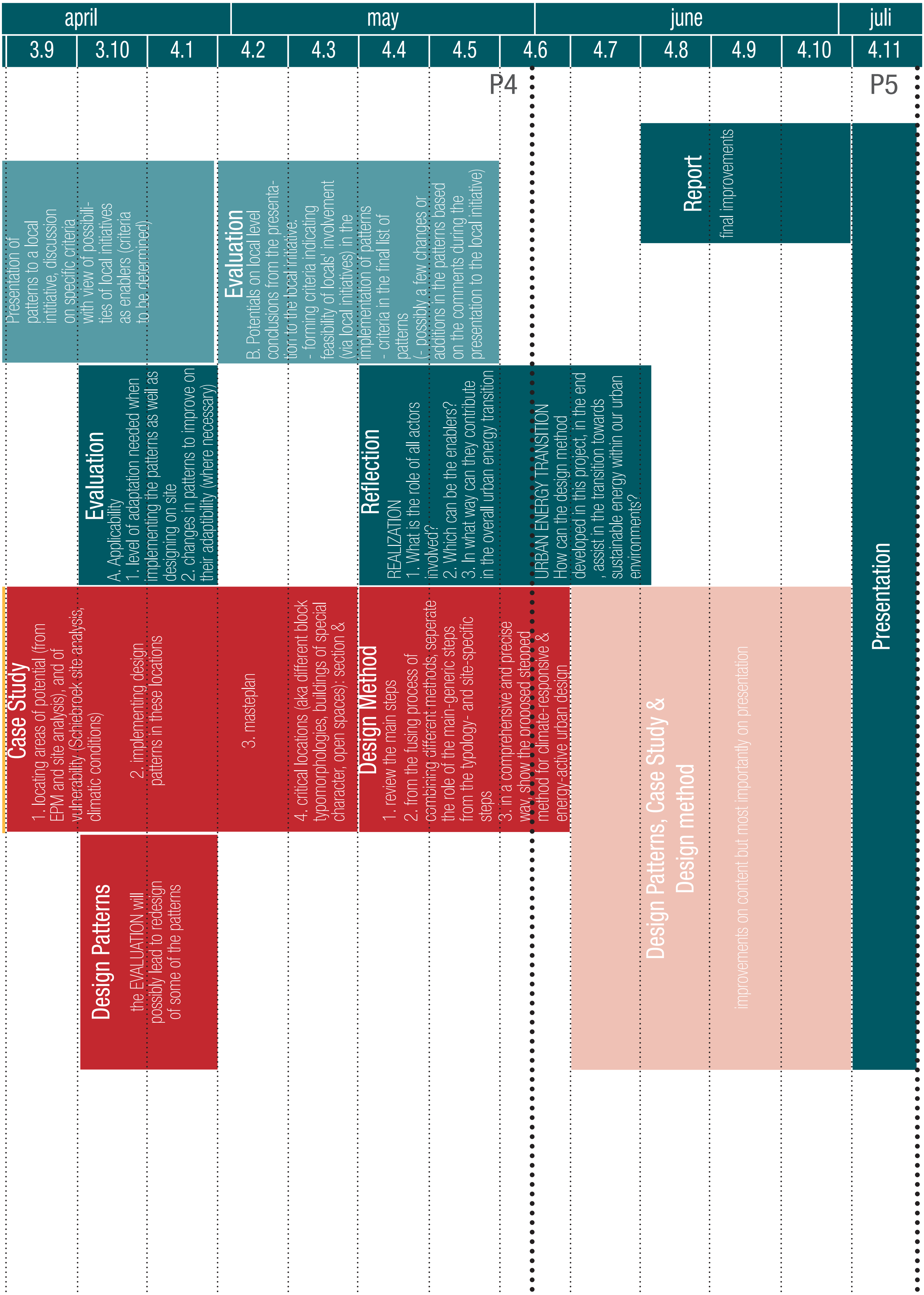
- Energy & climate Matrix
- Design patterns
- Case study: post-war neighbourhood of south Schiebroek - where the design patterns will be applied
- Design method - contributing in climate-responsive and energy-active urban design

4.3. METHODOLOGY



4.4. TIMEPLANNING




april
may
june
juli
3.9
3.10
4.1
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9
4.10
4.11
P4
P5
Presentation of patterns to a local intitiative, discussion on specific criteria with view of possibilities of local initiatives as enablers (criteria to be determined)
Evaluation
B. Potentials on local level conclusions from the presentation to the local initiative:
- forming criteria indicating feasibility of locals' involvement (via local initiatives) in the implementation of patterns
- criteria in the final list of patterns
(- possibly a few changes or additions in the patterns based on the comments during the presentation to the local initiative)
Report
final improvements
Evaluation
A. Applicability
1. level of adaptation needed when implementing the patterns as well as designing on site
2. changes in patterns to improve on their adaptibility (where necessary)
Reflection
REALIZATION
1. What is the role of all actors involved?
2. Which can be the enablers?
3. In what way can they contribute in the overall urban energy transition
URBAN ENERGY TRANSITION
How can the design method developed in this project, in the end , assist in the transition towards sustainable energy within our urban environments?
Case Study
1. locating areas of potential (from EPM and site analysis), and of vulnerability (Schiebroek site analysis, climatic conditions)
2. implementing design patterns in these locations
3. masteplan
4. critical locations (aka different block typomorphologies, buildings of special character, open spaces): section &
Design Method
1. review the main steps
2. from the fusing process of combining different methods, seperate the role of the main-generic steps from the typology- and site-specific steps
3. in a comprehensive and precise way, show the proposed stepped method for climate-responsive & energy-active urban design
Design Patterns
the EVALUATION will possibly lead to redesign of some of the patterns
Design Patterns, Case Study & Design method
improvements on content but most importantly on presentation
Presentation

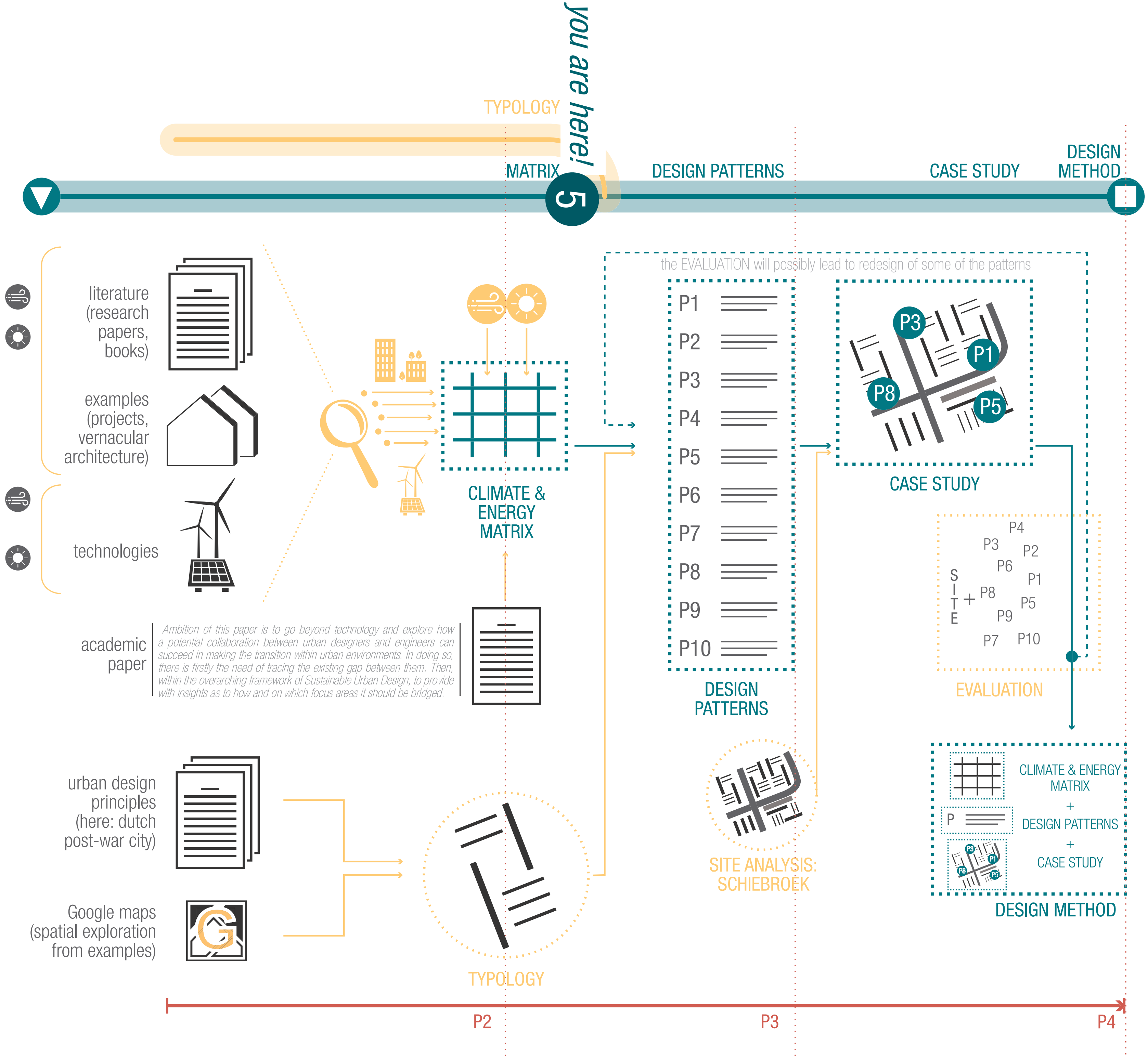
4.5. RELEVANCE

SOCIAL RELEVANCE

The rapid pace of urbanization (Petit, 2017) and the "imperial mode of living" (Brand and Wissen, 2012), in combination with emerging economies such as Brazil or China which increase the existing high pressure on energy resources, create a significant urgency. At the same time fossil resources become more and more scarce and climate change more and more evident. It seems therefore that the energy transition towards renewable energy sources is inevitable. However, as aforementioned the manner in which the transition will eventually materialize is extremely important on many different levels – economic, social as well as for natural and urban environments. For instance the oil-based economy created social and economic injustice as well as immense crises. This graduation project aspires to explore the potentials for a socially inclusive transition by exploring the potential lying in acting locally. As explored in literature decentralized energy systems can restore the social and financial injustice that the centralized fossil system created. So in this project design solutions are sought that could strengthen both local energy production and in general the balance between supply and demand by designing for energy conservation. Finally energy productive public spaces are proposed in this project in the direction of not only making people more aware of energy but also to offer spaces fueled by renewable energy for the community by providing the opportunity for more activities in the public sphere.

SCIENTIFIC RELEVANCE

As described in the problem statement, the current stage of implication of renewable energy technologies is limited in either intensive energy production fields (solar and wind parks, hydropower plants, etc) or in specific urban interventions which are however limited in productivity to cater for the needs of the habitants (e.g. solar roofs). In pursuit of a green economy and energy self-sufficiency in urban environments, partial energy production is not sufficient, we need to design for balance in supply and demand. This endeavour will take place in urban environments and therefore new urban energy systems and urban forms need to be proposed. Currently, these kind of interventions are carried out mostly by energy experts while urban designers are either indifferent to these technologies or lacking knowledge. This gap is what this graduation project wants to address by, firstly, gathering knowledge related to the relationship between energy and the built environment. And secondly, by translating this knowledge in space and proposing design solutions that will allow for cities to spend less energy as well as produce their own energy.



you are here!
5
TYPOLOGY
MATRIX
DESIGN PATTERNS
CASE STUDY
DESIGN METHOD
literature (research papers, books)
examples (projects, vernacular architecture)
technologies
academic paper
Ambition of this paper is to go beyond technology and explore how a potential collaboration between urban designers and engineers can succeed in making the transition within urban environments. In doing so, there is firstly the need of tracing the existing gap between them. Then, within the overarching framework of Sustainable Urban Design, to provide with insights as to how and on which focus areas it should be bridged.
urban design principles (here: dutch post-war city)
Google maps (spatial exploration from examples)
CLIMATE & ENERGY MATRIX
TYPOLOGY
the EVALUATION will possibly lead to redesign of some of the patterns
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
DESIGN PATTERNS
SITE ANALYSIS: SCHIEBROEK
CASE STUDY
S I T E + P8 P9 P7 P10 P5 P1 P6 P3 P2 P4
EVALUATION
CLIMATE & ENERGY MATRIX + DESIGN PATTERNS + CASE STUDY
DESIGN METHOD
P2
P3
P4

5

CLIMATE-RESPONSIVE & ENERGY-ACTIVE URBAN DESIGN: A MATRIX

Table 3. The sustainable urban design framework matrix.

	Regional	District/ neighbourhood	Block/street	Project/parcel
Energy use/GHG (transp./land use)	Robust transit network Robust bicycle networks Vehicular networks High land use mix (Macro scale) Compact development (for density/proximity)	Small and defined blocks High building/housing density High network connectivity Macro parking mgmt/design High land use mix (micro scale)	Multimodal street design Engaging pedestrian realm Robust bicycle infrastructure Design for transit Limiting auto impact Dense and street activating building typologies Micro parking mgmt/design Platting for density	Engaging public realm design Dense and street activating building typologies Engaged building/street relationship High internal and external connectivity Micro parking mgmt/design
Water	Avoid flood prone areas Compact development (for limited impact on nat. systems)	Robust stormwater mgmt. network (distributed/on-site recharge)	High surface permeability Extensive green stormwater infrastructure (GSI) Extensive urban forest canopy	High surface permeability Extensive green stormwater infrastructure (GSI) Extensive urban forest canopy Rainwater capture/re-use
Ecology/habitat	Avoid ecol. sensitive areas Robust and connected macro ecological systems and networks Compact development (for limited impact on nat. systems)	Avoid ecol. sensitive areas Ecological corridors/pockets High urban forest continuity/diversity Daylight/restore waterways	High surface permeability Micro-habitat creation High vertical complexity Native vegetation Mitigating habitat disruption Robust ecological area buffers Non-polluting lighting design	High surface permeability Micro-habitat creation High vertical complexity Native vegetation Mitigating habitat disruption Robust ecological area buffers Non-polluting lighting design
Energy use/production (non-transp.)	Compact development (for limited embodied energy in infrastructure)	Block size/street orientation for microclimate mitigation High building/housing density	Dense/energy efficient building typologies Microclimate mitigation Low albedo surface materials Urban forest and robust vegetation High street ht./width ratio Efficient street lighting design Platting for density and solar exposure	Infill development Dense/energy efficient building typologies Increase local energy production (solar/wind)
Equity and health	[Maximize accessibility and ped/bike safety (see energy use/GHG in transportation and land use)]			
	Equitable distribution of employment, housing, human services, open space, education facilities, and healthy food options	Equitable distribution of employment, housing, human services, open space, education facilities, and healthy food options Limit location of point source pollution and toxins	Active/attractive open space (for activity and quality of life) Lighting for safety Site design for ownership and surveillance Affordable housing typologies Complete streets for ped safety Urban forest and robust veg. (for pollution sequestration)	Mix of unit types Active/attractive open space Lighting for safety Site design for ownership and surveillance Affordable housing typologies

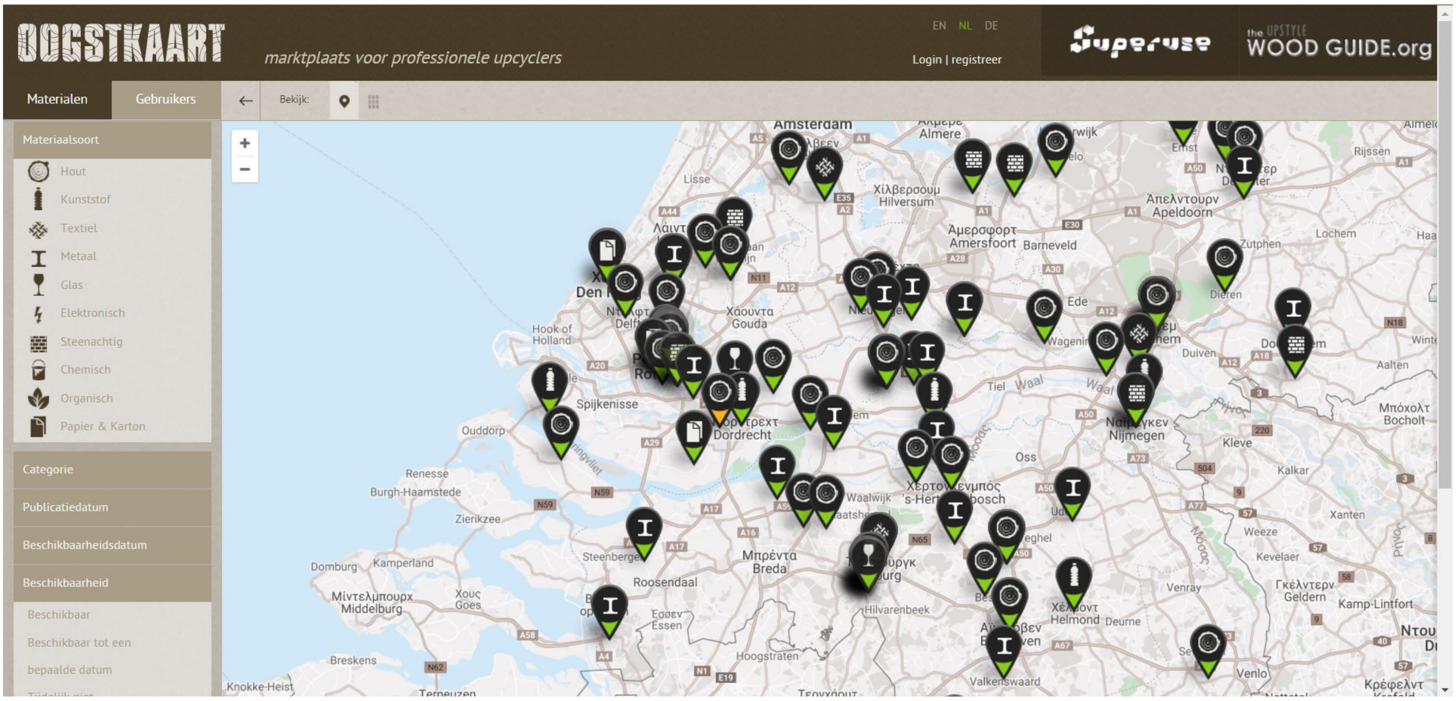
5.1. SUD FRAMEWORK

In this thesis Sustainable Urban Design (SUD) is described as an overarching framework which can provide the basis for the development of the desired collaboration between urban designers and engineers. For this purpose Nico Larco's paper (2016) entitled *"Sustainable urban design – a (draft) framework"* is chosen since it incorporates different theory models on sustainable development and provides a comprehensive and aggregate framework with clear focus on design, purposed for practitioners.

Larco's paper is aimed to address the lack of a cohesive framework that could guide practitioners on which elements are to be sustained and how, and on how they relate to each other. So Larco is providing an *overarching framework* that can help locate synergies and trade-offs that a single design move can entail in terms of sustainability. This is built by tracing the commonalities among the various models of sustainable development (e.g. Kenworthy's 'Critical Eco-city Dimensions') and making a framework – illustrated via a comprehensive matrix – that is organized in relation to the *specific elements of urban design that affect sustainability*. The actual matrix consists of 5 focus areas of sustainable design and geographic scales – from regional to parcel/project. The focus areas, as aforementioned, stem from the commonalities of the different models. In this way it becomes more tangible to understand *what kind of relationships can exist between different focus areas but also different scales*. For instance by looking into Larco's matrix it becomes easily visible that compact development not only improves energy use but also is desirable in ecological and water-related sustainability, since it limits the impact on natural systems (see table in opposite page).In this project (and further on in the thesis) from the five primary focus areas only one is being studied in detail: *energy use and production* (based on non-transport related uses). This focus area is subdivided to three additional focus areas: building energy use, outdoor lighting and embodied energy. All of them need to be addressed through the transdisciplinary collaboration that is proposed and design solutions and spatial principles need to be developed.

In the current thesis, even though all aspects are considered important, *only building energy use is addressed*. However it needs to be pointed out that whereas for outdoor lighting there has already been progress in many countries, in relation to embodied energy little is being done and awareness is still not achieved. It grows beyond our current understanding due to the ease of material access and transportation but we need to again reinvent the process of getting materials, and constructing (/assembling) and demolishing (/dismantling) buildings. There have been a few attempts related to reuse of materials among others. For instance in the Netherlands, via an online platform that shows available materials on a map to reinforce also the locality of supply (fig. 5).

The aim of the author is to offer a brief description of building energy use, and to highlight the areas where the gap exists and the potentials stemming from the desired collaboration. At the same time it is acknowledged that the nature of this gap is something that cannot be bridged by the author, but possible pathways are



Harvest map; marketplace for professional upcyclers (source: oogstkaart.nl)

"*Masdar City combines state-of-the-art technologies with the planning principals of traditional Arab settlements to create a desert community that aims to be carbon neutral and zero waste.*"

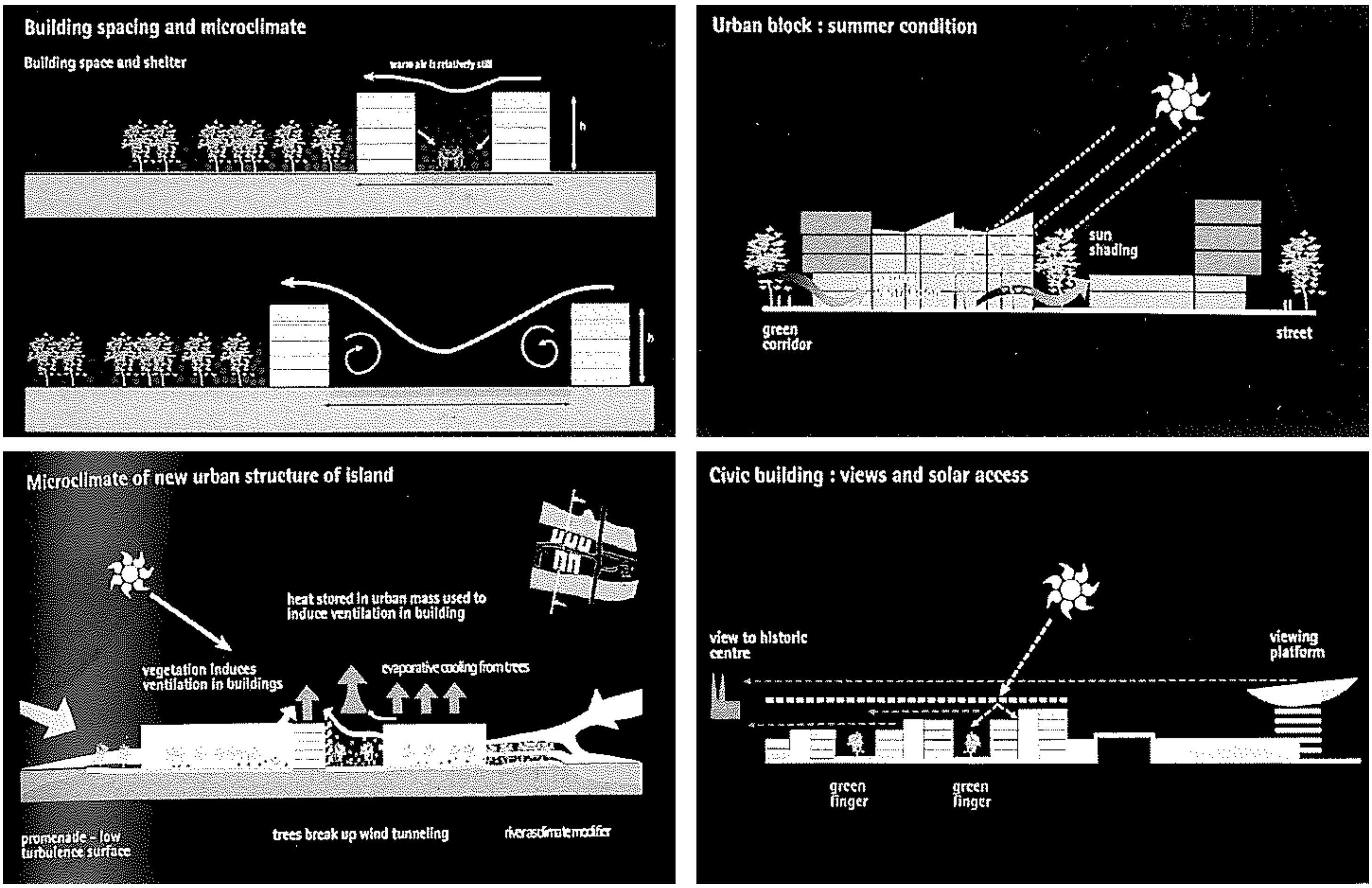
(source: https://www.fosterandpartners.com/projects/masdar-city/)

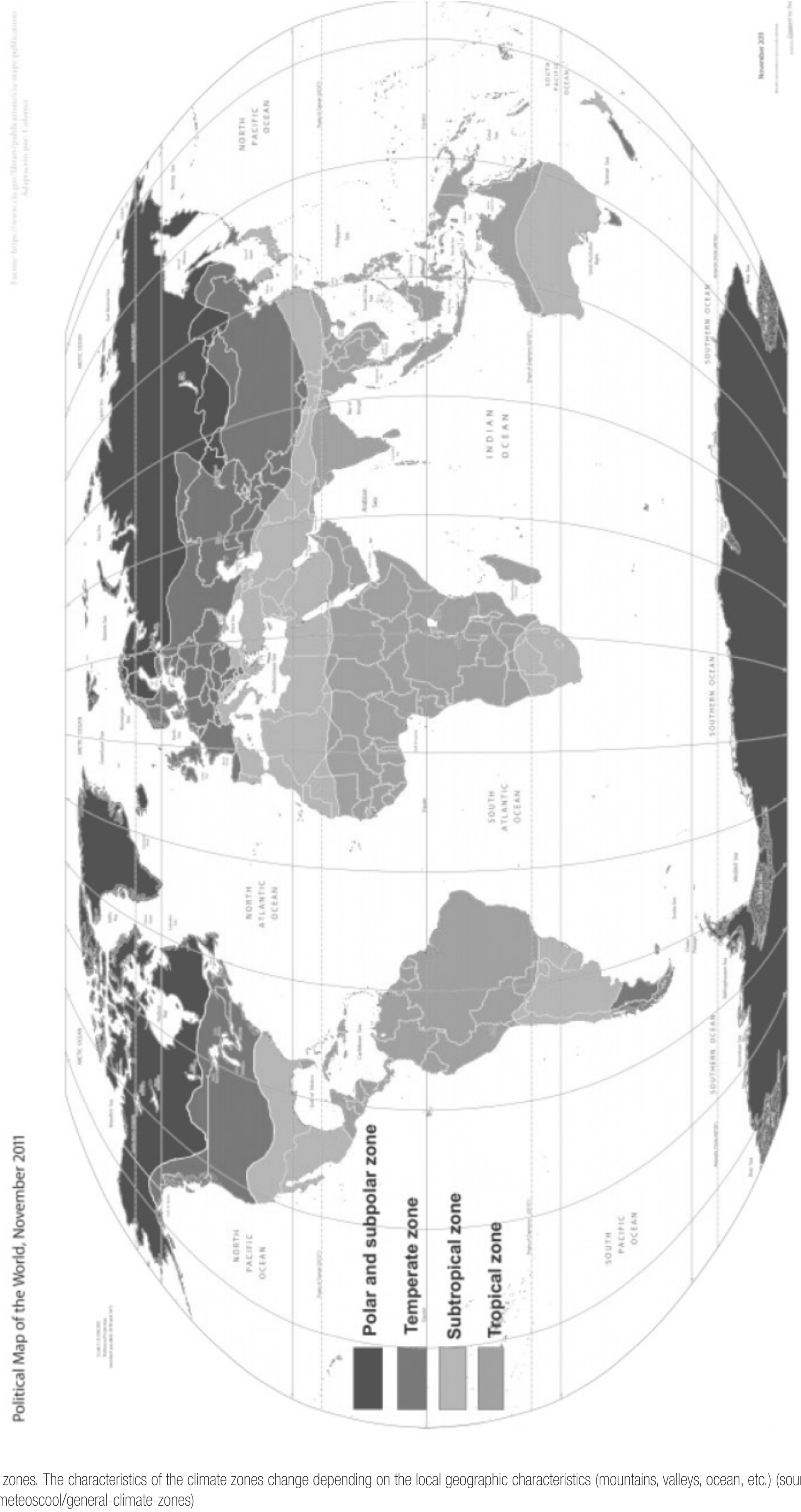
explored and proposals will be made towards bridging this gap. The *building energy use* is first and foremost, highly dependent on the *climatic conditions*. But as aforementioned, local climatic conditions are significantly *influenced by the urban form*. In particular it influences humidity, wind strength and temperature, to mention a few, however the way on which the form influences them is an unknown field for urban designers. Some of the basic elements that should, and in some cases are already taken into consideration are: solar orientation, buildings' sizes and depth, density and wind patterns. All those elements though are extremely dependent on local climatic conditions. Moreover often there can be *design decisions that while benefiting one of the conditions, they collide with others*. The climatic conditions and the physical rules concerning them are a knowledge field that belongs to physicists, engineers and environmental scientists. However the urban form is – and should be – designed by urban designers, which makes it clear that there needs to be a transfer of knowledge across disciplines in order for successful design solutions and spatial disciplines to be developed. There are existing examples that similar attempts have been made, for instance the Solar Quarter in Regensburg (Germany) or Masdar City (UAE), both by Foster and partners (fig. 6). Examples such as these can help along with examples from vernacular architecture in giving a better insight into physical rules that have to be followed

Housing designed in relation to the dessert climate and a wind tower within Masdar. Photograph: Clint McLean/Corbis (source: The Guardian)

for *climate- and energy-sensitive design*.
At this point it should be noted that even though Larco provides a very cohesive and aggregate framework, there is the need for more information in order for practitioners to be able to actually use this kind of matrix. The knowledge that needs to be developed in order to deliver successful principles and designs, should also incorporate values and data that will enable SUD to become less vague and qualitative. For instance, the urban heat island is an effect which can be described in a qualitative manner but it can also be measured (Larco, 2016). There is *a need to develop indicators* in a similar way, for instance an indicator that would be able by taking into consideration the strength and direction of the wind to calculate the optimum height of buildings or width of open space between buildings, based on the local climatic conditions. However this kind of data even though they exist for some values, *what is also lacking is an organizational structure* that will enable practitioners to be able, firstly not to get lost with various data, and secondly to compare them and identify trade-offs between different elements – e.g. wind and sun requirements related to density. Similarly it could work for a possible table of materials, incorporating characteristics related to locality of access, construction and demolition energy requirements, etc. – as related to embodied energy. This kind of matrixes could help urban designers to weigh different choices and decide accordingly to each case's requirements and potentials. This is the gap that the exchange of knowledge across disciplines – urban designers and engineers – will need to fill in the immediate future towards the urban energy transition.

The diagrams illustrate the approach of the designers to ecologically responsible design, from the project: Solar quarter in Regensburg, Germany, by Norman Foster and Partners (1996) (source: Ruano, 1999: 45)





The 4 major climate zones. The characteristics of the climate zones change depending on the local geographic characteristics (mountains, valleys, ocean, etc.) (source: https://content.meteoblue.com/en/meteoscool/general-climate-zones)

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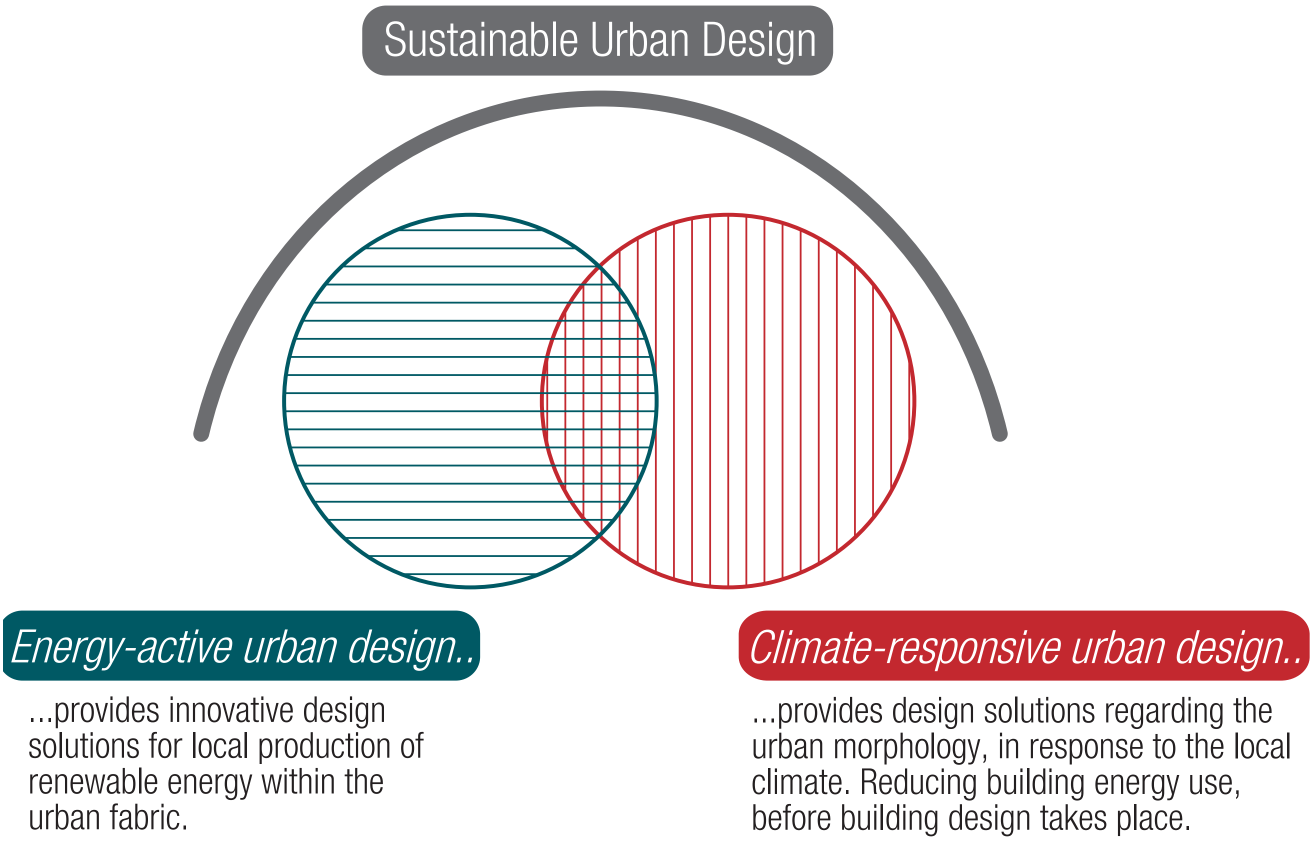
Since this project's emphasis lies on the urban energy transition the focus area chosen to emphasize on is, as aforementioned, the energy use and production – and in specific the building energy use. Therefore, when looking the table in more detail on those specific parts there is *another gap* that this framework cannot cover. As Larco also mentions in his paper: "*It should be emphasized that this framework is meant to help define the topics that need to be addressed, not necessarily how they are addressed as this is determined in part by local conditions.*" (Larco, 2016: 19). In the case of building energy use, local conditions are ever more relevant due to the *importance of climate* on the energy consumption connected to buildings. For instance in Larco's framework compact development is considered a contributing factor of sustainability when related to energy use. And though that is true when related to transport for reasons of proximity that limit travel distances, in relation to non-transport energy use it is more complicated. On one side compact development does limit embodied energy in infrastructure, but on the other the building energy use is not universally benefited by this kind of development because it is highly dependent on climatic conditions. So in cool climates (polar and subpolar) compact city form could help in protecting from the cold winds, but in hot-humid areas (part of the tropical zone) compact development wouldn't allow for breezes to pass through and help in the evaporation of the moisture (Olygay, 2015).

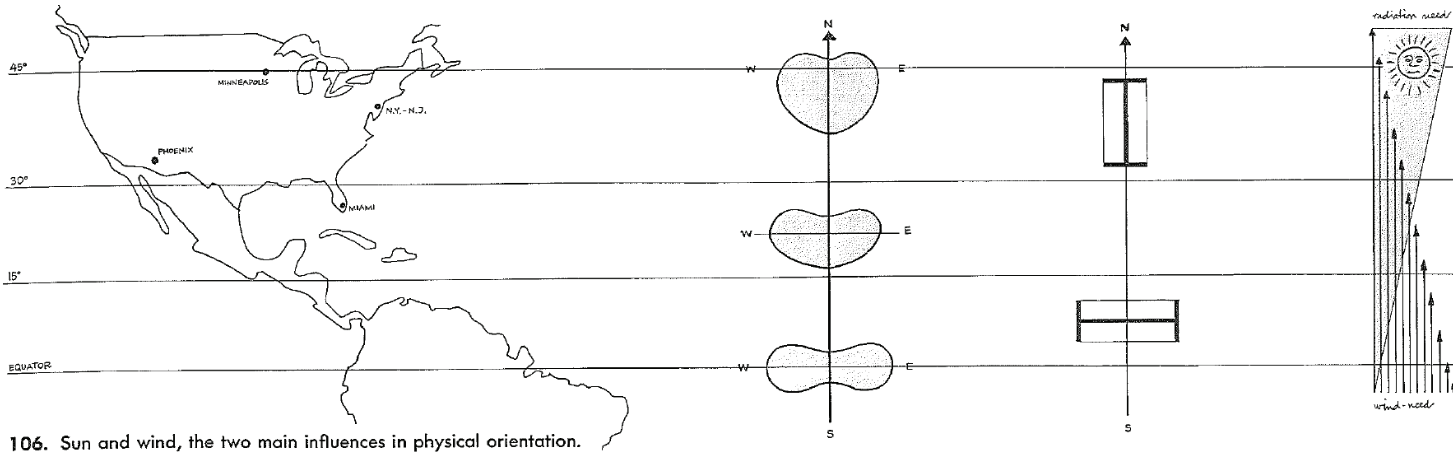
Therefore, in this project a new framework is proposed which lies within the overarching framework of SUD by Larco, but addresses energy use and production in relation to building energy use. To assist in setting the framework on the right basis two notions are used, linked with energy production and energy use accordingly:

- *Energy-active urban design* is purposed to provide innovative design solutions that enable the production of renewable energy on a local level within the urban fabric.
- *Climate-responsive urban design* is purposed to provide design solutions regarding the urban morphology, which respond to the local climate. Offering the potential for reduced building energy use even before building design takes place.

Those two notions of urban design set the guiding principles of urban design as pursued in this project. They are not to be considered as two separate branches of sustainable urban design, but as two more targeted and defined parts of it.

On this matter, as already discussed, exists a knowledge gap between urban designers and engineers and there is the need for covering the *unfamiliar ground of the relationship between climatic conditions and urban morphology*. The intention in this project is, on one hand, through relevant *examples of sustainable urban morphology* and different *scientific principles* related to climate and physics (behaviour of physical forms), to provide with some *optimum characteristics of urban morphology* for a specific climate, that will limit the building energy use. And on the other hand to *collect different technologies of renewables* that are appropriate for urban environments and that take advantage of local climatic conditions in the optimum way. Those two tasks respond accordingly to climate-responsive and to energy-active urban design. Apart from that there is recommendation for further transdisciplinary research that could go beyond examples and best practices and towards discovering the true potential existing in the collaboration among science, technology and urban design.





106. Sun and wind, the two main influences in physical orientation.

PARAMETERS OF URBAN MORPHOLOGY

Table 3. The sustainable urban design framework matrix.

	Regional	District/ neighbourhood	Block/street	Project/parcel
Energy use/GHG (transp./land use)	Robust transit network Robust bicycle networks Vehicular networks High land use mix (Macro scale) Compact development (for density/proximity)	Small and defined blocks High building/housing density High network connectivity Macro parking mgmt/design High land use mix (micro scale)	Multimodal street design Engaging pedestrian realm Robust bicycle infrastructure Design for transit Limiting auto impact Dense and street activating building typologies Micro parking mgmt/design Platting for density	Engaging public realm design Dense and street activating building typologies Engaged building/street relationship High internal and external connectivity Micro parking mgmt/design
Water	Avoid flood prone areas Compact development (for limited impact on nat. systems)	Robust stormwater mgmt. network (distributed/on-site recharge)	High surface permeability Extensive green stormwater infrastructure (GSI) Extensive urban forest canopy	High surface permeability Extensive green stormwater infrastructure (GSI) Extensive urban forest canopy Rainwater capture/re-use
Ecology/habitat	Avoid ecol. sensitive areas Robust and connected macro ecological systems and networks Compact development (for limited impact on nat. systems)	Avoid ecol. sensitive areas Ecological corridors/pockets High urban forest continuity/diversity Daylight/restore waterways	High surface permeability Micro-habitat creation High vertical complexity Native vegetation Mitigating habitat disruption Robust ecological area buffers Non-polluting lighting design	High surface permeability Micro-habitat creation High vertical complexity Native vegetation Mitigating habitat disruption Robust ecological area buffers Non-polluting lighting design
Energy use/production (non-transp.)	Compact development (for limited embodied energy in infrastructure)	Block size/street orientation for microclimate mitigation High building/housing density	Dense/energy efficient building typologies Microclimate mitigation Low albedo surface materials Urban forest and robust vegetation High street ht./width ratio Efficient street lighting design Platting for density and solar exposure	Infill development Dense/energy efficient building typologies Increase local energy production (solar/wind)
Equity and health	[Maximize accessibility and ped/bike safety (see energy use/GHG in transportation and land use)]			
	Equitable distribution of employment, housing, human services, open space, education facilities, and healthy food options	Equitable distribution of employment, housing, human services, open space, education facilities, and healthy food options Limit location of point source pollution and toxins	Active/attractive open space (for activity and quality of life) Lighting for safety Site design for ownership and surveillance Affordable housing typologies Complete streets for ped safety Urban forest and robust veg. (for pollution sequestration)	Mix of unit types Active/attractive open space Lighting for safety Site design for ownership and surveillance Affordable housing typologies

top: Nico Larco's SUD framework matrix with the "Energy use/prodution (non-transp.)" part of the matrix highlighted. The elements of this part formulate the parameters of urban morphology of the Energy & Climate Matrix

bottom: "Sun and wind, the two main influences in physical orientation", drawing shows the different latitudes (connected with different climates), two graphs related to insolation and orientation, and finally the needs for sun or wind depending on the season (Olygay et al., 2015: 55)

5.2. ENERGY & CLIMATE MATRIX

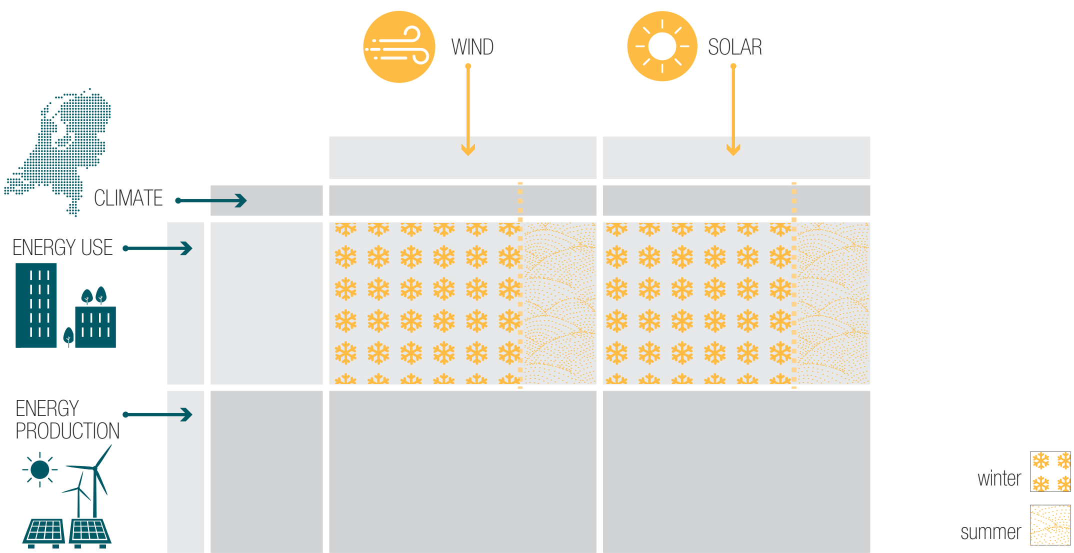
Platting for climate-sensitive and energy-active urban design – in the current project – requires the appropriate examples and scientific principles of optimum urban morphology characteristics related to building energy use and technologies of renewables. But it also requires an organisational structure that can allow for this collection of data to be useful and to help shape a design toolkit. For that purpose a matrix is made that collects all these examples and principles, the Energy & Climate Matrix. Larco's matrix is used as a guiding tool. In particular, the elements of the "Energy use/ production (non-transp.)" part formulate the parameters of urban morphology. Those parameters constitute the elements which are being studied in order to uncover the relationship between urban morphology and energy & climate. This information will be used in order to formulate the aforementioned design toolkit – aka the design patterns. The design patterns stem from the combination of the optimum urban morphology parameters and the morphological qualities of dutch post-war neighbourhoods – the latter will be analysed in the next chapter. By combining those two, design patterns can provide with design ideas on climate-responsive and energy-active urban design. But first the grounds on which the collaboration of the matrix and the typology will be set needs to be organised. The morphological parameters/ qualities of the matrix constitute this common ground with the typology.

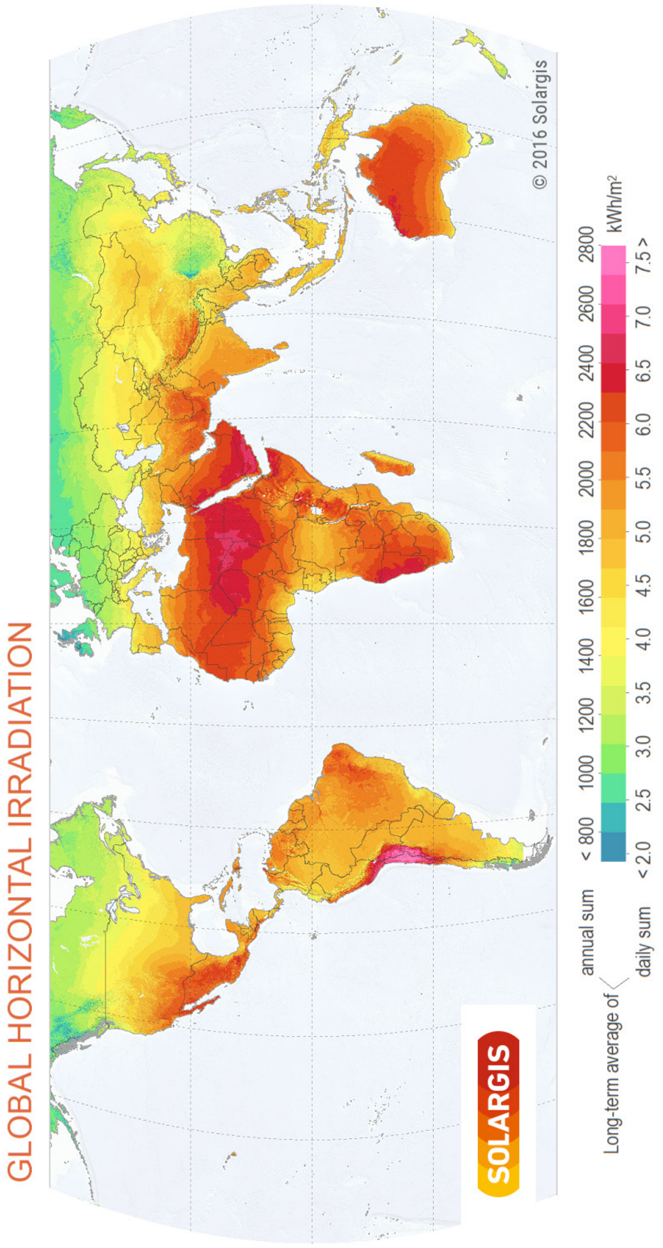
As it will be explained further on, the parameters are linked with specific climatic conditions, based on the premises of the project. The scales that Larco uses are also used here in the vertical axis of the project's matrix, along with the parameters in order to provide an orginisational structure.

For the Energy & Climate Matrix and for this project in general there are some basic elements – premises – that formulate the basis of the research:

1. The climate chosen – starting from the Matrix is the Dutch climate which is defined as *temperate maritime climate highly influenced by the North Sea*
2. Building energy use/production is subdivided in two parts: *energy use* and *energy production*
3. Energy use and energy production are both in relation to climatic condition in terms of learning how to respond and benefit from the *climate*. For climatic conditions *wind* and *solar* are chosen to be studied. Those two climatic conditions are the most influencial for macro- and micro-climate. Radiation affects the temperature of the air masses which determines their movement along with wind that affects the movement, the temperature but also can effectively shape the local climate but also change various other values of the climate (Olygay, 2015). For instance allowing the wind to flow within a settlement can lift humidity. Wind and solar not only affect elements of the climate but are directly connected with buildings' energy use – as it will be further explained – as well as energy production, which are the focus of this project. It is therefore made explicit that when stated that we need to learn to design with climate, the two climatic conditions used are wind and solar.
4. Climatic conditions change significantly from season to season, and they require different design approaches. In the current project *winter season* is chosen as a focus area. In temperate climates, such as the dutch, even though the winters are milder than in cool climates, it is proved that most of the energy use of buildings is connected to space heating – as it will be further explained. However due to urban heat island there is also some consideration regarding the summer months.

These premises are visible in the final Energy & Climate Matrix (see chapter 5.3) but they are also cohesively presented in a small table in the current chapter.





source: http://globalsolaratlas.info

1. Dutch climate

The dutch climate is the *temperate maritime climate, highly influenced by the North Sea.* The winters are mild and the summers are cool, the temperature extremes are limited. Average temperature in the summer doesn't go beyond 22°C and in winter below 0°C. Precipitation is high and evenly dispersed throught the year.

The climate of the Netherlands is influenced by three factors: the proximity to the North Sea, the lack of mountains and its location on a dividing line between warmer and colder zones (klimaatnederland.nl). Therefore there is often stormy weather especially since in general areas with that climate are located within the stormy westerlies (wikipedia.org). Also, even though the temperature during winter is not so low, wind chill can make the temperature feel colder (outdoors) and cause heat losses (indoors-buildings) because of forced convection – as it is explained in the following page. Finally, in combination with the high precipitation and the "depressie" (depression) phenomenon, insolation can be quite limited which affects the temperature.

3. Heat losses from wind & heat gains from solar

Heat transfer in the built environment is basically influenced by wind and by solar radiation (Olygay et al., 2015; Arens & Williams,1977), and it occurs in 3 ways:

a. *infiltration;* air pressure on a buildings surface due to wind (windward surface), results in colder air masses entering the building
b. *forced convection;* heat losses connected to direct heat transfer between air masses of different temperatures is increased due to the forceful movement of the wind.
c. *radiation:* heat is tranferred by electromagnetic waves

those 3 heat transfer processes are linked with buildings' energy use and they will be further explained through some basic physics principles.

a. Infiltration

Infiltration is the most common cause of heat loss in buildings and it accounts for 30 to 75% of the total heat losses (Arens & Williams, 1977: 77). For instance, in the computational fluid dynamics city models developed by Jurelionis & Bouris in their paper, a "41% increase in both air change rates and heat losses caused by air infiltration" was noted. But it is important to understand what infiltration is and what influences it. So, the difference in air pressure between the interior and the exterior of a building along with the wind velocity result in heat flows due to large but also microscopic apertures of the buildings envelope. These kind of apertures can be even small gaps where the wall meets the window frame, which – especially in post-war buildings – can be poorly shielded. At this point it is important to stress out that air pressure in an urban environment depends, among others, on "the aerodynamics of a building in relation to its surroundings" (Arens & Williams, 1977: 77). Indeed parameters of the urban morphology such as density or buildings' geometry, have proven to affect air pressure and therefore buildings energy use.

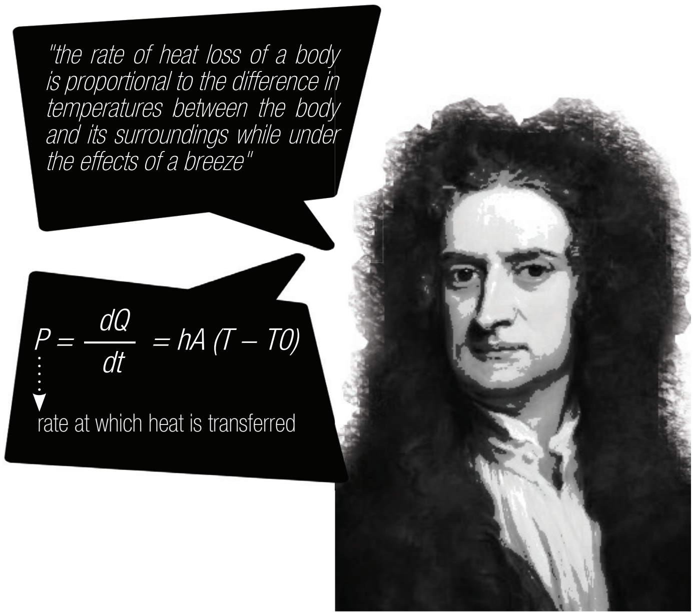
b. Forced convection

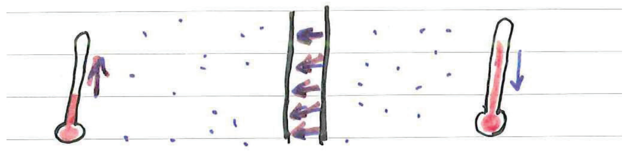
In order to explain forced convection two heat transfer phenomena need to be explained:

- *conduction:* direct transfer of heat between different objects or substances
- *convection:* heat is tranferred because of differences in the density of a fluid (in physics: gas or liquid) caused by temperature variations

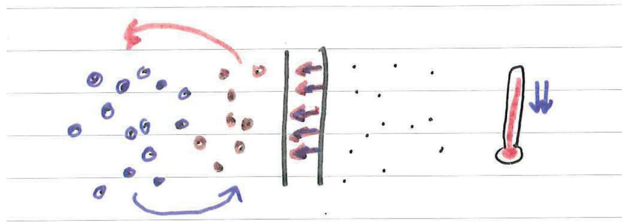
The first one, *conduction*, is simply the direct exchange of heat from the inside of the building to its envelope and finally to the (lower in temperature) air – or the inverse process, from outside in, depending on which is the warmest air mass. Since the heat exchange happens from the warm air mass to the colder,

Newton's Law of Cooling

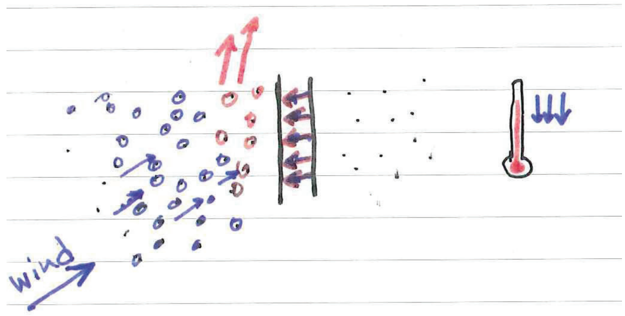




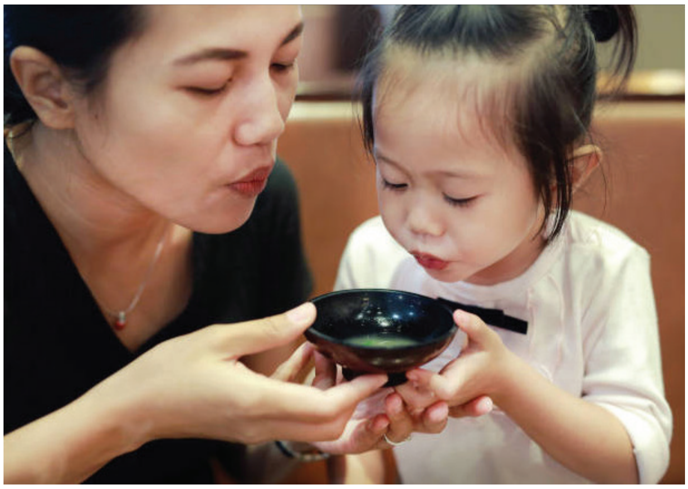
conduction – direct heat transfer from indoors to the envelope and to the outside

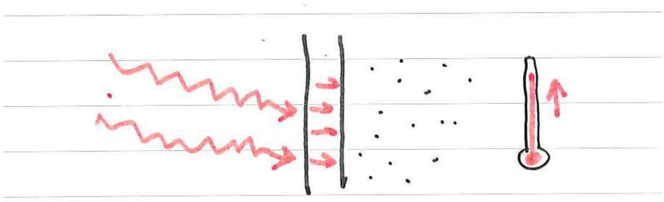


convection – heat loss caused by bulk movement of air due to temperature variations



forced convection – heat loss caused by wind





radiation – heat gain by the sun

Example of vernacular architecture typically found in Trøndelag, Norway; the building material is dark coloured wood that absorbs radiation from the sun during the cold winter of Norway (source: https://en.wikipedia.org/wiki/Architecture_of_Norway)

The old settlement (chora) of the greek island Serifos; all houses are painted white to reflect the sun during the extensive and hot summer of the local climate (source: http://greece.greekreporter.com)

in winter time it translates to heat losses for buildings – given that space heating systems are used. This kind of heat transfer can be reduced by better insulation and is the most known and applied kind of energy savings. *Convection* is basically the transfer of heat by bulk movement of a fluid. Therefore it becomes understandable that the air that gets heated by conduction from the building's higher temperature, then moves and lower temperature air comes in touch with the building. In this way, a repetition of the conduction phenomenon is caused and consequently more heat is lost from the building.

Forced convection is basically the above phenomenon under the influence of one more phenomenon: the forceful movement of an air mass. A simple example that could explain this phenomenon is our daily habit of blowing a hot cup of coffee or a hot bowl of soup so that it can cool faster. Accordingly, the wind that blows on the surface of the building causes a forceful movement of the air mass closest to the buildings envelope that has already being heated. This process results in the heat inside the building to get lost even faster than with simple convection.

c. Radiation

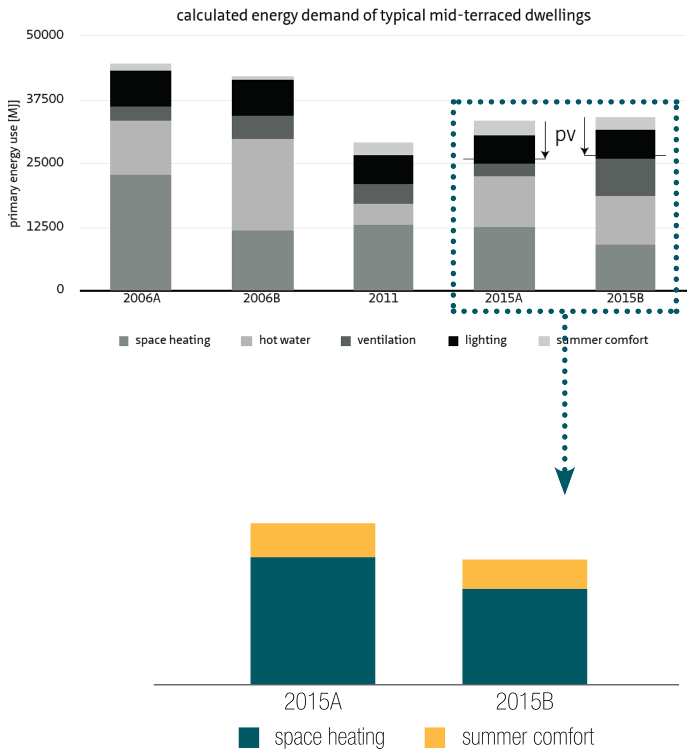
Radiation is another form of heat transfer which is extremely beneficial for winter and it should be platted for, and at the same time blocked during summer. In this case the heat transfer occurs via electromagnetic waves which gets absorbed by materials. The ratio of absorbance depends on the material and its characteristics. For instance dark colours have a higher level of heat absorption which is why in cold climates vernacular architecture is characterized by darker buildings and in hot climates the buildings have white or light colours to reflect the radiation. Other ways to control heat transfer from solar radiation are vegetation, the use of transparent (glass) or solid (walls) surfaces, overhanging structures, atria, etc.

4. Why winter season?

In the current project winter season is chosen as main focus of all measures and design solutions. The reasons for this choice are linked to the dutch climate, not as a e.g. Köppen climatic zone common with other areas of the world, but as specified also by its geographic characteristics. Therefore, even though winters are considered mild in the dutch climate – as in any temperate climate – local wind and solar conditions affect buildings' energy use during cold moths significantly. Specifically, the strong winds coming from the North Sea cause significant heat losses and meanwhile limited insolation means limited passive heating potential.

Additionally, the post-war residential buildings – that are the focus of the current project – were poorly insulated so protection from heat losses during winter months is almost non-existent.

Indeed as it is also visible in the diagram (right), the energy use for space heating that was recorded in 2015 for dutch mid-terraced dwellings, shows a significant discrepancy with that used for summer comfort. Finally, the reliance on central heating and gas for five decades now, makes the transition to alternative systems ever harder for the Netherlands.

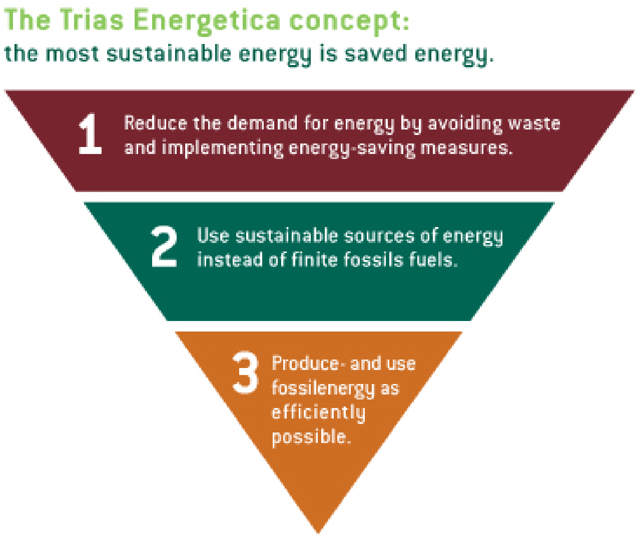


Calculated energy demand of typical mid-terraced dwellings: for 2015 and zooming in to space heating (winter energy demands) and summer comfort. Space heating is responsible for substantially larger energy demand, therefore winter is currently very demanding in energy consumption. It should be also noted that in the derivative diagram the hot water is not added to the winter energy demands, but it cannot be overlooked that the biggest amounts are used during winter months. (left: Looman, 2017: 59; right: deducted from latter by the author)

¬ *But what is really the energy & climate matrix?*

Another very important characteristic of the matrix in order for the data as a whole to become more comprehensible, is that due to different conditions there are often contradictions between optimum caracteristics. Often a form or orientation which is optimum for wind it can be less beneficiary for solar radiation. There is, therefore, the acknowledgement that designing with climate is a complex process and trade-offs need to be made. The synergies and trade-offs are part of the design face that will take place in the case study. In the end the local settings, the existing structures and possibilities will co-shape the final design decisions. There is no implication that there is one fix, one optimum form that can serve as a panacea, but there are number of optimum morphological parameters linked to specific measures or principles for wind protection or solar gains and to specific technologies for energy generation. The matrix is therefore a database that helps organise all relevant spatial information related to energy use and production in order to be used in making energy-informed design decisions.

In conclusion, the matrix is the accumulation of knowledge that stemmed from different papers, theories and principles, and technical details (in the case of renewable technologies). The actual table presented at the end of this chapter is a comprehensible and condensed organisation of this information. Organized in a way that clear connections can be made between urban morphological qualities and energy use and between energy production opportunities and their spatial requirements as part of the urban morphology. If applied as a whole, all the different elements would clearly create contradictions and – as it will be further elaboreted – one element (technology or measure) could negate the other. But the purpose of the matrix is to provide with the concentrated and focused knowledge which later in the patterns and even more in the case study will be used to discover which elements can work well together and which cannot be combined.



Trias Energetica or the stepped strategy for energy efficient design of buildings (source: https://www.eurima.org/energy-efficiency-in-buildings/trias-energetica)

5.2.1 ENERGY USE

The energy use part of the matrix emphasizes to all *parameters of urban morphology* that by adapting to the climate can limit the amount of energy consumed by buildings even before the building design takes place – or when the buildings are already in place and improvements on urban morphology are needed. This part of the matrix forms the basis for *climate-responsive urban design*. The aim is by searching through various sources – from scientific papers and computational models, to physics principles based on early settlements – to collect data on the *optimum characteristics* of urban morphology that respond well to the chosen climate.

At this point it is important to clarify that by responding to climate – as also used in the climate-responsive urban design notion – it expands beyond *energy savings* to include also *energy gains*. Namely, energy gains are not only about saving the energy that a fossil-based system generates within a building, but also about using the climate in order to require less energy to be produced. For instance solar gains during summer can provide with passive energy and allowing wind to enter the building during summer is a passive cooling system. In both cases the need for energy is limited, which is necessary even if we are to rely on renewable sources for energy generation. This clarification is necessary since, when it comes to energy use and buildings, a quite common misconception has been shaped over the years in relation to climate. It is widely perceived that energy use equals, almost exclussively, energy savings. For instance Trias Energetica, the model developed by TU Delft, guides building professionals through 3 basic steps towards energy efficient buildings. The first step refers to energy savings and then moves on to energy production from renewables. In this project the intention is to point out the possibilities lying also in energy gains from climate. For instance during winter by maximizing the solar exposure of a building, passive heating by direct and indirect sunlight can significantly decrease the need for space heating.

In short, the climate is seen as an enemy and ally at the same time. Thus, as aforementioned, we need to come up with urban design solutions that will allow us to "go back in time" to early settlements

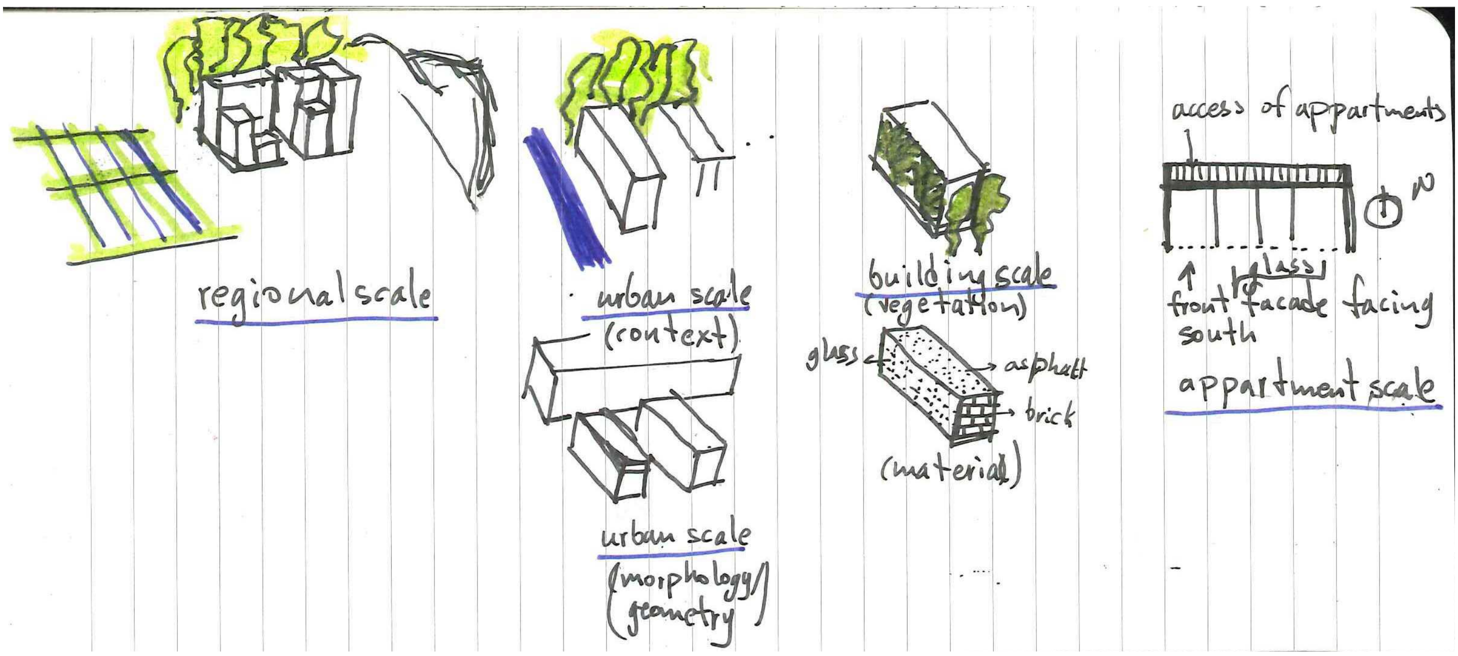
Beyond technogy; living with(in) the local climate

- *Acknowledge it* ⟶ *knowledge*
- *Build with(in) it* ⟶ *energy use*
- *Harness it* ⟶ *energy production*

and *adapt our current settlements – cities – to the local climate*. In order to do so a number of premises have been established here (see chapter 5.2.) to make the climate-related complexity more tangible. One of those premises is the season and it mostly affects the energy use and is therefore important to highlight it in this part of the report. Climatic conditions change significantly from season to season. Therefore the design of a form can be suitable for strong and cold winter winds but it might affect the summer micro-climate in a negative way. Due to the fact that *this study concerns the maritime temperate climate*, the season that *affects mostly energy use is the winter*. Indeed as found by Olygay et al. in 'Designing with climate', the highest average yearly needs for a temperate area (the case of New York was studied by Olygay et al.) were sun heat and wind protection, both accounting for 72% of sun and wind effects accordingly. Therefore winter is chosen as the main focus area in this project. However, due to climate change and the rising phenomenon of urban heat island, summer will also be taken into consideration.

The parameters of urban morpology that will be addressed are divided into *scales* in a similar way with Larco's matrix. That was considered necessary since it was obvious that some of the design solutions can affect the micro-climate differently depending on the scale. The design patterns that stem from this matrix will be also organised in different scales. Subsequently, the optimum characteristics found through the research will be presented categorized in those scales.

	CLIMATIC CONDITIONS FOR DUTCH CLIMATE (temperate maritime climate influenced by the North Sea)
ENERGY USE	**-district/neighbourhood**
	urban block morph.: heights
	urban forest
	street & open sp. orientation
	high housing density
	-urban block/street
	urban block morph.: form
	vegetation
	orientation
	width street ratio: Height/Width
	density & solar exposure
	-building (parcel)
	orientation
	vegetation
	bulding plan (envelope)
	infill development AND dense & energy efficient h.typ.



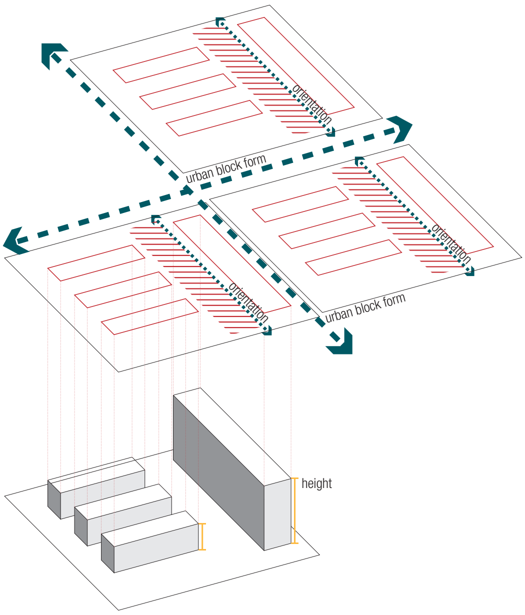
¬ District/neighbourhood

On the scale of the district/neighbourhood the urban elements that mostly affect the micro-climate are *the blocks and the streets*. Initially those elements are adopted from Larco's matrix. However he refers to block size and street orientation, and based on the research conducted there are more *characteristics* that are relevant to the micro-climate, such as form and height.

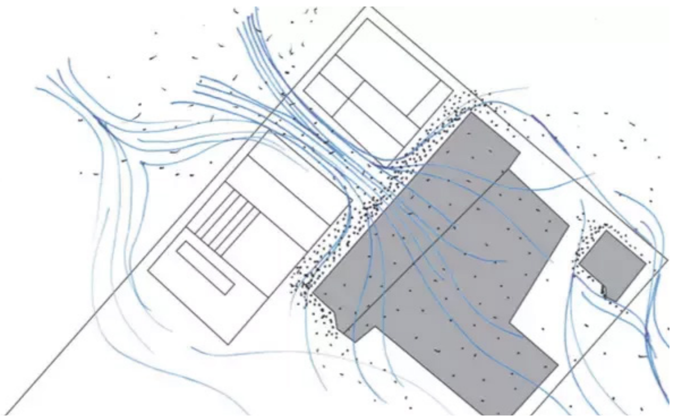
Street and open space orientation is particularly important in reference to wind protection. When wind direction is in parallel to street orientation or the buildings surrounding a long and narrow open space, it can create a tunnel effect. Namely, the wind tunnel effect occurs when the wind blows through a narrow passage surrounded by buildings (mostly in tall buildings). The wind streamlines get clustered within the narrow corridor, becoming stronger and faster. Therefore streets and narrow open spaces need to be *either oriented perpedincular to the wind or to be closed by built forms on the sensitive sides*. Especially for open spaces that it is possible it is prefered not to have long and narrow arrangement. However it is important to keep in mind that during summer months it is desireable not to block *summer breezes* which in the dutch climate can be very helpful since they originate from the North Sea.

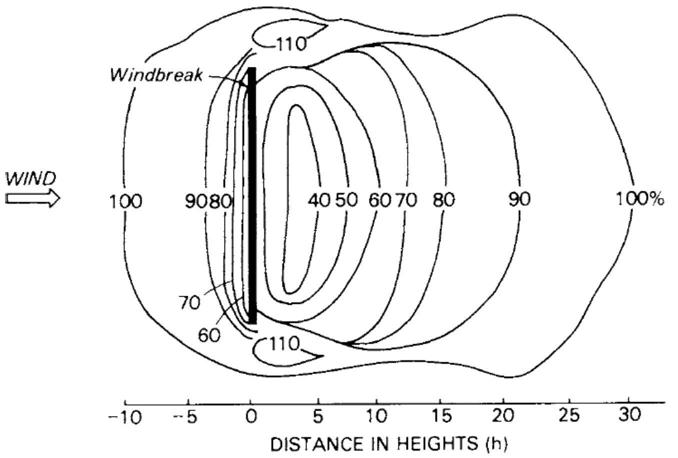
Usually a neighbourhood in a city is adjacent to another neighbourhood creating a dense urban structure where the wind behaves much differently than in the open. Wind is less strong and often regardless of the specific parameters of urban morphology, there is a commonly a general shelter zone in comparison to an open landscape. However in many occasions wide gaps in the built environment due to railway lines, highways or even rivers and canals, can destroy the sheltering effect for neighbourhoods adjacent to these gap lines. In cases like this a linear *urban forest* – planted on the side where the prevailing wind strikes first – can effectivelly decrease the wind effect and override the existing gap.

Another element that has a negative influence on th sheltering effect of an urban area is the existence of high rise buildings. According to Oke, a *high-rise building* (more than 10 storeys high) deflects the higher moving upper wind to the ground creating strong wind effects both on the building itself as well as in the cavity from the front shorter building. In this way not only it destroys the sheltering effect but it also accelerates the wind and in the end it might be even three times as strong as in the open. Apart from high-rise buidings, in general *height irregularities* can have a negative effect in the behaviour of wind. The difference in heights disturb the regularity of the wind patterns within an urban environment, often creating acceleration in the wind speed and increasing the turbulence of the wind (Oke, 1987).



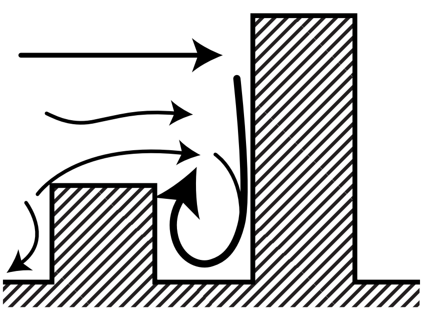
morphological parameters of district/neighbourhood (drawing by author)


wind tunnel effect; streamlines of wind cluster and accelerate when they enter the narrow passage (source: https://www.quora.com/Aerodynamics-What-is-a-wind-tunnel-effect



a vertical barrier (windbreak) to the prevailing wind protects the adjoining area by lowering the wind speed. Speeds expressed as a percentage of those in the open. (source: Oke, 1987: 245)

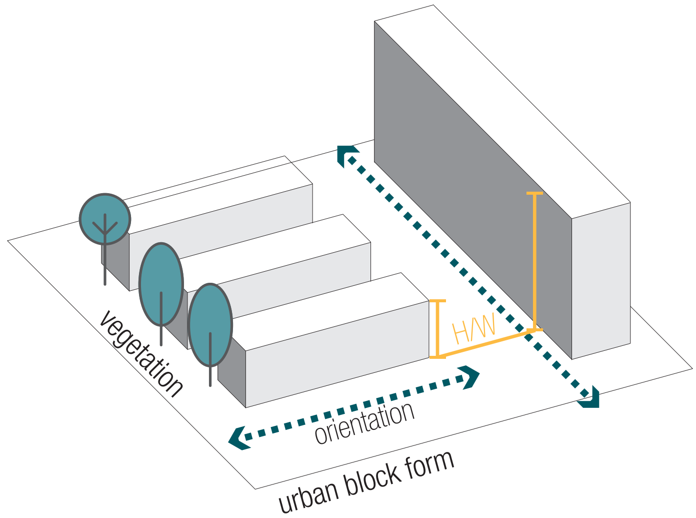
The tall building deflects the wind to the ground, the surface of the building is exposed and the wind becomes 3 times stronger as in the open (drawing by author and based on Oke,1987)



¬ Urban block/Street

On the scale of the urban block and the street two are the most important *characteristics* of urban morphology that need to be taken into account:

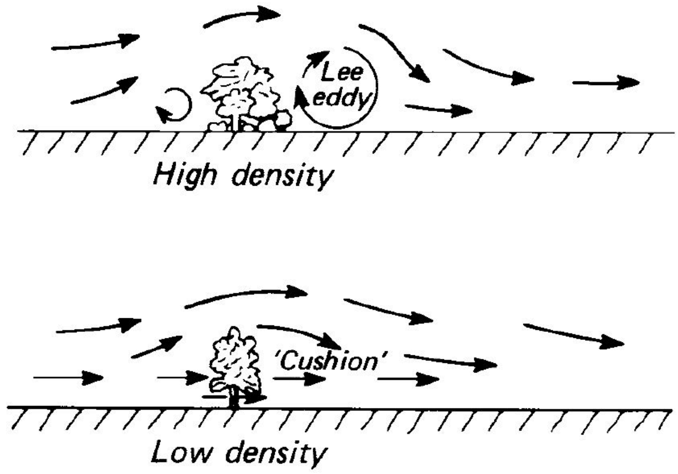
1. vegetation (low or high density, rows or urban forest)
2. height to width ratio (H/W); height of the buildings to the width of the urban canyon
3. urban bolck morphology
4. atrium; restoring energy efficiency



morphological parameters of urban block/street (drawing by author)

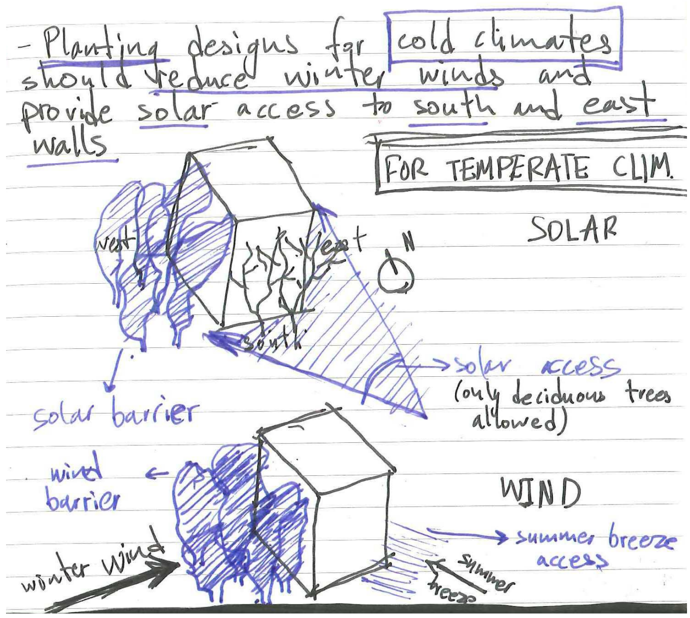
1. Vegetation

Vegetation is of key importance in designing with climate, both for winter and for summer months. However different kinds of vegetation are needed in different phenomenon and seasons. Firstly, during winter vegetation can be used for *wind protection*, however depending on its density the wind behaves in different manners. *High density* shows little or no penetration by the wind but at the same time after overcoming this barrier, a lee eddy with low speed but turbulent wind appears and then the wind regains full speed quickly after the cavity (Oke, 1987: 243-4). Therefore, this kind of vegetation, e.g. urban forests, is considered appropriate in urban blocks or buildings where there is a relatively open space preceding to the windward surface and the surface is therefore largely exposed to open winds. On the other hand, *low density* vegetation provides the least protection since it allows mos of the wind flow to pass through. However at the same time, it shows slow recovery of the wind speed and its flow remains mild. There is no lee eddy created by low density barriers and so they act as a cushion that softens the effect of wind on the buildings (Oke, 1987: 244). This kind of vegetation, e.g. single rows of trees, is considered more appropriate in cases where wind speeds are less strong than open wind. For instance a row of trees could be useful in protecting linear block surfaces and in between block spaces from the lee eddy effect. However in using vegetation there should always be consideration of the *summer sea breeze*, since it is desireable to remain unblocked.



High and low density vegetation and their effect on wind patterns (source: Oke, 1987: 244)

In respect to vegetation there should always be awareness in relation to *height*. If vegetation is to be used as wind protection then tree heights should be matching the height of the buildings otherwise the uper floors remain unprotected. This is also another reason that tall buildings should be avoided in windy climates such as the dutch. However another solution that is highly regarded in general in terms of sustainability are the *plant-covered walls*. In this case it can provide wind protection since it decreases the air movement on the surface – aka wind effect. At the same time during summer it can provide shading to the solar sensitive surfaces.



information on vegetation by McPherson, et al. (1988) translated into sketch by the author

As a means of *shading*, vegetation is of key importance for reducing the space cooling costs. For that purpose two are the most sensitive surfaces of a building: the west surface and the

"Studies have shown that vegetation on a building's walls will reduce ambient wind speed and improve the insulation of the building" (source: http://www.asente.ch/integrated-solutions/architectural-plants/)

green wall as a vertical forest; the building is protected from wind (source: https://www.dezeen.com)

Urban Morphology	Height of Buildings, m	H_b/W [1]
UM-1	18 m	1.00
UM-2	16 and 36 m	1.73
UM-3	8 to 16 m	0.76

Jurelionis & Bouris paper on the effect of different urban morphologies on buildings' energy use in relation to wind; comparison of different urban morphologies, their average heights and their H/W ratio (source: Jurelionis & Bouris, 2016: 4)

roof (McPherson, et al., 1988). Protection from sun exposure can be solved by trees and green roofs but also in energy-productive ways – as it will be shown in the Energy Production related sub-chapter. However since winter is still considered as the most energy-costly season in the dutch climate, the effects of summer sun protection should be firstly examined for their winter effects. Therefore the trees chosen should be *deciduous* in order to allow for maximum solar access during winter. Only exception could be if the direction of the prevailing wind is of western direction, in this case the vegetation used as sun protection could be also used for wind protection.

2. Height to width ratio (H/W)

The second most significant characteristic on this scale is *the height to width ratio (H/W) (2).* This indicator results from dividing the height of the buildings by the width of the street and it shows how narrow or wide a street or an open space can be. Oke (1987) studies three different ranges of H/W for linear buildings arranged in parallel rows, starting from widely spaced towards denser: H/W<0.3, H/W≤0.65 and H/W>0.65. The wind in each case behaves differently – a more comprehensible representation of the different results can be seen in the bottom drawing of the next page. In his book he describes the results in each case, however the optimum for the most protection from the wind effect is the *H/W>0.6* – the denser of the 3 typologies. In this case, the behaviour of the wind is described as *skimming flow* since the main flow starts to skim the buildings and the sheltering effect of the in between blocks remains unharmed (Oke, 1987: 266-267).

However, solar exposure should also be taken into consideration in reference to height to width ratio. Studies have shown that the depth of the street canyon – essentially the translation of H/W ratio in space – depends also on the orientation of the canyon as well. If it is E-W for instance, even low H/W ratios can prove problematic. But even if the orientation is the optimum for solar access – which is N-S – increased depth of the canyon can stop the light from entering the lower floors of the building. Therefore there is an upper limit for H/W ratio which based on these studies should be lower than 2 (H/W≤2) (Shishegar, 2013). Another reason is the demands for airflow which helps in keeping air pollution low. The ratio again in this case ought to be lower than 2 (Shishegar, 2013).

These numbers have emerged from specific studies which are based on models and premises which are multifaceted. For this reason *the width ratio is mostly taken into consideration in relation to densification* as an indicator that can show to the designer that even though densification is considered desirable in terms of energy efficiency in general, local climatic condition such as strong wind can render densification negative instead of positive. In this project it will be used as a rough indicator that will show which are the optimum spaces for densification and which should either remain unharmed or be improved. In relation to densification two other factors should be followed: avoidance of tall buildings and solar radiation access. *Solar access* during winter as well as the ability for *air to be renewed and the temperature to drop during summer months*, low width street ratio is again a prerequisite.

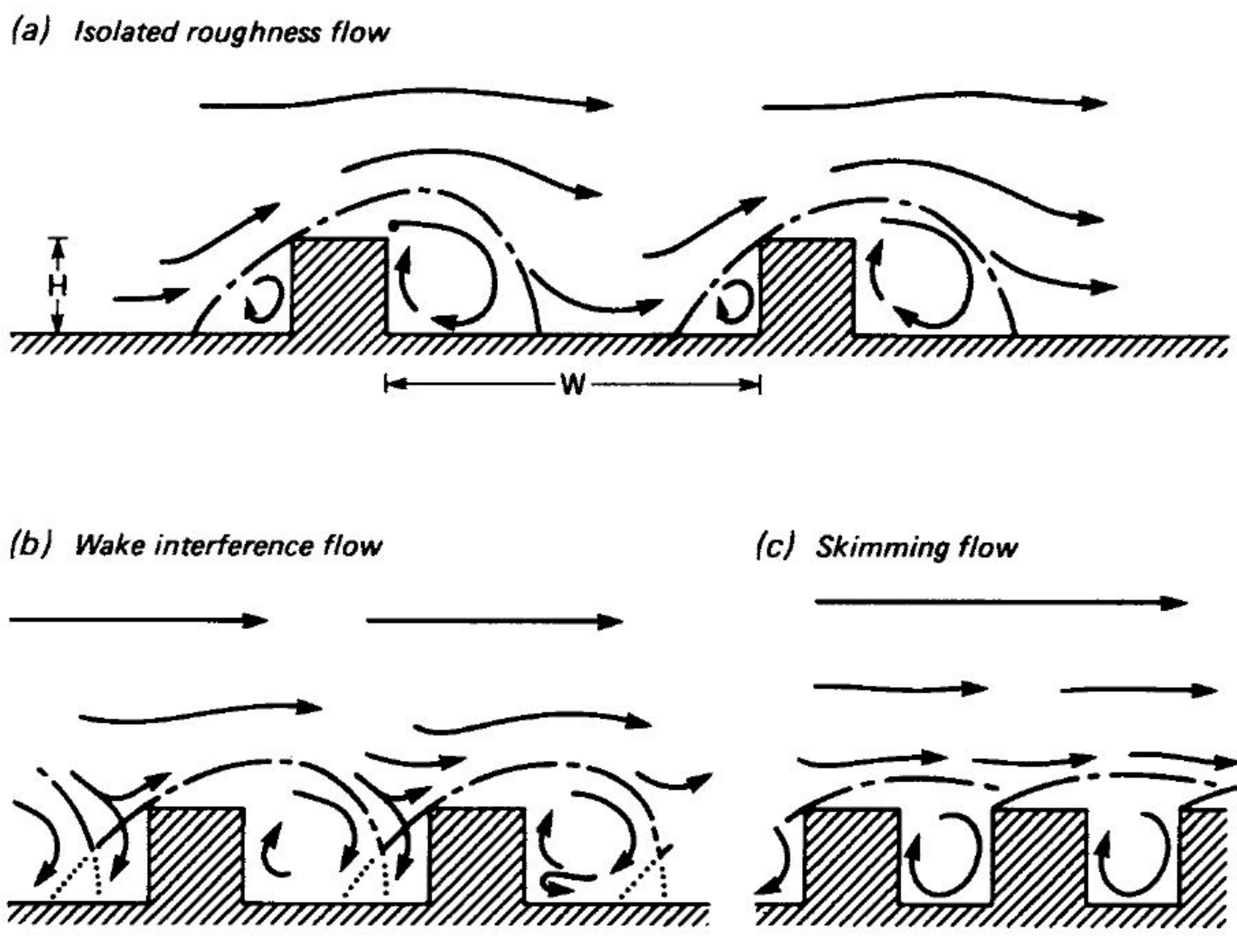
3. Urban block morphology

Finally, in reference to *urban block morphology (3)*, different sources as well as different requirements for sun and wind, lead to forms and heights which might be different from each other and in cases even contradicting. Therefore five *block forms* are being poroposed:

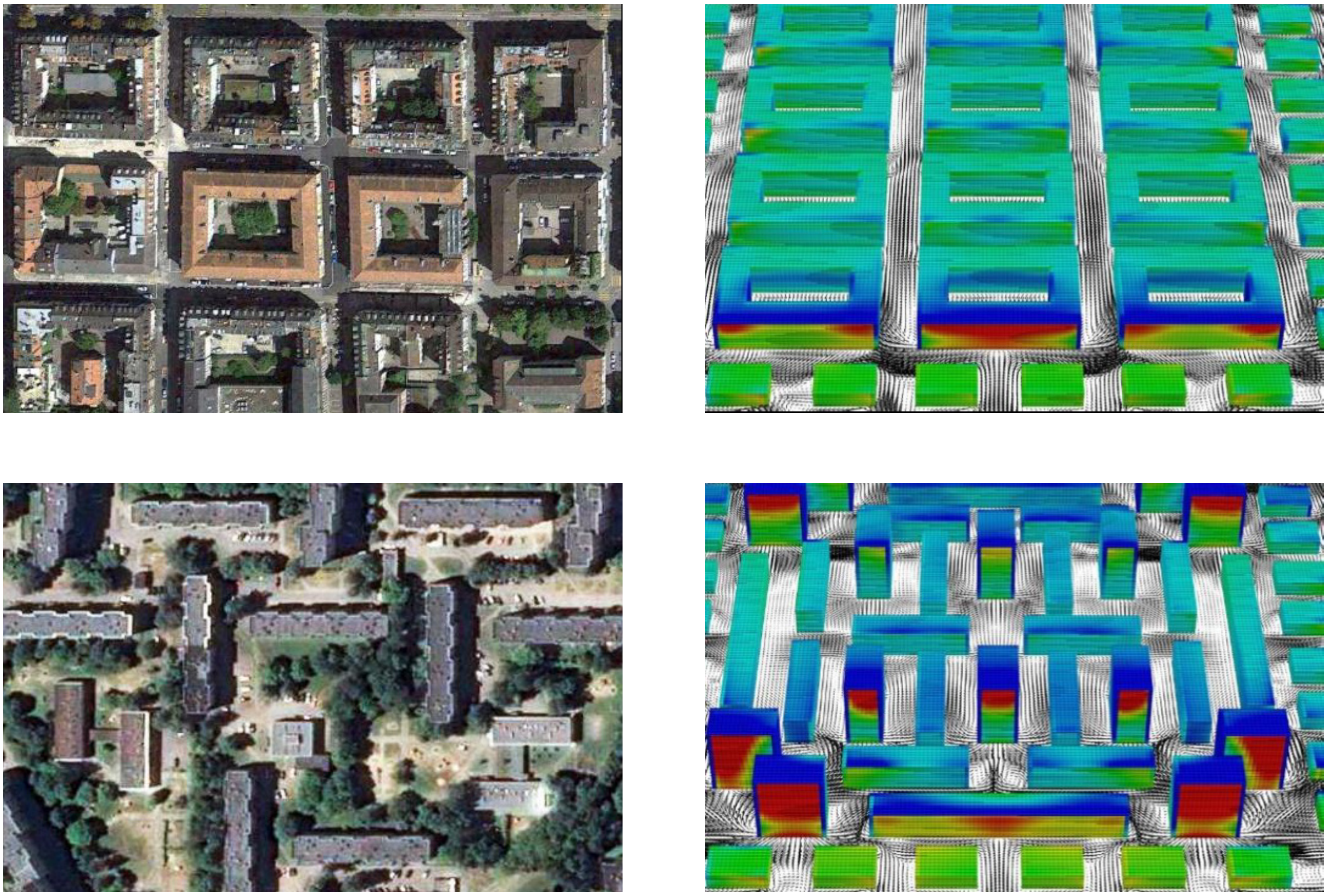
1. parallel rows or free arrangements of linear blocks (elongated forms)
2. T-shaped or cross forms
3. perimeter blocks
4. compact forms

Linear blocks (elongated forms) (1) are the only form that was found from different sources (Olygay et al., 2015; Oke, 1987) to be appropriate for both solar gains and wind protection. The only difference seems to be in the *arrangement* of the linear blocks in space in each case. However in the case of solar gains, the free arangement doesn't seem to be of importance. It is proposed by Olygay et al. as a more general principle that in climates – such as the temperate climate – where the climatic conditions are not so aggressive, it is desirable for built forms to merge and communicate with the natural environment (Olygay et al., 2015: 92). Therefore the free arrangement is considered as a loose principle which is to be changed whenever a more prevailing environmental influence dictates it. As Olygay et al. also mention as side condition of free arrangement, whenever there is a strong 'pressure', the "form closes its sensitive surfaces". Therefore wind protection prevails in deciding on the type of arrangement of linear blocks. According to Oke, the arrangement of linear blocks in *parallel rows* can be very effective in protecting them from strong winds.

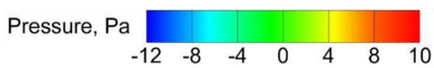
In particular, in order for parallel rows to work properly for wind protection, *orientation* is also of key importance. If the wind blows parallel to the long axis of the linear blocks then not only there is no protection but the wind is even more accelerated than it normally is in the urban environment. This phenomenon is called tunnel effect and will be further elaborated in the current sub-chapter. The optimum orientation is for the *long axis of the blocks to be situated vertical to the wind flow*. This formation causes a sheltering effect that protects the succeding blocks – those situated after the 1st in the wind path – from the wind. Namely, the sheltering effect is the decrease in strength and flow of the



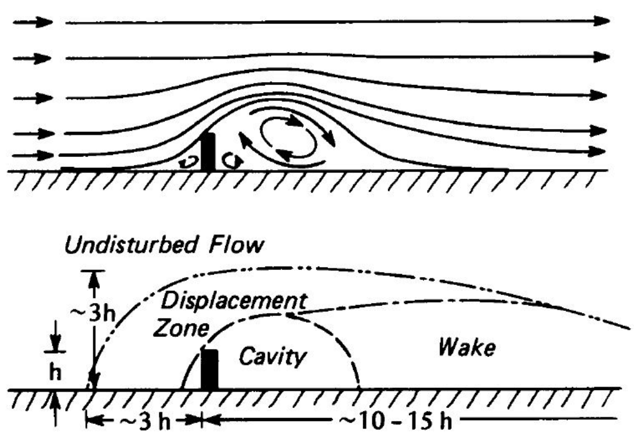
wind behavioural patterns in the urban environment depending on the density of the rows of linear buildings (source: Oke, 1987: 267)



Comparison of the two geometries: isolated linear blocks (bottom) and homogenous blocks (top); In this simulation the wind is perpendicular to the surfaces of the blocks and in red are the surfaces that experience the highest wind pressure (source: Jurelionis & Bouris, 2016: 5)



wind caused by an obstacle – in this case a block. The 'shelter' appears on the space behind the block – in this case behind means the surface parallel to the one accepting the wind. This shelter in physics is commonly reffered to as cavity and although protected from the prevailing wind it shows a weak, turbulent and unstable wind effect commonly known as lee eddy. This phenomenon is not very important but it will also be addressed on the bulding (parcel) scale. Nevertheless this significantly protected zone can be used for protection of the other blocks if *situated in parallel rows and relatively close to each other*. In this way, the wind flow skims the buildings and doesn't affect them. The proximity of the blocks is defined by the H/W ratio, the height of the buildings to the width of the urban canyon – which has already been explained in the present subchapter.



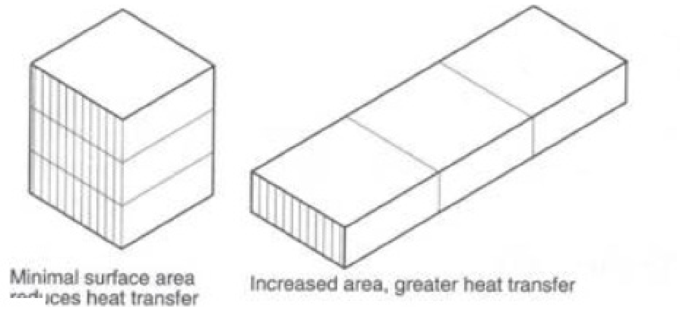
(top) streamlines that show the behaviour of wind in the presence of an obstacle and then (bottom) translated to behavioural flow zones; cavity is the zone behind the building that exhibits the sheltering effect (source: Oke, 1987: 243)

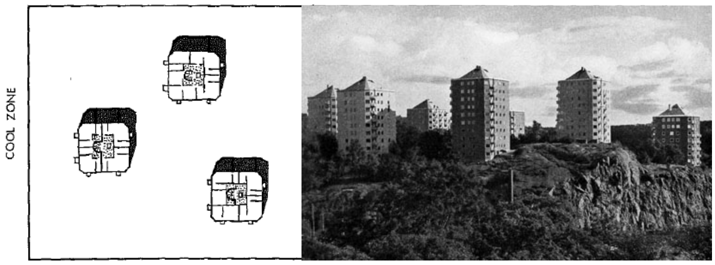
The *T-shaped or cross form* is mostly a variant of the elongated form in terms that it is possible since the temperate zone to have both forms. The most important characteristic of urban block morphology in terms of both solar gains and sun protection (during summer), is the *orientation* of buildings. According to different literatures (Olygay, et al., 2015; Yanovshtchinsky, et al., 2012), the *elongated forms on the east-west axis* constitute the optimum form.


Y-shaped building in Finsbury, London (similar to T-shaped forms); according to Olygay ideal for temperate climatic zone (Olygay et al., 2015: 101) (Image source: Google maps)

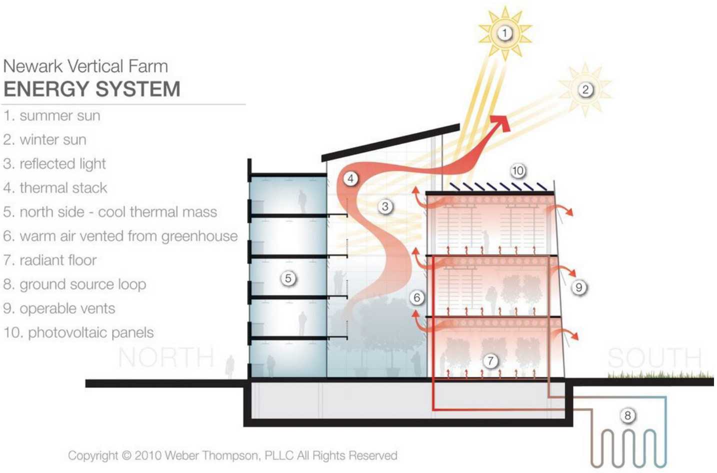
Perimeter blocks are composed of four linear blocks and in contrast to simple linear blocks they have only one side of each block exposed to the wind. Therefore, they have less surfaces unprotected which for windy climates such as the dutch climate can be positive. Indeed Jurelionis & Bouris research based on Computational Fluid Dynamics (CFD) models, and entitled *"Impact of Urban Morphology on Infiltration-Induced Building Energy Consumption"* has exhibited these kind of results. In particular, it shows that their aerodynamic form *reduces wind induced energy consumption by 41%* compared to another model of isolated linear bocks (Jurelionis & Bouris, 2016: 6). In detail, the computational models developed in this research studied three examples of urban morphology: homogenous blocks with no height variations; isolated linear blocks arranged in two vertical orientations and with significant height variations; comptact urban blocks with adjoining buildings and small height variations. The different geometrical models were examined under the same conditions - same wind speed and orientation, and same surrounding geometries. Homogenous blocks were proved to be the most appropriate form for windy environments. Even though the wind induced energy consumption was considerably lower thanks to its geometry, the same geometry is responsble for higher average wind speeds outside of cavities. Within cavities though the sheltering effect is maximum since it shows the lowest turbulent wind from all other geometries. The high average wind speed could be caused by the corners of the 'closed' block, since the wind after encountering the sharp corner accelerates and then the length of the surface allows it to continue accelerating.

In both cases of linear and perimeter blocks, *height* seems to be a significant factor in wind infused energy consumption. Also the





Compact form ideal for cool climatic zones (source: Oygay, et al., 2015: 92)



the double function of an atrium during winter and summer (source: http://verticalfarmblog.blogspot.com/)

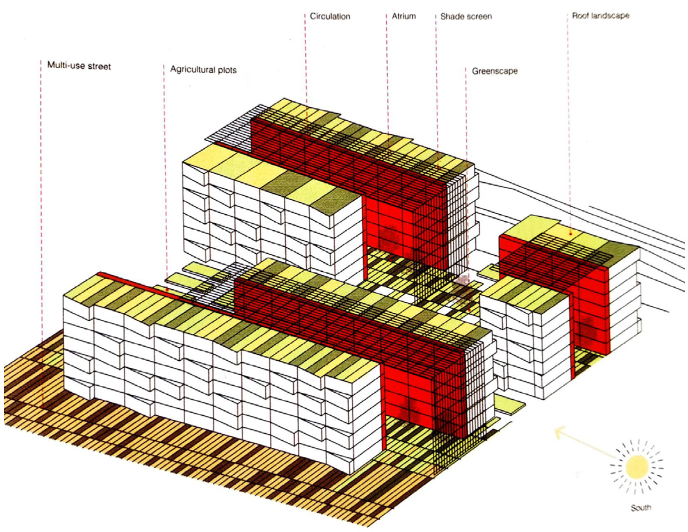
requirements seem to be matching in different examples: *height varriations and irregularities need to be minimised*. The negative effect of high-rise buildings on the surrounding area has already been explained in the District/neighbourhood scale part. Indeed, in the model developed by Jurelionis & Bouris, the mixed building heights, and the existence of high buildings in itself, along with a high street width ratio – which will be elaborated in the urban block/street part – resulted in increased heat losses due to the increased winf effect (Jurelionis & Bouris, 2016).

Compact form is defined by its floor plan and the number of storeys. The floor plan is almost square and preferably bilateral (apartments back-to-back), and buildings have multiple storeys. This form is considered especially advantageous for cold climates due to their minimal heat losses. Less roof surface is exposed which results to less heat transfer towards the environment. In some cases however it is hard also for light to enter, it is therefore beneficial for passive heating to restrict the square footage of the foor plan to no more than 100 m^2. This is also beneficial for less cold climates – such as the dutch – since during wamr summer months air ventialtion by simply opening the window can effectively lower the temperature. Furthermore, by effectively decreasing the roof surface, the building also absorbs less heat during summer.

4. Atrium

Finally as Larco also shows in his framework (Larco, 2015), in the urban block scale a designer should provide for solar exposure. When it comes to designing a new building solar exposure is something that can be done by correct orientation, avoiding shadow of buildings, planting only deciduous trees on the south side of the building, etc – further detailed on the building scale. However in cases where the existing buildings are disadvantageously oriented there are solutions that can be pursued on the block scale as well. For instance, for linear parallel buildings that are expanding from the south to the north – therefore the facades are facing east and west – there is a combined issue that can be solved in the inbetween space. The issue is that during winter there is not enough solar exposure because there are no windows on the south side and for summer the exposure to the west side heats up the living areas significantly. This is especially the case in many post-war neighbourhoods, as it will be further explained in chapter 6.

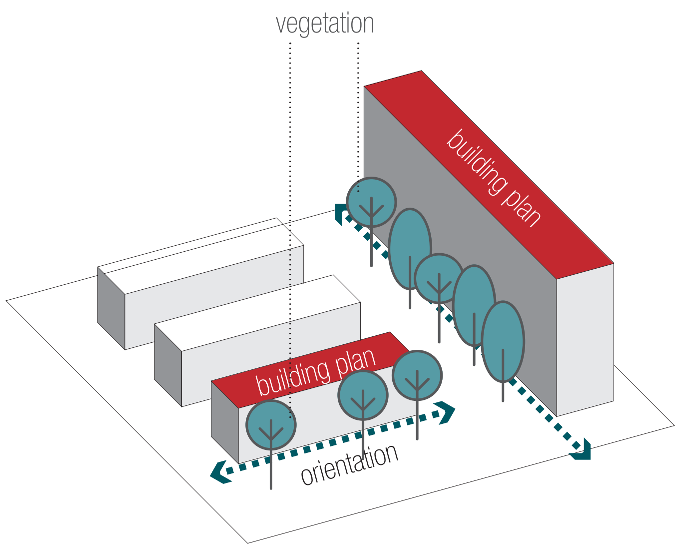
Atrium is a large open space, covered usually by a glass ceiling and it constitutes a part of a building that brings light in the interior. They have different forms and positions in a building, either in the middle or in the entrance of the building. Often an atrium is used to connect two neighbouring buildings and to create a protected environment that still maintains visual contact with the exterior environment. The latter form can be useful in the present case. For winter this space can function as a glasshouse that by connecting two north-to-south linear buildings, it creates a glass facade facing the south that allows for the inner space of the atrium to be heated. Then by conduction the heat can pass to the interior of the buildings recompansating for the lack of solar exposure. It also functions as a barrier for wind protecting even more the exposed surfaces of buildings. Meanwhile, during summer when the roof is the most sensitive area that needs to be protected from solar exposure, PV panels or other PV technologies can be used to both protect from the sun and generate energy. In this way also the west facade of the building would be in shadow and be further protected. Furthermore, an atrium can also be used for urban farming as in winter time it functions as a green house.



"the Atrium block is a concept where two blocks that face east-west share a glazed and shaded PV and power generating atrium space, (...) and which serves as a shared semi-indoor micro-climatic garden and thermal buffer." (Scott & Ben-Joseph, 2012: 243)

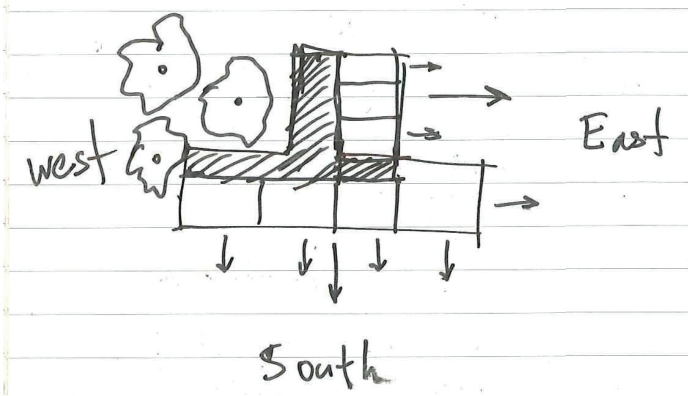
¬ *Building (parcel)*

The building scale is important to be addressed but apart from a couple of parameters and measures that will be explained in this sub-chapter, it *belongs mostly to architectural design* and not to urban design. Nevertheless there is a reference to some architectural features mostly as *guidelines* for architectural deisgn rather than actual design. The reason for these guidelines is that since there are proposals made related to, for instance, different forms of urban blocks (see neighbourhood scale), the effectiveness of these forms in energy efficiency also depends on some basic interioir spatial arrangements. For instance the T-shaped form, needs to have the living spaces oriented towards the east west for maximum solar radiation during winter and the common areas (such as staircases, elevators and corridors) on the west side of the building to provide maximum shading during summer. Or in linear blocks the building plan should be unilateral with the living spaces facing south (or southeast) (Olygay et al., 2015).



morphological parameters of building (/parcel) (drawing by author)

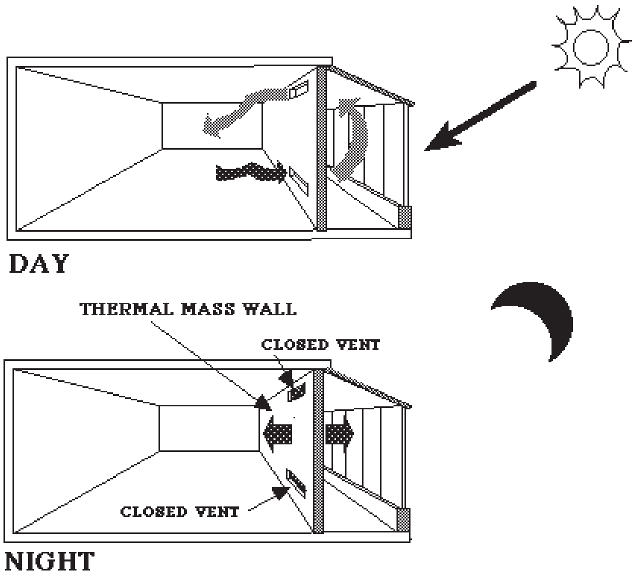
The aspects that belong to urban design have already been mentioned in the other scales. The seperate reference on this scale is done mostly because it needs to be pointed out that these elements need to be taken into consideration also during the architectural design of a building. First and foremost, the optimum *orientation* of the building is the long axis of the building perpendicular to the prevailing wind direction and to face



(top) orientation of living spaces in a T-shaped building form and (left) unilateral building with living spaces facing south

from south to east for maximum solar radiation during winter. As aforementioned the west side of the building is better to be closed to protect from the summer sun. *Vegetation* is also of key importance and should comply to the rules that have already been mentioned. Finally, *infill development* that Larco mentions in his own matrix is a signinficant parameter that needs to be addressed through guidelines. One of these guidelines could be to create infills in open spaces where the street width ratio (see urban block/street scale) is lower than 0.65. Or on top of buildings that exhibit a difference in heights from succeding buildings in order to reduce height irregularities (see neighbourhood scale). It needs to be pointed out though that since infill development is essentially the construction of new buildings or parts of them, there need to be energy efficient housing typologies (as Larco also points out in his own matrix) in contrast to the existing ones. Therefore, in the case of wind, protection from prevailing wind needs to be part of the design of the new building or built part. For instance the windward face could be protected by a "green" wall.

In reference to *solar access* during winter, solutions should be applied for maximization of passive heating by solar radiation. However, there are cases where the existing building is oriented disadvantageously (facade facing the north or west) or an obstacle is preventing the beneficial south (or east) winter radiation. In some of these cases the obstacle can be avoided by constructiong a glass jutty (built overhang space). This construction could function as a *'sunroom'*, aka a glass room that could transfer heat via conduction from the sunroom to the living space. This is an indirect gain system that utilizes 30-45% of the sun's energy entering the glass surface for space heating. In other cases however where the orientation is disadvantageous, it could be appropriate to create *infill development*. The reason for this is that often when densifying an existing built area there is the risk of new buildings to create shadow on existing ones. When there is already no potential for passive heating via solar radiation then densification is easier to take place there.



sunroom (source: http://passivesolar.sustainablesources.com/)

URBAN MORPHOLOGY [QUALITIES]

ENERGY USE

CLIMATIC CONDITIONS FOR DUTCH CLIMATE (temperate maritime climate influenced by the North Sea)	WIND PATTERNS: WINTER [MAIN FOCUS] moderate winters -cold & strong wind from North Sea	WIND PATTERNS: SUMMER [ACCOUNTED FOR] cool summers -sea breeze	WIND PATTERNS: SOURCES	SOLAR RADIATION: WINTER [MAIN FOCUS] moderate winters -cloudy; less solar radiation	SOLAR RADIATION: SUMMER [ACCOUNTED FOR] COOL SUMMERS	SOLAR RADIATION: SOURCES
-district/neighbourhood			[1] Oke, 1987; [2] Jurelionis, Bouris, 2016; [3] Eumorfopoulou, Kontoleon, 2009; [4] Salat, 2014			[14] McPherson et al., 1988; [15] Olygay et al., 2015; [16] Scott, Ben-Joseph, 2012; [4] Salat, 2014
urban block morph.: heights	min. height irregular., avoid tall buildings					
urban forest	urban forest (for fully exposed blocks)[I]	not perpendicular to summer breeze				
street & open sp. orientation	perpendicular or sidewards to the wind					
high housing density						
-urban block/street						
urban block morph.: form	(1) paral. rows of linear blocks/elong.forms			(1) free arr. of linear blocks/elong. forms		
	(2) perimeter blocks			(4) T-shaped/cross forms		
	(3) compact form					
vegetation	evergreen rows of trees, perpend. to wind[I]	summer breeze direction: no vegetation		deciduous trees: solar access for winter, shadow for summer	tree rows parall. to W faces	
orientation	perpendic. or sidewards (45º) to the wind					
width street ratio: Height/Width	H/W ≥0.65[1]	parallel or sidewards (45º)		H/W≤2 (traditional deep canyon),	high dens. in open spaces; blocks facing E-W, united with atrium	
density & solar exposure	infill where H/W≤0.65 (to achieve skimming flow and avoid wake interfer.)			by densif. keep H/W as low as possible; blocks facing E-W, united with atrium		
-building (parcel)						
orientation	wind perpendicular to long surface			East-West (length), pref. unilateral plan[IV]	west side closed[IV]	
vegetation	trees & plant-covered walls (cavities)[II]	summer breeze: no veg.		S&E surfaces: no/deciduous trees	trees W surf. & green roofs[V]	
bulding plan (envelope)		depth <6m; for nat.ventilat.[4]		depth<6m; for solar access[4]		
infill development AND dense & energy efficient h.typ.	open spaces (no tall buildings & ideallly in low H/W) & protected from wind effect			on west, north or without solar access building faces & sunrooms (building's facades with insufficient solar access)	minimum increase of roof surface	

I. low density vegetation (e.g. single row) acts as a "cushion" and doesn't create lee eddy, high density vegetation (e.g. urban forest) protects from wind penetration but creates lee eddy
II. for protection from lee eddy (windward face of succeding building & tall buldings)
III. uni-directional: turbines to the WSW of the building
IV. other possibilities: weighted or multilateral (also compatible with T-shaped built forms), buildings should be open to south and southeast for winter solar gain and closed on west sides for protection from summer sun

5.2.2 ENERGY PRODUCTION

The local and sustainable energy production is equally important to the energy use. No matter how much we manage to reduce our energy consumption through design, energy demand is still substancial. At this point it should be highlighted once more that the intention of this project isn't to compromise modern conveniences, following statements such as "lets return to a simple life, now past". It is the beliefef of the author that the role of designers is to come up with innovative solutions and proposals. And on these premises the project is platting for design solutions that will integrate innovative technologies in the urban environment. The solutions are intended to go beyond energy production and create quality spaces that can also have additional uses. Renewables are seen by people as lacking of aesthetic value and degrading the spaces where they are installed. Designers should take advantage of the innovations that technology provides and create solutions for productive spaces with a new aesthetic value, which can still be used by people.

As in energy use and as in the general purpose of this project, energy production makes use of the climate for energy production. Therefore the technologies studied and listed are wind and solar energy related. However since the implementation scene is the urban evironment, the technologies chosen are those appropriate for this kind of environments. Due to their different characteristics and the climatic conditions that they use for energy production, there needs to be an identification of spaces, orientation and urban morphologies that are optimum for energy production. As aforementioned along with some of the technologies there is also an idea as to how to use them to create or complement common spaces that can be used by people.

Micro-Wind Turbine Array Powers Intel's Headquarters (source: greenoptimistic.com)

(source: http://survivalprofile.com)

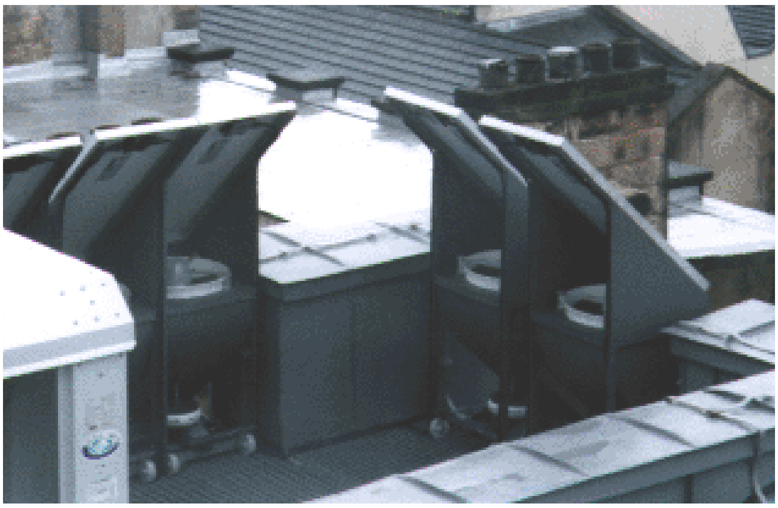
¬ *Wind energy*

Wind energy in the urban environment concerns mostly small wind turbines, which have already been around for some decades. However it is difficult to keep track of the numerous proposed new designs and have become a trend in many cities (Kris De Decker, 2008). The paradox of urban wind energy is that wind turbines are preferably placed on an open plain, as high as possible, with no obstacles around. In cities, however, this is not the case. Yet, technological progress in wind turbine technology seems to have managed to utilize on a certain degree lower wind speed.Furthermore there seems to be potential in using wind turbines in the built environment also because buildings tend to influence the behaviour of the wind and concentrate its flow and speed depending on the geometry of the building. At this point it is relevant to refer to Micallef et al., who in their paper entitled *"The influence of a cubic building on a roof mounted wind turbine"* concluded that:

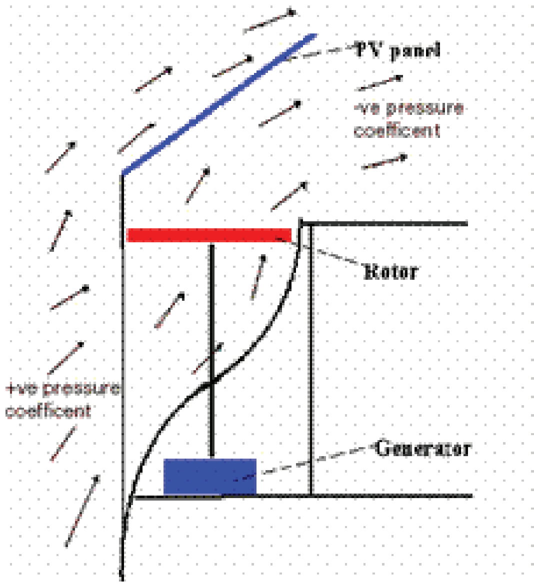
"The eficiency of such turbines is in many cases hampered due to the wind condition present at the turbine site. The aerodynamic design of such turbines usually attempts to address this issue but aerodynamic knowledge of the wind turbine to building interaction is lacking." (Micallef et al., 2016: 9)

For this purpose a number of paper have been studied by the author in order to uncover potentials for urban wind energy production on a local scale. It needs to be acknowledged though that the intention is more to bring forth immovative solutions that can be further examined and developed than to come up with concrete proposals for technologies.

The basic categories in wind turbine (WT) technologies are the following: *horizontal axis (HAWT), vertical axis (VAWT) and ducted wind turbines*. From these categories only the *small or micro wind turbines* will be used. Each technology works different in each geometry and height and is, therefore, attempted



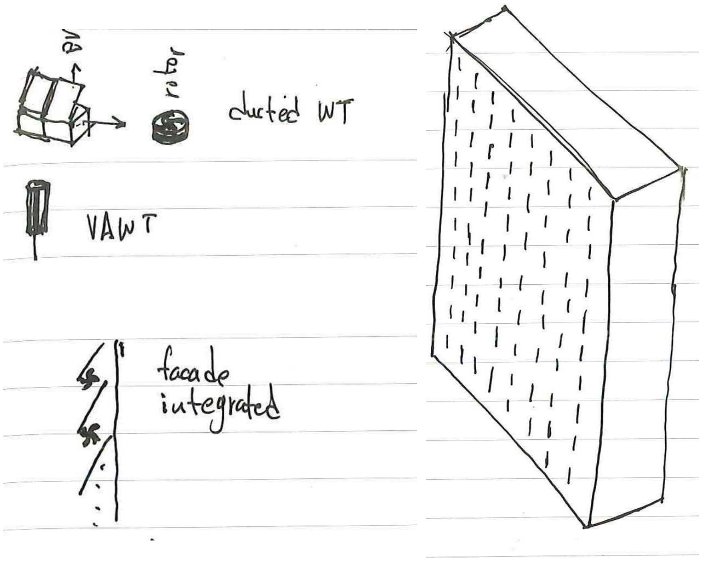
Ducted wind turbines; The devices are relatively small leaving little visual impact to the building
source: http://me1065.wikidot.com/types-of-wind-turbines-and-associated-advantages

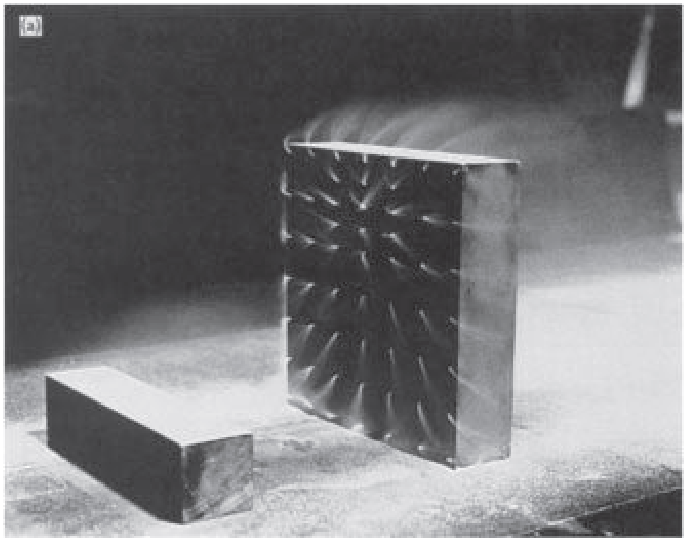


to study each building of specific height, what kind of technology in combination with morphology it needs. The buildings are divided in:

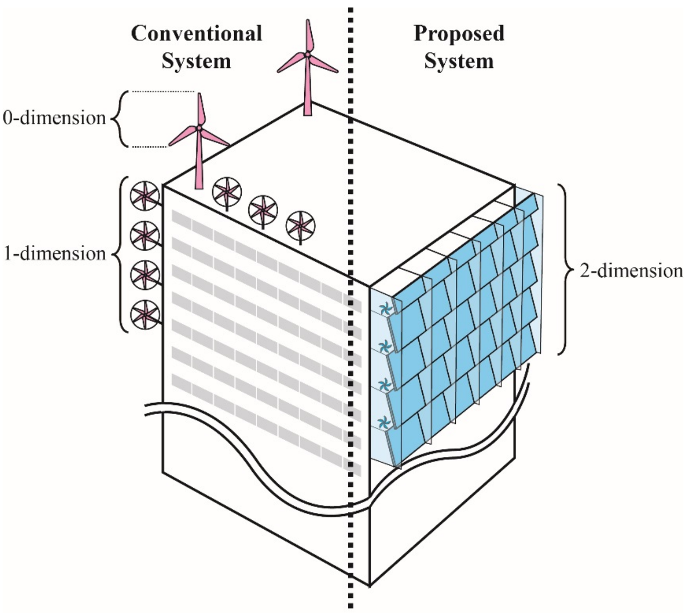
- high-rise (over 10 storeys)
- mid-rse (4-10 storeys)
- low-rise (below 4 storeys)

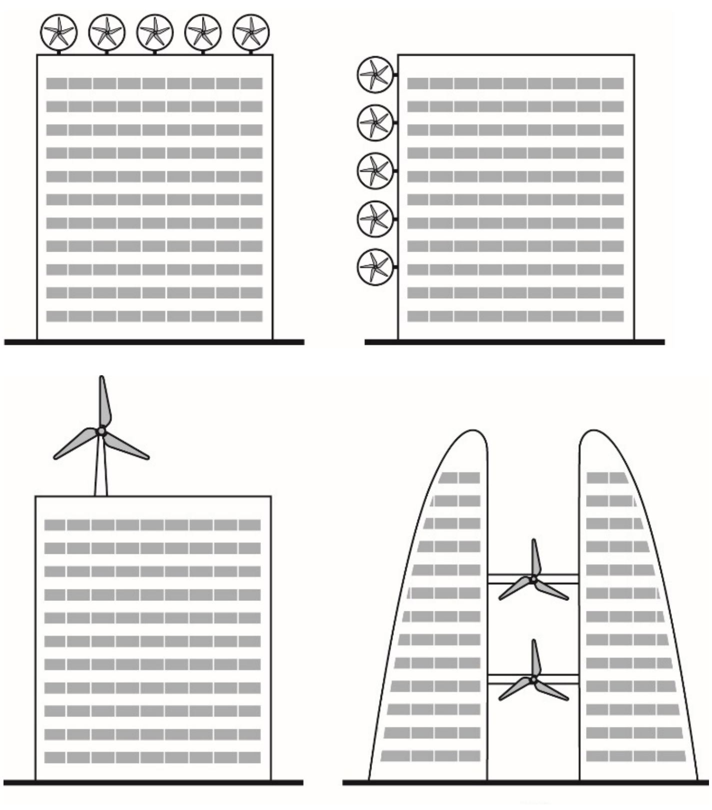
High-rise buildings because of access to higher and constant wind, have the highest potential in wind energy generation. The increased height grants access to higher and therefore stronger winds, obstacles are either non-existent or limited and, as aforementioned, the speed and strength of the wind due to the height of the building can be higher than in the open. High-rise buildings with flat roofs – typical roof form for this kind of buildings – present a very turbulent wind on the roofs, also because of the sharp edge, and are therefore not so suitable for HAWT since they need horizontal wind flows. The two most appropriate technologies that are already beeing applied are *VAWT* since they can utilize wind from different directions and *ducted WT*. The latter type is also ideal since it utilizes the airflow along a building's side and it also has a minimum visual impact (Guzzetta et al., 2007). HAWT is only meaningful, in terms of energy production, when the shape of the roof is vaulted. This is not taken so much into account in high-rise since it is rear to have this kind of roof and it would then require a plug-in which is undesireable for tall buildings. Therefore it will be further analysed in mid and low-rise buildings. Finally a new and innovative technology that aspires to become more productive than the existing are the *facade-integrated wind turbines.* This is a system of guide vanes that guide and help accelerate the wind that presses against the surface – thanks to the tunnel effect – and then they direct it to a rotor that generates energy (Park et al., 2015). This can work as a 'curtain' that covers the entire surface and it can also possible be compined with PV – especially with some of the innovative new materials that will be further elaborated.



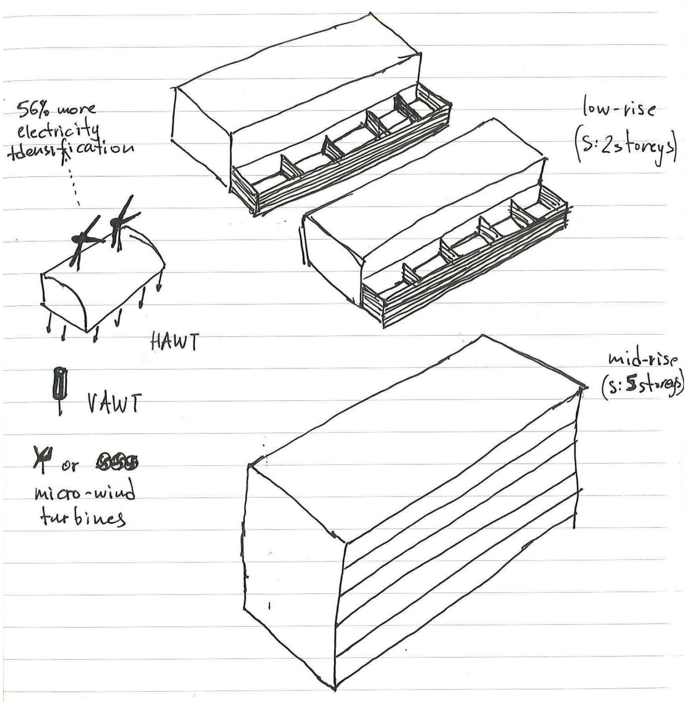


wind stagnation on high-rise building surface (Oke, 1987)

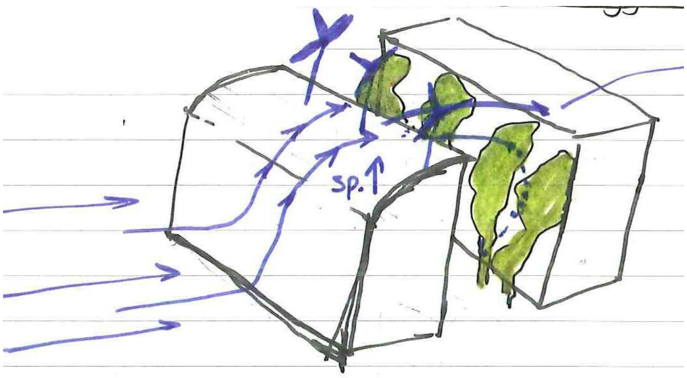




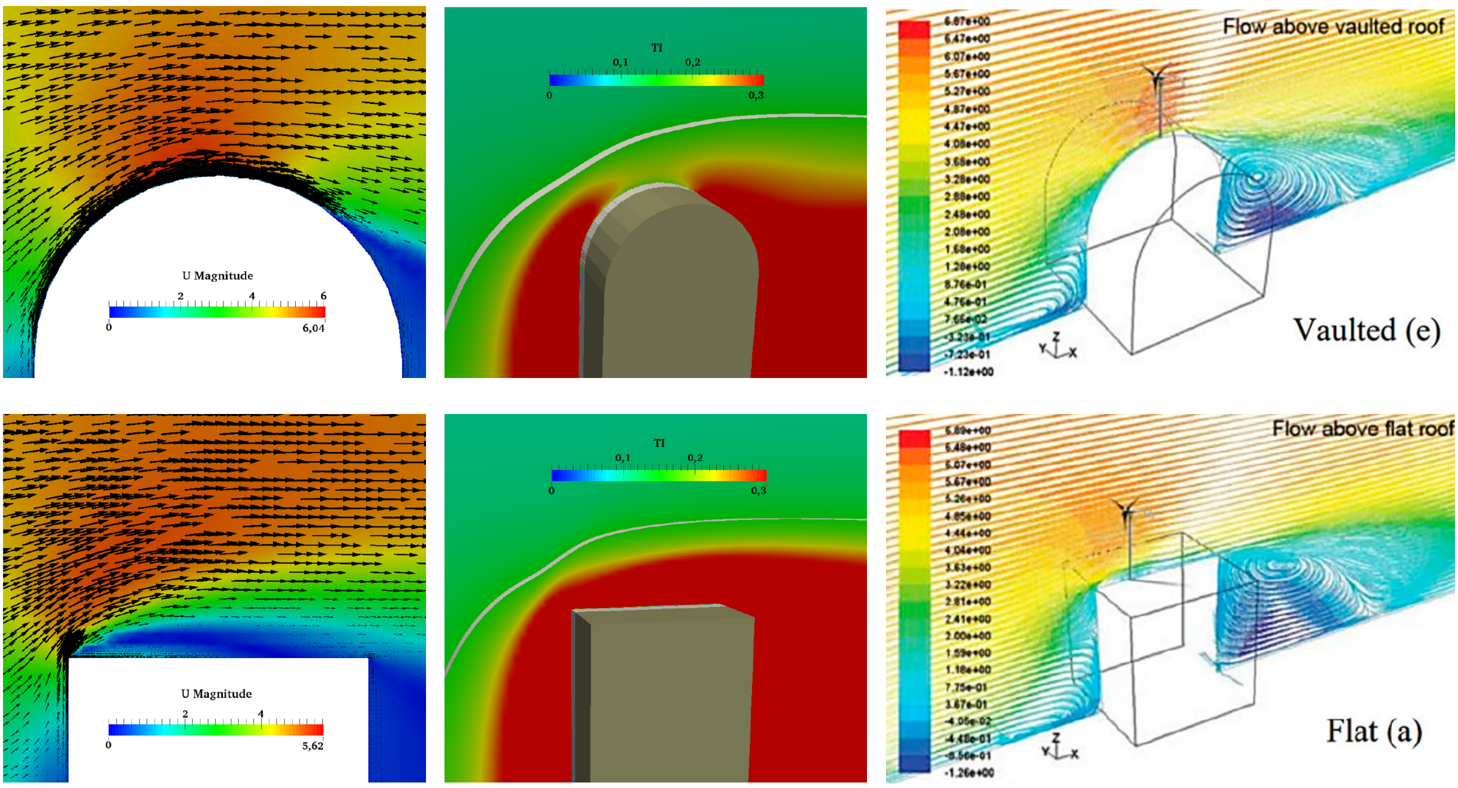
(Park et al., 2015: 11850)



Mid-rise buildings also show a lot of potential not because of high wind speed, but because they show less turbulence and there is also the possibility for extra storeys to be added. The latter relates to the potentials of *HAWT on vaulted roofs*. In a paper on roof geometry for urban wind energy exploitation, by Toja et al. (2015), different roof types were examined as for their influence on wind flows. From this research it was found that vaulted roofs exhibit the highest wind speed which actually – according to another study by Calautit et al. (2018) – *produced 56% more electricity than a stand-alone WT* at the exact place with similar flow settings (Calautit et al., 2018: 17). In low-rise buildings this potential is even more promising since the vaulted roof could also be a plug-in on the building. This is especially useful in terms of densification as well as in areas with higher buildings since in this way the height irregularities are decreased (see the neighbourhood scale in sub-chapter 5.2.1). In both mid- and low-rise buildings – with flat roofs – micro wind turbines can be used of either vertical or horizontal axis. However, especially in the low-rise it is preferred to use VAWT since they are more able to utilize wind on lower heights and of lower speed.



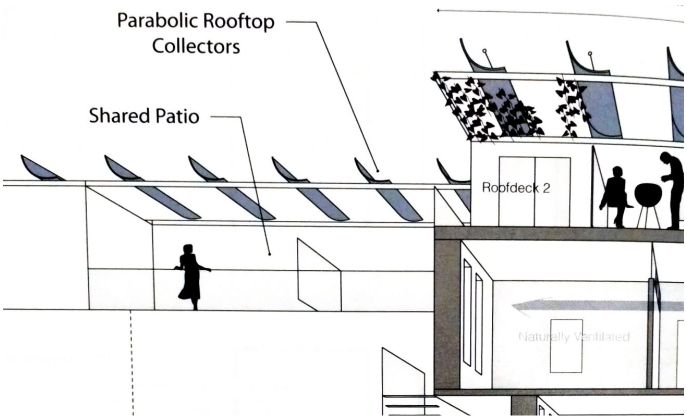
In implementing all these technologies however it should be taken into account that some of the morphological characteristics that allow for wind speeds to become faster, are undesirable in terms of energy use. As aforementioned, in the matrix the aim is to create the knowledge and then in the design patterns synergies will be made between different elements, to be further adapted and compromised during the case study.

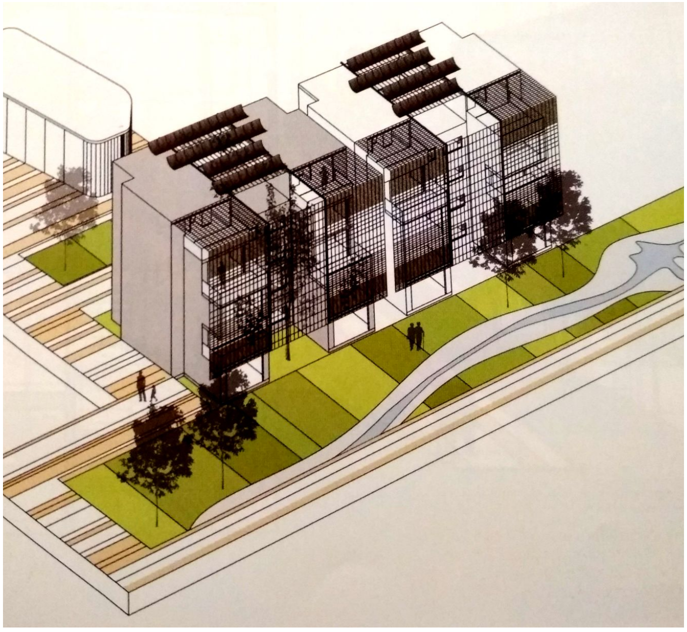


performance of a HAWT on roofs of different geometries (Toja et al, 2015)


TDMB wind turbines and solar panels (source: acu.edu.au)


Elena ducted wind turbines atop the Science of the Air center in Paris, France, 2010 (source: wind-works.org)





Shaded patios and rooftops (Scott, Ben-Joseph, 2012)

Pergola with built-in PV panels (Dickson, 2012)

¬ *Solar energy*

As it is already apparent, wind energy can be integrated in the urban environment but it occupies a specific space which cannot be utilized in any other way. On the contrary, solar energy technology can be part of a public space, used to shelter people from sun or even rain; It can be installed and unistalled much easier; it can gather energy and provide shade at the same time; it can even be a road. A lot of innovative ideas are changing the typical idea of solar energy as PV on the roofs that turn the roofs into unusable 'dead' spaces. It is therefore the intention of this project to come up with innovative ideas as to how both new technological acheivements but also traditional technologies such as PVs and parabolic collectors, can be used in order to produce new interesting spaces with quality and aesthetic value.

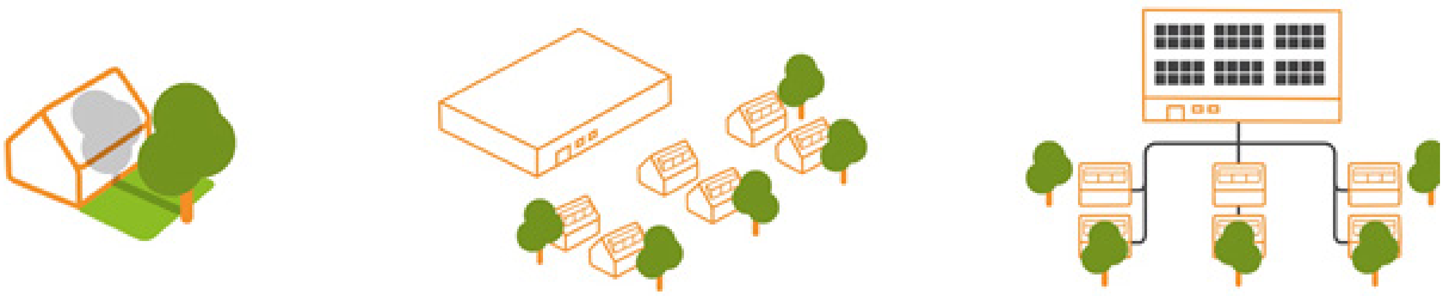
Firstly PVs and parabolic rooftops can be used on
- pergolas; which will offer shade during the summer
- on facades along with facade-integrated wind energy
- typically on roofs of buildings which are not used in any other way due to other factors

However when proposing PV panels we should be aware that during winter on one hand they are not that productive as in summer and on the other they prevent large surfaces of the building from absorbing passive solar energy. Therefore it is proposed that extensive solar 'roof parks' should only be located on top of non-residential buildings. Residential buildings need to gather passive solar heating during the day to use it during the night when the sun has set. Non-residential buildings don't have similar requirements since they are empty during the night. This kind of 'solar roofs' have already been happening around the Netherlands and also with users' participation organised through local initiatives. `

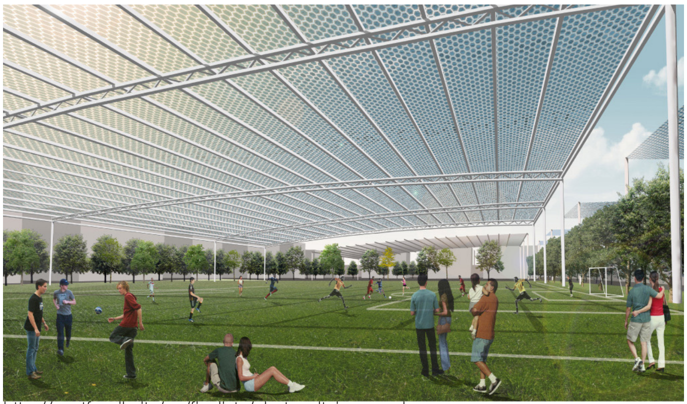
Another technology that seems promising and is becoming more and more popular are the solar roads. They are perhaps the best example of a means of energy production that can be used easily in daily life. However they need to be kept unshaded so in relation to buildings they should be placed in distance that guarantees that they will have solar access throughout the year.

source: https://inhabitat.com/flexible-lightweight-solar-fabric-by-ftl-solar/

source: http://www.dw.com/en/solar-roadways-a-way-forward-for-renewables/a-19048835



source: solargreenpoint, n.d.

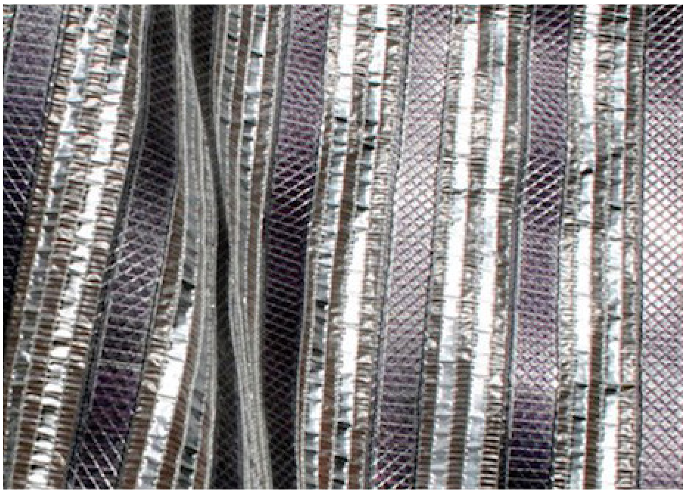

http://postfossil.city/en/finalists/photovoltaic-pergolas

Perhaps the most promising technology in terms of its possibilities in different uses is thin-film solar nanomaterials textile. This is practically a fabric from organic photovolatics, which has emerged from photoreactive polymers and can easily printed, with low cost and low carbon footprint. Therefore it has substantially less embodied energy than glass solar panels especially since as a textile, it is easy to store and transfer. Furthermore it can accept sunlight easily throught the day since it has a 120-degree range. However, in order to be productive, large surfaces should be used since organic photovolatics are still not as efficient as traditional glass solar panels (KVA MATx., 2010).

This technology is still being developed and even though it is not yet as efficient, it has so many advantages that it has the potential of being further developed and improved. Indeed some products of thin-film nanomaterials have been already in use for tents or shelters in the desert. The reason for this, the potential of this material is that it is flexible, it can be adapted and most importantly it can – literally – shelter other activities. This becomes more apparent by looking into different ideas that are being presented here. From a protected open air market to the rooftops of a dense neighbourhood of Porto. As described in Soft cities by KVA MATx (2010):

"Low-cost mass production, a generosity of surface large enough to create space, and the ability to harvest energy throughout the day, in a broad range of solar orientations, creates a clean energy paradigm with the potential for mass adoption in dense urban districts."


Tensile Solar, weatherproof and structurally reinforced photovoltaic modules that act almost like a fabric that can not only protect, but power.
http://www.core77.com/posts/19379/smit-tensile-solar-lightweight-modular-solar-power-19379


solar fabric; photoreactive polymer materials printed on flexible substrates (source: Mostafavi et al, 2010:286)

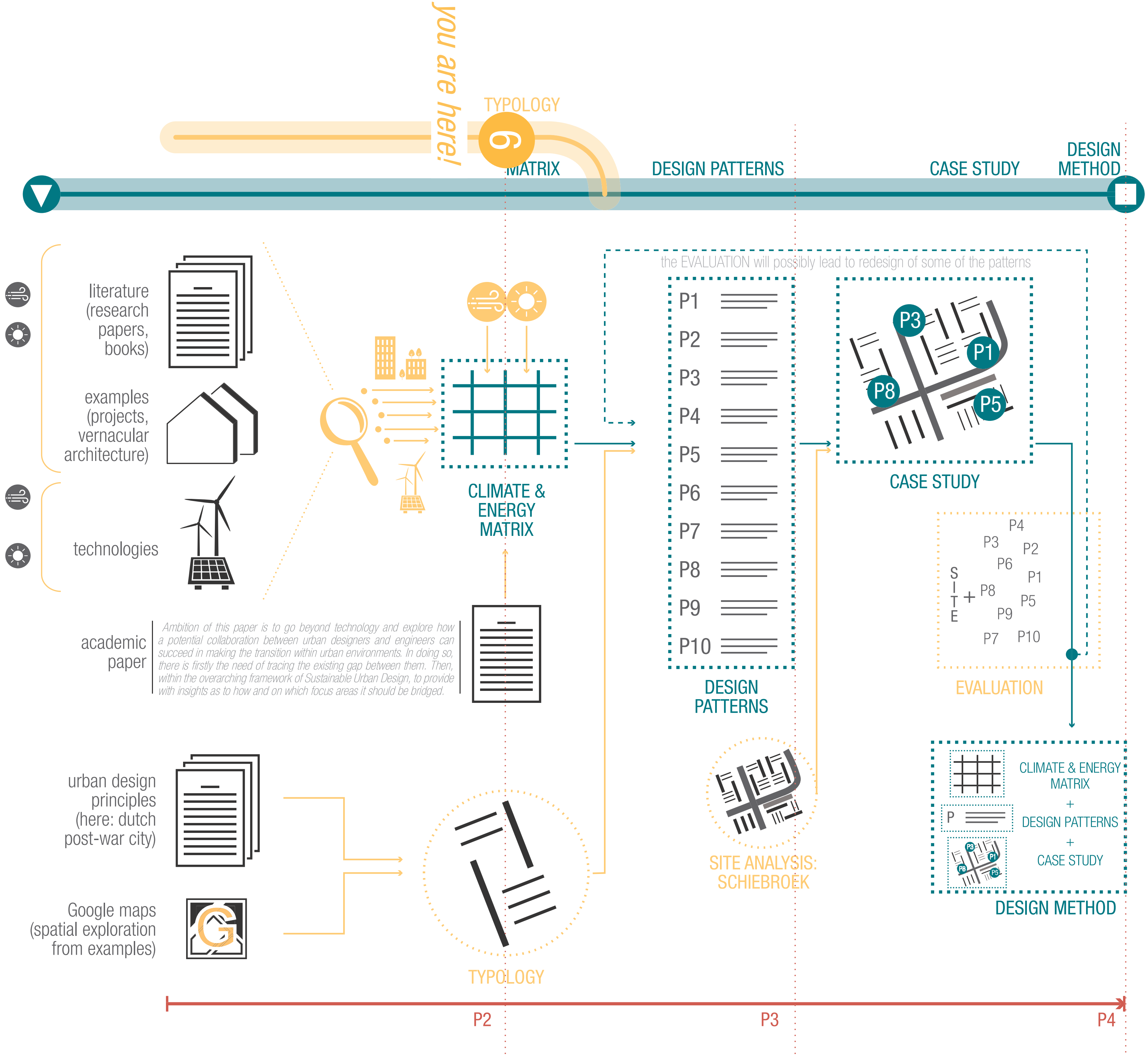

solar fabric on roofs of Porto; render from the project by KVA MATx "Soft Cities" (source: Mostafavi et al, 2010:284)

	CLIMATIC CONDITIONS FOR DUTCH CLIMATE (temperate maritime climate influenced by the North Sea)	WIND PATTERNS WINTER [MAIN FOCUS] moderate winters -cold & strong wind from North Sea	SUMMER [ACCOUNTED FOR] cool summers -sea breeze
ENERGY USE	**-district/neighbourhood**		
	urban block morph.: heights	min. height irregular., avoid tall buildings	
	urban forest	urban forest (for fully exposed blocks)[I]	not perpendicular to summer breeze
	street & open sp. orientation	perpendicular or sidewards to the wind	
	high housing density		
	-urban block/street		
	urban block morph.: form	(1) paral. rows of linear blocks/elong.forms	
		(2) perimeter blocks	
		(3) compact form	
	vegetation	evergreen rows of trees, perpend. to wind[I]	summer breeze direction: no vegetation
	orientation	perpendic. or sidewards (45º) to the wind	
	width street ratio: Height/Width	H/W ≥0.65[1]	parallel or sidewards (45º)
	density & solar exposure	infill where H/W≤0.65 (to achieve skimming flow and avoid wake interfer.)	
	-building (parcel)		
	orientation	wind perpendicular to long surface	
	vegetation	trees & plant-covered walls (cavities)[II]	summer breeze: no veg.
	bulding plan (envelope)		depth <6m; for nat.ventilat.[4]
	infill development AND dense & energy efficient h.typ.	open spaces (no tall buildings & ideallly in low H/W) & protected from wind effect	
ENERGY PRODUCTION	1 technology	HAWT (Horizontal Axis Wind Turbines)	
	orientation	windward (WT adjustable)	
	location	mid- & high-rise build., towers open sp.	
	morphology	roof (optimum type: curved)	
	2 technology	VAWT or micro-wind turbines or IRWES[13]	
	orientation	windward (only for micro-wind)	
	location	high- & mid-rise build. (possible for low)	
	morphology	flat roof, corners & facades	
	3 technology	ducted wind turbines	
	orientation	windward (fixed position)	
	location	high-rise build.	
	morphology	flat roof	
	4 technology	savonius VAWT or Binopterus VAWT	
	orientation	independent of orientation	
	location	bus stops, shelters, roof patios - open sp.	
	morphology	VAWT with wind booster system (vanes) are appropriate for low winds[12]	
	5 technology	Kite power systems	
	orientation	independent of orientation	
	location	mid- & high-rise build.	
	morphology	independent	

I. low density vegetation (e.g. single row) acts as a "cushion" and doesn't create lee eddy, high density vegetation (e.g. urban forest) protects from wind penetration but creates lee eddy
II. for protection from lee eddy (windward face of succeding building & tall buldings)
III. uni-directional: turbines to the WSW of the building

	SOLAR RADIATION		
Sources	Winter [main focus] moderate winters -cloudy; less solar radiation	Summer [accounted for] cool summers	Sources
[1]Oke, 1987; [2]Jurelionis, Bouris, 2016; [3]Eumorfopoulou, Kontoleon, 2009; [4]Salat, 2014			[14]McPherson et al., 1988; [15]Olygay et al., 2015; [16]Scott, Ben-Joseph, 2012; [4]Salat, 2014
	(1) free arr. of linear blocks/elong. forms		
	(4) T-shaped/cross forms		
	deciduous trees: solar access for winter, shadow for summer	tree rows parall. to W faces	
	H/W≤2 (traditional deep canyon), by densif. keep H/W as low as possible; blocks facing E-W, united with atrium	high dens. in open spaces; blocks facing E-W, united with atrium	
	East-West (length), pref. unilateral plan[IV]	west side closed[IV]	
	S&E surfaces: no/deciduous trees	trees W surf. & green roofs[V]	
	depth<6m; for solar access[4]		
	on west, north or without solar access building faces & sunrooms (building's facades with insufficient solar access)	minimum increase of roof surface	
[5]Wang et al., 2017; [6]Bell et al.,n.d.; [7]Guzzetta et al., 2007; [8]Smith et al., 2012; [9]Micallef et al., 2016 [10]Park et al., 2015 [11]Ledo et al., 2011; [12]Korprasertsak & Leephakpreeda, 2015; [13]Dekker, 2012	PV panels & parabolic collectors	parabolic rooftop collectors	[17]Mostafavi et al., 2010; [16]Scott, Ben-Joseph, 2012
	South to East	South to West	
	mid- & high-rise build.	mid- & high-rise build.	
	unshaded and spacious rooftops (prefer. on non-residential build.)	shaded roofgarden/patio	
	solar roads & paths		
	---		
	infrastructure & public space		
	away from buldings (low dens. vegetation)		
	thin-film solar (textile)	thin-film solar (textile)	
	South to East (120-degree range)	South to West	
	mid- & high-rise build.	build. & open spaces	
	large vertical blind facades	rooftops (summer terraces)	
	see-through transparent solar panels		
	South to East		
	buildings		
	balconies and windows		

IV. other possibilities: weighted or multilateral (also compatible with T-shaped built forms), buildings should be open to south and southeast for winter solar gain and closed on west sides for protection from summer sun
V. Shade screens is another idea that could be either be combined with vegetation or with photovoltaic panels (Scott, Ben-Joseph, 2012: 217)


you are here!
TYPOLOGY
6
MATRIX
DESIGN PATTERNS
CASE STUDY
DESIGN METHOD
literature (research papers, books)
examples (projects, vernacular architecture)
technologies
academic paper
Ambition of this paper is to go beyond technology and explore how a potential collaboration between urban designers and engineers can succeed in making the transition within urban environments. In doing so, there is firstly the need of tracing the existing gap between them. Then, within the overarching framework of Sustainable Urban Design, to provide with insights as to how and on which focus areas it should be bridged.
urban design principles (here: dutch post-war city)
Google maps (spatial exploration from examples)
CLIMATE & ENERGY MATRIX
TYPOLOGY
the EVALUATION will possibly lead to redesign of some of the patterns
P1 P2 P3 P4 P5 P6 P7 P8 P9 P10
DESIGN PATTERNS
SITE ANALYSIS: SCHIEBROEK
P3 P1 P8 P5
CASE STUDY
SITE + P4 P3 P2 P6 P1 P8 P5 P9 P7 P10
EVALUATION
CLIMATE & ENERGY MATRIX
+
DESIGN PATTERNS
+
CASE STUDY
DESIGN METHOD
P2
P3
P4

6

TYPOMORPHOLOGY: POST-WAR NEIGHBOURHOODS

6.1. EUROPE AND BEYOND: POST-WAR RECONSTRUCTION & EXPANSION

In the previous chapter, theories and principles are studied in order to come up with optimum morphological qualities for energy use and energy production. In order to be able to propose design solutions for post-war neighbourhoods there needs to be a clear comparison between these optimum qualities and the existing ones. However due to the fact that those solutions will be proposed for something as generic as dutch post-war neigbourhoods there needs to be an analysis that will eventually lead to comparable qualities between the typology and the Matrix. The historical background and the principles that were followed in post-war neighbourhoods around the world, along with some more specific that describe the dutch context more in detail, are the elements that enable the extraction of those morphological qualities.

Therefpre, the purpose of this chapter is to provide an overview of those historic elements that led to the development of post-war neighbourhoods and defined them as currently problematic and inherently unsustainable residential areas. The history and the principles upon which they were conceived, planned and finally constructed are complex and they led to certain threats and weaknesses but also important values – which tend to be dismissed. Therefore by exploring these elements, morphological qualities of post-war neighbourhoods can be extracted that along with some more unique elements of the dutch paradigm, can formulate a typomorphology of dutch post-war neighbourhoods. This is an essential tool to be used as the basis for the design patterns (chapter 7).

6.1.1. BRIEF OVERVIEW: MODERNISM AND POST-WAR PERIOD

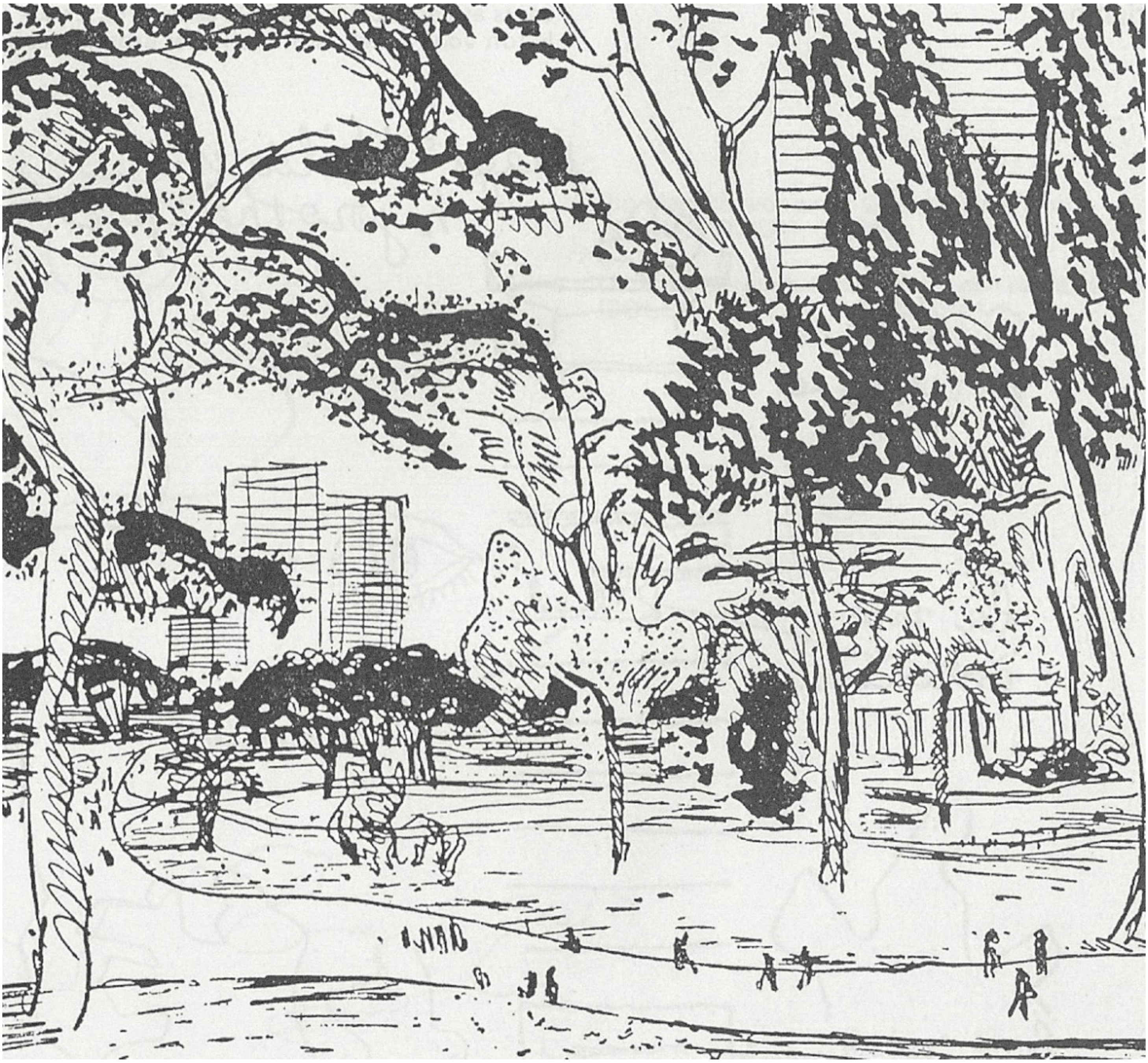
Modernism is a movement in architecture that started in the beginning of the 20th century and it has influenced architecture and cities in intentional and unintentional ways, with positive and negative effects. In its first phase it evolved around idealistic – and often utopian – visions of the future related mostly to a radical break from tradition while opting for new social order to which we could be led to with the assistance of technology which was rapidly advancing at the time. This movement chaged significantly after the second world war but it lies in the core of post-war reconstruction and expansion. In the following part the principles of the post-war modernism along with the appearing conditions of that time that changed its course will be described leading to the aforementioned morphological qualities. But before moving on with the analytical part, three thematics will be exhibited here in order to make it more comprehensible:

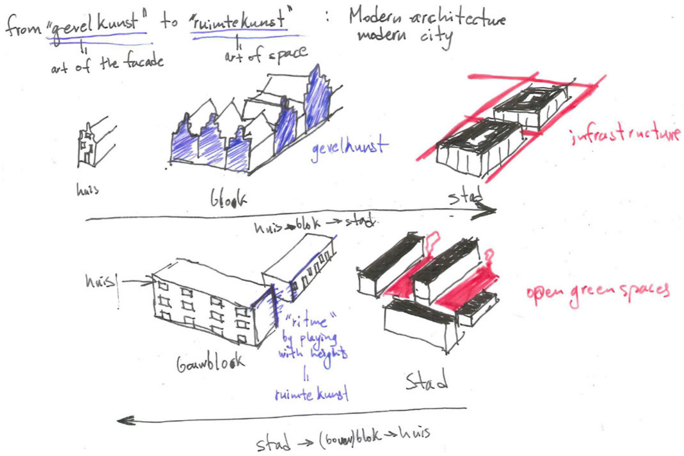
- Modernism principles; as aforementioned even though altered on many levels, some of its ideals remained and effectively shaped the post-war reconstruction period,
- Technological and spatial potentials; the advances of technology in the building sector along with the tabula rasa that was offered by the unoccupied areas on the outskirts of cities, offered great potential for architects to break free from the limited city space and create the visions of openness that modernism implanted.
- Housing needs and management; the steep housing needs and the speed in construction that was necessary, led to a managing system that proved effective but also created specific problems,

MODERNISM PRINCIPLES

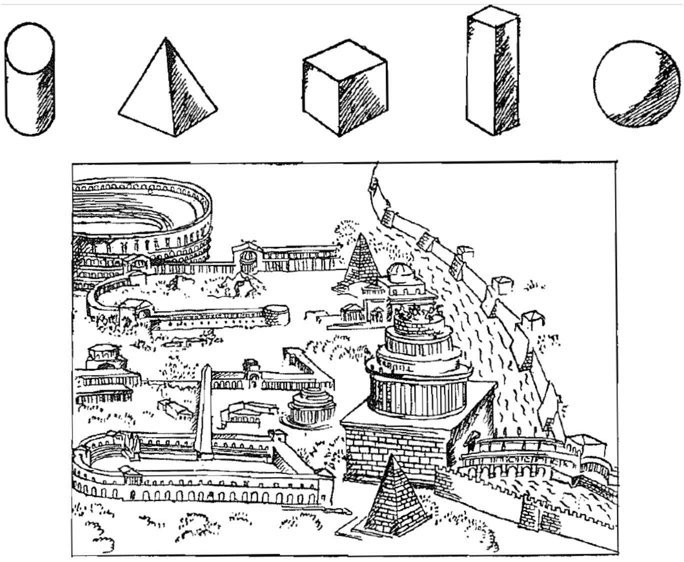
Modernism affected the post-war neighbourhoods significantly and it was the overhanging framework that shaped this new model of housing on many different levels. Modernist architects have developed already from the beginning of the 20th century ideas on architecture as well as social structure, and one of its key characteristics was the break from tradition. Existing social structures were heavily criticised and the structure of traditional medieval cities was rejected as outdated and unhealthy.

Firstly, architecture as an art was viewed from an entirely new perspective. It passed from beeing an art of craftmanship exhibited in the facades of the wealthy cities – in dutch 'gevelkunst' (Hereijgers and Van Velzen, 2001) – to a rythmic game of forms and light in space – *'ruimtekunst'*. In the words of Le Corbusier *"Architecture is the masterly, correct and magnificent play of masses brought together in light."* (Corbusier and Etchells, 1986). This new perspective gave its own signature to the new residential areas already *on the level of planning*. In


Ville Radieuse: sketch by Le Corbusier (1922) the ideal of openness and coexistence of buildings and nature (source: nanum.com)



The traditional and the modern city (sketch by the author)


Le Corbusier's sketch of primary forms and their identification in ancient Rome (Corbusier and Etchells, 1986: 159)


Unité d'habitation, Marseille, France, 1945 (source:fondationlecorbusier.fr)

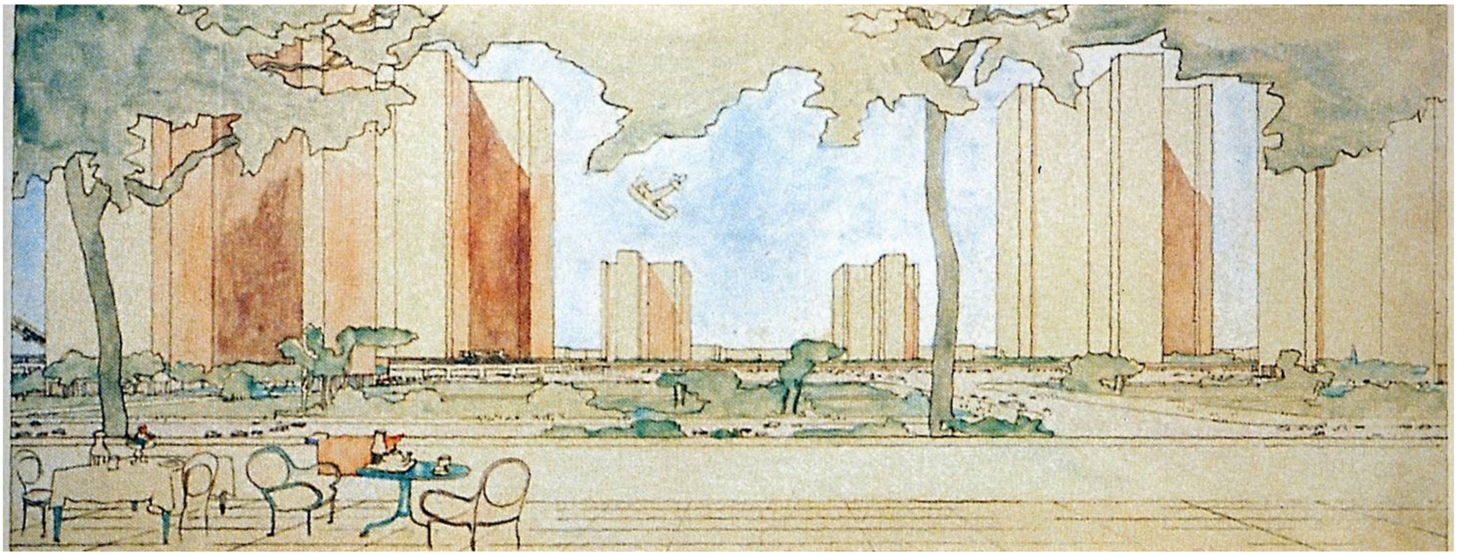
stark opposition to the medieval cities, buildings were planned with considerable distances in between them, giving space for life amidst buildings as well as light. The art of space and forms could be seen in the shifting of orientations between buildings as well as the height differences – however this is an element that is not common around the world, only on some cases and especially relevant for the dutch neighbourhoods for reasons that will be explained in the last part of this chapter. *On the level of design*, one can see this change in the simplicity of the buildings' forms; linear rectangular blocks with no 'unnecessary' decorations.

Another significant element that again stemmed from a reaction to the – in this case also literally – unhealthy medieval city was the *importance of nature*. If we were to sum up the basic ideas that modernists thought should be a given for residents it would be that of *openness, light and air*. On this aspect technological advances played a crucial role since they captured the imagination of architects by the potential of creating residential towers. A solution which seemed ideal since it would give abundant space for nature to exist within the city and people would enjoy it even from their wide windows. Therefore, it is visible in many of the post-war neighbourhoods, not only the existence of green but its role in the planning process. Green, open spaces were the ruling element that defined spaces between buildings in stead of infrastructure – the medieval city ruling element.

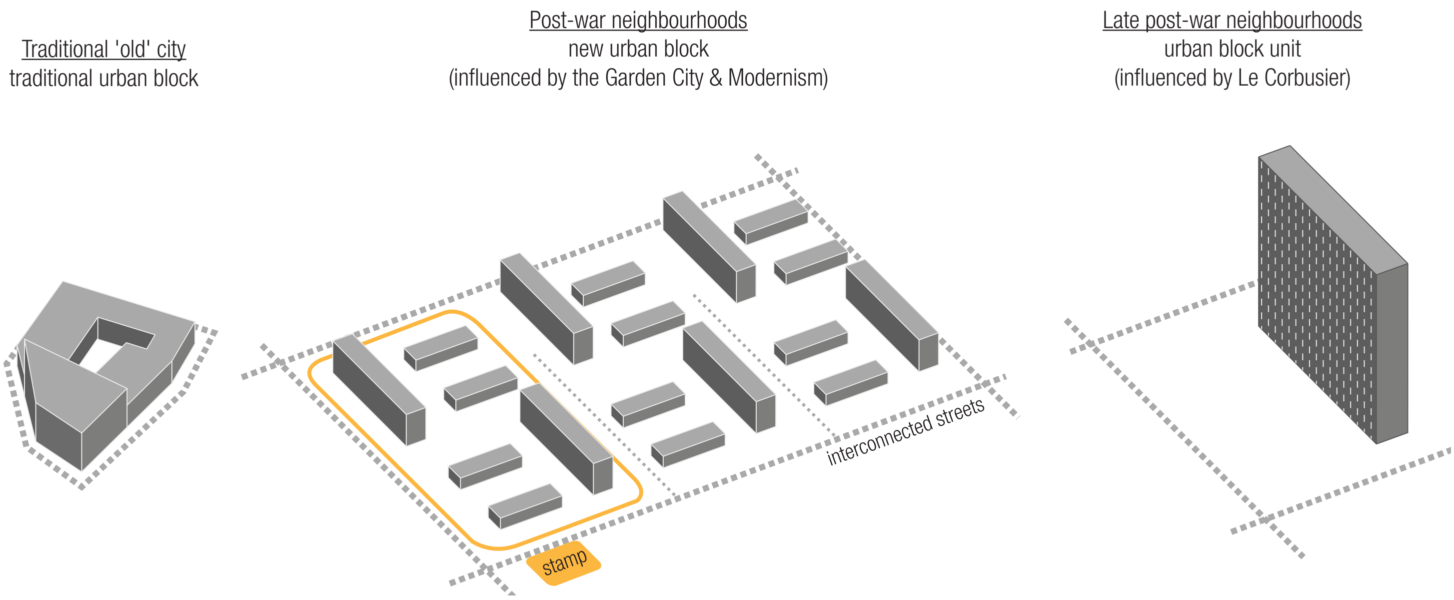
Finally another element perhaps less visible, is the *'neighbourhood'* concept – or in dutch 'wijkgedacht'. It was based on the already existing ideas that led to the garden city movement but it was more about social cohesion which was opted for by strictly defining even the size and the composition. Each neighbourhood was meant to provide different options in residences for different life phases. The goal was for residents to stay within the neighbourhood for all their lives, changing merely houses depending on each phase. Services and facilitites were also provided within the neighbourhood. Especially in the Netherlands this logic was not only prevailing but it is directly translated into space and form. Indeed buildings of different heights and choices between flats or (semi-)independent houses, garden or not, gave people different options and at the same time this can be seen within each urban block. Another core idea of modernism, especially expressed by Le Corbusier, was that of *'functionalism'*. Especially in the Netherlands, the implementation of functionalism on neighbourhoods was spread out by the Dutch CIAM group (Eichler, 2010). Housing, recreation, services and commercial centres were spatially separated and concentrated in specific points within the neighbourhood.

All those stark differences from the traditional city led in redefining the urban block. In the 'old' traditional city the urban block was a dense mass of buildings that was surrounded by a road and often had an internal open air space. Modernism as applied in ealry post-war neighbourhoods defined the urban block as an open space with buildings positioned within it. The buildings were devided by green spaces or deadend streets that led to parking spaces.

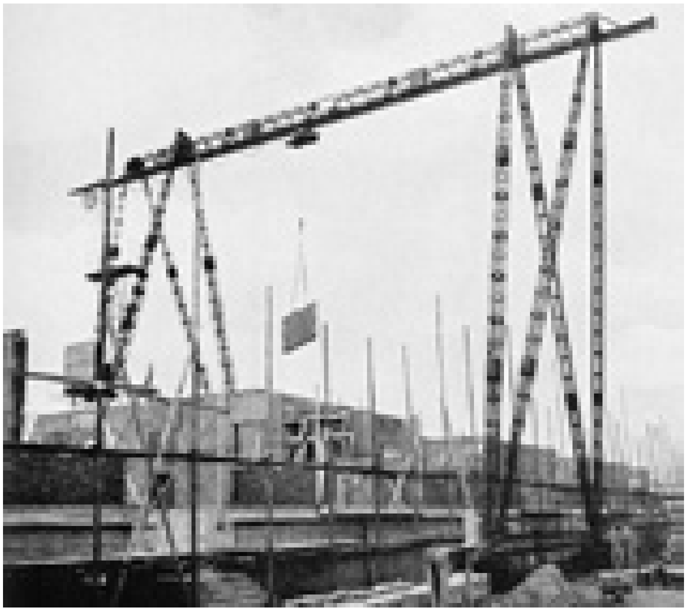
"Architecture is the masterly, correct and magnificent play of masses brought together in light."
Le Corbusier, 1923 (Corbusier and Etchells, 1986)



The city of tomorrow: sketch by Le Corbusier (1922) the ideal of openness and coexistence of buildings and nature (source: nanum.com)



workers assemblying prefabricated brick slabs with the help of a building crane (source: Wouter van Heusden, gemeentearchief Emmen)



crane determining the length of the block (source: Vereniging van systeembouwers, 1956: 13)

Urban blocks were separated by interconnected roads. In the late post-war period when towers were made possible the deifinition was most similar to the ideas of modernists and especially Le Corbusier. The urban block was practically one building, the high-rise tower that allowed for density while occupying the minimum area, giving space to nature. In this case then, the urban block consisted of the tower and the surrounding open space and was again separated by interconnscted roads.

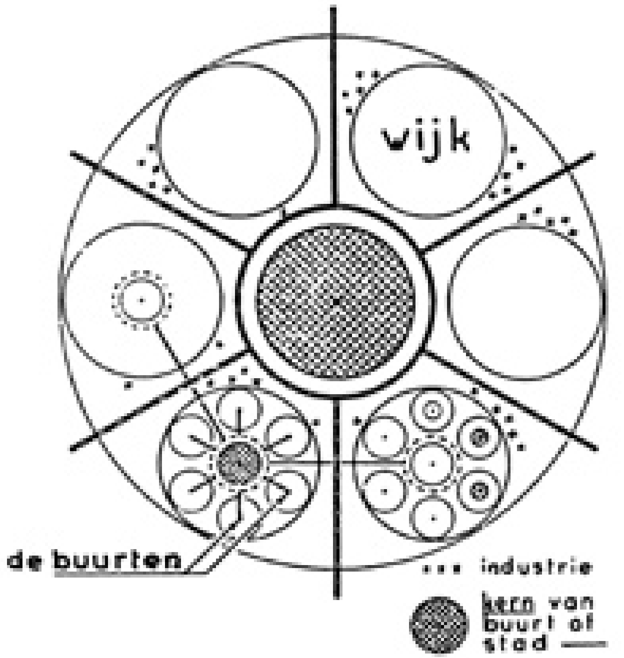
TECHNOLOGICAL AND SPATIAL POTENTIALS

In the core of the modernist movement laid the potential that the advances of technology had revealed. As aforementioned tall towers could be constructed thanks to reinforced concrete, and in addition central heating and the vast use of elevators enabled unimagined comforts to the new lifestyle. High residential buildings can be found in many dutch post-war neibourhoods since the early 60s,opening up the way for the mega-structure architectural period that took place in the Netherlands in the 70s (Ibelings et al., 1999).

Apart from those technological developments, another one which was also strongly embraced by modernists and was set as an opposition to traditional architecture, was *industrialization*. This development was about the process of constructing but it also greatly affected the urban form. The basic change was the fact that now building parts could be entirely made in factories and then with large canes transported to construction sites. This turned the on-site building process to an assembly of prefabricated parts. The process was immensely accelerated but this automation but eventually led to a repetition of the same building and block forms, introducing the term of '*stamps*'. A practice that fitted the ideas of modernism at that phase but it was also led by the housing needs and the top-down planning that wil be further explained in the next part. In order to make this effect on built form more explicit, we merely need to look at the *long linear building blocks* of post-war neighbourhoods. This form was in fact determined by the building crane; the length of the strip depended on the crane's distance capacity (ICOMOS, 2003).

In addition to the potentials offered by technology, the expansion towards the outskirts of cities gave modernists an abundance of space – a sort of "tabula rasa". Existing infrastructural lines were used as guiding planning lines but other than that the break from the limitations of the old cities made it possible to experiment with forms, nature and open spaces.

Schiebroek (case study in Rotterdam), Amsterdam Zuid and the Hague; some examples of high-rise buildings that started appearing in the early 60s and developed to the mega-structure architectural period of the 70s.

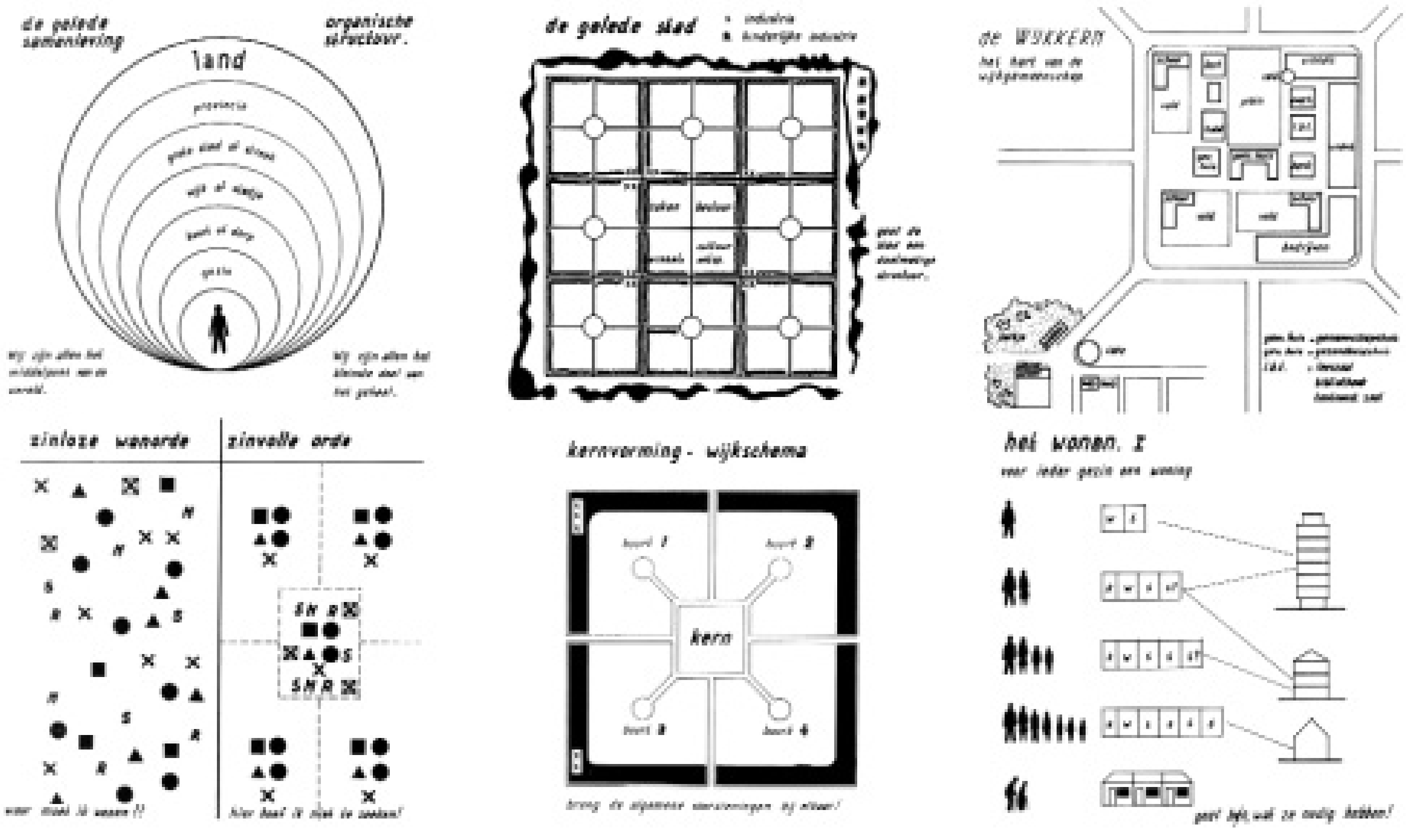


scheme for the neighbourhood concept – wijkgedacht or 'de gelede stad' by W.F. Geyl, 1947 (source: Blom, Jansen and Van der Heiden, 2004: 19)

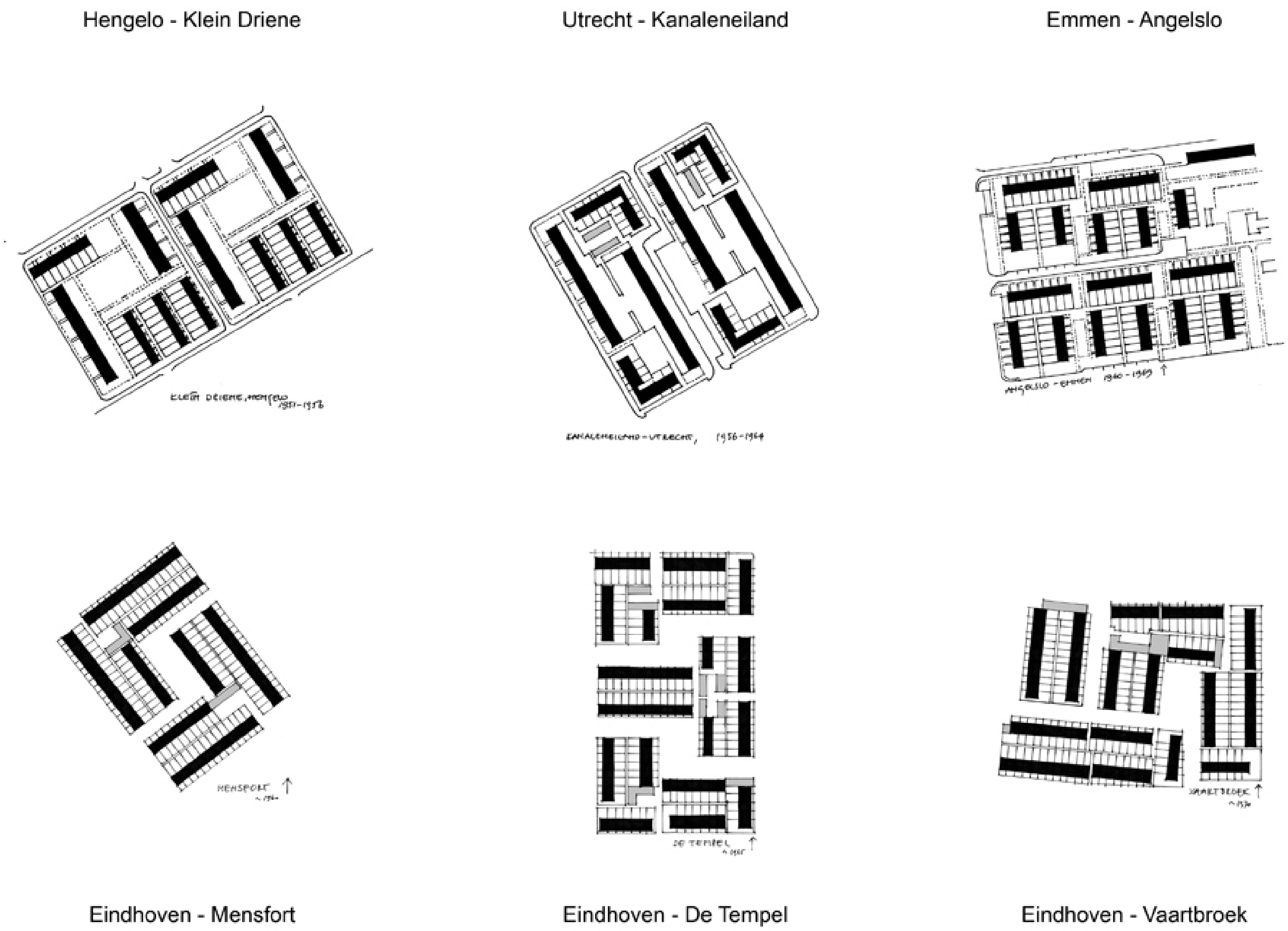
HOUSING NEEDS AND MANAGEMENT

One of the most defining elements for the development of post-war neighbourhoods were the pressing housing needs that followed WWII. Apart from the bombardements that destroyed vast areas in various cities of Europe and beyond, the generation of the baby boomers together with the intense urbanization, resulted in an immense housing shortage. Industrialization of construction helped immensely in addressing this problem worldwide. However the management of this period of (re-) construction depended also on each countriy's system. There was of course a tendency towards top-down planning processes which explain – along with modernism – the similarities between post-war neighbourhoods around the world. The differences amongst countries did nevertheless create differences also in the structure of the urban form.

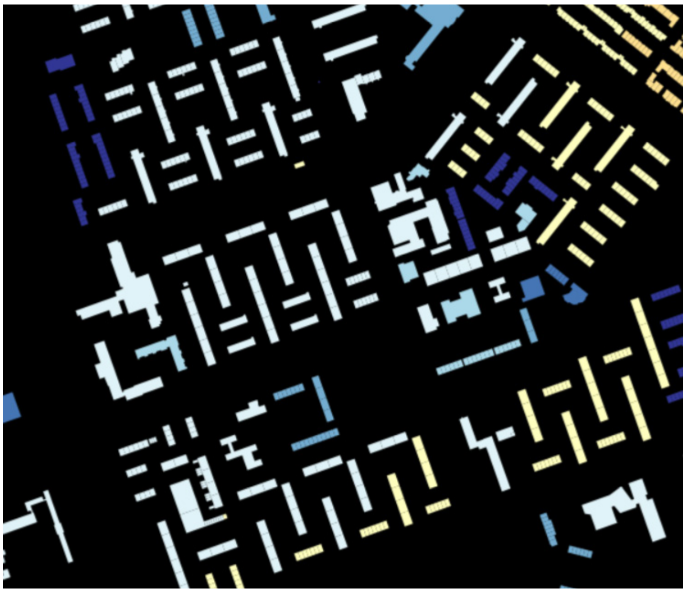
In the case of the Netherlands, of crucial importance for the development of post-war neighbourhoods as well as their current state has been their management from housing associations. These assiciations depended mostly on government subsidies until the 90s. So a small number of them was responsible for housing projects around the Netherlands. These resulted to similaritites ranging from materials to urban block structure and facilities. Planners and architects that worked on the construction of those neighbourhoods were part of the CIAM and they were deeply influenced also from social ideals of Modernism. This affected actively the planning and design of the urban blocks. The logic was that each urban block, or 'buurt', should be creating a social and family-type mix by including different housing typologies. Therefore (as can be seen in the scheme of the opposite page), depending on the number of members in a family, types and heights of buildings varied to better satisfy the needs for each person depending on their life phase. This variation of housing types and building forms within an urban block, was then repeated as a 'stamp' creating the neighbourhood. The variations between stamps were usually small.



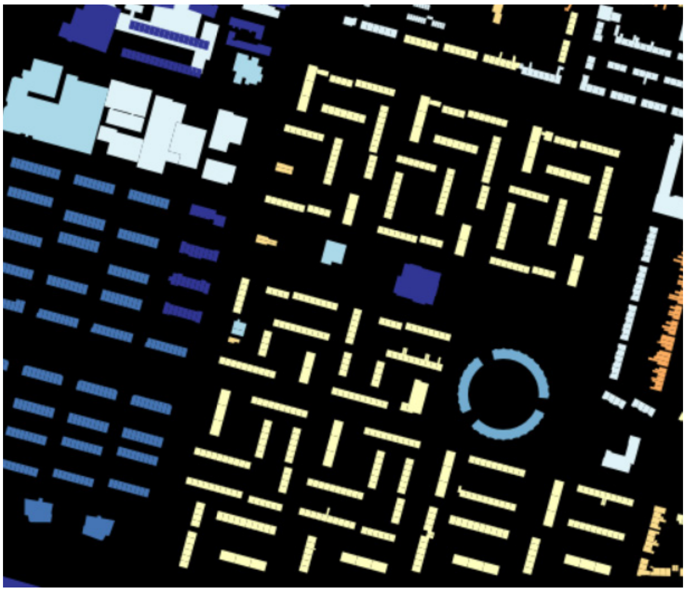
organization scheme of a new district (source: Blom, Jansen and Van der Heiden, 2004: 4)



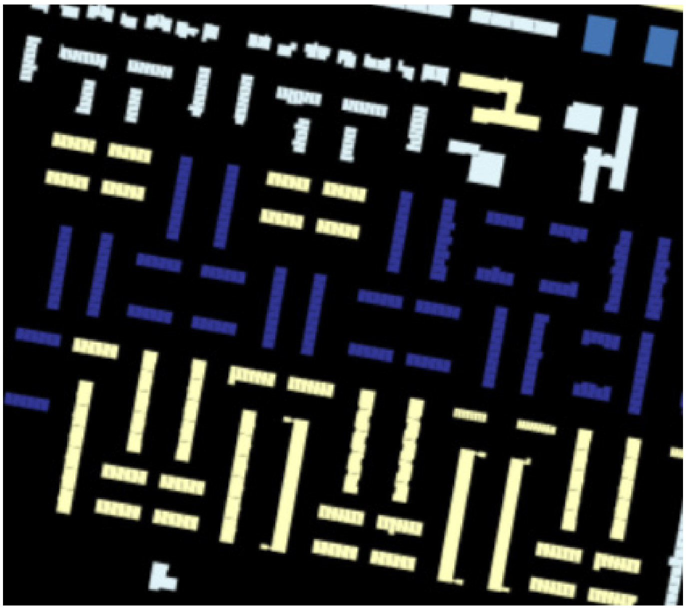
stempels in different neighbourhoods of different dutch cities (source: bestaandewoningbouw.nl)



Schiebroek, Rotterdam



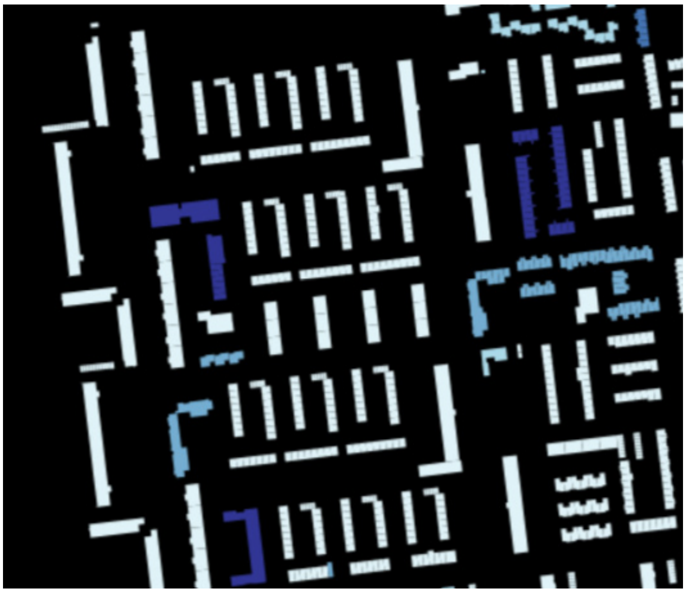
Grootstal, Nijmegen



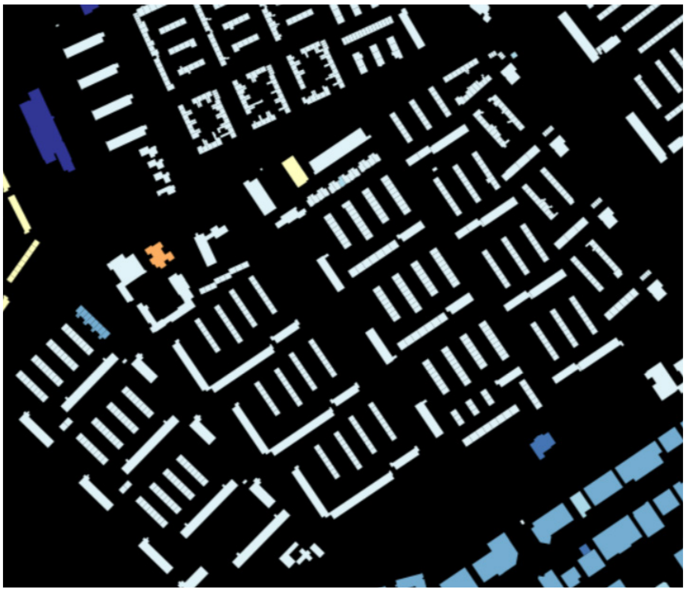
Pendrecht, Rotterdam

source:google maps

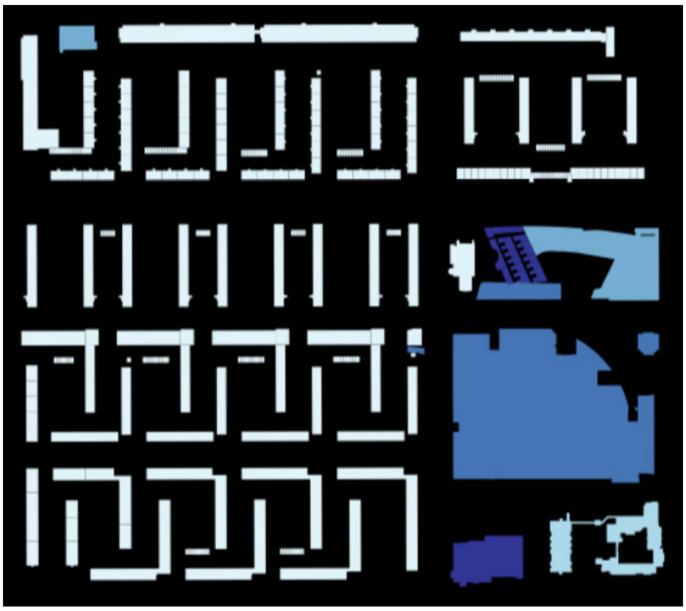
source: http://code.waag.org




Europawijk, Haarlem




Presikhaaf III, Arnhem




Amsterdam Zuid, Amsterdam

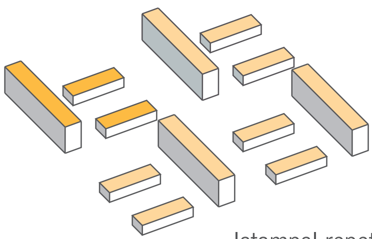
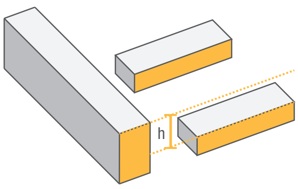
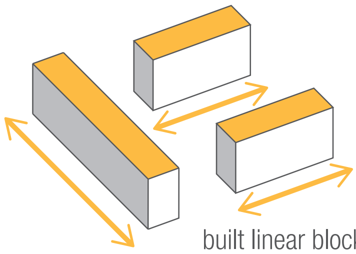
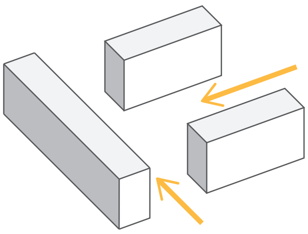
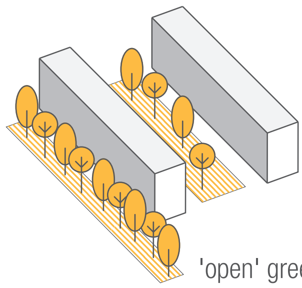
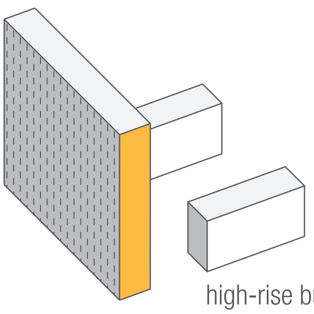
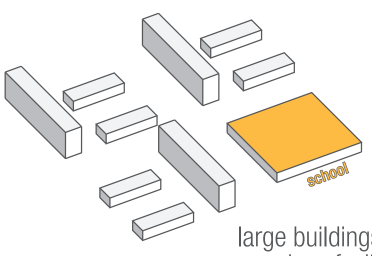
source: http://code.waag.org

source:google maps

6.1.2. DUTCH POST-WAR NEIGHBOURHOODS: TYPOLOGY

The description of the post-war construction period gives a clear image of specific morphological qualities that are repeated. Of course from country to country or even neighbourhood to neighbourhood, there are differences, but the unique characteristics of this era make possible the extraction of some significant similarities. Modernism as a prevailing architectural movement, the CIAM as a means of spreading it, indistrialization of construction as a process of simplification and automation, and the steep housing needs as an almost universal overhanging demand, are some of the key factors that led to these similarities.

Therefore a table of morphological characteristics is created by the author with expicit references to different principles that have been analysed in the previous part. Those qualities are used as the basis for the proposal of design patterns that follows in the chapter of Design Patterns.

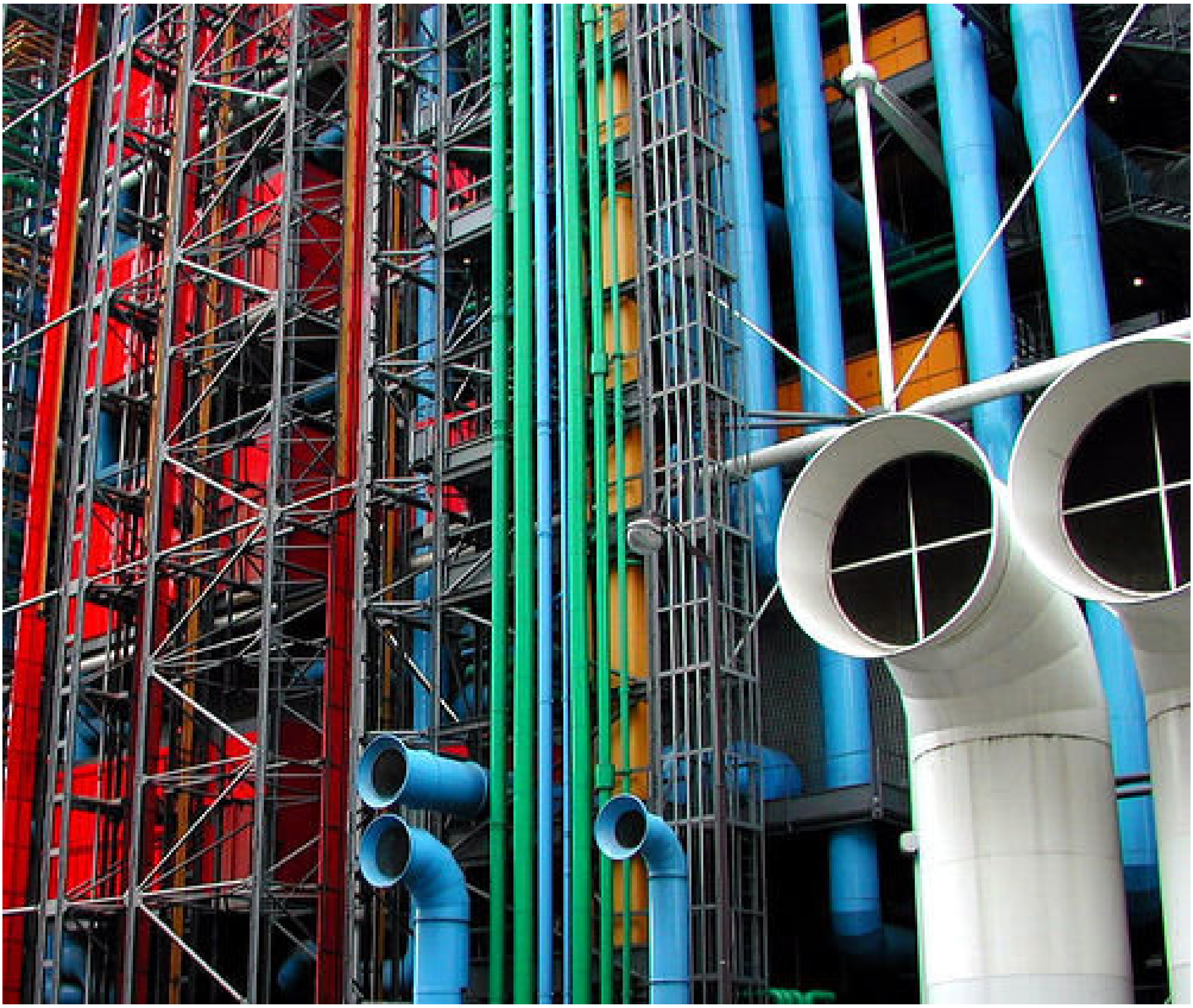
scales	Morphological qualities	Modern city principles	Dutch post-war principles
neighbourhood	 'stamps' repetition	¬ steep housing needs after the war ¬ prefabricated materials/building elements ¬ expansion to outskirts of cities - a lot of free space to be planned and built	¬ stamps included different housing types ¬ therefore, height irregularities and interchange of blocks and garden houses ¬ aim: social mixing of neighbourhoods
urban block	 height irregularities: mid-rise blocks & low-rise row houses	¬ from the art of the facade to the art of space	¬ wijkgedacht ¬ idea of social mixing ¬ living in the same neighbourhood all your life ¬ 'ritme' - 'ruimtekunst'
	 built linear blocks of different orientations	¬ from the art of the facade to the art of space ¬ simple geometries rhythmically arranged in open space	¬ post-war residential areas planned on polder land and according to their structure ¬ therefore, mostly two orientations, perpendicular to each other
	 'openess'	¬ (again) reaction to unhealthy cities ¬ more air and sun	
	 'open' green spaces	¬ nature as initiator of urban form ¬ reaction to unhealthy medieval cities ¬ more air and sun	
stamp	 high-rise buildings - towers	¬ Le Corbusier's idea of cities on towers to give space to nature ¬ central heating and elevators (late post-war period: late 60s, early 70s)	¬ gas in Slochtern ¬ gas pipelines through the country (60s)
building	 large buildings for various facilities	¬ zoning ¬ functionalism	

6.2. WORLDWIDE ADAPTATION AND INHERENT UNSUSTAINABILITY

Fig. Villa Savoye: ribbon windows; these windows not only provided rooms with equal light but also restored the possibility for well lit houses for northern climatic zones. (source: wikipedia)

Modernism and the modern city principles emerged as a reaction to the medieval city. The compactness of the old European cities, the sewage system, the lack of green and the narrow streets that hindered the natural ventilation of the city air. All those issues created many health hazards for the citizens and – along with the rapid urbanization that started in the 19th century due to the industrial revolution – cities became unhealthy and stressful environments to live in. Therefore, *Le Corbusier and the modern movement* preached for the value of openness, of natural air ventilation, the ideal of a coexistence of buildings and nature. The new building techniques and materials allowed for the model of living vertically in "towers" with intermissions of open green spaces with tall trees that allowed for shadow during the summer and for the feeling of nature for the urban dweller. Elevators made possible for the towers to grow in height without causing any discomfort to the residents; central heating systems raised the comfort levels for these kind of high residential buildings even more; and new building materials allowed for large windows that allowed the light to enter even to the lower storeys. According to Le Courbusier "The history of architecture is the history of the struggle for light" (Mayer, Bhatia, 2010). Le Corbusier's saying is related to the window and the role that technology played in creating ribbon windows that allowed for more light to enter the building. In general that was an era where technology thrived and architects came across many new possibilities which came in stark opposition to the ill-considered legacy of the medieval city.

So, the basic principle of modernism for light and air was mostly a reaction towards the "illnesses" that the medieval city had bestowed, but they were not really referring to light and air in terms of climate. On the contrary, the technological advances that enabled these crucial improvements in architecture, were also the ones that made *architects disregard climate* much more. Mechanical systems implemented on buildings made possible the existence of a completelly fabricated and artificial indoors climate. The fascination for those opportunities can be seen in words and actions of many architects even many years after the modernism era. For instance, the centre Georges Pompidou by Piano, Rodgers and Franchini, constructed in the 70s, is a perfect example of this mindset. It is a building with "a skin of infrastructure"; it is a display of how a mechanical system can


A skin of infrastructure; Centre Pompidou (hotelswelove.com)

render walls and insulation unnecessary. In fact, this logic it has not been foreshaken yet, even in the 21st century with the knowledge of the energy these artificial climates consume and with the upcoming climate change. Examples such as the Ski Dubai can be found around the globe making this point perfectly clear. The words of Reyner Banham can offer a witty insight into how this mindset is in the end linked to unsustainability as an inherent of the post-war building and planning tradition:

"For anyone who is prepared to foot the consequent bill for power consumed it is now possible to live in almost any type or form of house one likes to name in any region of the world that (one) takes fancy"

However, to return to the post-war period and the phenomenon of its residential areas, there are a few additional elements which led to the development of such inherently unsustainable areas around the world. Significant in order to understand the actual role of modernism in this, is that after WWII it changed from an idealistic movement to a development of prototypes that would answer to the stark needs of humanity around the world. Indeed the end of the war found many countries in a physical, economic and social reconstruction phase. Modernists found themselves obliged to contribute to this phase on a global scale and with the 6th CIAM meeting (1947) those ideas spread. This formed prototypes which, combined with the european education of many architects from around the globe, led to a period of *misapplication of european prototypes*. Especially in countries of South America and Africa (Barker, 2017) but also in countries of different climatic zones even within Europe – Spain, Former Yugoslavia, France, Greece, etc. Before WWII modern architeture was already spreading across Europe but it was adapting to local conditions, amongst which, to climate. After the war the needs for housing along with the technology that enabled prefabricated parts to be massively produced and then assembled on site, contributed to simplifying and speeding up the process of planning and building. The materials used lacked in insulation and the provision for the energy needs to heat those residences was also lacking since mechanical systems were considered the panacea.

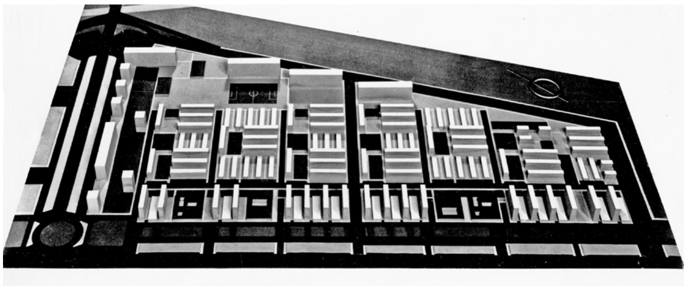
The elements described above constitute the inherent unsustainability of post-war neighbourhoods as defined in the current thesis. *Inherent unsustainability* is therefore defined as a state of the built environment that condemns it to be energy unefficient due to design and planning decisions which disregarded the local conditions and climate. Eventually this resulted in a negative response of the built environment to the local climatic conditions that in order to decrease energy needs for space heating you need to make structural trasformations.

Ski Dubai: ski resort in Dubai, a city with tropical desert climate (source: commons.wikimedia.org)

Pendrecht, Rotterdam

Sarcelles Locheres, near Paris

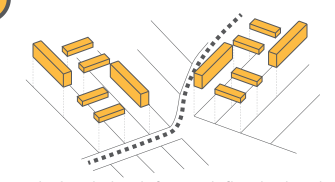
New Belgrade, Former Yugoslavia

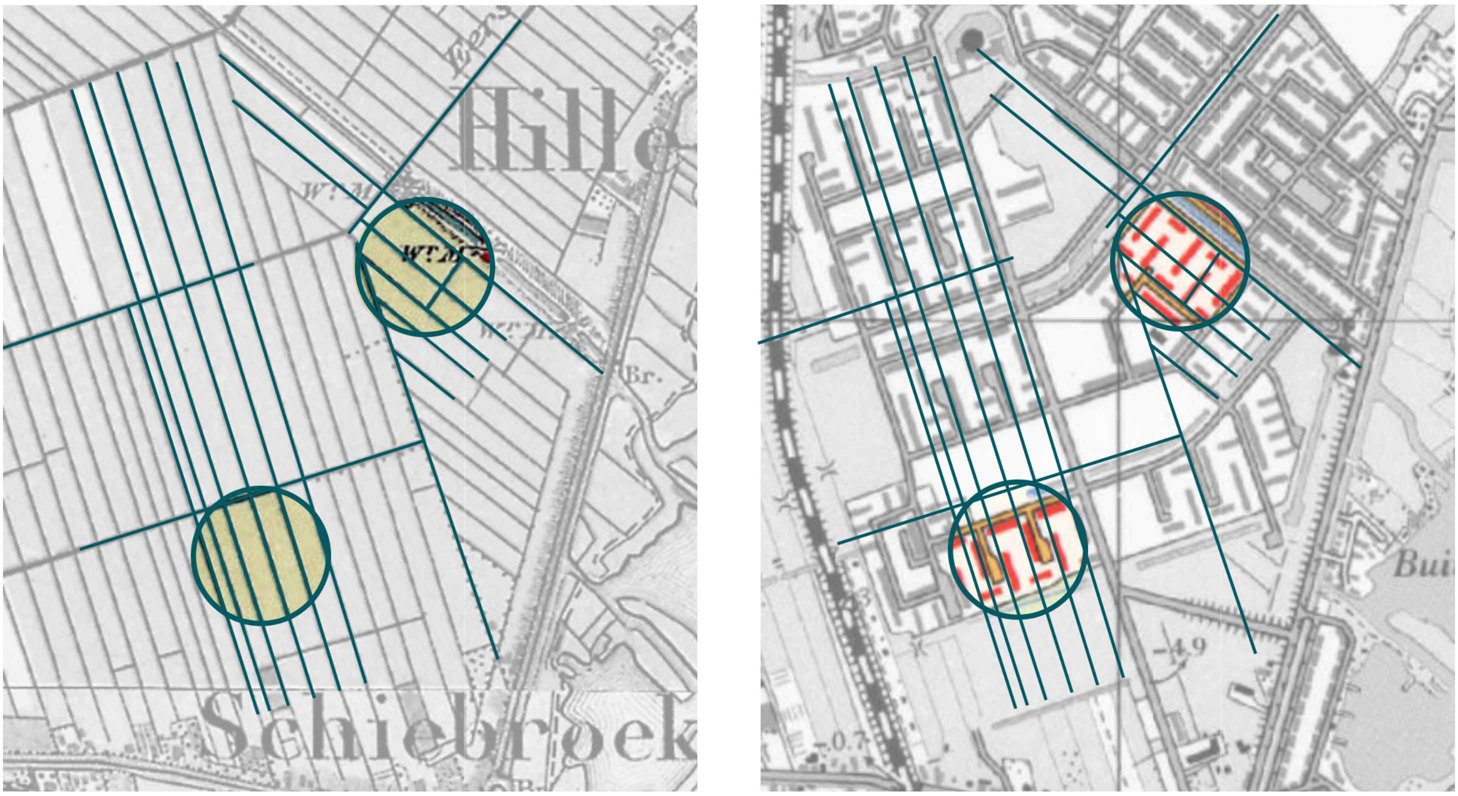


Model of Sudoeste del Besós, Barcelona

This inherent unsustainability of post-war neighbourhoods can be seen in most such neighbourhoods around Europe. But even in northern countries, where the post-war modernistic prototype initiated from and it is supposed to be adapted to the local climate, there are planned and built in disregard to climate. The reason for that is that planning and design decisions were made based on other factors and not local climate. If we take into consideration, for instance, how these neighbourhoods were planned expanding to free spaces around the existing city, the basic idea was to *build on available land by adjusting to existing structures*. So in the case of the Netherlands, polder lands surrounding the existing cities were used for new housing and their land structure defined the position and orientation of urban blocks and buildings. This can also be seen in Schiebroek (the case study of this project), where the orientation of the buildings changes according to the existing structure (infrastructure, polders).

In order for the aforementioned problematic of planning and design to become more comprehensible, one needs to bare in mind what has already been described as core characteristic of post-war housing projects: the logic of the stamp and the role of housing corporations. The speed in which these housing projects were done, the top-down planning process and the central management of the few housing corporations, made necessary the existence of a repetitive method that could be replicated *not only within a neighbourhood but also in different neighbourhoods, in different cities*, all centrally planned and in the control of the same corporations. The logic of the stamp depicts exactly this automated process; with minimal variations the stamps were replicated within a neighbourhood. A process that because of its very nature of simplifying the planning process, it ended up oversimplifying it, ignoring in this way local settings that can differ significantly. Indeed we can see the same structure repeating itself along with the same materials across the Netherlands – Amsterdam Zuid, Rotterdam, Haarlem, Nijmegen, Arnhem, etc (see following page).

scales	Morphological qualities	Modern city principles	Dutch post-war principles	Connection with Matr
neighbourhood	 roads & existing infrastr. defined planning	¬ streets dominated the structure of the city as cars became the main transporta-tion	¬ polders located on the outskirts of cities as the main structures for new residential areas	ENERGY USE



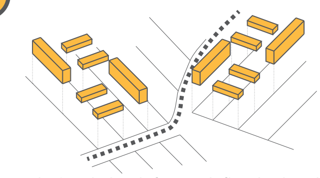
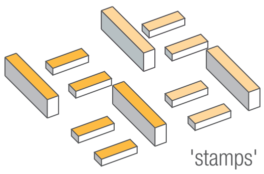
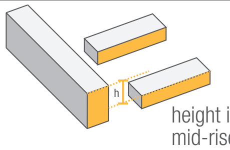
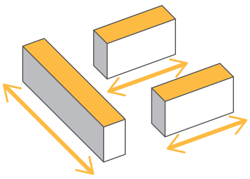
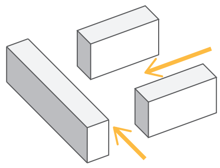
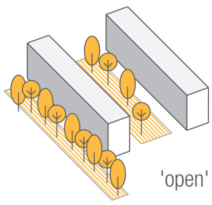
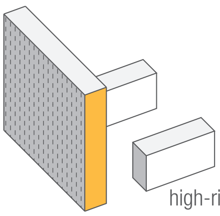
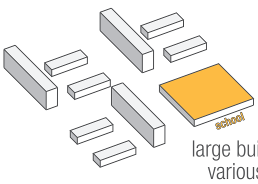
Schiebroek Zuid in 1900s (left) and in 1965 (right); the structure of the polders and the orientation of the canals is what determined the orientation of the post-war residential blocks. (source: background image by topotijdreis.nl and edited by author)

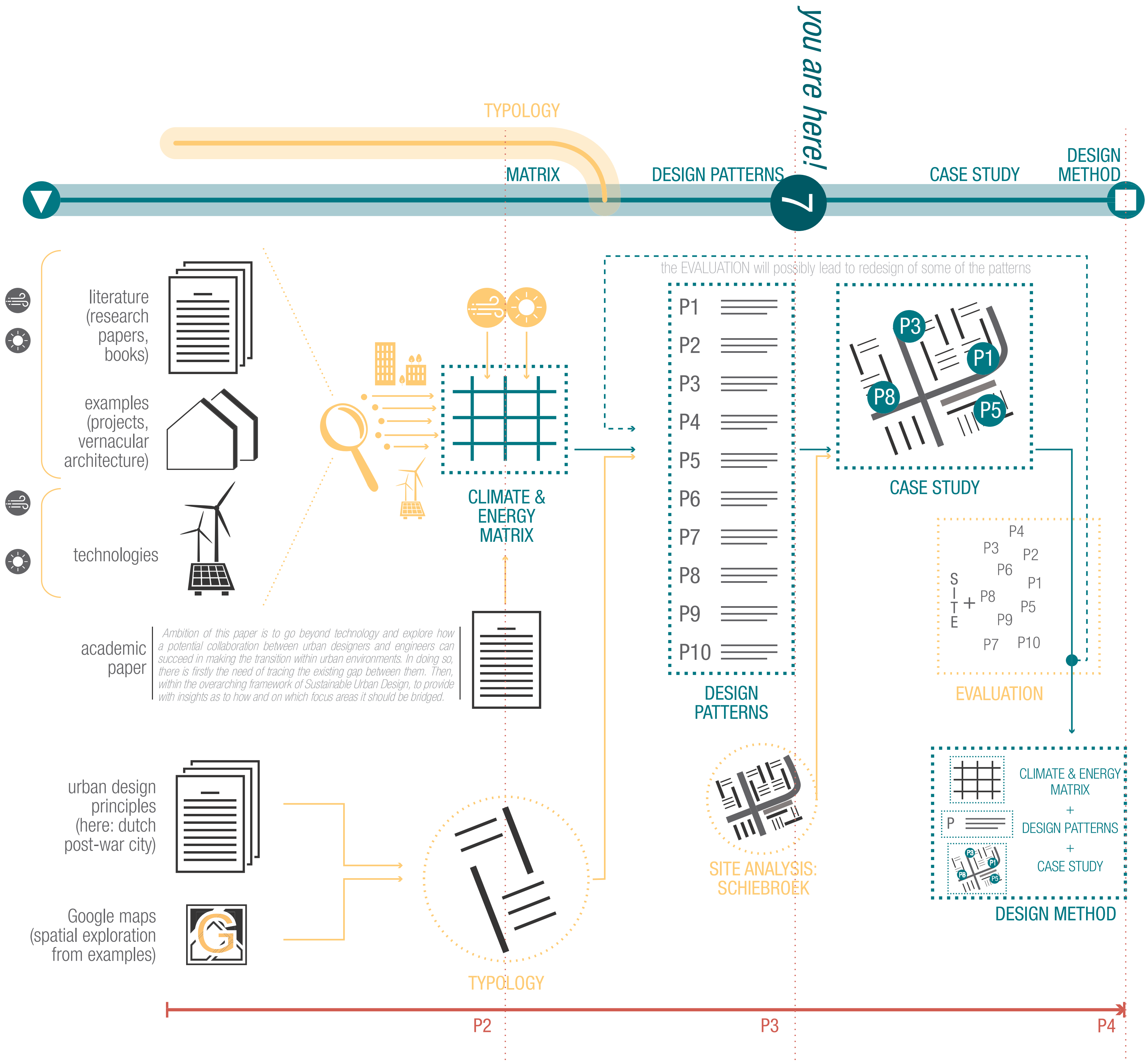
__Inherent unsustainability__
is (therefore) defined as a state of the built environment that condemns it to be energy unefficient due to design and planning decisions which disregarded the local conditions and climate.

6.3. CONCLUSION: THE SIGNIFICANCE OF LOCAL CONDITIONS

The inherent unsustainability along with social issues steming from the failure of the social mixing model, create the urgency for changes to take place in most of these neighbourhoods. As it has already been pointed out any kind of spatial interventions should remedy the mistake of not taking the local climate into consideration. However the importance of the local element in any intervention does not stop with climate. Many urban renewals disregard both the buildings by planning to demolish them, as well as the urban structure.

In this project urban renewal is viewed from a different perspective that favours preservation of what is local and existing – when and where this is possible of course. The reason for this choice is twofold; firstly, in terms of sustainability any unnecessary demolitions and reconstruction means spending energy and resources, so when there is another option it should be favoured. Secondly, apart from the problems that post-war neighbourhoods seem to pose, we should resist to the cliche of seeing them as merely problematic areas that need to be demolished (ICOMOS, 2003). Apart from the fact that they could be considered a cultural heritage that shouldn't completely vanish, they were based on spatial principles of specific values. The idea of openness, interchange between built and green, the light and air that made them healthier than the traditional city gives them a certain value that it shouldn't be entirely dismissed but radically improved.

scales	Morphological qualities	Modern city principles	Dutch post-war principles	Connection with Matrix
neighbourhood	 roads & existing infrastr. defined planning	¬ streets dominated the structure of the city as cars became the main transportation	¬ polders located on the outskirts of cities as the main structures for new residential areas	ENERGY USE
	 'stamps' repetition	¬ steep housing needs after the war ¬ prefabricated materials/building elements ¬ expansion to outskirts of cities - a lot of free space to be planned and built	¬ stamps included different housing types ¬ therefore, height irregularities and interchange of blocks and garden houses ¬ aim: social mixing of neighbourhoods	
urban block	 height irregularities: mid-rise blocks & low-rise row houses	¬ from the art of the facade to the art of space	¬ wijkgedacht ¬ idea of social mixing ¬ living in the same neighbourhood all your life ¬ 'ritme' - 'ruimtekunst'	ENERGY USE DENSIFICATION (POTENTIAL)
	 built linear blocks of different orientations	¬ from the art of the facade to the art of space ¬ simple geometries rhythmically arranged in open space	¬ post-war residential areas planned on polder land and according to their structure ¬ therefore, mostly two orientations, perpendicular to each other	ENERGY USE DENSIFICATION (POTENTIAL)
	 'openess'	¬ (again) reaction to unhealthy cities ¬ more air and sun		ENERGY USE DENSIFICATION (POTENTIAL)
	 'open' green spaces	¬ nature as initiator of urban form ¬ reaction to unhealthy medieval cities ¬ more air and sun		ENERGY USE DENSIFICATION (POTENTIAL)
stamp	 high-rise buildings - towers	¬ Le Corbusier's idea of cities on towers to give space to nature ¬ central heating and elevators (late post-war period: late 60s, early 70s)	¬ gas in Slochteren ¬ gas pipelines through the country (60s)	ENERGY USE ENERGY PRODUCTION
building	 large buildings for various facilities	¬ zoning ¬ functionalism		ENERGY PRODUCTION


TYPOLOGY
MATRIX
DESIGN PATTERNS
you are here!
7
CASE STUDY
DESIGN METHOD
literature (research papers, books)
examples (projects, vernacular architecture)
technologies
academic paper
Ambition of this paper is to go beyond technology and explore how a potential collaboration between urban designers and engineers can succeed in making the transition within urban environments. In doing so, there is firstly the need of tracing the existing gap between them. Then, within the overarching framework of Sustainable Urban Design, to provide with insights as to how and on which focus areas it should be bridged.
urban design principles (here: dutch post-war city)
Google maps (spatial exploration from examples)
CLIMATE & ENERGY MATRIX
TYPOLOGY
the EVALUATION will possibly lead to redesign of some of the patterns
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
DESIGN PATTERNS
SITE ANALYSIS: SCHIEBROEK
P3
P1
P8
P5
CASE STUDY
P4
P3
P2
P6
P1
S I T E + P8
P5
P9
P7
P10
EVALUATION
CLIMATE & ENERGY MATRIX
+
DESIGN PATTERNS
+
CASE STUDY
P
DESIGN METHOD
P2
P3
P4

7

DESIGN PATTERNS

7.1. DESIGN PATTERNS AND THEIR ROLE

The theory of design patterns and pattern language, launched by Alexander, has ever since found various different applications, in various fields and it has also faced compliments and critiques. It is therefore important when we are using this theory or tool, to be aware and clear as of the reason and the way we use it. In the current project design patterns are used as a catalogue of innovative design solutions trying to bridge the gap between engineering-technology and design in order to provide design solutions towards the urban energy transition. However those design solutions *should not be seen as fixed design proposals but as spatial guidelines and innovative ideas* meant to inspire designers. As Christopher Alexander says "*Each pattern describes a problem that occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice.".* This phrase describes the intention of the current project in the use of patterns. The aspiration of the author is to collect and fashion innovative design solutions, show possible ways of incorporating them in the urban environment, and in the end inspire designers to use them and design them in various ways.

It is important to point out that on one part, engineering and technologies can technically facilitate the energy transition, and on the other part that ideas – especially related to energy productive spaces – are already taking place around the world. Therefore partially *what is missing is an organisational structure* that can identify the spatial elements, the added value as well as the technological fixes. This structure helps in navigating through different renewable technologies and not only choosing the most appropriate for each situation but also in showing how the resulting productive landscape can have both an aesthetical quality and a use for the urban dweller. As with energy production, energy use is linked – in this case – with physics and engineering principles that are already in place. Those principles are part of the matrix, however, since they are less pursued than technological fixes, their practical translation and adaptation in an existing urban environment remains mostly an unknown ground. To cover this ground the design patterns *identify, in the case-specific example of post-war neighbourhoods, the problematic and exhibit a way of implementing the optimum on the existing morphology*.

This structure can help urban designers to speed up the process of individual neighbourhood energy transitions which could then contribute to the urban energy transition. In order to move towards this direction, it is necessary to escape from the individual solutions and to *discover the synergies between them as well as the possiblities for upscaling of smaller design patterns* (sub-patterns). In this way there can be an impact on the urban scale. Impact much needed if we are to talk about urban energy transition. Therefore the design patterns are subdivided into groups, main and sub-patterns and finally the synergies between them are exhbited.

"The elements of this language are entities called patterns. Each pattern describes a problem that occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice."
Christopher Alexander

sources: Mostafavi et al, 2010; IaaC, 2017; postfossil.city

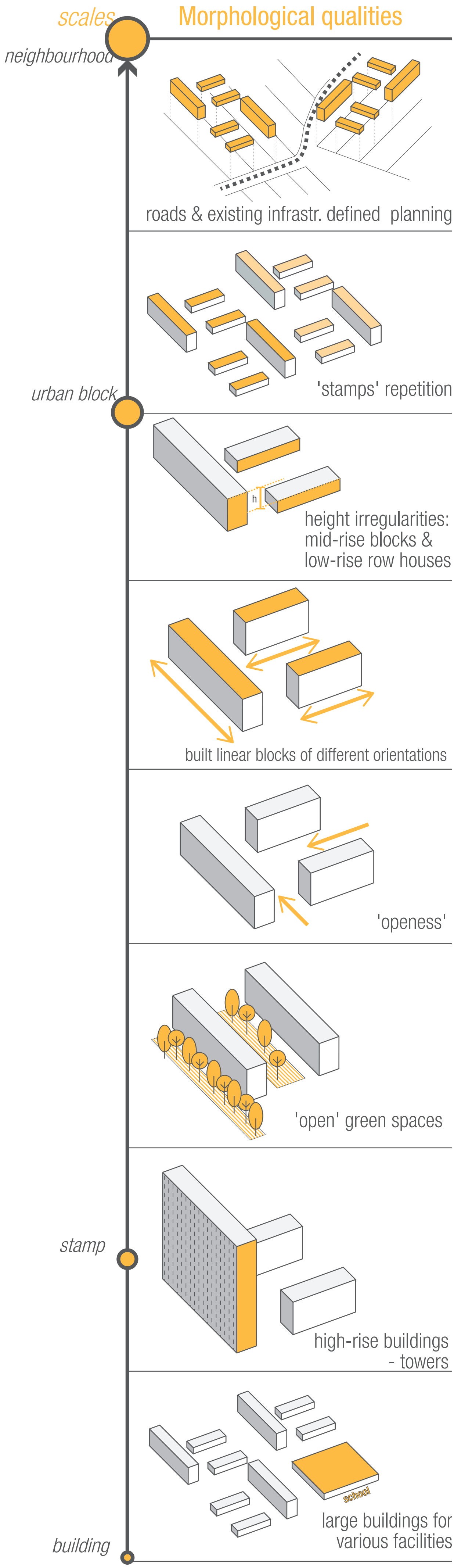
	CLIMATIC CONDITIONS FOR DUTCH CLIMATE (temperate maritime climate influenced by the North Sea)	WIND PATTERNS: WINTER [MAIN FOCUS] moderate winters -cold & strong wind from North Sea	WIND PATTERNS: SUMMER [ACCOUNTED FOR] cool summers -sea breeze	WIND PATTERNS: SOURCES	SOLAR RADIATION: WINTER [MAIN FOCUS] moderate winters -cloudy; less solar radiation	SOLAR RADIATION: SUMMER [ACCOUNTED FOR] COOL SUMMERS	SOLAR RADIATION: SOURCES
URBAN MORPHOLOGY [QUALITIES] – ENERGY USE	**-district/neighbourhood**			[1] Oke, 1987; [2] Jurelionis, Bouris, 2016; [3] Eumorfopoulou, Kontoleon, 2009; [4] Salat, 2014			[14] McPherson et al., 1988; [15] Olygay et al., 2015; [16] Scott, Ben-Joseph, 2012; [4] Salat, 2014
	urban block morph.: heights	min. height irregular., avoid tall buildings					
	urban forest	urban forest (for fully exposed blocks)[I]	not perpendicular to summer breeze				
	street & open sp. orientation	perpendicular or sidewards to the wind					
	high housing density						
	-urban block/street						
	urban block morph.: form	(1) paral. rows of linear blocks/elong.forms			(1) free arr. of linear blocks/elong. forms		
		(2) perimeter blocks			(4) T-shaped/cross forms		
		(3) compact form					
	vegetation	evergreen rows of trees, perpend. to wind[I]	summer breeze direction: no vegetation		deciduous trees: solar access for winter, shadow for summer		
	orientation	perpendic. or sidewards (45º) to the wind				tree rows parall. to W faces	
	width street ratio: Height/Width	H/W ≥0.65[1]	parallel or sidewards (45º)		H/W≤2 (traditional deep canyon),	high dens. in open spaces; blocks facing E-W, united with atrium	
	density & solar exposure	infill where H/W≤0.65 (to achieve skimming flow and avoid wake interfer.)			by densif. keep H/W as low as possible; blocks facing E-W, united with atrium		
	-building (parcel)						
	orientation	wind perpendicular to long surface			East-West (length), pref. unilateral plan[IV]	west side closed[IV]	
	vegetation	trees & plant-covered walls (cavities)[II]	summer breeze: no veg.		S&E surfaces: no/deciduous trees	trees W surf. & green roofs[V]	
	bulding plan (envelope)		depth <6m; for nat.ventilat.[4]		depth<6m; for solar access[4]		
	infill development AND dense & energy efficient h.typ.	open spaces (no tall buildings & ideallly in low H/W) & protected from wind effect			on west, north or without solar access building faces & sunrooms (building's facades with insufficient solar access)	minimum increase of roof surface	
URBAN MORPHOLOGY [QUALITIES] – ENERGY PRODUCTION	1 technology	HAWT (Horizontal Axis Wind Turbines)		[5] Wang et al., 2017; [6] Bell et al.,n.d.; [7] Guzzetta et al., 2007; [8] Smith et al., 2012; [9] Micallef et al., 2016 [10] Park et al., 2015 [11] Ledo et al., 2011; [12] Korprasertsak & Leephakpreeda, 2015; [13] Dekker, 2012	PV panels & parabolic collectors	parabolic rooftop collectors	[17] Mostafavi et al., 2010; [16] Scott, Ben-Joseph, 2012
	orientation	windward (WT adjustable)			South to East	South to West	
	location	mid- & high-rise build., towers open sp.			mid- & high-rise build.	mid- & high-rise build.	
	morphology	roof (optimum type: curved)			unshaded and spacious rooftops (prefer. on non-residential build.)	shaded roofgarden/patio	
	2 technology	VAWT or micro-wind turbines or IRWES[13]			solar roads & paths		
	orientation	windward (only for micro-wind)			---		
	location	high- & mid-rise build. (possible for low)			infrastructure & public space		
	morphology	flat roof, corners & facades			away from buldings (low dens. vegetation)		
	3 technology	ducted wind turbines			thin-film solar (textile)	thin-film solar (textile)	
	orientation	windward (fixed position)			South to East (120-degree range)	South to West	
	location	high-rise build.			mid- & high-rise build.	build. & open spaces	
	morphology	flat roof			large vertical blind facades	rooftops (summer terraces)	
	4 technology	savonius VAWT or Binopterus VAWT			see-through transparent solar panels		
	orientation	independent of orientation			South to East		
	location	bus stops, shelters, roof patios - open sp.			buildings		
	morphology	VAWT with wind booster system (vanes) are appropriate for low winds[12]			balconies and windows		
	5 technology	Kite power systems					
	orientation	independent of orientation					
	location	mid- & high-rise build.					
	morphology	independent					

I. low density vegetation (e.g. single row) acts as a "cushion" and doesn't create lee eddy, high density vegetation (e.g. urban forest) protects from wind penetration but creates lee eddy
II. for protection from lee eddy (windward face of succeding building & tall buildings)
III. uni-directional: turbines to the WSW of the building
IV. other possibilities: weighted or multilateral (also compatible with T-shaped built forms), buildings should be open to south and southeast for winter solar gain and closed on west sides for protection from summer sun
V. Shade screens is another idea that could be either be combined with vegetation or with photovoltaic panels (Scott, Ben-Joseph, 2012: 217)

7.2. EXTRACTION OF PATTERNS: MATRIX & TYPOLOGY

In chapter 5, though various different sources, a table (see opposite page) with optimum morphological characteristics for wind protection and solar gains (energy use), and renewable technologies along with the optimum morphology for maximum energy generation (energy production). This table works as a guideline when looking at the table of morphological qualities of dutch post-war neighbourhoods (figure on current page) which were concluded in chapter 6. In both tables the scale is of crucial importance in order to correspond the two and to successfully take the step towards the design patterns.

In order to show how the design patterns are extracted, there will be separate reference to the energy use and the energy production. Starting from energy use, the process starts with looking into the optimum morphological qualities of the matrix and then comparing them with the morphological qualities of dutch post-war neighbourhoods. In this way it becomes clear what kind of problems in relation to energy use any dutch post-war neighbourhood might be facing. For instance, in the matrix it is clear that height irregularities are undesireable due to their negative effect on wind behaviour – for more detailed reasoning see chapter 5, page 48. Then in the typology height irregularities – coexistence of low- and mid-rise buildings within the same stamp even – exists as one of the key characteristics of dutch post-war neighbourhoods. The next step of this process is by looking at the optimum to come up with design solutions adapted to the situation in hand. These solutions are essentially the design sub-patterns. However in order to make the design solutions comprehensible and handy for a designer, there is a need to – where possible – build on the commonalities of some of the different problems and present them in one structure. This is in the end the design pattern as proposed in the current project. Further details as for the inbetween relation of design patterns and sub-patterns is given in the next sub-chapter.



ENERGY USE

ENERGY PRODUCTION

DENSIFICATION (POTENTIAL)

URBAN MORPHOLOGY [QUALITIES]	CLIMATIC CONDITIONS FOR DUTCH CLIMATE (temperate maritime climate influenced by the North Sea)	WIND PATTERNS: WINTER [MAIN FOCUS] moderate winters -cold & strong wind from North Sea	WIND PATTERNS: SUMMER [ACCOUNTED FOR] cool summers -sea breeze	WIND PATTERNS: SOURCES	SOLAR RADIATION: WINTER [MAIN FOCUS] moderate winters -cloudy; less solar radiation	SOLAR RADIATION: SUMMER [ACCOUNTED FOR] COOL SUMMERS	SOLAR RADIATION: SOURCES
ENERGY USE	-district/neighbourhood			[1]Oke, 1987; [2]Jurelionis, Bouris, 2016; [3]Eumorfopoulou, Kontoleon, 2009; [4]Salat, 2014			McPherson et al., 1988; [15]Olygay et al., 2015; [16]Scott, Ben-Joseph, 2012; [4]Salat, 2014
	urban block morph.: heights	min. height irregular., avoid tall buildings					
	urban forest	urban forest (for fully exposed blocks)[I]	not perpendicular to summer breeze				
	street & open sp. orientation	perpendicular or sidewards to the wind					
	high housing density						
	-urban block/street						
	urban block morph.: form	(1) paral. rows of linear blocks/elong.forms			(1) free arr. of linear blocks/elong. forms		
		(2) perimeter blocks			(4) T-shaped/cross forms		
		(3) compact form					
	vegetation	evergreen rows of trees, perpend. to wind[I]	summer breeze direction: no vegetation		deciduous trees: solar access for winter, shadow for summer		
	orientation	perpendic. or sidewards (45º) to the wind				tree rows parall. to W faces	
	width street ratio: Height/Width	H/W ≥0.65[1]	parallel or sidewards (45º)		H/W≤2 (traditional deep canyon),	high dens. in open spaces;	
		infill where H/W≤0.65 (to achieve			by densif. keep H/W as low as possible;	blocks facing E-W, united	
	density & solar exposure	skimming flow and avoid wake interfer.)			blocks facing E-W, united with atrium	with atrium	
	-building (parcel)						
	orientation	wind perpendicular to long surface			East-West (length), pref. unilateral plan[IV]	west side closed[IV]	
	vegetation	trees & plant-covered walls (cavities)[II]	summer breeze: no veg.		S&E surfaces: no/deciduous trees	trees W surf. & green roofs[V]	
	bulding plan (envelope)		depth <6m; for nat.ventilat.[4]		depth<6m; for solar access[4]		
	infill development AND dense & energy efficient h.typ.	open spaces (no tall buildings & ideally in low H/W) & protected from wind effect			on west, north or without solar access building faces & sunrooms (building's facades with insufficient solar access)	minimum increase of roof surface	
ENERGY PRODUCTION	1 technology	HAWT (Horizontal Axis Wind Turbines)		[5]Wang et al., 2017; [6]Bell et al.,n.d.; [7]Guzzetta et al., 2007; [8]Smith et al., 2012; [9]Micallef et al., 2016; [10]Park et al., 2015; [11]Ledo et al., 2011; [12]Korprasertsak & Leephakpreeda, 2015; [13]Dekker, 2012	PV panels & parabolic collectors	parabolic rooftop collectors	[17]Mostafavi et al., 2010; [16]Scott, Ben-Joseph, 2012
	orientation	windward (WT adjustable)			South to East	South to West	
	location	mid- & high-rise build., towers open sp.			mid- & high-rise build.	mid- & high-rise build.	
	morphology	roof (optimum type: curved)			unshaded and spacious rooftops (prefer. on non-residential build.)	shaded roofgarden/patio	
	2 technology	VAWT or micro-wind turbines or IRWES[13]			solar roads & paths		
	orientation	windward (only for micro-wind)			---		
	location	high- & mid-rise build. (possible for low)			infrastructure & public space		
	morphology	flat roof, corners & facades			away from buldings (low dens. vegetation)		
	3 technology	ducted wind turbines			thin-film solar (textile)	thin-film solar (textile)	
	orientation	windward (fixed position)			South to East (120-degree range)	South to West	
	location	high-rise build.			mid- & high-rise build.	build. & open spaces	
	morphology	flat roof			large vertical blind facades	rooftops (summer terraces)	
	4 technology	savonius VAWT or Binopterus VAWT			see-through transparent solar panels		
	orientation	independent of orientation			South to East		
	location	bus stops, shelters, roof patios - open sp.			buildings		
	morphology	VAWT with wind booster system (vanes) are appropriate for low winds[12]			balconies and windows		
	5 technology	Kite power systems					
	orientation	independent of orientation					
	location	mid- & high-rise build.					
	morphology	independent					

7.3. DESIGN PATTERNS, GROUPS & SUB-PATTERNS

7.3.1. GUIDE FOR GROUPS, PATTERNS AND SUB-PATTERNS

In order to associate the optimum, provided from the matix, to the design patterns it is necessary to start the organisation of the patterns by dividing them to *groups*. The first two are directly connected to the matrix since energy use and energy production are the two clearly divided parts of it. Densification is a seperate groups for different reasons. Firstly it is an integral part of sustainability according to many different literatures and theories (Frey, 1999; Wheeler, 2000; Jabareen, 2006; Kenworthy, 2006; Farr, 2008; Larco, 2016) in terms of compactness, which is not only about creating a dense urban environment but also about populating it with a variety of land uses that will effectively decrease residents trips outside their neighbourhood. However, it needs to be pointed out that compactness is not panacea; on the contrary it can have nrgative results in terms of sustainability if not all surrounding factors are not taken equally into account. Therefore, in this project densification is mostly pursued in individual cases and only in connection with energy use. Another reason that densification is taken into consideration is that, as aforementioned, post-war neighbourhoods have the possibility to be densified and by doing so, there is a double benefit. Firstly, residents of different financial and social status can be attracted to these areas restablishing the social mixing that was originally intended for post-war neighbourhoods. And secondly it is an answer to the ever increasing urbanization rates, especially needed if we are opting for the future of the urban energy transiton.

DESIGN PATTERN GROUPS:

An important classification is between *design patterns and design sub-patterns*. Desing patterns are the outcome of comparing the optimums (matrix) with the existing situation (post-war neighbourhoods. This is the first step in order to apply the design patterns in any case study. The grouping process, apart from providing an organization without which the design solutions would be less comprehensible, is in its essence the pattern that a designer needs to use. So design sub-patterns are equivalents; they are part of the same design pattern and its problem statement, but they are important variations. In this way more ideas can be given to the designer in order to use them freely. Even though they are considered as variations, differences between sub-patterns do exist and should be taken into consideration. For this reason, in the end of each pattern, the sub-patterns are compared in a table as a tool to provide more information to the designer.

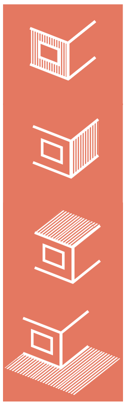
At this point it is important to clarify that *densification* is part of the patterns but it is not an individual pattern. It is desireable in terms of sustainability – in a wider sense as well as in energy-related sustainability – and in terms of urbanization, but in the design patterns densfication is proposed only in relation to energy use. Densification sub-patterns are proposed to provide solutions to energy use related issues, but they are given special attention and separate structure due to their complexity. So they are accompanied by an extra description that specifies how they are linked with energy use and some elements that should be looked into more carefully. This info alreasy exists in the matrix chapter (chapter 5) but it needs to be restated firstly because the patterns should be able to offer some basic information without the need for the detailed description of how urban morphology and energy use & production are connected. And secondly, because a more focused combination of principles for each densification sub-pattern is considered more helpful due to the fact that each new built form changes significantly the existing morphology.

ENERGY PRODUCTION	1	technology	HAWT (Horizontal Axis Wind Turbines)	[5]Wang et al., 2017; [6]Bell et al.,n.d.; [7]Guzzetta et al., 2007; [8]Smith et al., 2012; [9]Micallef et al., 2016 [10]Park et al., 2015 [11]Ledo et al., 2011; [12]Korprasertsak & Leephak-preeda, 2015; [13]Dekker, 2012	PV panels & parabolic collectors	parabolic rooftop collectors	[17]Mostafavi et al., 2010; [16]Scott, Ben-Joseph, 2012
		orientation	windward (WT adjustable)		South to East	South to West	
		location	mid- & high-rise build., towers open sp.		mid- & high-rise build.	mid- & high-rise build.	
		morphology	roof (optimum type: curved)		unshaded and spacious rooftops (prefer. on non-residential build.)	shaded roofgarden/patio	
	2	technology	VAWT or micro-wind turbines or IRWES[13]		solar roads & paths		
		orientation	windward (only for micro-wind)		---		
		location	high- & mid-rise build. (possible for low)		infrastructure & public space		
		morphology	flat roof, corners & facades		away from buldings (low dens. vegetation)		
	3	technology	ducted wind turbines		thin-film solar (textile)	thin-film solar (textile)	
		orientation	windward (fixed position)		South to East (120-degree range)	South to West	
		location	high-rise build.		mid- & high-rise build.	build. & open spaces	
		morphology	flat roof		large vertical blind facades	rooftops (summer terraces)	
	4	technology	savonius VAWT or Binopterus VAWT		see-through transparent solar panels		
		orientation	independent of orientation		South to East		
		location	bus stops, shelters, roof patios - open sp.		buildings		
		morphology	VAWT with wind booster system (vanes) are appropriate for low winds[12]		balconies and windows		
	5	technology	Kite power systems				
		orientation	independent of orientation				
		location	mid- & high-rise build.				
		morphology	independent				

DESIGN PATTERNS: LOCATION

- M — Mid-rise buildings (4-10 floors)
- L — High-rise buildings (≥10 floors)
- NR — Non-Residential buildings
- PS — Public spaces

DESIGN PATTERNS: MORPHOLOGY/SURFACES OF SENSITIVITY OR POTENTIAL



- facades
- blind walls
- rooftops
- 'open' space

Extra symbols are used in order to make the list of patterns easily legible. The *location* symbols are merely there to navigate easier through the patterns depending on what kind of buildings the case study consists of. The *morphology/surfaces of sensitivity or potential* are correlated to the building morphology of the matrix. Specifically in the energy production part of the matrix, the surfaces are incorporated in the "morphology" information of each technology. In the energy use, there is no explicit reference because the most important surfaces of sensitivity – that are also taken into account in the current project – are the facades of the buildings. The reason for that, is the fact that the apertures (windows) on the facades are the source for most of the energy loss but also for the solar gains. Exception of this rule only exists in pattern C as it will be exhibited.

Another intention of using symbols for surfaces in the patterns is to offer *a sense of the spatial synergies but also competitions*. Due to the fact that those design solutions in the end will be implemented on specific surfaces in space it can become easily imagineable that in the process of case study design decisions will have to be taken between competing sub-patterns.

		WIND	SOLAR
ENERGY USE		SURFACES/MORPHOLOGY LOCATION residential buildings DESIGN PATTERNS A,B	SURFACES/MORPHOLOGY LOCATION residential buildings DESIGN PATTERNS C
ENERGY PRODUCTION		SURFACES/MORPHOLOGY LOCATION M L PS DESIGN PATTERNS D, E, F, G	SURFACES/MORPHOLOGY LOCATION M L NR PS DESIGN PATTERNS D, E, F, G

The table above is a *conlusion table* that uses the structure of the matrix to show how all the elements that will be used in the patterns fit and are a part of the matrix. This helps make it easier *to trace back to the matrix* and in the next step to identify in the site which locations and surfaces need to be examined for sub-patterns to be applied. This step will be exhibited in the Case study in more detail.

Finally an *example* is exhibited here to make the structure of design patterns in this project more comprehensible – from pattern groups to patterns to sub-patterns and to the structure of the latter.

7.3.2. DESIGN PATTERNS CATALOGUE

A. FACADES EXPOSED TO PREVAILING WINTER WIND

Problem statement

Sides of building exposed to wind during winter have as a result significant loss of buildings' heat especially in the case of the poorly insulated post-war buildings. No or insufficient (deciduous) protection from vegetation is a common reason for exposure to wind. Also low H/W ratio for parallel rows results in wind's acceleration regaining. Meanwhile, parallel linear blocks with large open spaces inbetween them are common in dutch post-war neighbourhoods. Therefore high density barriers should be placed in the presence of main flow (full speed). Low density barriers are more appropriate in cases of wake interference or lee eddys.

B. WIND SPEED ACCELERATION DUE TO TUNNEL EFFECT

Problem statement

Parallel rows of buildings when oriented in parallel to the prevailing wind direction create an acceleration of the wind which in turn intensifies the negative impact of wind on building energy consumption. Therefore barriers should be placed to decrease, if not to block it entirely, the wind speed.

C. LACK OF PASSIVE HEATING

Problem statement

The optimum orientation of living spaces is facing south for solar passive heating. Indeed in some of the post war buildings the entrance is north so that living spaces can freely face the south. However it is also common for a 'stamp' to consist of different – often perpendicular to each other – orientated buildings. Therefore some buildings face E-W which is disadvantageous both for winter and summer moths. Therefore, where possible glazed spaces should be created to maximize passive heating during winter months and at the same time provide for cooling opportunities during summer. Where not possible or desireable, the possibility is given for infill development since there is already no solar exposure and densification is considered desireable.

D. UNUSED AND ENERGY-LACKING **ROOFTOPS OF RESIDENTIAL BUILDINGS**

Problem statement

Rooftops on residential buildings are under- or unused. In mid-rise buildings a combination of energy production and active use by residents is both desireable and possible.The height of mid-rise buildings shows lower wind speeds which means, on the hand specific technologies can only be productive, on the other hand they can be actively used by residents. Elements such as orientation, position, visual impact and combination with other uses, need to be taken into account for design decisions.

M

E. UNUSED AND ENERGY-LACKING **HIGH-RISE BUILDINGS' SURFACES**

Problem statement

In many post-war neighbourhoods there is a significant number of high rise buildings. The wind speeds at these heights are higher and unblocked by surrounding buildings, the same applies for sun on the higher floors.

L

F. UNDERUSED AND ENERGY-LACKING **PUBLIC SPACES**

Problem statement

The result of openess and zoning has been an abundance of public spaces for green or activities but are currently largely underused. These large and undefined spaces have the potential with the implementaion of various innovative technologies to be revitalized while contributing in lowering energy demand of buildings or more importantly in energy production.

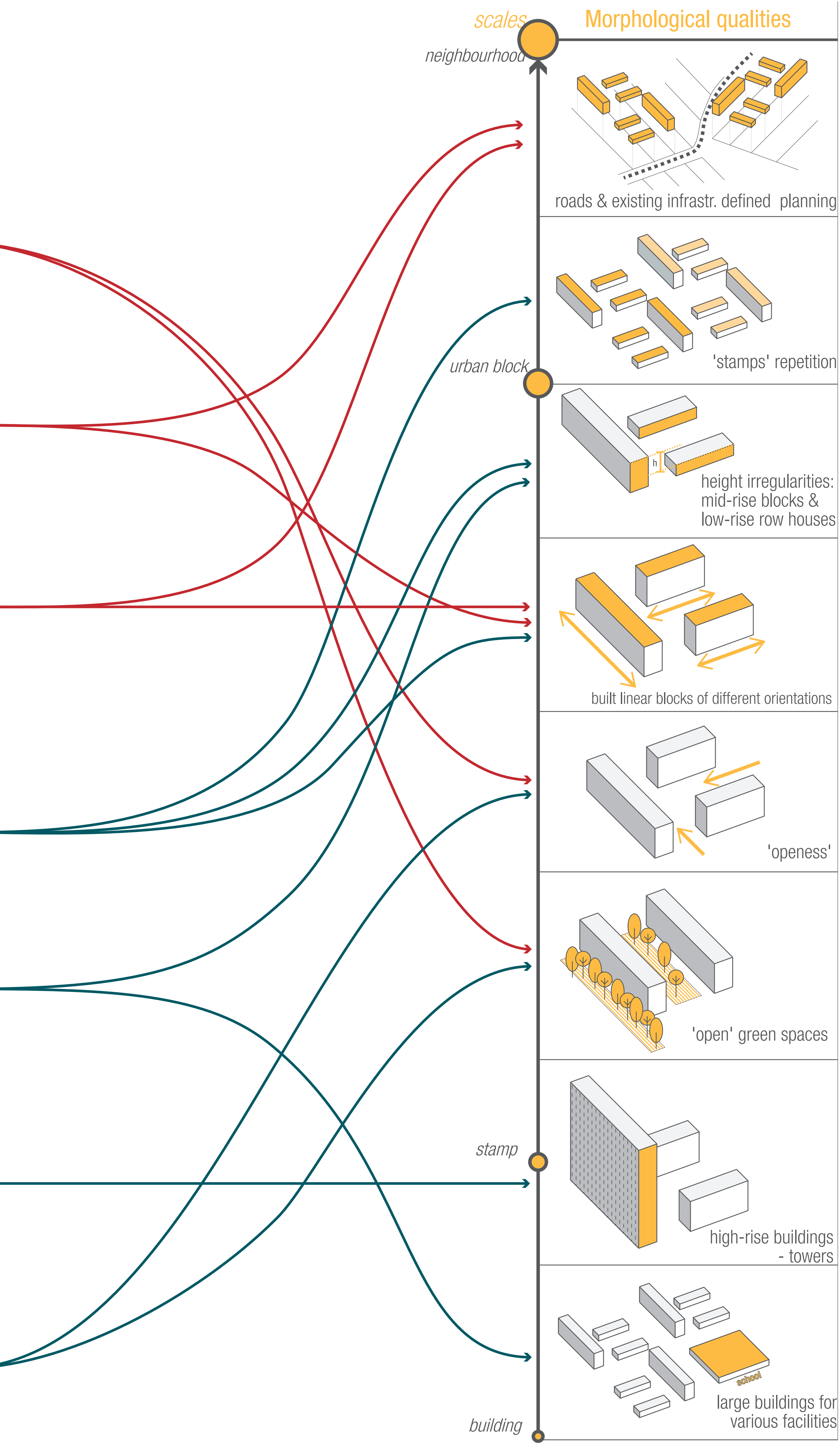
PS

G. SMALL OR UNPRODUCTIVE RESIDENTIAL ROOFTOPS

Problem statement

Rooftops on residential buildings can often be too small to produce enough energy or the circumastances might be unfavourable, such as shadow on single-family houses from blocks of flats. Public or commercial buildings located usually in the centre or orderly in relation to houses, usually have large rooftops appropriate for large installations of PV panels. Their location in relation to houses can serve well in connecting the houses to this more central installations.

NR



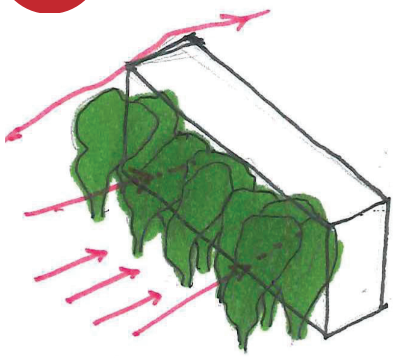
scales
Morphological qualities
neighbourhood
roads & existing infrastr. defined planning
'stamps' repetition
urban block
height irregularities: mid-rise blocks & low-rise row houses
h
built linear blocks of different orientations
'openess'
'open' green spaces
stamp
high-rise buildings - towers
school
large buildings for various facilities
building

A. FACADES EXPOSED TO PREVAILING WINTER WIND

Problem statement

Sides of building exposed to wind during winter have as a result significant loss of buildings' heat especially in the case of the poorly insulated post-war buildings. No or insufficient (deciduous) protection from vegetation is a common reason for exposure to wind. Also low H/W ratio for parallel rows results in wind's acceleration regaining. Meanwhile, parallel linear blocks with large open spaces inbetween them are common in dutch post-war neighbourhoods. Therefore high density barriers should be placed in the presence of main flow (full speed). Low density barriers are more appropriate in cases of wake interference or lee eddys.

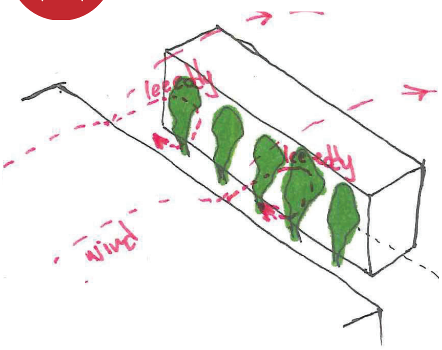
P1_URBAN FOREST



high density barrier

Reference
left: Azelia Residence (Bandar Sri Damansara, PJ)
right: The Court Square Press (Landworks Studio)

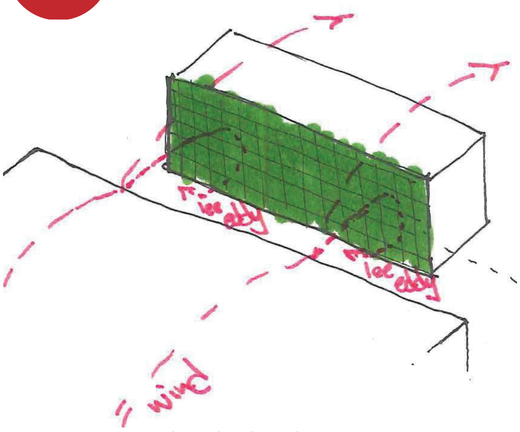
P2_EVERGREEN TREE ROW



low density barrier

Reference
Nieuw Leyden (MVRDV)

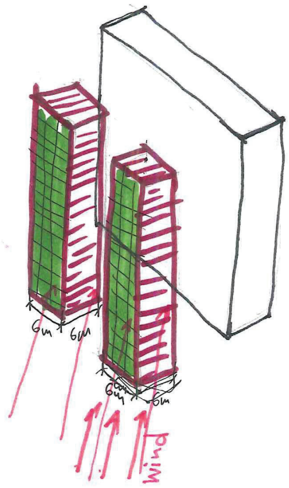
P3_'GREEN' WALLS



low density barrier

Reference
The greenscreen® trellis system of engineered mounting accessories is designed to hold greenscreen® trellis panels off the building surface, protecting the building's waterproof membrane from direct plant attachment and transferring the weight of the plants to the screen structure and the wall. Panels can be stacked side to side or top to bottom to cover larger areas.
Fishers Place Parking Structure Facade, Rockville MD (greenscreen)

P19_COMPACT FORM



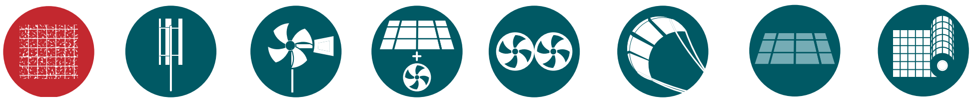
Description

Compact form – aka structure with minimum exterior surface and a roofplan analogy (width to length) of 1: 1.1-1.3 elongated on E-W axis – can sustain its inner heat better and if the width or legth remains under 10m it is easily heated. Therefore, and given current insulation systems and the incorporation of green walls, a line of compact towers can provide shelter for post-war high-rise buildings.

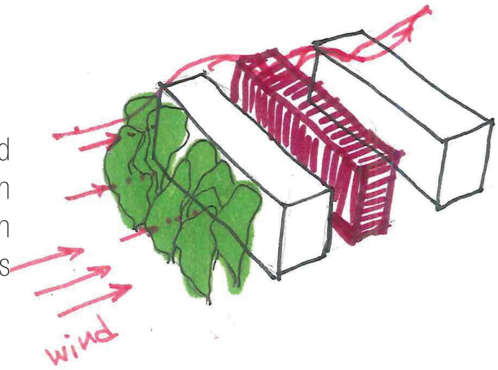
Neubau MFO-Park Zürich (Burckhardt+Partner AG, Raderschall Landschaftsarchitekten)

ReGen village vertical farming system (EFFEKT Architects)

Urban Farm at Pasona Tokyo Headquarters is a nine story high corporate office building (KONODESIGNS)



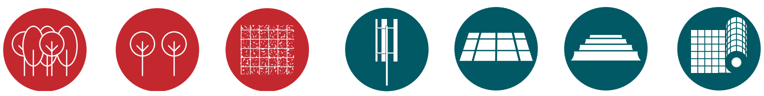
P20_PARALLEL ROWS DENSIFICATION



Description

The wind flow when encountering a hard-edged building (flat roof, vertical walls) is displced over the building which then functions as a shelter for succeeding buildings. However when the buildings set in parallel have large spacing in between them (low hight-to-width ratio) then the sheltering effect is lost. Densifying the in between space by adding a new row restores the sheltering effect.

Y:Cube (Rogers Stirk Harbour + Partners, YMCA London South West)



B. WIND SPEED ACCELERATION DUE TO TUNNEL EFFECT

Problem statement

Parallel rows of buildings when oriented in parallel to the prevailing wind direction create an acceleration of the wind which in turn intensifies the negative impact of wind on building energy consumption. Therefore barriers should be placed to decrease, if not to block it entirely, the wind speed.

P1_URBAN FOREST

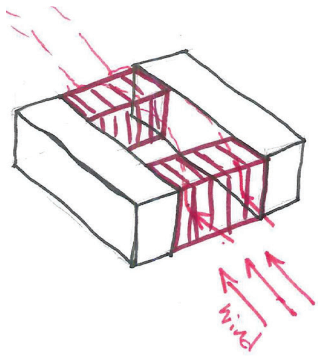
P2_EVERGREEN TREE ROW

P3_'GREEN' WALLS

P21_PARALLEL ROWS TO PERIMETER BLOCKS

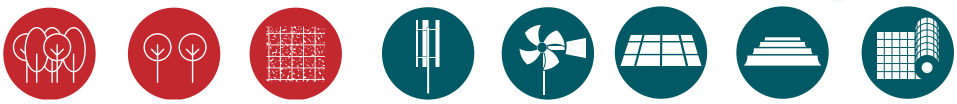
Description

Apart from blocking the prevailing wind, homogenous blocks show the best behaviour against wind in general (Jurelionis, Bouris, 2016). Only condition is for the infill blocks to have the same height as the existing ones.



Reference

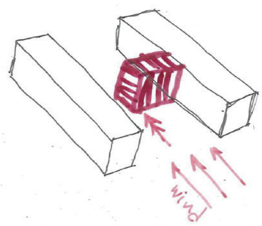
Aerial view of 'closed', homogeneous urban blocks in Zurich, Switzerland (Jurelionis, Bouris, 2016)



P22_T-SHAPED

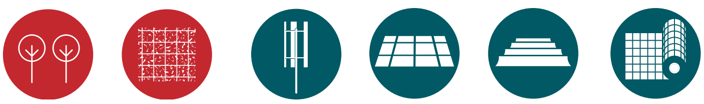
Description

This added volume apart from decreasing the wind speed, it offers a sheltering effect to the part succeding it in the course of the wind. If also combined with high density vegetation before the added volume, the wind will act as a skimming flow increasing the shelter.



Reference

Y-shaped bulding in Finsbury, London

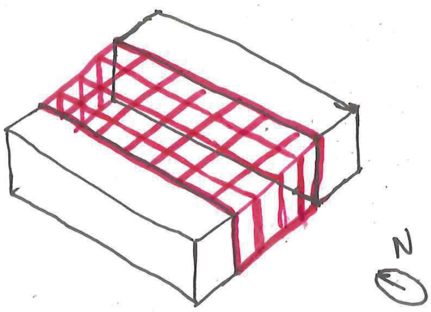


C. LACK OF PASSIVE HEATING

Problem statement

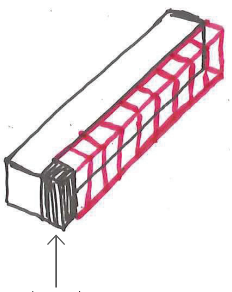
The optimum orientation of living spaces is facing south for solar passive heating. Indeed in some of the post war buildings the entrance is north so that living spaces can freely face the south. However it is also common for a 'stamp' to consist of different – often perpendicular to each other – orientated buildings. Therefore some buildings face E-W which is disadvantageous both for winter and summer moths. Therefore, where possible glazed spaces should be created to maximize passive heating during winter months and at the same time provide for cooling opportunities during summer. Where not possible or desireable, the possibility is given for infill development since there is already no solar exposure and densification is considered desireable.

P24_ATRIUM

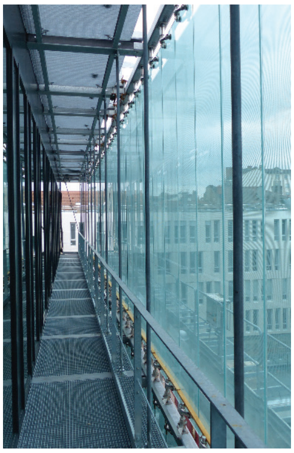


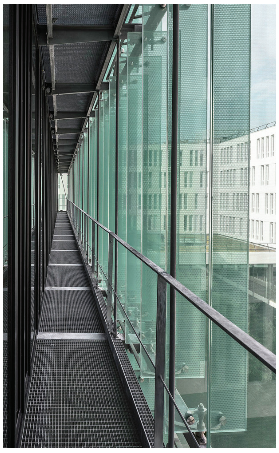
Reference
Bosch Siemens Hausgeräte (B/S/H/) in Hoofddorp; The ceiling of the atrium features building integrated photovoltaic panels. In addition a green living wall is part of the interior space. (source: inhabitat.com)

P25_SUNROOM



obstacle





Reference
University Centre "des Quais" in Lyon; vertical adjustable glass panels are integrated in the building thanks to an exterior structure. (source: archdaily.com)

P26_INFILL DEVELOPMENT

Description
Infill development essentially refers to densification so this is a complex sub-pattern that links to the 4 densification sub-patterns.

COMPARATIVE TABLE FOR ENERGY USE DESIGN SUB-PATTERNS

	BASIC ELEMENTS			EFFECT INFO		
	climatic condition	building size	morphology/ surface	density	effect on wind	restores H/W ratio
P1	wind	S & M		high	blocks	✓
P2	wind	S & M		low	decreases	✗
P3	wind	All		low	decreases	✗
P19	wind	L		high	blocks	✗
P20	wind	S & M		high	blocks	✓
P21	wind	S & M		high	blocks	✓
P22	solar	S & M		high	blocks	✓
P24	solar	All		-	blocks	✓
P25	solar	All		-	blocks	✗
P26	solar & wind	All		high	blocks	complex sub-pattern

blocks

decreases

COMPARATIVE TABLE FOR DENSIFICATION DESIGN SUB-PATTERNS

		P17_compact forms	P18_parallel linear blocks	P19_perimeter blocks	P22_T-shaped/cross forms
WINTER	wind protection	☺ ☺ ☺	☺ ☺	☺ ☺ ☺	☺
WINTER	solar gains	☺	☺ ☺	☹	☺
WINTER	heat preservation	☺ ☺ ☺	☺	☺ ☺ ☺	☺ ☺
SUMMER	all of the above into consideration	☺ ☺	☺	☹ ☹	▨

☺ works

☹ does not work

▨ irrelevant/unknown

Note
In this evaluation the appropriate orentation and position is assumed to be kept

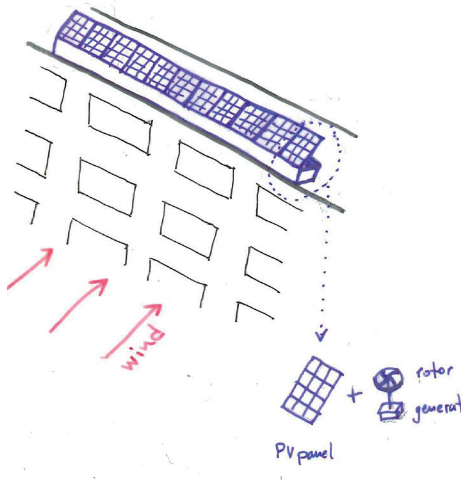
D. UNUSED AND ENERGY-LACKING ROOFTOPS OF RESIDENTIAL BUILDINGS

Problem statement

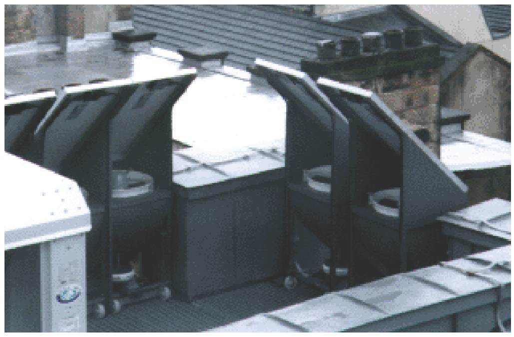
Rooftops on residential buildings are under- or unused. In mid-rise buildings a combination of energy production and active use by residents is both desireable and possible.The height of mid-rise buildings shows lower wind speeds which means, on the hand specific technologies can only be productive, on the other hand they can be actively used by residents. Elements such as orientation, position, visual impact and combination with other uses, need to be taken into account for design decisions.

P4_DUCTED WIND TURBINES

¬ PV panels (solar energy) and vertical wind turbines (wind energy)
¬ low visual impact
¬ fixed orientation (windward side)
¬ fixed position (edge)

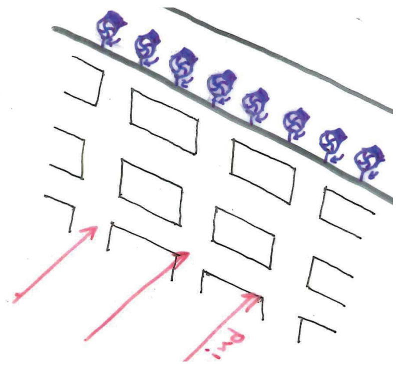


Reference
prototype ducted wind turbine as designed and fabricated by ESRU (University of Strathclyde)



P5_MICRO-WIND

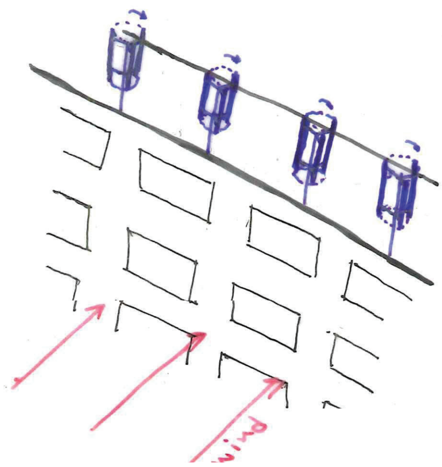
¬ fixed orientation (windward)
¬ wind energy generation with low wind speeds (starts at only 2m/s)
¬ low embodied energy



Reference
Motorwind developed by Researchers at Hong Kong University and Lucien Gambarota of Motorwave Ltd

P6_VAWT

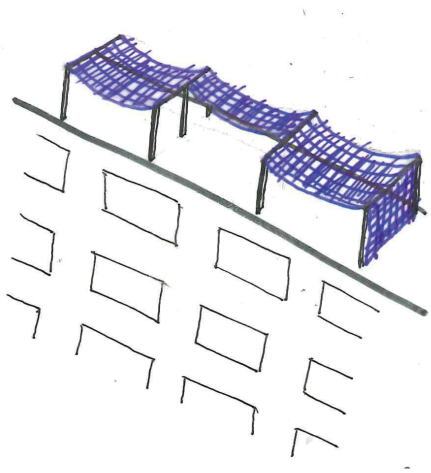
¬ fixed position (edge)
¬ free orientation
¬ ideal for low and turbulent wind
¬ low embodied energy



Reference
The omni-directional wind turbines have been integrated into the design of the building and precisely positioned to collect wind from both the North and South sides of the rooftop farm. (inhabitat.com)

P7_SOLAR 'FABRIC'

- 120-degree wide range
- textile (variety of uses)
- low cost
- low embodied energy

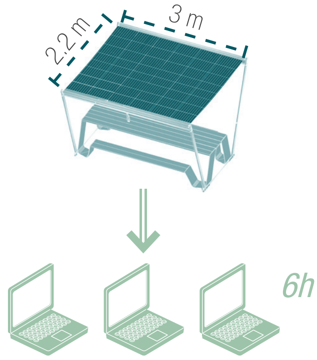


Reference
By day, the rooftop canopy provides energy, shading, and expanded rooftop living space; at night, the lightweight solar textiles are retracted and rolled into the stairwell for storage. Architectural rendering for the Casa Burguesa district of Porto, Portugal. (Mostafavi et al., 2010)

INSIGHT TO THE DESIGN METHOD

P7_SOLAR 'FABRIC'

Energy production: 0.2 kWh/day for 1m² → 2.2m x 3m → *1.3 kWh/day* → ***E≈ 4.7 MJ/day***
(based on dutch sun peak hours for WINTER)

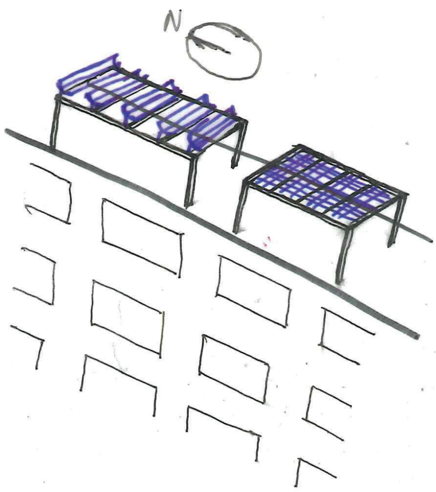


ENERGY CONSUMPTION of an average LAPTOP

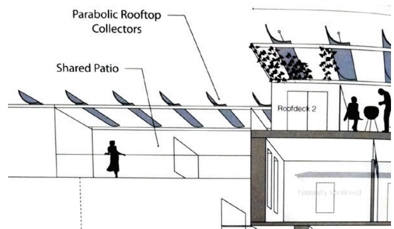
Average laptop: 60 W(J/s) → *t= 18h* → *or t=6h for 3 laptops*

P8_PV PANELS & PARABOLIC COLLECTORS

- relatively free orientation & position
- good combination with other uses (patios, pergolas)
- provides electricity and hot water

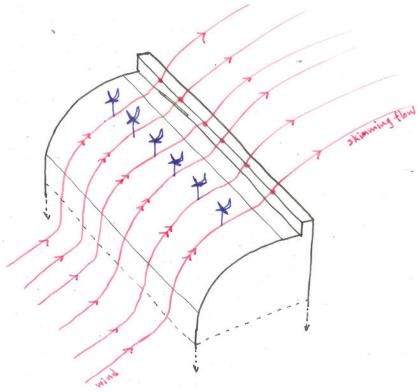


Reference
Shaded patios and rooftops (Scott, Ben-Joseph, 2012; Dickson, 2012)



P9_HAWTS
ON CURVED ROOFS

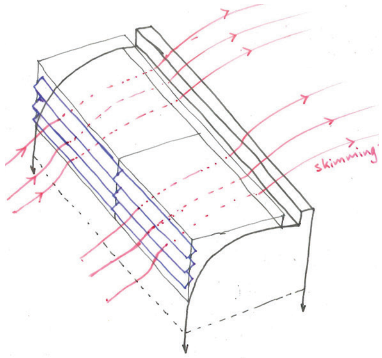
¬ high productivity (wind acceleration thanks to roof's geometry
¬ densification (plug-in to existing building)



Reference
"(...) the soft transition (curved edge) between wall and roof types produces an increase in speed-up. An optimum building roof shape for the wind energy exploitation necessarily occurs by the use of curved shapes." (Toja et al., 2015)

P10_VAWTS
ON CURVED ROOFS

¬ high productivity (wind acceleration thanks to roof's geometry
¬ densification (plug-in to existing building)
¬ combination with other uses (above the construction)



Reference
Under the solar roof a lined up installation of funnels and turbines is installed along the roof edge to capture the façade interacting flow and accelerate it towards the turbines. This ensures highest efficiency due to a concentrated air flow with increased wind speed, and introduces more operational hours as the turbine startup speed is reached more often. The problem of turbulence that most small wind mills in the urban environment suffer is also reduced as the turbulence intensity is reduced by the funneling. (ibispower.eu)


ibispower.eu


technischweekblad.nl

E. UNUSED AND ENERGY-LACKING **HIGH-RISE BUILDINGS' SURFACES**

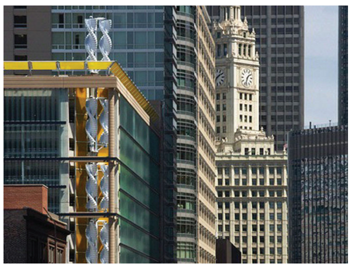
Problem statement
In many post-war neighbourhoods there is a significant number of high rise buildings. The wind speeds at these heights are higher and unblocked by surrounding buildings, the same applies for sun on the higher floors.

L

P6_VAWT

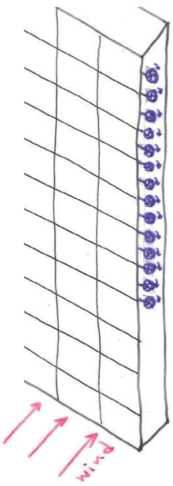
¬ position: rooftop or sides
¬ productive with turbulent wind

Reference
The street-facing facade of the Greenway Self-Park features 12 vertical-axis wind turbines that harvest the wind whipping through the city streets (inhabitat.com)

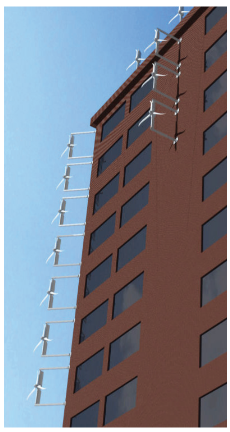


P12_HAWT

¬ position: rooftop or sides
¬ productive with high speed wind

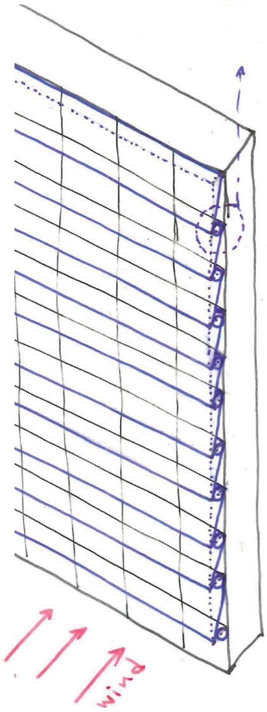


Reference
Integration of HAWTs in urban setting, renderings showing possible integrations of HAWTs in an urban setting (climatetechwiki.org; instructables.com)

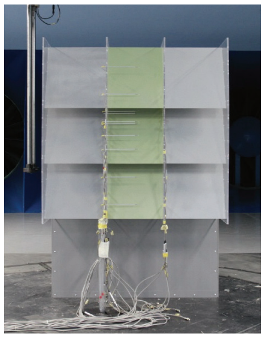


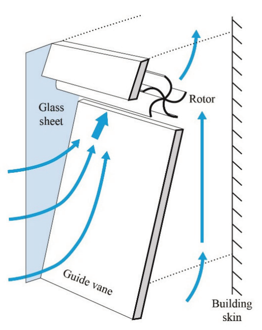
P13_MICRO-WIND ON FACADES AND BLIND WALLS

¬ position: facades
¬ fixed orientation (windward facade)
¬ arrangement accelerated the wind before it reaches the rotor
¬ productive with low wind speed
¬ no visual impact



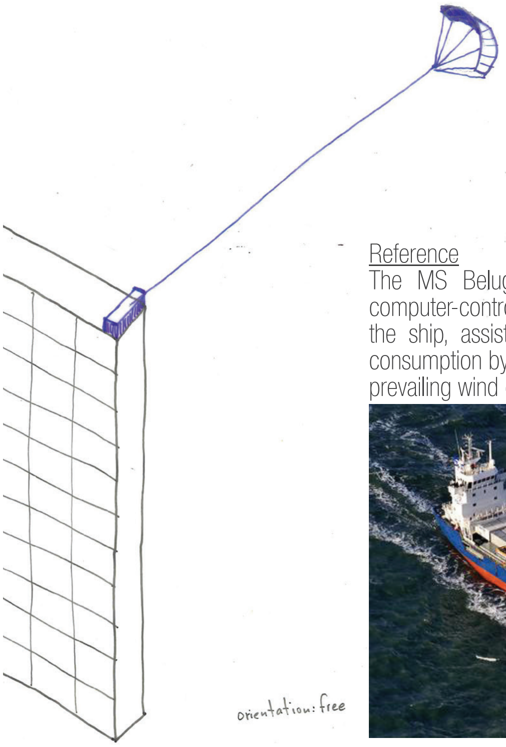
Reference
"Above the stagnation point on a building's windward wall, which is 70% of the building height, the wind flows toward the upper floors." (Park et al., 2015: 11852)
"The proposed system has been developed by combining a guide vane that is able to effectively collect the incoming wind and increase its speed and a rotor with an appropriate shape for specific conditions." (Park et al., 2015: 11846)





P14_KITE POWER SYSTEMS

¬ position: roof
¬ free orientation
¬ access to constant wind (steady energy generation)
¬ low visual impact (200m high) & more visual-friendly for people



Reference
The MS Beluga SkySails is pulled along by a computer-controlled kite attached to the bows of the ship, assisting the engines and reducing fuel consumption by up to 35 per cent depending on the prevailing wind conditions.)

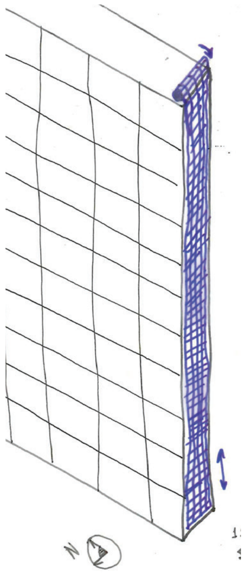
P15_SOLAR GLASS WINDOWS

¬ position: facade
¬ orientation: south
¬ no visual impact

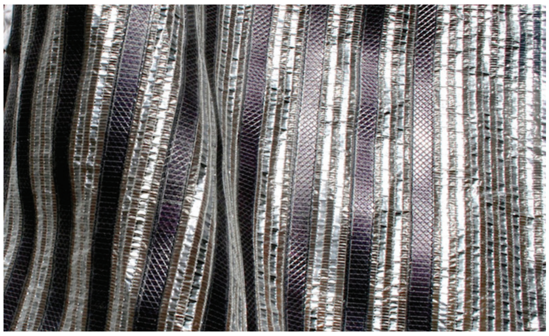
Reference
"Photovoltaic low-e glass: A glass for construction purposes that is able to generate its own energy. The focal point to take into account is the fact that this photovoltaic glass presents the same structural qualities as its conventional alternatives, thus providing a perfect opportunity for architects to transition to the new material." (nreionline.com)
Bursagaz, photovoltaic facade (onyxsolar.com)

P7_SOLAR 'FABRIC' VERTICAL

- 120-degree wide range
- textile (variety of uses)
- low cost
- low embodied energy



Reference
By day, the rooftop canopy provides energy, shading, and expanded rooftop living space; at night, the lightweight solar textiles are retracted and rolled into the stairwell for storage. Architectural rendering for the Casa Burguesa district of Porto, Portugal. (Mostafavi et al., 2010)



F. UNDERUSED AND ENERGY-LACKING **PUBLIC SPACES**

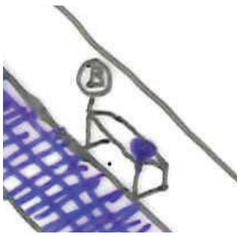
Problem statement
The result of openess and zoning has been an abundance of public spaces for green or activities but are currently largely underused. These large and undefined spaces have the potential with the implementaion of various innovative technologies to be revitalized while contributing in lowering energy demand of buildings or more importantly in energy production.

PS

¬ Urban Block scale

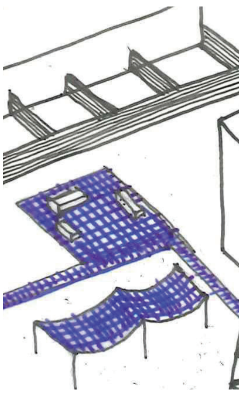
P16_VAWT SMALL SCALE

- free orientation
- productive with low wind speed
- combined with other uses



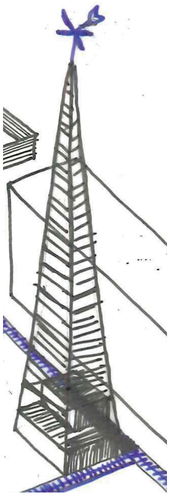
P7_SOLAR 'FABRIC'

- relatively free orientation
- combined with other uses
- waterproof fabric
- low cost



Reference
Tensile Solar, weatherproof and structurally reinforced photovoltaic modules that act almost like a fabric that can not only protect, but power. (source: www.core77.com)

P18_HAWT TOWER



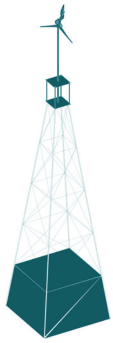
Reference
"Measuring the size of a ceiling fan and priced a little more than the latest Apple iPhone, this wind turbine can generate three to five kilowatt hours of electricity daily - enough to power a home." (thequint.com)

- combined with other uses
- low cost

INSIGHT TO THE DESIGN METHOD

P18_HAWT \TOWER

Energy production: 3-5 kWh/day → Average E≈ 14 MJ/day
Cost: 640 €



ENERGY CONSUMPTION of an average COFFEE MACHINE

1h= 3,600 s

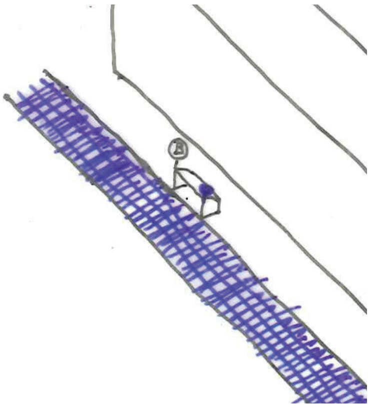
Average coffee machine: 800 W(J/s) → t≈ 5h

5h

¬ Urban scale

P17_SOLAR ROAD

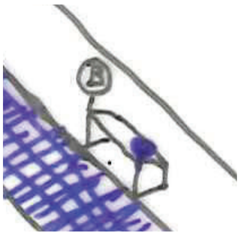
¬ variety of uses
¬ availability of spaces (due to its various uses)



Reference
"In the Netherlands, a 70-meter solar bike path was reported to have exceeded expectations by producing more than 3,000 kilowatt hours of electricity - enough to power a small household for a year." (http://www.dw.com/en/solar-roadways-a-way-forward-for-renewables/a-19048835)

P16_VAWT SMALL SCALE

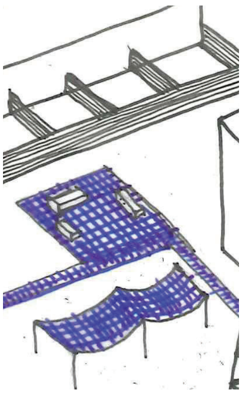
¬ free orientation
¬ productive with low wind speed
¬ combined with other uses



Reference
The bus stop in central Reykjavik, Iceland, modified by IceWind and installed the wind turbines above Storm Shelter. The two customized wind turbines made the bus stop completely independent from the grid and provided the lighting, Wi-Fi hotspot, mobile chargers and a remote controlled 70" ads screen. Its energy solution offers around 30 year lifetime, no effect on bird life and no need to face the wind direction. (Source: IceWind)

P7_SOLAR 'FABRIC'

¬ relatively free orientation
¬ combined with other uses
¬ waterproof fabric
¬ low cost



Reference
Tensile Solar, weatherproof and structurally reinforced photovoltaic modules that act almost like a fabric that can not only protect, but power. (source: www.core77.com)

P6_VAWT

Reference
PARIS SMART CITY 2050; the new urban image where solar, hydrodynamic and planted towers cover the existing city and on the other side of the street VAWTs cocreate the new image and are part of the productive urban environment

INSIGHT TO THE DESIGN METHOD

P6_VAWT

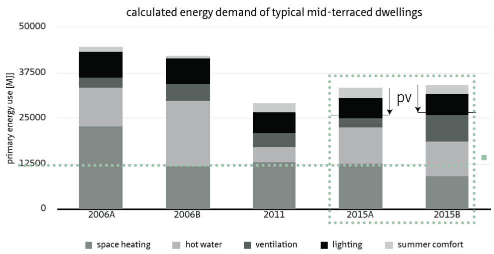
1 day=8,640 s

$P = \frac{1}{2} C_p \rho A v^3$ → *P= 681.7* → E= P·dt → *E≈ 5.9 MJ/day* → *E≈ 2,150 MJ/year*

P is power
Cp is the power coefficient,
ρ is air density,
A is the swept area of the turbine,
v is the wind speed

x 6

primary energy use of dutch mid-terraced dwelling



SPACE HEATING → *E≈ 12,500 MJ/year*

G. SMALL OR UNPRODUCTIVE RESIDENTIAL ROOFTOPS

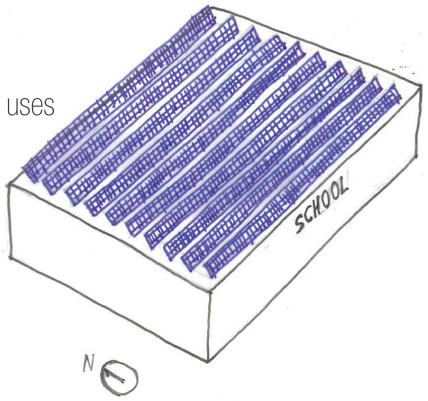
Problem statement

Rooftops on residential buildings can often be too small to produce enough energy or the circumastances might be unfavourable, such as shadow on single-family houses from blocks of flats. Public or commercial buildings located usually in the centre or orderly in relation to houses, usually have large rooftops appropriate for large installations of PV panels. Their location in relation to houses can serve well in connecting the houses to this more central installations.

NR

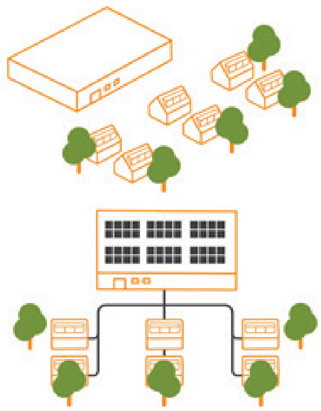
P11_PV PANELS ON NON-RESIDENTIAL BUILDINGS

- fixed orientation (south)
- no combination with other uses
- high productivity



Reference

"You build a solar park together with your neighbors. Buy Sun certificates in a solar park and contribute to a better world. Without having to worry about it. Moreover, you also have a lower energy bill! This is how you participate." (solargreenpoint, n.d.)



COMPARATIVE TABLE FOR ENERGY PRODUCTION DESIGN SUB-PATTERNS

	BASIC ELEMENTS			POSITIONING	DESIGN RELATED INFO		EXTRA TECHNICAL INFO		
	energy source	location	morphology/ surface	position/ orientation	combined with uses	visual impact	productivity	cost	embodied energy
P4	solar & wind	M & L		fixed	irrelevant/unknown	high	- (irrelevant/unknown)	- (irrelevant/unknown)	- (irrelevant/unknown)
P5	wind	M & L		fixed	works	high	low wind speeds (medium)	high	high
P6	wind	M & L		fixed/free	irrelevant/unknown	low	also low & turbulent (medium)	low	low
P7	solar	All & PS		free/120º range	works, works, works	low	low	high	high
P8	solar	M & PS		relatively free	works, works	low	high	low	low
P9	wind	M		fixed	does not work, does not work	low	high	- (irrelevant/unknown)	- (irrelevant/unknown)
P10	wind (& solar)	M		fixed	works	high	high	- (irrelevant/unknown)	- (irrelevant/unknown)
P11	solar	NR		fixed	does not work, does not work	high	high	low	low
P12	wind	L		fixed/free	irrelevant/unknown	low	high	- (irrelevant/unknown)	- (irrelevant/unknown)
P13	wind	L		fixed	irrelevant/unknown	high	- (irrelevant/unknown)	- (irrelevant/unknown)	- (irrelevant/unknown)
P14	wind	L		free	irrelevant/unknown	high	high	- (irrelevant/unknown)	high
P15	solar	L		fixed	irrelevant/unknown	high	high	low	- (irrelevant/unknown)
P16	wind	PS		free	works	low	low wind (medium)	- (irrelevant/unknown)	- (irrelevant/unknown)
P17	solar	PS		free	works, works	high	high	low	low
P18	wind	PS		free	works, works, works	low	- (medium)	high	high

works
does not work

high
medium
low

irrelevant/unknown

7.3.3 COMPARATIVE TABLES

As mentioned in the introduction part of the Design patterns' chapter (7.3.1), the sub-patterns are variations of equivalent solutions. However they present differences on various other aspects that are also significant for a designer to decide which sub-patterns to implement. Moreover, through the complex process of pattern implementation that will be further shown in the Case study, there is often the need after the first implementation attempt to review the selection of sub-patterns. In this case the table can be helpful in deciding on an alternative sub-pattern.

¬ *Energy use sub-patterns*

For the energy use sub-patterns two comparative tables are drafted. The *first* one incorporates all of the sub-patterns and compares their performances. The first information given that helps in orienting the designer on which are relevant for each situation has to do with what type of building each sub-pattern is appropriate for. Those belonging to wind protection are characterized based on whether they pose a high or low density barrier, by definition but because of the complexity in implementation decisions, the information on what effect they have on wind is given for all. Finally the effect they have on the H/W ratio, shows whether they can help in protecting the subsequent buildings. This information is in general important since the H/W ratio affects also, for instance how well the urban block will be ventilated or whether extra attention should be paid to the effect of the sub-pattern on the solar exposure of subsequent buildings.

The *second table* provides specific information on the densification sub-patterns. The specific information is related to a qualitative evaluation of the performance of each densification sub-pattern on the subjects of wind protection, solar gains but also heat preservation. The latter is clearly related only to built form and is especially relevant if we take into consideration that energy efficient housing typologies – as also proposed by Larco – are extremely significant for energy use. At the same time, separate attention is given to how the same qualities that affect energy use during winter, affect energy use during summer.

¬ *Energy production sub-patterns*

The comparison table of the energy production sub-patterns has 3 functions. Firstly to orient the designer – similarly to the first energy use comparative table – on which are the relevants sub-patterns for each situation depending on which source is available, what type of building and which surface of the bulding (or if it's on the public space). Secondly, to help in positioning each technology in the right way to be produstive. Finally extra information is given in order to cover other significant aspects related to the design as well as some extra details (technical, financial and sustainability-related). The design-related information is particularly important for the design phase since it gives both a sense of whether each sub-pattern can be well combined with other uses and its visual impact. Those two characteristics constitute the added value that each technology can entail. The extra details are mostly speculative based on various information gathered by the author

COMPARATIVE TABLE FOR ENERGY USE DESIGN SUB-PATTERNS

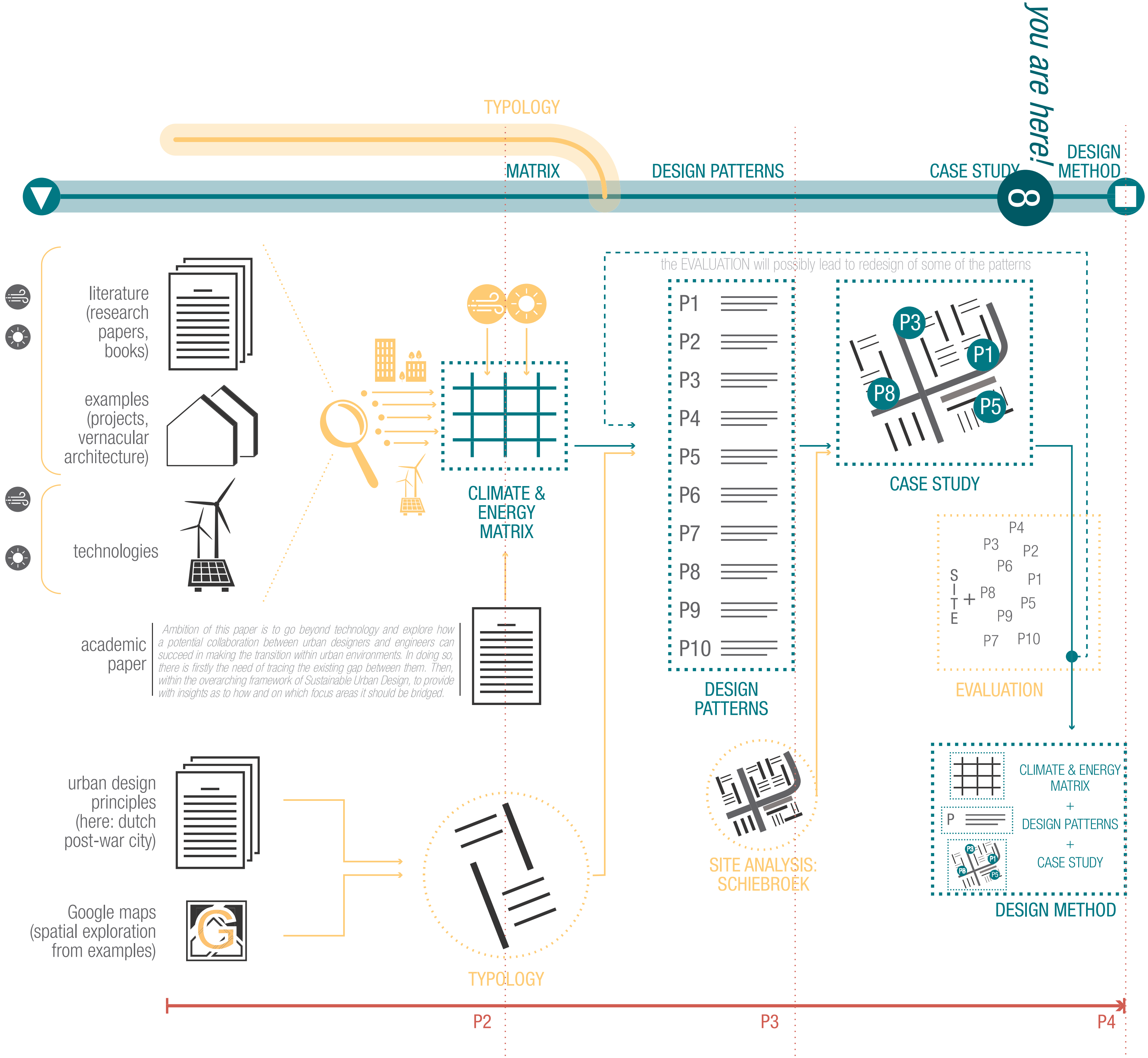
	BASIC ELEMENTS			EFFECT INFO		
	climatic condition	building size	morphology/ surface	density	effect on wind	restores H/W ratio
P1	wind	S & M		high	blocks	✓
P2	wind	S & M		low	decreases	✗
P3	wind	All		low	decreases	✗
P19	wind	L		high	blocks	✗
P20	wind	S & M		high	blocks	✓
P21	wind	S & M		high	blocks	✓
P22	solar	S & M		high	blocks	✓
P24	solar	All		-	blocks	✓
P25	solar	All		-	blocks	✗
P26	solar & wind	All		high	blocks	complex sub-pattern

blocks
decreases

COMPARATIVE TABLE FOR DENSIFICATION DESIGN SUB-PATTERNS

		P17_compact forms	P18_parallel linear blocks	P19_perimeter blocks	P22_T-shaped/cross forms
WINTER	wind protection	☺ ☺ ☺	☺ ☺	☺ ☺ ☺	☺
	solar gains	☺	☺ ☺	☹	☺
	heat preservation	☺ ☺ ☺	☺	☺ ☺ ☺	☺ ☺
SUMMER	all of the above into consideration	☺ ☺	☺	☹ ☹	irrelevant/unknown

☺ works
☹ does not work
irrelevant/unknown



you are here!
8
TYPOLOGY
MATRIX
DESIGN PATTERNS
CASE STUDY
DESIGN METHOD
literature (research papers, books)
examples (projects, vernacular architecture)
technologies
academic paper
Ambition of this paper is to go beyond technology and explore how a potential collaboration between urban designers and engineers can succeed in making the transition within urban environments. In doing so, there is firstly the need of tracing the existing gap between them. Then, within the overarching framework of Sustainable Urban Design, to provide with insights as to how and on which focus areas it should be bridged.
urban design principles (here: dutch post-war city)
Google maps (spatial exploration from examples)
CLIMATE & ENERGY MATRIX
TYPOLOGY
the EVALUATION will possibly lead to redesign of some of the patterns
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
DESIGN PATTERNS
SITE ANALYSIS: SCHIEBROEK
P3
P1
P8
P5
CASE STUDY
S I T E + P4 P3 P2 P6 P1 P8 P5 P9 P7 P10
EVALUATION
CLIMATE & ENERGY MATRIX
+
DESIGN PATTERNS
+
CASE STUDY
DESIGN METHOD
P2
P3
P4

8

CASE STUDY: SCHIEBROEK

8.1. INTRODUCTION AND JUSTIFICATION OF CHOICE

As aforementioned (see methodology) the location is used as a physical space where the *case study* will land in. Therefore it will be a way of assessing the effectiveness and appicability of the design patterns. Since the intention of this project is to address the gap between engineering and urban design, and come up with design patterns towards the urban energy transition, a lock-in in a specific location is not desirable. However any intervention within an urban environment should never be a mere application of engineering solutions. The alteration of form and use need to be carefully designed and to the new spaces that will be designed there should always be given the added value that people need. So the case study works not only as a test of the design solutions but also as an example of how these patterns should be integrated in urban design and in the end what will the new urban environment look like.

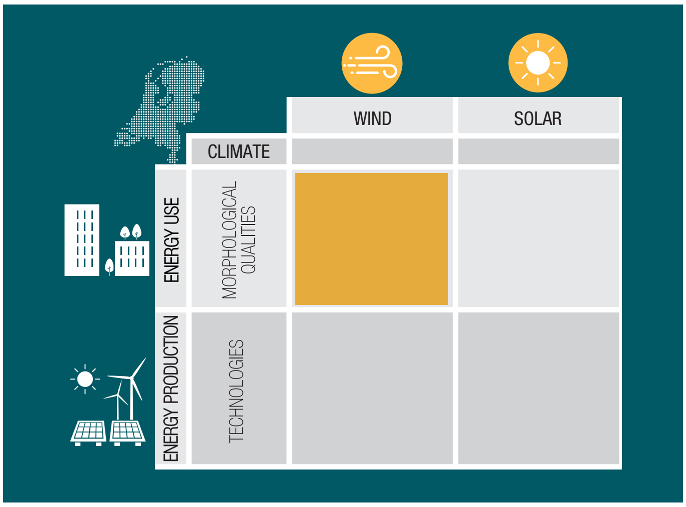
The location for the case study is critically chosen so as to be a representative speciment and to be able to extract some of the final results as part of the design method. Therefore the case study concerns a *post-war neighbourhood* in the Netherlands, South Schiebroek as a typical example of post-war neighbourhood. It is located in the north of Rotterdam and the construction of the neighbourhood started in the late 50s. Few of the buildings have been renovated or demolished and rebuilt, and the vast majority is still in its original state. This makes it an ideal neighbourhood as a case study, since the buildings are still poorly insulated and at the same time it seems that urban renewal is planned to happen. The plans opt for partly demolition and partly renovation of the housing stock, and sustainability is also a clear goal of the municipality as well as the housing corporations. When it comes to sustainable energy, Schiebroek faces difficulties since it seems dificult and to expensive to connect it to district heating (Tillie, 2018). This is the currently most common system that housing associations apply in post-war neighbourhoods and it therefore poses a serious issue in the transition of Schiebroek. Finally, in terms of densification Schiebroek Zuid is advantageously located close to two metro stations, and close to the airport and a natural area that it is even planned to be expanded and enriched.

The analysis that has been done for the site is primarily related to all elements linked to urban morphology, climatic conditions, natural assets and any other element relevant to climate-resonsive and energy-active urban design. Despite the focus on climatic and energy related analysis, when related to densification of urban blocks or urban scale intervensions and design, land uses and neighbourhood accessibility, amongst others, are also being examined.

8.2. LOCAL CONDITIONS: SCHIEBROEK ZUID

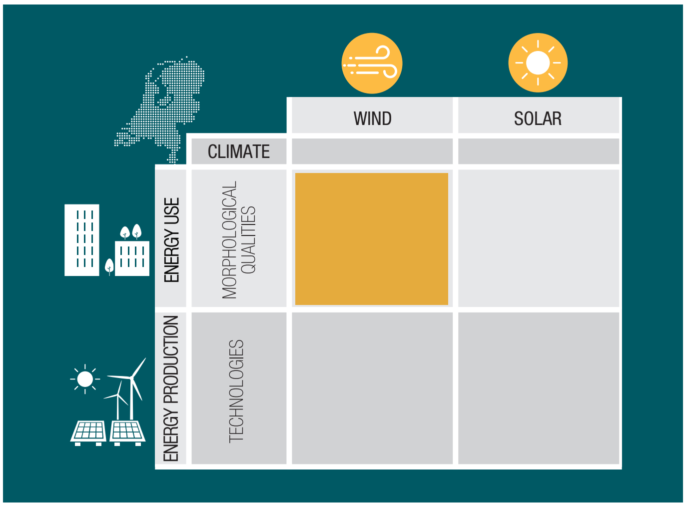
As it has already been stressed out, local conditions play a crucial role when it comes to sustainable urban design. Characteristics such as the distance from the equator or the specific climatic zone, to name a few, affect the behaviour and direction of prevailing wind, the ammount and peak of sun. Those characteristings along with local settings need to be taken into account before even the analysis starts. Those local conditions are given in corralation with the parameters of the matrix for energy use since they are directly connected to some of them. Some of those local conditions are also connected with the energy production and therefore a scheme of the matrix shown which areas of the matrix these local conditions affect.

8.2.1. LOCAL CONDITIONS: DISTRICT/NEIGHBOURHOOD



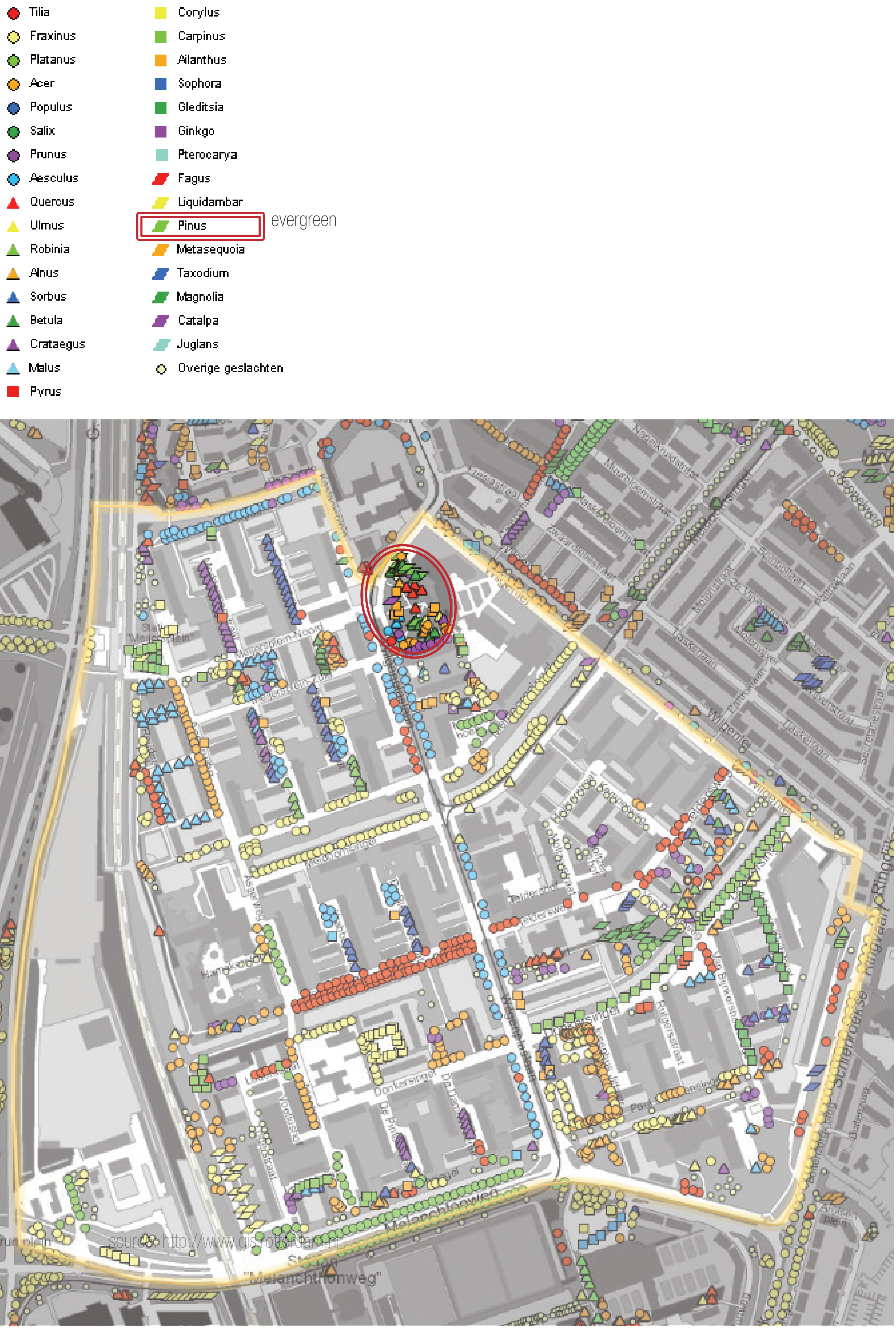
1. HEIGHT IRREGULARITIES

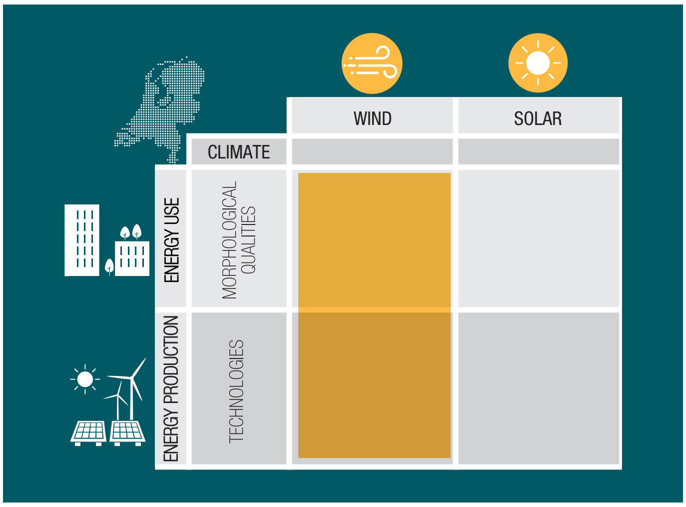
As it has already been discussed – and is part of the matrix – height irregularities in an urban area can have extremely negative results in energy demand. Therefore there needs to be a mapping of heights within the whole neighbourhood in order to examine how sensitive it is to wind overall. Schiebroek Zuid in particular is significantly vulnerable to wind induced energy losses since the height irregularities are present throughout the neighbourhood.

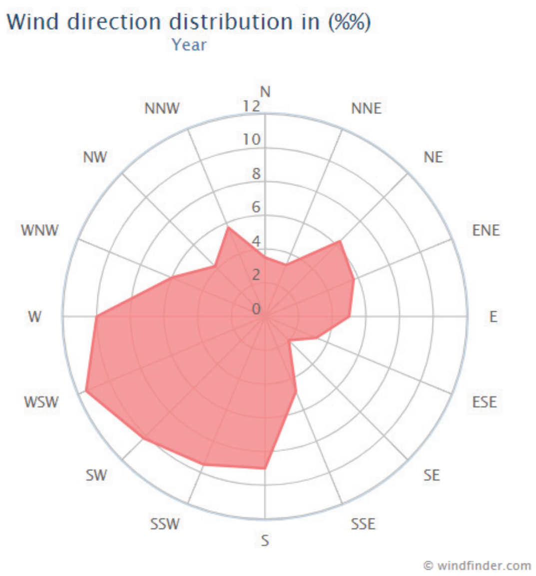


2. *URBAN FOREST*

As it has already been discussed – and is part of the matrix – one of the most important shielda against strong wind is vegetation. In the case of Schiebroek most of the trees are deciduous (e.g. platanus, acer and tilia) and their height ranges from less than 4m to 25 m. In the typologies that have already been shown most of the windward buildings are roughly 20 m high (four storeys). Therefore there is minimum protection from the wind during winter time, maximizing heat losses in this way (Jurelionis,Bouris, 2016).


Tilia
Fraxinus
Platanus
Acer
Populus
Salix
Prunus
Aesculus
Quercus
Ulmus
Robinia
Alnus
Sorbus
Betula
Crataegus
Malus
Pyrus
Corylus
Carpinus
Ailanthus
Sophora
Gleditsia
Ginkgo
Pterocarya
Fagus
Liquidambar
Pinus
evergreen
Metasequoia
Taxodium
Magnolia
Catalpa
Juglans
Overige geslachten

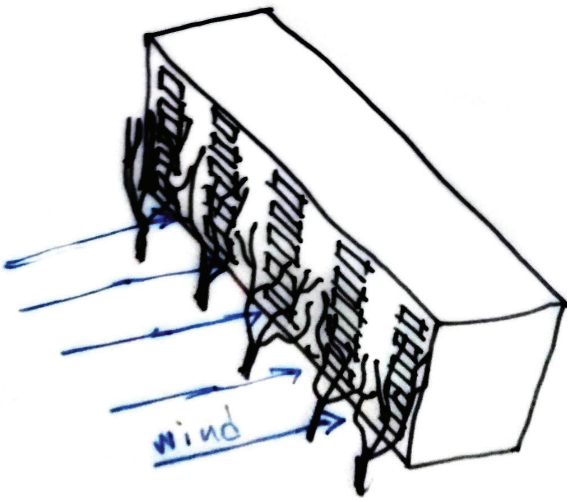


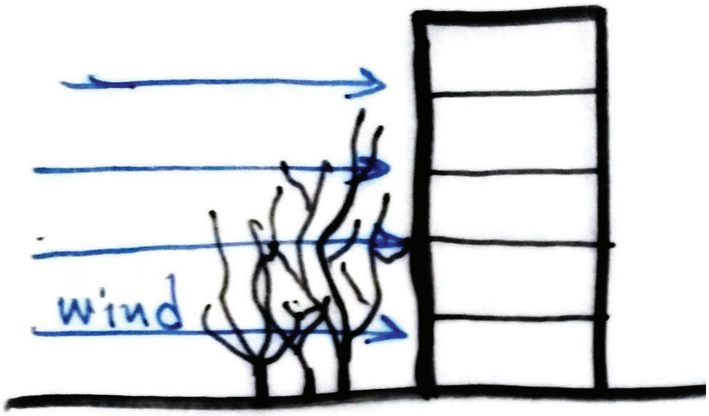


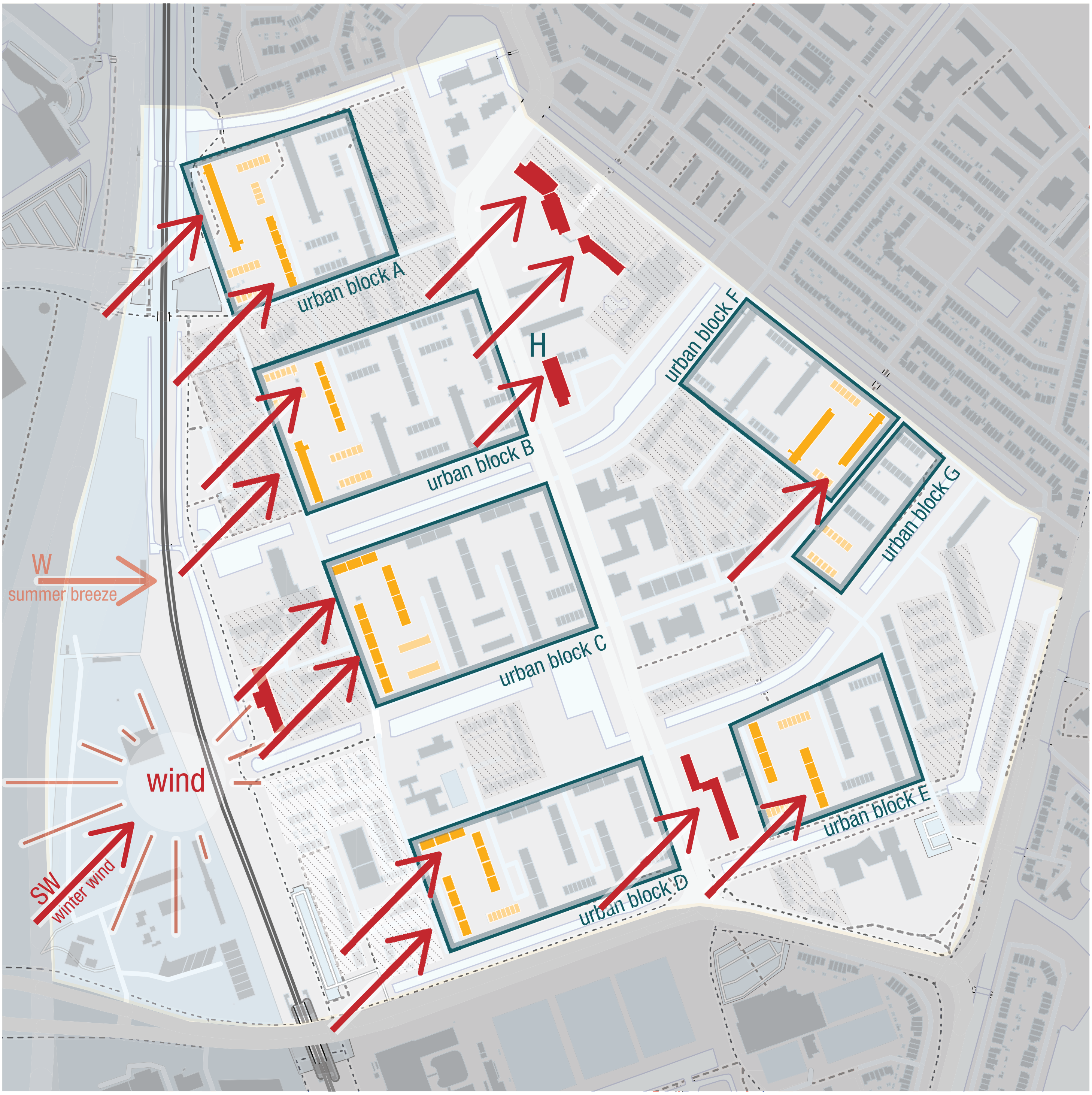
3. STREET AND OPEN SPACE ORIENTATION

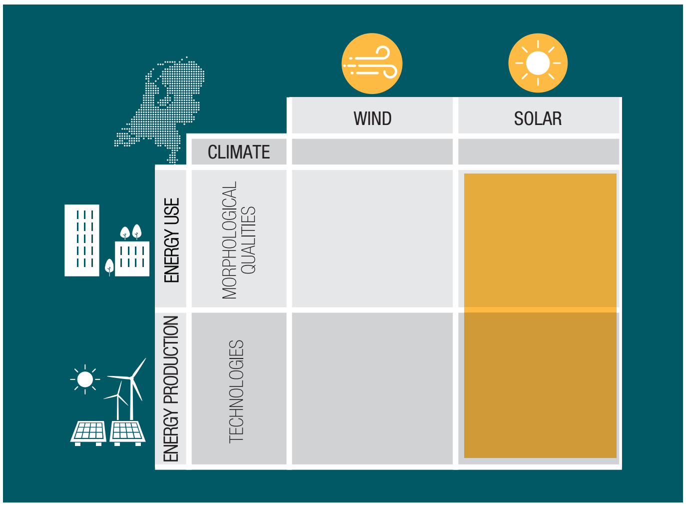
Deciduous trees offer minimum protection which in case of lee eddys it could be relatively satisfactory, but in cases of full speed wind they offer no real protection. Therefore in the first building of a block or if the H/W street ratio within the block is too low and then the sheltering effect is lost (see matrix chapter), stronger protection is necessary.

Another local characteristic that is of crucial importance for wind protection as well as wind energy generation, is the direction of the prevailing wind. In the case of Rotterdam the direction is SW (for winter of course). With the assumptions made regarding vegetation and wind direction, a map is made in order to show the first sense of the impact of the wind in the neighbourhood and in the different blocks.






urban block A
urban block B
urban block C
urban block D
urban block E
urban block F
urban block G
H
W
summer breeze
wind
SW
winter wind



4. *SUN PEAK HOURS*

Finally for the district/neighbourhood scale it is also important to know before the analysis or pattern implementation take place, the amount of sun peak hours. Officially this is not part of the matrix but when it comes to energy production it is of key importance.

So, by sun peak hours we mean the hours that the sun has its maximum value and those are the hours that account for for passive heating as well as solar energy. The sun peak hours are defined by the specific geographical location and the period within the year. In this project the winter is mainly taken into account, therefore the winter solstice is taken as time since it is the time of the least sun hours. So in terms of passive heating and solar energy, the Netherlands is peaked as a specific location and the winter solstice as specific time period. The result is that 2 hours can be considered in the analysis.

The average sun hours by month have been calculated by the Met Office in the UK, based on averaged data from 2000 to 2010, and are shown below:

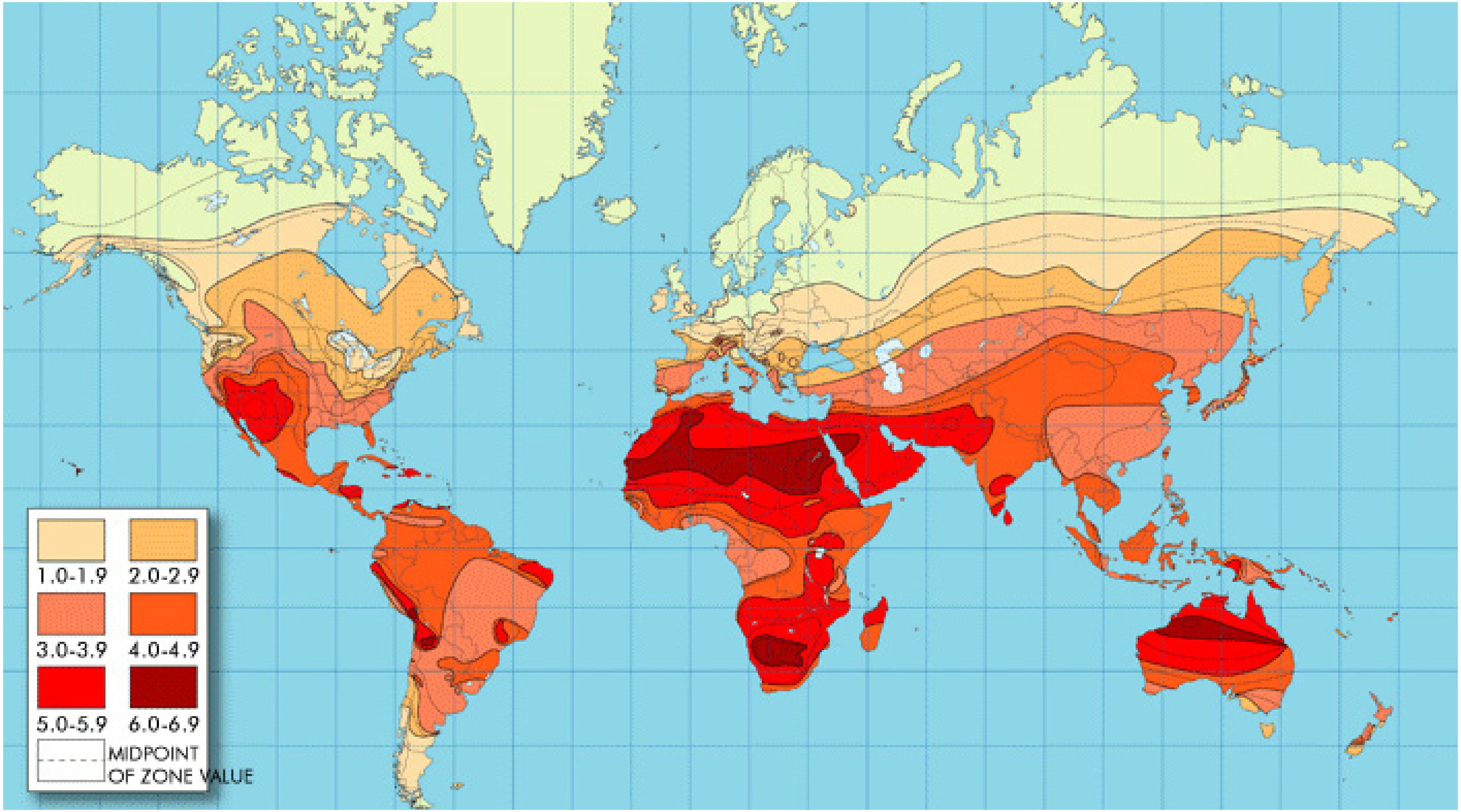
- January - 2 Hours
- February - 3 Hours
- March - 4 Hours
- April - 6 Hours
- May - 6 Hours
- June - 7 Hours
- July - 7 Hours
- August - 6 Hours
- September - 5 Hours
- October - 4 Hours
- November - 3 Hours
- December - 2 Hours

If you wish to estimate a rough daily output for a solar system, this can be done using the figures quoted above and the following equation:

Peak sun hours per day x PV systems rated output (Watts) x 0.85 = Estimated daily output in Watts per day.

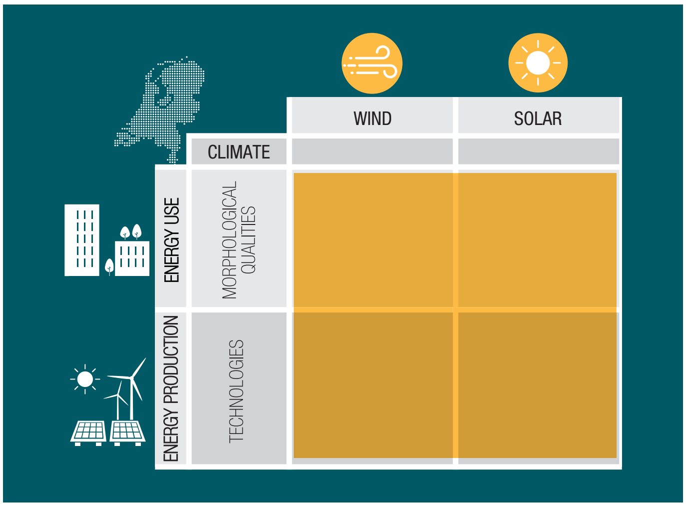
World Insolation Map

This map shows the amount of solar energy in hours, received each day on an optimally tilted surface during the worst month of the year. (Based on accumulated worlwide solar insolation data.)



solar insolation worldmap (altestore.com)

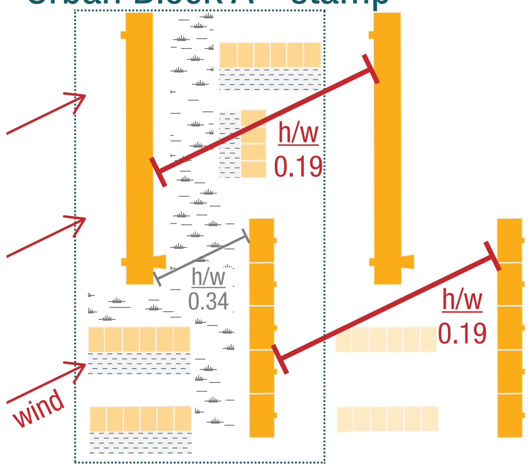
8.2.2. LOCAL CONDITIONS: URBAN BLOCK/STREET

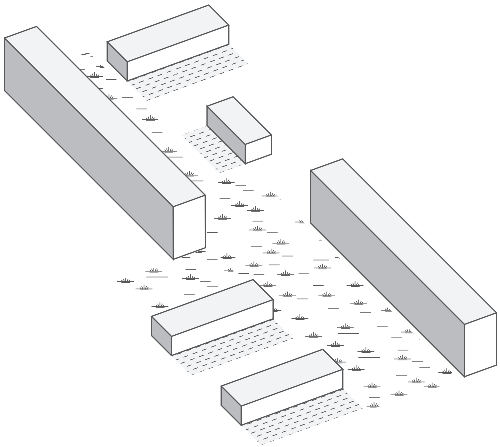


1. URBAN BLOCK TYPOLOGY

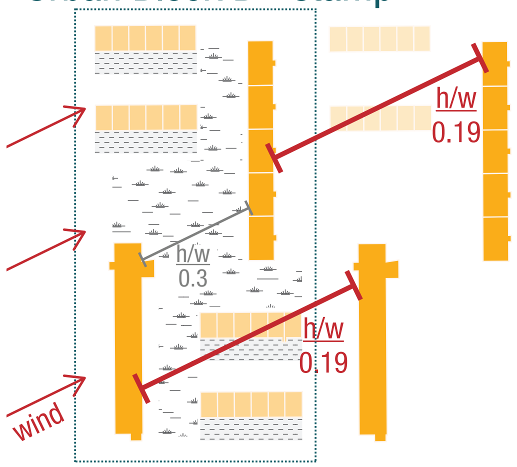
Important step in implementing the patterns, was to separate the urban blocks and within each block to identify the stamp that repeated itself throught the block. A more analytical profile with heights, private gardens and open spaces is drawn in order to understand the structure of each stamp. This last step is also really important in the stage of impact maps (see urban scale subchapter), since a better knowledge of the stamp structure helped in applying some patterns to different stamps without undergoing the analysis phase for each urban block again. Nevertheless it needs to be pointed out that implementation of patterns based on the similarity of various stamps is, firstly, to be considered as an initial orientation for the actual pattern implementation, and secondly the application of patterns should not be confused with the design of the block. Namely, even if the patterns can be extracted from a similar stamp of another block, the design process of the block cannot be copied and it needs to be processed from scratch.

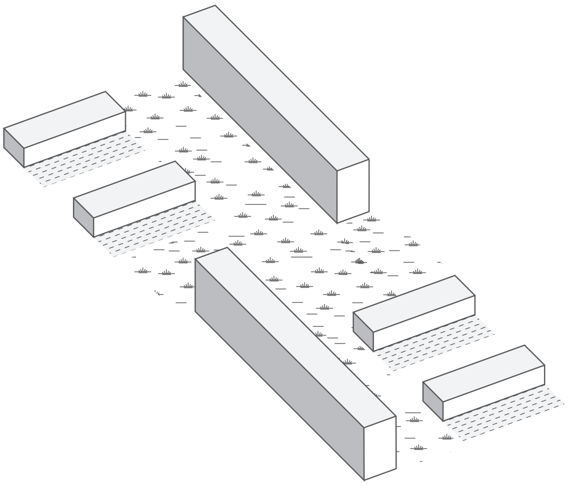
Urban Block A - stamp



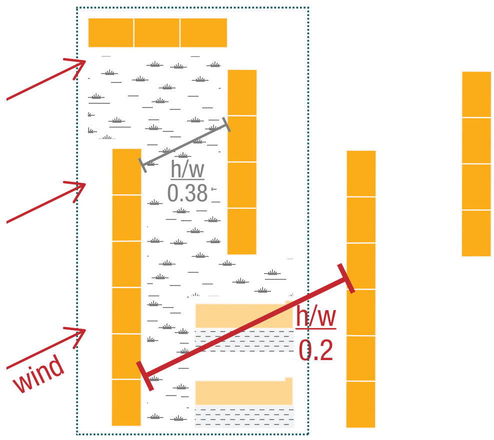


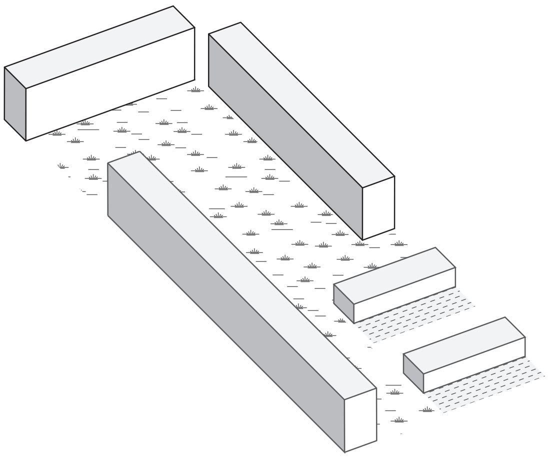
Urban Block B - stamp

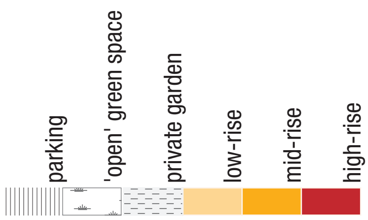




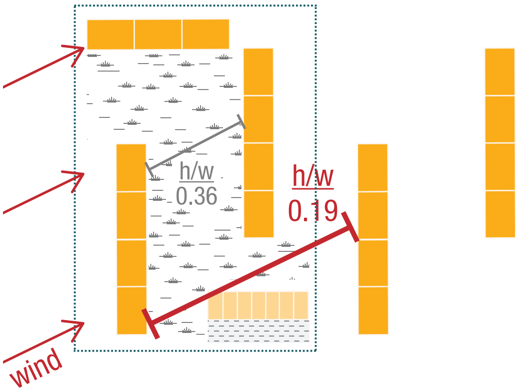
Urban Block C - stamp

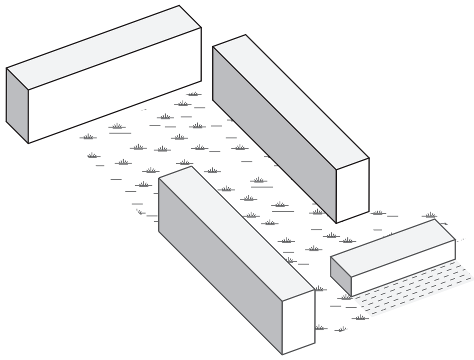




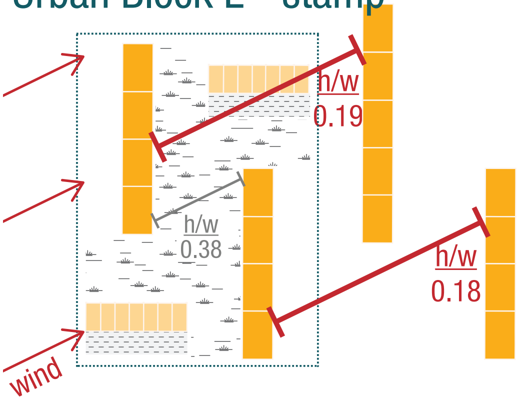


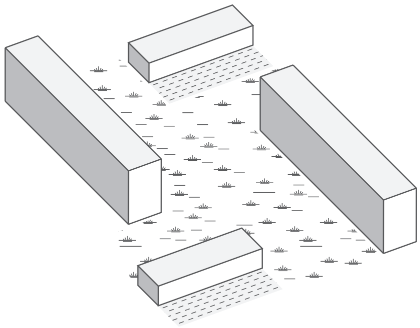
Urban Block D - stamp



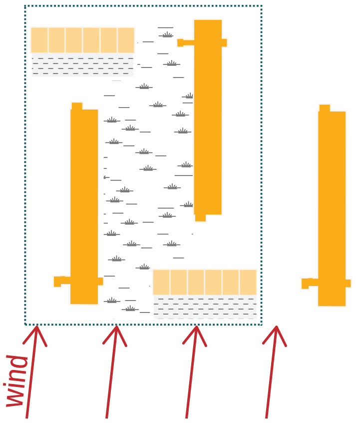


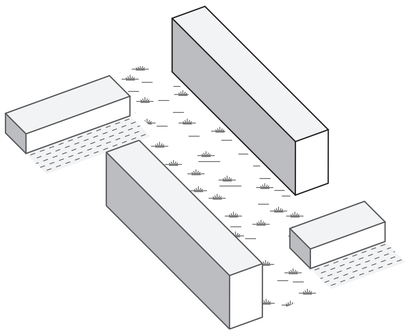
Urban Block E - stamp

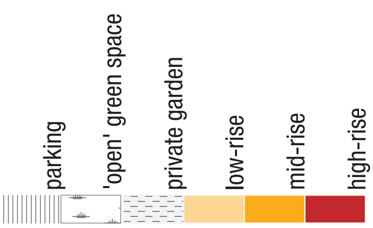




Urban Block F - stamp



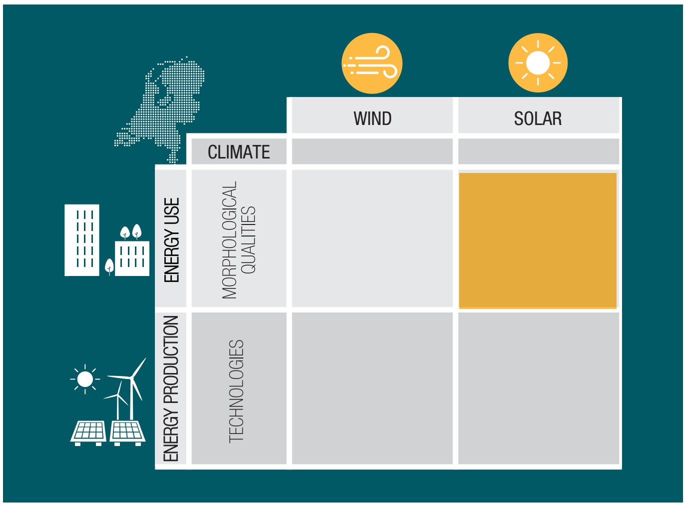




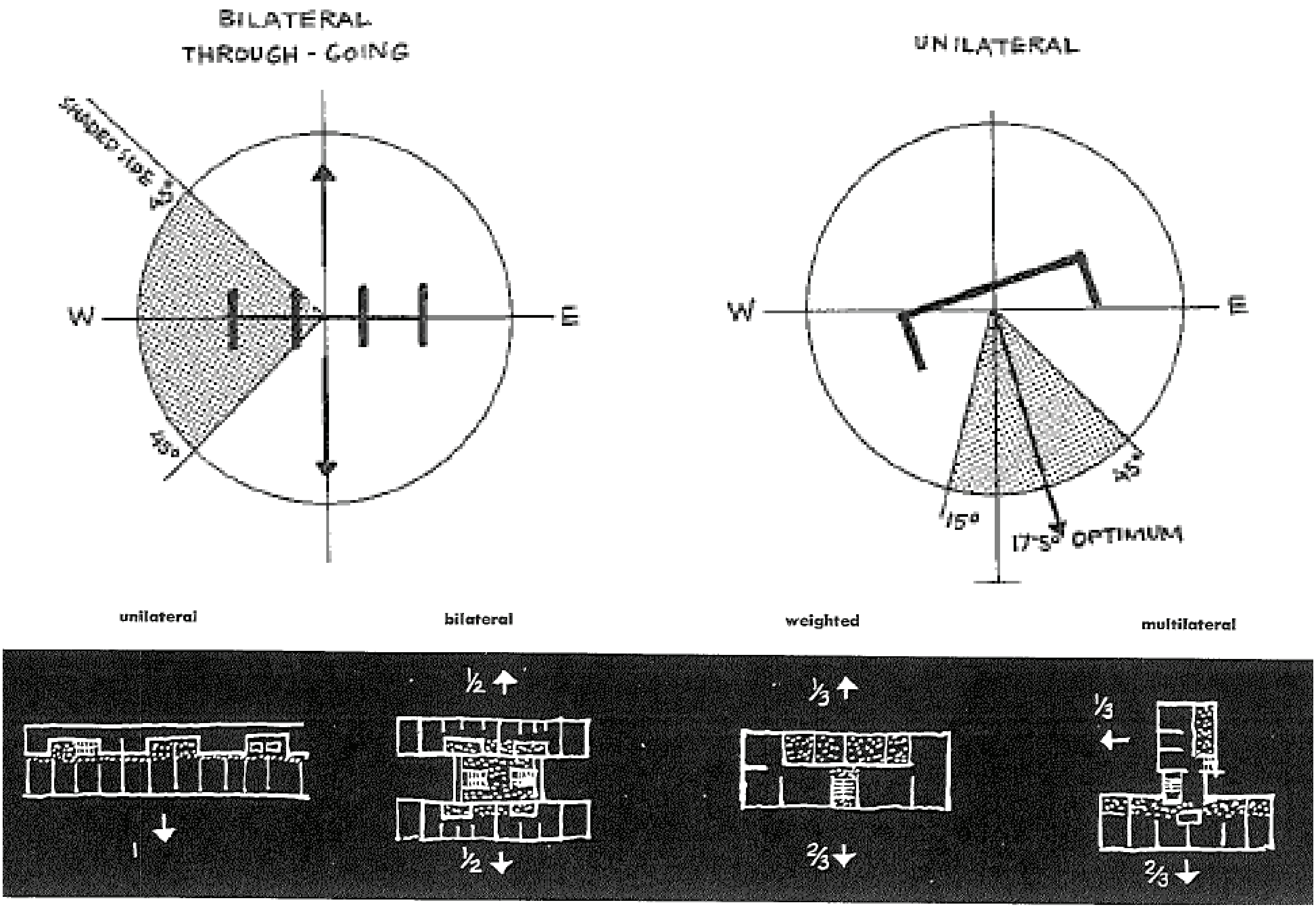
The H/W ratio as an urban block/street parameter is incorporated in the urban block typology. For each urban block a different ratio exist although it is visible that in many cases the H/W ratio of the six out of five urban blocks is almost the same due to the similarities in plannar structure as well as in heights. First of all the H/W ration is calculated by taking into account the direction of the wind. Secondly in order to analyse the whole block the first step is to check the H/W ratio within the stamp of the block and then by positioning the subsequent stamp the next step is to calculate the ratio for the buildings across the stamps. Also it should be noted that the ratio is not calculated for low-rise buildings since the effect of the wind is considered significantly lower than in mid-rise and above.

8.2.3. LOCAL CONDITIONS: BUILDING (PARCEL)

1. BUILDING PLAN (ENVELOPE)

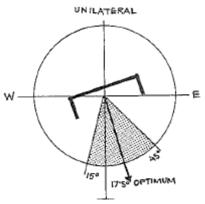


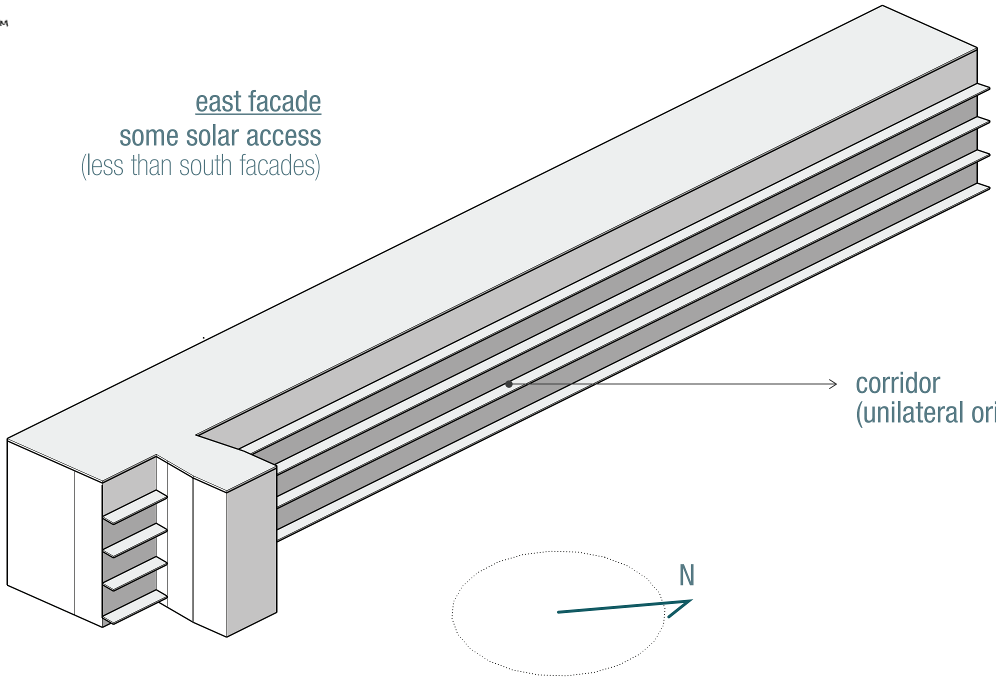
An extra element that should be taken into account when applying patterns to an urban block and also when identifying similarities between different stamps is the type of residential buildings. The characteristics that matter in this case, are the ones connected fo passive heating. Therefore, the orientation of the floorplan as well as overhanging shelters or balconies or (in this case) corridors, can determine – also depending on the orientation of the building – whether the houses can get enough sunlight or not (Olygay et al, 2015). For instance two linear buildings with the same orientation, for instance N-E, can have remarkable differences in passive heating depending on the floor plan orientation. In the N-E case, a bilateral building will absorb heat from the east, whereas a unilateral building facing the west – like the example of the building in stamps A,B & E – will have no passive heating.

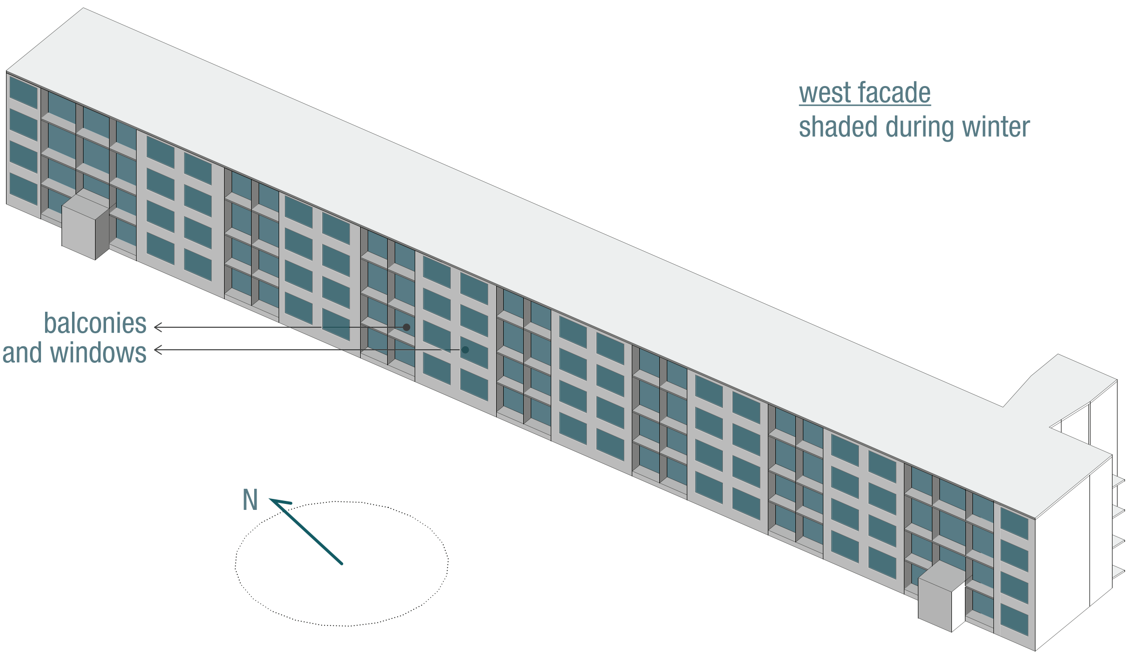


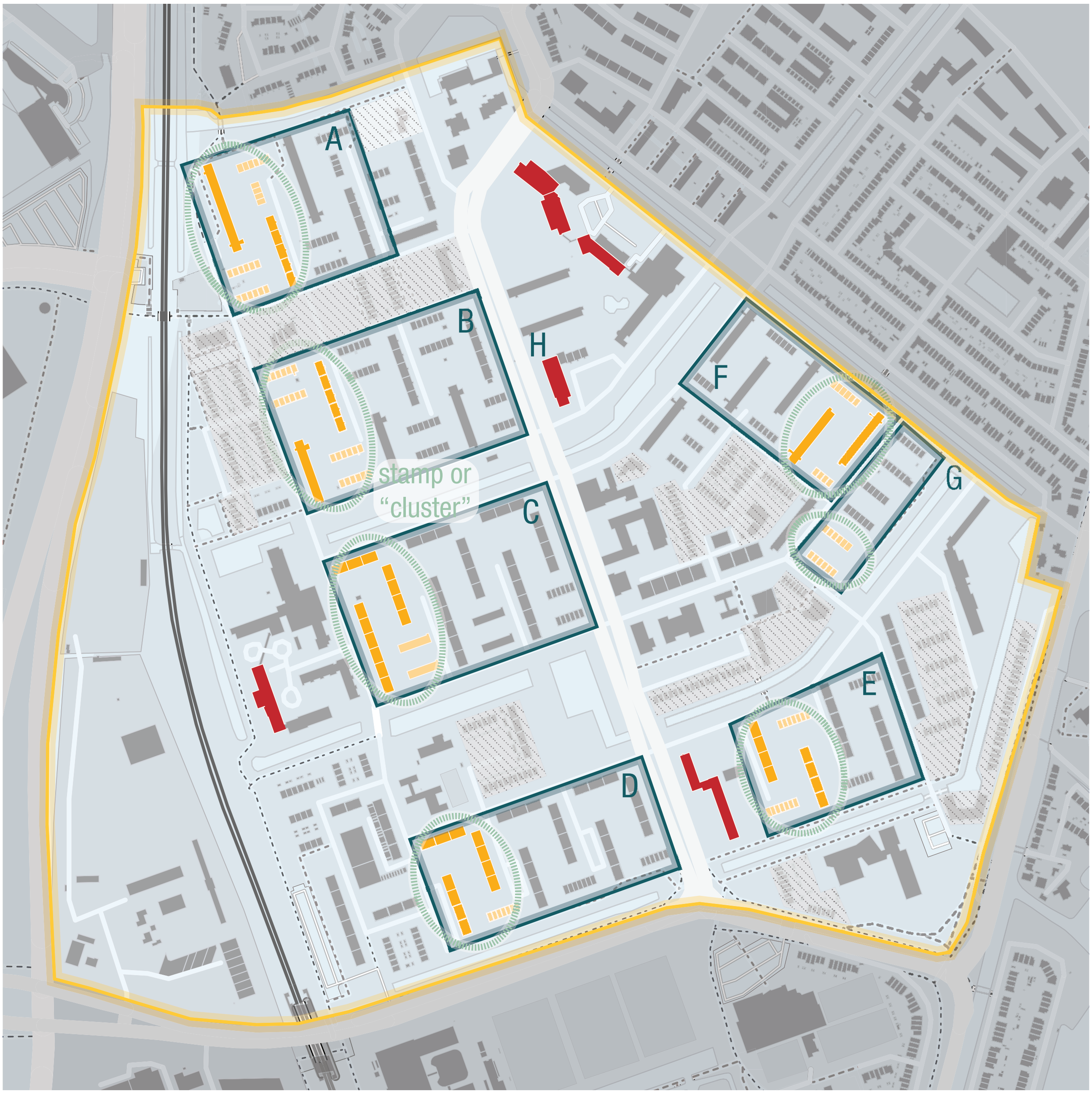
(source: Olygay et al, 2015)

stamps A, B & E

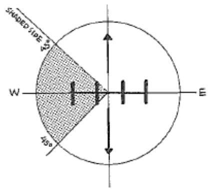

UNILATERAL
W
E
45°
15°
17·5° OPTIMUM


east facade
some solar access
(less than south facades)
corridor
(unilateral orientation)
N


west facade
shaded during winter
balconies
and windows
N

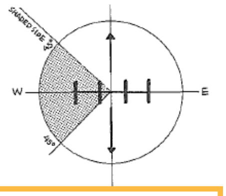

A
B
C
D
E
F
G
H
stamp or
"cluster"

BILATERAL
THROUGH - GOING



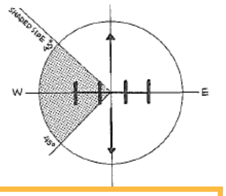
all stamps

BILATERAL
THROUGH - GOING



stamps A & B

BILATERAL
THROUGH - GOING

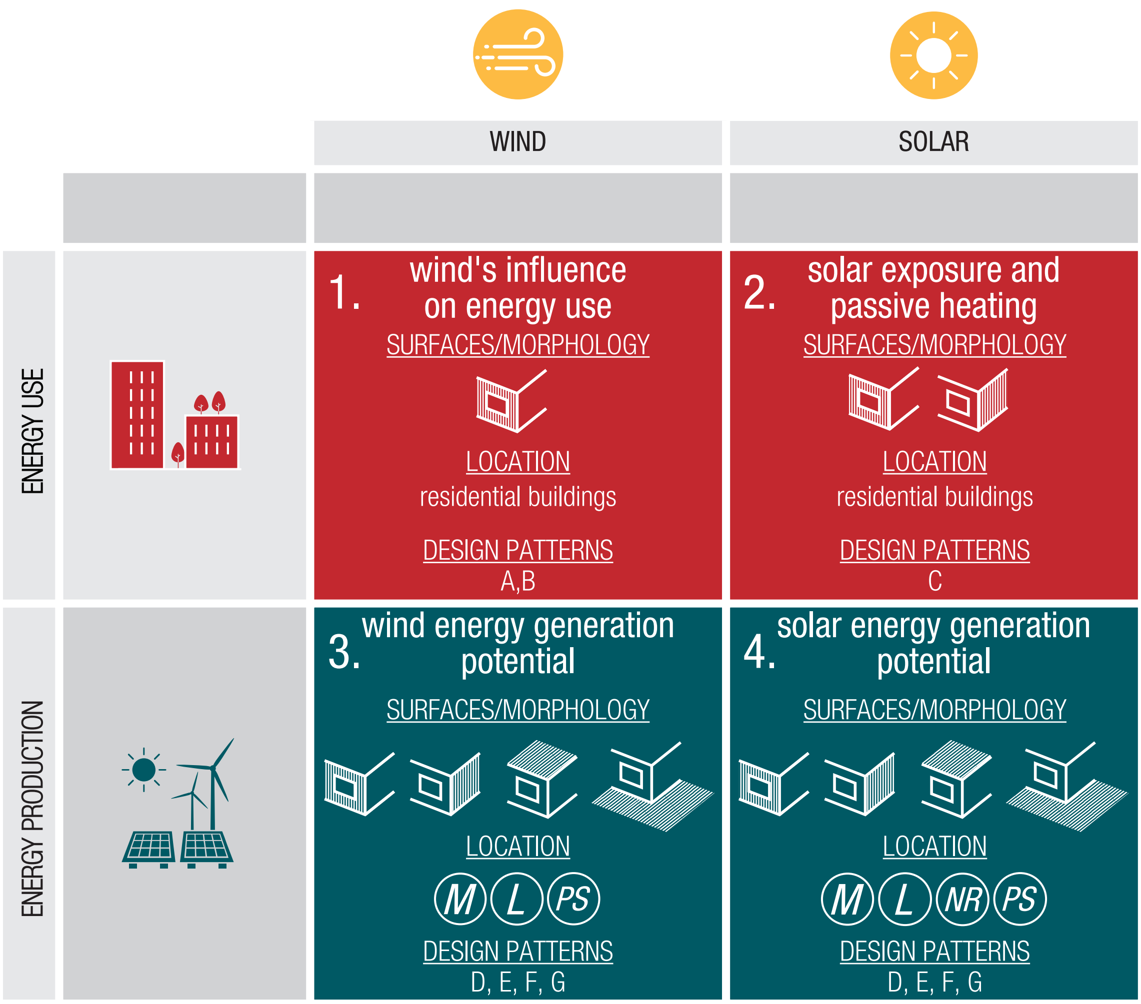


stamps C, D & E

8.3. FOCUS AREAS: DESIGN PATTERNS IMPLEMENTATION AND DESIGN

From the whole neighbourhood of Schiebroek Zuid, 2 areas will be studied in detail and there will be a separate focus on the urban scale. The *two focus areas are chosen as representative speciments of the early and late periods of post-war neighbourhoods*, and accordingly of the urban block as it was considered in each period (as it has already been elaborated on in chapter 6). The first focus area – *urban block A* – is chosen as one of the examples of urban blocks in order to show how the analysis, patterns implementation and design works, so as a guideline to the methodological approach of urban blocks. The second focus area is the *tower square* and is chosen in order to show how a high-rise building could be treated. This focus area is more complicated due to the difficulty of protecting high-rise buildings as well as the increased attention that needs to be given in designing the space around them. Finally, the third focus area consists of a different process and result. The previous two address the urban scale through either their repetition or distinct role. *The third focus area addresses directly the neighbourhood scale* since it examines upcaled design patterns or it upscales existing patterns. The analysis needed for the design, focuses apart from wind and solar also in land uses, accesibility, points of concentration, etc.

The first stage of the analysis, however, concerns for each focus area its urban morphological qualities that affect the energy use and its potential for energy production. This happens by *4 layers of analysis maps* that later on are overlayed for the final pattern implementation. *Each layer is connected with a specific quarter of the Matrix* – as it can be seen in the diagrammatic Matrix below – *and with specific Design patterns*. In this way it becomes easier for the designer to understand which locations, surfaces and parameters such as wind direction or solar orientation, need to be taken into consideration on each layer analysis map. This will be further elaborated on each layer analysis map. At this point it needs to be notified that even though each layer is linked with a number of Design patterns, that does not mean that each focus area can be described by all Design patterns of each layer. For the energy use Design patterns it depends on the climatic conditions. For instance, Design pattern B is related to the tunnel effect which appears only when the wind direction is in parallel to the long axis of the building or open space. As for the energy production, which Design patterns are relevant to each focus area depends on the types of 'location' within the area. For instance, when there are no high-rise buildings in a focus area design pattern E is irrelevant.

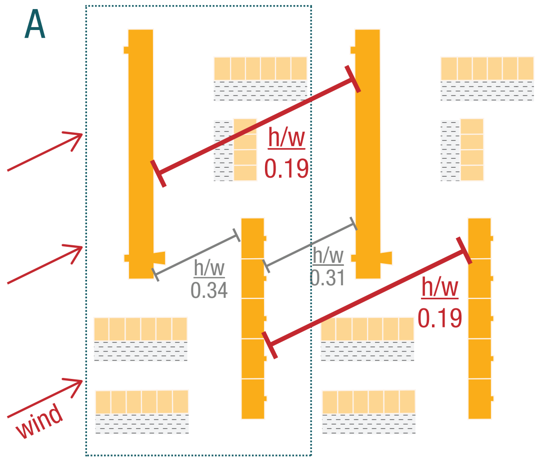


8.3.1. URBAN BLOCK A

There are *4 layers of analysis maps* needed:
- wind's influence on energy use – Design Pattern A
- potential for wind energy generation – Design Pattern D & F
- solar exposure and passive heating – Design Pattern C
- potential for solar energy generation – Design Pattern D & F

In the analysis maps related to energy generation, public spaces are also taken into account. For wind related analysis the direction of the wind and the principles defined by Oke are used in order to ideitify which areas, surfaces are exposed to wind. All solar related maps are made via Google Sketchup and use solar insolation that uses the specific location and time zone, and as a date the 21st of December (winter solstice).

To each layer analysis map patterns are applied without looking in parallel the other layers and in the end when all layers of pattern maps are reasy they will be overlaid. At the next stage is when synergies and contradictions appear and compromises need to be made. At this stage it is desireable for each layer to offer as many possible design subpatterns in order to have more possibilities for compromises after the overlay of the layers.

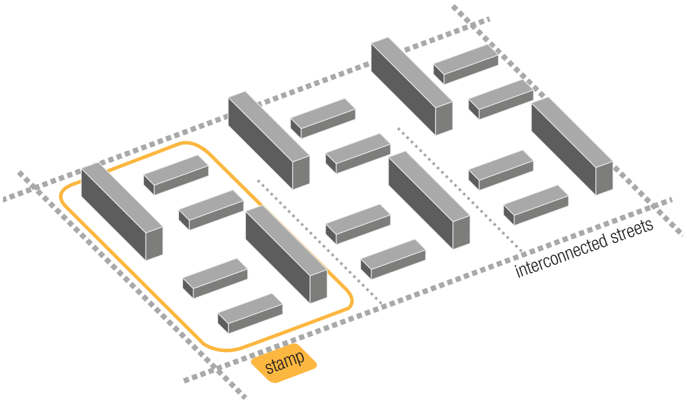


¬ wind's influence on energy use: Design Pattern A

The wind's influence on energy use represents the 1st of the four quarters of the matrix (see opposite page) and design patterns A and B provide with sollutions to the negative influence. In the case of urban block A, design pattern B is irrelevant since we can see that the direction of the prevailing wind is not parallel to the long axis of the buildings or open spaces.

Firstly, when starting the layer analysis mapping for each layer we need to know *where the analysis happens*. As shown in the diagrammatic matrix (see opposite page) for this layer the analysis focusses on facades (surfaces) of residential buildings (location). In order to identify which facades are exposed and need to be protected firstly the prevailing wind direction needs to be placed. Then two things are taken into account:
- H/W ratio; in the matrix this ratio is considered to show optimum for a value between 0.6 and 2. However in this project the openess of modernism is considered valuable to be completely destroyed. Therefore values above 0.3 – which is mostly the case for mid-rise buildings within a stamp – are being protected with low density barriers (rows of trees or green walls). Below this value, high density barriers are used in order to restore the H/W ratio.

Post-war neighbourhoods
new urban block
(influenced by the Garden City & Modernism)

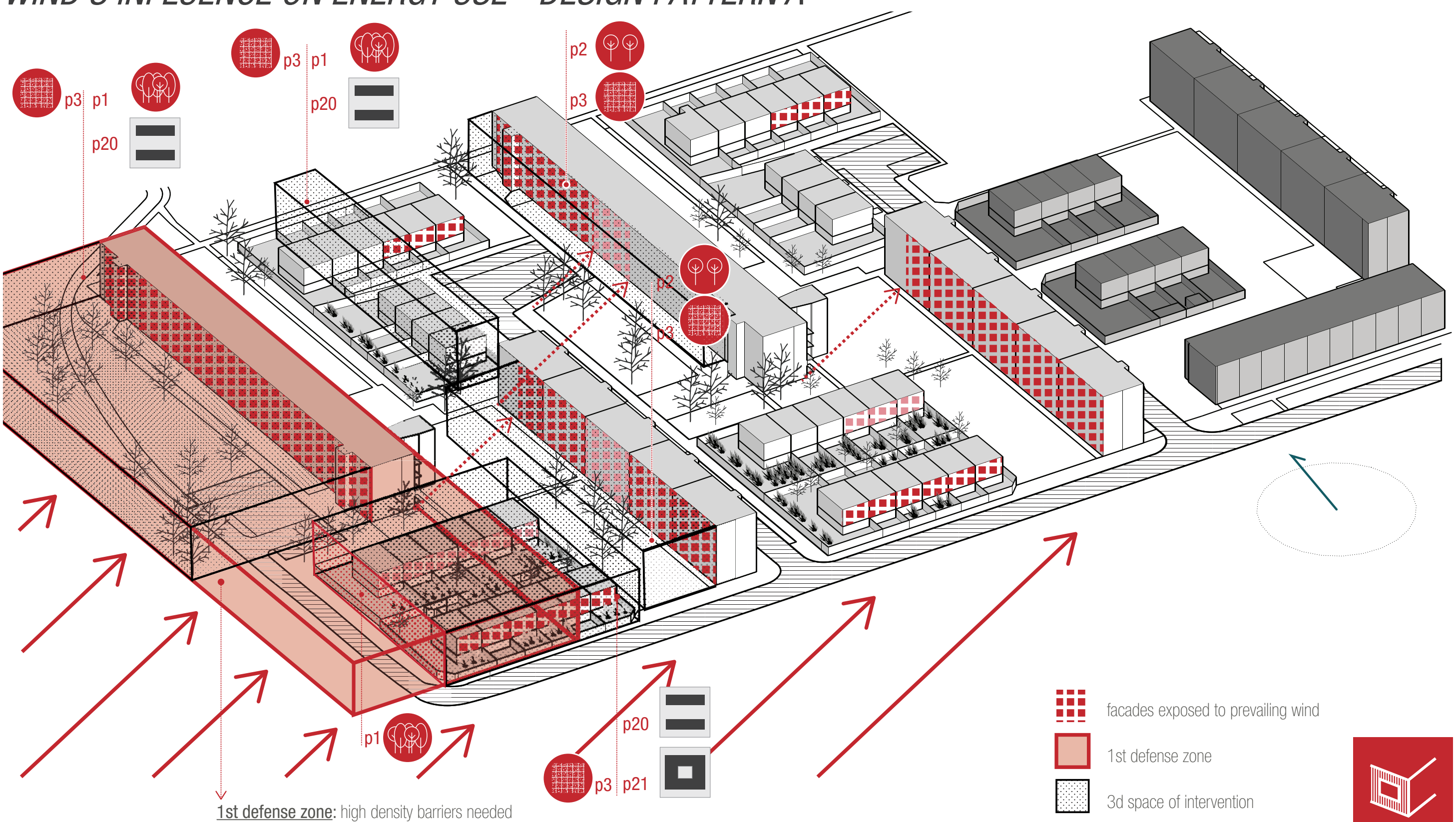


- vegetation; even though protection from deciduous trees is considered low it needs to be taken into account for the analysis.

So when the vegetation is sufficient (evergreen and dense, not just a row of trees) or the H/W ratio between two buildings (wind direction taken into account for calcualtion of H/W) is higher than 0.3 then the subsequent building's facade is under wind shadow, which means it is protected. The *pattern implementation*, based on the aforementioned analysis, takes place in the stamp of the urban block and in the first zone that connects two stamps (since the structure and distance might be different). Then the implementation on the rest of the stamps of the block is implicit.

Finally there is another aspect that needs to be taken into consideration. The urban block based on its modernistic definition – which has already been explained in chapter 6 –is spatially defined by interconnected streets. This characteristic in terms of wind protection, means that the first buildings of the block are more exposed to the wind than the subsequent ones. For that reason they fristly need to be better protected themselves and also the denser the protection of this first zone the more protected the subsequent buildings are. This area constitutes the *1st defense zone* and high density barriers are required.

WIND'S INFLUENCE ON ENERGY USE - DESIGN PATTERN A



A. FACADES EXPOSED TO PREVAILING WINTER WIND

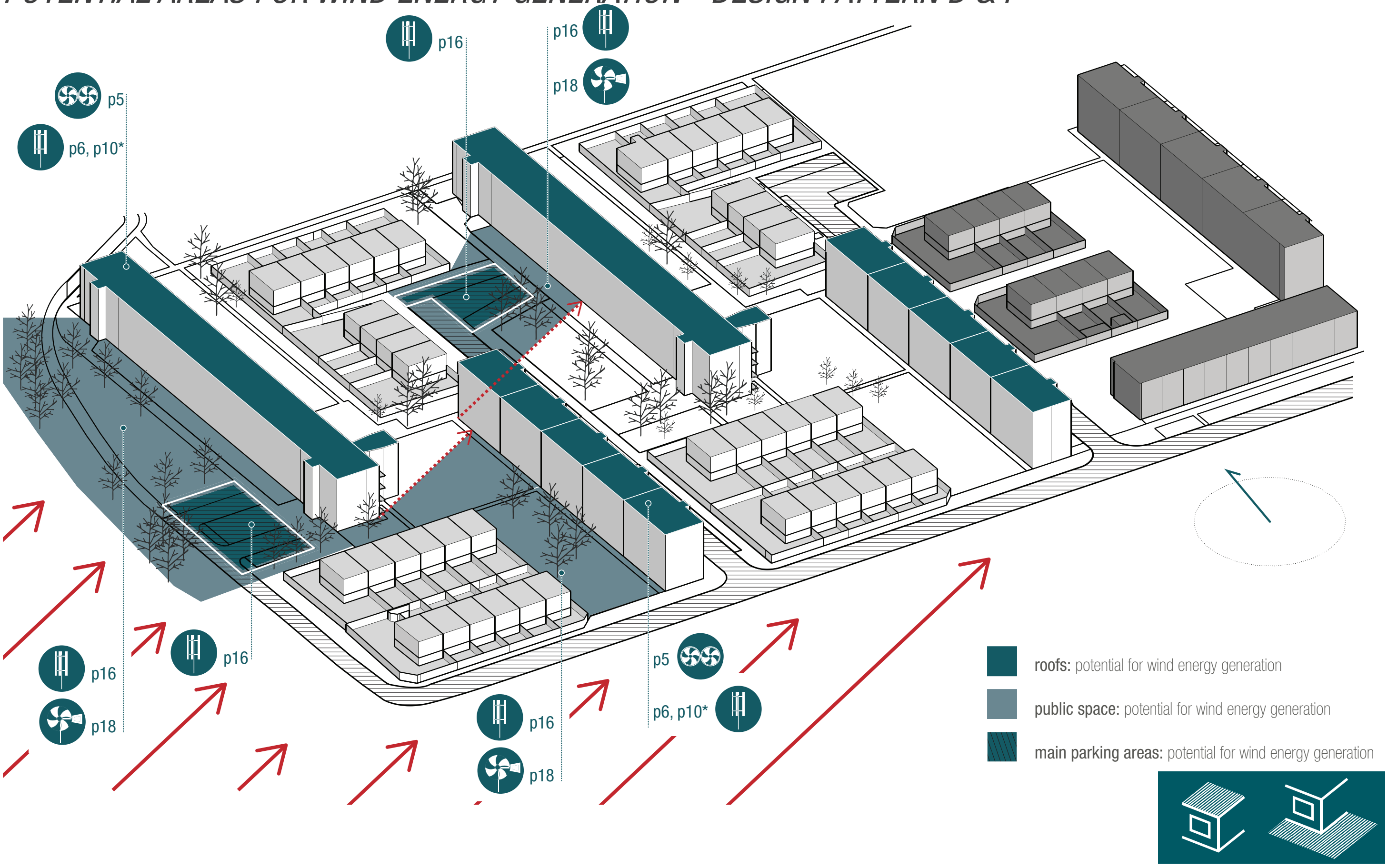
Problem statement

Sides of building exposed to wind during winter have as a result significant loss of buildings' heat especially in the case of the poorly insulated post-war buildings. No or insufficient (deciduous) protection from vegetation is a common reason for exposure to wind. Also low H/W ratio for parallel rows results in wind's acceleration regaining. Meanwhile, parallel linear blocks with large open spaces inbetween them are common in dutch post-war neighbourhoods. Therefore high density barriers should be placed in the presence of main flow (full speed). Low density barriers are more appropriate in cases of wake interference or lee eddys.

¬ *potential areas for wind energy generation: Design Pattern D & F*

Similarly to the 'wind's influence on energy use' layer, the first step is to mark the direction of the prevailing wind. The next step is to locate where the potential areas should be found. The particular layer belongs to the 3rd of the four quarters of the matrix (see p. 136), but all the surfaces and locations are not to be found in all urban blocks. Urban block A in particular has no high-rise or non-residential buildings. Therefore the design patterns used are only the D and F which are related to mid-rise residential buildings and public spaces. So the after finding the related design patterns the surfaces are easy to determine: roofs and public spaces.

POTENTIAL AREAS FOR WIND ENERGY GENERATION - DESIGN PATTERN D & F



D. UNUSED AND ENERGY-LACKING ***ROOFTOPS OF RESIDENTIAL BUILDINGS***

Problem statement

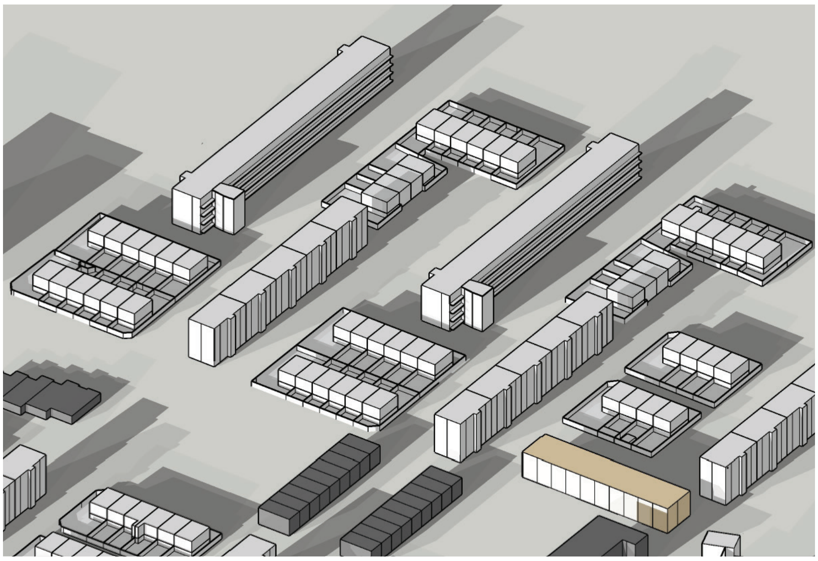
Rooftops on residential buildings are under- or unused. In mid-rise buildings a combination of energy production and active use by residents is both desireable and possible.The height of mid-rise buildings shows lower wind speeds which means, on the hand specific technologies can only be productive, on the other hand they can be actively used by residents. Elements such as orientation, position, visual impact and combination with other uses, need to be taken into account for design decisions.

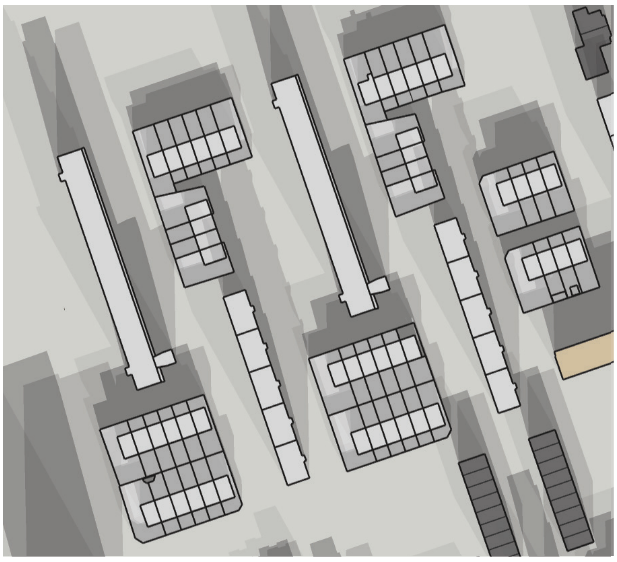
F. UNDERUSED AND ENERGY-LACKING ***PUBLIC SPACES***

Problem statement

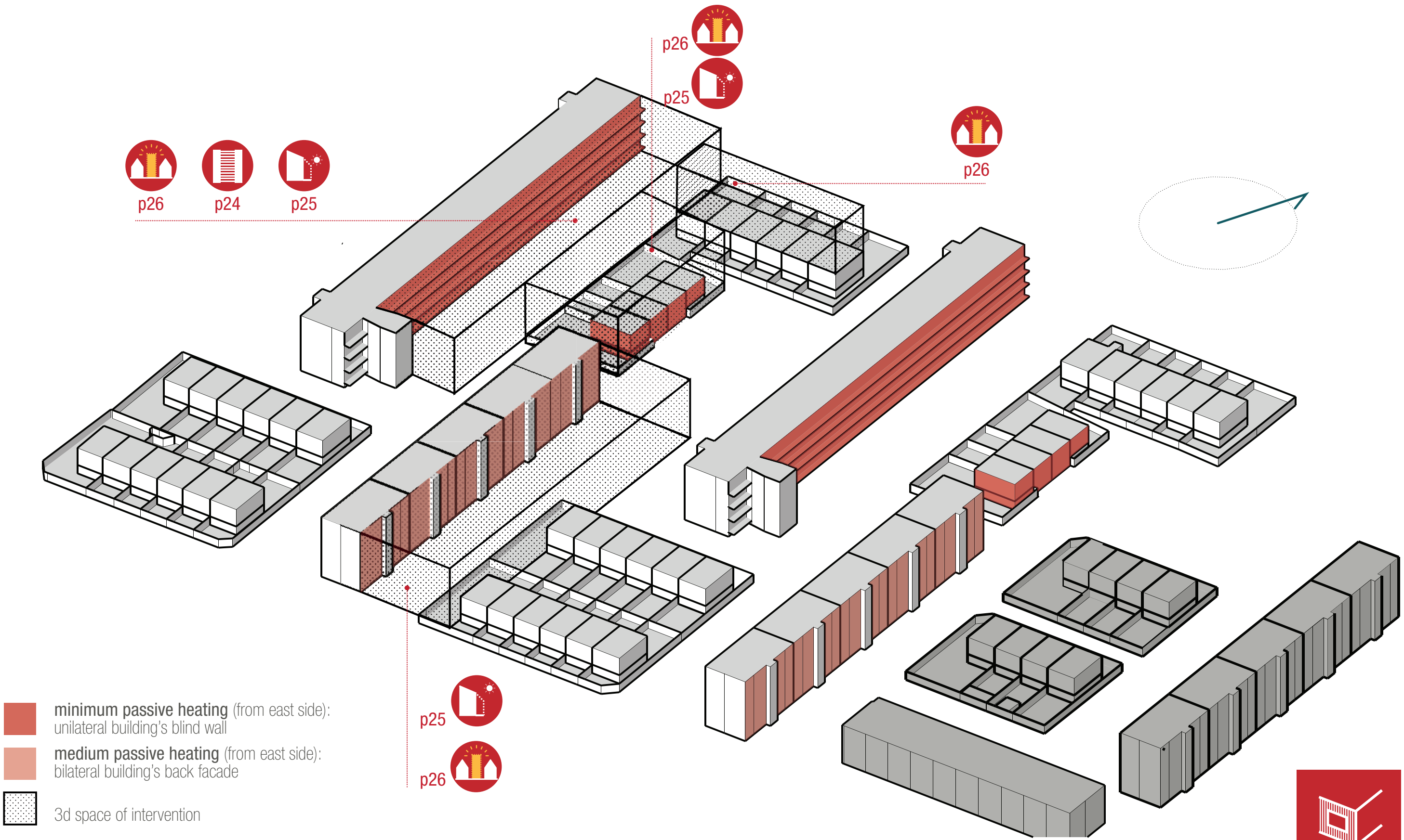
The result of openess and zoning has been an abundance of public spaces for green or activities but are currently largely underused. These large and undefined spaces have the potential with the implementaion of various innovative technologies to be revitalized while contributing in lowering energy demand of buildings or more importantly in energy production.

OVERLAPPING IMAGES OF SHADOW FROM 11:40 TO 13:40 (ONE IMAGE EVERY HOUR). IN THIS CASE THE 21ST OF DECEMBER IS TAKEN INTO CONSIDERATION (WINTER SOLSTICE).





RESIDENCES LACKING IN SOLAR EXPOSURE (LACK OF PASSIVE HEATING) - DESIGN PATTERN C



C. LACK OF PASSIVE HEATING

Problem statement

The optimum orientation of living spaces is facing south for solar passive heating. Indeed in some of the post war buildings the entrance is north so that living spaces can freely face the south. However it is also common for a 'stamp' to consist of different – often perpendicular to each other – orientated buildings. Therefore some buildings face E-W which is disadvantageous both for winter and summer moths. Therefore, where possible glazed spaces should be created to maximize passive heating during winter months and at the same time provide for cooling opportunities during summer. Where not possible or desireable, the possibility is given for infill development since there is already no solar exposure and densification is considered desireable.

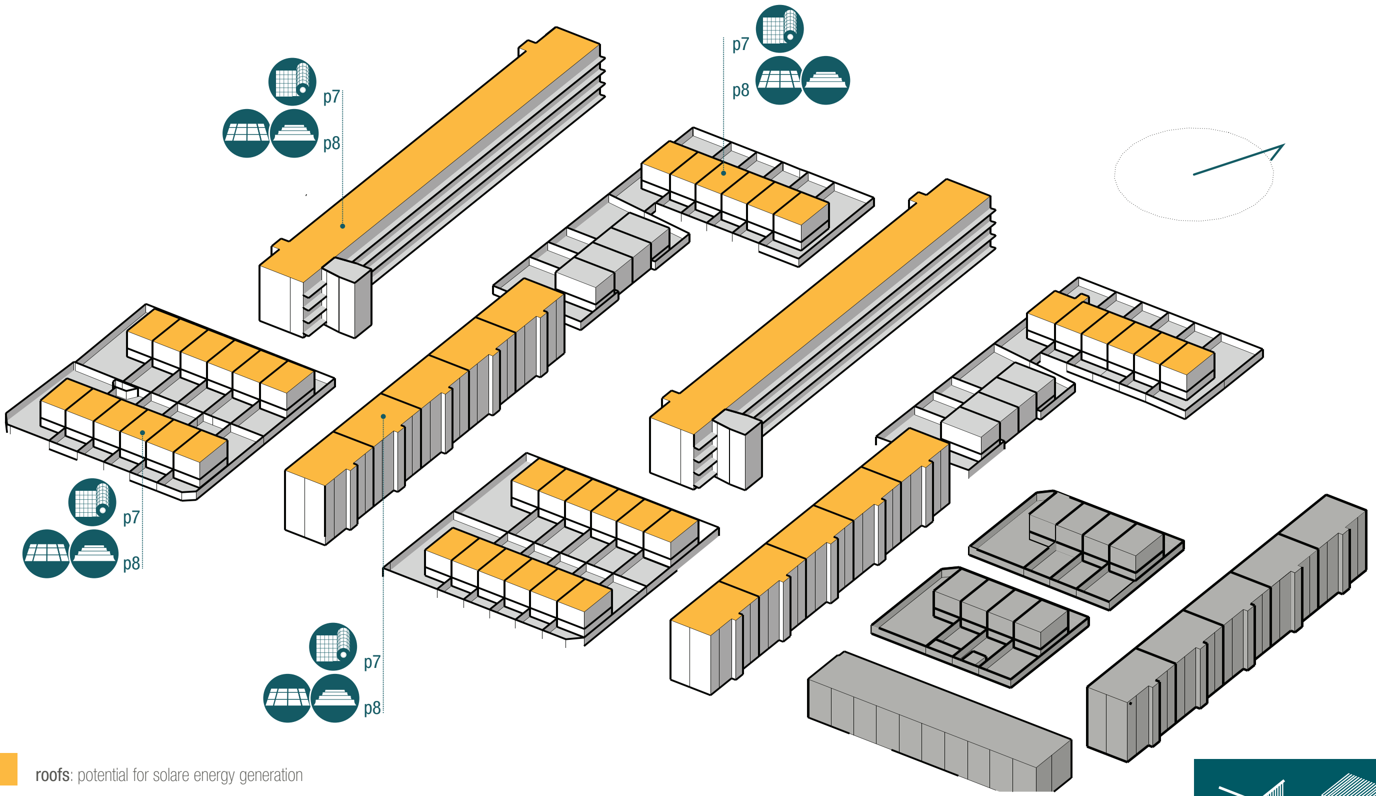
¬ solar exposure and passive heating: Design Pattern C

Passive heating belongs to the 2nd quarter of the Matrix and it is described by Design pattern C. The location is residential buildings and the surfaces that need to be looked into are the facades and the blind walls. In the case of solar exposure during winter – as it has already been explained in chapter 5 – two sides are taken into consideration: the south and the east. Another important parameter is the building envelope – as it can be found both in the Matrix on the building scale and at the beginning of the current chapter in the local conditions. In the case of urban block A there are two types of buildings: unilateral and bilateral. The unilateral buildings have the worst orientation since the facade faces the west and the blind wall faces the east which offers minimum passive heating potential but it has the potential with the use of either the atrium or the sunroom pattern to receive passive heating via conduction. The bilateral buildings have more potential for passive heating but because of the 4 entrances and utilities vertical zones (elevators and stairs), it is still characterized as medium.

¬ potential areas for solar energy generation: Design Pattern D & F

The solar energy potential constitutes the 4th quarter of the Matrix and it is described by Design patterns D & F. Two different analysis maps are used fore this layer in order to make the pattern implementation easier. The reason for that division is that Design pattern F has to do with public spaces which in the case of solar access it is easier to indentify the areas with solar access on a planar view (see p. 142) rather than an axonometric view. Design pattern D describes residential buildings and the surface that the sub-patterns will be implemented are the roofs (see opposite page).

POTENTIAL FOR SOLAR ENERGY GENERATION: ROOFTOPS WITH SOLAR ACCESS - DESIGN PATTERN D

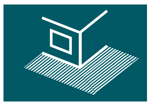


D. UNUSED AND ENERGY-LACKING **ROOFTOPS OF RESIDENTIAL BUILDINGS**

Problem statement

Rooftops on residential buildings are under- or unused. In mid-rise buildings a combination of energy production and active use by residents is both desireable and possible.The height of mid-rise buildings shows lower wind speeds which means, on the hand specific technologies can only be productive, on the other hand they can be actively used by residents. Elements such as orientation, position, visual impact and combination with other uses, need to be taken into account for design decisions.

POTENTIAL FOR SOLAR ENERGY GENERATION: PUBLIC SPACES WITH SOLAR ACCESS – DESIGN PATTERN F



F. *UNDERUSED AND ENERGY-LACKING **PUBLIC SPACES***

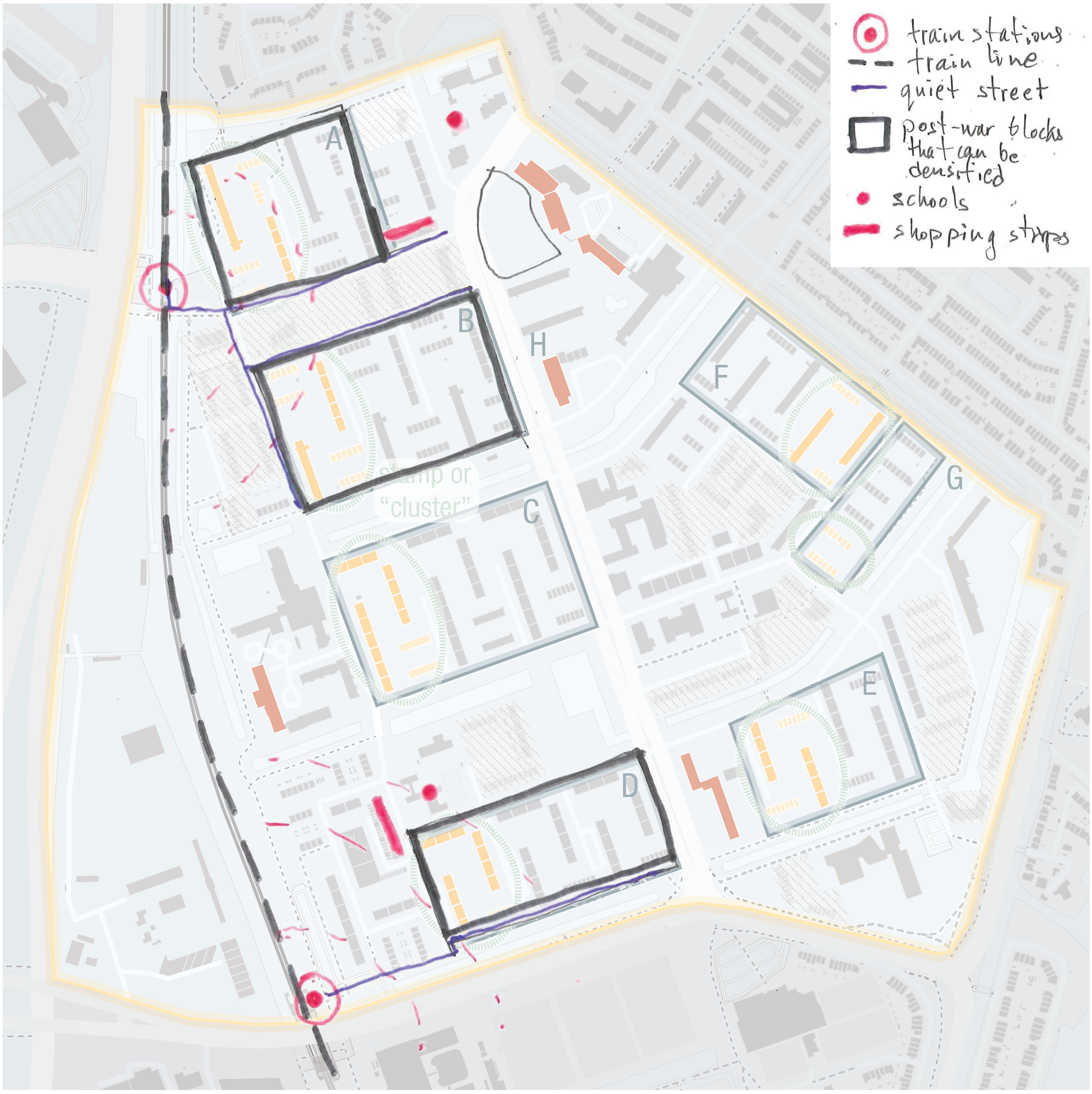
Problem statement

The result of openess and zoning has been an abundance of public spaces for green or activities but are currently largely underused. These large and undefined spaces have the potential with the implementaion of various innovative technologies to be revitalized while contributing in lowering energy demand of buildings or more importantly in energy production.

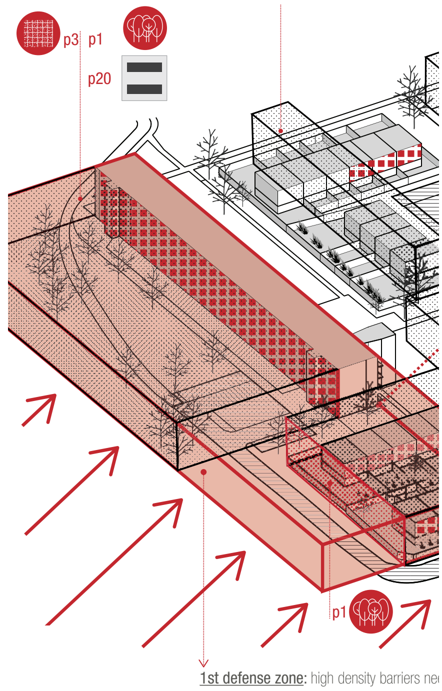
DENSIFICATION: STRATEGIC POINTS IN THE NEIGHBOURHOOD

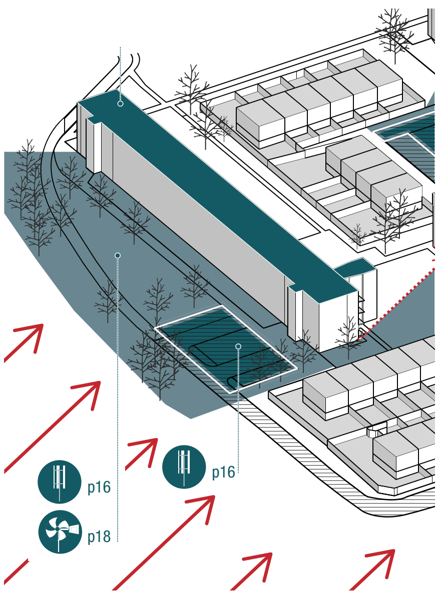
After the first implementation of the design subpatterns and the overlay of layer pattern maps, another aspect is examined. SInce some of the subpatterns concern densification, apart from the possibilities of each urban block the neighbourhood as a whole ought to be examined. Namely based on metro stations, commercial or service centres, we can determine the urban blocks that are better located for densification. I

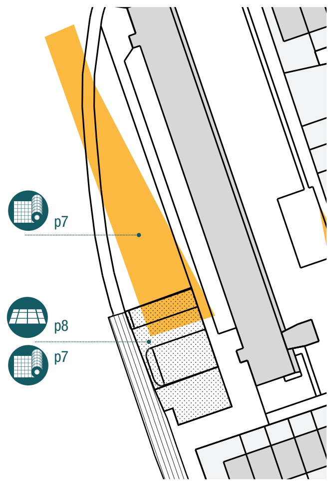
In particular, Urban Block A is adjacent to the metro station Meijersplein, and it also located close to a core of services (medical centre, library, school) and some shops. Therefore after deciding on the design subpatterns of the block for all layers, I reviewed the space in order to try to deinsify more than I had initially.



INSIGHT TO THE DESIGN METHOD







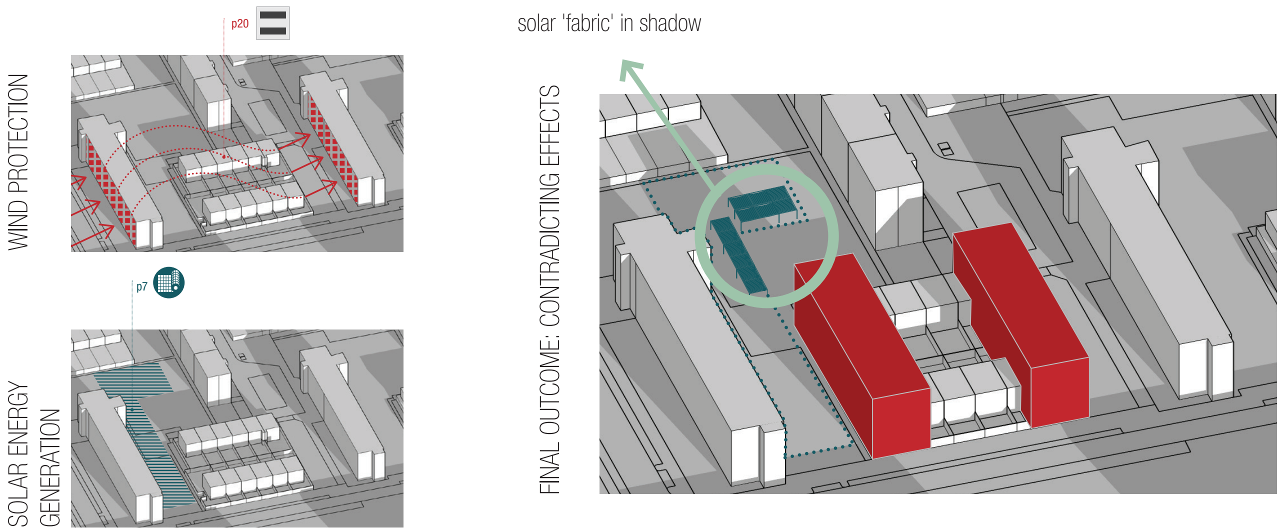
From the layer analysis mapping towards the final sub-pattern implementation and the final design of the urban block, there is a process of decision-making that takes place which will be explained through the current example. By overlaying the different layers a spatial competition occurs between different patterns. Some of the sub-patterns can form synergies and can be applied together. However many sub-patterns form conflicts not only spacially but also in terms of contradicting effects. As it can be seen in the diagram (top of opposite page), if for instance a dendification sub-pattern is applied at the same time with a solar 'fabric' on public space there is a significant risk for the solar 'fabric' to be unproductive due to the shadow of the new building. Therefore for the final implementation attention should be given firstly to the efficacy of each subpattern and there might be a need to revisit the analysis or even the design patterns catalogue – or the comparative tables according to the pattern group that they belong.

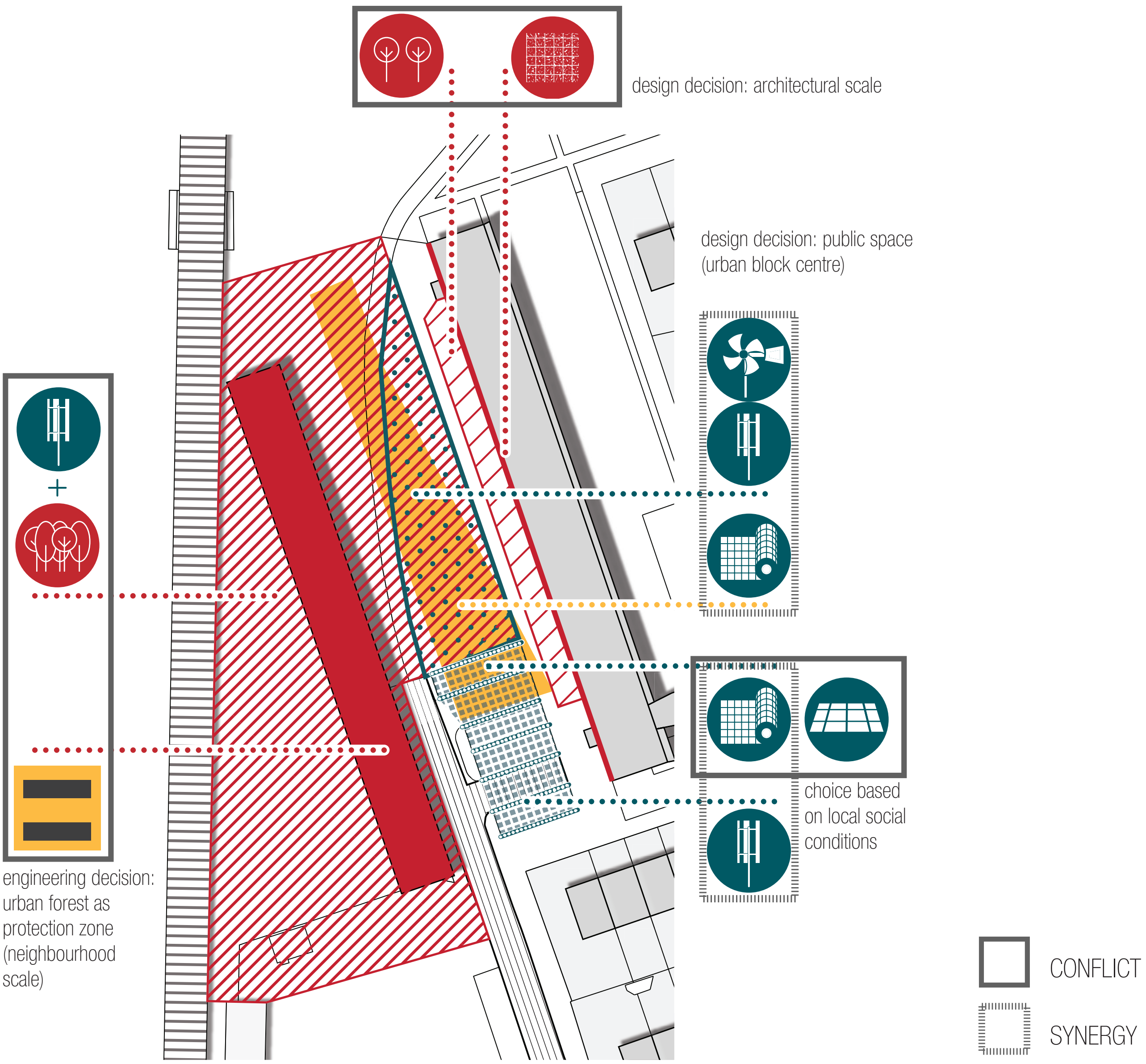
After these kinds of conflicts are resolved there is still the conflict of space, since more than one subpatterns can be located in the same space. To resolve these conflicts decisions must be taken from the designer which can be of different nature, these can vary depending on different factors. Two of them are definitely part of all such decisions: engineering and design. An element that they share is the scale which, depending on which space the specific design might apply to, might entail different parameters to take into consideration for each scale.

Engineering decisions concern which of the possible sub-patterns are the most needed or the most appropriate for the space at hand. For instance in the current example and as the drawing shows (opposite page) in the western part of the zoom-in area there can be either a densification pattern or urban forrest combined with VAWTs. In both cases a high density barrier for the southwestern wind would be created. However the urban forest was considered more desireable firstly due to the ability to be extended towards the southeastern part of the neighbourhood. This was desireable because from that side the railway and highway create a gap that alllows for the wind to gain full speed. Therefore the forest serves as a shield for the entire neighbourhood. Furthermore its combination with an accompanied wind energy generation corridor (VAWTs) creates an energy productive urban landscape.

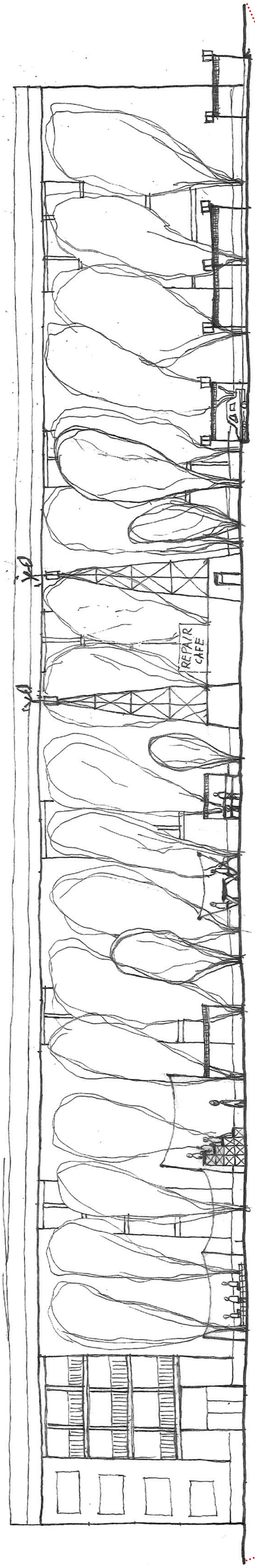
Design decisions are based on the spatial exploration of the zoom-in area or – depending on the role of the area in the wider neighbourhood – of the effect on the urban scale. The spatial exploration is pursued as in any design process through plans, sections or any other means of representation that aids the designer. In the following pages (p. 148-149) the design process for Urban Block A is exhibited as it was carried out by the author.

Finally, there are also other kinds of decisions that might be needed. For instance in the current example for the parking area there were two possibilities for solar energy generation: PV panels or solar 'fabric'. This decision was taken in reference to the local social conditions. Namely due to the financial and social issues of Schiebroek Zuid, the solar 'fabric' is a more sensible choice because of it is easier and cheaper to replace in case of vandalism, for instance.


WIND PROTECTION
p20
p7
SOLAR ENERGY GENERATION
FINAL OUTCOME: CONTRADICTING EFFECTS
solar 'fabric' in shadow

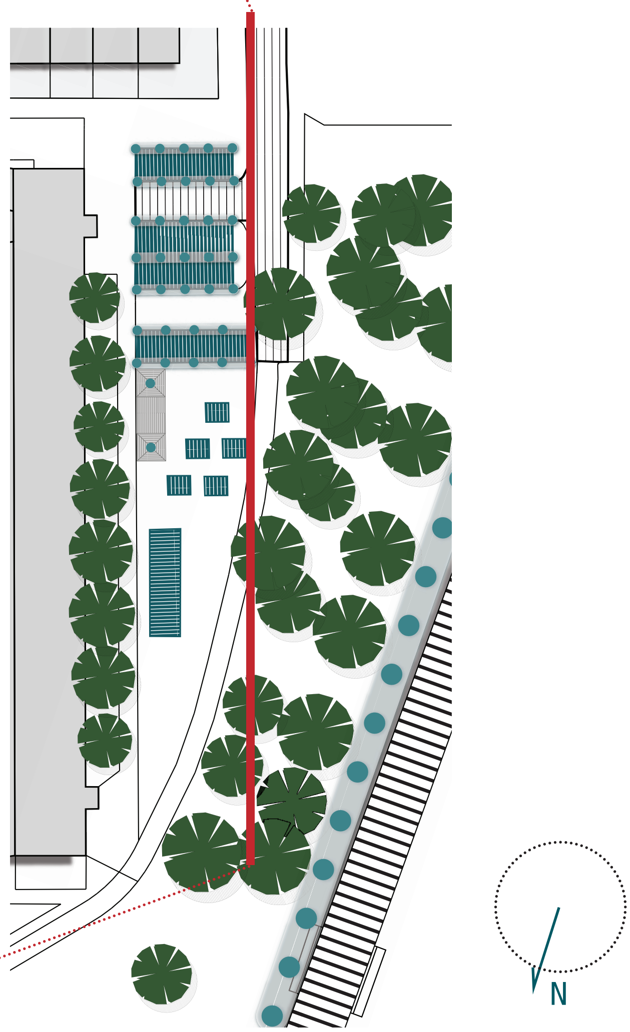

design decision: architectural scale
design decision: public space (urban block centre)
engineering decision: urban forest as protection zone (neighbourhood scale)
choice based on local social conditions
CONFLICT
SYNERGY

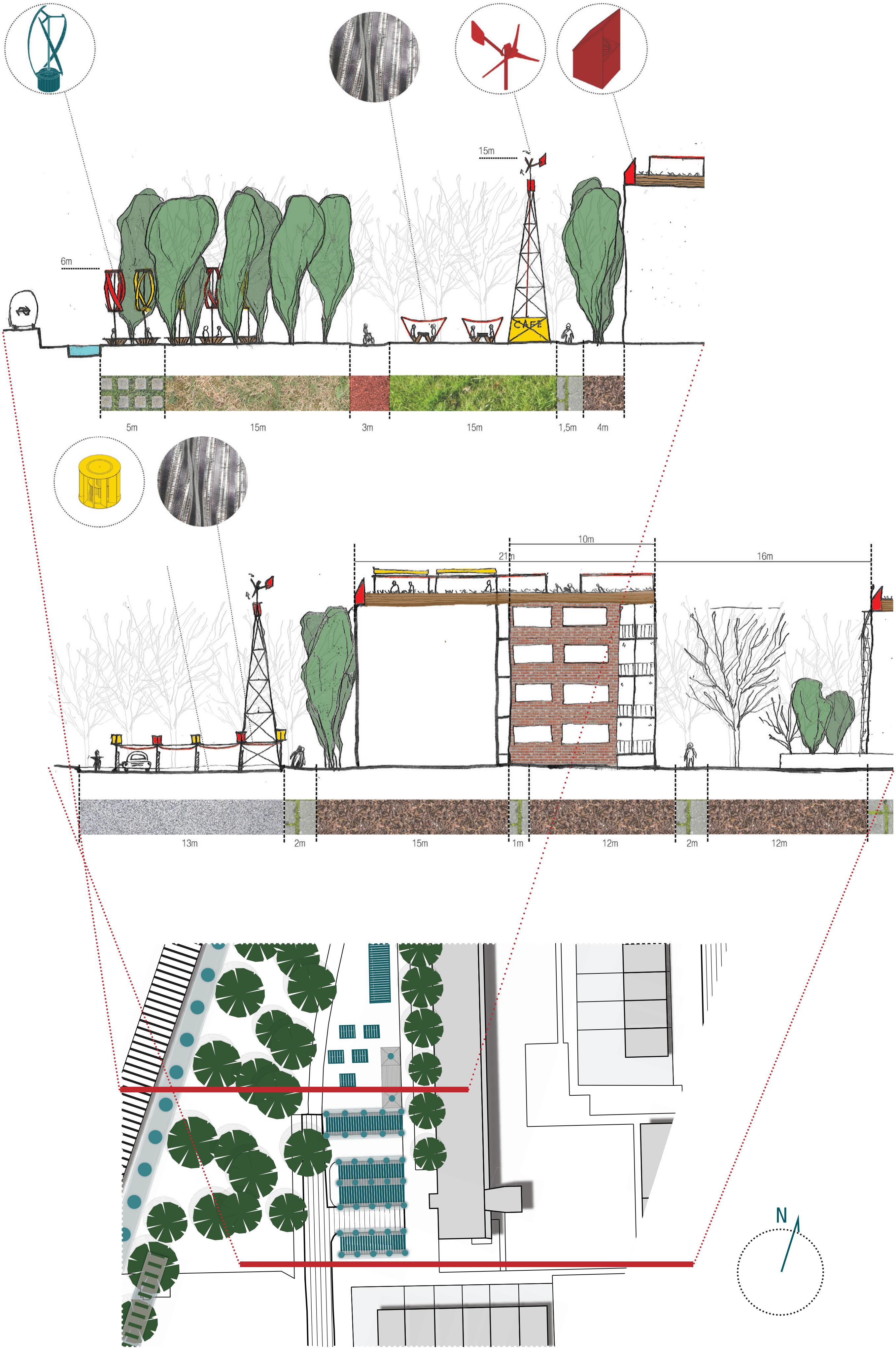
DESIGN PHASE



After all the layer aanalysis maps finished, I overlaid them in order to see synergies and contradictions. At this point it needs to be noted that contradictions do not only concern spatial competetion of different design patterns. Another extremely important element that needs to be kept in mind and thoroughly studied, is the consequences of each design subpattern on other design subpatterns. For instance, in a public space you might have placed solar fabric that based on the shadow map of the existing residential building it has plenty of solar access. If, though, western or eastern than this space there is also a densfication pattern applied and therefore a new building, the result might be that the solar fabric will be now located in shadow.

Therefore this process has the function of a loop. It is necessary to apply the patterns, then check the result and then probably go back to the layer pattern maps and choose another pattern to apply. Even when the conclusion map of design patterns in the block is finished, when zooming in to design the space from users' perspective changes still might be necessary.

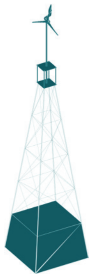



15m
6m
CAFE
5m
15m
3m
15m
1,5m
4m
10m
21m
16m
13m
2m
15m
1m
12m
2m
12m
N

INSIGHT TO THE DESIGN METHOD

P18_HAWT \TOWER

Energy production: 3-5 kWh/day → **Average E≈ 14 MJ/day**
Cost: 640 €



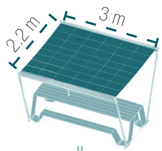
ENERGY CONSUMPTION of an average COFFEE MACHINE

1h= 3,600 s
Average coffee machine: 800 W(J/s) → t≈ 5 h

5h

P7_SOLAR 'FABRIC'

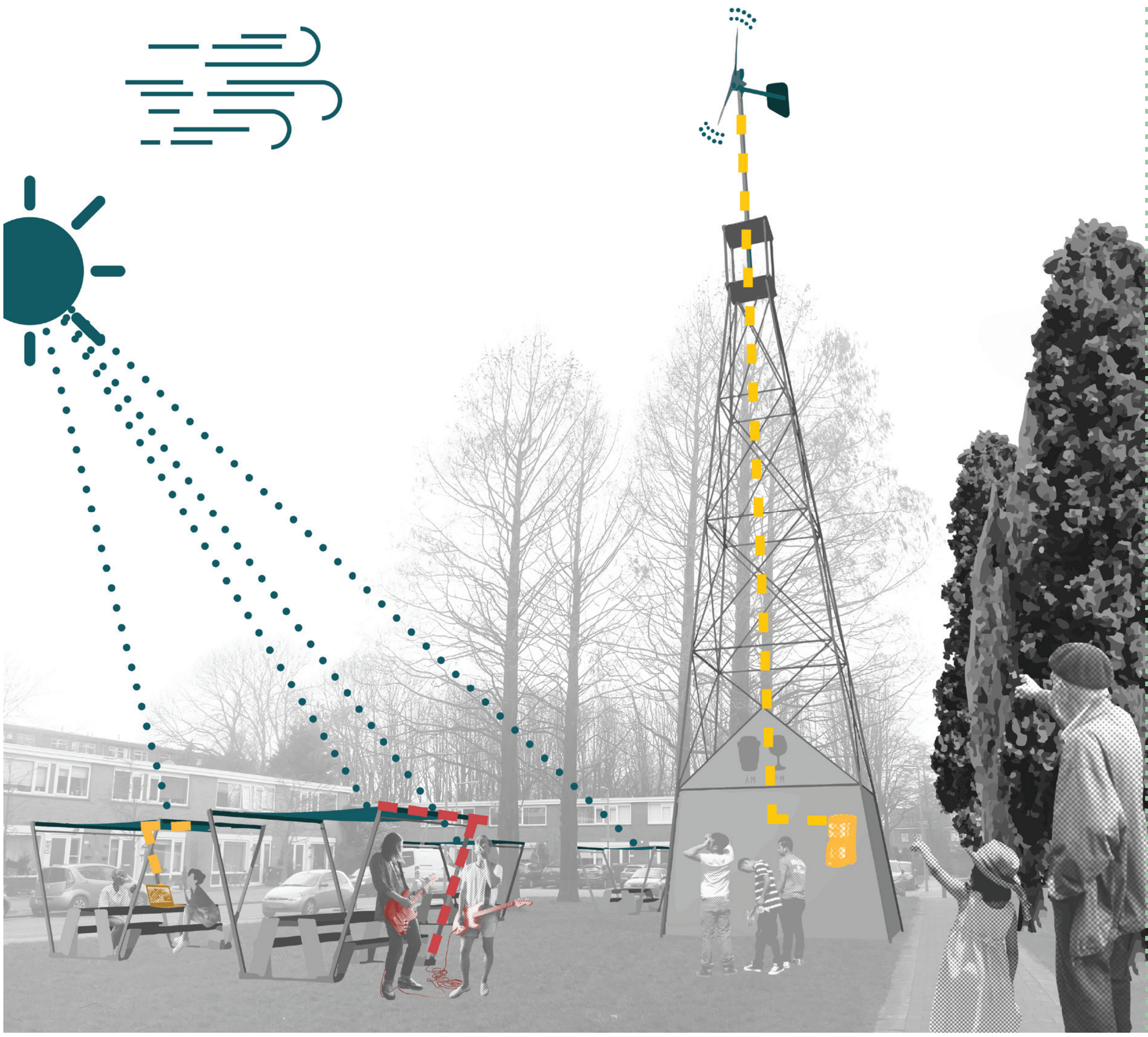
Energy production: 0.2 kWh/day for 1m² → (2.2m x 3m) → 1.3 kWh/day → **E≈ 4.7 MJ/day**
(based on dutch sun peak hours for WINTER)

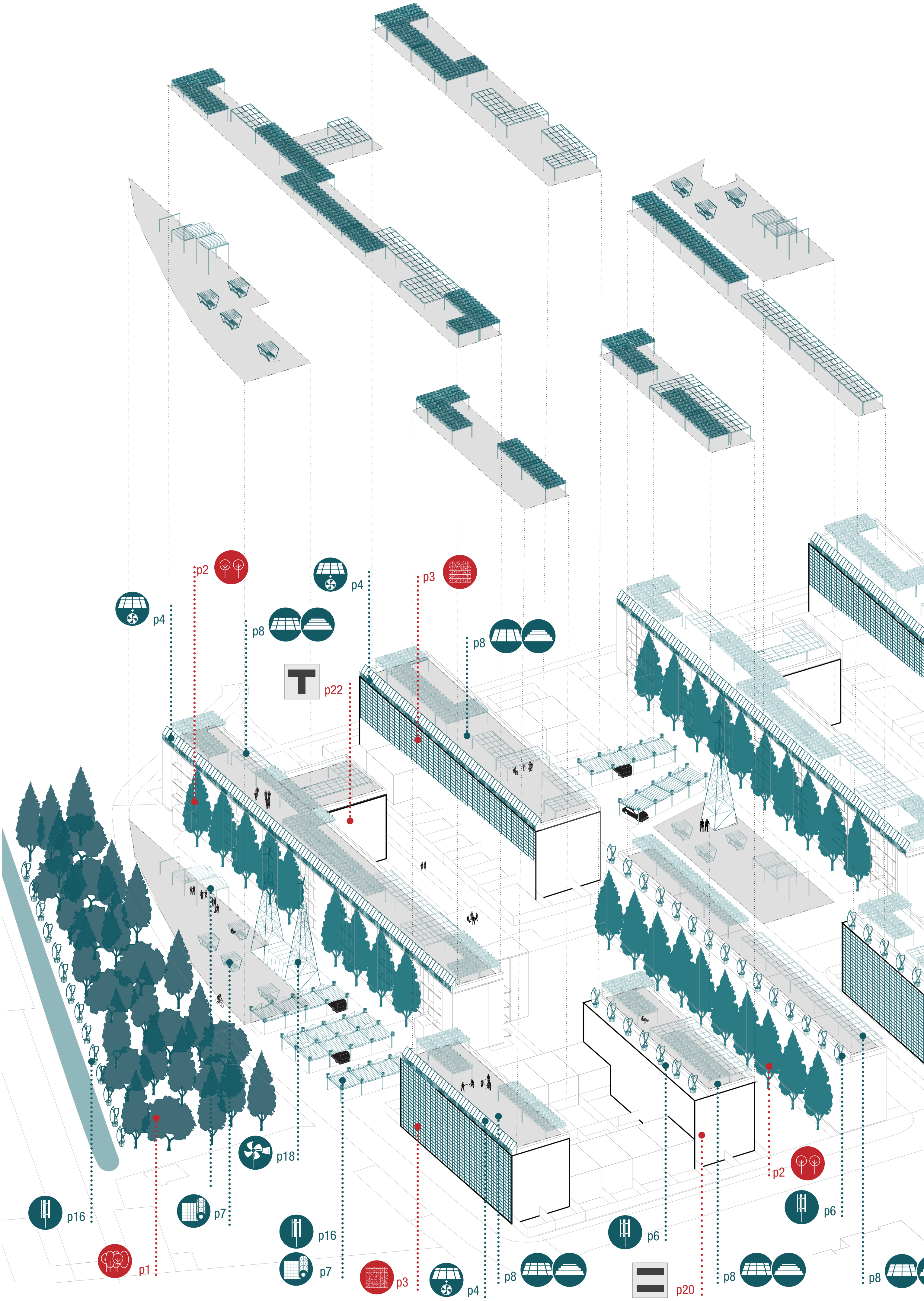


ENERGY CONSUMPTION of an average LAPTOP

6h

Average laptop: 60 W(J/s) → t= 18h → or t=6h for 3 laptops





p2
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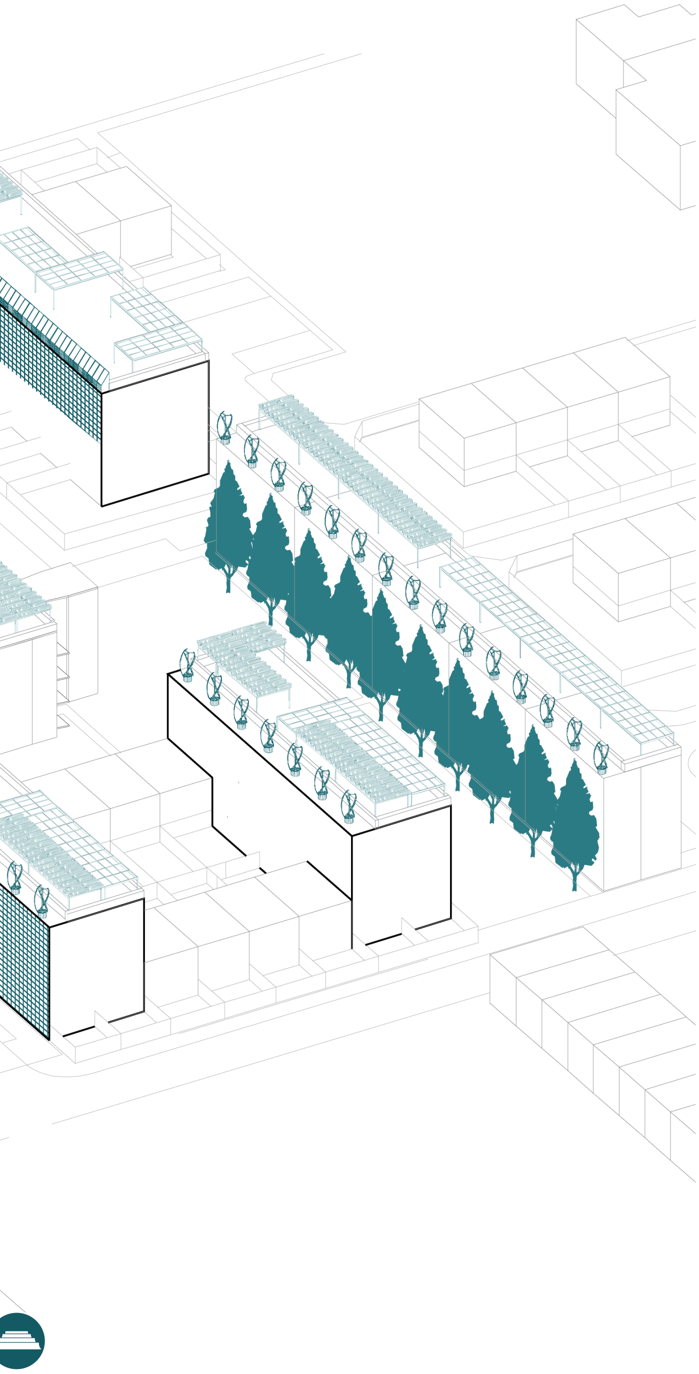


IMPACT ON THE URBAN SCALE

By mapping the design subpatterns used in Urban Block A separately for each design pattern, the impact on the urban scale needs to be shown. Two examples are being exhibited here, the urban impact of Design patterns A and D.

The subpatterns used in some cases can be upscaled as in the example of Pattern A where the subpattern of urban forrest grows beyond the block. In some other cases, and based on the urban block typology (see 8.2), some of the patterns can be copied in different blocks with similar stamps. Depending on the level of parameters and analysis each design pattern requires it can be easier or harder to extrat patterns from the studied urban

A. FACADES EXPOSED TO PREVAILING WINTER WIND

Problem statement

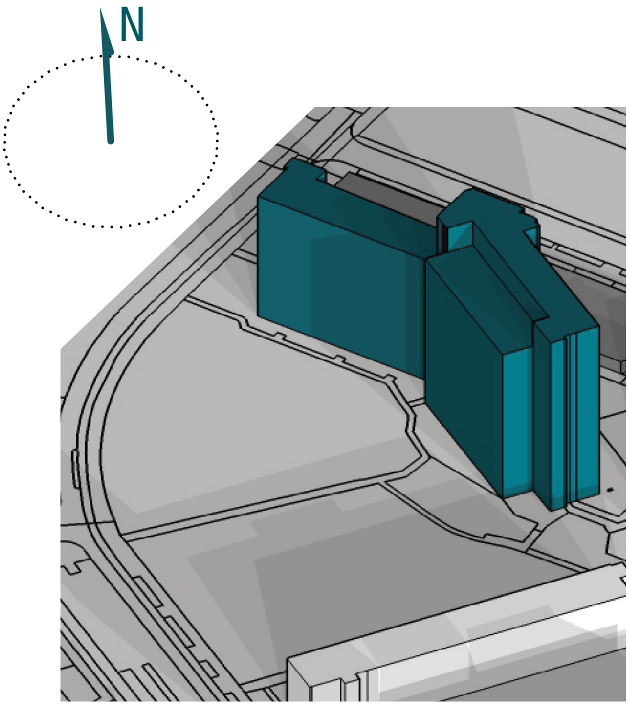
Sides of building exposed to wind during winter have as a result significant loss of buildings' heat especially in the case of the poorly insulated post-war buildings. No or insufficient (deciduous) protection from vegetation is a common reason for exposure to wind. Also low H/W ratio for parallel rows results in wind's acceleration regaining. Meanwhile, parallel linear blocks with large open spaces inbetween them are common in dutch post-war neighbourhoods. Therefore high density barriers should be placed in the presence of main flow (full speed). Low density barriers are more appropriate in cases of wake interference or lee eddys.

block to another one. For instance when it comes to Pattern A the surroundings as well as the urban morphology specifics (e.g. order and height of buildings in combination) make it harder and more arbitrary to apply subpatterns from one urban block to another. On the contrary in the case of Pattern C it is easier to extract subpatterns from one urban block and apply them to another. The reason is that, for example, the skimming effect that might complicate application for Pattern A, does not affect rooftops.

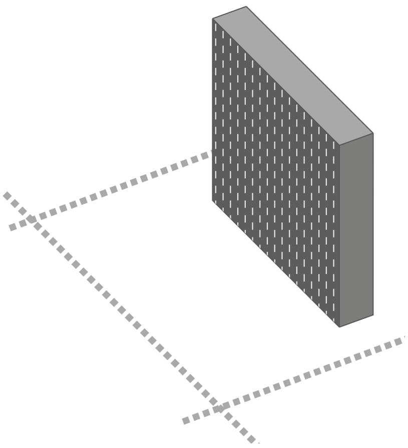
D. *UNUSED AND ENERGY-LACKING* ***ROOFTOPS OF RESIDENTIAL BUILDINGS***

Problem statement

Rooftops on residential buildings are under- or unused. In mid-rise buildings a combination of energy production and active use by residents is both desireable and possible.The height of mid-rise buildings shows lower wind speeds which means, on the hand specific technologies can only be productive, on the other hand they can be actively used by residents. Elements such as orientation, position, visual impact and combination with other uses, need to be taken into account for design decisions.



Late post-war neighbourhoods
urban block unit
(influenced by Le Corbusier)



8.3.2. TOWER SQUARE

This area consists of a high-rise building bock and a square and it can be defined as an urban block based on the ideas of modernists (and especially Le Corbusier) and the late period of post-war neighbourhoods (for more details see chapter 6). The height of the building along with the square in front of it and with the fact that the wind comes from the street to the open space of the square and then to the building, makes this focus area different than urban block A. Therefore only *2 layers of analysis maps* will be used for pattern implementation for reasons that will be further explained:

- wind's influence on energy use – Design Pattern A
- potential for wind energy generation – Design Pattern D & F

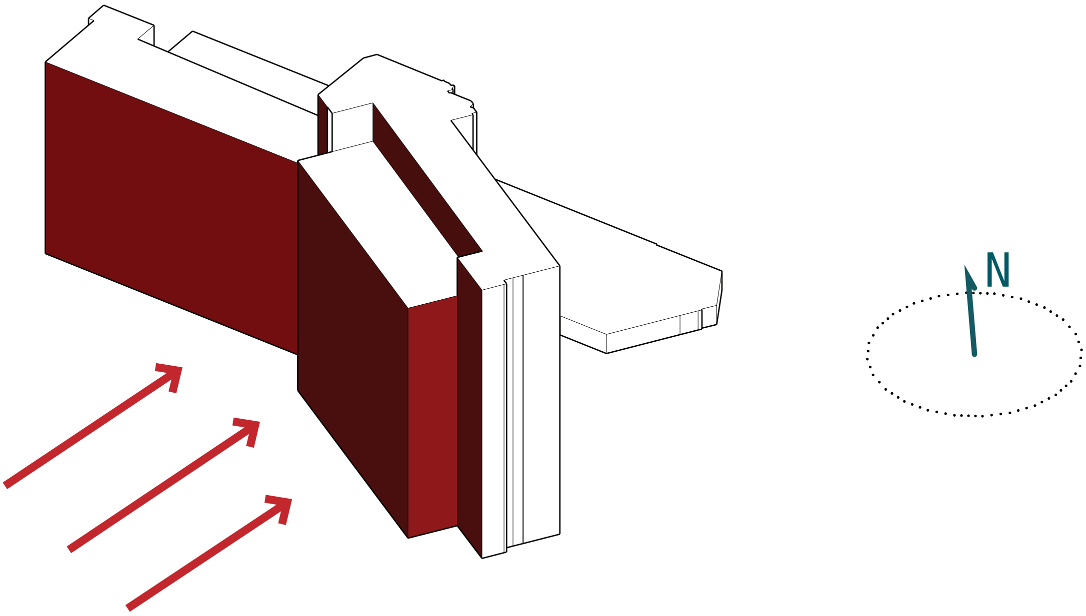
¬ wind's influence on energy use: Design Pattern A

The height of the building makes it more difficult to provide a high density barrier, since for instance an urban forest of evergreen trees can only protect the lower floors. Meanwhile a green wall is not sufficient to prevent the full wind effect, which is strengthened by the opens space of the square and the street. Furthermore, in reference to passive heating from sun, the building is disadvantegousely oriented since its facade is facing west.

Therefore in order to protect the facade from wind, a high-rise and high-density barrier needs to be placed in the open space in front of the building. By looking into the Design pattern A – which describes the problem – and the according sub-patterns it becomes clear that sub-pattern 19, 'P19_compact form', can address this issue effectively. Five towers of compact form are placed as wind barriers, in a formation that allows for solar access from the southeast and blocks the prevailing wind from the southwest. This becomes possible by placing the towers in offset from each other on the southwest axis and bridging them with green walls in the form of vertical gardens that also function as corridors.

The choice of infill development as a wind barrier is also made by taking into consideration whether the site is appropriate for densification. The square in front of the high-rise building is adjacent to the central street of the neighbourhood where the tram and bus pass. It is also in close proximity to a small service core with a medical centre, a school and a library. It is also within walking distance from the metro station Meijersplein. It is therefore an appropriate area for densification. Furthermore exactly because of the significance of the square as an important juncture, the towers create a compact densification model that offers the necessary space for the square to maintain and enrich its function.

WIND'S INFLUENCE ON ENERGY USE - DESIGN PATTERN A



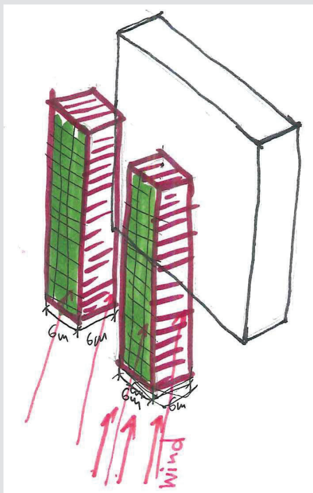
A. FACADES EXPOSED TO PREVAILING WINTER WIND

Problem statement

Sides of building exposed to wind during winter have as a result significant loss of buildings' heat especially in the case of the poorly insulated post-war buildings. No or insufficient (deciduous) protection from vegetation is a common reason for exposure to wind. Also low H/W ratio for parallel rows results in wind's acceleration regaining. Meanwhile, parallel linear blocks with large open spaces inbetween them are common in dutch post-war neighbourhoods. Therefore high density barriers should be placed in the presence of main flow (full speed). Low density barriers are more appropriate in cases of wake interference or lee eddys.

DESIGN PATTERN A – SUB-PATTERN 19 IMPLEMENTATION

P19_COMPACT FORM



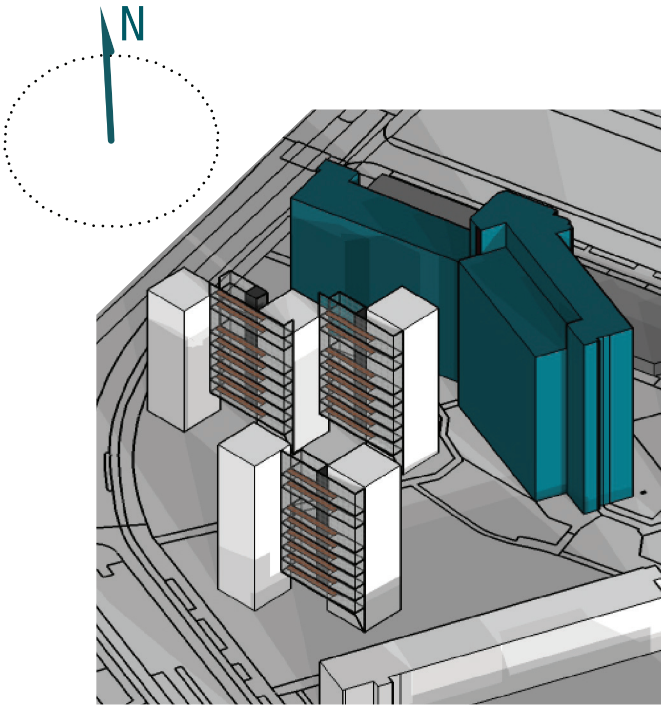
Description

Compact form – aka structure with minimum exterior surface and a roofplan analogy (width to length) of 1: 1.1-1.3 elongated on E-W axis – can sustain its inner heat better and if the width or legth remains under 10m it is easily heated. Therefore, and given current insulation systems and the incorporation of green walls, a line of compact towers can provide shelter for post-war high-rise buildings.

Neubau MFO-Park Zürich (Burckhardt+Partner AG, Raderschall Landschaftsarchitekten)

ReGen village vertical farming system (EFFEKT Architects)

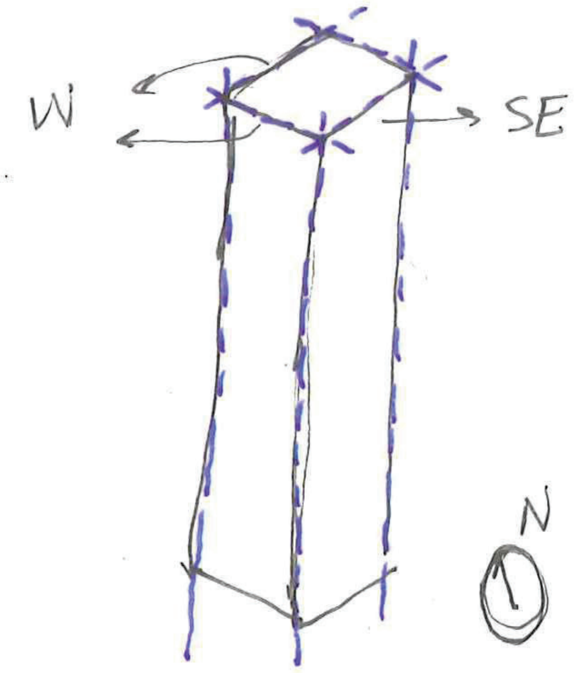
Urban Farm at Pasona Tokyo Headquarters is a nine story high corporate office building (KONODESIGNS)

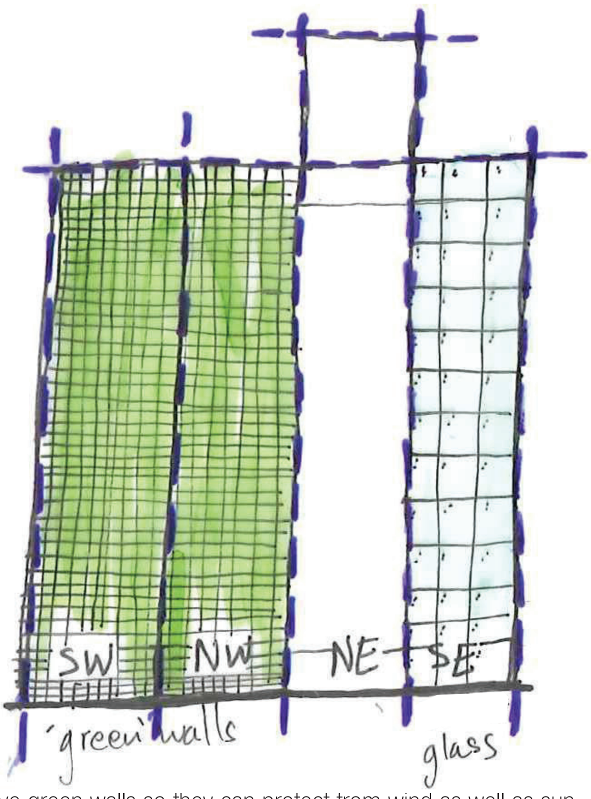


the formation of the towers in front of the post-war high-rise building; they are spaced in such a way that it is possible for at least some solar access on the south side and, along with the vertical gardens that unite them, so they can block the wind.

¬ *potential areas for wind energy generation: Design Pattern D & F*

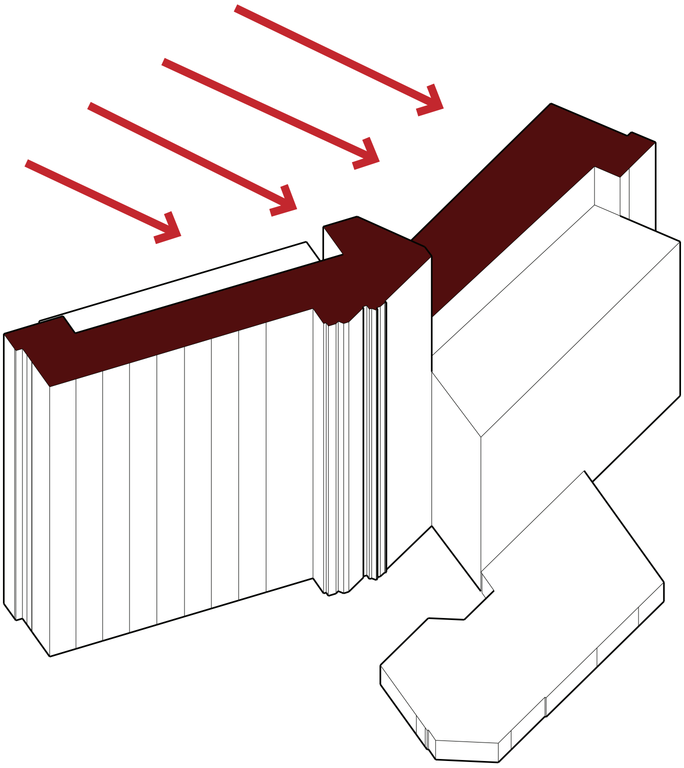
The layer analysis map of wind protection and wind energy generation showed that – due to the direction of the wind – the heat losses are significant and need to be addressed but also the potential for energy production is quite high. Due to the prevailing problem of the wind protection of the high-rise building the sub-pattern implementation clearly starts from the 'P19_Compact form' sub-pattern and then the towers created were taken into consideration for the rest of the layer analysis maps. Due to the height of the new towers the layer analysis map of 'Potential for solar generation' shows that the public space around the towers doesn't have enough sun during peak sun hours. This affects the possibilities for energy generation in the square and it is therefore prefered to have wind energy generation.

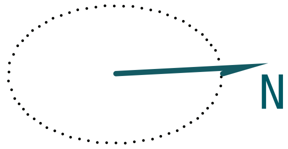




each tower has different surfaces depending on the orientation; the SW and the NW have green walls so they can protect from wind as well as sun during the summer months and the SE side has glass in order to provide with as much solar heating as possible.

POTENTIAL FOR WIND ENERGY GENERATION - DESIGN PATTERN E





*E. UNUSED AND ENERGY-LACKING **HIGH-RISE BUILDINGS' SURFACES***

Problem statement

In many post-war neighbourhoods there is a significant number of high rise buildings. The wind speeds at these heights are higher and unblocked by surrounding buildings, the same applies for sun on the higher floors.

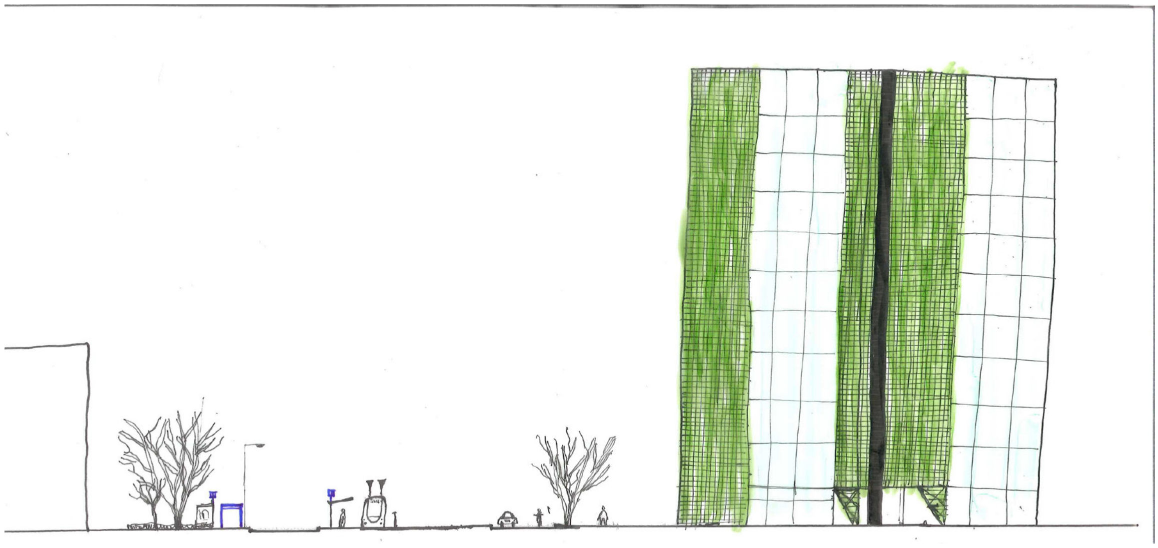
POTENTIAL FOR SOLAR ENEGY GENERATION IN PUBLIC SPACE – DESIGN PATTERN F

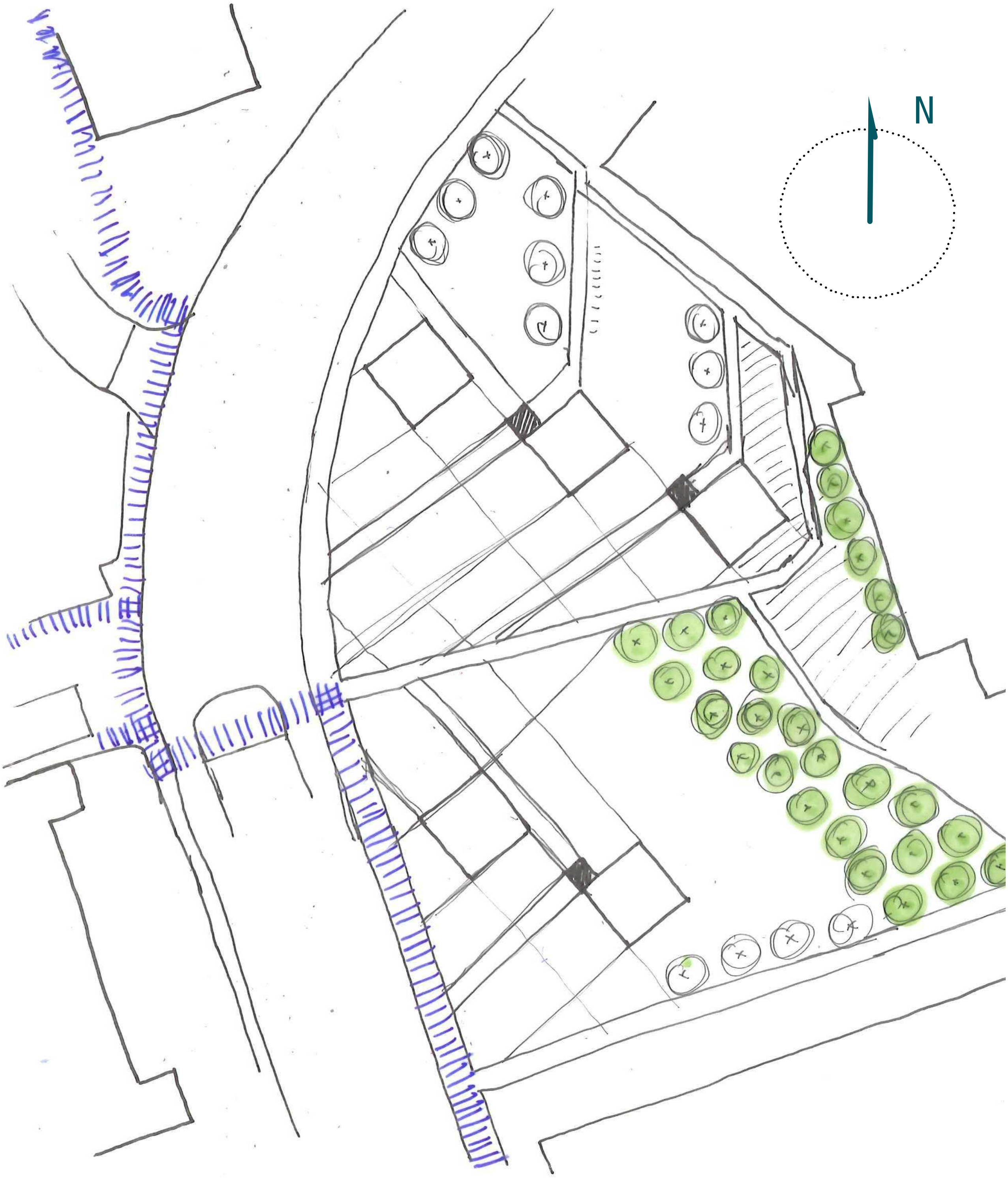
overlapping images of shadow from 11:40 to 13:40 (one image every hour). In this case the 21st of December is taken into consideration (winter solstice).

*F. UNDERUSED AND ENERGY-LACKING **PUBLIC SPACES***

Problem statement

The result of openess and zoning has been an abundance of public spaces for green or activities but are currently largely underused. These large and undefined spaces have the potential with the implementaion of various innovative technologies to be revitalized while contributing in lowering energy demand of buildings or more importantly in energy production.

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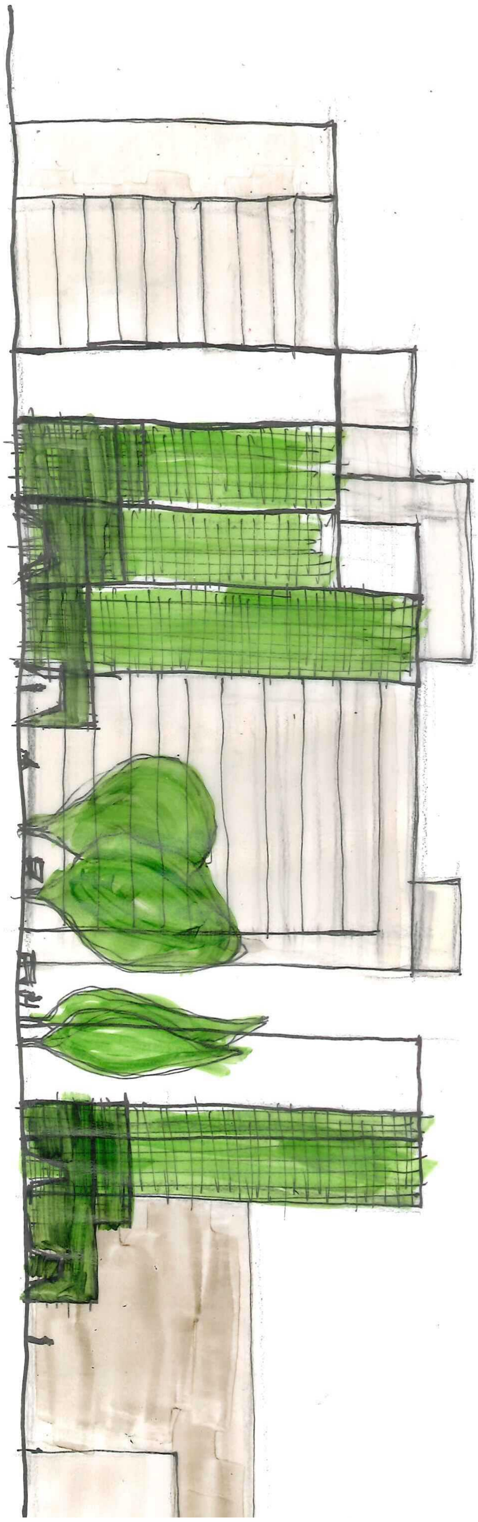
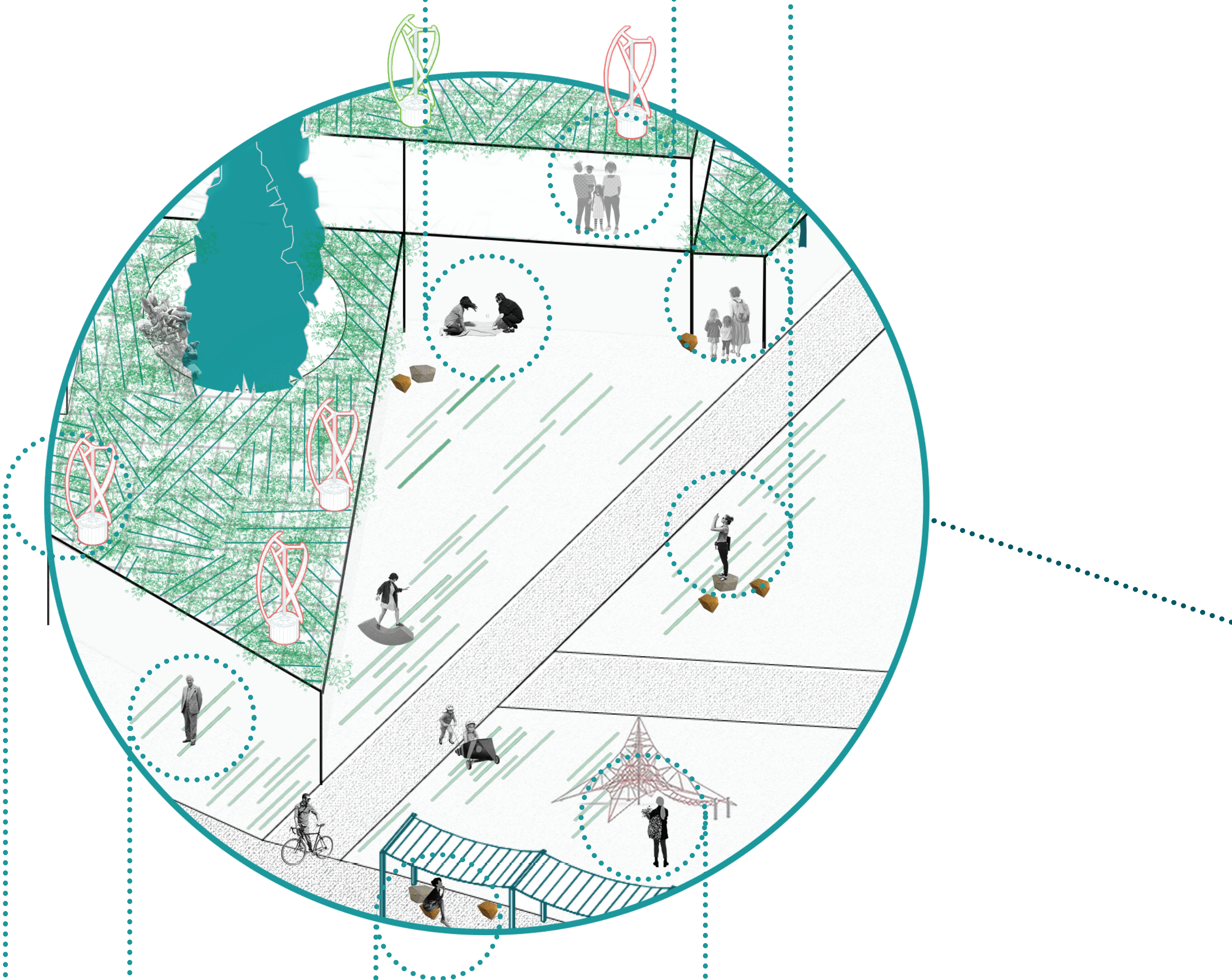
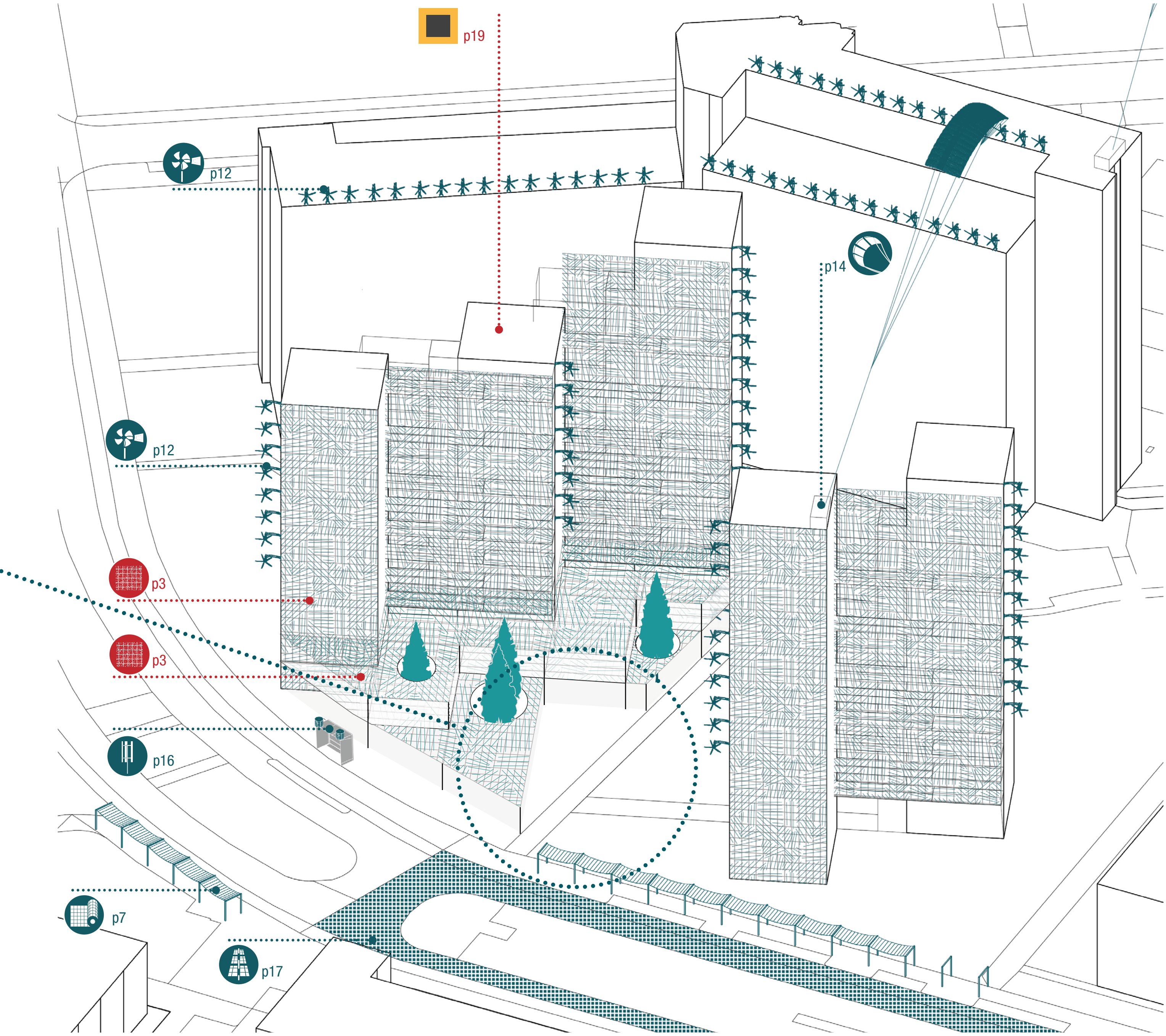


DESIGN PHASE

In the case of the tower square, and because of new high-rise buildings are placed, extra attention needed to be paid also in reference to the design of the area. Through plans and sections, the relationship between the new towers, the adjacent public space that is being redisigned with the addition of sub-patterns and the street, is being explored. One of the key elements of the square in its existing situation is the strong presence of green, trees, bushes and grass. Therefore – as it is also visible in the section – attention has been paid in the greening of the new public space, and not just for energy use reasons. Another element that was taken into account was the limited amount of sunlight in public spaces (see 'Potential for solar enegy generation in public space' layer map, p. 153) . So in the few areas that have solar access, the trees need to be deciduous and mostly from the west side so that in the winter people can enjoy some sunlight.


opportunities for leisure
a picnic day
a new landscape
look outside!
new attraction in the neighbourhood
time for a photo!
wind turbines as art objects
painted in different colours
permeable soil
resting point
under the solar fabric
new social and leisure infrastructures
new residents - new demands

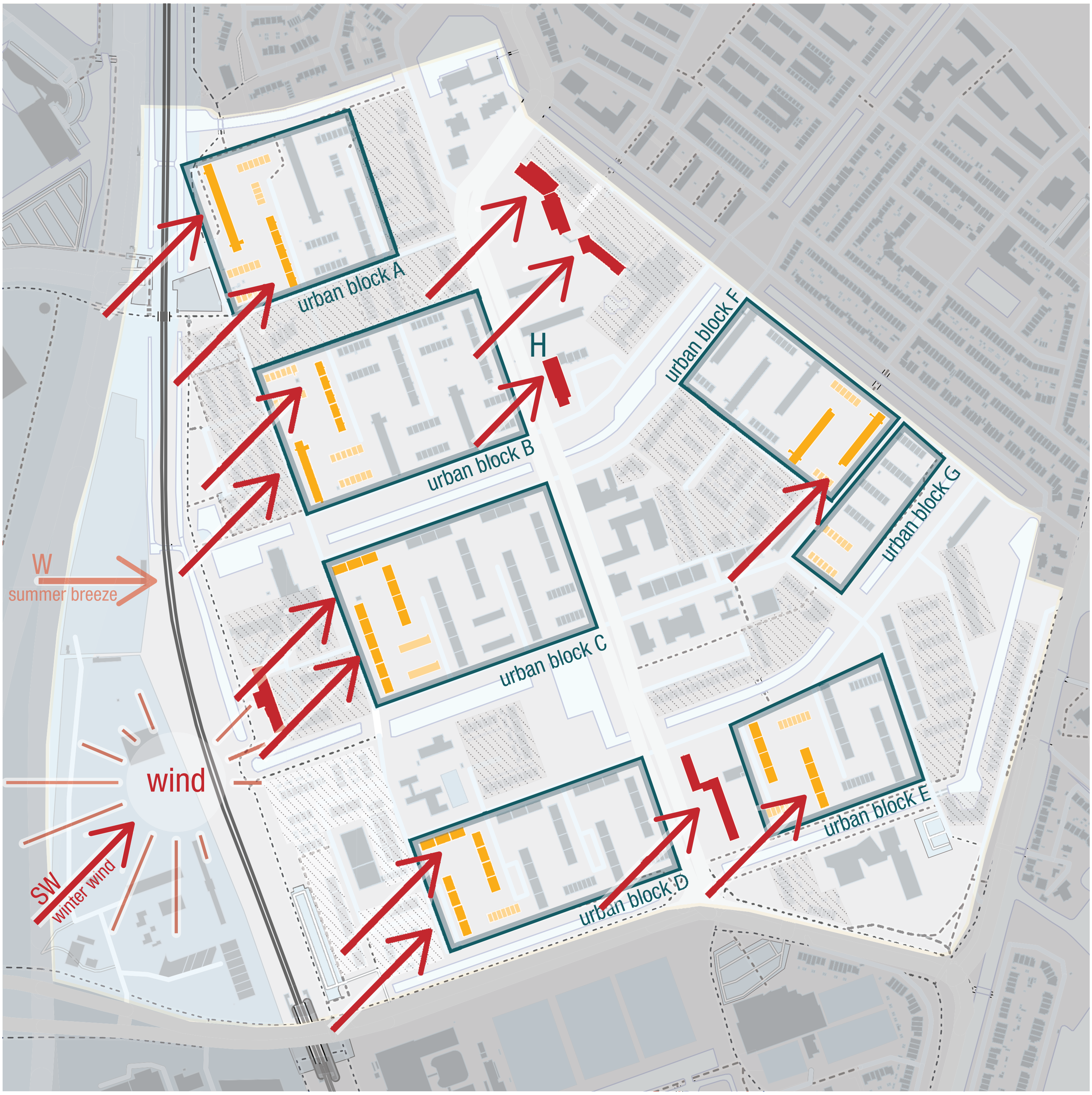

p19
p12
p14
p12
p3
p3
p16
p7
p17

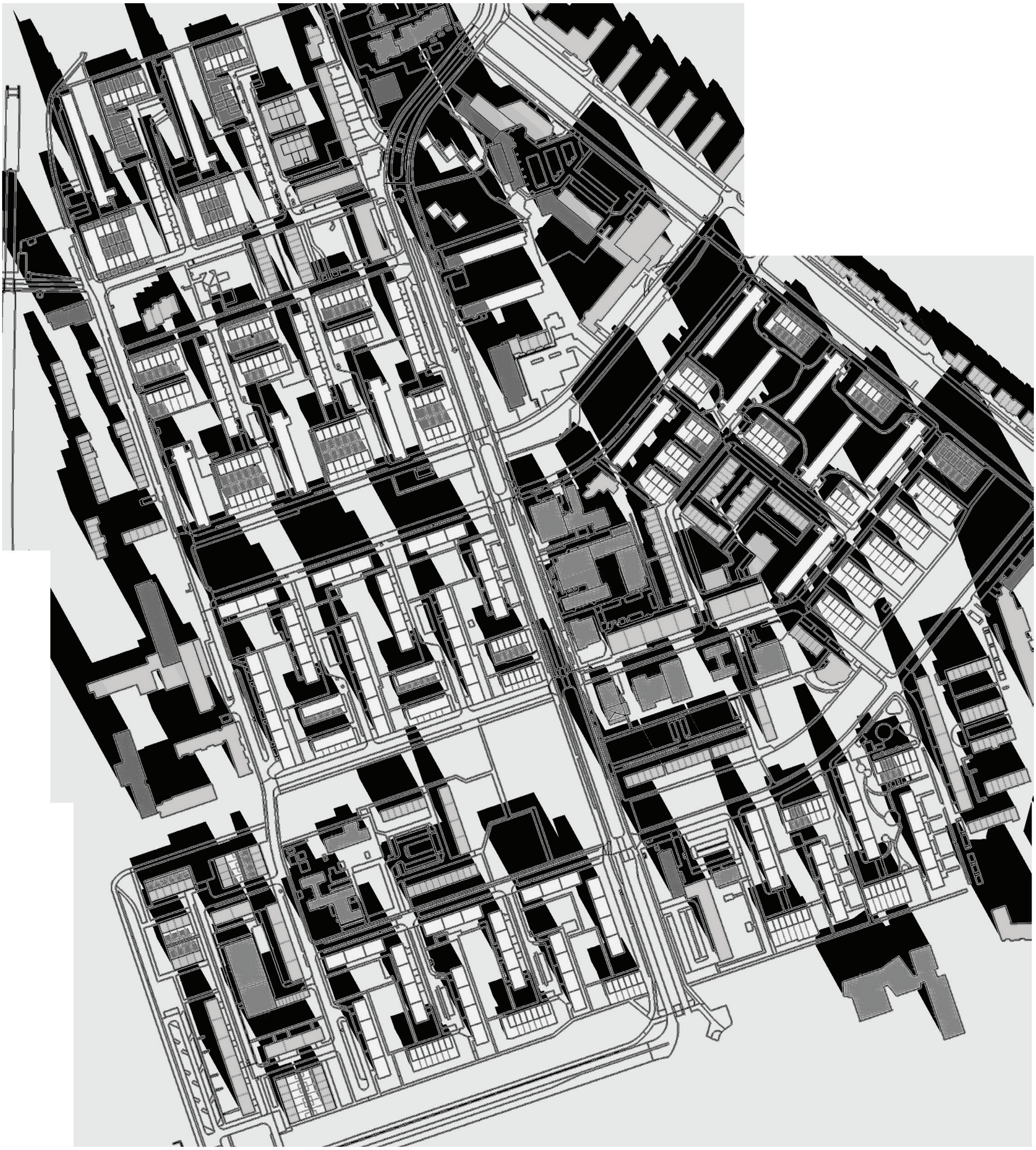
8.3.3. URBAN SCALE

The third focus area consists of a different process and result. The previous two address the urban scale through either their repetition or distinct role. The third focus area it addresses the urban scale directly since it examines upcaled design patterns or it upscales existing patterns. The analysis needed for the design, focuses apart from wind and solar also in land uses, accesibility, points of concentration, etc.

The first part is to analyze solar access and wind exposure in order to locate the areas of potential for solar and wind energy generation accordingly. The second part is to identify the structure and use of different spaces in the neighbourhood in order to provide with energy productive solutions that can also have an added value for users. Added value in terms of activities but also new urban landscapes with a certain aesthetic value. Purpose of this kind of design solutions is mainly to educate and motivate people towards the energy transition. For this reason most of the upscaled subpatterns that are applied are not to provide the houses with energy but to provide energy to the activites that take place in/around/under them.

The shadow map (below) is showing the shade at 11:40 (noon). Some of the vast unshadowed areas are areas with green and canals are not taken into account. Appart from those, the most solar access can be found in the two main S-N streets of the neighbourhood. The wind map (opposite page) shows as a general observation that the spaces and streets expanding from SW to SE exhibit the most exposure to wind





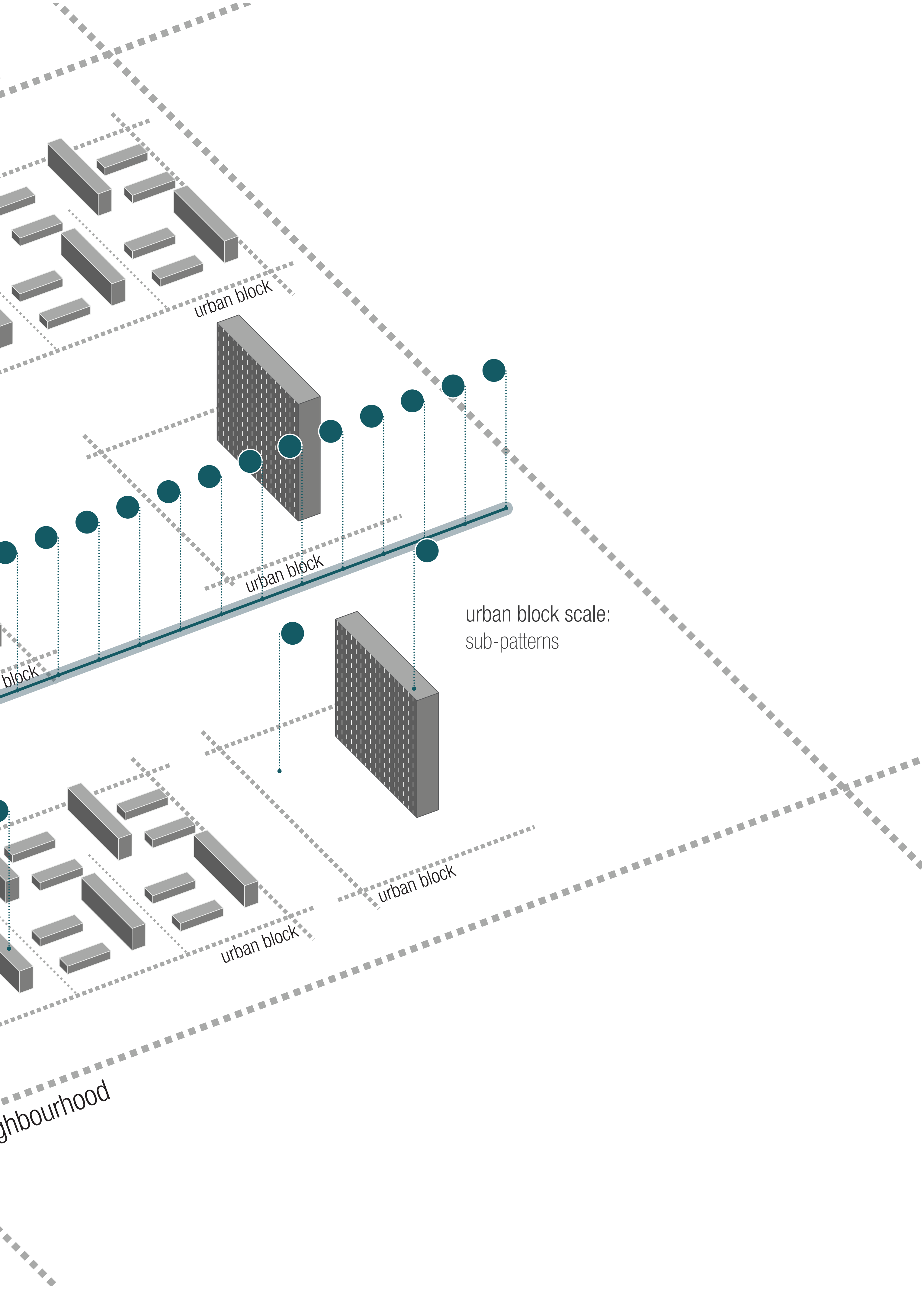
F. UNDERUSED AND ENERGY-LACKING **PUBLIC SPACES**

Problem statement

The result of openess and zoning has been an abundance of public spaces for green or activities but are currently largely underused. These large and undefined spaces have the potential with the implementaion of various innovative technologies to be revitalized while contributing in lowering energy demand of buildings or more importantly in energy production.

PS


urban block scale: sub-patterns
urban block scale: sub-patterns
urban block
stamp
urban scale:
upscaled patterns
urban scale:
upscaled patterns


urban block
urban block
block
urban block scale:
sub-patterns
urban block
urban block
ghbourhood

INSIGHT TO THE DESIGN METHOD

P6_VAWT

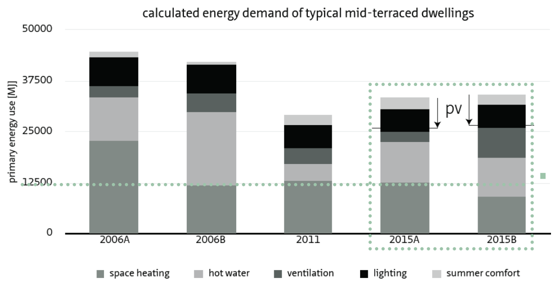
1 day=8,640 s

$P = \frac{1}{2} C_p \rho A v^3$ → *P= 681.7* → $E = P\,dt$ → *E≈ 5.9 MJ/day* → *E≈ 2,150 MJ/year*

P is power
Cp is the power coefficient,
ρ is air density,
A is the swept area of the turbine,
v is the wind speed

x 6

primary energy use of dutch mid-terraced dwelling



SPACE HEATING → *E≈ 12,500 MJ/year*

FOR THE WHOLE POST-WAR NEIGBOURHOOD OF SCHIEBROEK ZUID

4 wind corridors
total length: 2.2 km
VAWTS: 275

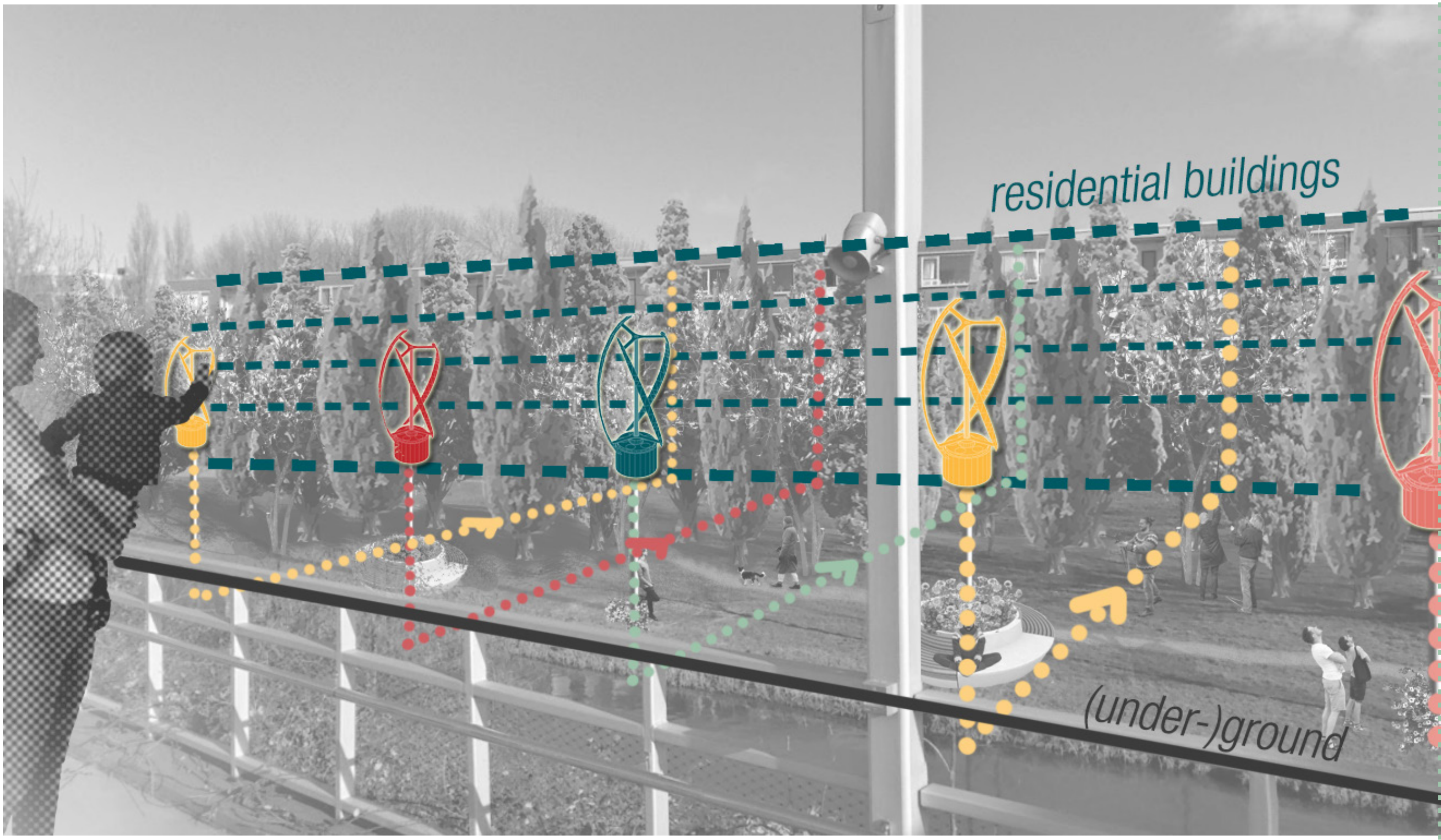
x 275 → *x 49*

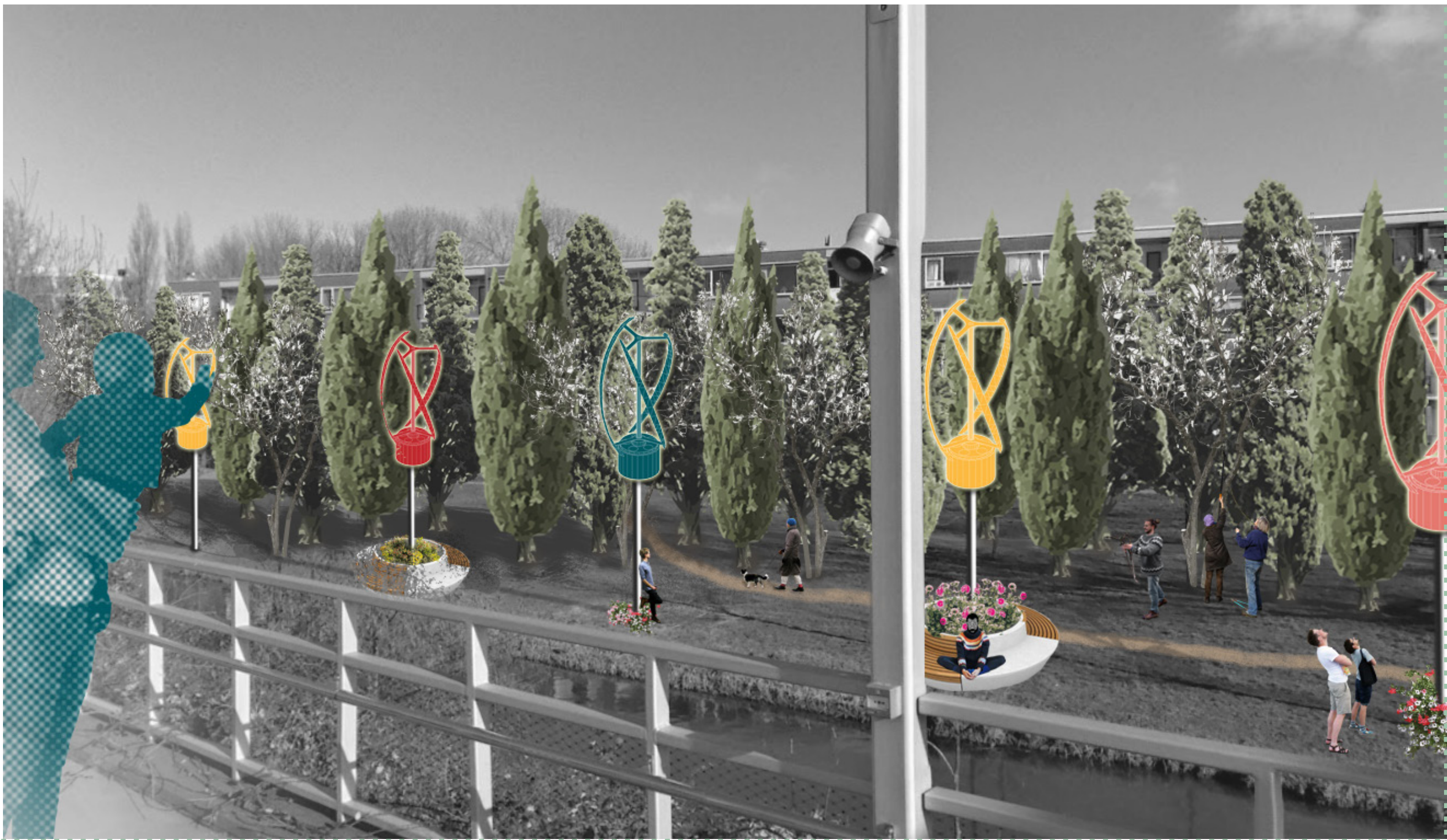
490 mid-terraced dwellings within the studied part of Schiebroek Zuid

x 490

energy for space heating for the 10% of the mid-terraced housing stock

10%


residential buildings
(under-)ground




A
B
H
F
C
D
E
block centres
neighbourhood subcenters
neighbourhood centre
centres to-be-created
shopping strips
important facilities (educational, recreational, cultural)
train station
tram station
bus station
railway
main street
tram line
neighbourhood streets
energy productive strips (tram lines & singels)

F. UNDERUSED AND ENERGY-LACKING **PUBLIC SPACES**

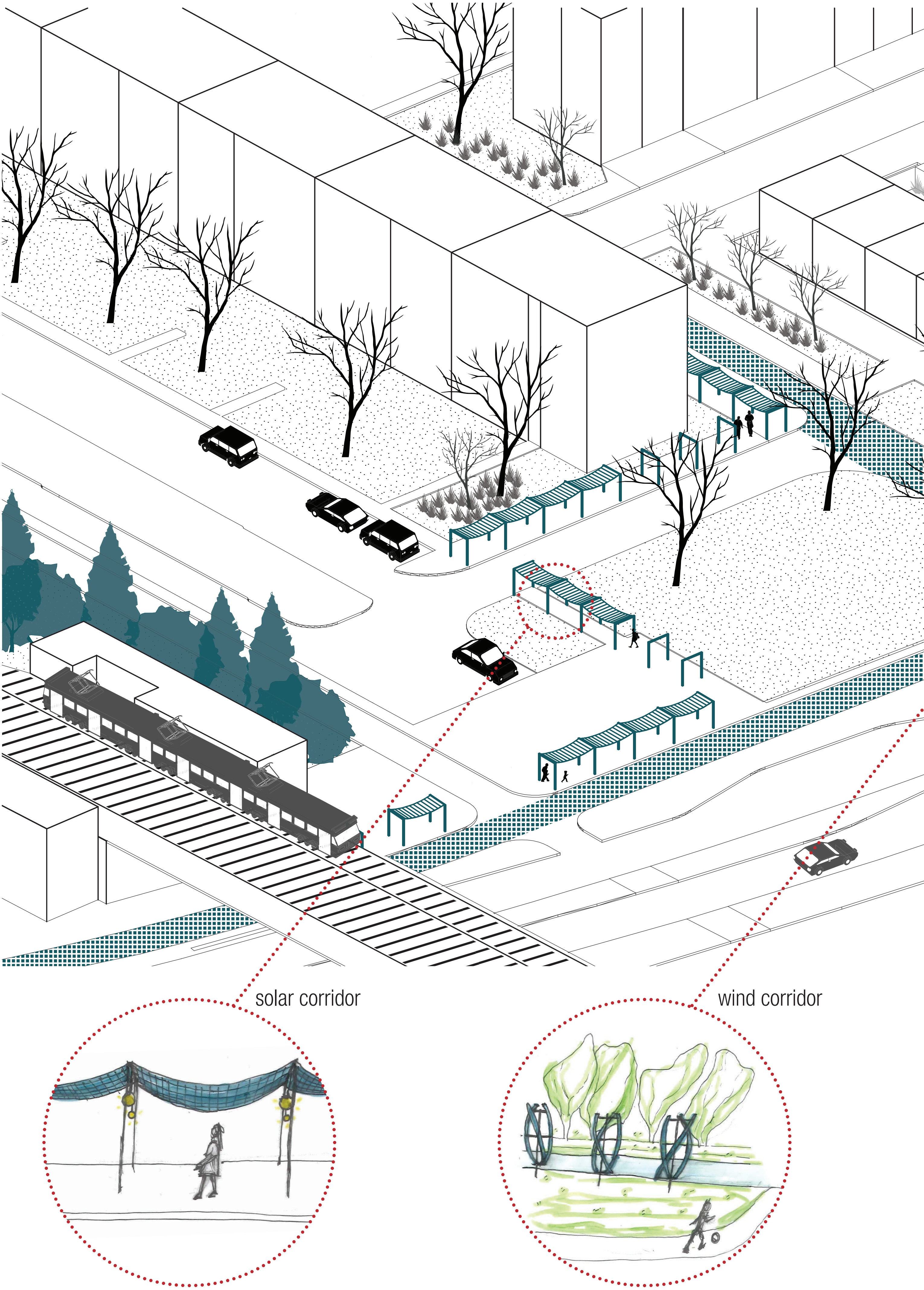
Problem statement

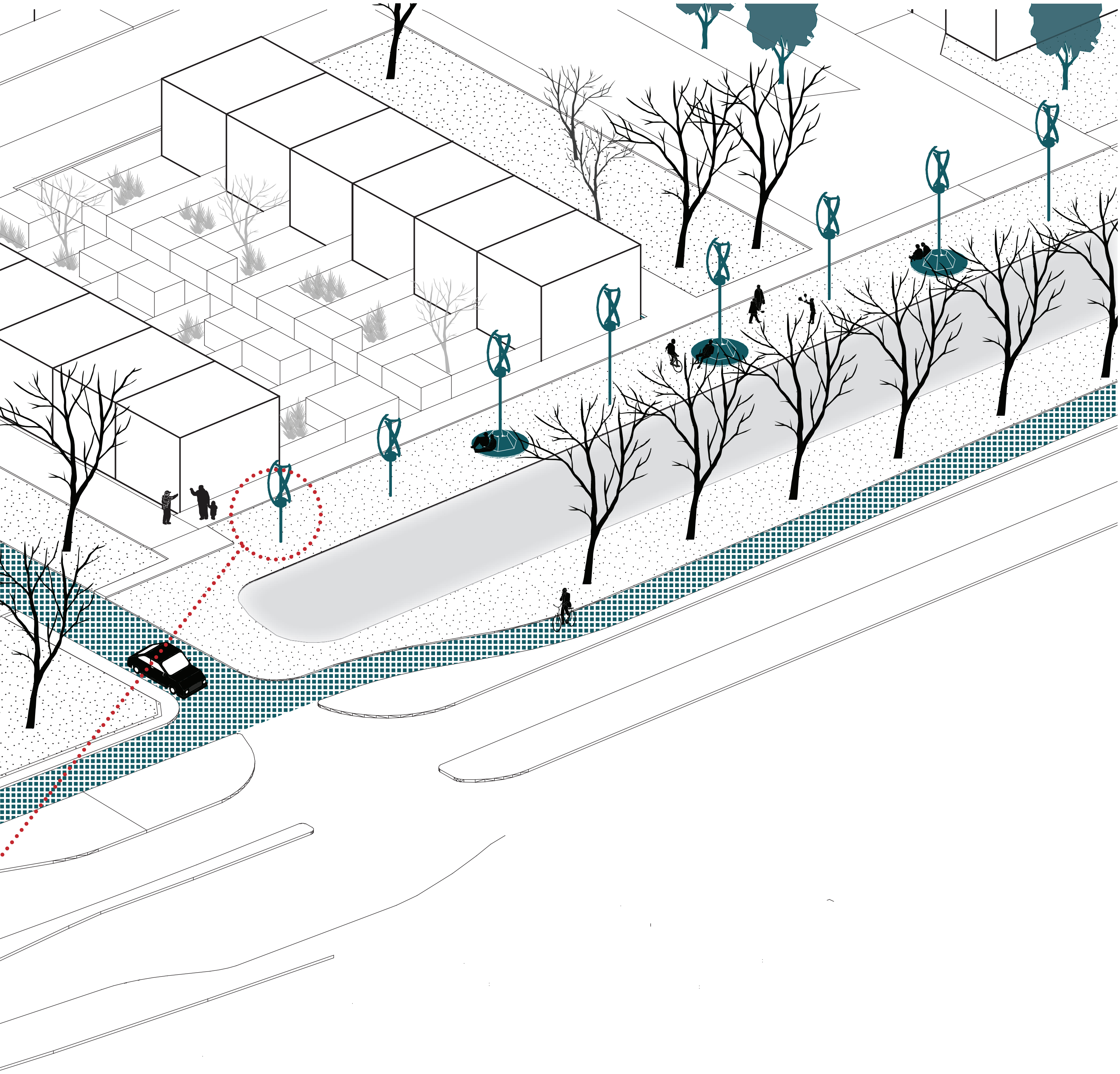
The result of openess and zoning has been an abundance of public spaces for green or activities but are currently largely underused. These large and undefined spaces have the potential with the implementaion of various innovative technologies to be revitalized while contributing in lowering energy demand of buildings or more importantly in energy production.

PS

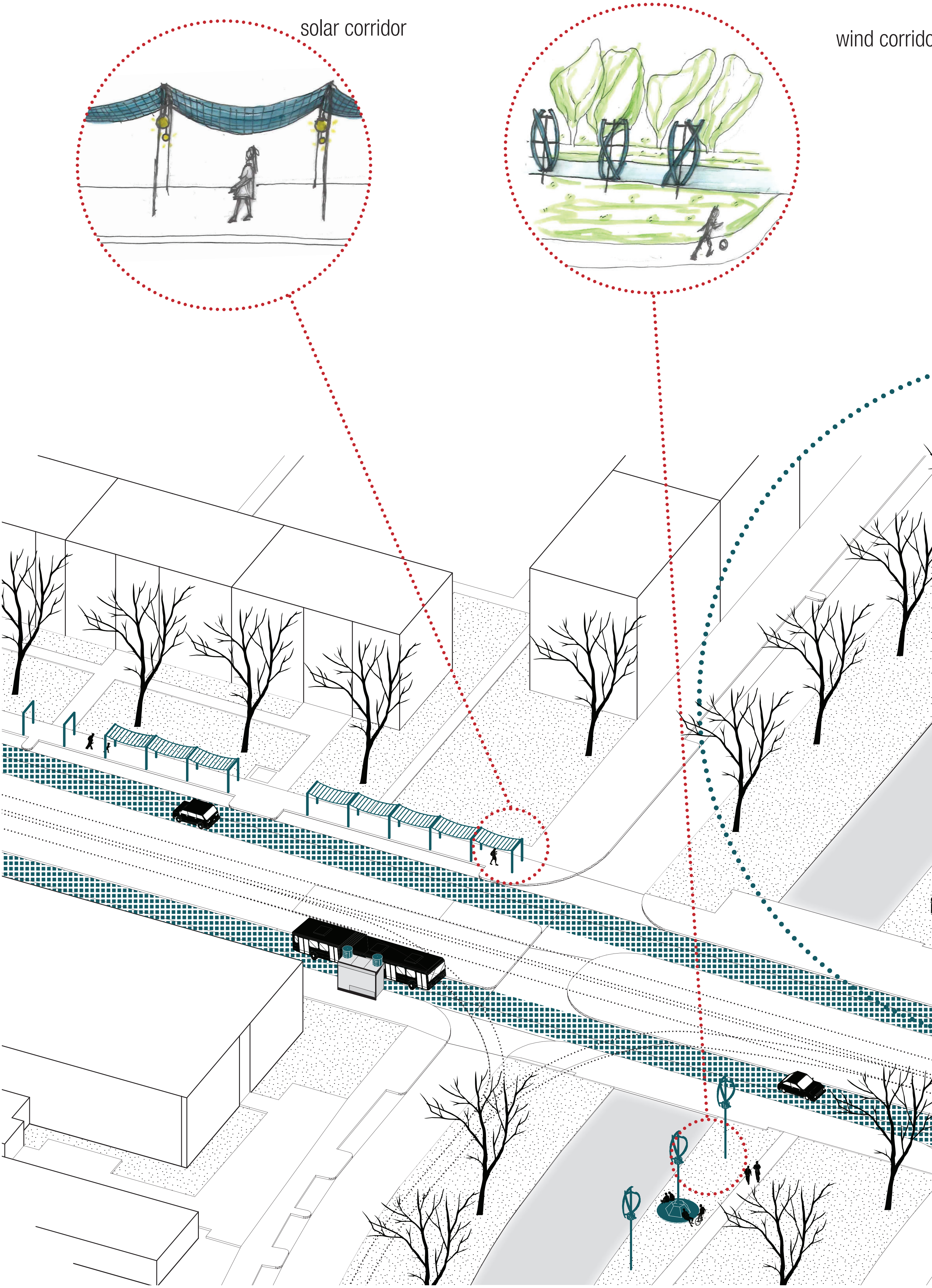
solar corridor

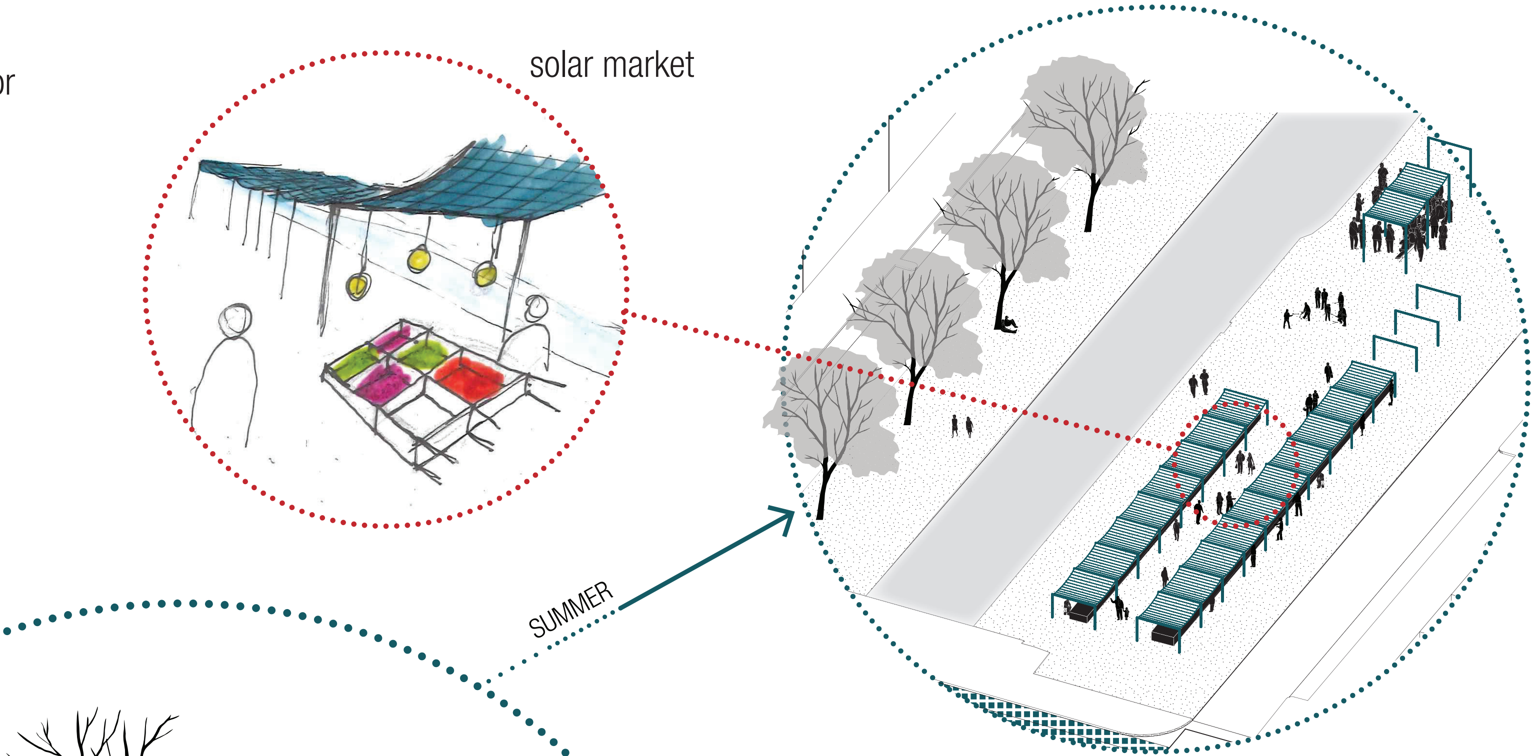
wind corridor

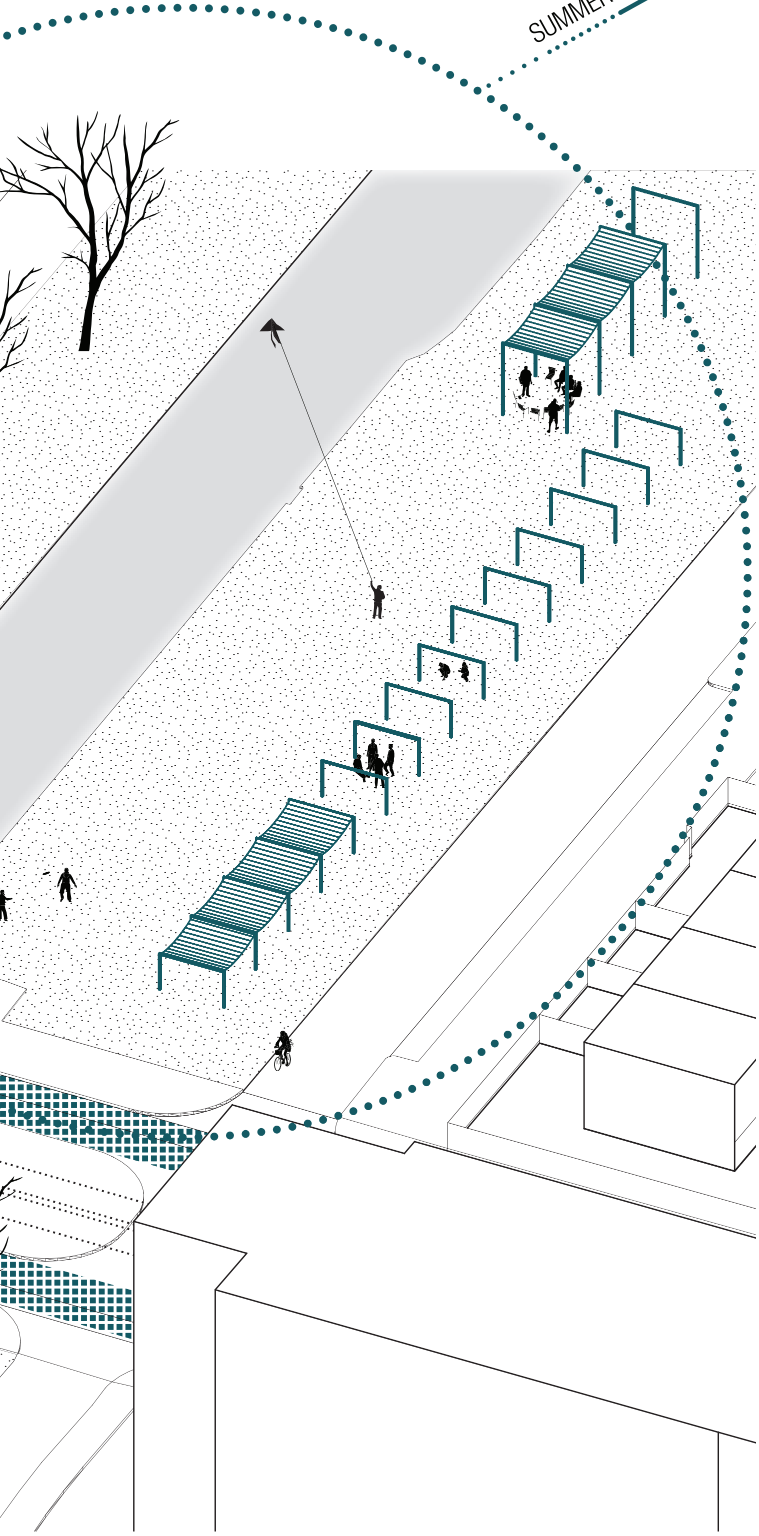

solar corridor
wind corridor

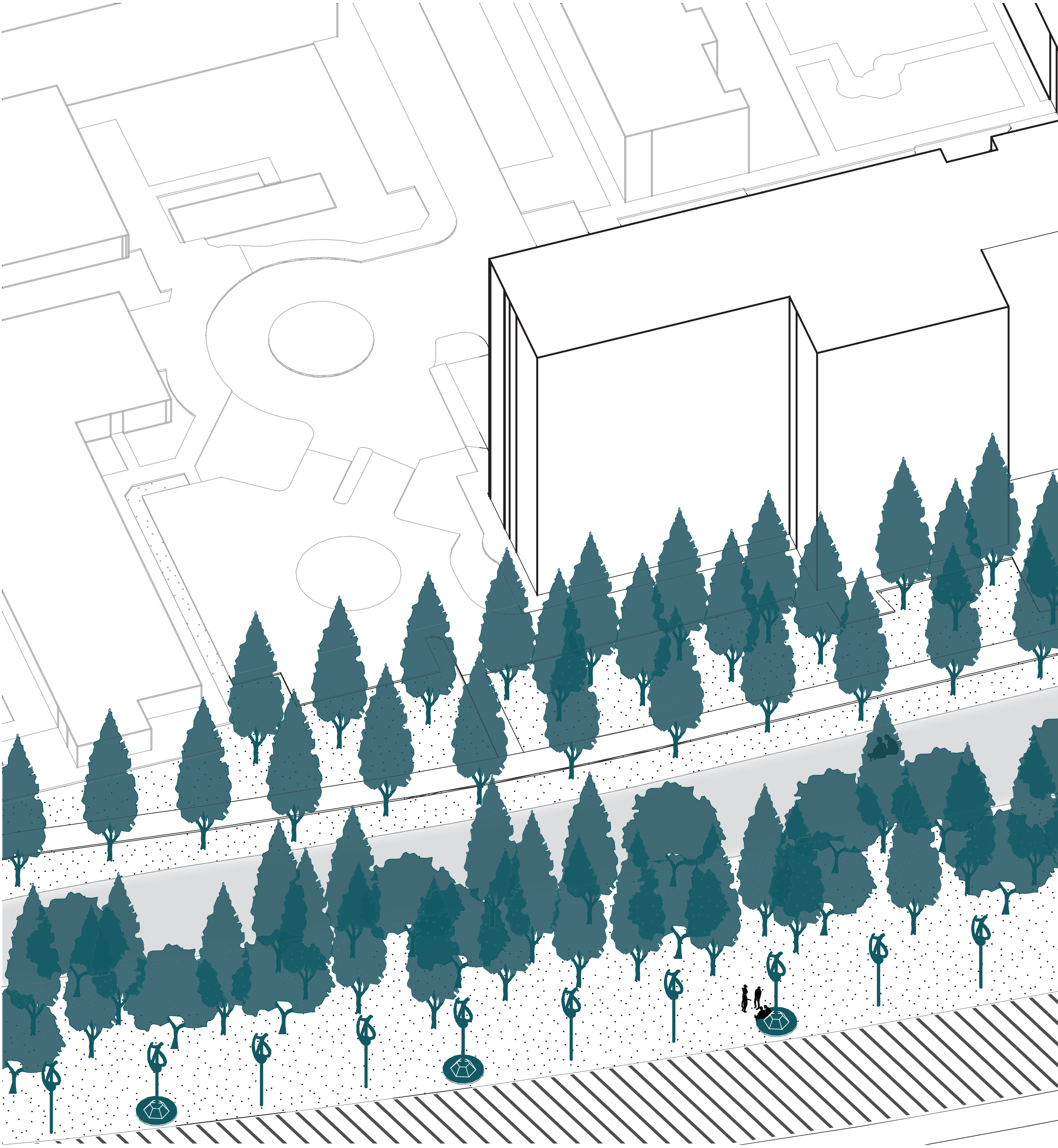


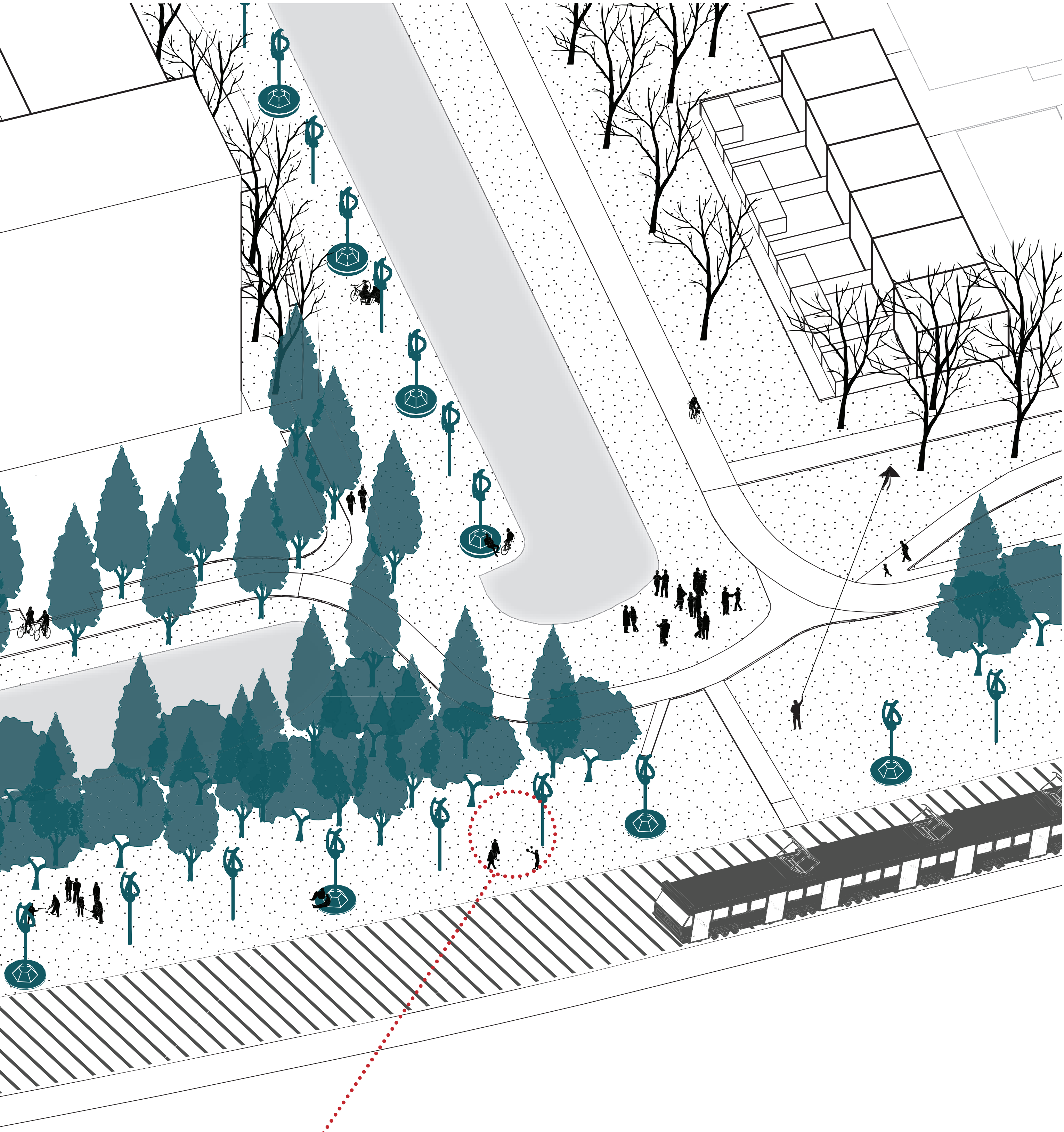

3

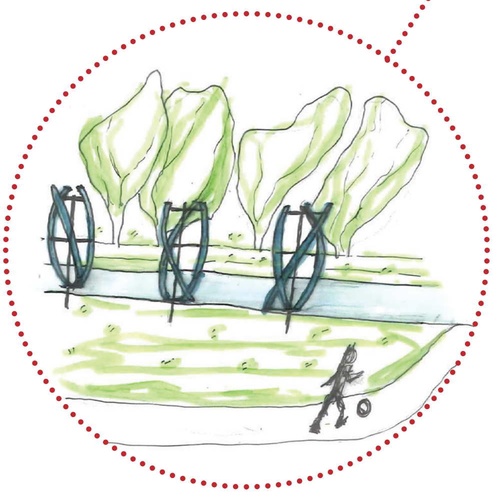

solar corridor
wind corrido


or
solar market
SUMMER





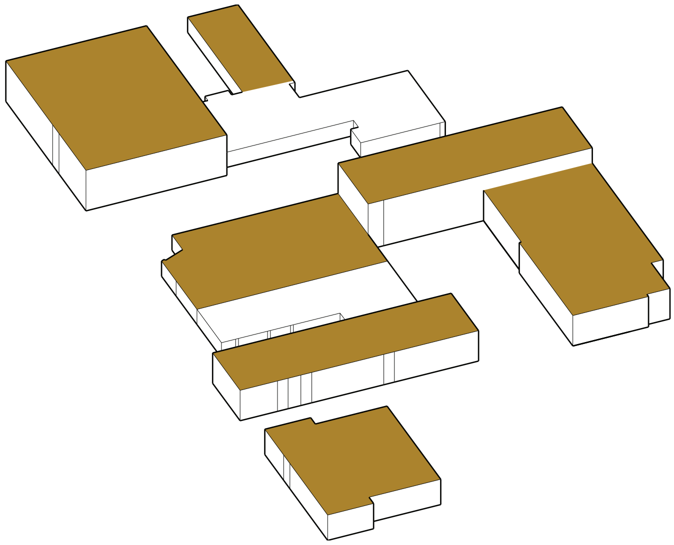


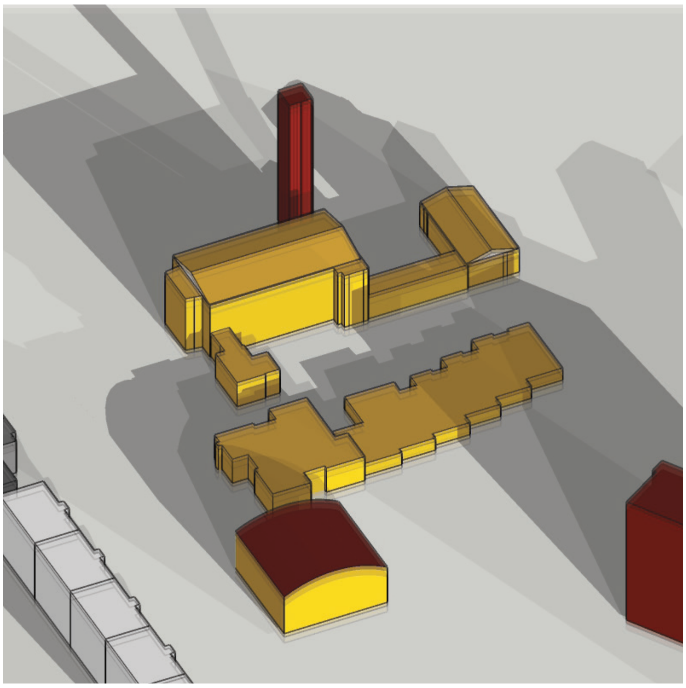


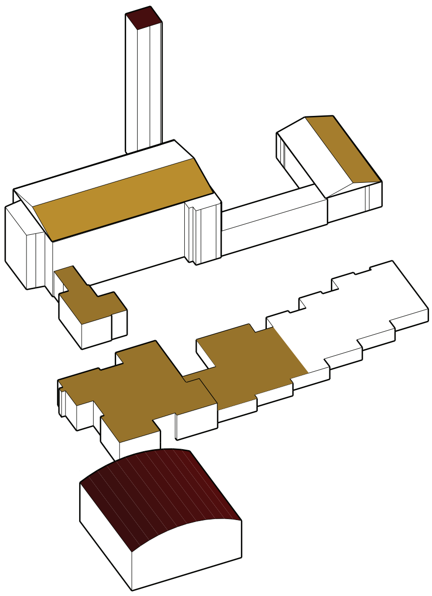
wind corridor

NON-RESIDENTIAL BUILDING OR 'OPEN' SPACES THAT CAN BE USED FOR ENERGY PRODUCTION

SOME EXAMPLES







G. SMALL OR UNPRODUCTIVE RESIDENTIAL ROOFTOPS

Problem statement

Rooftops on residential buildings can often be too small to produce enough energy or the circumstances might be unfavourable, such as shadow on single-family houses from blocks of flats. Public or commercial buildings located usually in the centre or orderly in relation to houses, usually have large rooftops appropriate for large installations of PV panels. Their location in relation to houses can serve well in connecting the houses to this more central installations.

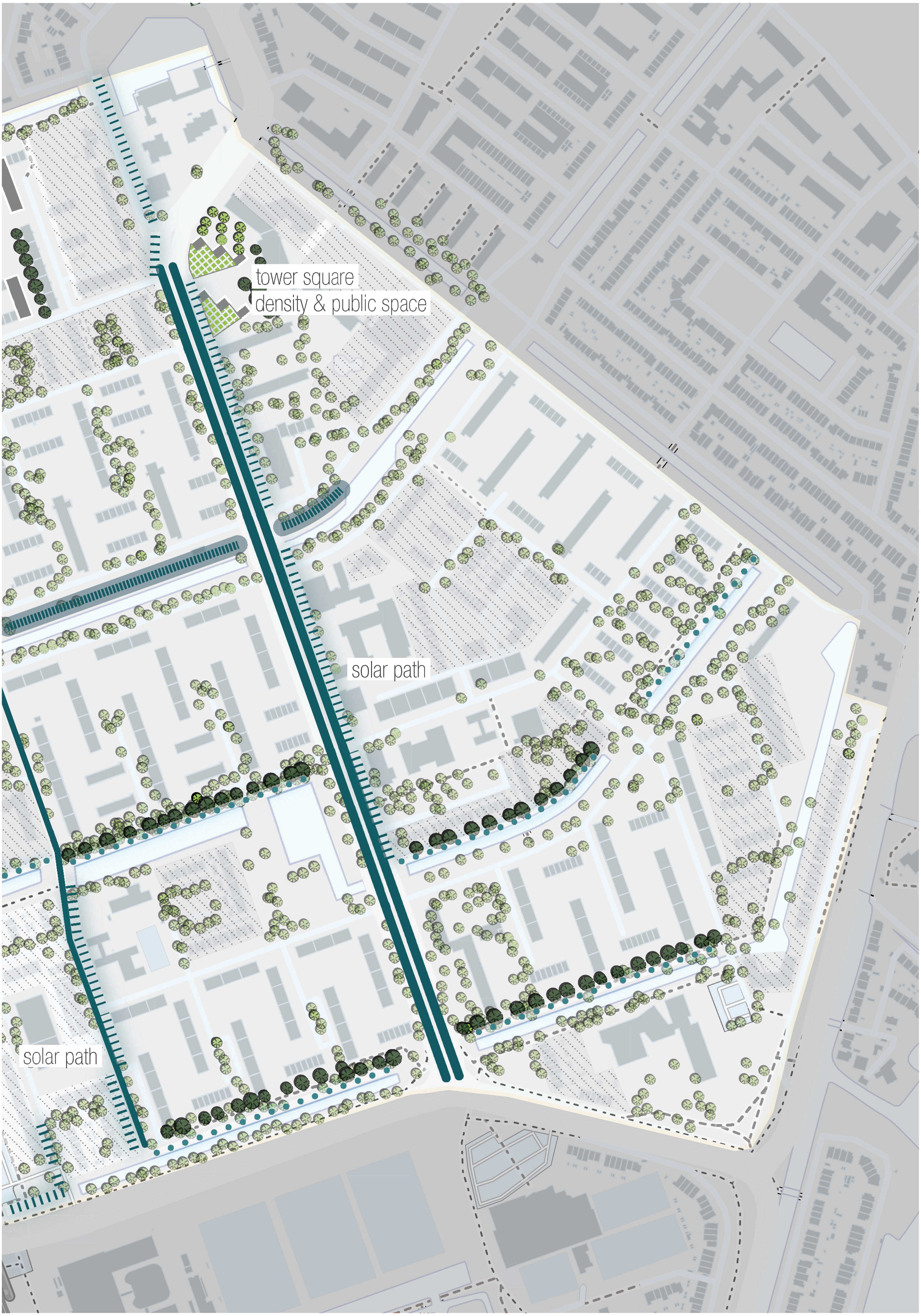
NR

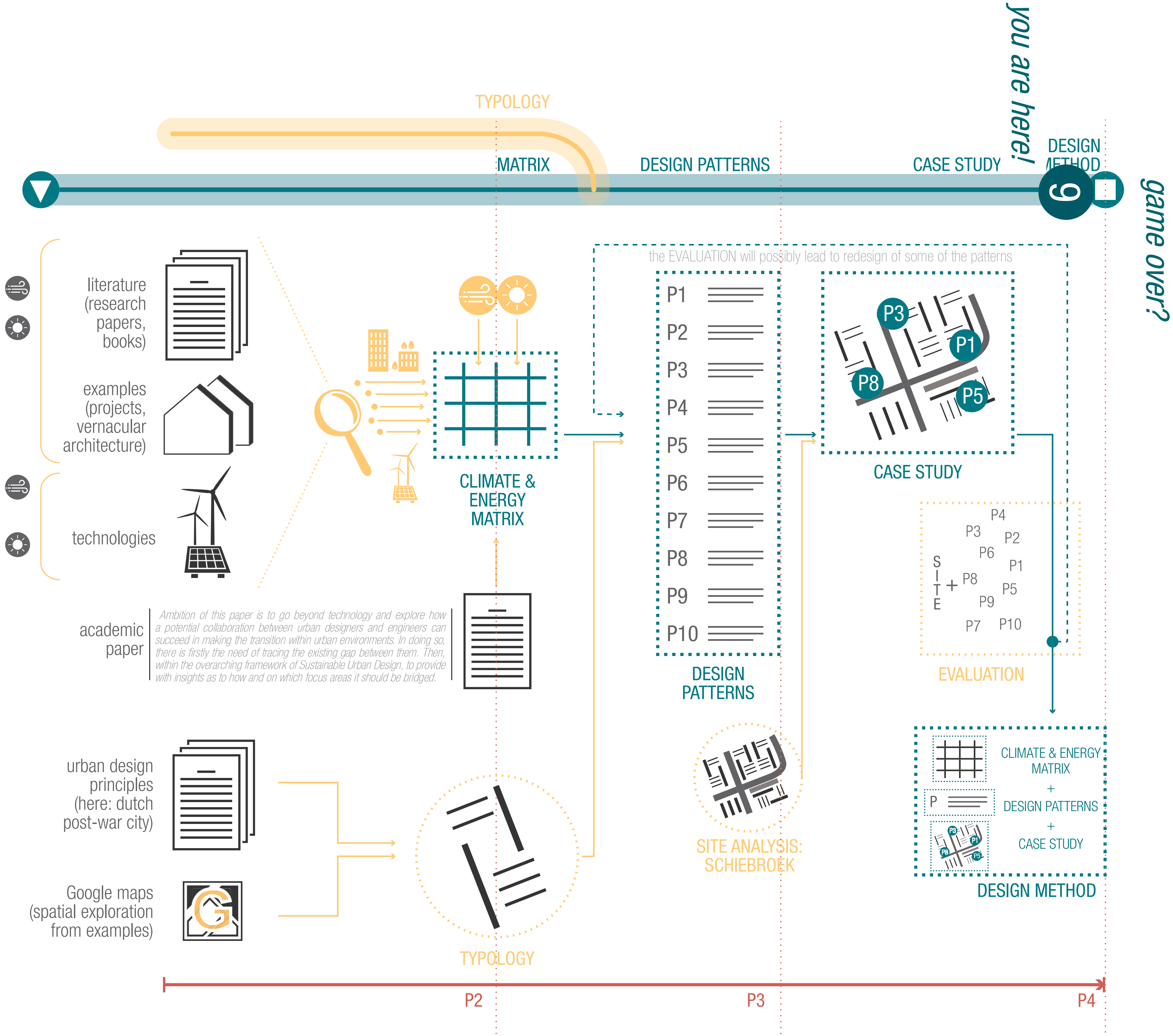
E. UNUSED AND ENERGY-LACKING **HIGH-RISE BUILDINGS' SURFACES**

Problem statement

In many post-war neighbourhoods there is a significant number of high rise buildings. The wind speeds at these heights are higher and unblocked by surrounding buildings, the same applies for sun on the higher floors.

8.4.3. IMPACT ON THE URBAN SCALE

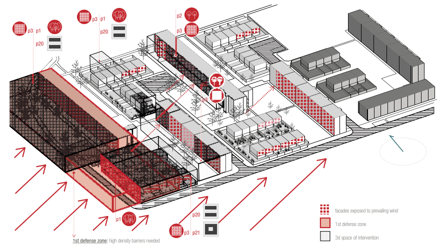

tower square
density & public space
solar path
solar path



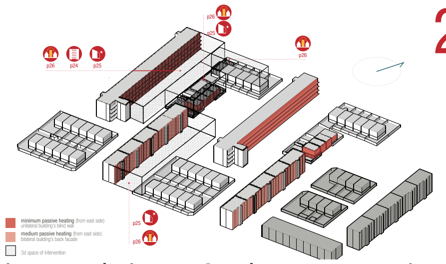
TYPOLOGY
MATRIX
DESIGN PATTERNS
CASE STUDY
you are here!
DESIGN METHOD
9
game over?
literature (research papers, books)
examples (projects, vernacular architecture)
technologies
CLIMATE & ENERGY MATRIX
academic paper
Ambition of this paper is to go beyond technology and explore how a potential collaboration between urban designers and engineers can succeed in making the transition within urban environments. In doing so, there is firstly the need of tracing the existing gap between them. Then, within the overarching framework of Sustainable Urban Design, to provide with insights as to how and on which focus areas it should be bridged.
urban design principles (here: dutch post-war city)
Google maps (spatial exploration from examples)
TYPOLOGY
the EVALUATION will possibly lead to redesign of some of the patterns
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
DESIGN PATTERNS
SITE ANALYSIS: SCHIEBROEK
P3
P1
P8
P5
CASE STUDY
S I T E + P4 P3 P2 P6 P1 P8 P5 P9 P7 P10
EVALUATION
CLIMATE & ENERGY MATRIX
+
DESIGN PATTERNS
+
CASE STUDY
DESIGN METHOD
P2
P3
P4

9

DESIGN METHOD

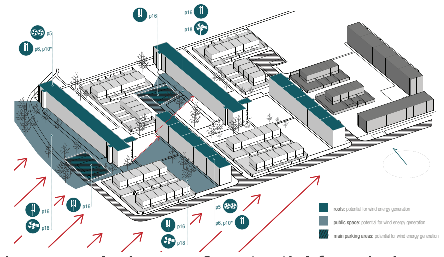


1. Layer analysis map 1: wind's influence on energy use

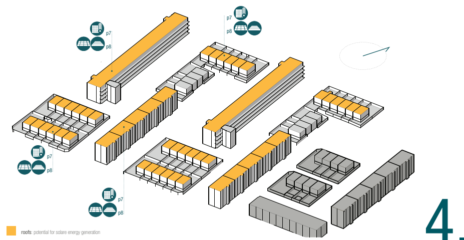


2. Layer analysis map 2: solar exposure and passive heating

		WIND	SOLAR
ENERGY USE		1. wind's influence on energy use SURFACES/MORPHOLOGY LOCATION residential buildings DESIGN PATTERNS A,B	2. solar exposure and passive heating SURFACES/MORPHOLOGY LOCATION residential buildings DESIGN PATTERNS C
ENERGY PRODUCTION		3. wind energy generation potential SURFACES/MORPHOLOGY LOCATION M L PS DESIGN PATTERNS D, E, F, G	4. solar energy generation potential SURFACES/MORPHOLOGY LOCATION M L NR PS DESIGN PATTERNS D, E, F, G



3. Layer analysis map 3: potential for wind energy generation



4. Layer analysis map 4: potential for solar energy generation

relevant design pattern (Design pattern A: facades exposed to prevailing wind)

Design patterns catalogue

A. FACADES EXPOSED TO PREVAILING WINTER WIND

Problem statement

Sides of building exposed to wind during winter have as a result significant loss of buildings' heat especially in the case of the poorly insulated post-war buildings. No or insufficient (deciduous) protection from vegetation is a common reason for exposure to wind. Also low H/W ratio for parallel rows results in wind's acceleration regaining. Meanwhile, parallel linear blocks with large open spaces inbetween them are common in dutch post-war neighbourhoods. Therefore high density barriers should be placed in the presence of main flow (full speed). Low density barriers are more appropriate in cases of wake interference or lee eddys.

B. WIND SPEED ACCELERATION DUE TO TUNNEL EFFECT

Problem statement

Parallel rows of buildings when oriented in parallel to the prevailing wind direction create an acceleration of the wind which in turn intensifies the negative impact of wind on building energy consumption. Therefore barriers should be placed to decrease, if not to block it entirely, the wind speed.

C. LACK OF PASSIVE HEATING

Problem statement

The optimum orientation of living spaces is facing south for solar passive heating. Indeed in some of the post war buildings the entrance is north so that living spaces can freely face the south. However it is also common for a 'stamp' to consist of different – often perpendicular to each other – orientated buildings. Therefore some buildings face E-W which is disadvantageous both for winter and summer moths. Therefore, where possible glazed spaces should be created to maximize passive heating during winter months and at the same time provide for cooling opportunities during summer. Where not possible or desireable, the possibility is given for infill development since there is already no solar exposure and densification is considered desireable.

D. UNUSED AND ENERGY-LACKING **ROOFTOPS OF RESIDENTIAL BUILDINGS**

Problem statement

Rooftops on residential buildings are under- or unused. In mid-rise buildings a combination of energy production and active use by residents is both desireable and possible.The height of mid-rise buildings shows lower wind speeds which means, on the hand specific technologies can only be productive, on the other hand they can be actively used by residents. Elements such as orientation, position, visual impact and combination with other uses, need to be taken into account for design decisions.

M

E. UNUSED AND ENERGY-LACKING **HIGH-RISE BUILDINGS' SURFACES**

Problem statement

In many post-war neighbourhoods there is a significant number of high rise buildings. The wind speeds at these heights are higher and unblocked by surrounding buildings, the same applies for sun on the higher floors.

L

F. UNDERUSED AND ENERGY-LACKING **PUBLIC SPACES**

Problem statement

The result of openess and zoning has been an abundance of public spaces for green or activities but are currently largely underused. These large and undefined spaces have the potential with the implementaion of various innovative technologies to be revitalized while contributing in lowering energy demand of buildings or more importantly in energy production.

PS

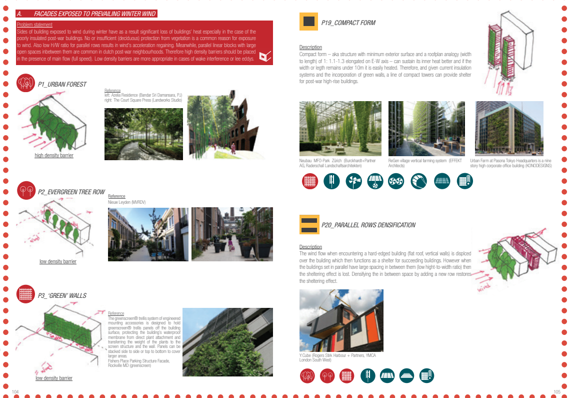
G. SMALL OR UNPRODUCTIVE RESIDENTIAL ROOFTOPS

Problem statement

Rooftops on residential buildings can often be too small to produce enough energy or the circumastances might be unfavourable, such as shadow on single-family houses from blocks of flats. Public or commercial buildings located usually in the centre or orderly in relation to houses, usually have large rooftops appropriate for large installations of PV panels. Their location in relation to houses can serve well in connecting the houses to this more central installations.

NR

relevant Design pattern's (A): sub-patterns

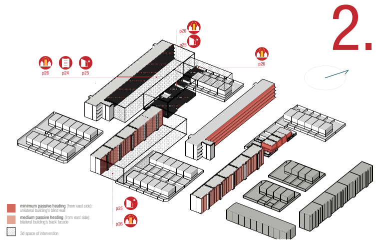


Comparative table for relevant design pattern group (Energy Use)

	BASIC ELEMENTS			EFFECT INFO		
	climatic condition	building size	morphology/ surface	density	effect on wind	restores H/W ratio
P1	wind	S & M		high	blocks	✓
P2	wind	S & M		low	decreases	✗
P3	wind	All		low	decreases	✗
P19	wind	L		high	blocks	✗
P20	wind	S & M		high	blocks	✓
P21	wind	S & M		high	blocks	✓
P22	solar	S & M		high	blocks	✓
P24	solar	All		-	blocks	✓
P25	solar	All		-	blocks	✗
P26	solar & wind	All		high	blocks	complex sub-pattern

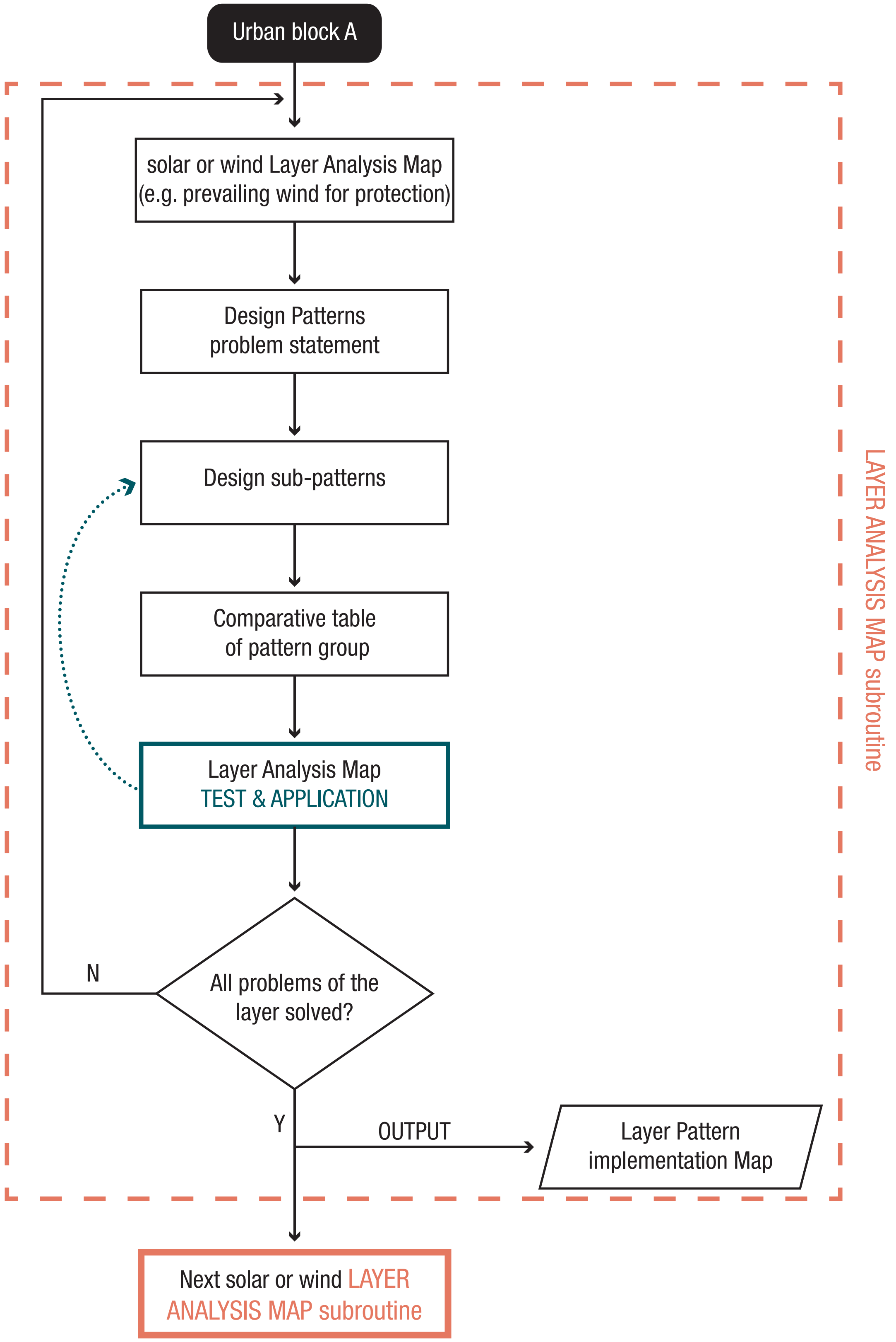
blocks / decreases

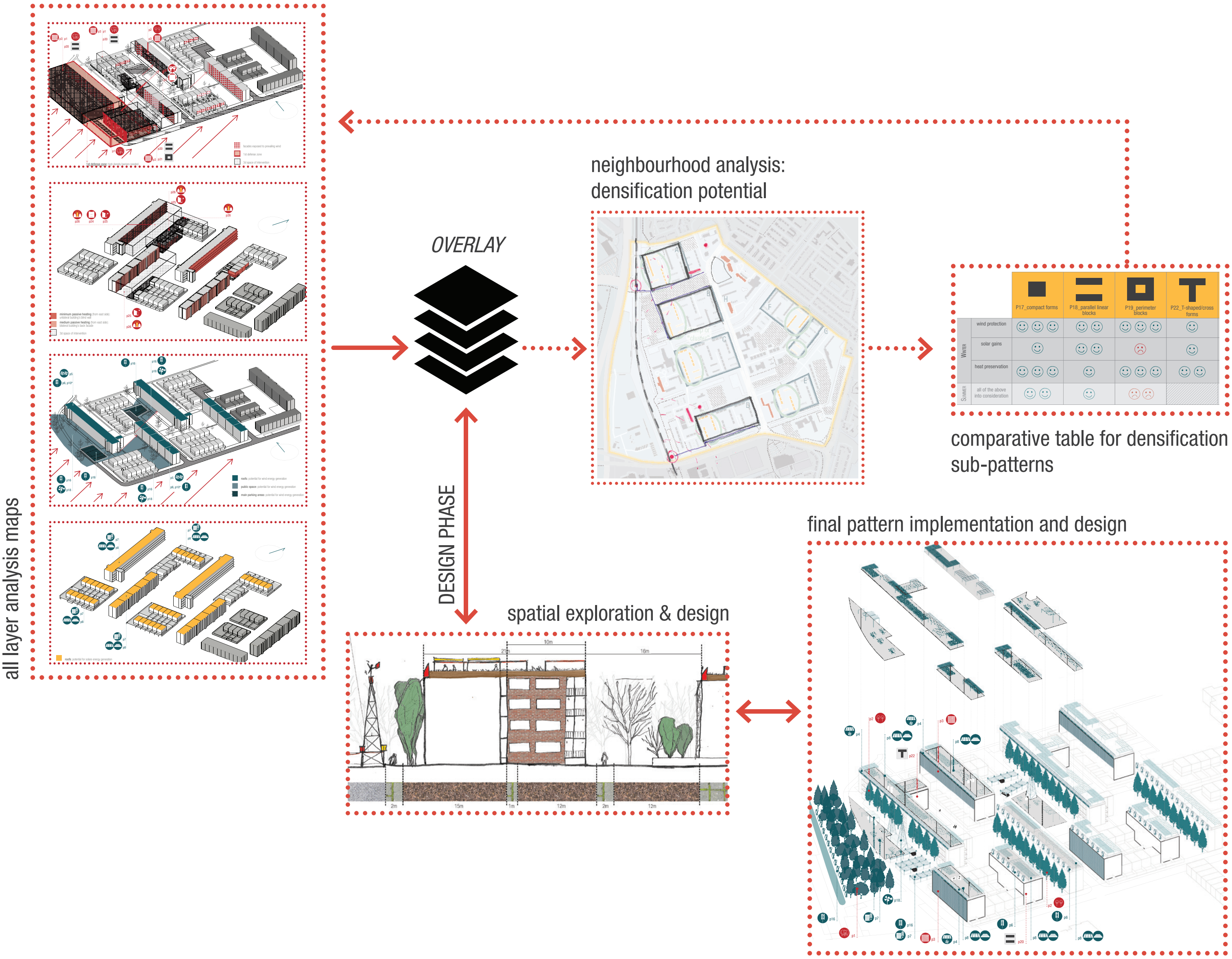
Next layer analysis map



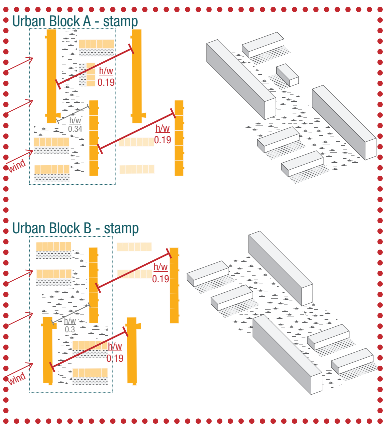
2.

9.1. DESIGN METHOD

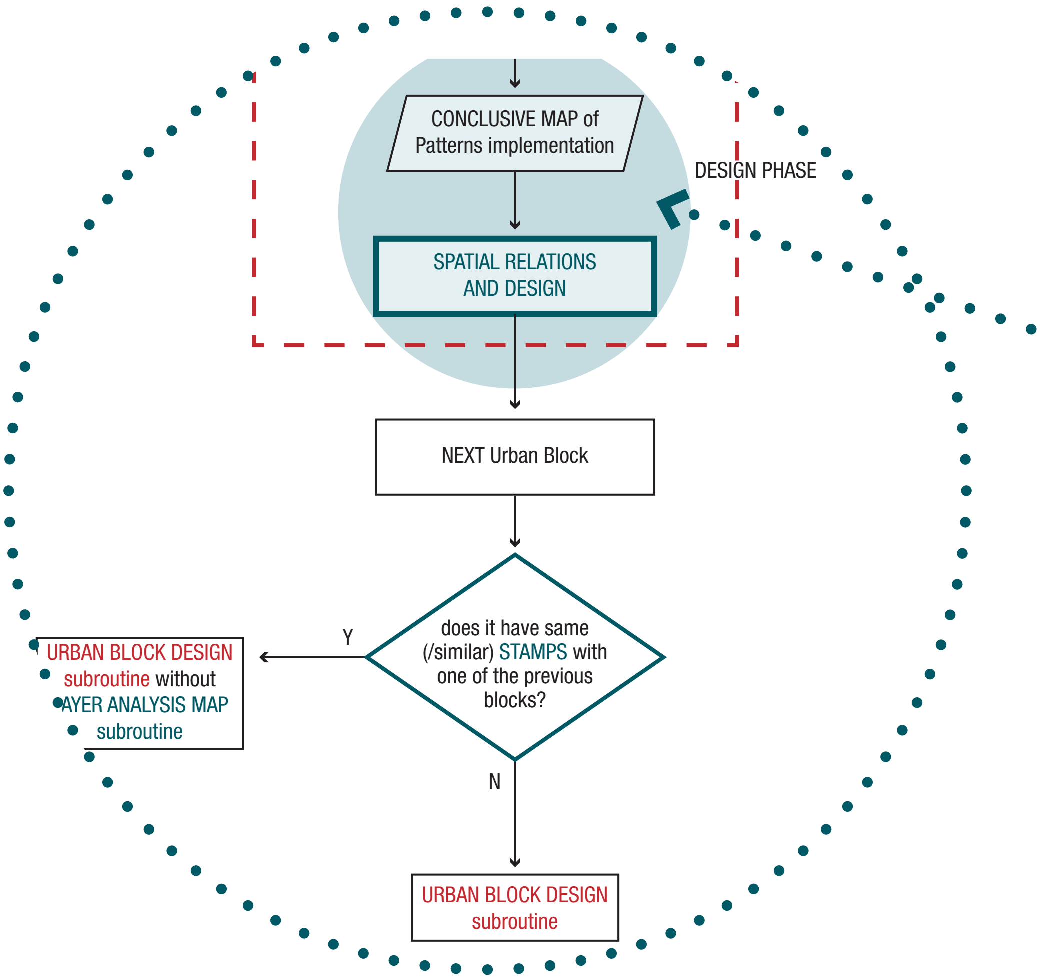


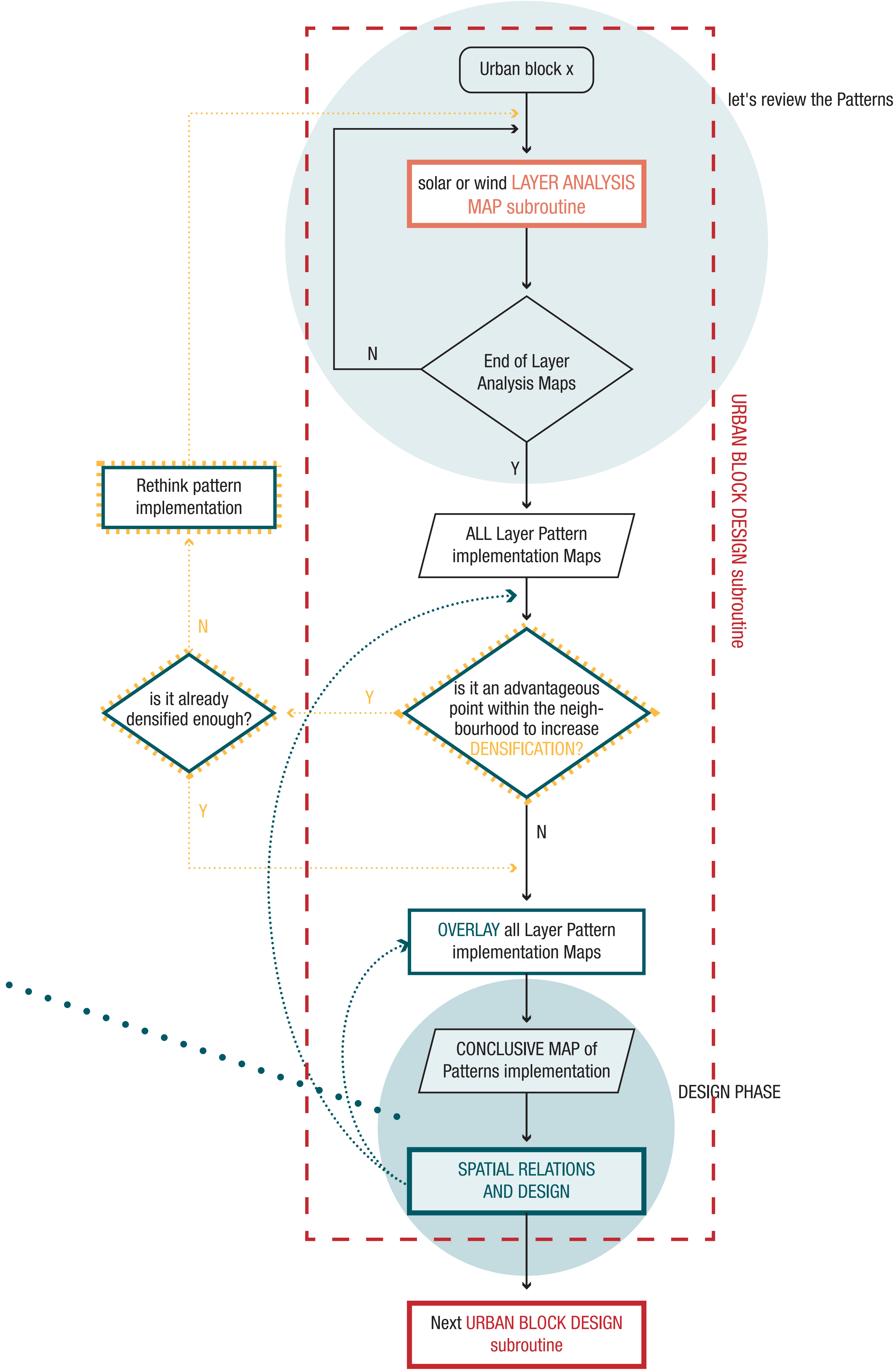


THE POSSIBLE ROLE OF STAMPS IN ACCELERATING THE PROCESS



urban block typology




Urban block x
let's review the Patterns
solar or wind LAYER ANALYSIS MAP subroutine
N
End of Layer Analysis Maps
Y
URBAN BLOCK DESIGN subroutine
Rethink pattern implementation
ALL Layer Pattern implementation Maps
N
Y
is it already densified enough?
is it an advantageous point within the neigh-bourhood to increase DENSIFICATION?
Y
N
OVERLAY all Layer Pattern implementation Maps
CONCLUSIVE MAP of Patterns implementation
DESIGN PHASE
SPATIAL RELATIONS AND DESIGN
Next URBAN BLOCK DESIGN subroutine

9.2. DESIGN METHOD AND CONCLUSION

The design method is at the same time the conclusion of the whole graduation project and the final goal. The reason for this twofold role is the fact that, firstly, it recaps the steps taken and it graphically illustrates the role each of them had as well as how it connects to the rest. Also by looking through the project and then at the design method it becomes clear that there are indeed steps that cannot be clear in the method. For instance the first part of the design method that concerns one layer analysis map entails an analysis based on the Matrix and then an application of all possible solutions based on the Design patterns. When it comes to overlaying all layer analysis maps, though, it gets more complicated because it involves conflicts and therefore decisions of different natures – engineering, design, social, etc. Therefore it is evident that the Matrix as well as the Design patterns can be used as the guiding framework but when it comes to final decisions and even more to the final design, it is the role of the designer to explore the space, the solutions, the social background etc. before designing. To this direction the Case study is the neccessary example to show this more fluid process and the extra parameters that might appear and need to be taken into consideration.

The second role of the design method is responding to the original goal of creating a list of steps that could contribute in climate-responsive and energy-active urban design. Even though there are steps that cannot be given, the overal process shows to a designer: how the Matrix should be used to do the analysis needed to apply the Design patterns; how to navigate through the equivalent design sub-patterns by making use of the comparative table that gives you concentrated and extra information; how and in which point to take densification into consideration. So in this way it makes climate-responsive and energy-active urban design more tangible, since the designer knows which elements to address, how to do so and in which parts there is a need for all those extra parameters – that are always part of urban design – to be taken into consideration.

Finally, another conclusion is important to be highlighted in reference to all the individual parts. The design method is not made to trap them in a strict process. They still constitute individual products which in the case of the Matrix and the Design patterns they can be used independently. Especially the Matrix, provides with an optimum form that any other form, not just post-war neighbourhoods can be compared in order to become more climate-responsive and energy-productive. However, it should not be forgotten that – as described in the Matrx chapter – the optimum is directly linked to the dutch climate. Therefore if it is to be used for another climate the parameters of urban morphology can still be taken from the Matrix but different values will apply. Even more conditional are the Design patterns because they take into consideration the morphological qualities of dutch post-war neighbourhoods. Nevertheless it is possible that a different type of area could have similar qualities. In order to discover this, the problem statement of each design pattern needs to be thoroughly studied.

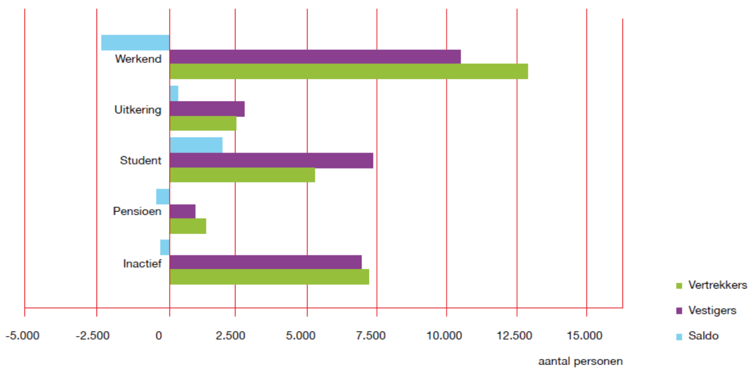
10

REFLECTION

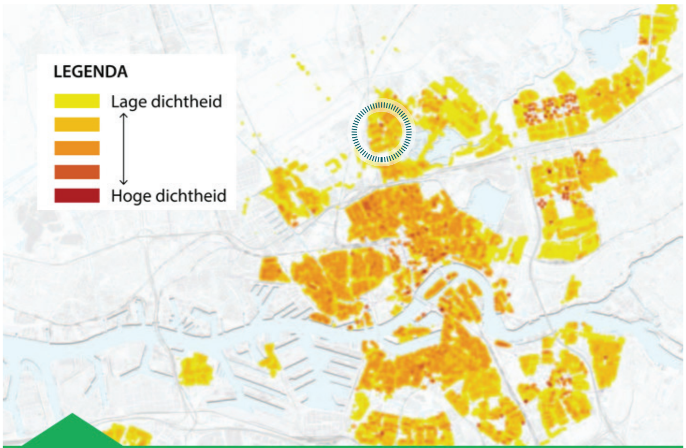
10.1. PERSPECTIVES OF REALIZATION

Overall, this thesis focuses on bridging the engineering and design gap by translating engineering solutions and renewable technologies not just in spatial qualities but also in design values. The case study has been an effort to show how this could be approached in a post-war neighbourhood. However all this process has been mostly viewed from the perspective of the designer. Indeed all the steps of the process as well as the final design method are meant to be handed to designers as a guide towards the urban energy transition. The realization part, though has not been explicitly addressed in the project. One of the most important realization factors for an urban project like this are the actors involved.

FIGUUR: SELECTIEVE MIGRATIE ROTTERDAM 2003



Bron: COS, nov. 2005



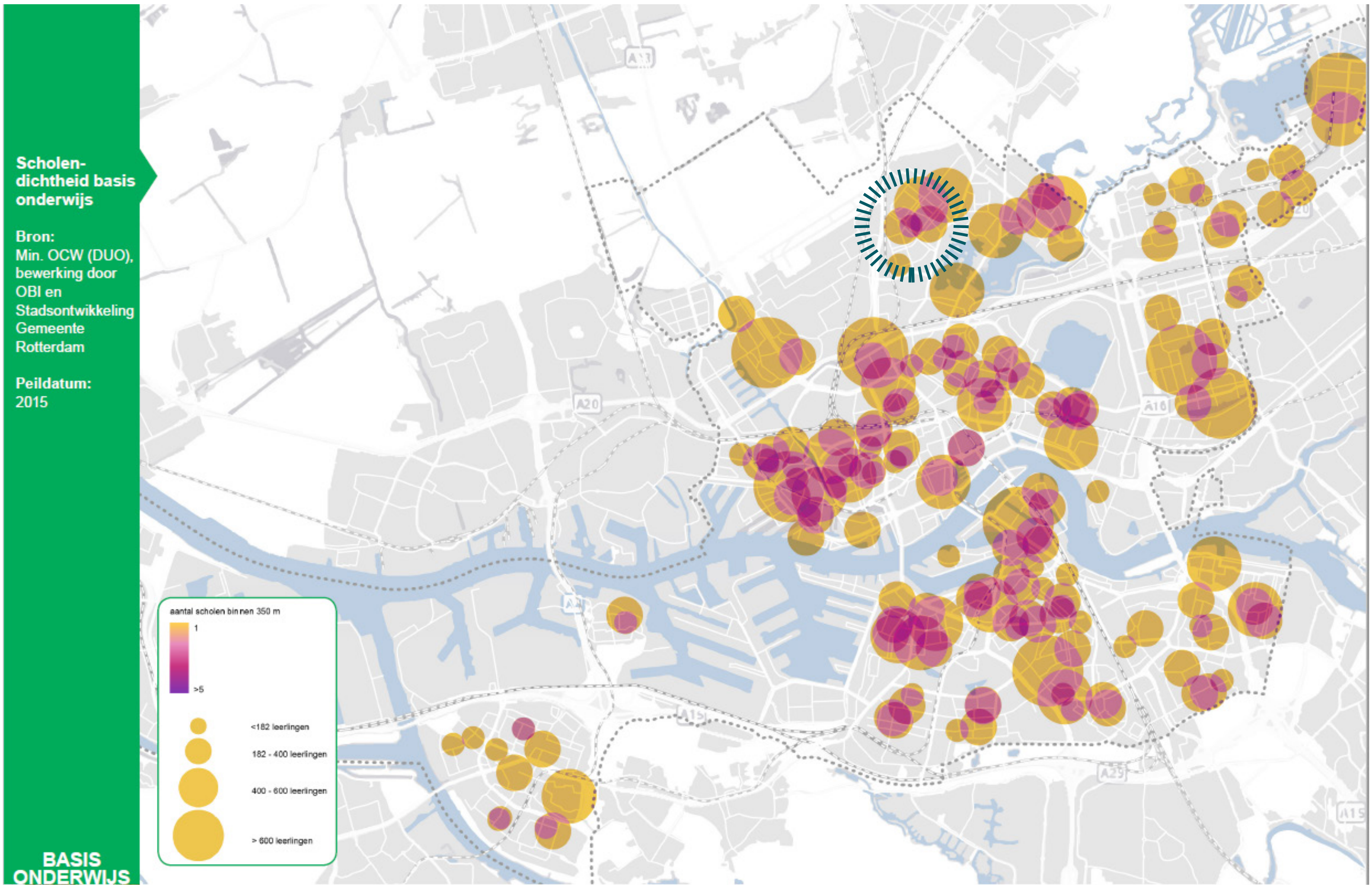
Woningdichtheid per hectare.

Bron: OBI, bewerking Stadsontwikkeling

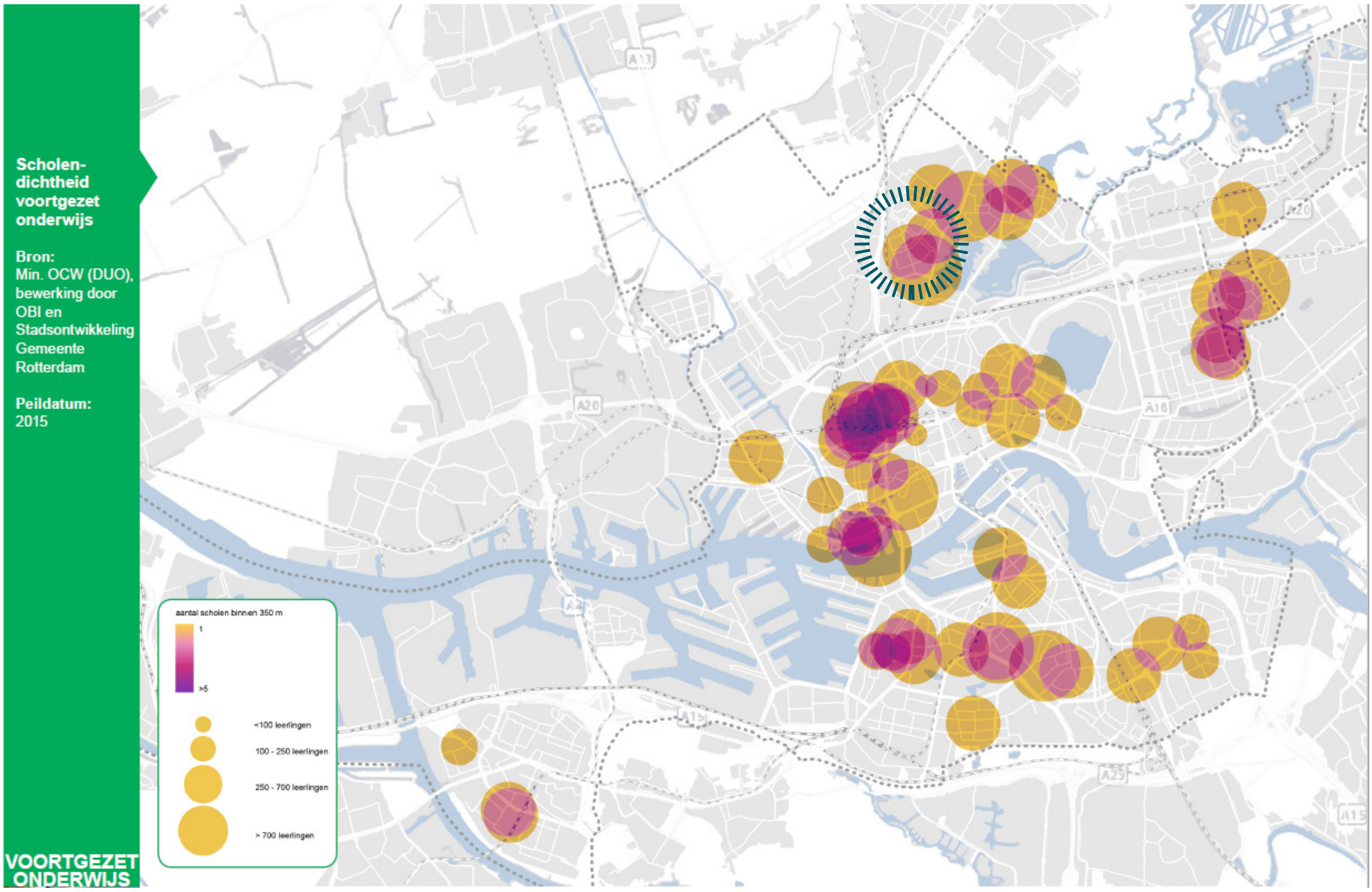
The role of the various actors will be seen from the perspective of municipality visions (documents on Schiebroek Zuid and Rotterdam), interviews held by me with people involved in the subject from different posts and on the social profile of Schiebroek Zuid. The actors examined are:

- the municipality of Rotterdam
- housing associations
- local energy initiatives
- residents of Schiebroek Zuid

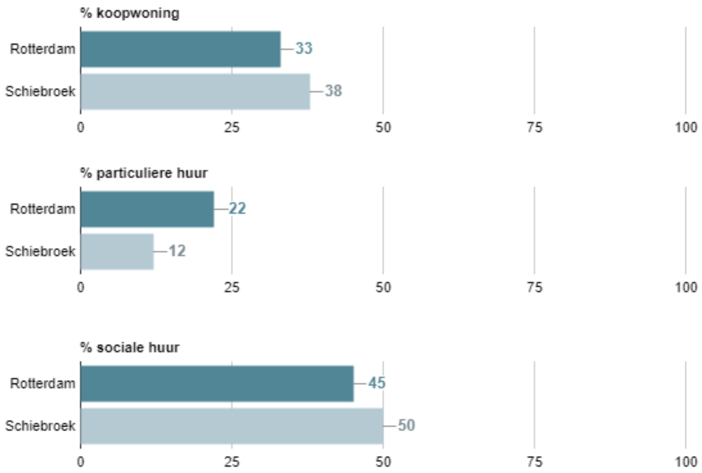
The *municiplaity of Rotterdam* is interested in two things that could potentially make them an ally for this kind of project. Firstly, it is facing the pressing issue of *selective migration* out of the city. Namely, many young educated people that have studied in Rotterdam and have found their first job there, when they decide to have a family they choose to leave from Rotterdam. The reason for this selective migration is a shortage in quality houses for families within the city. This phenomenon is negative for the city since these educated and higher income social groups can work in benefit of the 'roltrapfunctie' (gemeente Rotterdam, 2007). This is a social mechanism that improves the social status of the whole city, since it works as a "draging" force for the lower social and income groups. It is therefore the desire of the municipality to create quality houses appropriate for young families and the according urban environment. Schiebroek Zuid as a post-war neighbourhood could be densified in order to welcome young families and additionally, it seems to have a sufficient number of schools for primary and higher general continued education (the three maps of this and the opposite page).
Secondly, the municipality has exhibited a clear direction towards sustainability on all levels. Specifically, by 2025 Rotterdam wants to have *sustainable electricity* with energy from wind, solar and biomass (Gemeente Rotterdam, 2007).



the density of schools of primary educational level (Bron: Min. OCW (DUO), bewerking door OBI en Stadsontwikkeling Gemeente Rotterdam)



the density of schools of secondary educational level (Bron: Min. OCW (DUO), bewerking door OBI en Stadsontwikkeling Gemeente Rotterdam)



source: wijkprofiel.rotterdam.nl

Indeed there are ways to provide with an energy efficient housing stock without neither demoliting the existing post-war buildings nor insulating them highly which skyrockets the expenses. Urban morphology and designing for a synergy between newly built highly efficient buildings and post-war buildings – as part of the densification that has been pursued throughout the project – can protect buildings from climatic related energy losses. Therefore this project replies both to the emotional needs of people to remain in their homes, as well as the sustainability goals of housing associations which stem from the municipality and beyond.

However since the mid 90s that *housing associations* became independent (ICOMOS, 2003) most post-war neighbourhoods, such as Schiebroek Zuid, belong to them while some houses are privately owned. This complex ownership status makes the role of individual actors less clear and therefore actions are less possible to take place. In the case of Schiebroek – statistics show the bigger area of Schiebroek, not just the Zuid – 50% of property belongs to housing associations. The data does not allow certain conclusions about the ownership percentages of Schiebroek Zuid, however the number of visions from housing corporations on the neighbourhood shows that social housing isa substantial part of the overall housing. Indeed plans and visions have been made, especially from Vestia for the area. The main focus of these visions are: new higher quality residences and sustainability. As it is visible in their visions, housing associations prefer to demolish existing buildings and erect new ones – especially since this is part of national policy for post-war residential areas (Priemus, 2006). In contradiction to that, tenants commonly insist on maintenance of their houses instead of demolition.

In reference to *sustainable energy*, housing associations are facing certain issues due to lack of insulation. Poor insulation means huge amounts of money in order to renovate and add insulation to post-war buildings. Therefore what associations try to do is to connect their residential areas to district heating systems. However district heating is not (yet) available everywhere and the cost of connecting its residence to it is stil quite high (Schrederhof, 2018). So according to two interviews I had with Karin Schrederhof (Woonbron) and Paul Broekhuisen (urban designer in the municipality of Rotterdam), housing associations are therefore looking for solutions that could help lower the energy bill without having to heavily insulate old buildings. In the words of Karin Schrederhof "*(...) if there are solutions that have a relation with our housing I think you have a partner in the housing association.*" This kind of logic could perhaps make housing associations interested in applying design solutions related to densification as well as energy use and production when it comes to te residential buildings. Indeed there are ways to provide with an energy efficient housing stock without neither demoliting the existing post-war buildings nor insulating them highly which skyrockets the expenses. Urban morphology and designing for a synergy between newly built highly efficient buildings and post-war buildings – as part of the densification that has been

"I think how better the ideas are, how more able we are to change the system of the nets in Holland. If you have good solutions maybe we think about another system."

Karin Schrederhof, Woonbron (2018)

Sustainable Schiebroek-Zuid

Social housing neighborhood redevelopment

pursued throughout the project – can protect buildings from climatic related energy losses. Therefore this project replies both to the emotional needs of people to remain in their homes, as well as the sustainability goals – the energy related of course – of housing associations which essentially stem from the municipality and beyond.

Local energy initiatives are currently collaborating only with house owners that can invest in sustainable energy, so higher income groups. People of lower income and people on rental they are not interested in generating sustainable energy because they don't have the initial capital to invest (Schrederhof, 2018; Boejinga, 2018). So even though, post-war neighbourhoods heve a significant number of non-residential buildings that could be used for installation of solar panels with the help of energy initiatives, it might not be feasible. Inhabitants of many of the post-war neighbourhoods are of low income so they probably wouldn't have enough capital to invest. It is my personal belief that energy initiatives show great potential not only in assisting people to lower their energy bills but also in contributing to a decentralized sustainable energy network. Nevertheless it seems that in the case of rented social houses in post-war neighbourhoods with low income population there is no fertile ground in the current phase for local energy initiatives to actively contribute.

Finally, *local residents* as aforementioned they couldn't probably invest in any of these design solutions. But, as it is also suggested in literature (Sijmons et al., 2014; Janda, 2011), my personal belief is that users' engagement is of crucial importance for the transition to sustainable energy. Therefore in this project it is attempted to view public energy generation solutions as a type of sustainable energy pedagogy (ENORME STUDIO, 2018). Most of the public space design solutions are, as aforementioned, not meant to provide the houses with energy but to provide various public activities – cafes, repair cafes, community centres, markets, play spaces, etc. – with the energy they need. In this way it is hoped that the sharing of these spaces and the visibility of renewable technologies can stimulate people to care about the source and use of energy in their lives. There is however growing concern that this kind of interventions in a neighbourhood with many financial and social issues will not be welcomed. In particular in an interview with Rolf Bleeker (Schiebroek wijkmanager), it was clearly stated that interventions such as energy producing urban furniture could face vandalism. Therefore there has been an effort for cheaper and easily replaceable technologies (such as solar fabric or the low-cost vertical wind turbine) but there is no answer as to hoe actions like these would be actually perceived. In conclusion residents in this case is not an actor that could be held as main players in this kind of project.

10.2. PERSONAL REFLECTION

The graduation project is a process that seems like a walk through the fog, even though you might start with a clear idea of where you are and where you want to go, the things that will unexpectedly appear on your way will eventually change it. And even the destination in the end will not be the same as this first image that made you set out towards it. This allegory describes briefly my personal experience through this project.

The starting point was the idea of a design language that would manage to incorporate renewable technologies in cities, in a way that they could both contribute to the energy transition but also a new urban landscape would be formed. This new urban landscape would spatially embrace renewables – in contrast to what has been happening so far – which could happen with the help of designers both to create aesthetic value to technologies as well as the added value of giving them a role in the city and making it possible for people to use them and accept them. This idea didn't cease to be a significant part of my final destination but by delving deeper into the subject of the energy transition, new aspects were revealed. Energy systems in my understanding until then had to do with technical possibilities and infrastructure, getting acquainted with notions such as fossil dependency, invisible energy, carbon lock-in and energy equity, changed my perception of the energy transition. This, for me, was a desirable and necessary change that didn't stop me from moving towards my destination but made the final result more grounded to reality and more multifaceted.

Processing the information and complexity of energy systems and their transitions has been the hardest part of this project. The ideas about the connection of energy to financial and social justice, to the form of the city, to people's lifestyles, etc. created a troublesome but wonderful journey that added depth and value to my actions and design. After overcoming the chaos that some of the vaguest or the most theoretical notions created, this framework helped me understand the roots of the fossil dependency and the areas of action, as well as how to start dealing with them. The effort to ground those notions to urban design led me to trace the spatial manifestations of the fossil dependency within the city which then led me to one of the pillars of this project: post-war neighbourhoods and the need for their densification. The second part of this grounding effort has been to locate within theories the reasons that led to this lock-in state. The search for reasons actually led me to understand not only what the factors were but also to what I should address with my project. The new, much more specified, notions that came out of this process – climate and energy use and production, post-war neighbourhoods and densification – were based on an in-depth study of energy systems but also an intuitive approach that became more organized and conscious through time.

After having fitting the different notions into different parts of the process and figuring out the method in which they would come to bind, came a period of concentrated knowledge that has been perhaps the most interesting for me. Learning about different climates and how they affected the form of human settlements and cities before fossil as well as the physics behind the behaviour of wind and how the designer can influence its behaviour with the structure of space and built form, has been inspiring for me. The first moment of excitement for the success of the method came after I had gained a good understanding of the optimum morphological qualities in relation to climate, and I started studying modernism and post-war neighbourhoods. The comparison that first happened in my head while reading and then became specific when the design patterns and sub-patterns were designed, made me realise that intervention is indeed needed and could improve the existing situation without demolitions needed. The second most exciting moment was when the application of the patterns on Schiebroek Zuid came. Firstly, because the morphological qualities of dutch post-war neighbourhoods actually applied in the specific neighbourhood. Secondly, because by the application the Matrix, the Typology of dutch post-war neighbourhoods and the Design Patterns – the 3 pillars of the project – fell in place and the links between them became much clearer.

The expected destination of the project has been since the very beginning to create a method for designers that – based on the knowledge I gained through the process – would guide them in applying urban design solutions towards conservation and generation of energy in relation to climate. This can hopefully assist in making the urban energy transition a reality. The complexity that was evident when applying the design patterns on the case study shows that there are social, financial and other location-specific parameters that perplex the step-to-step method. In the end the design method is firstly a set of instructions on how a designer can use the knowledge gathered in the project and secondly a set of design ideas that can be an inspiration for the designer to incorporate in his/her own design. After all, what is needed for this transition, apart from the knowledge, is the ability to imagine the future and then share the images of the future with the world. This is in the end my modest contribution to urban design, searching and combining information of different disciplines and the latest technological advances in order firstly to make a framework and then providing with design ideas that can use this knowledge and make the urban energy transition imaginable.

10.3.. LINK WITH RESEARCH GROUP

The current graduation project is located in between 'Smart City and Urban Metabolism" and "Complex cities" research groups. The subject links future transformation of urban areas – especially connected with urbanization – with the energy transition and explores the design tools that can assist urban designers towards the urban energy transition. This transition is much needed towards our way for sustainable living environments, and in this project attempts to show a path that can *accelerate the transition without compromising our quality of life*. Because as stated in one of the research questions of the Urban Metabolism group, urban metabolism should be influenced by our strategies in such a way that not only the transition will be accelerated but the resulting sustainable living environment will be characterized by a high quality of life (urbanmetabolism. weblog.tudelft.nl).

In the process of searching for possible answers, the micro-climate – as a factor affecting heat losses/gains of heat (aka energy), in buildings – became increasingly important. Wind patterns, solar radiation and other climatic conditions are explored in reference to urban morphology in order to come up with design solutions concerning energy use as well as production. Literature or existing examples are used in order to discover the optimum characteristics of urban morphology in relation to each climatic condition. Ultimately the purpose is to explore how we could redefine current practices in lines of climate-responsive and energy-active urban design. The correlation of the urban morphology with the micro-climate, constitute essentially the study of flows of energy from the open to the urban environment to the exterior and eventually the interior of a building, as well as the other way around. The in depth study is directly linked with the understanding of the flows of energy in the city and it should be therefore a core part of urban metabolism in relation to the energy circle.

In the same line, to address the energy circle there also needs to be a clear understanding of the existing energy "feeding" system. Namely, the infrastructures that are currently providing with energy and not only their physical dimensions but also the political and economical. This project has been exploring these subjects in order to sed light on varying aspects that relate to the transition and its obstacles. A research that I believe is both relevant and extremely important in order to successfully tackle the energy transition.

11

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APPENDIX

THEORY PAPER

Technology is not the answer to the Energy Transition:

Why designers and engineers should work together towards Sustainable Urban Design.

TU Delft
Faculty of architecture
MSc Architecture, urbanism and building sciences
MSc track Urbanism
Research group: Complex Cities

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December 2017

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Abstract: The environmental crisis and the depletion of fossil resources have influenced our planet and are penetrating our lives more and more (from economic crisis caused by oil and gas crisis to the raised number of storms, floods and other extreme weather conditions). At the same time scientists and technology experts have been progressing exponentially in renewable energy technologies. Prices are dropping, technologies become more and more adaptable (e.g. solar textile energy systems) and the fossil giants are investing in these technologies. As a result, there is a prevailing perception among practitioners as well as researchers that the current crisis will be resolved by technological advances. Ambition of this paper is to go beyond technology and explore how a potential collaboration between urban designers and engineers can succeed in making the transition within urban environments. In doing so, there is firstly the need of tracing the existing gap between them. Then, within the overarching framework of Sustainable Urban Design, to provide with insights as to how and on which focus areas it should be bridged.

Keywords: energy transition, sustainable urban design, urban form, engineering, technology, transdisciplinary

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* The format of this paper is based on the template that was given in the methodology course

Contents

1. Introduction

The environmental crisis has been present for more than half a century – scientists have been studying global warming from the 60s – but only recently has it started becoming more and more apparent in our lives. Extreme weather phenomenon such as heat waves, coastal flooding, and severe droughts on some areas and extreme precipitation on others, are directly linked to climate change and they are influencing people's lives around the world. In the Netherlands, rising sea level and coastal flooding poses a grave threat for the whole country but also phenomenon such as supercells[1] which in 2016 produced hailstones "the size of tennis balls" (dutchnews.nl) causing at the greenhouses of North Brabant alone, damages of millions of euros. At the same time the fossil resources – mainly accountable for the environmental crisis – are facing depletion (fig. 1) and the reserves are becoming smaller and less economically viable to extract. In the Netherlands the natural gas field in Slochteren has almost depleted and the fracking technique that is used in order to extract more gas is causing the so-called "shallow gas quakes"[2]. Therefore it is widely acceptable that the energy transition towards renewable energy sources will inevitably occur (Rotmans et al., 2001; Loorbach, Van der Brugge and Taanman, 2008; Hocks, 2017; Kokhuis, 2017; Witte, 2017).

However the manner on which the energy transition will take place is still not certain but it is of paramount importance. So far it has been mostly pursued via wind farms in the sea, on the mountains and on agricultural land, and solar parks in the dessert or again on agricultural land. Meanwhile technological progress has allowed these technologies to become more efficient, less less expensive and more adaptable, and their potential can be seen also in the fact that fossil giants (e.g. Shell or ExxonMobil) are investing in renewable energy. But also in literature (Berger, 2014) we can see that there is a popular "misconception that dealing with the environment is merely an engineering problem to be overcome by technology" as Carmona states (p.52, Carmona, 2009). The way they are currently applied though (like aforementioned), in oceans, desserts, forests, agricultural land, mountains or any other so-called free space, it occupies more and more of the available land. Thus if we are also to

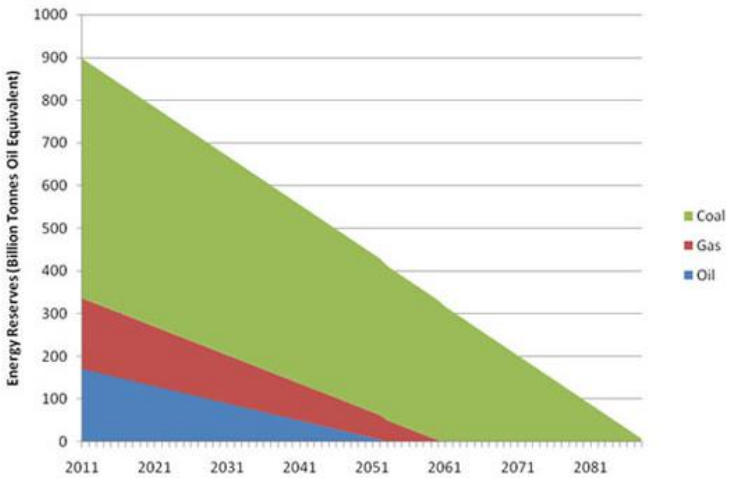


figure 1: end of fossil fuels (source: www.ecotricity.co.uk)

[1] A supercell is the least common and the most severe classification of thunderstorm (4 classifications in total). They usually produce large amount of hail, etc. The research for conclusive proof that climate change is linked to the increase in severity and frequency is still ongoing (www.ucsusa.org/global-warming/science-and-impacts/impacts/extreme-weather-climate-change.html)

[2] A shallow "gas quake" of 2 on the Richter scale has a lot more impact than a natural earthquake of the same magnitude 20 to 100 km deep. Experts agree that the Richter scale doesn't do the situation in Groningen justice and only serves to trivialize the case (http://www.dwarshuis.com).

take into consideration the growing population, urbanization rates and our current spending patterns, the energy demand will grow exponentially in the future. Will we be able then to accommodate all our needs and our population in, for instance, 2050? So based on the most common definition of sustainable development[3], are the current practices sufficient to make a successful transition or the future generations will have to face similar issues? Therefore the current paper as well as the thesis aspires to answer the two issues of increasing energy demands and of space occupation.

In order to provide a possible answer, it is necessary to go beyond technology and examine the urban environment and the behavioural patterns of the users. As it is going to be explained further on, the fossil era has affected both urban environments and users' behaviour and it has created unsustainable cities which are currently in a state of – as Broto (2017) describes it – carbon lock-in[4]. This lock-in state acquires action on specific aspects of cities and by specific actors. This paper provides an overview of these aspects and actors, but it will focus on the urban form and on professionals of the built environment, in particular urban designers and engineers. The focus on those two types of professionals, is not intended to illustrate their individual duties. On the contrary it is intended to explore the gap between the two and then on which aspects of the urban context their collaboration can contribute in successfully overcoming our carbon lock-in.

The first section of the paper will examine the urban environment in order to provide a better understanding of the unsustainability and the carbon lock-in apparent in our cities and lifestyles. For this purpose the literature used is varied in order to cover the different aspects of unsustainability and to show its link with energy use. The second section of the paper focuses on sustainable urban design since it can provide the ground on which the collaboration between urban designers and engineers can be built on. In particular the framework drafted by Nico Larco (2016) in his paper "Sustainable urban design – a (draft) framework", will be used as a basis due to the incorporation of different theory models on sustainable urban in one comprehensive organisational structure which emphasizes on design elements of sustainable development. Finally in the conclusions, the potential in residents' participation via energy initiatives will be briefly explored – keeping always in view the ultimate goal, the energy transition.

2. Tracing the gap

As it has been observed in practice (Hocks, 2017) as well as in literature (Janda & Parag, 2013; Van Den Dobbelsteen et al., 2011), there is a gap between urban design and engineering in our trajectory towards the energy transition. Indeed in an interview conducted by the author, Borris Hocks – an urban designer and cofounding member of the Dutch office for spatial strategies "Posad" employed also in energy projects – stated that there is a need for developing a design language similar to the water-sensitive design language. Namely designers so far have been applying engineering solutions, by learning technical details and spatial restrictions, but there is a need for learning how to design with those technologies (Hocks, 2017). Similarly, organisations such as Architecture 2030 – established in 2002 by the architect Edward Mazria – consider the architects duty to provide innovative solutions for the built environment by creating strategies and making use of technologies (fig. 2).

Design solutions are, undoubtedly, necessary in our trajectory to the urban energy transition but not sufficient (Janda, 2011). As aforementioned (see introduction) if we are to take the future of cities into consideration, we need to go beyond energy production. We need to reinvent the way we perceive our urban environments and our relationship with energy holistically. Droege (2006) in his book "The renewable city: a comprehensive guide to an urban revolution", he studies the connection between cities and energy. Interestingly the particular subchapter of the book is entitled "Form follows fuel". In this subchapter he describes how the coal influenced not only the expansion of cities but also their development along rail corridors due to the steam engine and how electricity (that stemmed from coal) transformed cities into "magic citadels of bright lights and motorised motion" (Droege, 2006: 131). Later on the oil and gas fully facilitated the growth of cities and served well in the

[3] Sustainable development is defined as "meeting the needs and aspirations of the present generation without compromising the ability of future generations to meet their needs" (Brundtland, 1987: 292)
[4] The discovery of large fossil fuel reserves is a historical event which made socio-technical and socio-ecological systems to coevolve – development of institutions, economic interests, lifestyles and technological developments – in a deterministic pattern that created an inertia. The present in such cases remains within this inertia and whatever differentiates from the established systems meets resistance, for instance renewable energy and sustainable development. In other words, as Broto (2017: 757) describes it, "with the development of infrastructures, institutions and social habits, moving away from fossil fuels may prove an impossible enterprise, which is described as carbon lock-in". This state finds its spatial manifestation in the city in terms of urban obduracy, namely the resistance of the built environment to change following our current needs.

steep housing demands of the post-war period. With oil and gas there is not even the need for proximity to the source as with coal. The extraction points are located far from cities and transportation services along with a large centralized distribution networks provide cities with 'invisible' energy (Hommels, 2005). Buildings, streets, transportation services, household devices were all built with dependence to this fuel system.

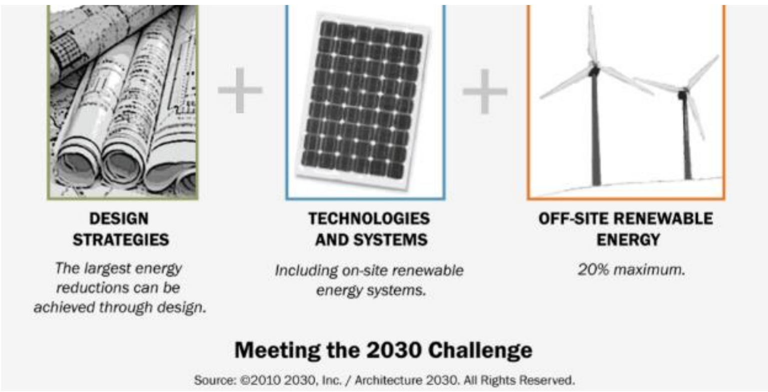
Therefore it is visible that the gap is not as simple as initially perceived. On the contrary it is deeply rooted into the urban form as it was shaped by the fossil era. This process has been ongoing for the last half century and more, leading to a generation not only of end users (Janda, 2011) but also professionals (architects, planners, engineers, etc.), which are alienated from natural processes. This is also evident when looking into the ecological footprint per capita of each country (fig. 3). Western developed countries even though they possess the technological and economic means to reduce their ecological footprint, they seem to have the largest environmental impact and they also appear to be unaware of it (Carmona, 2009).

This is essentially the state of carbon lock-in that Broto (2017) analyses and it is manifested in various ways within the urban context. In this paper 3 actors of energy related unsustainability are chosen based on their impact: built environment, transport and users' behaviour. However only the built environment will be further addressed as the ground of collaboration between urban designers and engineers. Users' behaviour is perceived as a controversial actor, designers are divided as to whether the design should aspire to actively include users in the process towards sustainability. Perspectives on its importance and potential will be briefly presented in the latter part of this paper.

Transport and the built environment are more apparently connected and mutually influenced. Already from the 70s when the first oil crisis occurred and the first discussions on making cities more independent from fossil fuels, transport was the first sector that was examined. Excessive fuel consumption because of urban sprawl and in general the lifestyle of the automobile, were criticised and new models of urban development were proposed. Examples of these are the compact city, transit oriented development (TOD), etc. Furthermore electric cars started appearing, biofuels are also part of the future plans and even autonomous vehicles are expected to play a part in this (Newman et al., 2017). However there are other issues which are again embedded into urban form which still need to be resolved. Apart from the most apparent which is sprawl, the post-war period bequeathed to us large monofunctional residential areas contiguous to city centres. These monofunctional areas render the endeavour of independence from private cars almost impossible.

figure 2: the pathway towards carbon neutral by 2030 as illustrated in the 2030 challenge (source: architecture2030.org)

figure 3: World map of countries by ecological footprint; data is given in global hectares per capita – data of 2016 (source: wikipedia)



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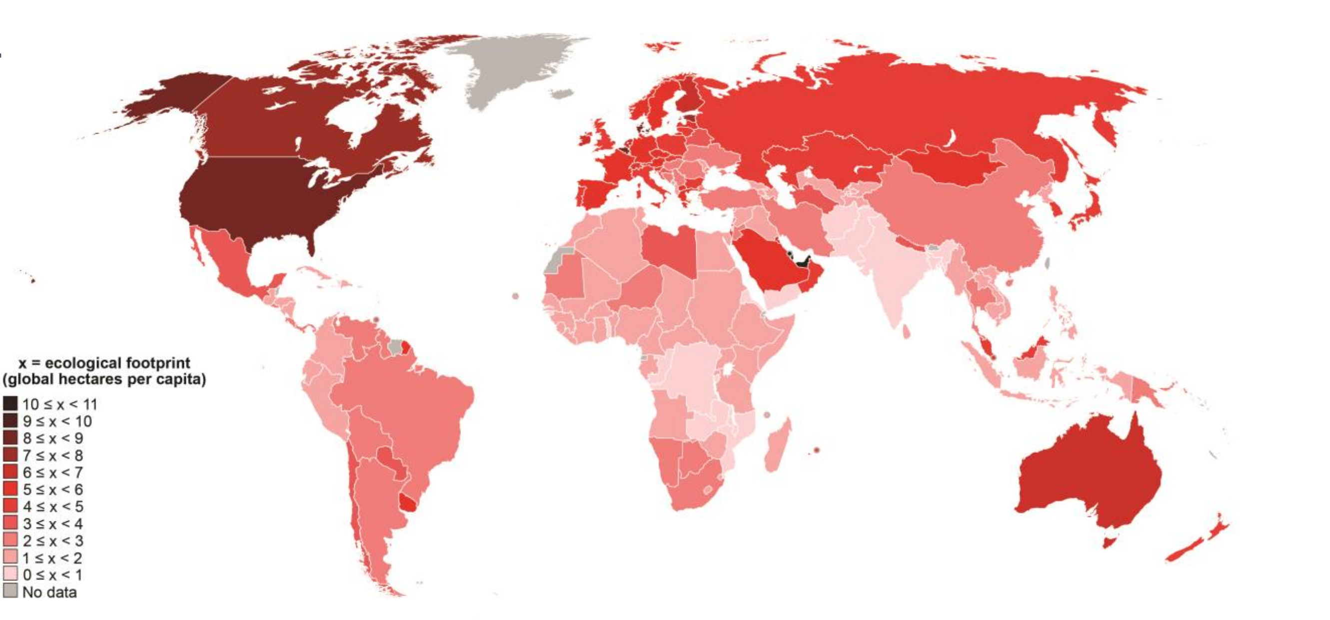

In the case of the built environment, existing knowledge is more limited and there are still key features that affect energy consumption which are mostly ignored by practitioners. For instance lack of vegetation, concrete and asphalt have led to the urban heat island effect (Newman et al., 2017), which has affected even countries with cooler climates creating various issues including health problems. Furthermore there is a direct link between urban heat island and space heating requirements. But urban heat island is a phenomenon that becomes more evident in cities in particular periods – namely summer and winter. As Owens (1987) describes in her article "The urban future: does energy really matter", the micro-climate and all elements of the build form – orientation, height and density of buildings, width of roads, vegetation, etc. – that affect it on a local level have an immense influence on the thermal comfort inside buildings and therefore on energy consumption. The root of this problem lies in fossil fuels as a cheap energy that shaped urban areas – built since the coal era and even more, later in the oil and gas era – ignorant to the local context (Droege, 2006). Namely, climate, orientation, weather conditions, sunlight and even materials, all of which were important before fossil fuels. Climatic distinctions that characterized urban settlements, such as bright colours, narrow passages or small windows for warm climates or the opposite design choices for cold climates – dark colours, large windows – have been forsaken. And it is of course no coincidence that the two large urban growth periods – 19th and 20th century – took place hand in hand with this fuel system. But precisely this fact makes sustainability even harder to pursue due to rigid structures which are in place and thus hard to change. Therefore the challenge of our century is on one hand, as Droege states (1987: 131), "undoing the negative effects of almost three generations of planning priorities bred in an era that was gripped by great collective delusions about limitless growth". And on the other hand to solve this problem on the local context by producing climate- and energy-sensitive design solutions.

In brief, there is a paradox when it comes to technology and urban context. Technology seems – especially nowadays – to evolve rapidly. On the other hand, its spatial manifestation in the urban context – infrastructure, bridges, transportation facilities, etc. – is fixed, stable and obdurate (Hommels, 2005). Recent studies by historians of technology (e.g. Hård and Stippak) highlight the potential of transdisciplinary collaboration of the fields of urban studies with technology studies in tackling the urban obduracy. In the following section Sustainable Urban Design is studied as an overarching framework where climate- and energy-sensitive design can be developed and as the grounds for the collaboration between urban designers and engineers.

3. Sustainable Urban Design (SUD)

In this section Sustainable Urban Design (SUD) is described as an overarching framework which can provide the basis for the development of the desired collaboration between urban designers and engineers. For this purpose Nico Larco's paper (2016) entitled "Sustainable urban design – a (draft) framework" is chosen since it incorporates different theory models on sustainable urban form and provides a comprehensive and aggregate framework with clear divisions, purposed for practitioners. Larco separates SUD into five primary focus areas, in this paper (and further on in the thesis) one of this areas is being studied in detail: energy use and production (based on non-transport related uses). This focus area is subdivided to three additional focus areas: building energy use, outdoor lighting and embodied energy. All of them need to be addressed through the transdisciplinary collaboration that is proposed and in the end design solutions and spatial principles need to be developed. The aim of the author is to offer a brief description and to highlight the areas where the gap exists and the potentials stemming from the desired collaboration. At the same time it is acknowledged that the nature of this gap is something that cannot be bridged by the author, but possible pathways are explored and proposals will be made towards bridging this gap.

First focus area is the building energy use which is highly dependent on the climatic conditions. But as aforementioned, local conditions are significantly influenced by the urban form. In particular it influences humidity, wind strength and temperature, to to mention a few, however the way on which the form influences them is an unknown field for urban designers. Some of the basic elements that should, and in some cases are already taken into consideration are: solar orientation, buildings' sizes and depth, density and wind streams. All those elements though are extremely dependent on local climatic conditions. Moreover often there can be design decisions that while benefiting one of the conditions, they collide with others. The climatic conditions and the physical rules concerning them are a knowledge field that belongs to physicists, engineers and environmental scientists. However the urban form is – and should be – designed by urban designers, which makes it clear that there needs to be a transfer of knowledge across disciplines in order for successful design solutions and spatial disciplines to be developed. There are existing examples that similar attempts have been made, for instance the Solar Quarter in Regensburg (Germany) or Masdar City (UAE), both by Foster and partners (fig. 4). Examples such as these can help along with examples from

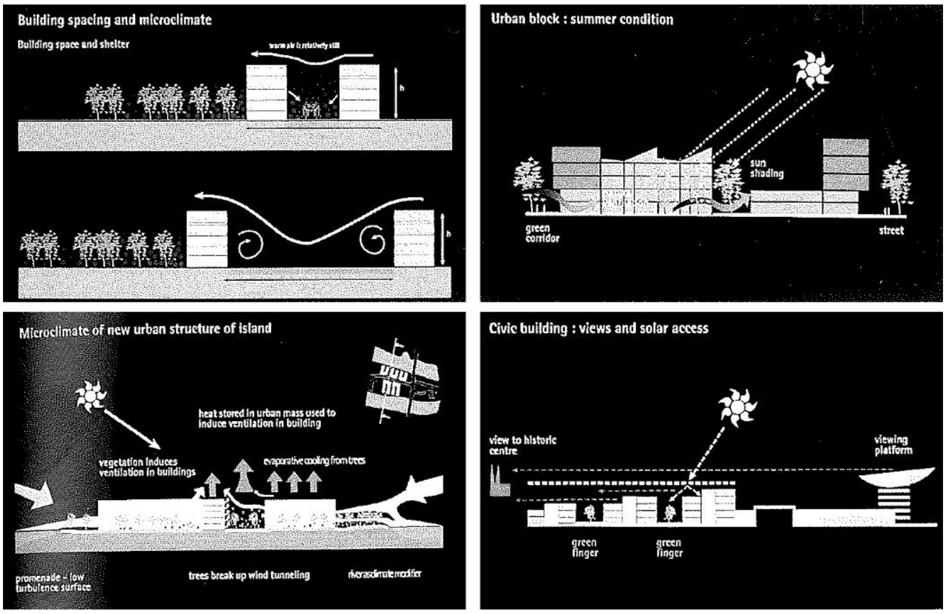

figure 4: The diagrams illustrate the approach of the designers to ecologically responsible design

[Solar quarter; Unterer Wöhrd, Regensburg, Germany, 1996- Norman Foster and Partners (source: Ruano, 1999: 45)]

vernacular architecture in giving a better insight into physical rules that have to be followed for climate- and energy-sensitive design.

Embodied energy is a part that even sustainable projects fail to address because it grows beyond our current understanding due to the conveniences that cheap energy brought. It entails all energy spent from the production of building materials to transportation and finally to construction or even demolition. Once again, as in building energy use, two are the key features in order to limit energy consumption: knowledge of materials, construction and demolition specifications, and the types and possibilities of local (what range from the site) materials. In order to accomplish that there is a need both to become more aware of all the processes entailed in building – something that hardly even is known to engineers, let alone urban designers – and to be able to draft tables of materials with the key elements influencing embodied energy, in order to be able to make energy-informed decisions.

At this point it should be noted that even though Larco provides a very cohesive and aggregate framework, there is the need for more information in order for practitioners to be able to actually use this kind of matrix. The knowledge that needs to be developed in order to deliver successful principles and designs, should also incorporate values and data that will enable SUD to become less vague and qualitative. For instance, the urban heat island is an effect which can be described in a qualitative manner but it can also be measured (Larco, 2016). There is a need to develop indicators in a similar way, for instance an indicator that would be able by taking into consideration the strength and direction of the wind to calculate the optimum height of buildings or width of open space between buildings, based on the local climatic conditions. However this kind of data even though they exist for some values, what is also lacking is an organizational structure that will enable practitioners to be able, firstly not to get lost with various data, and secondly to compare them and identify trade-offs between different elements – e.g. wind and sun requirements related to density. Similarly it could work for a possible table of materials – as described above. This kind of matrixes could help urban designers to weigh different choices and decide accordingly to each case's requirements and potentials. This is the gap that the exchange of knowledge across disciplines – urban designers and engineers – will need to fill in the immediate future towards the urban energy transition.

However we need to make sure that we do not get trapped in the rigour of the profession if we are to avoid mistakes of the past, such as the monofunctional, residential expansions of the post-war period. And rigour does not only refer, in this case, to each separate discipline but also to their pragmatic role in the current challenges of the urban environment. Namely, as Newman et al. distinctively noted we are transitioning towards an "era of citizen utility" (Newman et al., 2017: 38), where citizens will be energy-aware – in both reducing it and producing it. Indeed in a research conducted on the Zero Energy Home development by the name of Premier Gardens (Sacramento, USA), it was discovered that even though the residential development was done by the rules of Zero Energy, the final result was far from zero energy. By looking more carefully into the electricity bills it was evident that the residents had the same energy spending patterns as an average city dweller, which practically defeated the sustainable design in terms of effectiveness (Janda, 2011). It is therefore crucial to understand that designers "need to develop professional expertise and seek ways of integrating user involvement in building performance" (Janda, 2011: 16).

4. Conclusions

In this final section apart from the conclusions, there will be some recommendations for further research related to the gap as was defined in the paper, and the potential lying in users' engagement in sustainable urban design. The energy transition towards renewable energy sources is a puzzling subject. It has managed to gather vast and global attention, international agreements have been made and it has been included in the agenda of numerous countries. Nevertheless it seems to be hindered without explicit reasons. This paper first and foremost, explores what seems to be often overlooked by technology experts: in order to successfully transition to a new fuel economy we need to take into consideration the obstacles that the lock-in state of the fossil economy poses in the way. The increasing energy demands, the urbanization rates and the population growth could finally lead to the occupation of free spaces. Design solutions and possibly a design language incorporating renewables, is undoubtedly necessary but not sufficient. Broto's (2017) definition of carbon lock-in and urban obduracy effectively illustrates the reasons for this insufficiency.

This paper analyses the specific elements that create this unsustainability for some specific actors (built environment, transport and users' behaviour), in an effort to become more explicit. This step has been helpful in comprehending the issues that need to be tackled (e.g. climatic conditions for the built environment or monofunctional residential areas for transport) towards achieving sustainability in terms of energy. Larco's framework of Sustainable Urban Design is a compact and comprehensive fusion of different models of sustainable development and urban form. It focuses on the design part of these theory models and is meant for practitioners to use in order to produce sustainable development. After presenting the proposed framework, the paper suggests that it is very useful in our endeavour for sustainability and ultimately for the urban energy transition. However it is highlighted that there is a need to enrich the data and indicators, as well as provide an organisational structure which can allow practitioners to make energy-informed decisions. On this matter, the paper concludes that there is a knowledge gap between urban designers and engineers. Both to cover the unknown ground of the relationship between climatic conditions and urban form as well as to assist SUD to become less vague and more quantifiable and practical for urban designers.

At this point, it needs to be acknowledged that the gap highlighted in this paper is a complicated knowledge gap. The intention of the author is, firstly to explore through relevant examples of sustainable urban form and to make use of data and indicators, in order to tackle (in the thesis) unsustainability based on specific climatic conditions and to explore potentials that will assist in achieving urban energy transition. Apart from that there is recommendation for further transdisciplinary research that could go beyond examples and best practices and towards discovering the true potential existing in the collaboration among science, technology and urban design. Nonetheless, as abovementioned (see section 3) professional rigour has led to failures in the past which in order to avoid we need to realise that currently the involvement of people is not only desired and necessary, but also underway. Indeed the local energy initiatives (already 300 in the Netherlands alone) are already creating a significant difference in the renewable energy production (hieropgewekt.nl). Not only because they produce their own energy but also because through these community-driven initiatives they create knowledge. The potentials lying in the combination of these initiatives with the expertise of professionals can be very promising in overcoming the issues existing so far with renewables (e.g. NIMBY) and even lead to a new fuel economy which can be both environmentally and socially just.

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COMPARATIVE STUDY:
ECOVILLAGES AND ECOURBAN NEIGHBOORHOODS

BOEKEL ECODORP, NETHERLANDS

"Now we are close to realizing our dreams. We learned a lot in the last 5 years. We are going to grow our food with Permaculture, heat our homes with Rocket Mass Heaters.
We are going to build our houses with wood, straw bales and hemp.
We are going to build a polydome as an example for sustainable food production
We are going to build the nicest tree huts for ecotourists. And we will be a center of sustainable companies that create win-win situations for each other and the partners we work with
So that can happen when you go with the flow. You have no idea where you are going, and not how long it takes. So be sure to make the trip worthwhile . Then it does not matter where you end up or how long it takes. It only means that you can realize your dream and make your part of the world a bit better..

	SIZE	CURRENT STAGE	POSITION RELATED TO URBAN CENTRE	ENERGY					FOOD	WATER	WASTE
				WIND	SOLAR	BIOMASS	GEOTHERMAL	SYSTEM & STORAGE			
			Fringe of the small town of Boekel 1km away from its centre	Max 12m	Solar panels, solar collectors on the roofs	Wood, biogas from composting		Smart Grid – 1kWh battery storage per kWp to PV FUTURE: Hydrogen energy storage	Food forest Permaculture garden Fish farm	Helium filter: toilets Hemel (s) water: rain water infiltration micro-algae reactor: toilets and agriculture	Compost toilets Vegetable waste → chicken & fish deconstruction: 2nd hand materials
synergies					●■	□			● ○	●	□

MATERIALS	NATURAL ASSETS	STRUCTURE/FORM		BASIC PLANNING CONCEPTS	PHASING	ORGANIZATION & PROFIT
		Architecture	Urban/village			
Organic & renewable Proximity of origin Slightly processed 2nd hand materials	D'n Eik forest	High insulation A lot of daylight Passive solar Solar tubes & LED lights	Small houses: less materials, less energy to build & to heat, cool, etc. Neighbourhood house	Permaculture Biomimicry Healing architecture Pattern language Polydome	P1 preparation exploring potentials, allocation of tasks P2 grouping Attract people (experts, volunteers, supporters) →action oriented organization P3 agreement with municipality • Temporary occupation • Boomhuttenhotel • Food forest	Cooperative Ecodorp Boekel (rental company): residents will be renting the houses Model: Holarchie Profit: Boomhuttenhotel "Dragon dreaming" Project management service (external)
○	○	■				

IEWAN - STROWIJK NIJMEGEN, NETHERLANDS

The community provides space for families, residential groups, singles and dwellers. At Iewan there are currently 44 adults and 7 children. Together they take care of their living environment. They share a number of common areas and facilities, and there is also the possibility of renting a work space. In addition to a large property with residential units, De Kleine Wiel is a multifunctional building where various activities are organized. The common garden is built on the basis of permaculture, an ecosystem that maintains itself and produces as many edible products as possible. The project has been built as ecologically as possible. This is not only due to the choice of environmentally friendly building materials such as straw and sludge, but also in applications that encourage reuse and energy savings.

	SIZE	CURRENT STAGE	POSITION RELATED TO URBAN CENTRE	ENERGY					FOOD	WATER	WASTE
				WIND	SOLAR	BIOMASS	GEOTHERMAL	SYSTEM & STORAGE			
	51 residents 24 housing units	All living spaces occupied	Located in the residential extension area of Nijmegen (Lent) 3,4km away from the centre of Nijmegen		solar panels	wood pellets		No gas connections	Permaculture garden voco (food cooperative) for the joint purchase of organic food products	Reed filter: waste water	waste wood or FSC wood → wood pellets
synergies					■	○			●	□	○

MATERIALS	NATURAL ASSETS	STRUCTURE/FORM		BASIC PLANNING CONCEPTS	PHASING	ORGANIZATION & PROFIT
		Architecture	Urban/village			
straw, loam and wood green concrete Limestone sandstone Ecological paint		5 types of living spaces 3-storey residential buildings De Kleine Wiel: green terrace favourable orientation to the south high insulation value of straw LED lamps	24 housing units Workplaces (for residents) Shared spaces and facilities: laundry room, common living room and kitchen, guest rooms, a voco (food cooperative) for the joint purchase of organic food products the multi-purpose space De Kleine Wiel Green: permaculture garden around the buildings, courtyard garden	Permaculture Sharing (vacuum cleaners, cars, washing machines and tools)	March 17, 2014 Construction started 2015 One year later construction completed	Iewan 'Initiative Group of Organic Living Nijmegen' Model: Sharing Profit: De Kleine Wiel Housing corporation Talis (external)
○		■	□ ●			

MUNKSØGÅRD, DENMARK

Munksøgård is the name of an eco-village in the outskirt of the city of Roskilde located about 25 km west of Copenhagen, Denmark.

The development that includes 100 row houses was established in 2000. The key idea behind the community was to create a development that integrates environmental friendly technologies and practices in the construction of the houses as well as in the operation. At the same time high priorities have been given to establish a strong community among residents supported by houses for joint activities, common areas etc. The residents have planned the development with assistance of professionals, and the residents are in charge of management of the settlement.

	SIZE	CURRENT STAGE	POSITION RELATED TO URBAN CENTRE	ENERGY					FOOD	WATER	WASTE
				WIND	SOLAR	BIOMASS	GEOTHERMAL	SYSTEM & STORAGE			
	225 residents 100 row houses	Operational since 2000	Located on the edge of the city of Roskilde adjacent to farm fields Integrated part of a newly developed neighbourhood named "Trekroner" close to a railway station 4,7km away from the centre of Roskilde		Solar collectors, solar cells	Wood pellets		District heating, local decentralized heat pumps	organic vegetables (individually) corn on adjacent fields (in groups) Sheep & cattle (in groups)	Biological sand filter: waste water Laundry rooms: rainwater Separation toilets	Urine → farm fields Waste recycling station Food scraps & garden waste →composted Clothes recycling
synergies					■				●	○	○

MATERIALS	NATURAL ASSETS	STRUCTURE/FORM		BASIC PLANNING CONCEPTS	PHASING	ORGANIZATION & PROFIT
		Architecture	Urban/village			
Wood, non-burned compressed soil bricks, gypsum building boards (,straw bale) Paper based insulation Ecological paint Gravel roads and walkways		Wooden row houses Outer walls without plastic vapour barrier (better indoor climate) energy efficient windows under floor heating 2-storey residential buildings	Diversity in housing sizes, ownership types and in support of different age groups 100 row houses five dwelling groups Each dwelling group has their own common house farm buildings for common activities Sheltered bike storage Green area for gardens and animals			Associations with general assemblies and resident elected board of directors The technical operation & social activities are managed in a number of working groups e.g. snow clearing All residents are expected to take part in at least one working group Roskilde Building Association (external) 3/5 dwelling gr. co-operative association 1/5 dwelling gr. privately owned 1/5 dwelling gr. Profit: farm buildings
		■	○ ●			

GEODESIGN & SUSTAINABILITY:
SELF-ORGANIZED WORKSHOP

2018

Geodesign & Sustainability

SELF-ORGANIZED WORKSHOP REPORT

FEBRUARY 14TH

Introduction

This report is the reflection of a self-organized activity that took place on February 14th of 2018 for the course ***Graduation orientation AR3U040****. The workshop was organized by a group of 8 students from 3 different research groups: Urban Metabolism, Delta Interventions and Complex Cities (Table 1). Even though the projects are quite diverse in terms of scale, location and approach, the group shared a common interest: sustainability. Indeed, sustainability is a broad topic and have different definitions and aspects. However, regardless of a specific conceptualization, there is an undoubted interrelationship between sustainable goals and design. In that sense, as we move towards our final semester at TU Delft, we are faced with the challenge of transitioning towards design phases, as well as combining them with research while pursuing sustainability. Considering that we work alone most of the time and we have limited chance of getting external counseling, this workshop intends to provide extra input and new insight of the design process, as well as additional methods that can contribute to assist us on this transition.*

Name and student #	Research group	Project title	Project location	Project focus
Donald Böing 4533100	Delta Interventions	Surges of the 21st century	Red Hook, Brooklyn, New York, USA	Reducing flood risk in Red Hook
Nilofer Afza Tajuddin 4618963	Complex cities	Keeping your feet dry	Chennai, India	Community flood resilience in Chennai Metropolitan Area
Carolina Eboli 4573811	Urban Metabolism	Metabolic Horizon	Belo Horizonte Metropolitan Region (RMBH), Brazil	Regional strategy for wastewater and solid waste of RMBH
Angeliki Bazaiou 4625102	Urban Metabolism	Towards urban energy transition	Schiebroek, Rotterdam, The Netherlands	How climate-responsive and energy-active urban design can facilitate the urban energy transition
Xue Cui 4619277	Urban Metabolism	Repower the petroleumscape of Daqing	Daqing, Heilongjiang, China	Using urban landscape for renewable energy production while improving sustainability
IJsbrand Heeringa 4216318	Complex cities	Re-imagining the European periphery - Shrinking regions	Asturias, Spain	Utilizing the opportunities that stem from shrinkage

		and opportunities for great European projects		to improve regions in terms of water resilience, energy efficiency and ecology
Karishma Asarpota 4619625	Complex cities	Laying the roadmap for energy transition in Dubai	Dubai, UAE	Using spatial planning as a tool to improve energy efficiency and develop a spatial strategy for Dubai's energy transition
Weizhen Luo 4623754	Urban Metabolism	Towards circular economy eco-city	Chengdu, Sichuan province, China	Exploring the circular economy integrated urban planning framework

Topic choice

It has to be noted that there are several different design methods, which have specific goals and are sustained by different theories. The group carried out several meetings, where personal interests and knowledge were discussed. Apart from discussions and brainstorming, the group carried out an activity to narrow down the group focus, where each student formulated 3-4 questions that they would be interested in addressing in the workshop. After the compilation of this material, another discussion session took place, where 3 main themes were defined: design process; the evaluation of sustainability and best practices. Within these themes, the group collectively decided to follow the first topic: design process, since all students believed it to be more beneficial to their projects. While considering the potential subjects and speakers for this activity, Geodesign presented itself as an interesting theme to be explored (see Relevance item), with the help of two researchers in the Urbanism Department (Alex Wandl and Franklin van der Hoeven). Franklin van der Hoeven was available and enthusiastic with the idea and a meeting was carried out with him to align the format and scope of the activity.

Event title: *Geodesign as a process method*

Lecturer: *Franklin van der Hoeven - Director of Research at the Faculty of Architecture and Associate Professor of Urban Design at TU Delft.*

Place and time: *14th of February 2018. BG West 640. 9:00 - 13:00*

Format: *Lecture + round table*

Scope:

1. *Elevator pitch of students projects.*
2. *Presentation of Geodesign framework: conceptual framework, interpretations and limitations.*
3. *Presentation of Hotterdam project and the relation between Geodesign and the development of the project / products.*
4. *Overview of Haagse Hitte project (unpublished / off the record), pointing out the main differences in the process, given the gained knowledge from Hotterdam.*
5. *Round table: discussion on the use of the method, benefits, challenges and theoretical interpretations.*

Aim

One of the aims of the Urbanism track in the Master of Architecture Urbanism and Building *Science is to 'integrate social, cultural, economic and political perspectives with the natural and man-made conditions of the site in order to shape and plan for more sustainable development' (TUDelft Department of Urbanism, n.d.). As mentioned before, since the students are in the process of translating their initial research into design proposals, a framework could prove to provide an essential guiding structure in this critical transition step. The aim of the activity is therefore to gain knowledge on the Geodesign framework and test aspects of this framework into the personal graduation projects. The main objective however, is not to completely incorporate the Geodesign framework, but to understand its concepts to assist the students with moving between steps and making the transition towards the design phase of the theses. To successfully implement certain concepts that stem from Geodesign, it helps to review projects with a similar implementation. The lecture presented by Franklin van der Hoeven should not only help the students to understand the concept of Geodesign better, but also elaborate on the implementation of the concept in practice. Moreover, presenting concrete examples will have to generate input for the round table discussion, which combined will give the students an idea how to use Geodesign in a comparable way in their respective projects.*

Relevance of Geodesign

'Geodesign is an invented word, and a very useful term to describe a collaborative activity that is not the exclusive territory of any design professions, geographic science or information technology. Each participant must know and be able to contribute something that the others cannot do or do not….yet during the process, no one need lose his or her professional, scientific or personal identity'.
Adapted from C. Steinitz, 2012, A Framework for Geodesign, Preface

Geodesign can be understood as an iterative design method that uses stakeholder input, spatial modelling, impact simulations and feedback to facilitate a comprehensive decision making in the *design process. Steinitz presents a framework within which all design decisions are made. The framework comprises of 6 questions that are answered multiple times within the design process.*

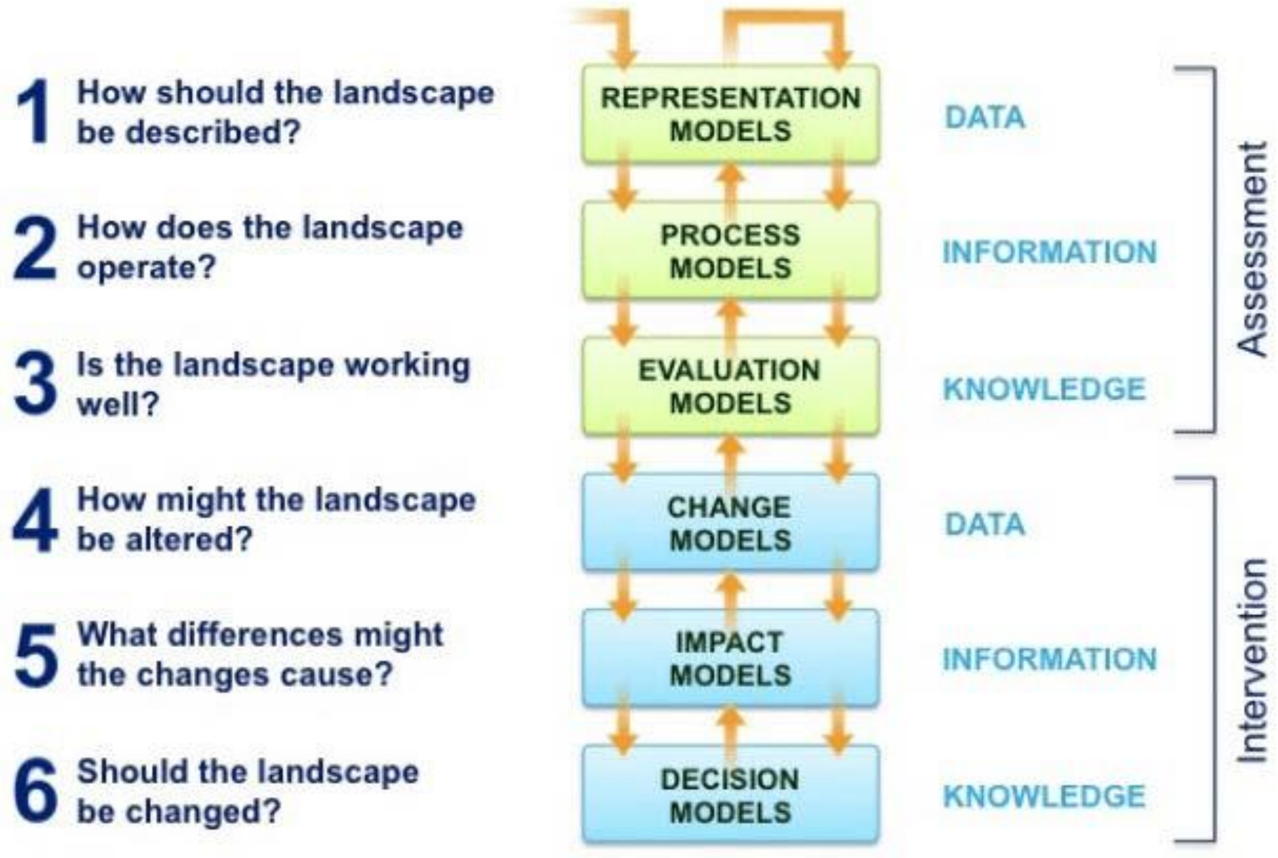


Figure 1 - Geodesign framework by Carl Steinitz (2012), A framework for geodesign: Changing geography by design

The 6 questions within the framework divide the design process into two parts - assessment of the existing problem context or landscape and proposed interventions. The answer to each question is described with a model. The first question of each part is about data, the second about information and the third about knowledge. Every duo of questions is answered through the same medium. For example, process models and impact models can be a a set of diagrams represented in the same graphical style. The assessment consists of representation models describe the problem context or existing landscape, followed by process models that show how the landscape operates and evaluation models that highlight the operation of the landscape system. The interventions are comprised of change models to speculate how the landscape might be altered, followed by impact models to simulate the suggested changes and decision models to test the proposed design.

Geodesign is not a new concept. Its principle ideas have been established in a tradition of landscape architecture. Important figures like Patrick Geddes and Warren H. Manning argued of designing with nature and the interdependencies existed within one territory. The biggest influence on the geodesign approach was Ian McHarg. He continued the line of environmental *based design, and combined it with geo-based techniques that allowed multiple maps to be consulted within one model (Miller, 2012).*

Geodesign takes McHarg's layer based approach as a starting point and sets about formalizing that approach supported by computer based modelling. This formal approach creates more clarity in the design process and makes it easy to discuss interdependencies between different aspects within one model. It extends the capacity of McHargs ideas by allowing us to integrate many more layers of data into one model.

With the increasing ability of GIS systems and the ever increasing richness in data, the integration of data is an increasingly large problem for designers, planners and decision-makers. Geodesign proofs its relevance by being one of the few tools that facilitates large groups of professionals to share and combine complicated information sets.

Figure 2 – self-organised workshop, round table discussion

Summary

At the beginning of the workshop, students gave a brief introduction about their projects, in order to clarify the aim of this workshop: exploring the way of using Geodesign as a tool to help connect primary research with design in their graduation thesis. Franklin van der Hoeven then started the presentation with explaining the complexity of defining Geodesign. During his presentation, the Hotterdam project and Haagse Hitte project were introduced as examples of applying the framework of Geodesign on research-based design projects. The background of the two projects is the fact that climate change has led to an increase in mortality rate among the elderly in European countries. Geodesign was introduced as a tool to investigate this problem, which works as a multidisciplinary framework that combines various considerations such as health, governance, architecture, landscape, urban planning, resource management, and public participation, etc. During his presentation, Franklin explained in detail their geo map site analysis and collection of temperature data (worked through the installation of sensors in local homes and traffic signs) in several-selected neighborhood in Rotterdam. However, in the end, Franklin remained critical towards Geodesign: he pointed out that in practice, working with Geodesign can be a rather complicated and time-consuming process, and sometimes may be affected by unexpected external events.

Round table discussions:
Geodesign is not always helpful, finishing design within three days is not realistic in most cases.
Design process did not go deep into the problem, missing politics changes.
How does Geodesign differ from the other design methods?
Inspiring geodesign practice, students remain critical about the method.

Round table – Questions & discussion
The round table discussion took place after the lecturer's presentation of Geodesign and the two projects. During this discussion, we asked questions trying to define Geodesign as a design process better through the presented projects and the experience of the lecturer. In addition, to reflect on Geodesign in respect to its effectiveness, limitations and, in the end, how useful it could be for our individual design processes.

1. Connection of Geodesign with the two projects:

At first, we tried through questions to explicitly trace how Geodesign was involved within the Hotterdam and the Haagse Hitte project. The Hotterdam was the first of the 2 projects to be completed, and according to the lecturer, during this project Geodesign was not consciously pursued. However, they came to the realisation that its concept was intuitively followed throughout the project. Indeed as it is already described the inclusion of so many different disciplines and the analysis maps produced through this stage as well as GIS and the sensors placed in Rotterdam, are practically describing the actors and steps of Geodesign (development of models, disciplines, diagrams). Furthermore, what they came to realise was that the project was basically bottom-up. It was a process that actively involved material and feedback from the *people. Therefore in the Hotterdam project they were, in a sense, acting according to Geodesign principles but in a more natural and intuitive way. This also stems from the fact that – as it will be further elaborated in the criticism – that as an actual project that involved a commission from engineering, collaboration with governance (municipality) and specialists (such as health specialists) and participation of people, it cannot follow a rigid methodological structure with more or less linear logic such as Geodesign suggests.*

In the Haagse Hitte project – having already gained the experience from Hotterdam – they learned from the social processes that were part of the bottom-up approach and it helped them become more structured and conscious in the method followed. Once again, the Geodesign framework was not followed as a fixed step of steps but more in a broader way. However, a key observation that the lecturer made, was that partly naturally partly through Geodesign, what did change in their approach was the shift from the urban planners/designer's perspective to the specialist's perspective. Therefore, by engaging into sustainability related projects and in such a scale – as the Rotterdam or the Hague – they needed to take the most from the specialist and come up with a way to process and integrate the information gained. So it becomes apparent that the basic concept of Geodesign is a relevant one in sustainability projects. However, it has limitations and it involves simplifications that became more explicit during the discussion – as it will be elaborated further on.

2. Criticism of the Geodesign framework:

During the roundtable session, the relevance of the geodesign framework and its application in practice was actively questioned and discussed upon. The first criticism of the framework was that of the aspect of time. Franklin van der Hoeven suggested that while theoretically, Carl Steinitz insisted that the design process spans approximately a week, in practice, time was an important factor to be considered. Urban design and planning processes in a majority of cases take a considerable amount of time, years in fact, in order to understand the context deeply and design for it. Furthermore, while the framework is a well-structured methodology and advocates a lateral design process, in practice, this process is quite complex with multiple influences and hence is more time-consuming. The second criticism is that the methodology and framework do not take into consideration the internal and external problems that influence design. For instance, internal problems are that of the inherent issues in the context and external is that of the influences that may change the context over time.

On the other hand, this consideration was taken into account in the two projects presented by Franklin van der Hoven, through an in-depth analysis of the site and different factors influencing the urban heat island effect in Rotterdam and The Hague. The third criticism was that the geodesign framework does not address policy changes to support the design. The participants, being from the Urbanism track and well aware of the need for the design of policy recommendations, agreed on this aspect. The final criticism was that of the diagrammatic approach of Carl Steinitz. As part of the ideation process, a series of diagrams were created as possible solutions. However, during the compilation of these diagrams into one single design, a *process of cancelling out overlapping or dissimilar diagrams was carried out. This in turn may lead to untested solutions that may lead to different or effective designs. Hence, one of the key takeaway was also that of disadvantage of the flattening processes of multiple ideas and as a result of this, the loss of possible design solutions.*

Personal reflections

Donald Böing

As the title of the project suggests, my thesis will focus on two surges that are currently playing a role in urbanized coastal areas. The project location involves the neighbourhood of Red Hook, Brooklyn, where both these surges are playing a very strong part. To illustrate the relevance of a geodesign framework for my project, the surges will be briefly elaborated first.

The first surge is the thread of climate change and an increased chance of flooding events. Many of the low-lying urbanized coastal areas are susceptible to flooding. These flooding events can occur through a number of different causes, often working in combination with each other. Astronomical high tides, storm surges, increased discharge of rivers, and stormwater runoff are amongst the most significant causes for flooding events. However, not only an increase in natural triggered events because of climate change, have an impact on the increasing flood risk. Coastal areas have become incredibly urbanized. These so called 'human induced stresses' on the environment play a substantial role in the sensitive position of coastal cities. Several studies have indicated that the consequences of human actions, like socio-economic dynamics and extreme (unplanned) urbanisation contribute more to the increase in flood risk than climate change itself.

To summarize: the first surge is the thread of climate change and an increased chance of flooding events, plus the second one depicting the rapid increase of extreme urbanization in coastal areas. Not only have these regions become more sensitive for flooding events, they are hosting more inhabitants than ever before and continue to see an increase in urbanization.

As can be understood from this short introduction, many areas of expertise are required to successfully address these complex problems. Climatology, Geology, Hydrology, Civil engineering, Urban planning, Sociology, Ecology and Economy are all professions that are highly relevant in trying to create a successful project around this topic. The definition of Geodesign differs slightly from person to person, as Franklin van der Hoeven presented in his lecture. However, most definitions agree on the notion that the framework of Geodesign enables multiple areas of expertise, in which every person should contribute something others can't. It often uses large amounts of GIS information to make data informed decisions, in which the real challenge is to have an efficient communication and collaboration process between different areas of expertise. Since the thesis is an individual project, you sometimes have to play the role *of an Civil engineer or Ecologist for example. As Urban planner I personally feel a large responsibility to link the different areas of expertise together, as we are often comfortable in visualizing both social and technical aspects with diagrams and other forms of graphical design. The geodesign framework has helped me realise once again the strong need for creating the links between these different professions, as a necessary condition for a successful project.*

Carolina Eboli

My project is located in the Metropolitan Region of Belo Horizonte, which has gone through an intense process of rapid urbanization for the past century, having sprawl, pressure on resources, infrastructure shortage and environmental hazards as consequences. A new perspective on its urban comprehension is, thus, necessary in order to embrace existing proposals and develop solutions that increase its environmental performance and resilience. Urban Metabolism, can contribute to this understanding, by looking at the urban relations and flows rather than only focusing on territorial aspects. My thesis focuses on wastewater and solid waste flows, especially due to their environmental implications and reliance on heavy infrastructure and their potential to interconnect in a regional scale, which would permit circularity and contribute to the sustainable development of the region.

Geodesign is a topic that I had already come across during my graduation before this activity. However, my previous knowledge was based mainly on the Geodesign framework of Carl Steinitz and the 6-models approach (representation, process, evaluation, change, impact and decision), with their associated questions and their 3 levels of iterations. Already in the first part of the activity (presentation of the concept), I understood that this framework had multiple definitions and interpretations, rather than a single consolidated concept. Apart from that aspect, as a result of the discussion, my understanding of Geodesign shifted towards seeing it as a framework which combines simulations made with GIS modeling and a strong focus on stakeholders. Therefore, the underlying idea of Geodesign relates to the recognition of the existing complex urban processes and that we, as urban planners and designers, are only one component of a web of specialists. In that sense, this method appears suitable when working with the so called "wicked problems". In other words, this framework is optimal in complex situations where multiple stakeholders and actors are involved. Moreover, the aspect of availability of precise data (GIS, satellite technologies, among others) presents itself as a crucial difference.

Considering what was exposed previously, for me this activity was helpful in two fronts. The first one relates directly to the methodology I used for my metabolic analysis - material flow analysis (MFA), which was entirely based on GIS data. Considering that one aspect of Geodesign is the optimization of data processing, in my project, the use of GIS allowed me to produce more information and have a broader perspective of my problem field and site. However, the activity triggered a reflection upon the relation between goal and simulation models. In other words, there is a need to set specific goals prior to the simulation exercise. This aspect is particular interesting for me, since I still have to develop the MFA of my second flow (solid waste).

Therefore, having the Geodesign approach as a background guide can be helpful to optimize my data processing, by analyzing if the indicators I choose are directly related to the simulations goals I desire.

The second aspect of Geodesign that can assist my work relates to the active engagement with stakeholders. I have a field trip taking place in a month and I am currently planning collaborations with local actors. This activity triggered me to think about the role of the urban planner, since part of its definition relates to the indispensability of all actors and their equal contribution. Geodesign urges the humble position of urban planners and collaboration as main premise. Therefore, I can use this method to get insight on how to take the most from the specialists I engage with. This activity also reinforced the benefits of collaborating with local population rather than only focusing on specialists, especially considering the ethical dimension of my project (the relation between society and waste flows). This was particularly discussed within the different concept definitions from Carl Steinitz and Steffen Nijhuis, since the first is closer related to the pragmatic application of the method, whereas the last focuses on the interrelationship of actors. Therefore, I will also consider different ways to engage with the local population, which until now I was not focusing on.

In conclusion, this activity allowed me to deepen my knowledge on Geodesign concepts and highlighted the close relation of my graduation project with this framework. Moreover, it pointed to different aspects I can consider in order to get better results and achieve my thesis' goals. Lastly, this activity personally put this method as a potential tool for regional urban strategies, which I can take in consideration for my further works.

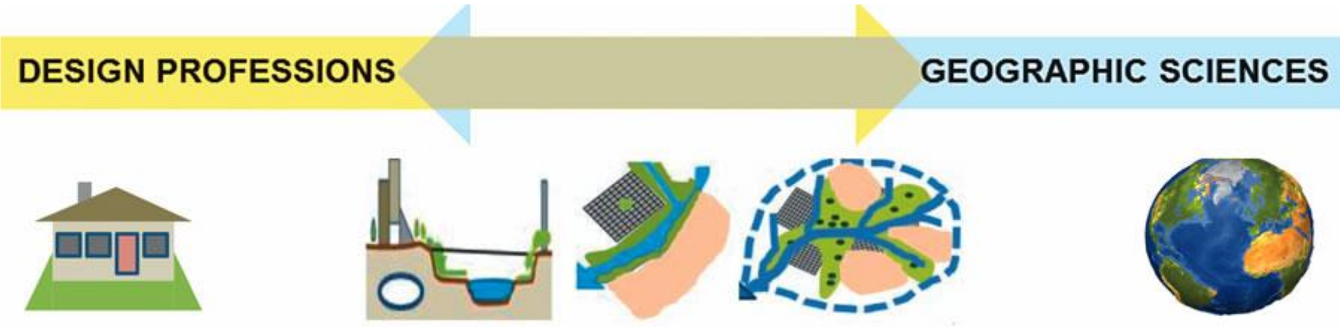
Nilofer Afza Tajuddin

My thesis project focuses on local strategies for flood resilience in a developing context and also explores the potential of bottom-up strategies to achieve social and community resilience. Due to the continuity and uncertainty of the flood risk, the project approach focuses on social resilience as key to building adaptive communities. The thesis addresses civic engagement in design and implementation processes in order to achieve integrated management of water resources which in turn leads to social integration and conservation of natural resources. This approach requires a multi-stakeholder and interdisciplinary approach in order to address the different actors and the local potentials. In order to channel these ideas into design proposals, the Geo-design workshop presented an interesting manner in which research, data and ideas can be formulated into a collaborative design proposal. While the methodology was not applied as is, the fundamental principles resonate well with the project and will further guide 'informed decision making' as preached by Carl Steinitz. Especially in the case of my project, integrated water and flood management calls for a collaboration between the various actors and users of the hydrological system.

This implies that through design, I will be exploring ways to integrate different disciplines such as building design, landscape design, governance and policy recommendations, engineering, *disaster management, health, waste management and urban design. An important learning from the concept and workshop itself is the ability to sieve through multiple ideas and to be able to negotiate between the dissimilar and conflicting ideas. For instance, while water management yields diverse solutions and opportunities, the diagrammatic approach will help me compile the many possibilities and help me evaluate the most relevant proposal. As an interesting GIS-planning tool, the framework also gives insight on using technology and GIS mapping to analyse data and formulate designs accordingly. This data based analysis further supports the diagrammatic design approach and helps make informed design decisions. Further, the geo-design framework also emphasises on the participatory approach and local engagement in order to plan and design for change. During the workshop, the lecture which showcased the urban heat island effect projects in Rotterdam and The Hague explored how direct involvement of citizens in the research, data collection and design process can yield valuable findings. Being an iterative process driven approach, it is important to consider local users in the entire process in addition to the various disciplines. This principle is especially useful for fieldwork, in order to understand the local perceptions and accordingly design for it.*

Angeliki Bazaiou

The subject of my thesis is related to the energy transition but it is sought within urban environments and it studies how we can build and design with the climate. In terms of not only renewable technologies but also in how the urban morphology can affect energy gains and losses. For instance before the discovery of the large gas and oil reserves, indigenous people around the globe knew how to shape their buildings and settlements in relation to the local climate. This is a field that has remained largely neglected in modern times, but it has significant potential given the technical knowledge that engineers and physicists have gained in relevant fields. Geodesign is a process that can activate the desirable collaboration between different disciplines such as urban designers, physicists, mechanical and chemical engineers, climate specialists, etc.



Therefore, Geodesign is a process that can serve also as an organisational scheme for the much needed and upcoming transdisciplinary collaboration towards the energy transition. Something that I also have been studying as part of the theoretical background of the thesis. However, this gap existing between disciplines, even with a helpful framework such as Geodesign's, cannot be bridged in a student's project, since in this case the potential for interdisciplinary collaboration is somehow unlikely. Nevertheless, it can help set the questions *that you need to answer and to be aware of what kind of data you need and how exactly you will use them. For instance, GIS is an extremely useful tool which represents the information technology and which is indissolubly connected to the Geodesign itself. However it is very common for designers to get lost in the excess of data. The Geodesign framework and the 6 basic questions can assist the designer to become more precise and focused in his/her search for data. And this is especially useful for students since we lack both the experience and the contact with specialists that would be of great assistance in navigating through the pile of data we can access.*

Furthermore, since it is part of my thesis – but also part of the energy transition in general – to engage with end users – in this case urban dwellers – it will personally help me also in my interaction with people from local initiatives. Local initiatives as small scale local companies which possess some technical know-how and address neighbourhoods as target groups. So the first part would be to develop the visual language (diagrams, maps, sketches, etc.) that would allow the discussion with people who are not designers. But also a language that can help them in providing me with input which I can use in the design phase of the case study. At his point again the basic framework of urban design can provide me with the questions expected to be answered through the participation process and how to make use of the input I will get. In this way the same process becomes less time-consuming and at the same time the results become clearer and more helpful for the design phase.

Xue Cui

My thesis focuses on the energy and economic transition of Daqing (located in the northeast fringe of China) as a post-oil city. As petroleum depletion and climate change becoming evident, it is relevant for urban designers and planners to think within a new energy paradigm contextualized by post-petroleum era. My project proposes using Daqing's urban landscape to facilitate renewable energy production and contribute to neutralizing the energy and economic crisis of the post-petroleum era while extending its own sustainability. The project is organized in a research-based design methodology, which is divided into four steps: Analyzing present conditions, mapping near-future development, illustrating possible far-futures by scenario building, and identifying energy-conscious spatial interventions (largely agrees with the 'five-stepped approach' developed by Stremke & Van Den Dobbelsteen (2012)).

We found during the workshop that due to its multidisciplinary and participatory characteristic, Geodesign has limited possibilities to be directly applied to an individual graduation thesis. I learned from this workshop (as well as an earlier Geodesign workshop organized by the Urban Metabolism research group) that the Geodesign process comprises six models: representation models, process models, evaluation models, change models, impact models, and decision models. Although not directly applying these models, my project refers to the main idea reflected in this process, which contribute to connecting my primary research with spatial design: spatial elements should be clearly and carefully defined, analyzed and designed in each step of a project.

To be specific, my project defines four aspects as its concerned spatial elements: natural landscape, human settlements, renewable energy landscape, and petroleumscape. The present spatial conditions of Daqing are analyzed to provide a comprehensive understanding of the situation. Scenario building is then applied as a scholarly research method to picture spatial consequences of Daqing powered by renewable energy. Four scenarios are generated and transferred into the base of spatial strategies through an evaluation of environmental sustainability. Ultimately, this project designs spatial strategies on the regional scale and the neighborhood scale.

However, although Geodesign involves the consideration of spatial elements (especially addressing the process of collecting and mapping data), the following decision-making process remains opaque to me. During the workshop, we browsed some interesting regional scale mapping, while remaining unclear about how the geo maps lead to a regional strategy. Besides, working with GIS can be rather time-consuming when the data is not available and need to be collected manually.

IJsbrand Heeringa

My thesis is concerned with shrinkage in European regions. It is specifically aimed at identifying and exploiting the opportunities that stem from processes of decline. One of the results of shrinkage is an abundance of unused land and structures, think of brownfields, greyfields, abandoned factories and vacated towns. These results are often regarded a negative factors in an environment.

However, an abundance of vacant space is also an opportunity for the development of new land-uses. Most notably the development of land-uses that in other more competitive land-markets might be less viable, think of ecosystem regeneration and renewable energy.
Acknowledging that a brownfield might be converted into a solar-plant is not very complicated. However, identifying which brownfield might be used for the production of solar power and which might be better suited to be turned into a floodplain, is much more complex question. Especially when you are dealing with a large territory.

This is where the concept of geodesign is of importance to my thesis. The concept of geodesign enables us to see the interdependencies between different natural and artificial systems. The interdepencies are of vital importance in order for us to make well-informed assessments regarding aspects of landscape change.

I have used this concept throughout my thesis. For instance; by uncovering which vacant plots and buildings were positioned areas prone to torrential flooding events, and thus could fulfill a new role as stormwater storage sites.

However, within the scope of my thesis I will not be able to fully exploit the potential of geodesign. In the end the process is too elaborate to fit into the scope of my thesis. This is *partly related to the large amounts of structured data that would be required to make the geodesign models work. And my own lack of expertise when it comes to GIS-modelling.*

Karishma Asarpota

My thesis aims to develop a strategy for Dubai's energy transition. Dubai aspires to become a global leader in tourism, trade and transportation. This competition is pushing Dubai to go 'green' and move towards adopting sustainable development principles. The energy transition is defined as shifting to an energy system that is more clean and efficient. The thesis explores how spatial planning can help Dubai government to achieve this. Spatial planning has been recognized by many authors as an essential tool to achieving sustainable development in cities. Spatial planning plays a critical role in urban development and is a key tool to facilitating the energy transition in Dubai. Spatial planning is seen as a policy tool to influence change within how the urban form operates and move towards reducing energy consumption and increasing energy production through renewable sources.

To do this, first the relationship between spatial planning and energy transition should be made explicit. As it stands, there is a literature gap that can quantify the impact of spatial planning measures on energy consumption at a scale larger than the individual building. The availability of data to develop models that can link land use change to energy use is still lacking. Moreover, there is a lack of academic work that studies the urban development of Dubai. One of the reasons this is attributed to is the lack of accessible data. In Dubai, there are multiple organizations with development rights to the city. Fast growth, overriding economic policies and the passive role of the Dubai Municipality has led to a disconnected urban plan fuelled by non-integrative policies and an economic dependence on oil and gas. This makes understanding the complexity of the problem very difficult. The lack of data poses a big challenge to interpret how the energy system functions within the existing urban form. An approach that does not depend on the grain of definition of data is needed to unravel the layers of the problem field and put forward design interventions.

Considering these challenges, the geo design framework as proposed by Carl Steinitz can provide a way to compartmentalize the design process and outline a framework to bring together different professions and stakeholders to develop a strategy for Dubai. Geo design in this context can help to diagrammatize processes that are spatial in a systematic way without necessarily having precise geospatial data. The application of this technique need not be limited to digital mapping techniques and can be explored using analogous techniques as well. In my thesis I want to add to the interpretations of the geo design framework within a problem context that lacks precise geospatial data.

Further, I will be using a scenario approach to explore the possibilities of the energy transition in Dubai and evaluate the results of my interventions. The iterative process of geo design will be specifically used to systematically move through scales and link stakeholders to each other. The 6 steps can be applied to every scenario and every corresponding response can be overlapped. Since I will be started the majority of the mapping in my thesis at this point, I believe geo design framework can provide a useful outline to visually guide the proposed strategy for Dubai.

Weizhen Luo

After the economic reform in 1978, China has changed entirely from various aspects. While enjoying the benefits brought by the rapid urbanisation, the harmful effects of this development became the primary concern for Chinese government and scholars. Inspired by the successful examples from Europe, USA and Japan, China presented several initiatives for achieving sustainable development. Among these plans, CE is the primary policy in China to decouple the economic growth with environmental contamination. Since 2008, there are several actions based on CE principles has been taken place around China. Those plans were aiming to tackle the side effects of the rapid urbanisation from three different levels, namely, 'Cleaner production', 'Eco-industrial parks 'and 'Eco-city'. While the first two levels have accomplished their objectives, China is planning to reach the final goal: Eco-city, where provides vibrant economy, sustainable environment and harmonious society.

The objective of this graduation project is to form a model or planning framework for Chengdu to achieve eco-city based on the principles of Circular Economy. Normally, the notion of CE has been discussed within the scope of industrial symbiosis, closing the loop of material and energy for a quite long time. However, how to integrate the principles of CE with the land-use planning is still a vague topic, which require further researching. The start point of this graduation project is to form an abstract model representing the mechanism of CE based eco-city. As a promising approach for changing the current urban metabolism into a more sustainable model, the flows within the urban area and the facilities storing and processing all the flows should be systematically researched. The second part of my project is to use the previous knowledge in a specific site (Chengdu) by introducing the geographic condition into the abstract model. During this stage, I shall find the spatial mismatches between the existing situation and the abstract eco-city model. After several iterations of changing (by design) and evaluation, an empirical planning framework will be the outcome of this project.

In order to reach the final step, a suitable method should be introduced to structure this project. Based on the theme and scale of this project, Geodesign, which consist of a set of questions and methods, is a perfect fit. Geodesign is aiming to solve large, complicated and significant design problems, often at geographic scales ranging from a neighborhood to a city. This problem solving process requires seamless collaboration and cooperation among several groups. Since this project that only have one participant, the collaboration could be done in another way. However, the workflow of Geodesign is the most valuable for me. It integrates the geographic sciences with design professions. Although the framework of Geodesign is relatively strict, which may be not fully fit my project, it is the foundation for my succeeding research work. Besides, this workshop is a great exercise for an urbanism student.