Dare to switch off

The transformative Urban Energy Landscape of Oud-Crooswijk

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MSc thesis
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Abstract

Abstract

The Netherlands has lost its connection to their energy landscape. Uninhibited energy consumption forces exploitative energy production to meet the demand (Our World in Data, 2021). The current energy system causes climate change, pollution, and pressure on space (Our World in Data, 2021) (Withagen, 1994) (KNMI, 2020)(NOS, 2017). The energy transition begins to take shape, companies are investing in large-scale wind farms at sea, and people are installing solar panels on their roofs.
However, nothing changed in lifestyle and energy consumption. By approaching the energy transition from with the current mindset, it tackles the problems surrounding climate change and pollution, but the pressure on space will increase (Sijmons et al., 2014).
Throughout history, the relationship between space and energy has been great; the energy landscape significantly influenced our living environment (PBL, 2003)(Toekomstatelier NL2100, 2022). Over the years, it has become increasingly distant from our immediate living environment. Out of sight, out of mind (PBL, 2003). As a result, the consequences of unrestrained energy consumption are unclear, and people are not inclined to change. This research focuses on how this problem came about and the possibilities for the future. The design brings the energy landscape back into the living environment in the middle of the city.

The research focuses on Oud-Crooswijk, a neighbourhood in the city of Rotterdam, the Netherlands. Here, the design investigates the potential of inner-city energy production and its spatial consequences. The energy transition is the catalyst for investment in spatial quality in the district. If the development is already there, much more can be made possible.
In addition, the research shows how our lifestyle needs to change to achieve the intended quality. How people should adjust their behaviour and become more frugal and at the same time work together. As a result, the design creates a more conscious and social living environment. The research shows that by changing our behaviour and decentralise sustainable energy generation we can improve spatial quality, microclimate, and community. Now it is just a matter of daring to switch off.

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1. Introduction

1.1 Personal motivation

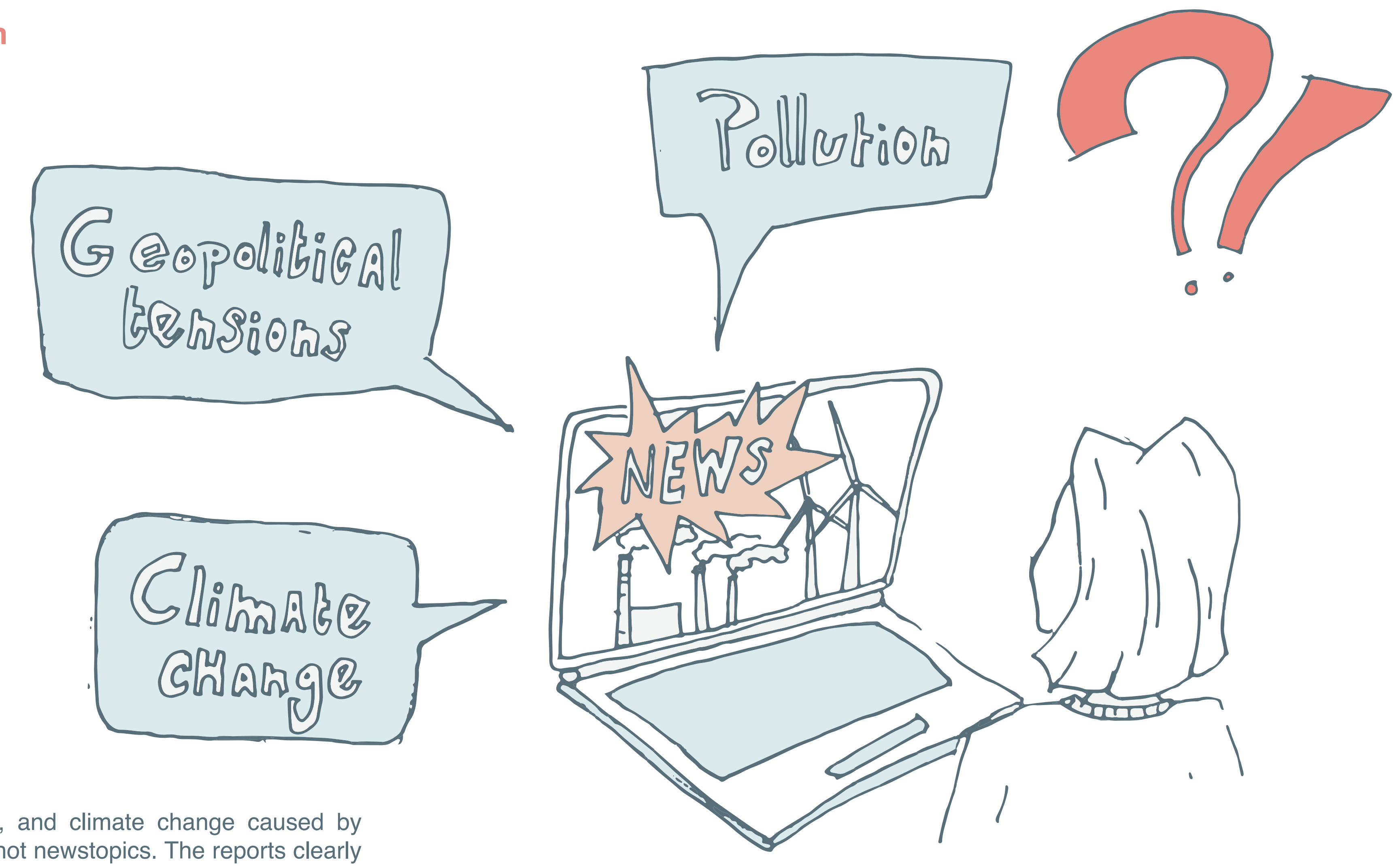


Figure 1: Illustration on news on urgency energy transition

Pollution, geopolitical tensions, and climate change caused by our current energy system are hot newstopics. The reports clearly show us the detrimental effect of our lifestyles and changing the amount of energy we consume is necessary.

However, these reports also leave the viewer dispirited. Because, climate agreements have goals, political plans, and hopeful policies to tackle the energy crisis. Nevertheless, it is unclear whether and how we will reach these goals. Furthermore, the question remains what this newly transformed world will resemble.

This research aims to show what is possible in a sustainable future.

2. Problematisation

What is energy, how is it generated, and why does this cause problems? This chapter touches on these questions and explains why ourcurrent energy system needs to change. The global and local effects of the system are then related to our lifestyle.

Picture: 1: Power plant, maker: Dorli Photography

2.1 What is Energy?

Energy means the potential to move, heat, or otherwise do work (Doeleman, 2017) (Helmenstine, 2017) (EIA, 2021). It shows a physical quantity, the measurement of a physical character (Doeleman, 2017)(Helmenstine, 2017). Energy is often measured in Joules, regardless of the form or source of energy (Helmenstine, 2017), and is a comparable unit, as seen in figure 2. Joule is the official unit, kWh is also widely used.

There are primary and secondary energy sources. The term "generating energy" is often used in colloquial speech (Doeleman, 2017) (Helmenstine, 2017). However, energy does not arise because it is already there. There is only the possibility of conserving or converting it (Doeleman, 2017)(Helmenstine, 2017) (EIA, 2021). Energy can also not be lost, although it can end up in an unusable form (Helmenstine, 2017)(Doeleman, 2017). Lost energy, for example, can be residual heat, and by repurposing this heat, it is again a source (Helmenstine, 2017).

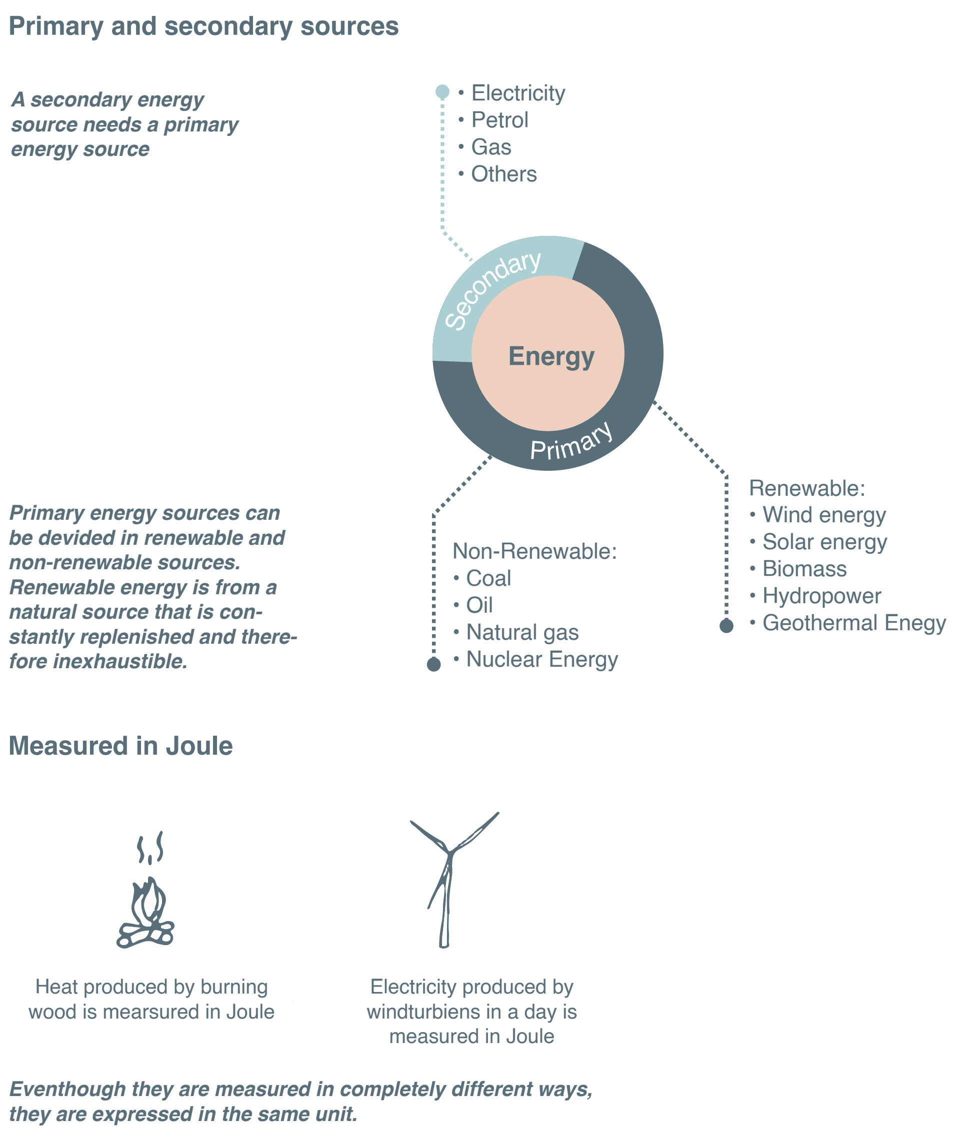


Figure 2: Illustration on types and measurement of energy (EIA, 2021) (Helmenstine, 2017)

2.2 How do we use energy?

The sectors of industry, built environment, and mobility use the most energy in the Netherlands, as seen in figure 3 (CBS, 2021). Heating needs the most energy among multiple sectors (CBS, 2021). The sources of energy consumption differ considerably per sector (Energie in Nederland, 2022).

Petroleum is the source of only a 50% share in industries, while this is 98% for mobility (Energie in Nederland, 2022). Natural gas is the source of 25% of the energy used in industries, while for mobility, this is only 0.5% (Energie in Nederland, 2022).

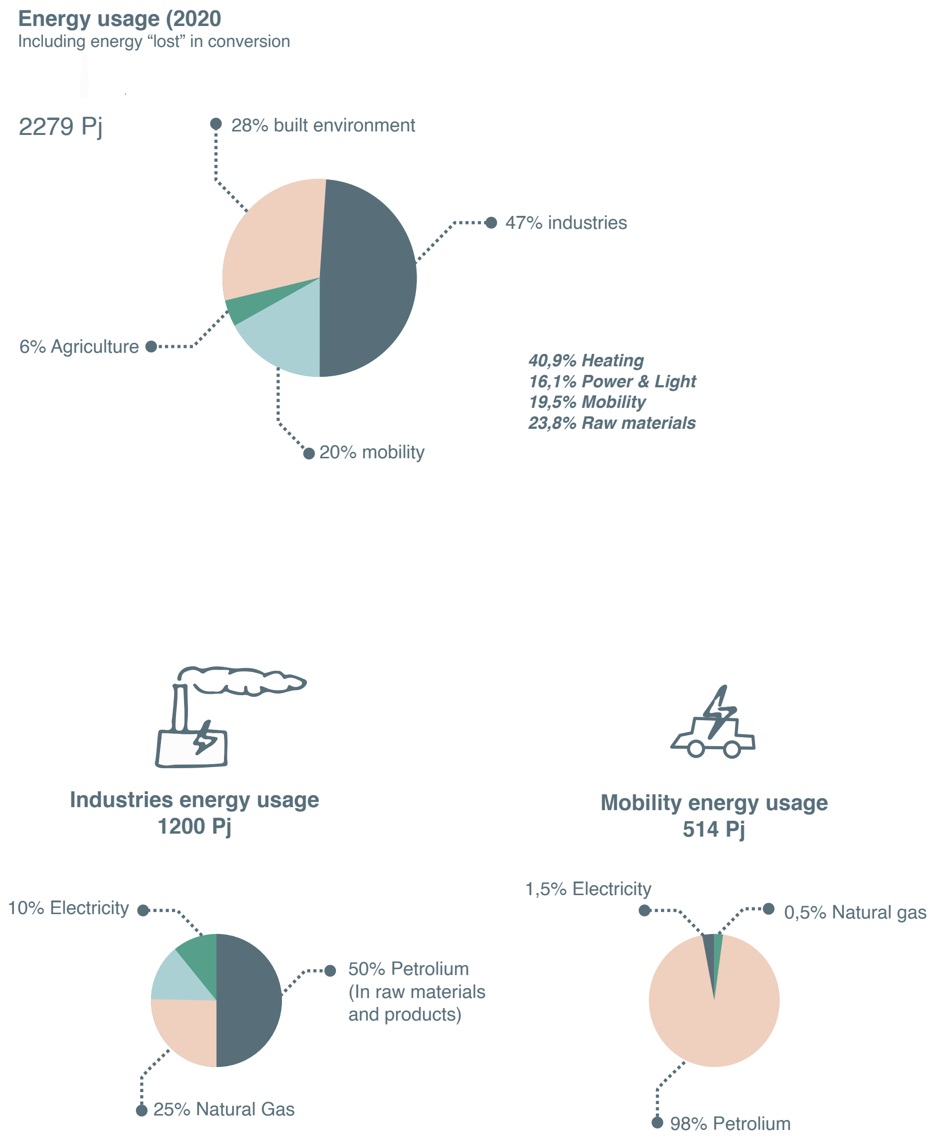


Figure 3: Illustration on energy usage in various sectors (Energie in Nederland, 2022)

2.3 Problem definition - global effects

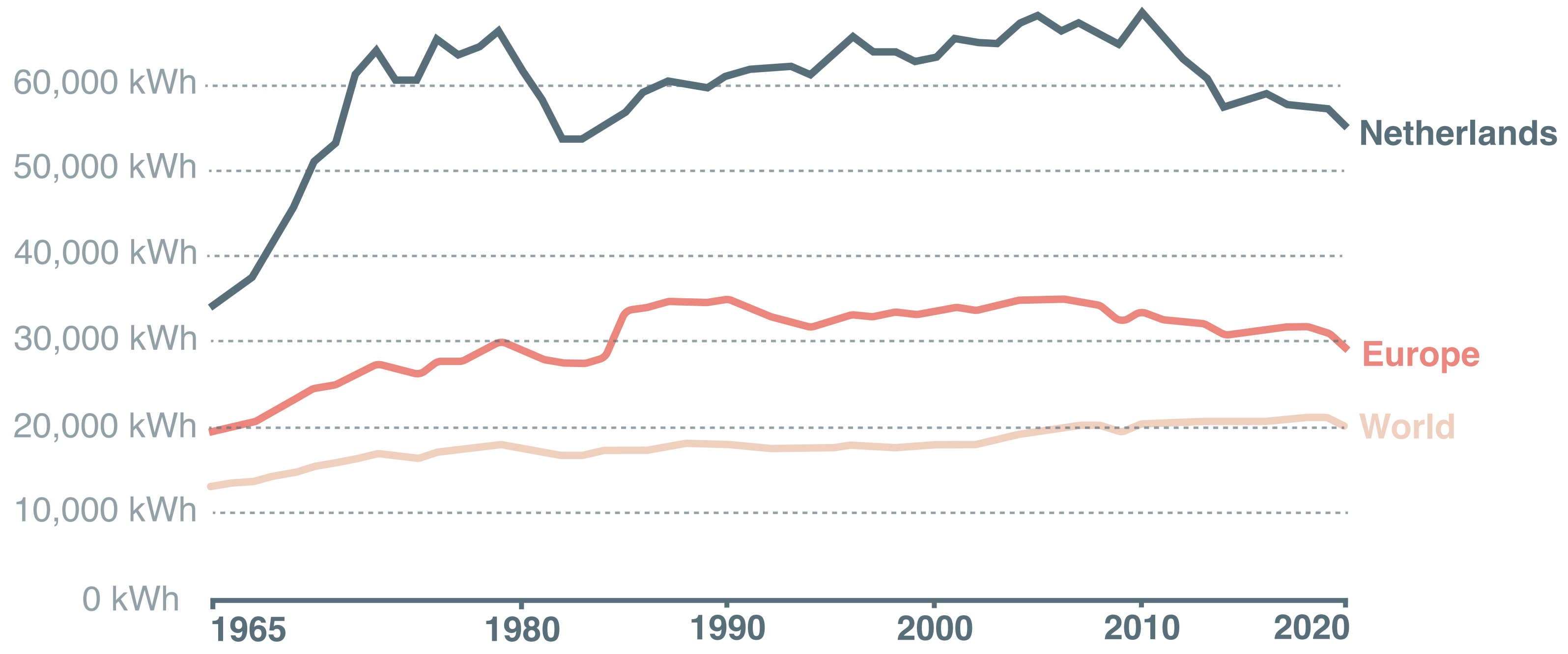


Figure 4: Energy use per person, not only including electricity, but also other areas of consumption including transport, heating and cooking (Our World in Data, 2021).

Various trends and developments within our current energy system provide for the urgency of the transition to a new energy system.

2.3.1 Exploitative usage

Figure 4 shows the energy consumption per person. The figure compares the Netherlands with the average of Europe and the world (Our World in Data, 2021). The European average is already well above the world average (Our World in Data, 2021). The average in the Netherlands is many times higher (Our World in Data, 2021).

Figure 4 shows the energy consumption of electricity and other consumption areas such as transport, heating, and cooking (Our World in Data, 2021).

In the Netherlands, heating is a large share of energy consumption (Energie in Nederland, 2022). Perhaps the Netherlands' climate and living standards may explain why use is higher than in other countries.

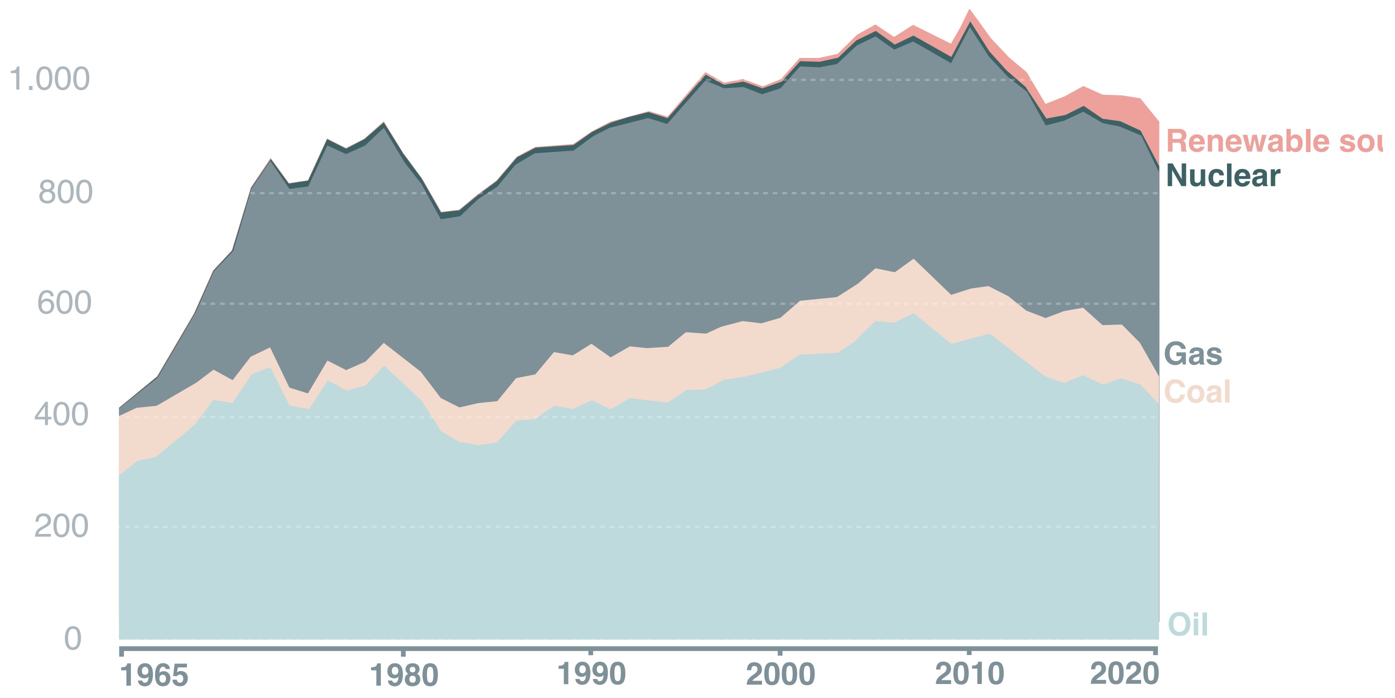


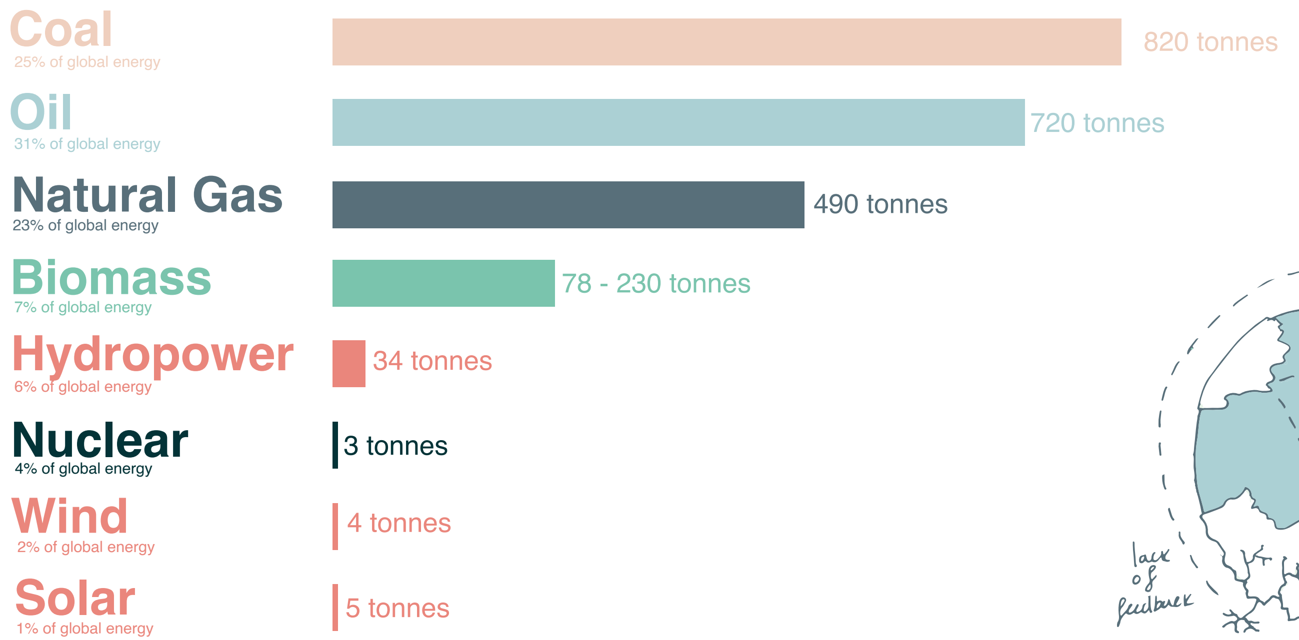
Figure 5: Energy consumption by source, primary energy consumption is measured in terawatt-hours (Our World in Data, 2021).

2.3.2 Fossil fuels

Non-renewable sources are the main source of energy in the Netherlands, as shown in figure 5 (IEA, 2020)(Our World in Data, 2021). Oil and gas are the primary energy sources in the Netherlands (IEA, 2020)(Our World in Data, 2021). The share of renewable fuels is growing.

Nonetheless, it is still an almost negligible part of the total energy share (IEA, 2020)(Our World in Data, 2021). The definition of these non-renewable resources is that they are exhaustible.

The Netherlands is already facing problems with the depletion of resources for indigenous gas production (NAM, 2022) (NOS, 2017). This is further explained on page 15.



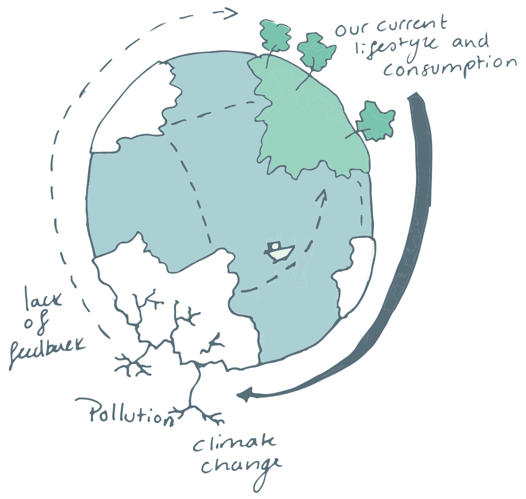


Figure 6: Greenhouse gas emissions per energy source (Our World in Data, 2021)

Figure 7: Simplistic illustration of global consequences of energy consumption

2.3.3 Pollution

Besides the fact that non-renewable resources eventually run out, they also create other problems. For example, polluting sources cause air, water, and soil pollution (Withagen, 1994).

A significant problem is the emission of Co2, which contributes to global warming (Withagen, 1994). As seen in figure 6, the Netherlands mainly uses the top 3 most polluting sources (Our World in Data, 2021).

The consequences of these energy sources extend many times beyond the borders of our country, as seen in figure 7 (Withagen, 1994). In this way, our choices indirectly contribute to major climate problems all over the world. (IEA, 2018).

2.4 Problem analysis - local effects

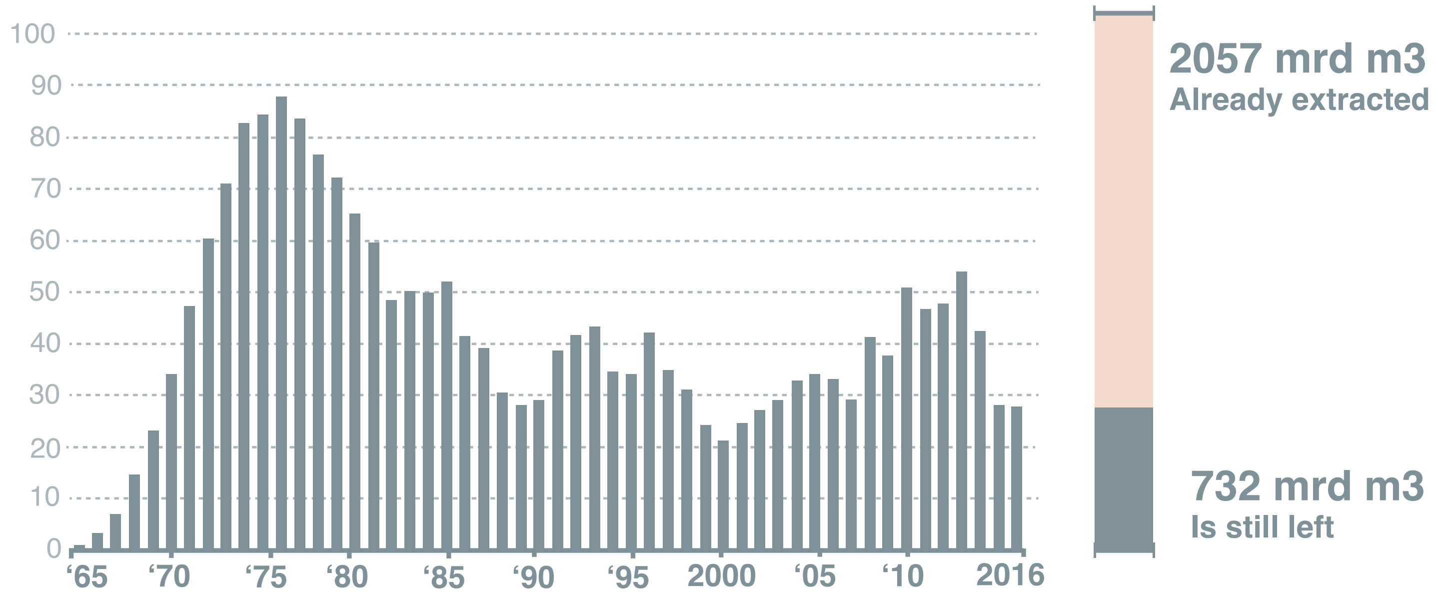


Figure 8: Natural gas extraction, total gas extracted from the Groningen gas field in billions of Nm3 (NAM, 2022) (NOS, 2017).

2.4.1 The gas is running out

Figure 8 shows that the Netherlands has already lost much of its gas supply (NAM, 2022) (NOS, 2017). The Netherlands has already extracted 2057 billion m3 of the gas stock, while 732 billion m3 is still available (NAM, 2022) (NOS, 2017).
The Netherlands has used almost 75% of the available gas (NAM, 2022) (NOS, 2017). Gas was mainly extracted in the 1970s and 1980s, after which gas consumption decreased (NAM, 2022) (NOS, 2017).

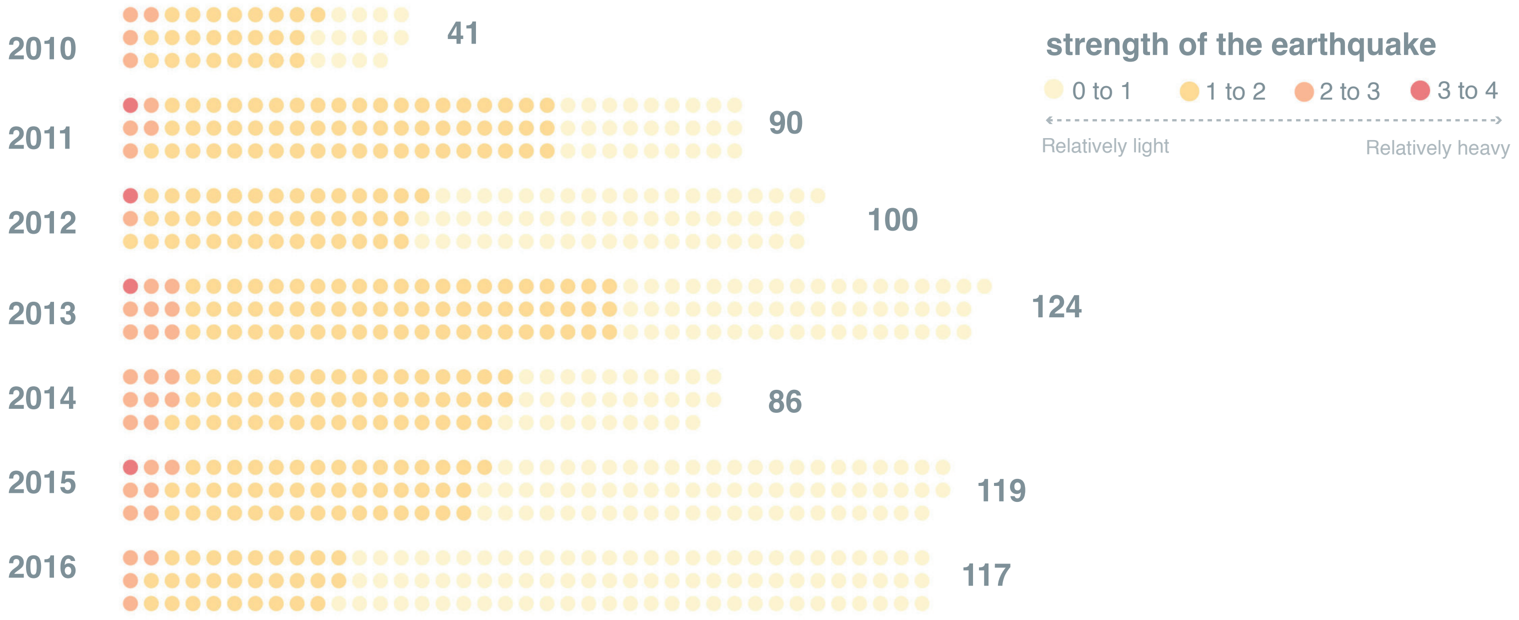


Figure 9: Number of earthquakes in the north of the Netherlands, in and around the province of Groningen as a direct result of natural gas extraction (KNMI, 2020) (NOS, 2017).

2.4.2 Earthquakes due to gas extraction

In addition, gas extraction in the Netherlands also causes significant problems in the immediate vicinity (KNMI, 2020)(NOS, 2017). Most of the extracted gas comes from Groningen and this has caused enormous subsidence and earthquakes in the area, as shown by figure 9 (KNMI, 2020) (NOS, 2017). These earthquakes are increasing in number and severity (NOS, 2017).

2.4.3 Increasingly dependent

The local problems, like the earthquakes, caused a shift in policy (CBS, 2019). The Netherlands produces considerably less gas within its borders (CBS, 2019)(IEA, 2020). Figure 10 shows that the Netherlands is increasingly dependent on energy imports (Statista Research Department, 2022).
Imports create other problems, for example, energy dependence (Statista Research Department, 2022). Energy dependency is closely related to political tensions and creates an insecure position related to our energy security (Ministerie van Algemene Zaken, 2022).

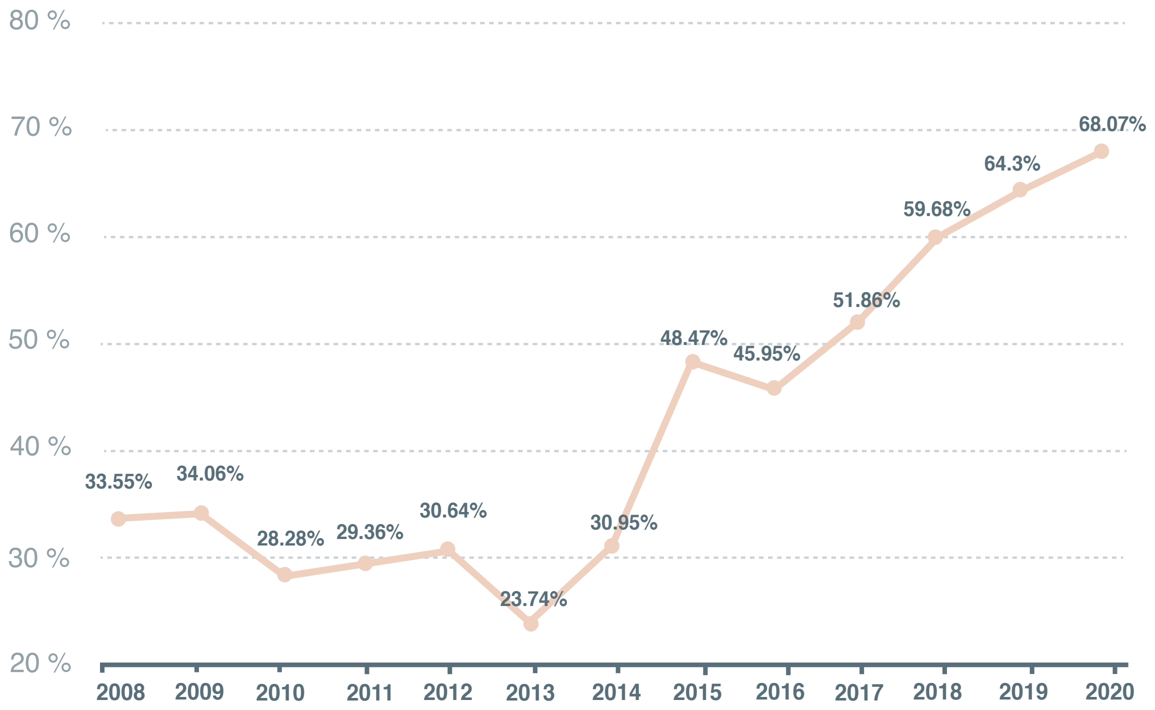


Figure 10: Dependency on Energy Imports in The Netherlands (Statista Research Department, 2022)

The current war in Ukraine made this more than evident. The dependence on Russian gas imports has caused debate (Hensen et al., 2022). The sudden motive accelerated plans to become more energy-independent again (Ministerie van Algemene Zaken, 2022) (Hensen et al., 2022).

On Monday 30th of May, 2022, EU members decided on a Russian oil boycott (Hensen et al., 2022). That same night the Netherlands was cut off from Russian gas (Hensen et al., 2022).

GasTerra is the biggest gas trader in the Netherlands (Het Parool, 2022). Gasterra took a gas stop into account and made new contracts for imports (Het Parool, 2022). Households do not have to notice the stop because of new import contracts and existing gas stocks (Het Parool, 2022). However, it is suddenly abundantly clear to many Dutch people how dependent they are.

2.5 problem statement

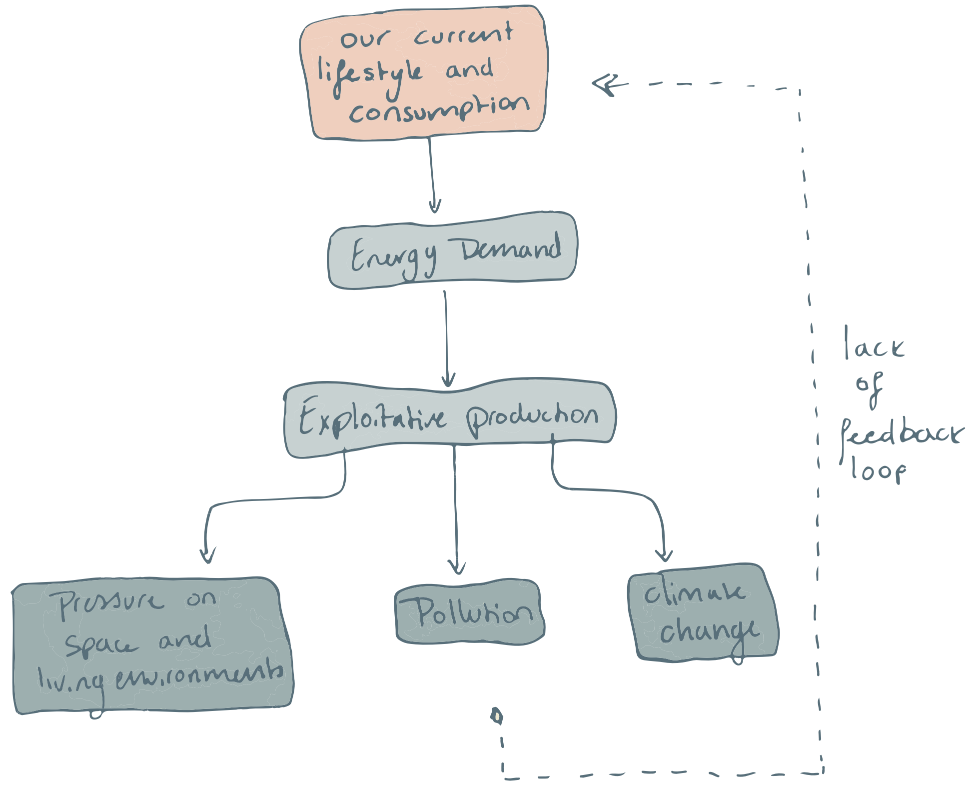


Figure 11: Illustration of problem statement

This chapter showed that Dutch consumers use energy excessively, way above the world average (Our World in Data, 2021). The energy consumed is from fossil fuels, namely oil and gas (IEA, 2020)(Our World in Data, 2021). Fossil fuels are among the most Co2 emitting energy sources (Our World in Data, 2021). Fossil fuels contribute to pollution and climate change (Withagen, 1994). On top of that, the consequences extend beyond a country's borders. For example, the energy used in the Netherlands affects the climate on the other side of the world, where the inhabitants of the Netherlands are not affected by it (PBL, 2020) (IEA, 2018).

The domestic extraction of natural gas causes problems (KNMI, 2020) (NOS, 2017). KNMI measures an increasing amount of earthquakes in Groningen (KNMI, 2020) (NOS, 2017). The earthquakes cause much damage, making the local population revolt (NOS, 2017). Furthermore, 75% of the available gas has already been used (NAM, 2022) (NOS, 2017). The natural gas fields are the only primary energy source in the Netherlands.
As a result, the Netherlands has to fall back on importing fossil fuels from other countries, such as Russia (Ministerie van Algemene Zaken, 2022)(Hensen et al., 2022). With a drop in energy security due to political tensions (Ministerie van Algemene Zaken, 2022). As mentioned before, the current war in Ukraine is affecting our energy security (Ministerie van Algemene Zaken, 2022) (Hensen et al., 2022). It shows that our current energy consumption causes a multitude of problems. Our lifestyle and form of consumption maintain this system (Our World in Data, 2021).

The consequences of our energy system are namely; pollution, pressure on space, and climate change (NAM, 2022) (NOS, 2017) (Withagen, 1994). These examples often take place out of sight. Most people in the Netherlands do not experience the direct adverse effects of the energy system that they do benefit from (PBL, 2020). Consumers transfer the burden to others, without having to think of it themselves. It is essential to look for alternative production methods and sustainable consumption methods to change the system. The whole system has to adapt, and thus so do we.

In short, this shows that our uninhibited energy consumption forces exploitative energy production to meet our demand. It leads to pressure on space, pollution, and climate change and shows a lost connection between us and our energy landscape.

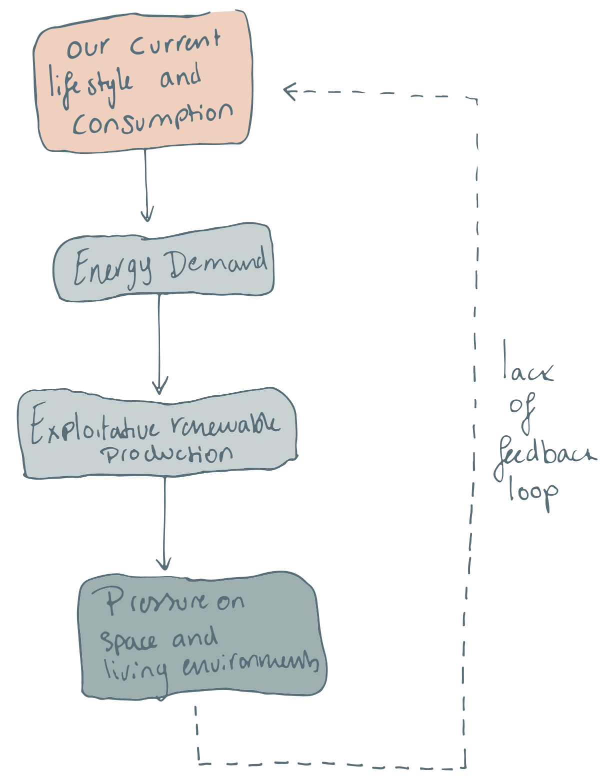


Figure 12: Simplistic illustration of problem statement of energy system of renewable energy

Figure 12 shows that the current attitude toward renewable energy reflects the same problems as that of our, now fossil fuel dominated, energy system. There is a lack of realization that the consumption and the entire system needs to be adjusted. The current energy transition plans only replace the generation method with a sustainable variant.

The plans will solve climate problems (Our World in Data, 2021). Yet, the pressure on space will increase (Sijmons et al., 2014). The current location of wind turbines shows this pressure on space. Wind parks are placed as far away as possible from large-scale civilizations (Windstats, 2022).

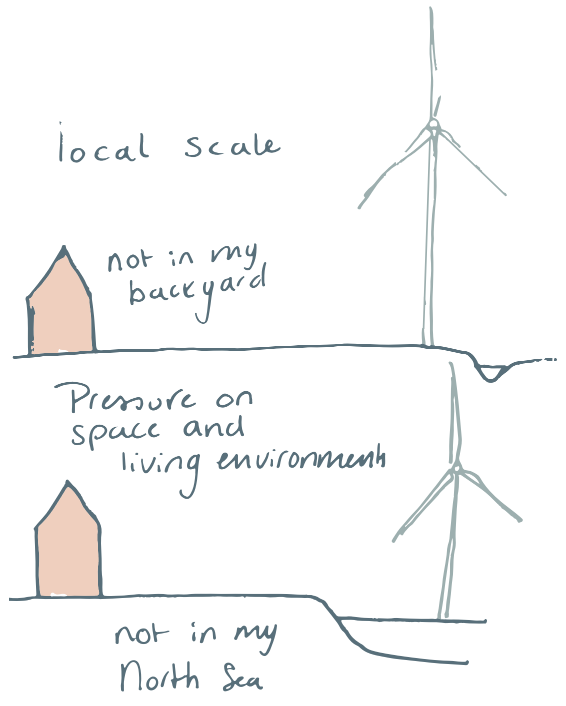


Figure 13: Simplistic illustration of not in my backyard effect

The locals, people who live close to these wind farms, are protesting, as illustrated in figure 13 (NOS, 2021). The examples show that there is still pressure on space and that only transitioning to renewable energy does not solve the problems with the entire system.

3. Methods

The problem statement is further explored and defined in this research. Different methods contribute to understanding the problem and formulating the possibilities. This chapter details which methods are used and why. It shows the purpose of the research, the questions, and the approach.

Picture: 2: Wind turbines in spain
Image Credit: Public domain (CC0 1.0) https://www.ispionline.it/it/pubblicazione/path-towards-green-spain-36774

3.1 Research framework

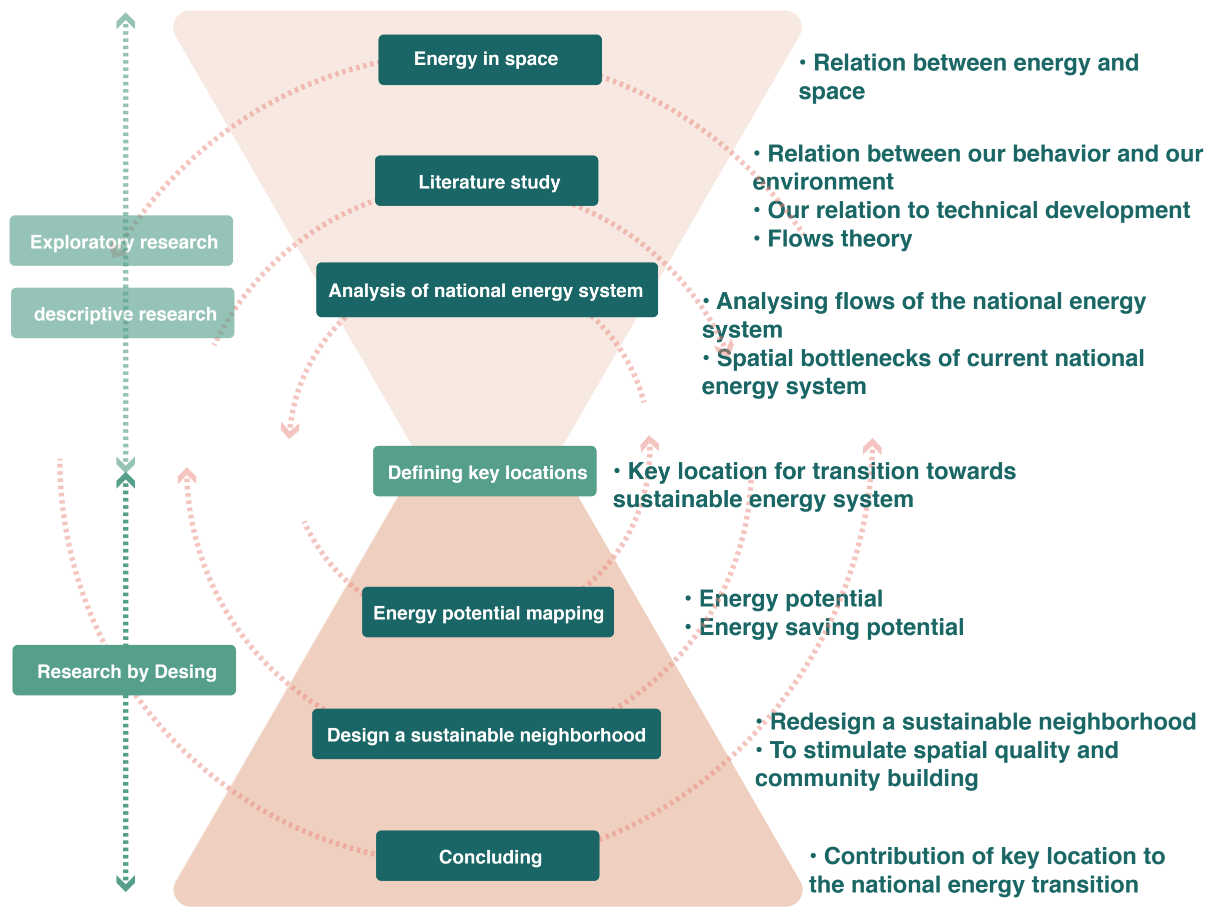


Figure 14: Scheme of research framework

The research approach

The research starts with exploratory and descriptive research, as defined by Breen (2019). Descriptive research assists in studying the state of the current energy system. It examines, through data and literature, what the problems are and what the relationship is between space and energy. In addition to defining and describing these phenomena, exploratory research helps to gain insight into why our energy system works the way it does. Exploratory studies help understand how the current energy system originated, how our behaviour contributes to the current system, and why it is difficult to change it.

Key locations arise through exploratory and descriptive research. These are important places in the system that inspire possibilities for transition.

From that point on, the research progresses in different stages of the research by design study, shown in figure 14, according to Roggema's (2017) definition of research by design. The first phase is the analyzing phase, the pre-design research. In this phase the spatial challenges and possibilities of the critical location are defined. In the second fase we formulate goals to answer the challenges stated in the analysis. After defining these goals, possibilities develop into concrete, spatial proposals.

3.2 Conceptual framework

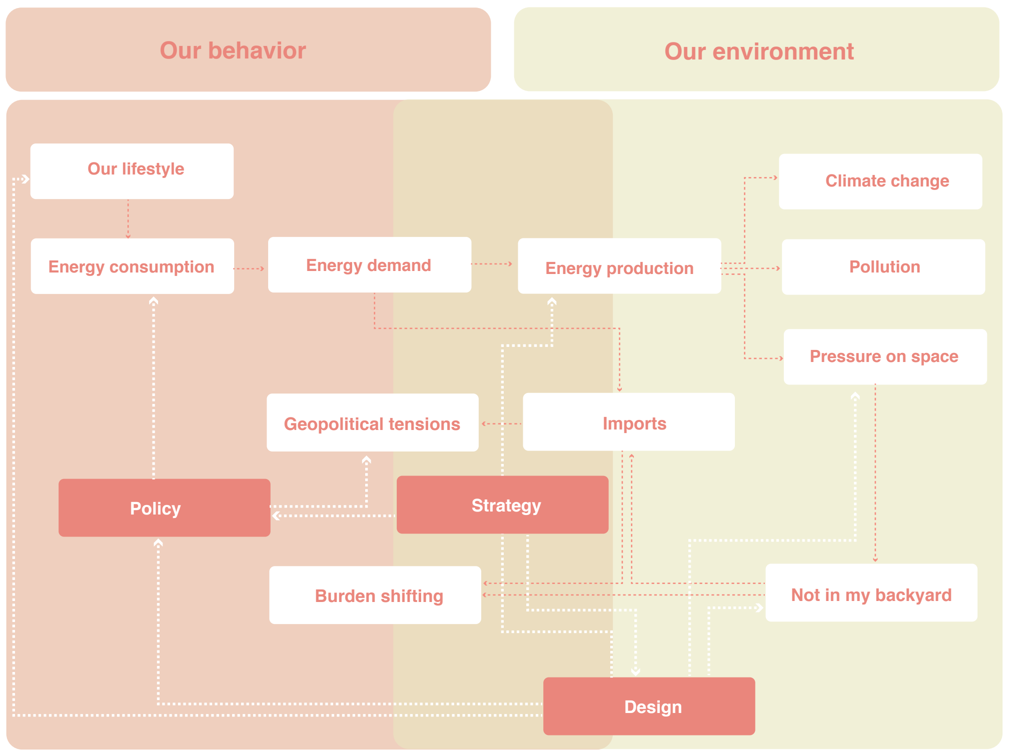


Figure 15: Scheme of conceptual framework

In the third phase, synthesis, communication takes place. In this phase spatial proposals are presented in a synthesized form. This form makes it able to show the coherence between consistency, reasoning and probability

At the start of the research, the locations are not yet specific. More specificity will arise through theoretical and spatial analysis. Objectives may be adapted for locations where severe problems are found.

The conceptual framework

The processes within the energy system are within the interplay between our behaviour and our living environment. Figure 15 shows that the problem statement explains how our behaviour and attitude toward energy consumption lead to various problems. The conceptual framework shows the steps that occur in this process. It also shows that this research moves in different places within this interaction. The design plays into the physical environment. The design intends to answer the pressure on space by influencing our lifestyle, among other things. Policy will help as an instrument for impacting behaviour differently.

3.3 Research question

The research design shows the sub-questions that help to answer the main research question. It also shows the instruments and methods on how to answer these sub-questions.

Research question:

What are the potentials of the shift towards a decentralised energy system to facilitate a sustainable neighbourhood design while stimulating community spirit in the context of the national energy transition?

Subquestions

- Where do the flows of the current national energy system create spatial bottlenecks, and what are the key locations for transition within the national energy system?
- What is the energy potential of a critical location, and what is the spatial impact of harvesting them?
- How can people be encouraged to make a shift in their behaviour to live more sustainably and therefore contribute to community building?
- How can we redesign a critical location that stimulates spatial quality and community spirit?
- Can this redesign contribute to the national energy transition?

3.4 Research design

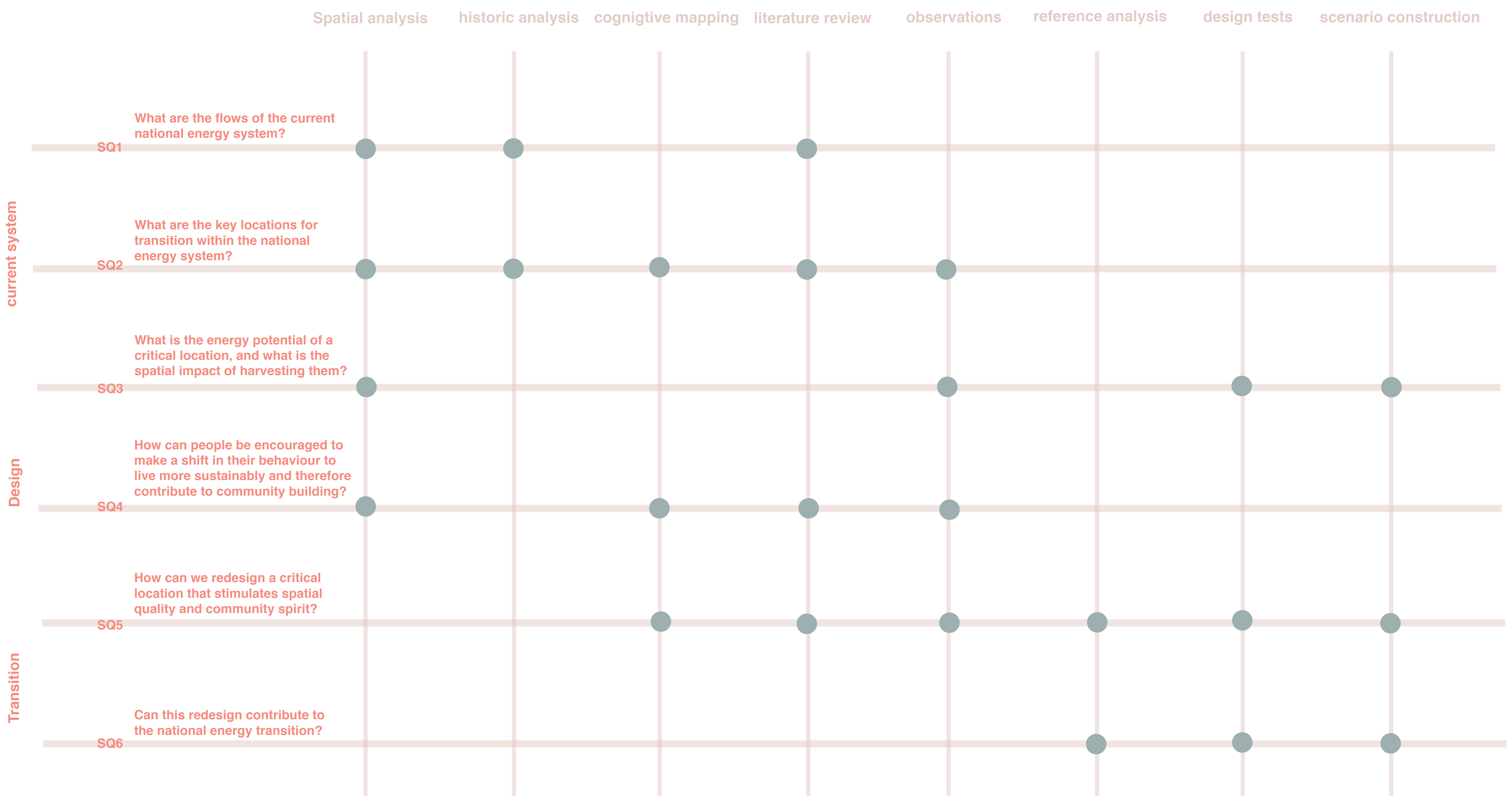


Figure 16: Scheme of research design

4. Theory

The theory is an essential building block in this research, and this chapter discusses the theory to gain a better understanding of human behaviour. Why we form certain habits and why we struggle with change. In addition, urban metabolism is discussed, what it entails and how it can be studied. Moreover, our relation to technological progress and how this relates to other systems on the earth is shown.

Picture: 3: Windmills in the Netherlands, Creative Commons Zero - CC0

4.1 How our behaviour shapes our energy landscape
The environmental psychology

"Behaviour can affect our environment. Human behaviour can protect or destroy the environmental conditions and resources that support life on earth."

The handbook of environmental psychology by Bechtel and Churchman (2003) defines environmental psychology as the study of how our environment shapes us and our behaviour. The opposite is equally valid. Behaviour is a variable like sound, smell, and the physical environment. This chapter discusses ways to encourage pro-environmental behaviour and why people struggle with change.

Behavioural change

To begin with, Bechtel and Churchman (2003) state that there are two ways of behavioural change: Curtailment behaviours and efficiency behaviours. Curtailment behaviours focus on reducing consumption. It includes, for example, carpooling or taking a shorter shower. These are actions that mainly concern individual behaviour. On the other hand, efficiency behaviours lead to the reduction of resource consumption of equipment and machinery. It means buying an energy-efficient product. The responsibility here lies more with the producer.

The difference here is that curtailment behaviours often require the repeated execution of an inconvenient action, while efficiency behaviours require a one-time purchase. Placing the responsibility on the industry for making the processes more energy-efficient can yield more results than focusing on individual behaviour and its adaptation.

To be successful in creating a long-term effect.

Bechtel and Churchman (2003) mention essential factors in this:

- Every level of the organization must support a change by understanding the rationale behind the intervention.
- Indigenous staff must be able to provide input in the design and put a formal accountability system in place.
- The intervention should be reviewed constantly for continuous improvement.
- There should be group and individual rewards.

Three basic principles for designing a procedure

Discussed by Bechtel and Churchman (2003):
The first principle is the focus of the intervention on observable behaviour. It means to target specifically chosen behaviours. In addition, it is necessary to observe what people do and why they do it. Finally, it allows the intervention's applicability to the research and analysis of existing behaviour.

The second principle is looking at how external factors can improve performance. People's instinctive movements and attitudes are difficult to measure. External factors, on the other hand, can also significantly impact behaviour and are measurable, such as reward and punishment, policy, and supervisory behaviour.
The third principle is that it is crucial to focus on positive consequences and not negative ones to motivate people toward the desired behaviour. The most powerful motivating factors are "soon" and "certain". It means that people are more likely to do something if they quickly see and are sure of the effect. The effect of fossil fuels is fast, and the convenience is certain and significant. As a result, there is an enormous incentive for its use. In addition, we learn more from our successes than from our mistakes.

The DO IT process

To successfully implement an intervention, Bechtel and Churchman (2003) propose the DO IT process.
Here "D" stands for Define. Thus, it is essential to define the target behaviours for the intervention as a first step.
"O" stands for observing. Observe how and how often the target behaviours occur in a natural environment and conditions.
The "I" stands for intervention. This phase implements the designed intervention. It is essential here that the focus is on adapting to external conditions and that the adjustment is soon, certain and sizable. And with a focus on positive feedback. It makes it easier for people to learn new behaviours. The research shows that people often revert to their original behaviour when the positive feedback stimuli stop.
"T" is testing to gather information to refine or change the intervention if this does not result in the desired behaviour.

The goal of behavioural change

The goal of behavioural change is for people to go from unconsciously incompetent, a bad habit someone does not realise the effect of, to consciously incompetent. It means that people realise that their behaviour has adverse effects. From this, people can consciously become competent by adjusting their behaviour and continuing to pay attention to it. The goal is that this creates a positive habit in the long run.

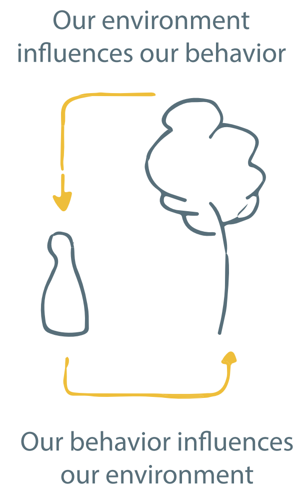


Figure 17: Illustration behaviour and environment

Figure 18: Illustration of decision making dependant on certainty and timespan

Reactions to change

People do not tolerate change well (Sijmons & van Dorst, 2014). Wherever there are plans to install wind turbines, there are also residents who are against this (NOS, 2021). These residents' objections are often related to health (Sijmons & van Dorst, 2014). The symptoms people often mention are; headache, sleep problems, tinnitus, concentration and memory loss, dizziness, and nausea (Sijmons & van Dorst, 2014). These symptoms are self-diagnosed (Sijmons & van Dorst, 2014). However, there has never been a proven link between wind turbines and our physical health (Sijmons & van Dorst, 2014).

Sijmons & van Dorst (2014) state the often-mentioned causes of these reported symptoms:

- The noise is between 24 and 54 dB. In comparison, normal background noise is already 30 dB.
- Nonetheless, the perceived noise of the wind turbine sounds louder at night because there is less ambient noise.
- In the visual aspect, people consider a wind turbine more disruptive in an environment with more contrast. Additionally, the size of the windmill in comparison to its environment is also essential.
- The stroboscopic effect occurs when the sun shines through the blades of the wind turbine, and the blades block the light at a low frequency. It has no immediate health risk. Nevertheless, indirectly it can be distracting for drivers in traffic.
- Windmills can also cause stress through infrasound.

Self-reported symptoms

People notice these symptoms in themselves, without a scientific reason for this, because people like to have a predictable environment (Sijmons & van Dorst, 2014). A pleasant living environment is known and identifiable, but to some extent, also mysterious and surprising (Sijmons & van Dorst, 2014). But this is a balance that is disturbed by wind turbines (Sijmons & van Dorst, 2014). It is not the first time in history that a new invention or application has confused this balance (Sijmons & van Dorst, 2014). It also happened with the invention of the train, television, PC, and high-rise buildings (Sijmons & van Dorst, 2014). People noticed several physical phenomena with all of these developments (Sijmons & van Dorst, 2014).

In addition, it is essential to note that even though these symptoms were not proven to be a direct result of these developments (Sijmons & van Dorst, 2014). That does not mean these symptoms are fake (Sijmons & van Dorst, 2014). The stress-induced symptoms are real and may disappear after a period of habitation (Sijmons & van Dorst, 2014).

Figure 19: Illustration on identification with surrounding environment

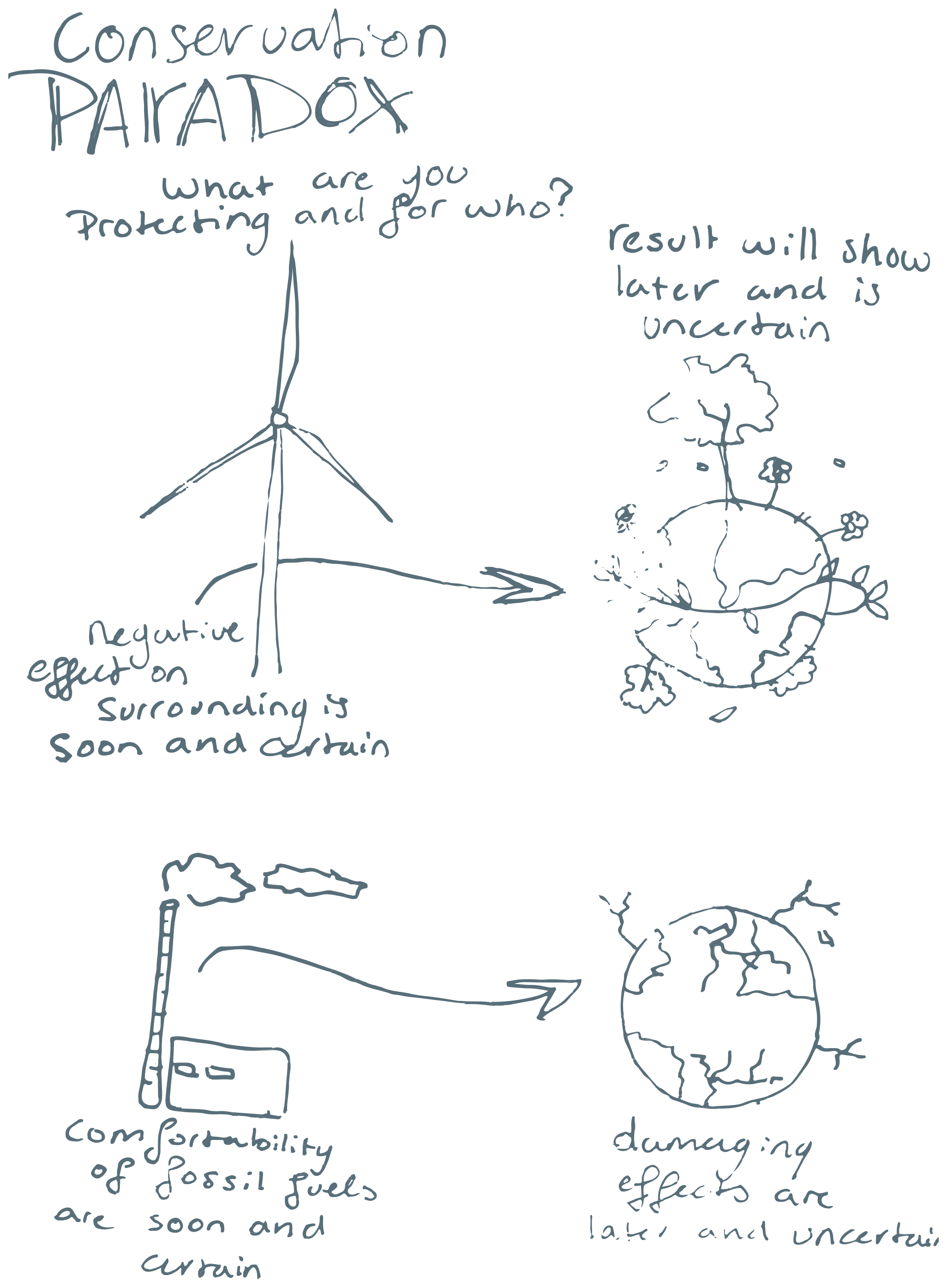


Figure 20: Illustration of conservation paradox

Why do these developments stress people?

It is because changes conflict with our identity (Sijmons & van Dorst, 2014). Our identity is shaped by, among other things, our perception of the world around us (Sijmons & van Dorst, 2014). When our perception of the world changes, so does our identity. People want to protect our perception of their identity and consequently like to keep our environment as it is (Sijmons & van Dorst, 2014). It is, therefore, crucial in the discussion about the energy transition to understand that they are not rational but rather emotional motives (Sijmons & van Dorst, 2014).

Another reason for the fuss about change is that we as a society are used to drawing up a balance (Sijmons & van Dorst, 2014). A balance of benefits and costs, disadvantages and advantages (Sijmons & van Dorst, 2014). An example of a disadvantage could be the fall in house prices after installing wind turbine parks (Sijmons & van Dorst, 2014). The problem is that the wind turbines certainly provide advantages; only the residents do not notice this immediately (Sijmons & van Dorst, 2014). As a result, the ratio of costs and profits is out of balance for residents (Sijmons & van Dorst, 2014). Research has shown that if this ratio is the other way around and there are more advantages than disadvantages for residents, they favor development (Sijmons & van Dorst, 2014).

Another trend is the aestheticization of our worldview (Sijmons & van Dorst, 2014), a trend in which people prioritize the importance of beauty and pleasantness in their lives (Sijmons & van Dorst, 2014). Dirty work is no longer in sight (Sijmons & van Dorst, 2014). Most fossil sources are not visible, and the wind turbine, on the other hand, is very visual (Sijmons & van Dorst, 2014).

4.2 Urban metabolism

When analyzing the energy system, it is necessary to look at the flows. But what exactly are flows, and how are they managed? This research defines and analyses urban metabolism based on the description by Furlan et al. (2020). The following paragraphs explain Furlan's description of urban metabolism and how this applies to this research.

A flow is part of a system; this system is not boxed but can exist at different scales. This system has inputs and outputs, and these can be measured. It creates a quantitative value and makes the system measurable. A flow suggests a movement of goods, energy, or other values. As a result, It suggests a place of departure, arrival, direction, and quantity. The flows constitute the metabolism of a system in a city, environment, or even of the earth. The following questions help to understand the energy system; where the energy comes from, and what is this energy? How is this processed and ultimately ends up with the user? For example, places of storage and processing are essential here because they are switching points in an energy flow.

Nevertheless, a flow is more than just a movement of goods. It has several dimensions that play a role in the character of this flow. They are thus essential to research and understanding.

Figure 21: Simplistic illustration of flows on national scale

The spatial dimension

It is essential to take into account the physical nature of a flow. It means the movement of an energy flow and what it looks like in the landscape. For example, the physical characteristics of a pipeline are very different from a high-voltage pylon. Both have different influences and abilities.

The time dimension

The flows also go through the time dimension, which is essential to understand the system. The dimension of time is about the timespan of a flow and how a flow can change over time. In the energy system, this can be about the storage of energy. Energy is not always needed somewhere at the time of generation, and the dimension of time plays a significant role in this. Preserving energy in one place for a certain period is an issue in the energy transition. It can also be about constantly adjusting flows of imports and exports depending on supply, demand, and geopolitical considerations.

The quality dimension

Not every flow is of the same quality, even when it comes to the same form of flow. With the gas system, it is vital to understand the difference in gas types. Where they come from and where they are going. The quality of the gas has determined the entire gas infrastructure. Moreover, flows of other qualities of gas must transform to connect to the existing infrastructure and built environment.

Figure 22: Simplistic illustration of spheres on earth

4.3 A mutualistic relationship

A mutualistic relationship between our society and our energy landscapes. What does this mean?

A mutualistic relationship is an understanding where both parties benefit from the interaction, so a beneficial relationship (Boucher, 1985). It does not mean that there are only profits on both sides (Boucher, 1985). There are still disadvantages (Boucher, 1985). However, the profits outway the costs on both sides (Boucher, 1985).

In the case of our energy landscape, this is more convoluted because several systems and elements play a role here. Parts of the energy landscape consist within different systems. The energy landscape consists of energy expressions, the land, and the human being (the observer) (Appendix 5).

Land can mean the lithosphere, biosphere, atmosphere, and hydrosphere (Haff, 2014). The land is the physical soil, the plants that grow there, the water that runs through it, and the air that nourishes it (Haff, 2014).
Man and energy exploitation are part of the technosphere (Haff, 2014). The technosphere is the new paradigm in which the processing of fossil fuels in all processes of industrial production, transport and communication systems, and others is a separate system (Haff, 2014). It is a standalone system in which people are no more than a part (Haff, 2014). A facilitating component but not, as people like to think, a guiding component (Haff, 2014).

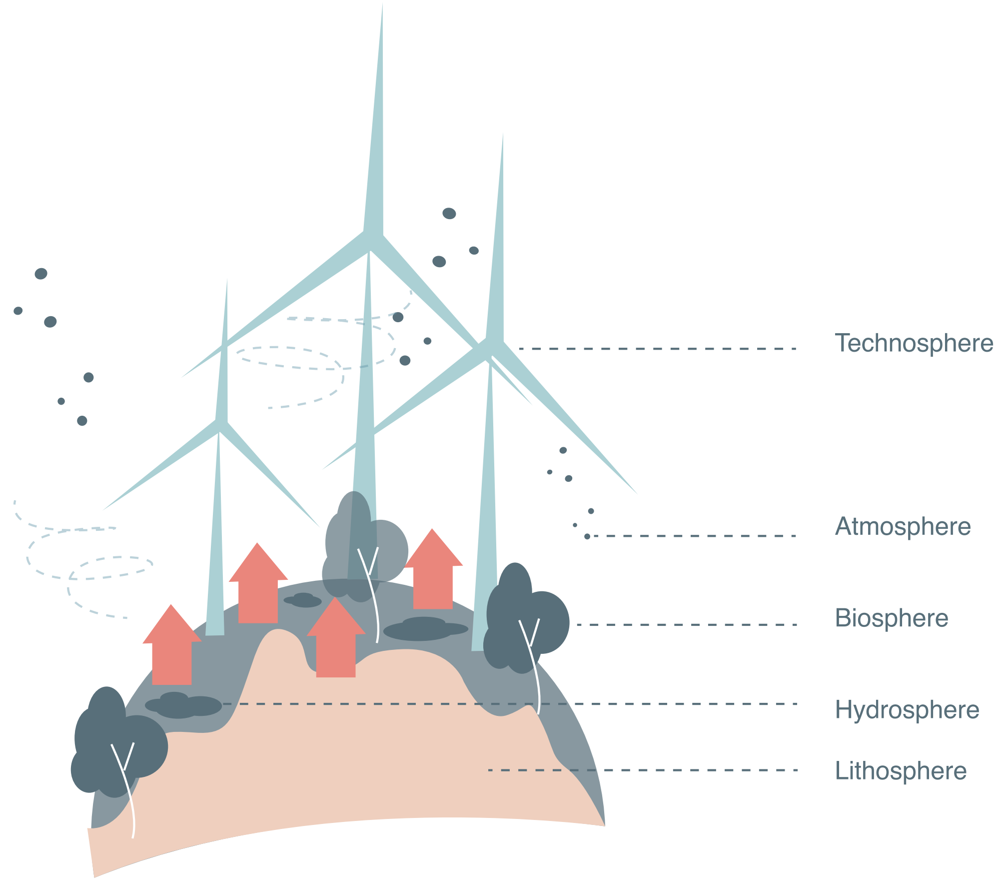


Figure 24: Simplistic illustration of spheres on earth

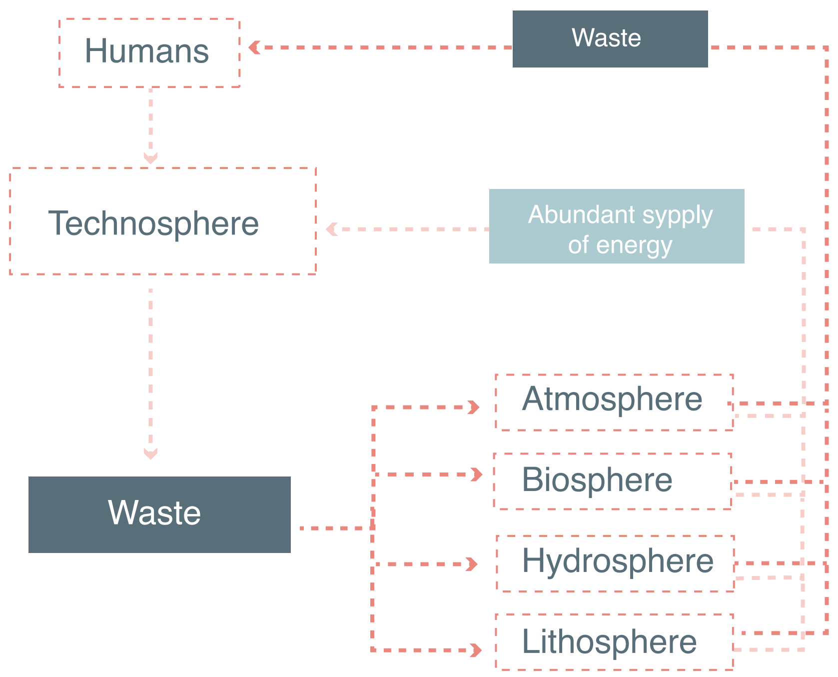


Figure 25: Simplistic scheme of current relationship between technosphere and other spheres

The problem with the technosphere is that it is not a stable circular system (Haff, 2014). It is no exception in the earth's history (Haff, 2014). The biosphere has also had to learn to become stable through decades of errors (Haff, 2014). The waste produced by the technosphere contaminates the other spheres due to, for example, air pollution and soil pollution (Haff, 2014). At the same time, these are also necessary spheres for the operation of the technosphere, and as a result, it is not a stable system and works itself into the abyss (Haff, 2014).
The diagram shows that a mutualistic relationship already exists between the technospheres and humans at this point. Both benefit from each other in the process and can exist without each other (Haff, 2014). Man cannot do without his devised systems, from transportation to bureaucracy (Haff, 2014). Moreover, these systems of the technosphere cannot exist without humans either (Haff, 2014).
To turn the current unstable wasteful system into a stable, sustainable system, there should be a mutualistic relationship between the technosphere and the other spheres. There is currently a link but not a mutualistic one. It only consists of waste, with which we pollute the other spheres. The question is, accordingly, how this link can be used instead of wasted. In a way, this is beneficial to the other spheres.

How can the parasitic relationship between energy production and the other spheres change into a circular sustainable relationship that benefits both?

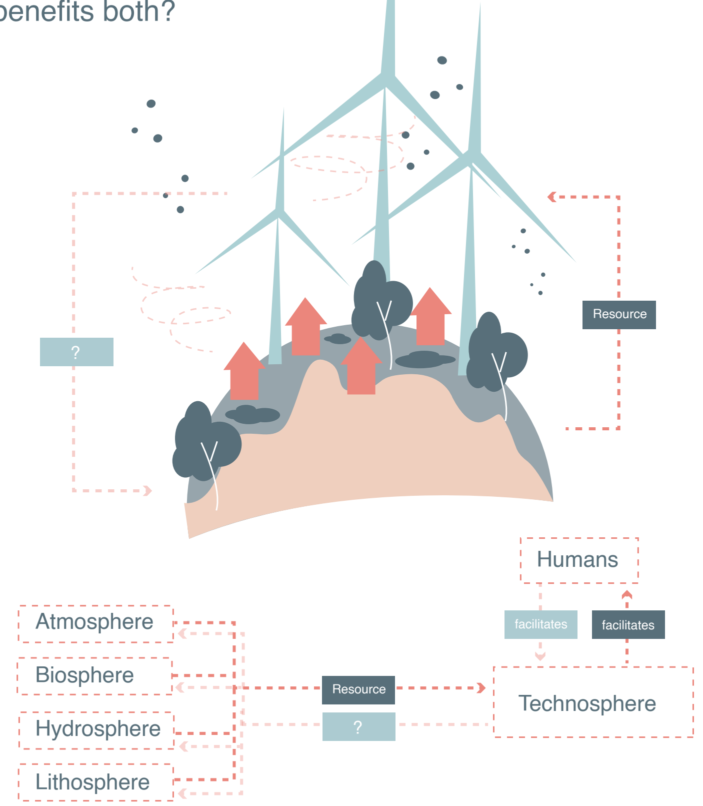


Figure 26: Simplistic scheme of desired mutualistic relationship between technosphere and other spheres

5. Energy in space

The relationship between energy and space is large and important. This chapter details how this has turned out throughout history. What are the current effects of this on our landscape. After this, the spatial impact of various sustainable energy sources is discussed.

Picture: 4: Gerry Machen,
https://www.flickr.com/photos/gellscom/9460755014

5.1 Energy in history

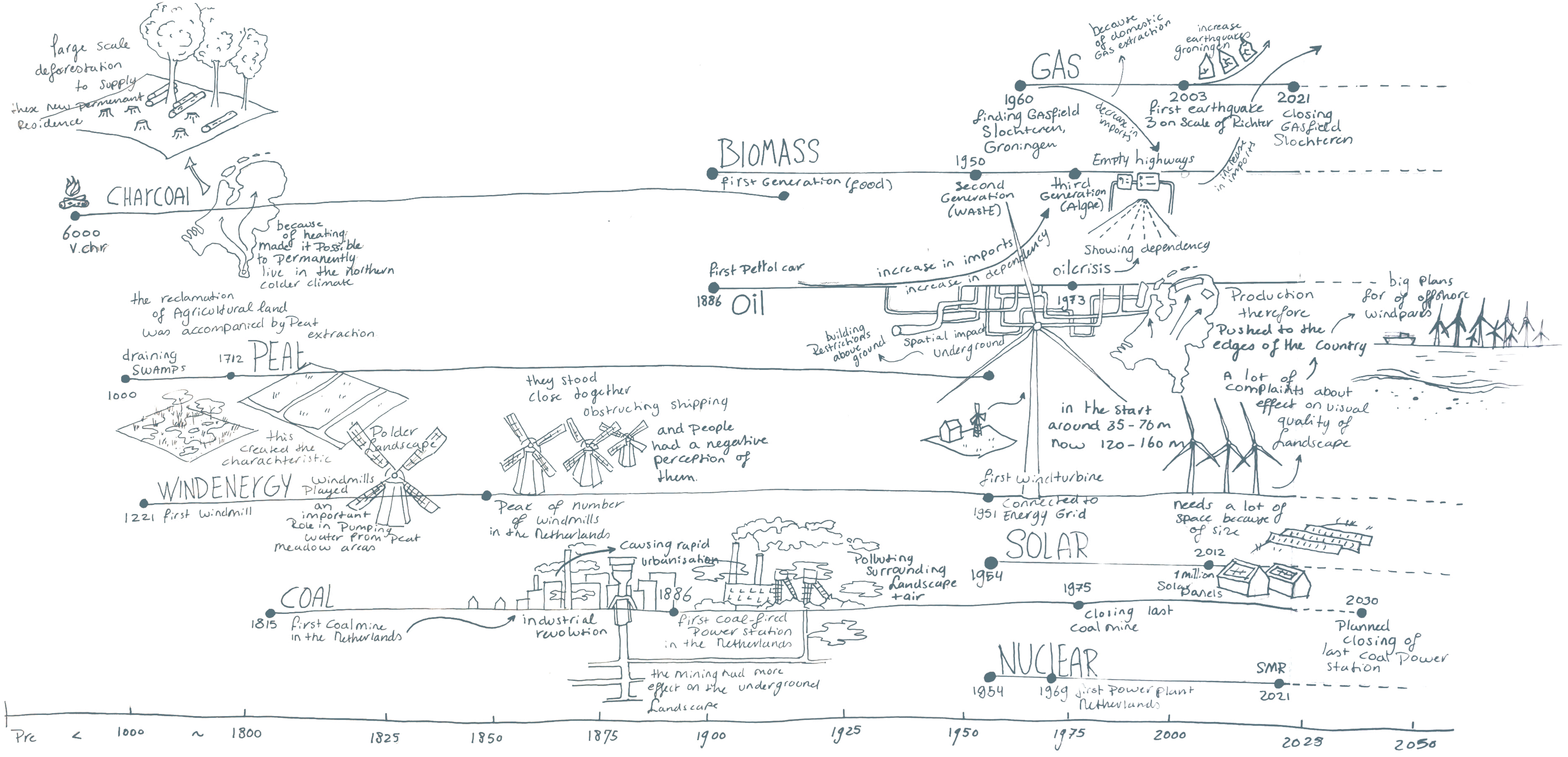


Figure 27: Timeline of energy resources in space throughout history

This chapter details the relationship between energy and space throughout history. It outlines the different ways of generating energy in a timeline and concludes what effect these energy sources had on the Dutch landscape, society, settlements, and infrastructure. Finally, this chapter also discusses the public perception of different energy sources.

Burning wood

For much of human history, fire sufficed as the sole energy source. Hunters and gatherers provided heat, light, and food preparation through burning wood (Toekomstatelier NL2100, 2022). The control of fire had significant effects on the Dutch landscape (Toekomstatelier NL2100, 2022). The Netherlands was not permanently inhabited before because of the cold climate (PBL, 2003). People settled permanently in the Netherlands around 4400 BC (PBL, 2003). Much wood, the primary energy source, was needed to meet the energy supply of these new permanent settlements (PBL, 2003). Large-scale deforestation in the Netherlands was the result (PBL, 2003). It shows the principle of the relationship between energy usage and its effects on the landscape (Toekomstatelier NL2100, 2022). Throughout this time, there was friction between using wood as an energy supply and a food supply (PBL, 2003). The forests were necessary to provide the settlements with energy; the same forests also had to be cut down for agricultural land (PBL, 2003). As a result, agricultural development at a certain point reached a flat and stagnation (PBL, 2003).

Settlements could not develop further without having more energy, and other sources of energy production were invented (PBL, 2003).

Peat extraction

Around 1000, the Netherlands started a large-scale landscape intervention, the reclamation. The peat soils were drained (PBL, 2003). Around 1712, early settlers discovered that the extracted peat could function as fuel (PBL, 2003). It resulted in large-scale peat extraction, starting with low moors and later with raised moors (PBL, 2003). Eventually, it created the characteristic polder landscape in the Netherlands (PBL, 2003). The reclaimed polders were cultivated, affecting settlements and infrastructure (PBL, 2003). It is how "lintdorpen" (ribbon villages) were created (PBL, 2003). They are linear structures that arose organically along a dike, road, or canal. The Dutch landscape still consists of these structures in many places (PBL, 2003). Again, it confirms this relationship between energy and land use.

Wind energy

Wind energy has a long history in the Dutch landscape. The first windmill was built in 1221 (Toekomstatelier NL2100, 2022). Furthermore, these windmills were especially important in the Netherlands for draining peat landscapes (PBL, 2003)(Toekomstatelier NL2100, 2022). Windmills had an indirect role in energy production but significantly affected the landscape (PBL, 2003). They mainly helped with the grinding of grain (PBL, 2003). Public opinion was not too enthusiastic about the windmills in the Dutch landscape (PBL, 2003). Wind energy was reintroduced into energy production in the era of sustainability by wind turbines (PBL, 2003)(Toekomstatelier NL2100, 2022). In 1951 the first wind turbine was connected to the energy grid. Over the years, wind turbines have grown in length and number (Kuijers et al., 2018). The first wind turbines were around 35 meters in size, and now they are between 120 and 160 meters (Kuijers et al., 2018). There is much resistance to the projects of these wind farms (NOS, 2021). Many think it pollutes the horizon and ruins the landscape and the view (NOS, 2021). As a result, most projects take place far from inhabited civilizations and, to a large extent, at sea (Windstats, 2022).

Coal mines

In 1815 the first coal mine in the Netherlands was opened (PBL, 2003)(Toekomstatelier NL2100, 2022). The introduction of coal and the invention of the steam engine ushered in a new era, the era of the industrial revolution, and accelerated urbanization (PBL, 2003). The first coal-fired power station opened in the Netherlands in 1886 (Toekomstatelier NL2100, 2022). Coal mining had a relatively minor landscape contribution, but its indirect consequences, on the other hand, have been enormous for the development of the Dutch landscape (PBL, 2003). The effect of the coal mines mainly took place underground, so the landscape effects were many times smaller than those of peat extraction (PBL, 2003). It did affect infrastructure projects, for example, the transport of coal extracted from Limburg (PBL, 2003). New canals were excavated, and new railway connections were built, which has led to subsidence of 8 meters in some places (PBL, 2003). The coal-fired power stations pollute the area's air and soil (PBL, 2003). It became a more significant problem over time as usage increased (PBL, 2003). As a result, cleaner alternatives became more popular later on (PBL, 2003). The last coal mine in the Netherlands was closed in 1975, and the government plans to close the last coal-fired power station in 2030 (PBL, 2003).

Oil

In 1886 the first petrol car was introduced and with it a new energy source of oil (Toekomstatelier NL2100, 2022). The Netherlands imported oil and did not extract it on own land (PBL, 2003). As a result, dependency on imports increased in the Netherlands (PBL, 2003). The effects on the Dutch landscape were less significant, but a network of pipelines is located underground for the distribution of oil throughout the Netherlands (PBL, 2003). The effect of these pipelines creates restrictions above ground for some developments (PBL, 2003). Energy dependence and geopolitical tensions became even more apparent in the 1973 oil crisis (PBL, 2003). It was a deliberate oil boycott of the Arab oil-producing countries against the West (PBL, 2003). It showed the geopolitical tensions and how they are entangled with energy (PBL, 2003). The effect was clear, empty highways, the Netherlands is dependent (PBL, 2003).

5.2 Recent history

Fossil fuels - Natural gas

The Netherlands discovered the gas field in Slochteren in Groningen in 1960 (Toekomstatelier NL2100, 2022). It meant a turning point in the Dutch energy policy; the Netherlands quickly closed all coal mines (PBL, 2003). Much gas was used domestically and exported to surrounding countries (PBL, 2003). The gas was drawn as if it were a bottomless pit. As a result, the Netherlands quickly went through a large part of the stock. After the oil crisis of 1973, the importance of having our energy source suddenly became clear (PBL, 2003). The Netherlands wanted to be less dependent on other countries and use the gas stock more sparingly (PBL, 2003). Oil and gas companies searched for other gas fields in the area and the North Sea (PBL, 2003). The effect of discovery of the gas fields, just like the other fossil fuels, has a significant impact, mainly underground (PBL, 2003). Thus the extracted gas had to be distributed (PBL, 2003). It also had an impact on households themselves (PBL, 2003). The households were all connected to gas. Every house now had a gas stove for cooking (PBL, 2003). In 2003, KNMI measured the first earthquakes in Groningen at three on the Richter scale (KNMI, 2020). These earthquakes have no tectonic origin but are a direct result of the gas extraction in Groningen (KNMI, 2020). The earthquakes have only increased in frequency and severity in the following years (KNMI, 2020). As a result, the government changed the gas policy again and wanted to stop gas extraction in Groningen. Only recent developments with tensions surrounding Russia, caused by the war in Ukraine, have shed a different light on this because the Netherlands no longer wants to be dependent on Russian imports at all costs (Ministerie van Algemene Zaken, 2022). It means that the import of gas from Groningen is being re-examined (Ministerie van Algemene Zaken, 2022). The effect of the war in Ukraine and the plans to become independent from Russian energy are discussed in the following subchapter.

Nuclear energy

The Netherlands has one large nuclear power plant for electricity generation, Borssele (Ministerie van AlgemeneZaken, 2017). The Netherlands also has several small nuclear power stations, such as in Delft, for research (PBL, 2003). At one point, people saw Nuclear energy as an answer to energy dependency (Högselius, 2018). After the Suez Crisis in 1956, the dependence became apparent (Högselius, 2018) (PBL, 2003). There was a discussion in the Netherlands about coal stocks. Also, in 1970, the conversation about the depletion of fossil fuel sources became part of the public debate. Nuclear energy seemed to answer these concerns (Högselius, 2018). The Netherlands would be less dependent and have inexhaustible energy, which led to plans for expansion. The nuclear disaster in Chernobyl suddenly changed these plans on the 26th of April, 1986 (Högselius, 2018). The disaster shocked everyone so much that public perception was utterly changed, and people were firmly against it, and expansion plans were canceled (Högselius, 2018).

The Netherlands has historically known many different forms of energy, and these had varying effects on the landscape. In the principles of society, these were significant landscape changes that have shaped the present landscape (PBL, 2003). Later, with the discovery of fossil fuels, the effects became less and less visible above ground (PBL, 2003). An increasingly extensive network was built underground to distribute these fuels (PBL, 2003). Also, throughout history, energy dependence has become a more significant part of public debate and political policy (PBL, 2003) (Högselius, 2018). The people who made these choices in energy sources did this with a particular zeitgeist with the knowledge available at the time (PBL, 2003)(Högselius, 2018). However, these choices affect us and our living environment to this day. Therefore, it is essential to learn from this and to be able to estimate the effects in the short and long term.

5.3 Policies on energy transition

The Netherlands has a climate agreement with the national goal of reducing greenhouse gases by 2030. To reduce greenhouse gases by 49%, compared to 1990 (Ministerie van Economische Zaken en Klimaat, 2019). This agreement also contains a target for renewable energy in 2030 (Ministerie van Economische Zaken en Klimaat, 2019). The European Commission has approved the target of 26% renewable production from the Netherlands, compared to the EU's renewable energy target of 32% (Ministerie van Economische Zaken en Klimaat, 2019). The Netherlands shows ambition and aims to achieve at least a 27% share of renewable energy by 2030 (Ministerie van Economische Zaken en Klimaat, 2019).

In the field of energy-saving, a European target for 2030 of 32.5% (Ministerie van Economische Zaken en Klimaat, 2019). The Netherlands aims for primary energy consumption of 1950 petajoules in 2030 (Ministerie van Economische Zaken en Klimaat, 2019). The government means to reach these goals with new measures (Ministerie van Economische Zaken en Klimaat, 2019). The 40-point plan Urgenda Foundation. Some of the measures mentioned include:

- 100,000 energy-neutral rental houses in 2022 (built environment)
- Reducing livestock and making agriculture more sustainable (agricultural industries)
- Reduce the speed limit on roads (mobility)
- Subsidizing with an extra budget for home insulation (built environment)

Figure 28: Plans to reduce energy bills by Rijksoverheid (Ministerie van Binnenlandse Zaken enKoninkrijksrelaties, 2021)

5.4 International dependencies

Russia is one of the largest suppliers of oil and gas (de Groot & Reijerman, 2022). Many countries import from Russia and are, consequently, partly dependent on the energy that Russia supplies (de Groot & Reijerman, 2022). It is complicated in the current political situation (de Groot & Reijerman, 2022). Because of the war in Ukraine, many countries want to be independent of Russia and do not support the country financially (Ministerie van Algemene Zaken, 2022)(de Groot & Reijerman, 2022). However, it is difficult for many countries, including the Netherlands (Ministerie van Algemene Zaken, 2022) (Högselius, 2018).

Figure 29 shows the dependencies on Russian gas for the Netherlands and other EU member states (de Groot & Reijerman, 2022). The Netherlands aims to be independent of Russian energy by the end of 2022 (Ministerie van Algemene Zaken, 2022). The government wants to achieve this by using fewer fossil fuels, importing more LNG, and using gas stocks (Ministerie van Algemene Zaken, 2022). All this is only possible in good cooperation with the rest of Europe (Ministerie van Algemene Zaken, 2022).

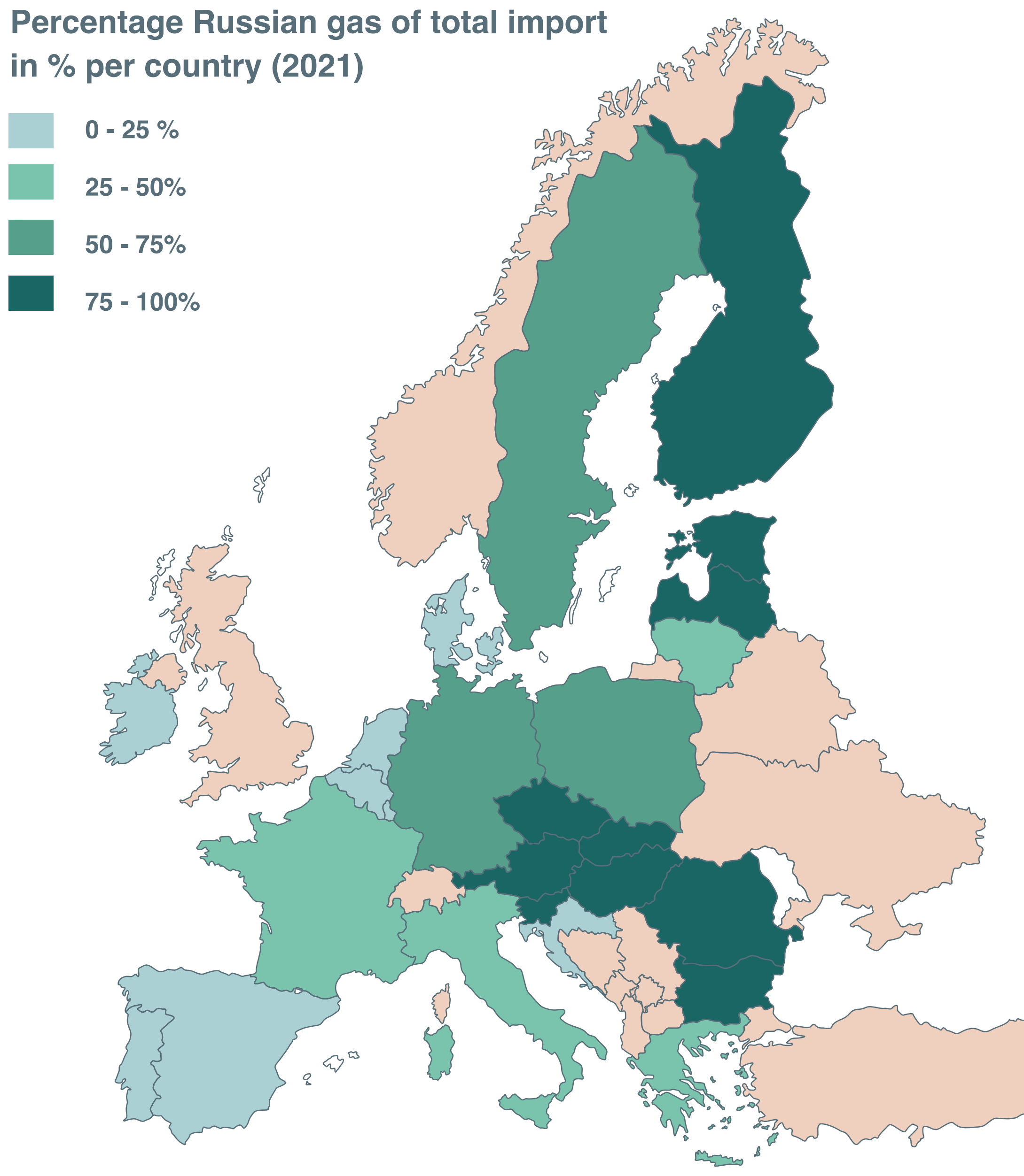


Figure 29: European dependancies on Russian Gas (de Groot & Reijerman, 2022).

5.5 Energy in space, designing with energy

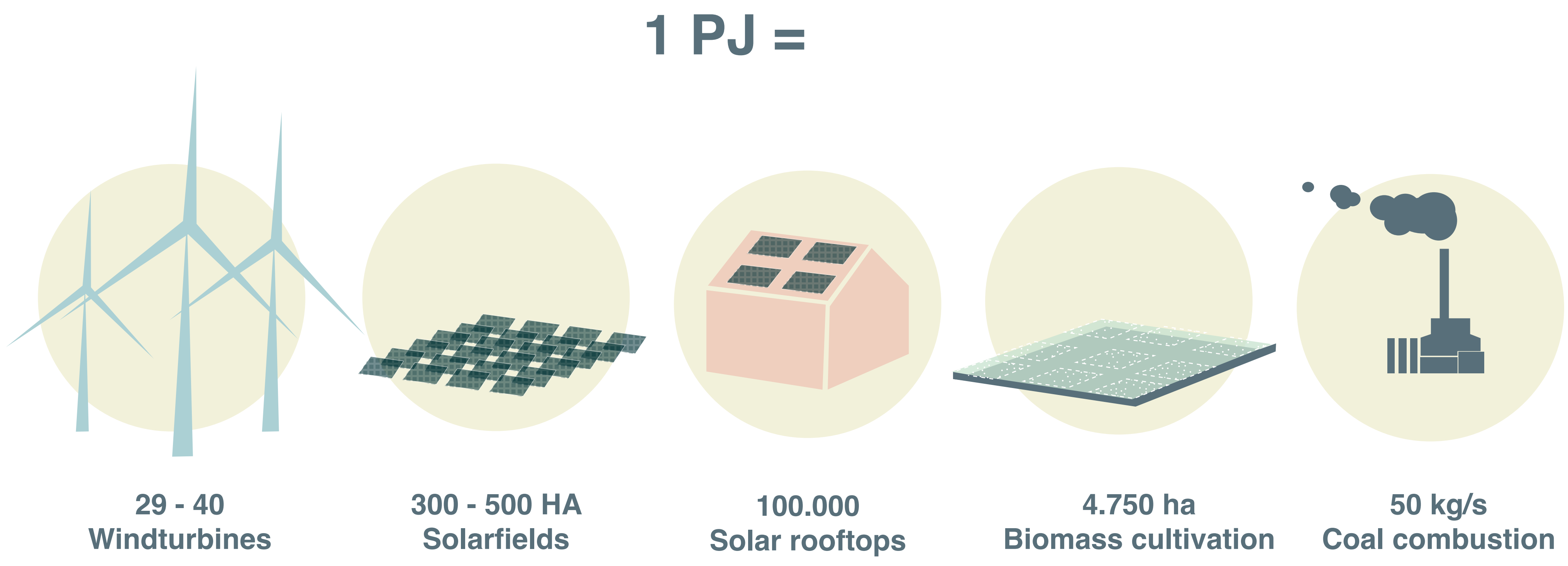


Figure 30: Types of energy to produce 1 PJ (Kuijers et al., 2018).

Energy is space; every manner of generating, storing, or transporting energy has a physical dimension. It differs per energy source how much space this takes.

This subchapter explains the physical dimensions of different energy types and the conditions that result from this. This chapter only discusses energy types relevant to the research. So these are only renewable energy types.

This research keeps an eye on new developments within the energy sector. The study mainly uses existing instruments. Because many of the discoveries are still in the development phase, these are not relevant for a study of urgent large-scale applications.

Solar and wind energy are most relevant for the production of electricity. Both have the best chance in the Dutch landscape and climate. The options of residual heat and geothermal energy are relevant for the energy used as heat. Geothermal energy can also be relevant as a source of electricity. Storage is an important issue because of the increased generation of more renewable energy.

5.6 Geothermal heat

Geothermal energy is a much-discussed alternative in combination with heat networks and residual heat to meet our heating demand. As mentioned earlier, this is a significant part of our energy demand. Figure 31 shows a schematic display of geothermal energy (TNO, 2020). The diagram shows that the sources of different depths are used (TNO, 2020). From a depth of 500 meters, it has the term geothermal. We speak of ultra-deep geothermal energy from a depth of 4000 meters (Kuijers et al., 2018).

Depending on the depth and capacity of the source, geothermal projects deliver heat that can connect approximately 4,000 to 10,000 homes (Kuijers et al., 2018). For example, a small source of 7 MW involves approximately 4,000 homes, and a more prominent source of 20 MW is approximately 10,000 homes (Kuijers et al., 2018). Therefore, it is better to locate these houses as close to the source as possible (Kuijers et al., 2018).

The indirect underground footprint of a geothermal source is much larger than the direct footprint above ground; underground, it has a density of 2 kWh per 1 m2 (Sijmons et al., 2014). Thus, supplying heat to 1 million households requires 700,000 hectares of the extraction area. On the other hand, the surface area for instillation is only about 1 ha (Sijmons et al., 2014).

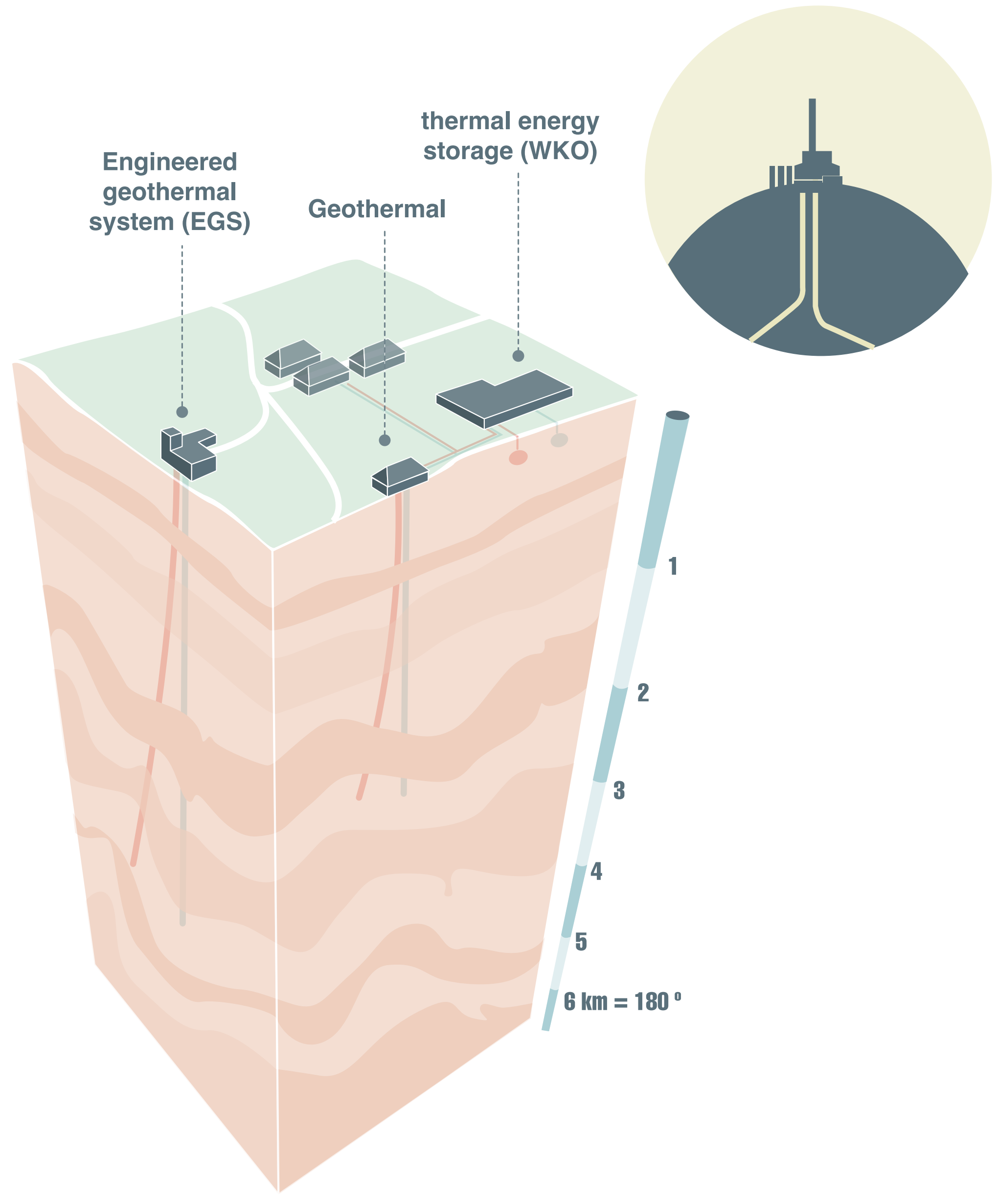
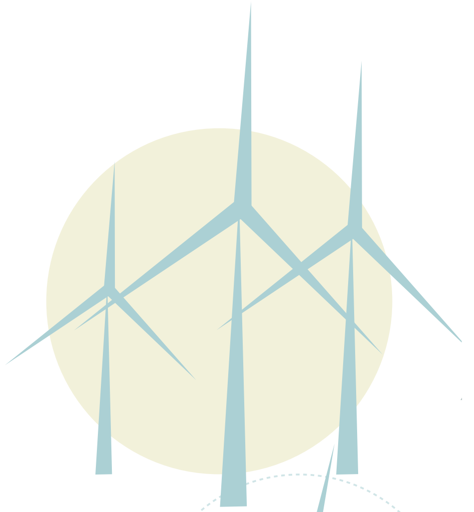


Figure 31: Schematic construction of geothermal energy, enhanced geothermal systems (EGS) and heat and cold storage (ATES) (TNO, 2020).

5.7 Wind energy



Wind turbines can be found all over the Netherlands. They have grown in size over the years (Kuijers et al., 2018). The size determines the power of a windmill. Today's tallest wind turbines are more than 300 meters high and can generate 150 MW (Kuijers et al., 2018). A smaller model, about 175 meters high, produces about 3 MW (Kuijers et al., 2018). This model produces 6,000,000 to 7,500,000 kWh of electricity per year. Households use an average of 2,479 kWh (CBS, 2021). One such turbine can generate electricity for about 2.400 to 3000 households, which is a rough estimate and requires more customization, but it does give a good indication.

The efficiency of a wind turbine strongly depends on the location and the arrangement (Kuijers et al., 2018). For example, wind turbines cannot be too close because they will be in each other's wind (Kuijers et al., 2018). Also, the wind is not equally strong everywhere in the Netherlands. The wind speeds are highest along the coast (Kuijers et al., 2018). That is why the government is investing a lot in offshore wind.

The spatial framing of wind turbines depends on various reasons (Sijmons et al., 2014). Firstly, due to the distance that a blade can travel when it becomes detached from the wind turbine due to a technical error. Besides, sound also has an influence, as well as the blades that cast a shadow, when the sun shines through the wind turbine (Sijmons et al., 2014). As a result, wind turbines do not stand near residential areas and quiet areas (Kuijers et al.,

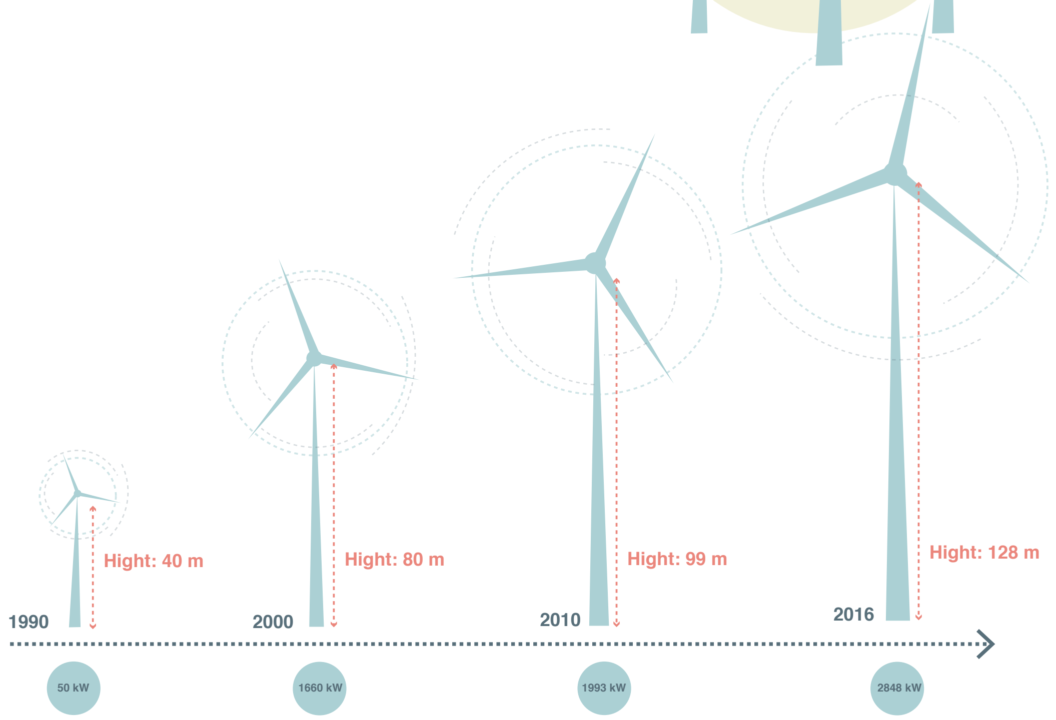
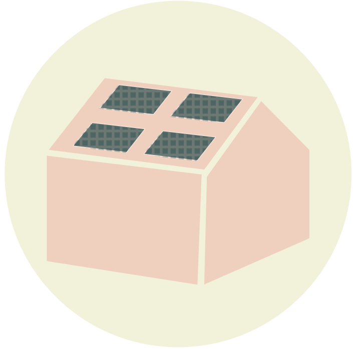


Figure 32: Wind turbines grown in size over the years (Heinrich-Böll-Stiftung, 2017)

2018). At sea, windmills can also not be located in Natura 2000 protected areas or within a helicopter zone (Kuijers et al., 2018).

Wind turbines cannot be near residential areas, but there may be options for integration with other functions, such as infrastructure or industry (Kuijers et al., 2018).

5.7 Solar energy



Solar panels have fewer spatial restrictions than the earlier-mentioned energy production methods. Nevertheless, they are very dependent on their environment. For example, solar panels do not generate the same amount of energy everywhere; this has to do with their position in the sun or shade and their temperature.

Solar panels work best if they are far enough apart not to cast shadows on each other (Kuijers et al., 2018). They can catch more sun if they face south (Kuijers et al., 2018). Yet, the efficiency decreases when the solar cells become too hot. As a result, it can be more efficient in some places to place the panel more to the west or east (Kuijers et al., 2018). The substrate also affects the operation. For example, there is a significant difference between a solar panel on an average or a green roof, while a green roof cools down and prevents the solar cells from overheating (Kuijers et al., 2018).

One household will need about ten panels. For example, a rooftop facing south could generate 0,37 GJ/m2, and a rooftop facing east 0,33 GJ/m2.

2,479 x 1,1 = 2726 devided by 330 = 8,3 solar panels

Electricity usage varies per household, and generation is very dependent on the location of solar panels. Solar panels are a very suitable source in the built environment, and government organizations stimulate it by using subsidies.

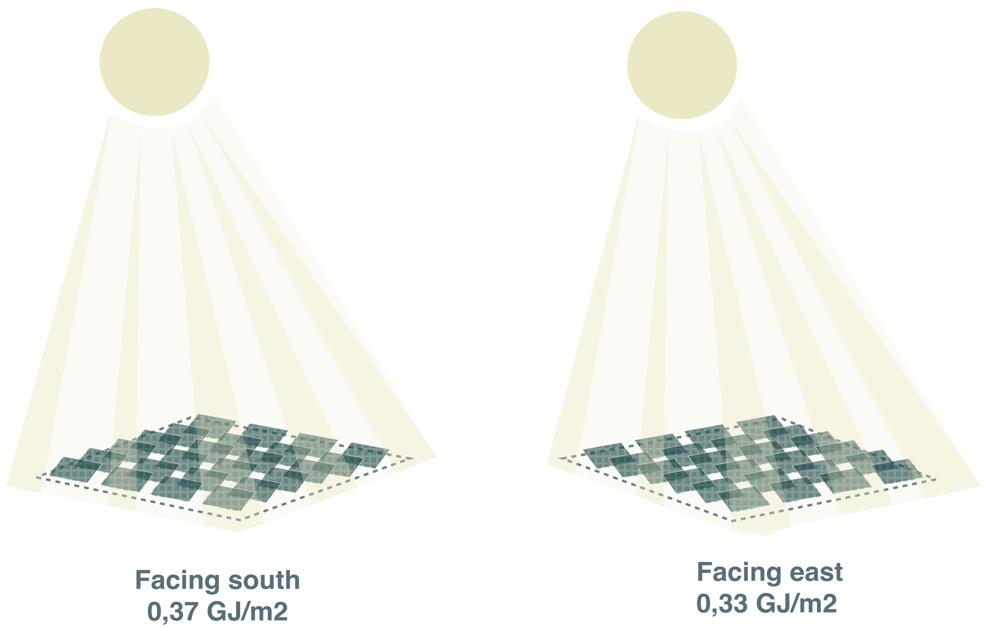


Figure 33: Solar panels oriented in different directions generate a variable amount of energy

6. Flows of the energy system

How does the gas from the ground eventually reach people's homes? Energy is a flow that is transported, processed, and stored. All this has a spatial dimension. But how exactly does that take shape? How do these flows move through the Netherlands and what does that look like?

6.1 Flows - gas system

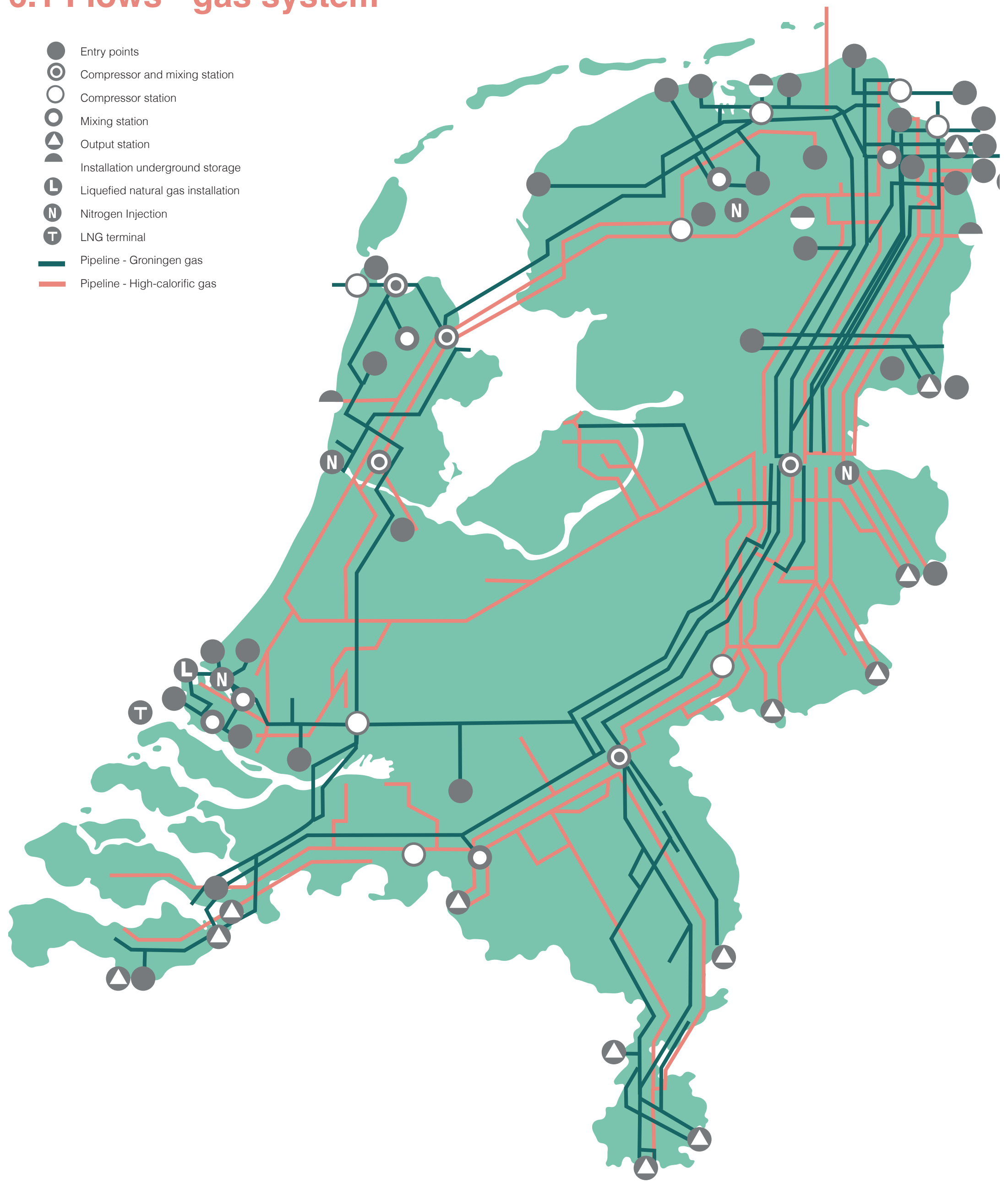


Figure 35: Symplistic illustration of distribution of Gas network in The Netherlands

Gas system of the Netherlands

Based on the literature review, there is a clear understanding that an essential share of the energy system in the Netherlands exists out of Natural gas. Both through domestic production and imports. Figure 35 displays the gas distribution throughout the Netherlands. It shows the different entry points and the pipelines that distribute the gas throughout the Netherlands. Many of the entry points are around the Groningen area because of the domestic production and imports. The entry points in the port of Rotterdam are there because of imports.

The pipelines follow the main structure, the spine of the Netherlands, from which it distributes to households and industries. The map also shows the main living areas in orange. The entry points are typically not located in living environments. The center of gravity of the gas system is on the eastern side of the Netherlands, as seen in figure 34, which is remarkable because fewer people live here. It is because essential gas pipelines run from the east of the Netherlands to the Ruhr area in Germany, an important industrial area and energy consumer.

Figure 34: Flows of the gas system on National scale (Banken, 2020) (cbs, 2020).

6.2 Flows - electricity grid

Figure 36: Flows of the electricity grid on National scale, projected on map of area's that are at risk for energy poverty (TenneT, 2022) (cbs, 2020)

Electricity network in the Netherlands

The electricity network has a similar shape to that of the gas network. In the Netherlands, electricity comes from various power plants. Because electricity, as mentioned before, is not a primary energy source. In the Netherlands, electricity is often generated by burning gas. So there is a connection to the gas network at these points. The Netherlands has approximately 70 power plants, 44 of which are gas-based. The rest run on coal, biomass, waste, water, or nuclear.

These powerplants are located closer to living areas. But the electricity grid also has a distribution similar to that of gas. There is a main connection, the high voltage highway, and this is divided into living environments and is more finely meshed. The voltage in habitats is also lower. Households are not directly connected to high voltage.

6.3 Systemic section - Groningen gas

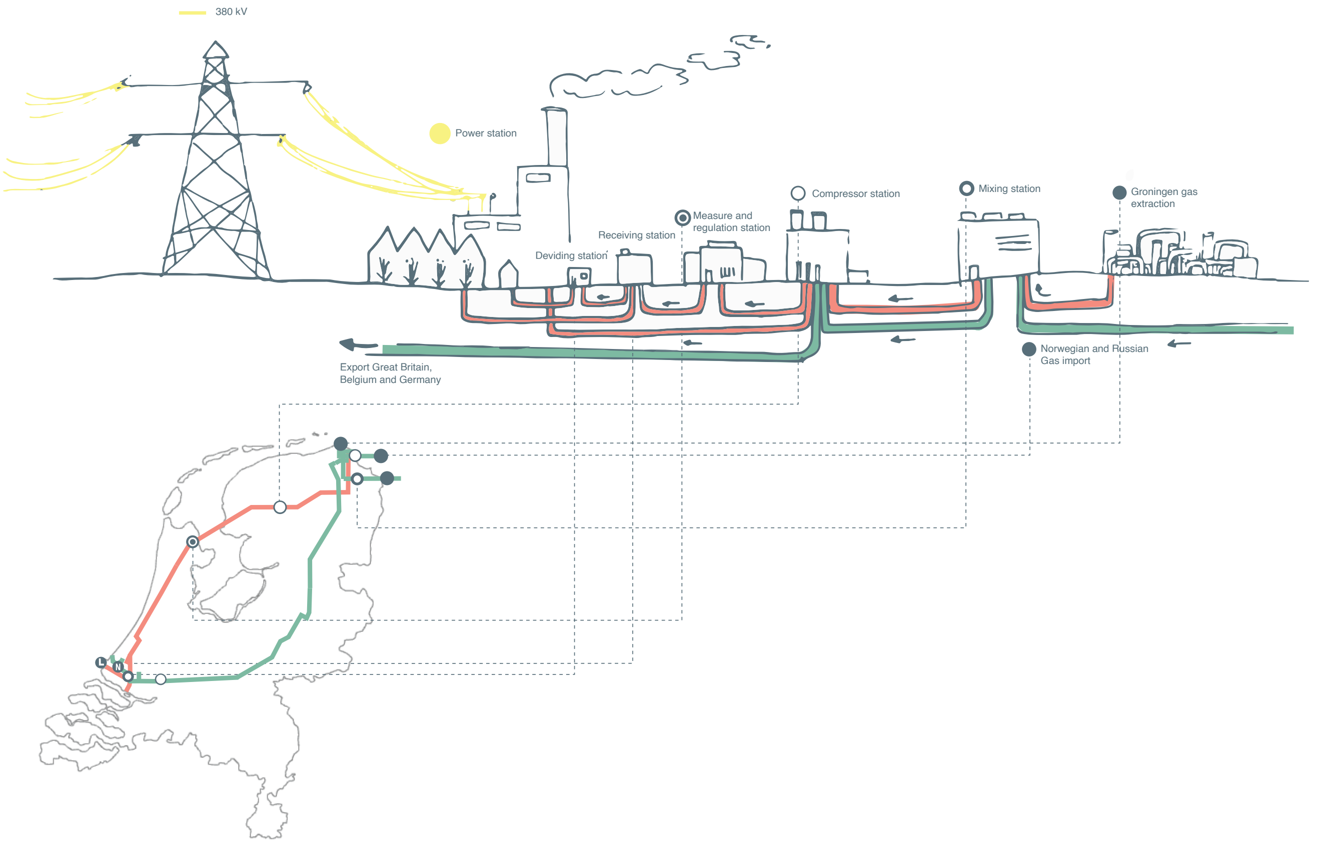


Figure 37: Systemic section of Groningen gas system national scale (Banken, 2020)

Groningen gas in systemic section

Willy Banken (2020), coordinator of maintenance mechanical engineering & instrumentation installations at Gasunie, explains that Groningen gas is a domestic energy source. The Groningen gas (35mj/m3) is not high-calorific (43 MJ/m3), nor is it a low-calorific gas (30 MJ/m3). It is distributed to a mixing station to mix to the correct composition. After that, it arrives through pipelines at a compressor station, where it reduces pressure, and from there on, the gas is pressurized every 100 km. When the gas arrives at a measuring and control station, the pressure is reduced again, and a smell is added to the odorless gas to be recognizable to users. After which, it arrives at the gas receiving station. From here, the regional distribution companies ensure that the gas reaches companies and homes. The systemic section also shows how this gas network connects to the electricity network. The high voltage line distributes the electricity from the power station.

6.4 Systemic section - high caloric gas

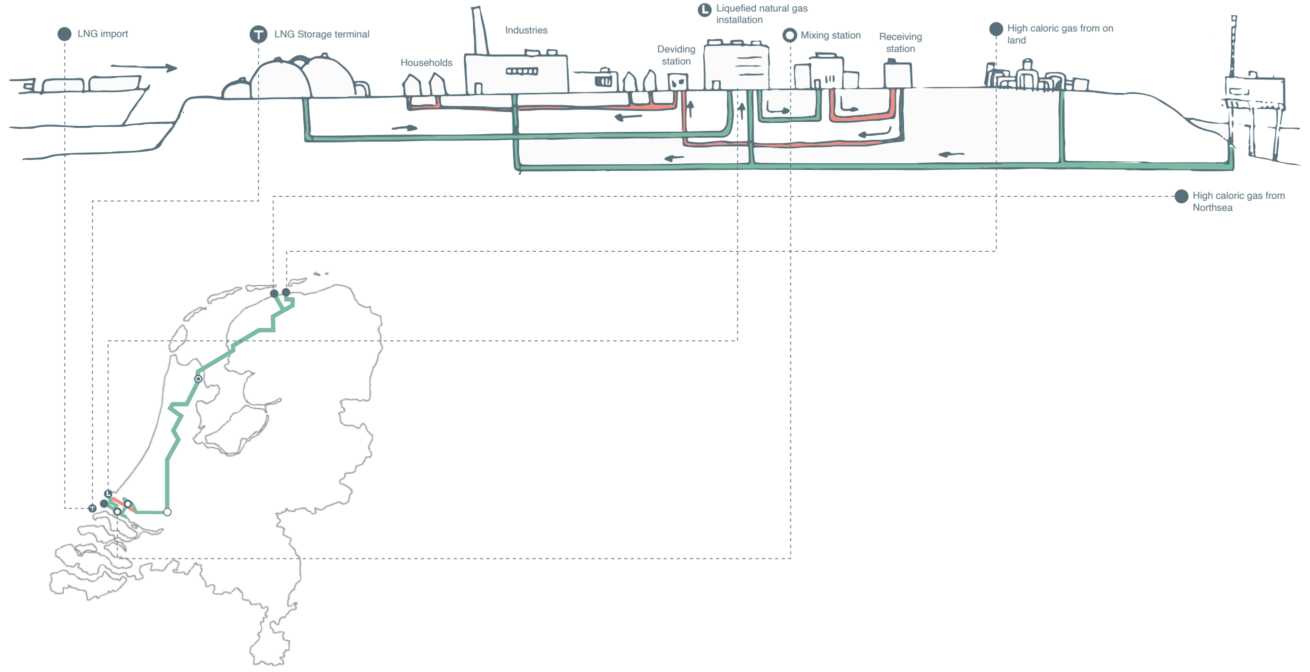


Figure 38: Systemic section of high caloric gas system national scale (Banken, 2020)

High caloric gas in systemic section

Banken (2020) clarifies that the Netherlands makes use of High and low-caloric natural gas in addition to Groningen gas. High caloric gas (HC) comes from the North Sea, land reclamation, and imports. Large industries can immediately use this gas and export part of it, but it is not suitable for households yet. Before households can use this gas, it first passes through a mixing station, a compressor station, and a measuring and regulating station, after which it arrives at a receiving station. From here, it spreads among companies and later to households through a gas distribution station.

Imports of liquefied natural gas (LNG) arrive through the port of Rotterdam, where it is stored. From there, it also enters a mixing station and follows the same path as high-calorific gas.

6.5 Systemic section - electricity usage

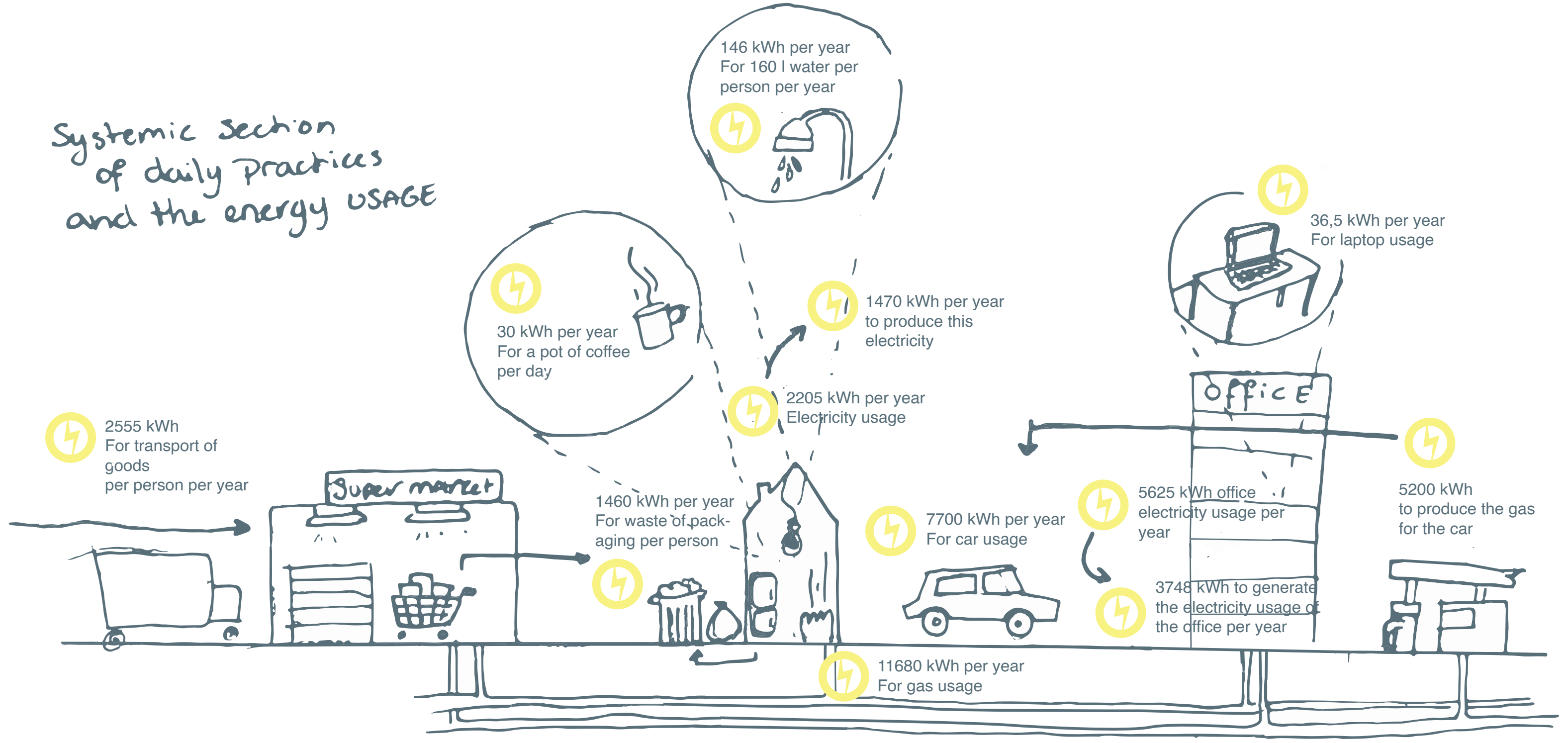


Figure 39: Systemic section example of direct and indirect energy usage

Energy usage in systemic section

When discussing energy usage, it often refers to using gas and electricity at home. This is only a tiny part of the whole. The indirect usage is many times greater. Everything we own and use also takes energy to be made and transported.

The groceries we buy are carefully produced and shipped to the supermarket. The packaging that we throw away is often processed. The car we drive costs energy to produce. But the same is true for the oil that is needed for the car the operate.

6.6 Conclusions flows on national scale

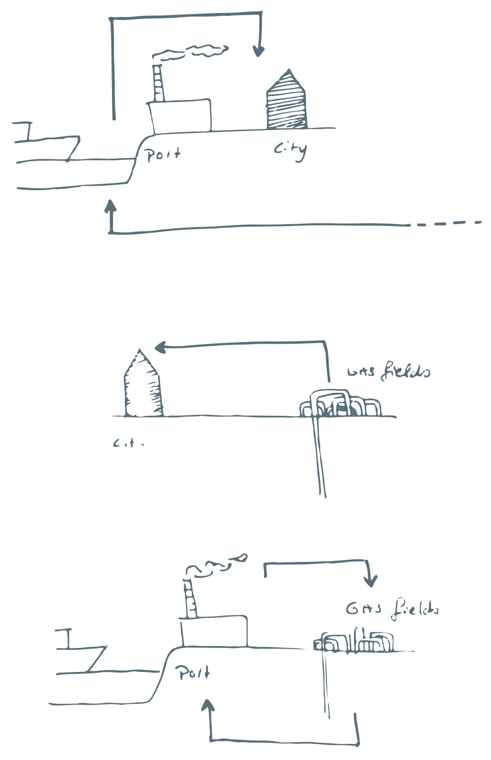


Figure 40: Conclusion flows and leverage points

By looking at the most critical flows within the energy system in the Netherlands, some places show up repeatedly. A compressed version of the national energy system shows an exchange between the gas extraction site in Groningen, the port of Rotterdam, and residential areas. These flows of energy move through the spine of the grid. Gas travels from the extraction site to the consumer, sometimes overseas and through multiple countries, or liquefied across the ocean on a boat.

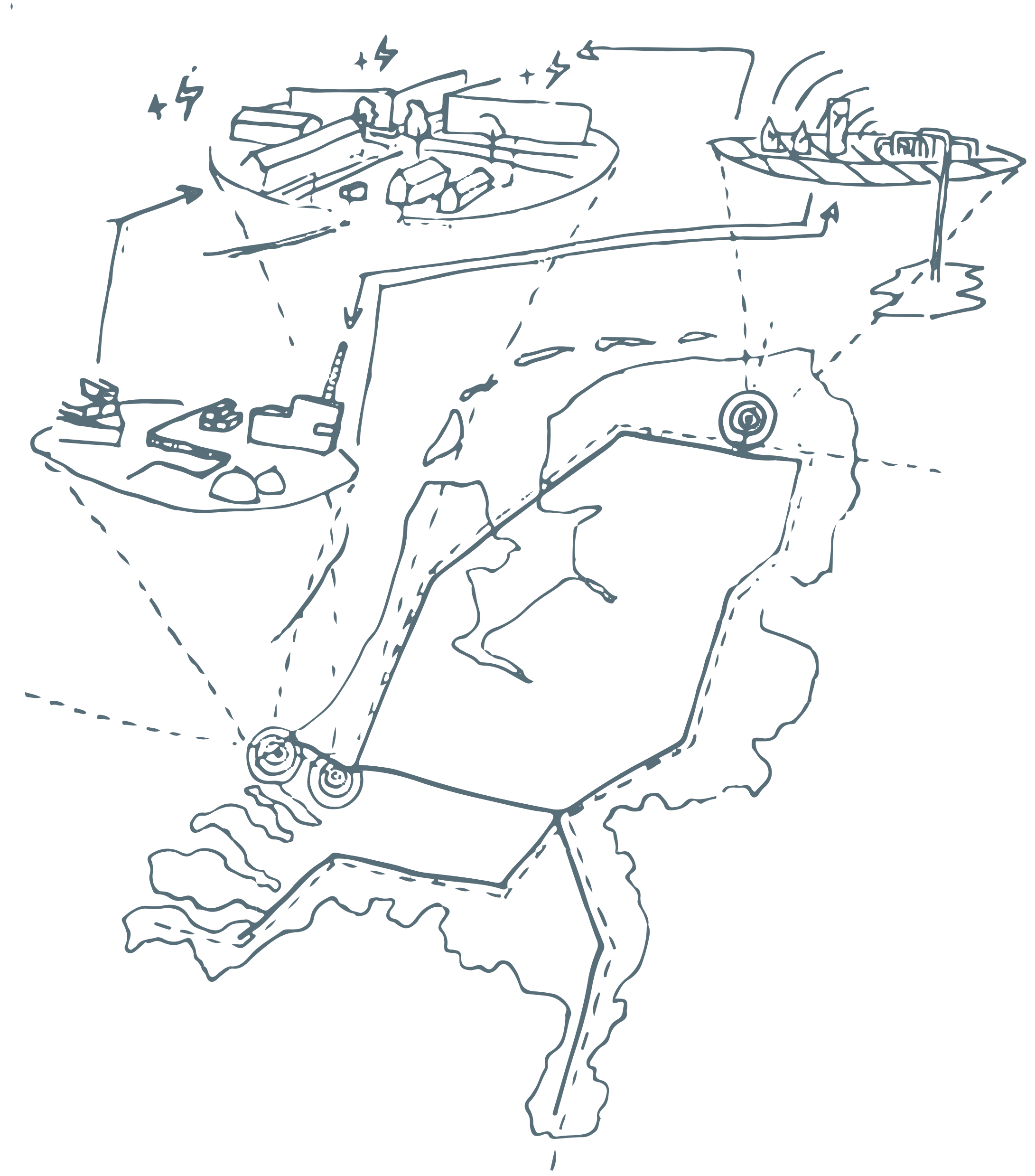


Figure 41: Conclusion flows in small systemic sections showing key points in system

6.7 Conclusions leverage points

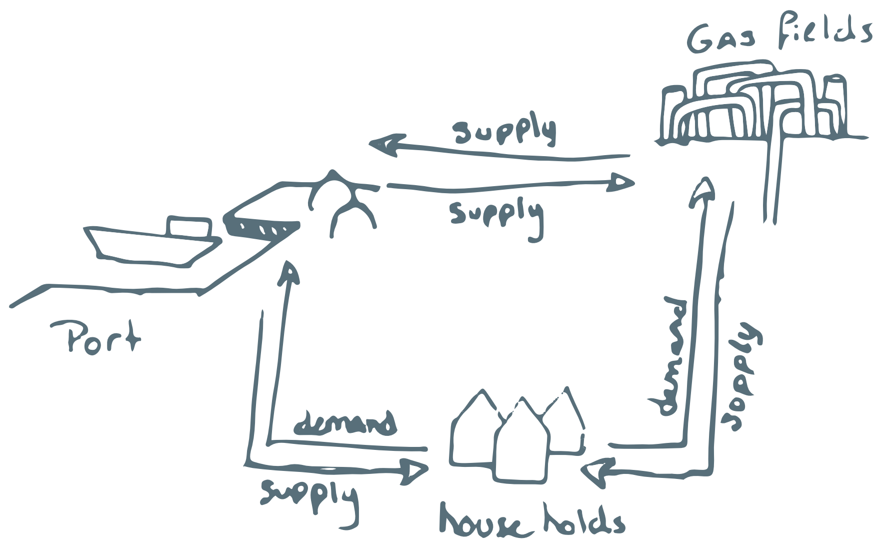


Figure 42: Conclusion flows in small scheme showing key points in system and relation to eachother

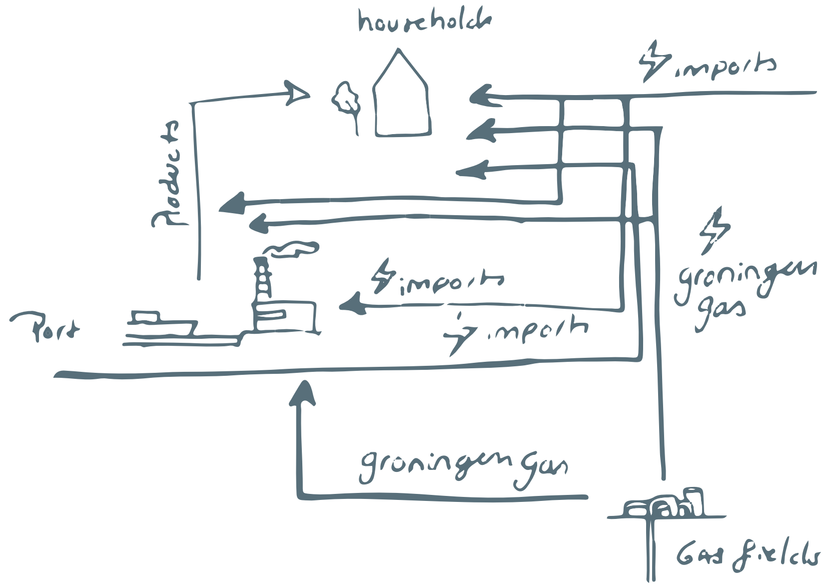


Figure 43: Conclusion flows on national and international scale in small scheme showing key points in system and relation to eachother

Systemic overview leverage points

The relationship between the port, gas extraction sites, and households is not mutualistic. Instead, the port and extraction sites give in to the demand created by consumers. At the same time, the port and other extraction sites and imports are of great importance for the system's functioning. Visualizing the content of these supply and demand connections makes their relation to each other clear.
The energy grid infrastructure is essential for international trade in imports and exports. A large part of what flows through the gas pipelines is immediately exported again.

6.8 Zoom in on leverage points

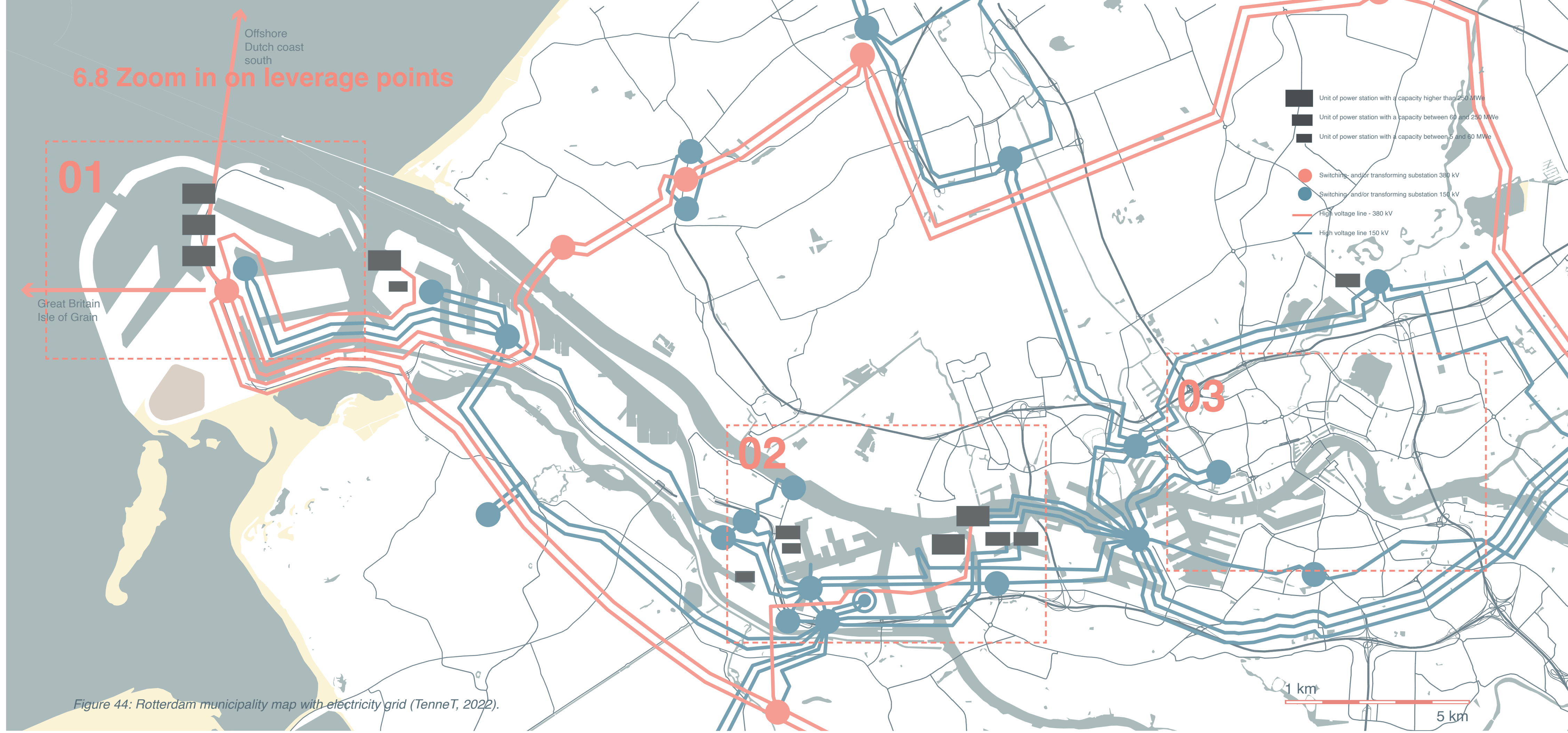


Figure 44: Rotterdam municipality map with electricity grid (TenneT, 2022).

Figure 44 shows a more detailed look at the flows of the current energy system. It zoomed in on two of the system's essential key locations: the port and the city. It reaffirms the conclusions on the scale of the Netherlands.
The map shows the electricity network, which mainly runs south of Rotterdam. The main structure is in the harbour, where most switching, substations and power stations are located. Most power stations are located in the Botlek and on the Maasvlakte, which are also larger. While in the city itself, there are none to be found. The high-voltage 380 kV network runs around the city. There are three cutouts, from the Maasvlakte, the Botlek and the city itself, to show how these areas relate to each other. The Maasvlakte is an industrial port area far from the inhabited city. The Botlek is also a port area; however, closer to the urban fabric. There is a lot of energy infrastructure and production sites in both areas. The city is the third crop.

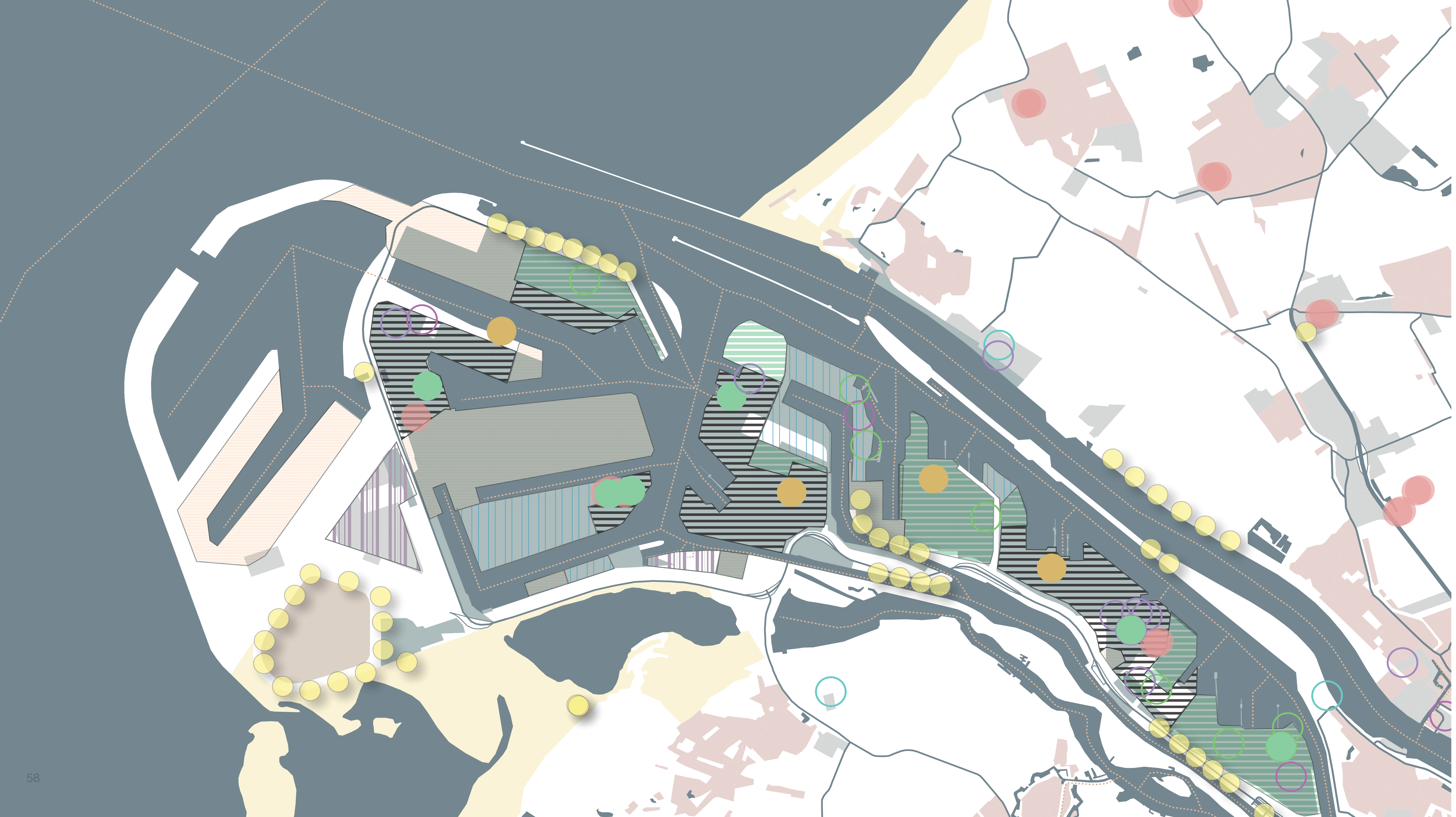


Figure 45: Rotterdam Maasvlakte area energy functions.
(Stedin netwerk; Lisa data : bedrijven; PDOK Dataset: Potentiekaart restwarmte; Gemeente rotterdam map; PDOK Dataset: Vaarroutes; Rotterdam port functions, Portofrotterdam.nl)

The Maasvlakte is an integral part of the Port of Rotterdam, on the tip of the port and most distant from the city. A large part of the space is also devoted to the energy sector. There is a collection of wind turbines, so sustainable energy is also present. There is still a lot of space available for fossil fuels, in the form of refineries, for example. In addition, the area uses a considerable amount of gas and electricity (appendix 4).

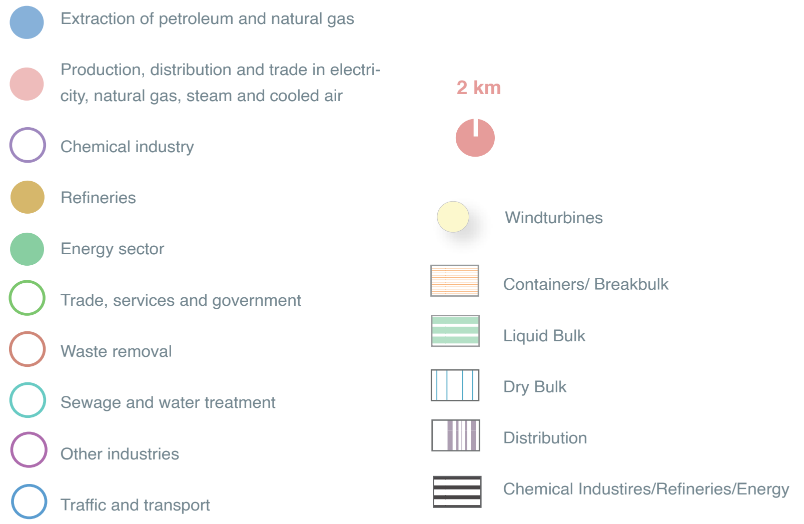


Figure 46: Rotterdam Maasvlakte area energy functions.
(Stedin netwerk; Lisa data : bedrijven; PDOK Dataset: Potentiekaart restwarmte; Gemeente rotterdam map; PDOK Dataset: Vaarroutes; Rotterdam port functions, Portofrotterdam.nl)

The Botlek is an industrial area with heavy industry located relatively close to Rotterdam. It is a port area with dirty industries, mainly characterized by the petrochemical industry and tank storage companies. The energy sector plays a prominent role in the area, from refineries to storage facilities. Furthermore, the area uses a lot of gas and electricity for these industries (appendix 3).

Figure 47: Rotterdam Maasvlakte area energy functions.
(Stedin netwerk; Lisa data : bedrijven; PDOK Dataset: Potentiekaart restwarmte; Gemeente rotterdam map; PDOK Dataset: Vaarroutes; Rotterdam port functions, Portofrotterdam.nl)

Zoomed in on the Rotterdam city area

A detailed map of the electricity grid shows that this is a fine-mesh grid in Rotterdam to provide all homes and businesses with energy. In addition, the map shows that in the city of Rotterdam, several companies in the centre are active in the sector of production, distribution, and trade in electricity, natural gas, steam, and cooled air. It is, of course, still a broad categorization. There are no refineries or extraction sites in the city itself. Other heavy industries such as chemical, waste removal, or sewage treatment are also located outside the boundaries of the residential areas.

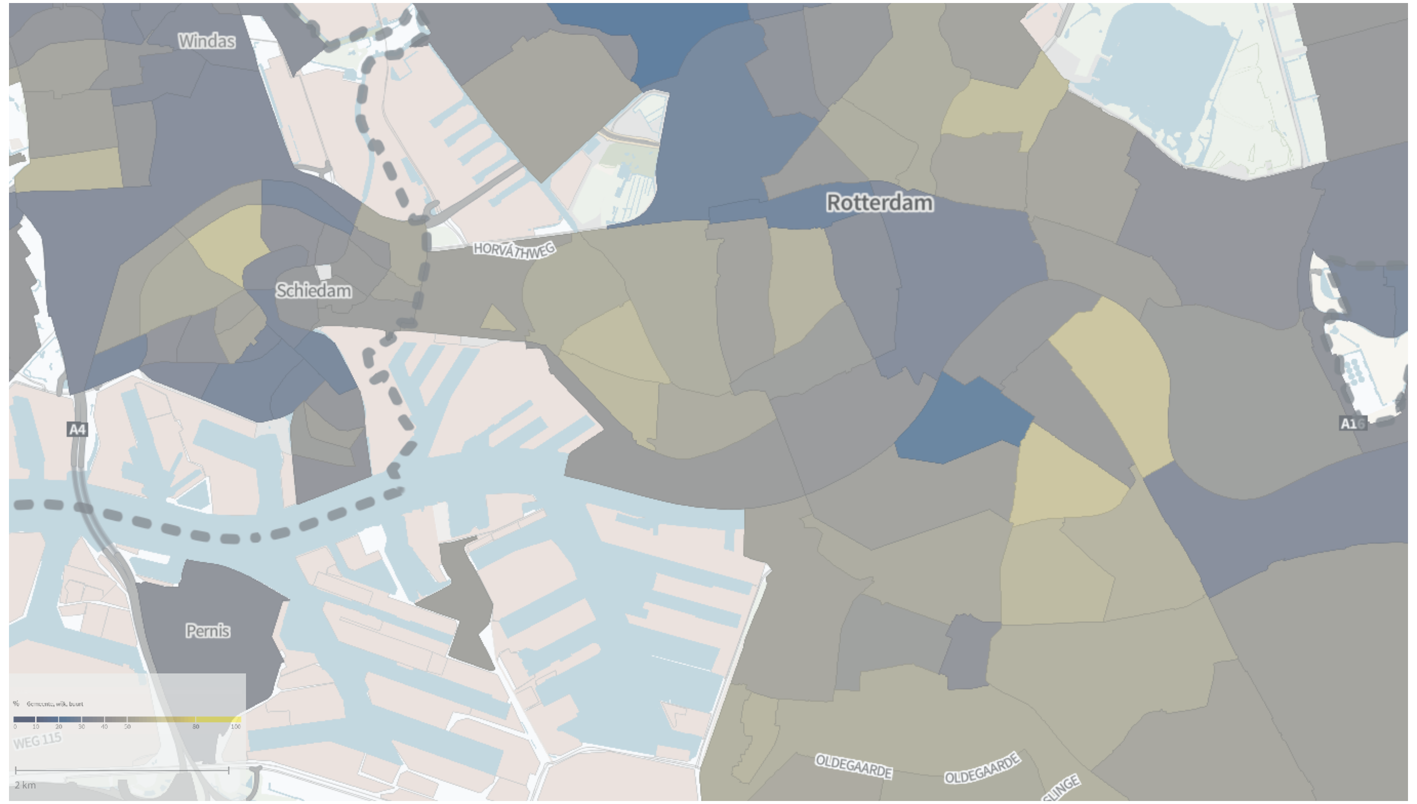


Figure 48: Percentage households in the nationwide 40% of households with lowest income (Datavoorziening VNG Realisatie, 2019)

40% of households with lowest income

The figure shows the percentage of households within the national income distribution in the lowest 40 %. The variation in income per district is considerable in Rotterdam. This map shows many lower-income neighbourhoods in Rotterdam South, Rotterdam West and a few in Rotterdam North. In addition, they have a high percentage of average low-income households compared to the national average.

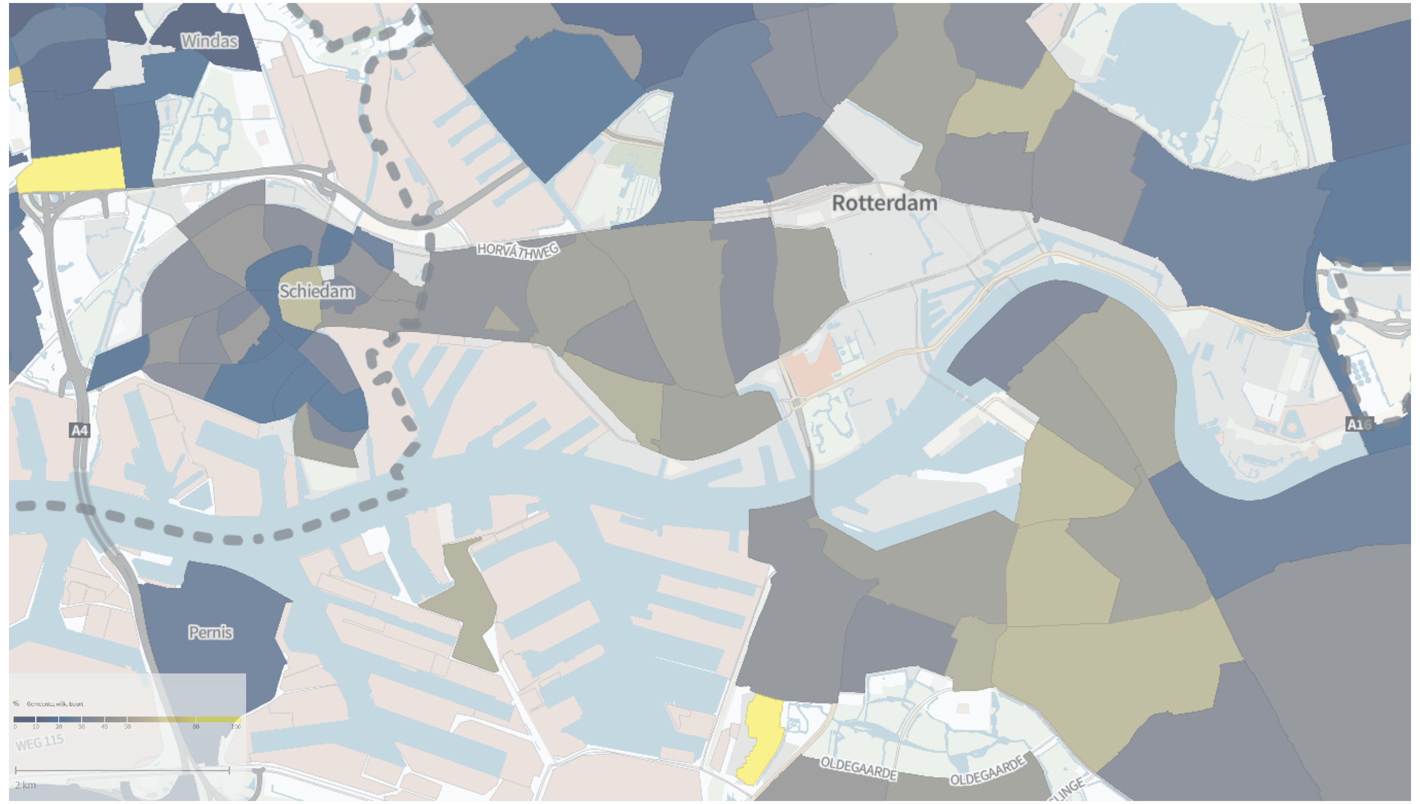


Figure 49: Percentage low income and high gas usage. Income within 25% of households with lowest income and gas usage in highest 50% (Datavoorziening VNG Realisatie, 2019).

Households within the 25% lowest income and 50% highest gas usage

Household income data compared with gas consumption shows that some neighbourhoods have a high percentage of households that earn below average but spend a notable amount on gas consumption. This problem can be caused by, for example, poorly maintained and insulated houses. People who cannot afford to live in new buildings or better insulate their homes are stuck in a situation and cannot do anything themselves to reduce gas consumption. It is also not always possible to replace or make household appliances more sustainable.

7. Key findings and location

After studying the current national energy system, several important conclusions can be drawn. Finally, it is also possible to conclude the most critical points within this system. Furthermore, where there is the most significant potential for transition. These are the key locations of this research.

Picture: 5: Gerry Machen,
https://www.flickr.com/photos/gellscom/9460755014

7.1 Main conclusions

Dependencies
Dependence on imports shows when the import source comes to a standstill, resulting in a problem with energy security (Högselius, 2018). There are several examples of this throughout history, including the oil crisis in 1973. Such events have consequences throughout the Netherlands because the entire system in the Netherlands is also interconnected.

Peak loads
The electricity grid is often experiencing peak loads and sometimes cannot support the amount of electricity generated, which causes problems (Högselius, 2018). Mainly due to the rise of renewable energy (Högselius, 2018). The addition of renewable energy makes the peaks more significant and unpredictable because it cannot be determined how hard the wind blows or how strong the sun shines (Högselius, 2018).

Shared grid
A solution for this is the shared grid. The electricity grid is connected in larger sizes and on a larger scale, also with other countries (Högselius, 2018). It allows controlling peaks on a larger scale because a peak quantity can end up in a place with demand. This shared grid has the opposite vulnerability (Högselius, 2018). If a power failure occurs, the effect can be noticeable throughout the grid (Högselius, 2018). As a result, power failures become increasingly less local (Högselius, 2018).

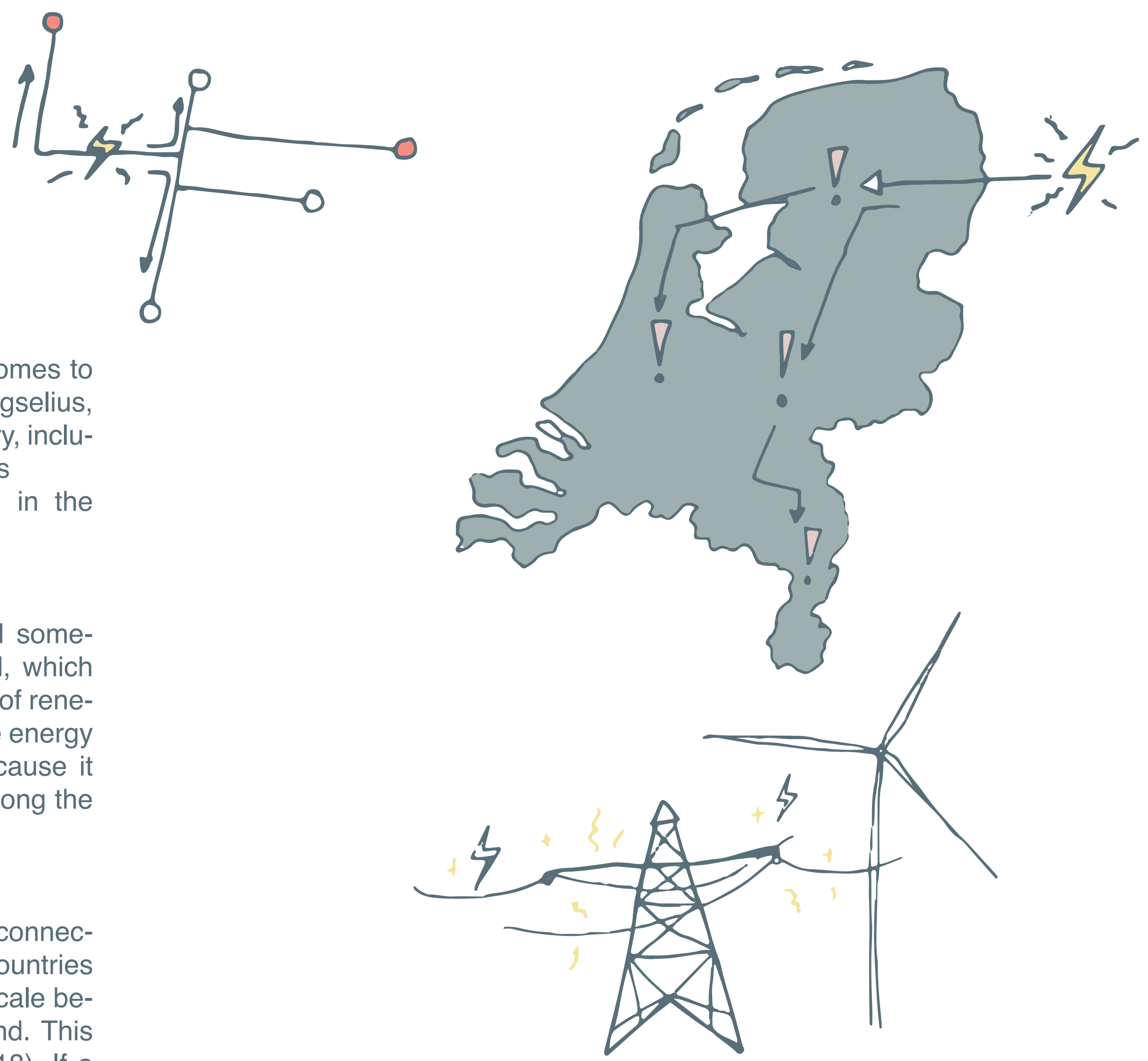


Figure 50: Illustration of key findings

Earthquakes due to gas extraction
The manner and the pace at which companies extracted gas from the ground since the discovery of the Slochteren gas field caused problems (KNMI, 2020). Earthquakes and subsidence directly result from gas extraction (KNMI, 2020). And with it, dissatisfaction and political mistrust among residents (NOS, 2021). The Netherlands went through the stock rapidly, meaning that a lot of it has already been used up (NOS, 2021).

The physical nature of the cloud
We are globally connected and dependent on physical connections; cables at the bottom of the ocean. These are relatively fragile structures and, combined with the reliance on global imports, make us vulnerable. It is a misconception that the Internet takes place in the cloud; it is a physical and spatial phenomenon. So, for example, All the data we save is stored in a physical facility, a data centre.

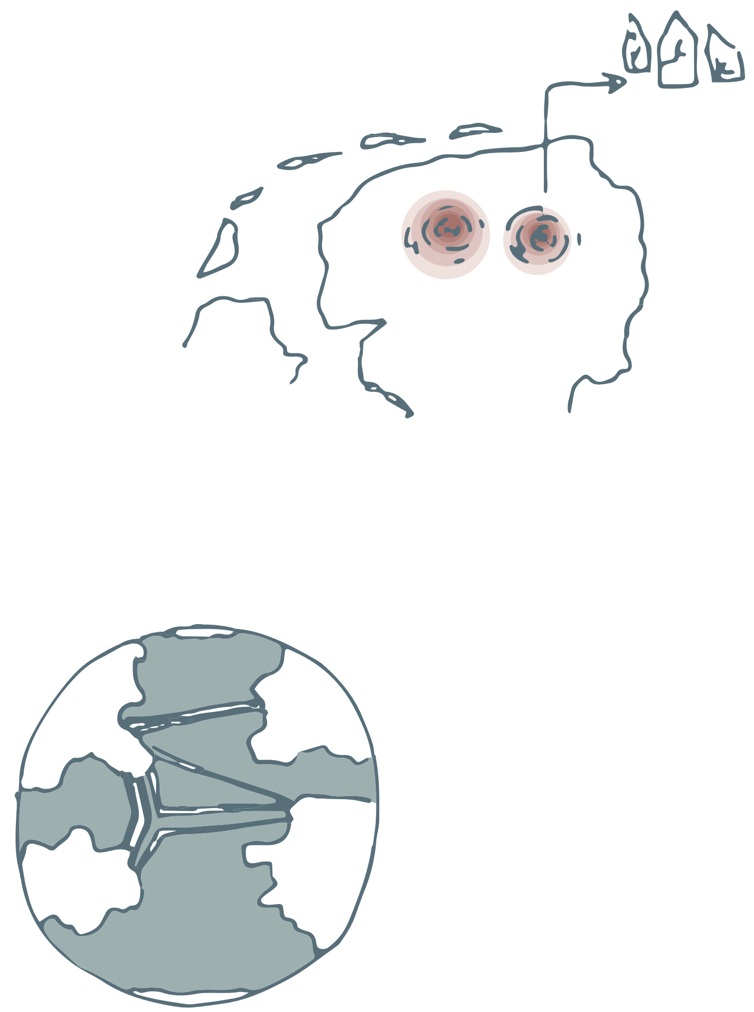


Figure 51: Illustration of key findings

Underground network
All these underground networks also have an above-ground effect (PBL, 2003). Construction projects above ground are often complex, limited, or impossible because of what goes underground (PBL, 2003). Because there are also many private parties, this can be extra complex because not everything is always known to all parties. Poor documentation of underground networks throughout history can slow down and complicate construction projects.

Ruins of energy structures
Many of these above and below-ground structures have a long-lasting effect on the environment (PBL, 2003) (Pasqualetti & Stremke, 2018). It may be because the structures are semi-permanent or very polluting (Pasqualetti & Stremke, 2018). It requires a creative approach to existing structures of energy systems that we no longer use or want to use, such as coal mines. It also requires thinking ahead about the permanent effects on the living environment and the state of the landscape it leaves behind.

New networks
A new system often requires a new network. Old systems must be thought about creatively because it is often challenging and unprofitable to reuse them for a new energy type. It is often also because these developments occur side by side. For example, all new wind farms and solar panels need to make a new connection to the network.

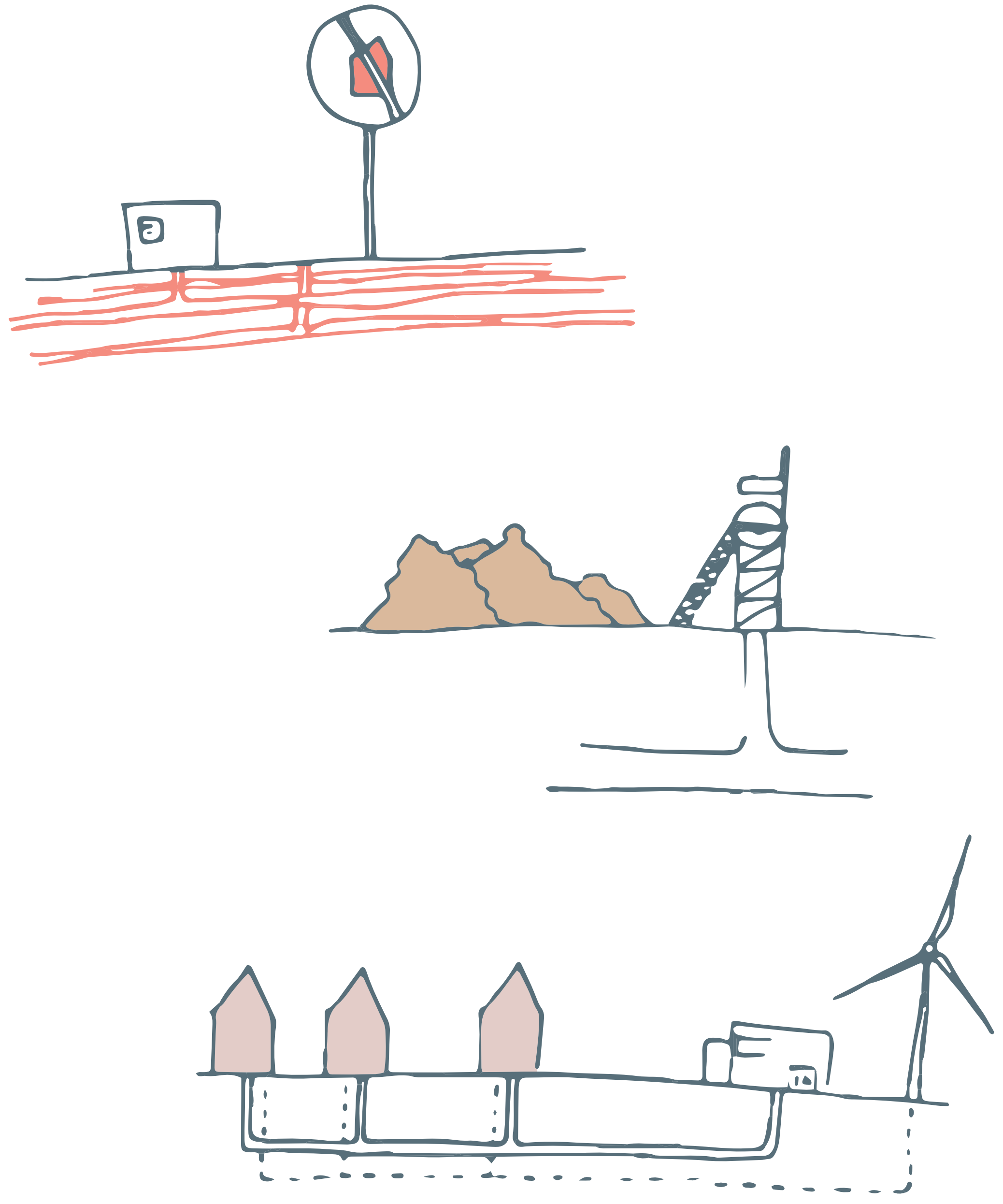


Figure 52: Illustration of key findings

Energy storage
One of the most significant expenditures of renewable energy is to store it. So there is a greater demand for batteries that contribute to the imaginative integration of this energy.

Spatial potential
Due to the construction of new networks, many existing structures must be deconstructed. When a road is already under construction, there is the possibility of developing the streetscape at the same time. With this, the street is only opened once, and the energy transition creates an opportunity to promote spatial quality.

Figure 53: Illustration of key findings

7.2 key location for zoom in

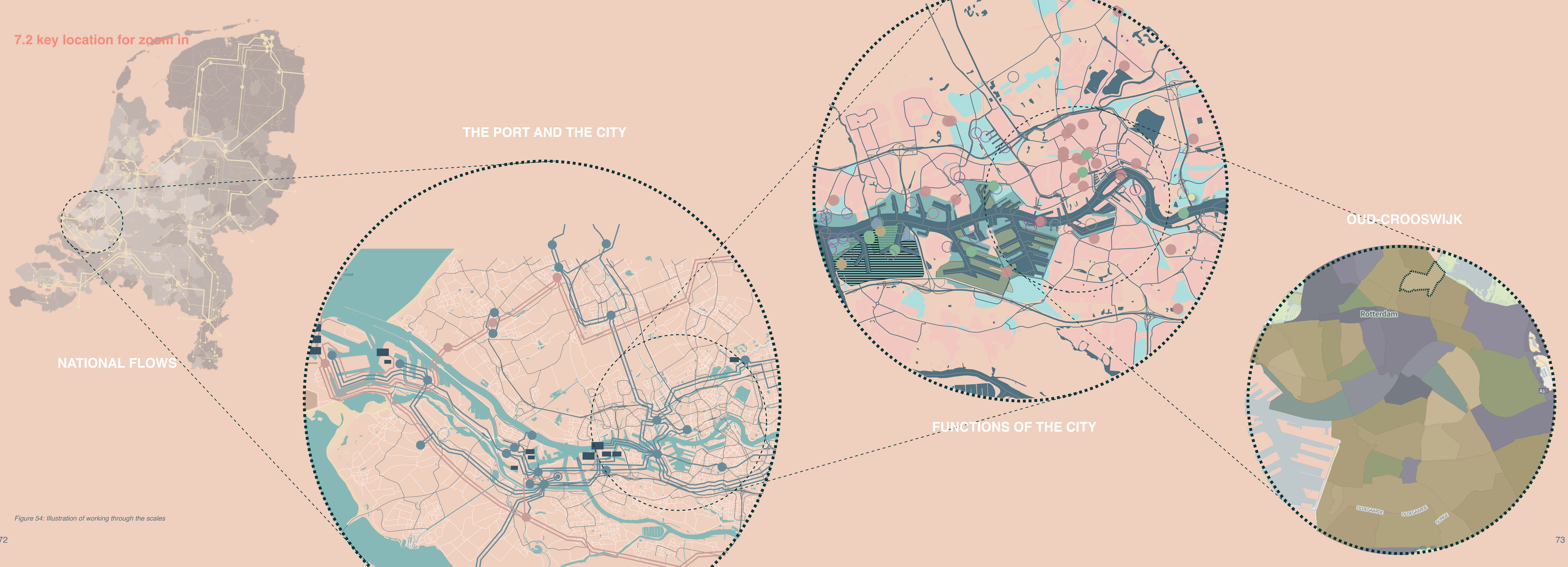


Figure 54: Illustration of working through the scales

Key locations of the system

This research goes through all layers of the energy system. Each layer brings new insights and complexity. The previous chapter started with flows on a national scale. It showed that the system consists of several key points. These key locations are where energy is created, used, and traded. Rotterdam is an exciting location where the port and the city connect. Zooming in on Rotterdam reveals the socio-economic layer, showing that some neighbourhoods within Rotterdam experience more problems from the current system than others.
For example, Oud-Crooswijk, a central district in the north of Rotterdam.Oud-Crooswijk is the starting point for the continuation of this research.

Figure 55: Picture of Crooswijksesingel

Research goal

The first part of this research exists out of these goals:

- To understand the current energy system.
- To define the problems of the current energy system.
- To define the key locations and spatial bottlenecks of the current energy system.

The second part of this research continues with the findings of the first part:

- To analyze the key location to grasp the complexity.
- To redesign a key location in a conscious and decentralised manner.
- To see if this could create spatial quality and stimulate the community.
- To understand the effect of a conscious and decentralised system on a bigger scale.
- To see if and how this would affect other key locations within the system.

Design goal

To design a decentralised and sustainable energy system in Oud-Crooswijk, a transitioned energy system that creates spatial quality and stimulates the community.

The goal is to:

- Use energy responsibly.
- Produce energy consciously .
- The neighbourhood will not be autonomous but accountable.
- It will not be self-sufficient but self-liable.
- The system is interconnected and subsists at different scales, but the emphasis is on local responsibility.

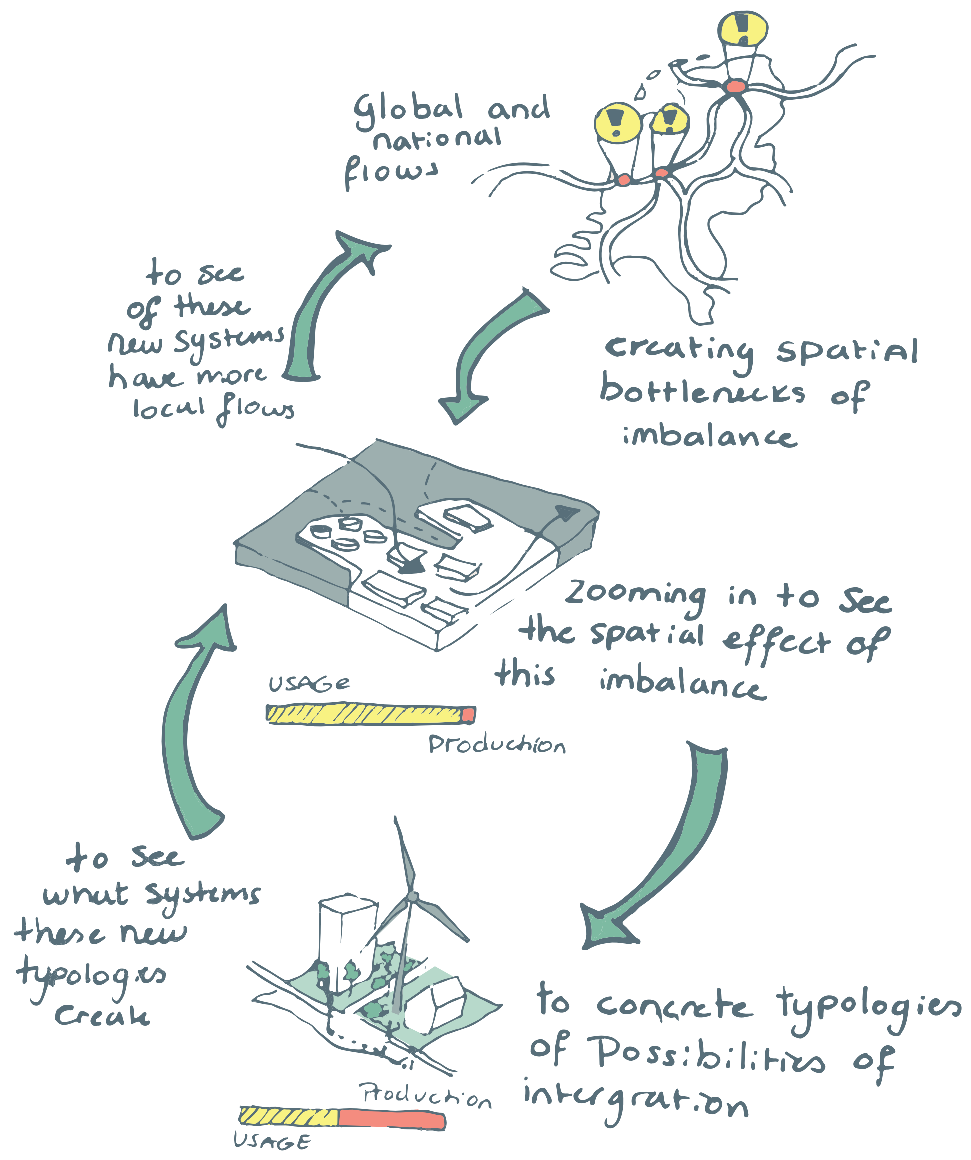


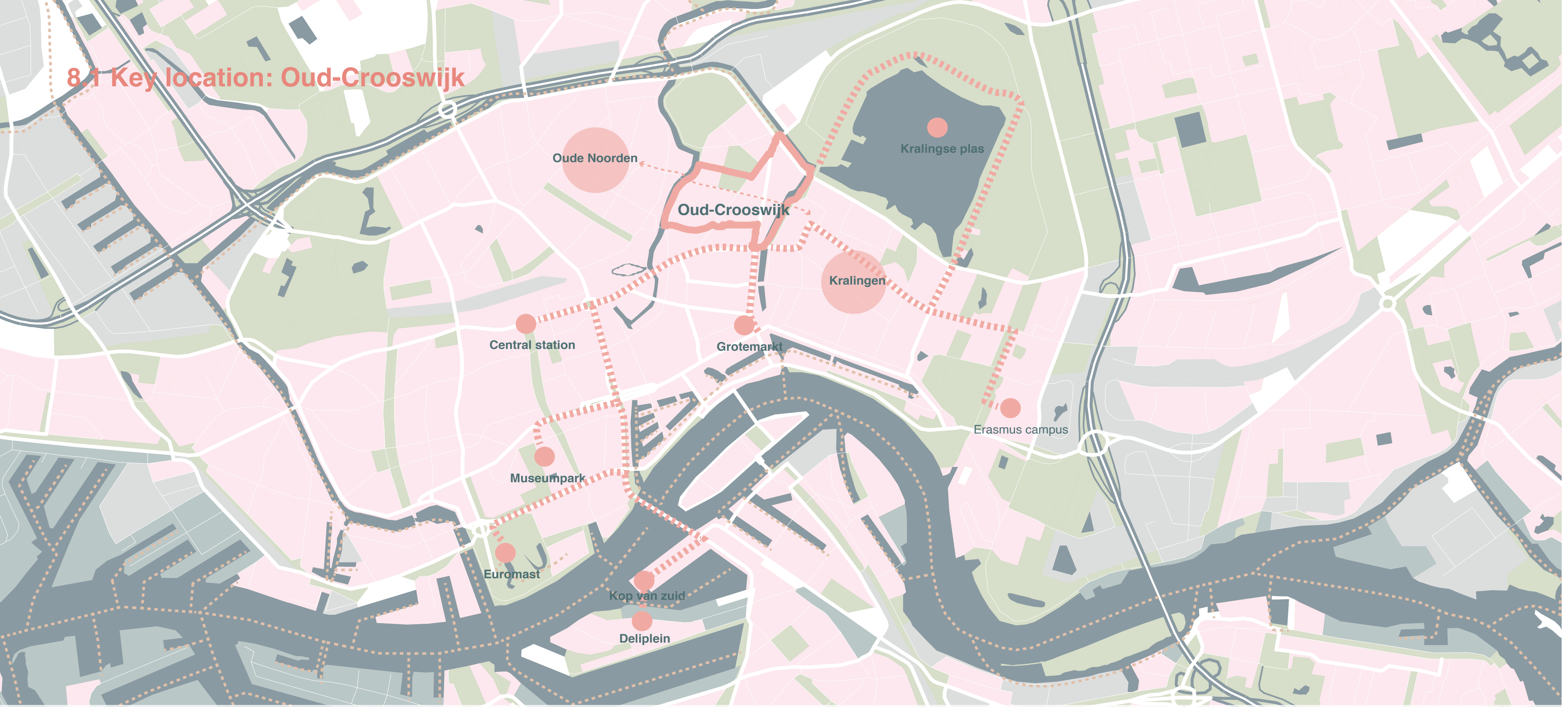
Figure 56: Illustration of working through the scales

8. Oud-Crooswijk

The research continues with exploring Oud-Crooswijk. This chapter analyzes the neighbourhood spatially and socially to conclude the challenges and potentials within the area.

Picture: 6: Oud-Crooswijk from rooftop of Heineken Gebouw

8.1 Key location: Oud-Crooswijk



Oud-Crooswijk is a central district north of Rotterdam. The district is well-connected to essential attraction points in the city. The district is well-connected, but there are not many essential traffic arteries. It is often unnecessary to drive or cycle through the neighbourhood to get somewhere in the city, but everything is easily accessible from the neighbourhood.

- 10 min bike ride, 22 min walk to the Central station
- 6 min bike ride, 19 min walk to the large market square
- 13 min bike ride to the Erasmus University campus
- 16 min bike ride to the Kop van Zuid

Figure 57: Map of city centre of Rotterdam with energy usage per neighbourhood. Connections of Oud-Crooswijk and other important spots in the city

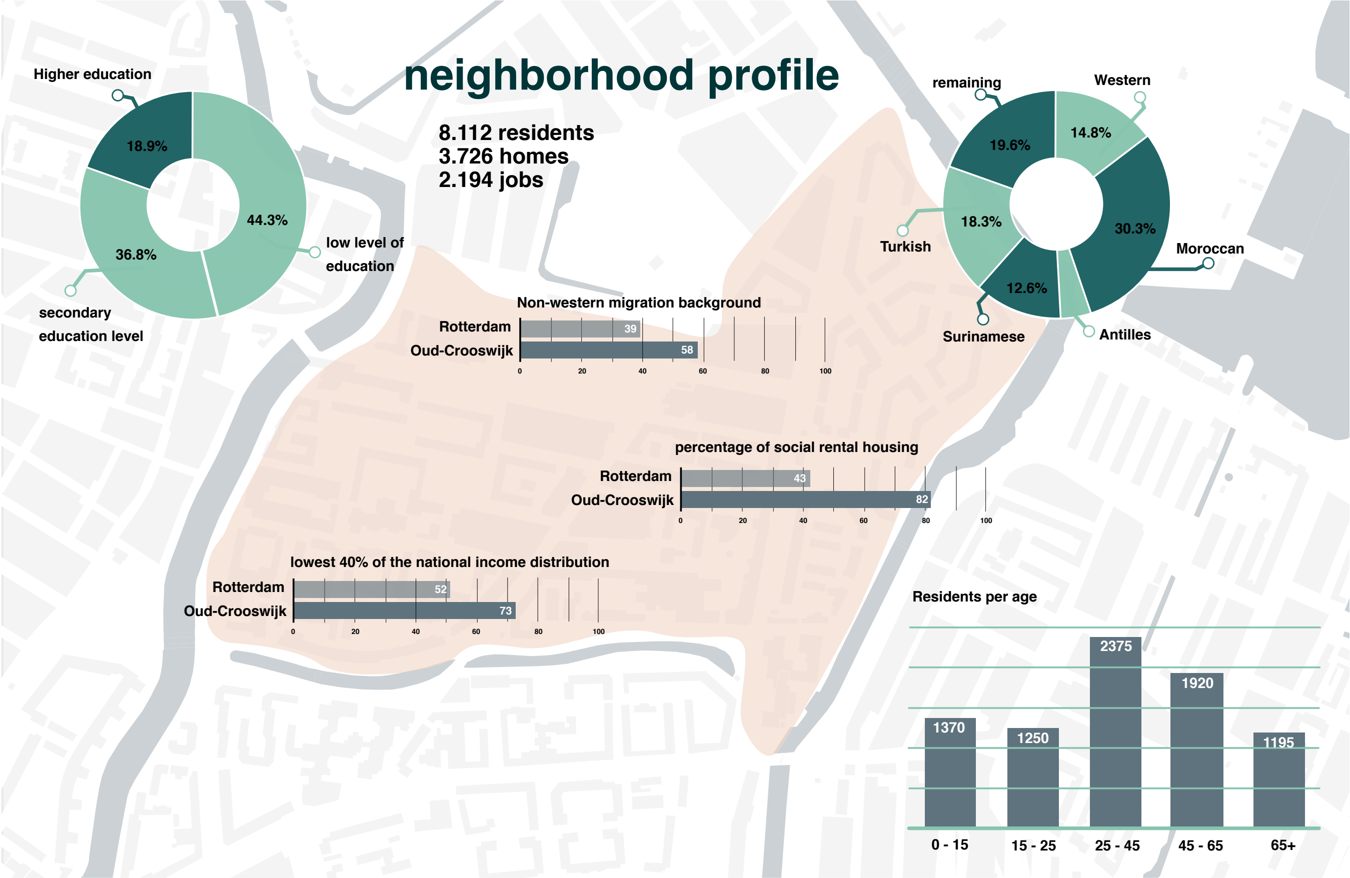


Figure 58: Map of Oud-Crooswijk with statistics on residents (Gemeente Rotterdam, 2022)

Neighbourhood profile

Oud-Crooswijk is a city district dominated by a residential program. 8112 people are living there in the 3.726 homes. The area exists for around 80% of built-up area, so there is relatively little public space. More than 80% of the people only have a lower or secondary education level. 73% of the neighbourhood lives within the 40% lowest national income distribution. Therefore the neighbourhood has 82% social housing.

Figure 58 compares their percentages with the Rotterdam city average for comparison. Furthermore, Oud-Crooswijk is a mixed neighbourhood with people of different ages and backgrounds.

Figure 59: Map of Oud-Crooswijk with all social housing highlighted (Woonlastenatlas, 2014)

Social housing locations

Currently, 82% of all housing in the neighbourhood is social housing. Social housing has the subcategories: “social basis” and “social plus”. Oud-Crooswijk has 3065 “social basis” houses and 357 “social plus”. The rent of social basis is 680,0 euros a month, and social plus has a rent of 680,0 - 752,0 euros. Currently, the leading social housing corporation in the neighbourhood is Havensteder.

They have plans to improve the living conditions and thus plan to renovate. It would mean that a significant share of the currently “social basis” rental homes would become “social plus”. There would only be 1819 “social basis” houses left, and there would be an increase in the “social plus” and regular rental properties.

Figure 60: Map of construction year within Oud-Crooswijk (Atlas leefomgeving, 2018)

Construction year

54% of the housing in the neighbourhood is from the ‘80s. A large share, 24%, is still from before 1945. The main typology in the neighbourhood is apartment buildings. As mentioned before, most of the houses are social housing. The remaining share is 9% private rent and 8% privately owned homes.

Figure 61: Map of neigborhood borders Oud-Crooswijk

Neighbourhood borders

The district surrounds itself with water from three sides. On the west side, this is the Rotte. The Rottekade is also an important route into the city that many people use to walk or drive along. On the south side, Crooswijkse Singel borders the district; this green singel is very suitable for walking by. The connection of the Crooswijkse Singel on a larger scale is not as prominent of a connection as other alternatives. People use the Goudse Rijweg more often as an east-west connection between Oude Noorden and Kralingen. On the east side, the Boezem borders the district, a popular place for residents to walk past or go fishing.

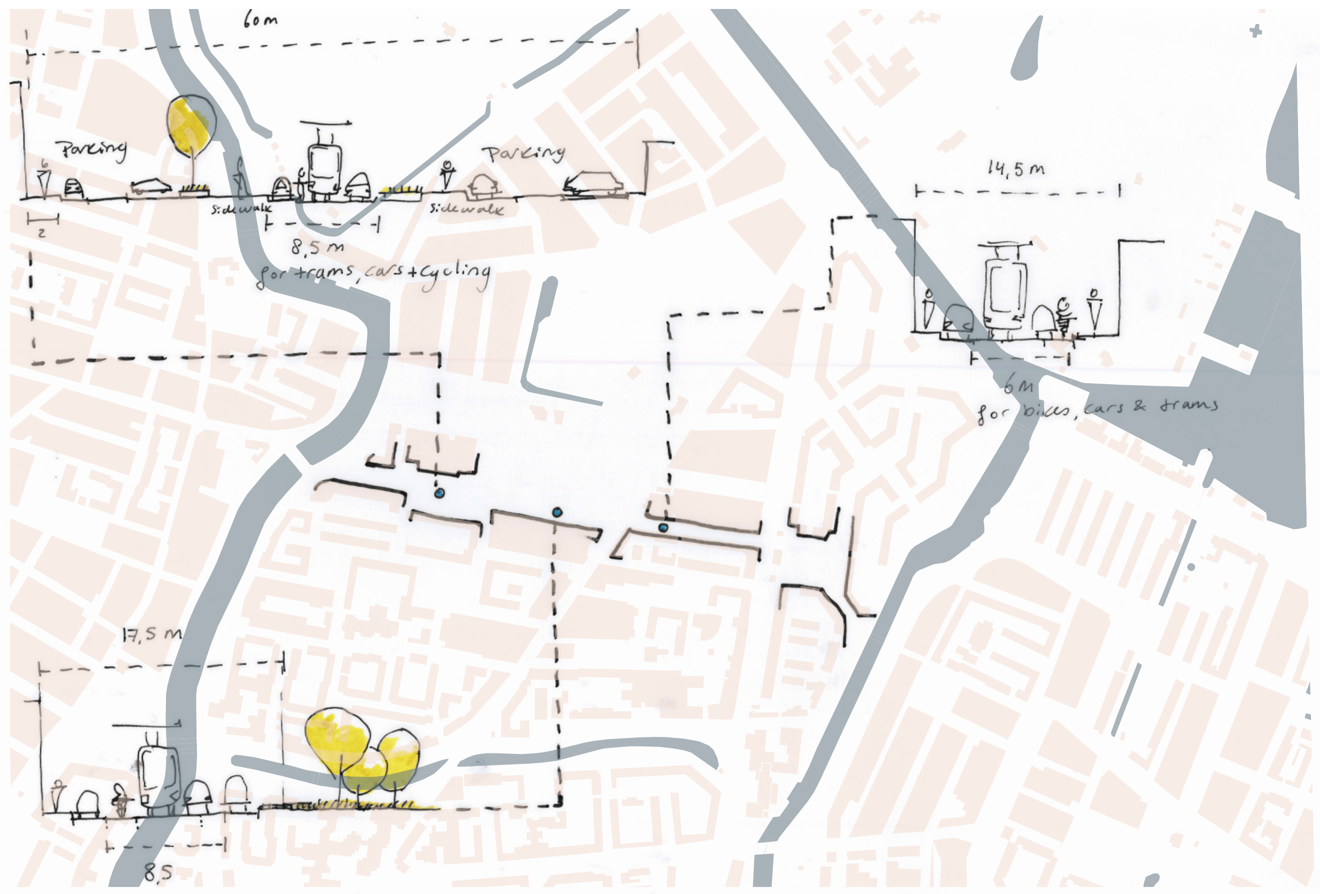


Figure 62: Map of Oud-Crooswijk with sections showing the Crooswijksestraat at three points

Crooswijkstraat

There is also another possible connection between Oude Noorden and Kralingen by bicycle, the shortest as the crow flies, and the bridge over the Boezem on the east side is only for slow traffic. In theory, this would thus be the most obvious route to cycle. However, this is not a popular choice because it is a busy route for motorists and the tram. Moreover, all these flows must pass over a tight street profile, as seen in figure 62.

It is a road where many accidents happen. The cross-sections show that, at some points, the entire profile is broad, but most of the space includes parking. Consequently, there is an opportunity to make this connection more pedestrian and bicycle-friendly.

8.2 Oud-Crooswijk challenges

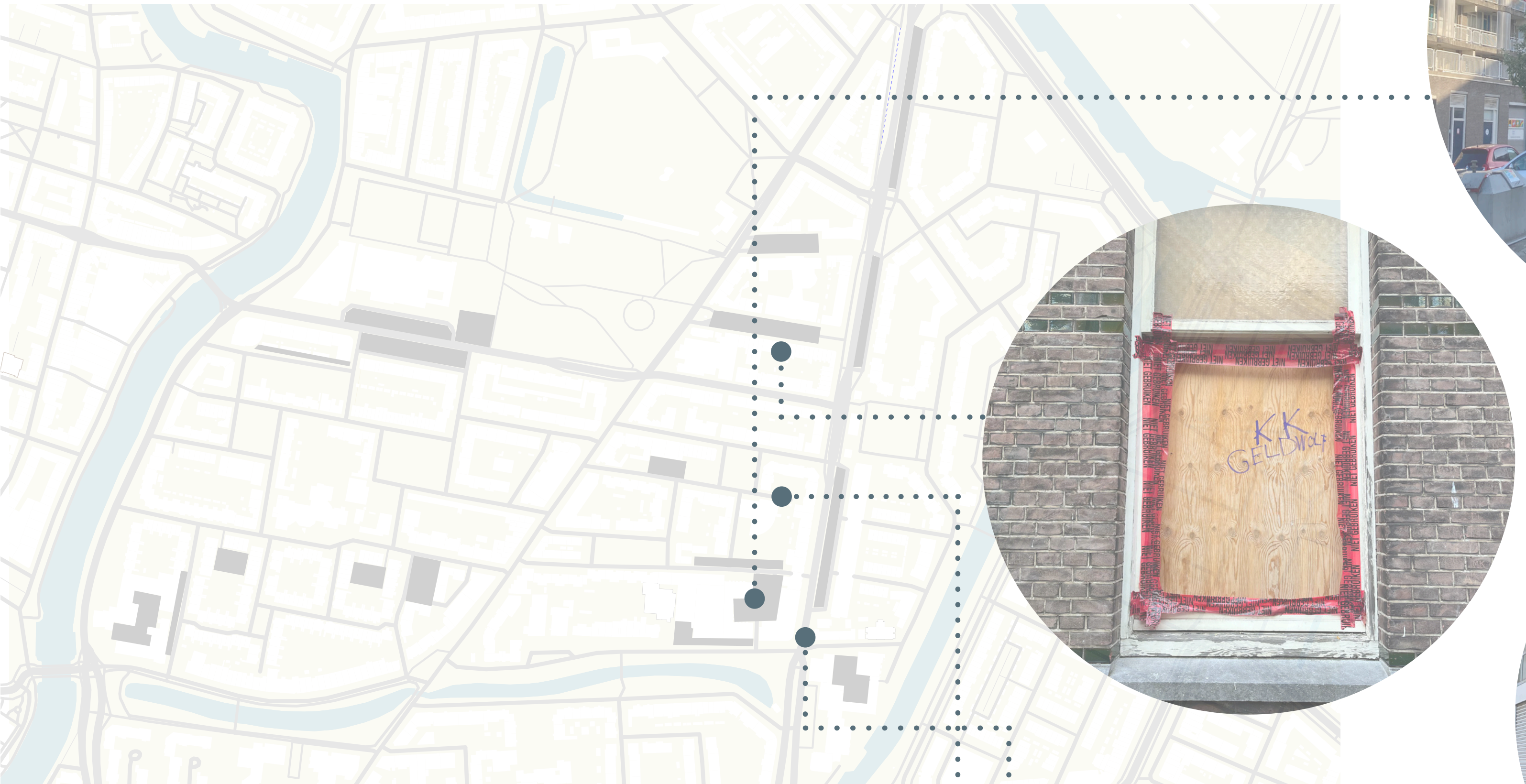


Figure 63: Map of Oud-Crooswijk with main parking locations and pictures showing challenges in the neighbourhood

Oud-Crooswijk has many beautiful spots. Yet, also places that could benefit from some change. The district has several places where the streetscape is entirely dominated by cars.
For example, street profiles in the neighbourhood are broad because there are parallel streets where parking is available. As a result, cars occupy most of the public space. Moreover, there is less room for people to walk and interact. There are also many parking lots in the area, in courtyards and at the backs of houses. It creates uninviting spaces, which can also feel unsafe, because of the lack of social control. In addition, the deferred maintenance and signs of vandalism in the area create an impression of an unreliable neighbourhood.

8.3 Oud-Crooswijk opportunities

Figure 64: Map of Oud-Crooswijk with main green structues and pictures showing opportunities in the neighbourhood

There are many existing qualities in the district. Beautiful green structures surround the neighbourhood. It has public spaces that are well-used by residents and lively shopping streets where people meet each other. There is a lot of street art to see and numerous green facades.

There is an opportunity to maintain better, safeguard and sometimes better connect these spaces.

9. Energy Potential

How much energy would a wind turbine generate in the middle of the neighbourhood? Or what if we fill all public spaces with solar panels? There are many ways to generate energy, so the district has much potential. What do these different ways look like, and how much does it yield? This chapter looks at the energy potential per renewable energy source.

Picture: 7: Solar panels on the roof of ING Cedar office.
© Hans Wilschut - www.hanswilschut.com/

9.1 What is an energy potential?

The goal of the design is to produce energy consciously; this chapter starts with the energy potential. The energy potential shows how much energy can be produced sustainably in and for the neighbourhood. Some sustainable resources are impossible to realise within the neighbourhood.The research only focuses on proven and applied methods of sustainable energy production.

For each energy source, a map shows a potential location in the district and how much energy this could generate. As well as how much this could generate at different times of the year. It is necessary first to see the energy potential to be able to conclude the possibilities.

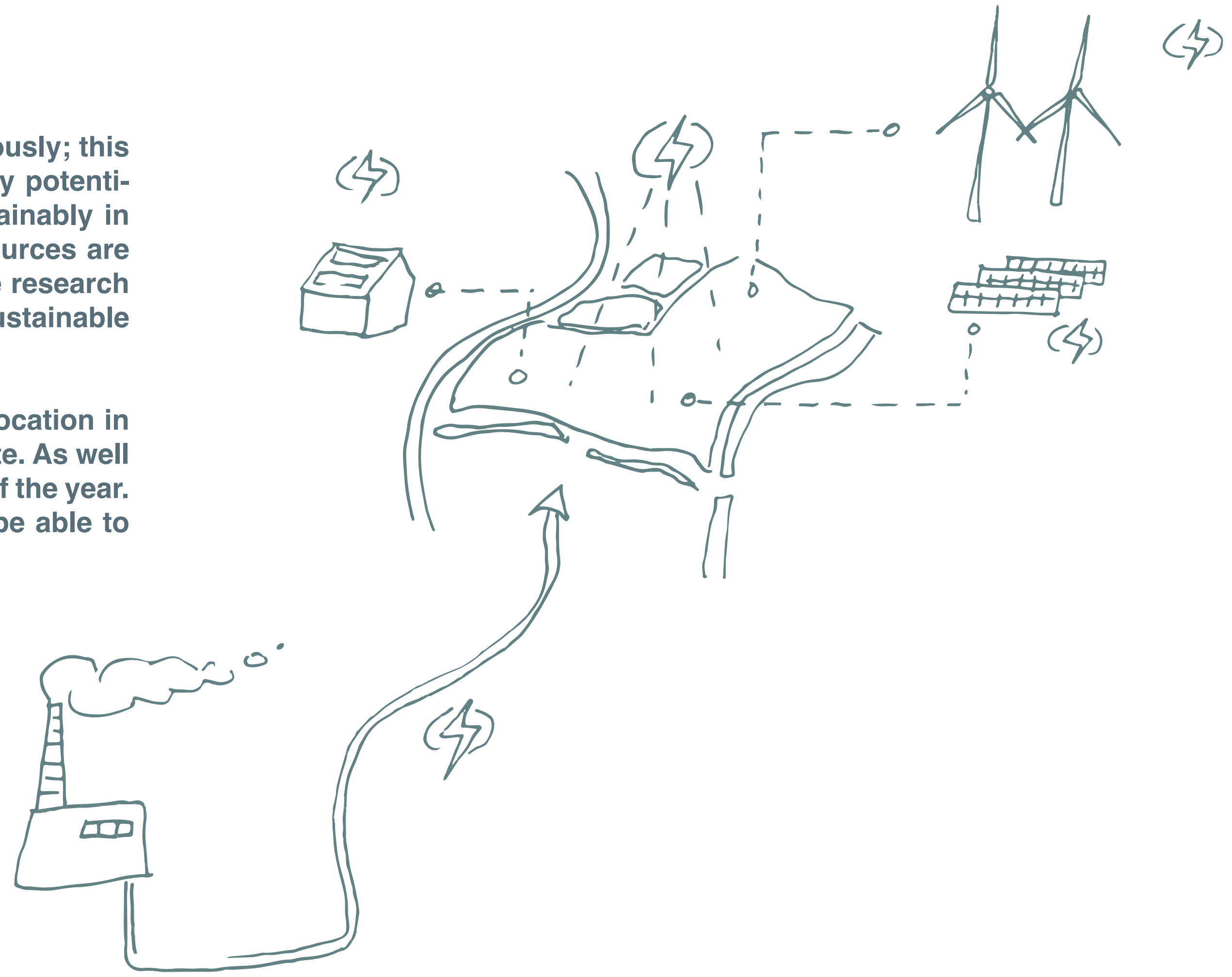


Figure 65: Illustration of energy potential of the neighbourhood

9.2 Thermal energy surface water - standard

Method

Thermal energy surface water extracts energy from existing water bodies and takes advantage of the temperature differences of the surface water during the seasons (Kruit et al., 2018). Surface water heats up by the sun, and it is possible to extract this heat. In the summer, heat from the surface water is stored, for example, in an ATES installation (heat and cold storage) (Kruit et al., 2018). The standard way starts when the water temperature is above 15 degrees and stops decreasing when the water temperature has decreased by 6 degrees (Kruit et al., 2018).

Advantages

The advantages of this production method are that surface water can be found all around Oud-Crooswijk and that the potential is significant. It also does not have a substantial spatial impact.
In addition, it can help with heat stress in the summer because water can retain heat for a long time and increase the urban heat island effect. Taking the heat off can help relieve heat stress.

Disadvantages

The disadvantage of this method is that it is only available in the summer when the water is heated. There is also an ecological risk in manually adjusting the water temperature. In addition, as described in the method, additional installations are required.

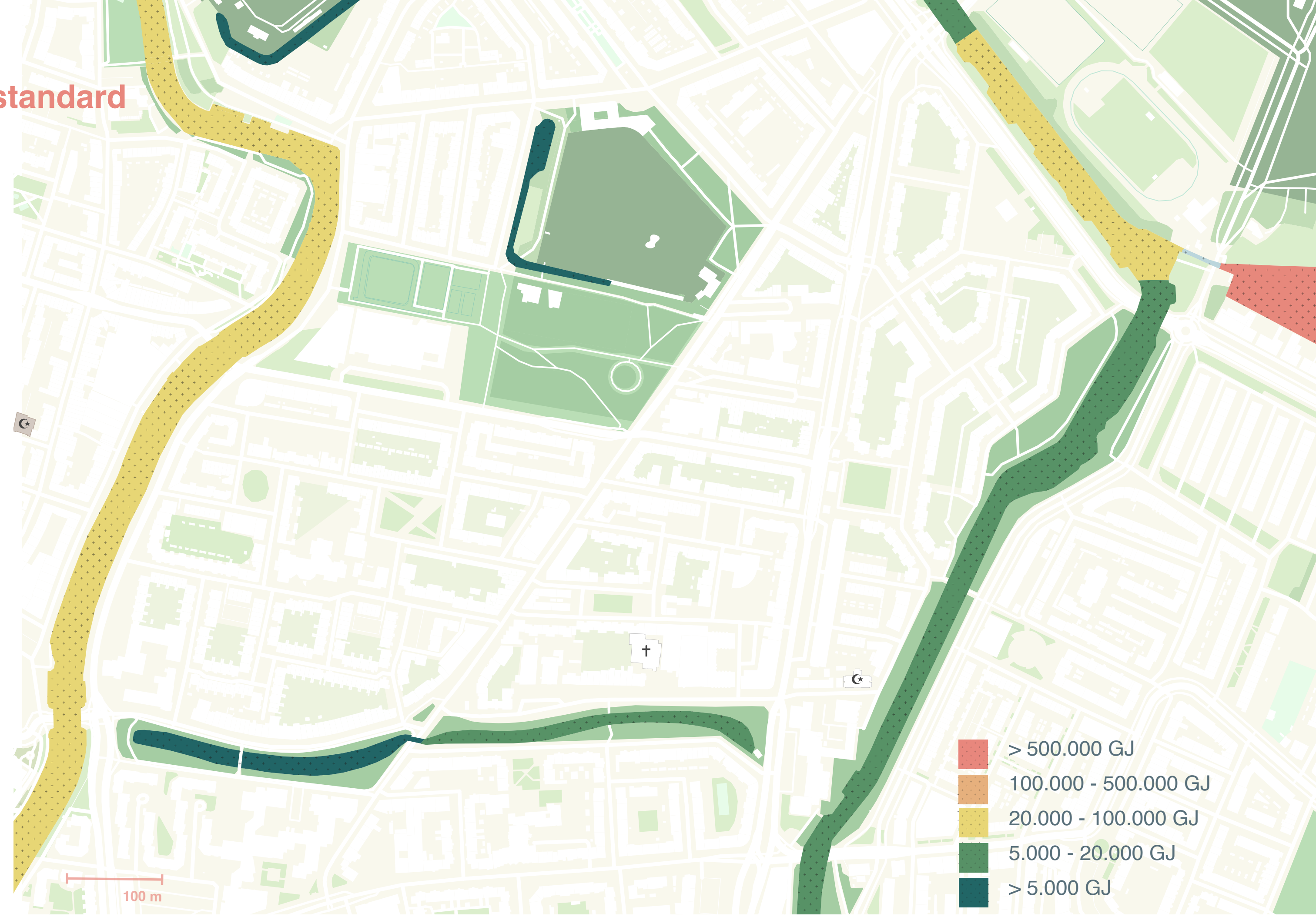


Figure 66: Thermal energy surface water - standard
Source: Deltares, Syntraal, KWR en Mapgear B.V., met medewerking van STOWA, Rijkswaterstaat en Netwerk Aquathermie. (2021) programma: WarmingUP (https://warmingup.geoapps.nl/aquathermie?permalink=3076edd04a1c47a1bbd11dd985a4331d)

Potential: 114.688 GJ/year
min: 83.911 GJ/Year
max: 148.123 GJ/Year

9.3 Thermal energy surface water - year round

Method

Similar to the method of the standard version of thermal energy surface water, but with one difference. As the name implies, this applies all year round. The starting temperature for the water is above 7 degrees Celsius, with a maximum drop of 6 degrees (Kruit et al., 2018). Moreover, the water should not fall below 4 degrees, so it is possible to extract heat from the water for a large part of the year.

Advantages

A significant advantage is that this method can be used all year round, compared to only during the summer. In addition, it also has the advantages of the aforementioned standard method. So it does not have a significant spatial impact and can help with the urban heat island effect.

Disadvantages

The energy potential of this method is much lower. In addition, the ecological risk is also greater. Furthermore, with this method, additional ATES installations are required. Because it is only possible to generate relatively little energy, the question is whether the advantage of producing all year round outweighs this.

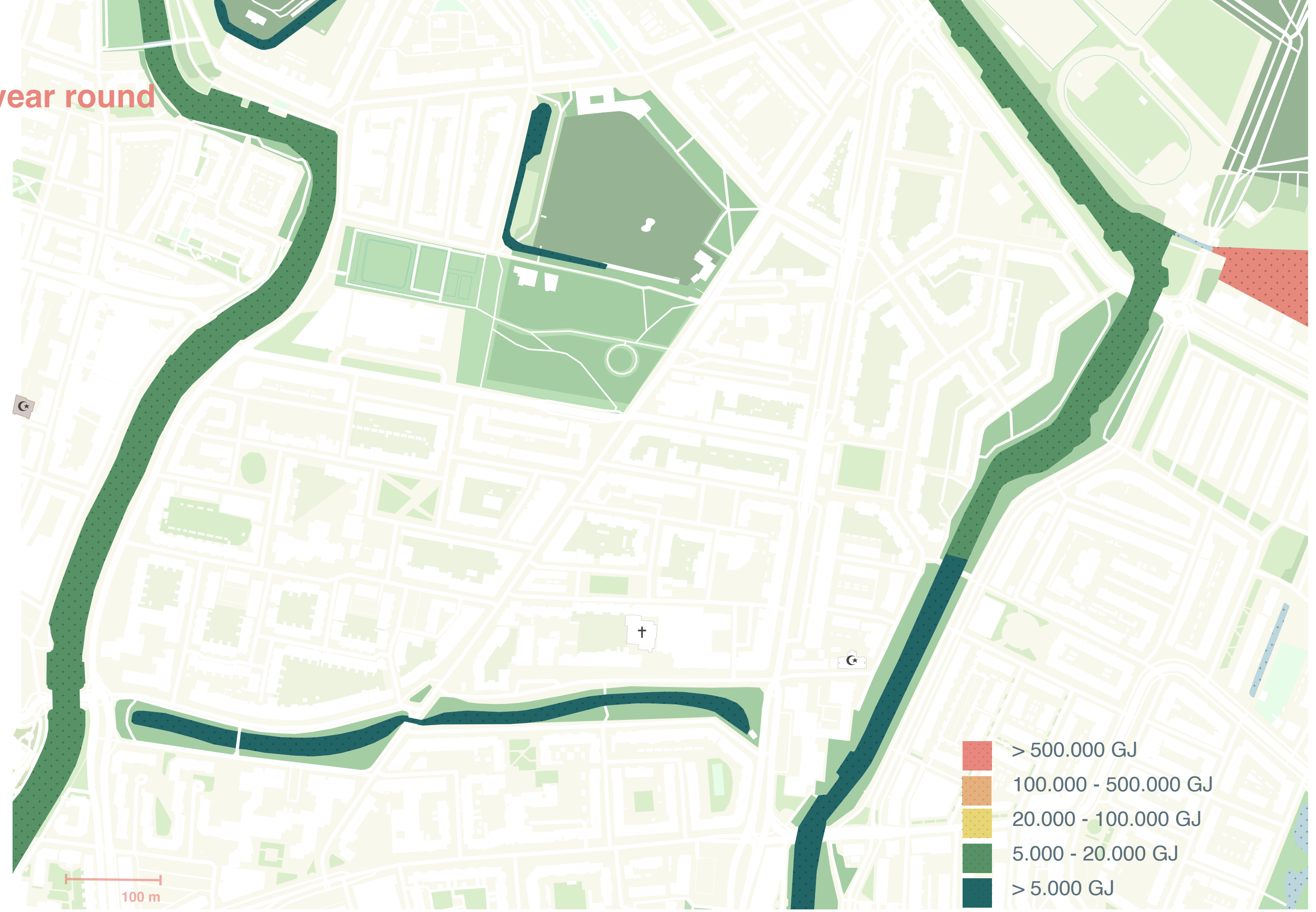


Figure 67: Thermal energy surface water - year round
Source: Deltares, Syntraal, KWR en Mapgear B.V., met medewerking van STOWA, Rijkswaterstaat en Netwerk Aquathermie. (2021) programma: WarmingUP (https://warmingup.geoapps.nl/aquathermie?permalink=3076edd04a1c47a1bbd11dd985a4331d)

Potential: 43.326 GJ/year
min: 26.681 GJ/Year
max: 62.040 GJ/Year

9.4 Residual heat network

Method

A residual heat network uses heat produced by existing industries. This heat is often a discharged residual product. By utilizing a heat network, the residual heat is used to heat homes. Rotterdam already has a heat network, for which the heat produced by a waste processing company in the port is used (Rotterdamse Transitievisie Warmte, 2021). The entire city is not yet connected, and not all resources have been used (Rotterdamse Transitievisie Warmte, 2021).

Advantages

An advantage is that residual heat can be produced and used all year round. Of course, this depends on the source, but most industries run all year round. Another advantage of this network is that the spatial impact is minimal once it has been installed. However, all streets must first be broken open to construct this. The municipality of Rotterdam estimated the district that residual heat is the best alternative for the neighbourhood, other factors, such as costs, were also included in the analysis by the municipality (Rotterdamse Transitievisie Warmte, 2021).

Disadvantages

Currently, the source is not sustainable because waste processing is not circular. It is, thus, not a good option from the point of view of a sustainable future. The residual heat, which continues all year round, can also cause heat stress in the summer.

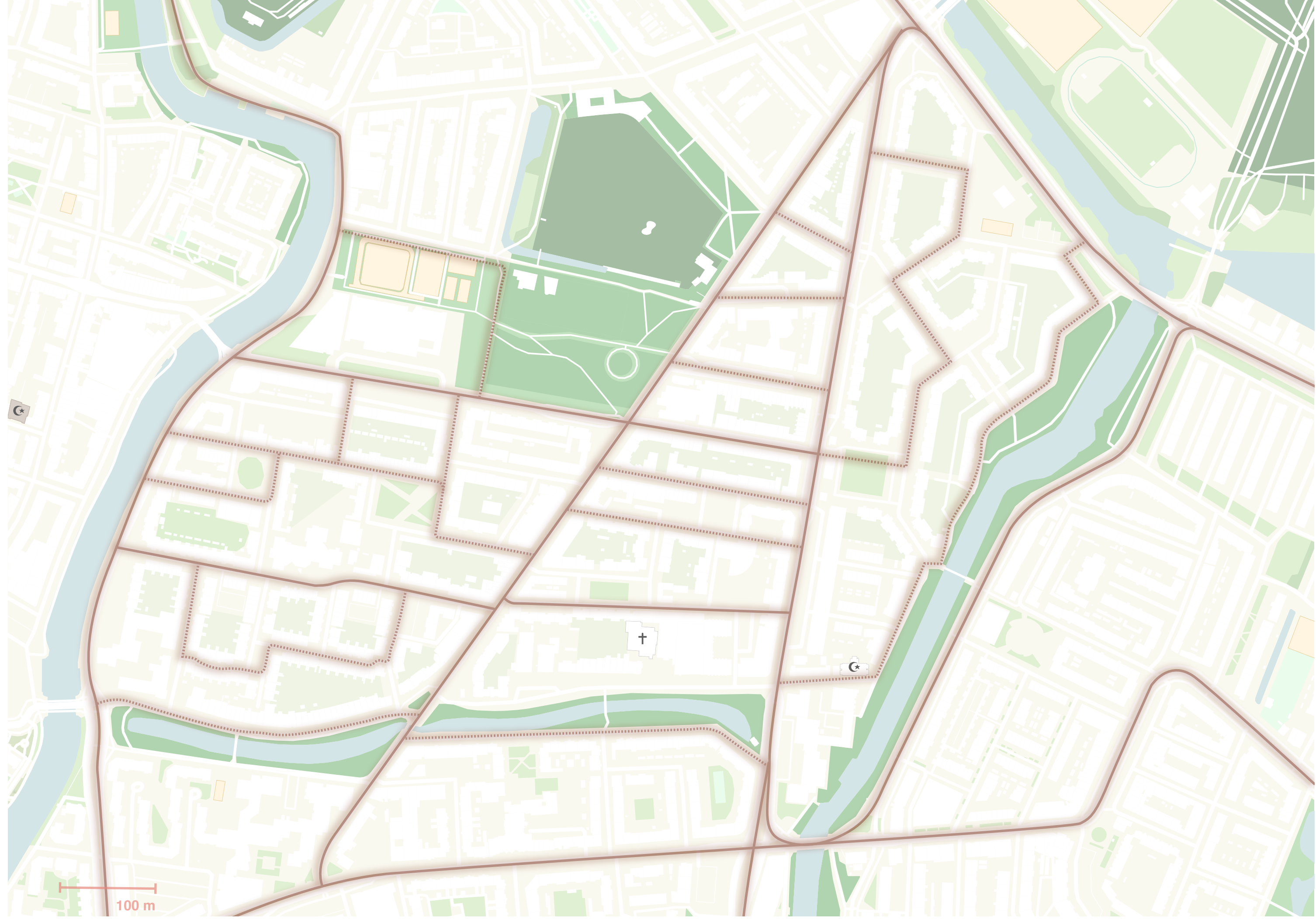
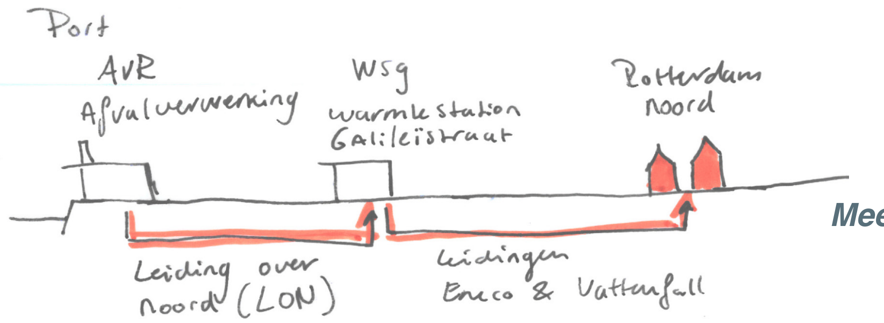
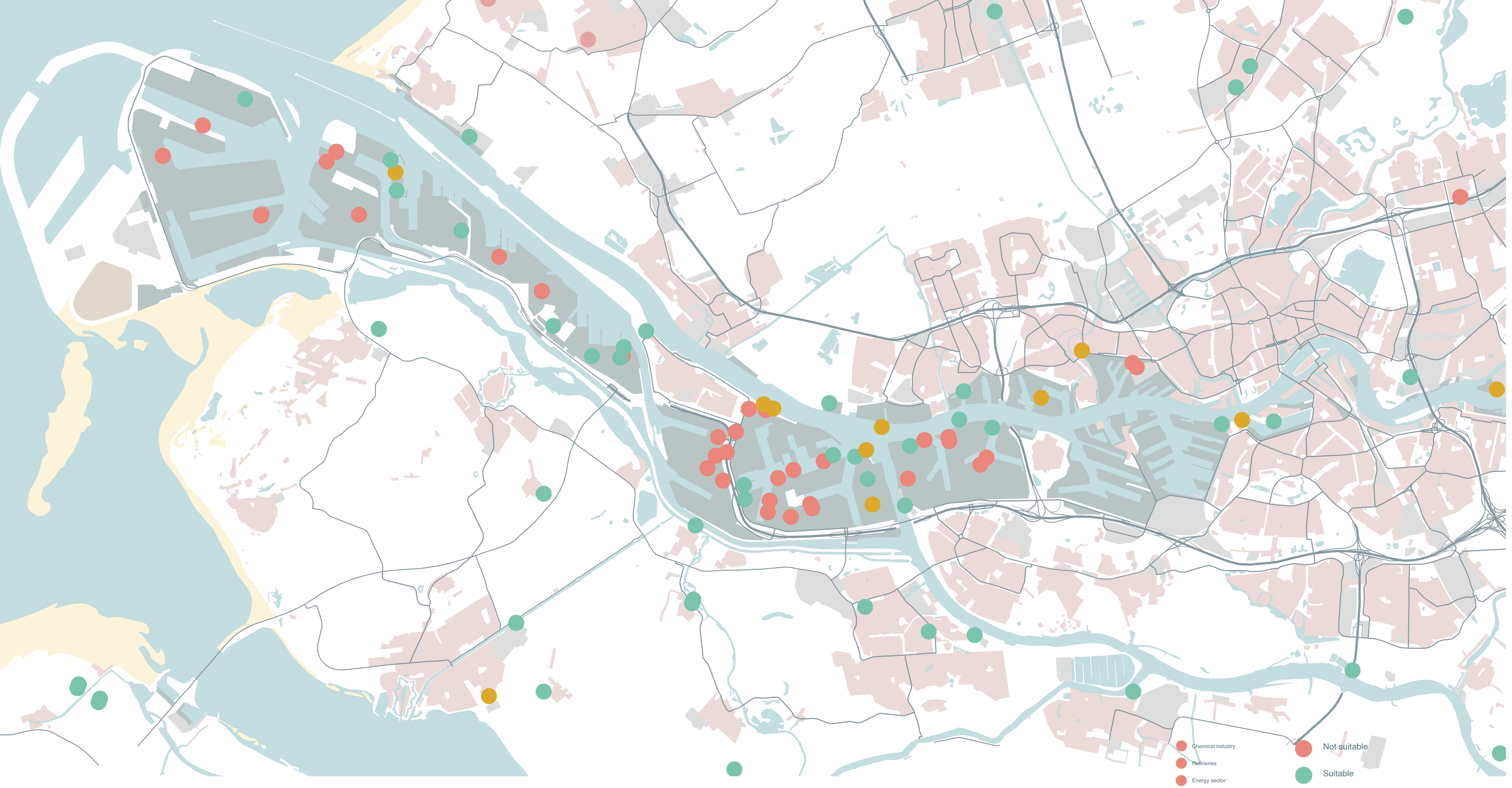


Figure 68: Residual heat network projected on Oud-Crooswijk



Potential:
Meets the heat demand of the area



Other sources

Many industries in the port can potentially contribute to the heat network. Many of these industries are not sustainable in the long run—for example, refineries, the chemical industry, or the current source of waste incineration. Some industries, such as transport companies or sewage and water treatment plants, are suitable sources for a sustainable future.

Figure 69: Potential residual heat network sources in the port of Rotterdam
Source: Rijksdienst voor Ondernemend Nederland (RvO) (2010) Nationale EnergieAtlas (https://nationaleenergieatlas.nl/kaarten?config=418d0f56-0f0c-4fd4-9001-2ead4e1e22d6&gm-x=150000&gm-y=460000&gm-z=3&gm-b=1542632922900,true,1;1555074151231,true,1;&activeTools=layercollection,-search,info,bookmark,measure,draw&activateOnStart=layermanager)

9.5 Geothermal heat

Method

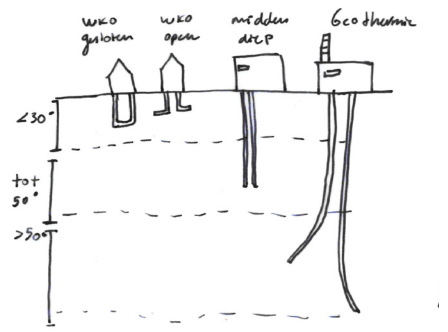
Geothermal heat uses the natural heat of the earth itself. It will be excavated at different depths between 500 meters and 6 kilometres. The depth influences the temperature (Kuijers et al., 2018). Two wells are needed, one to pump the warm water and one to let the cooled water back into the ground (Kuijers et al., 2018).

Advantages

Geothermal heat is a resource that can be used all year round. The source is also not dependent on weather influences and other systems, such as residual heat from industries.

Disadvantages

The construction of a geothermal system is costly. In addition, there are risks of earthquakes and contamination of the groundwater. Moreover, the installation size is considerable compared to the neighbourhood (Sijmons et al., 2014).



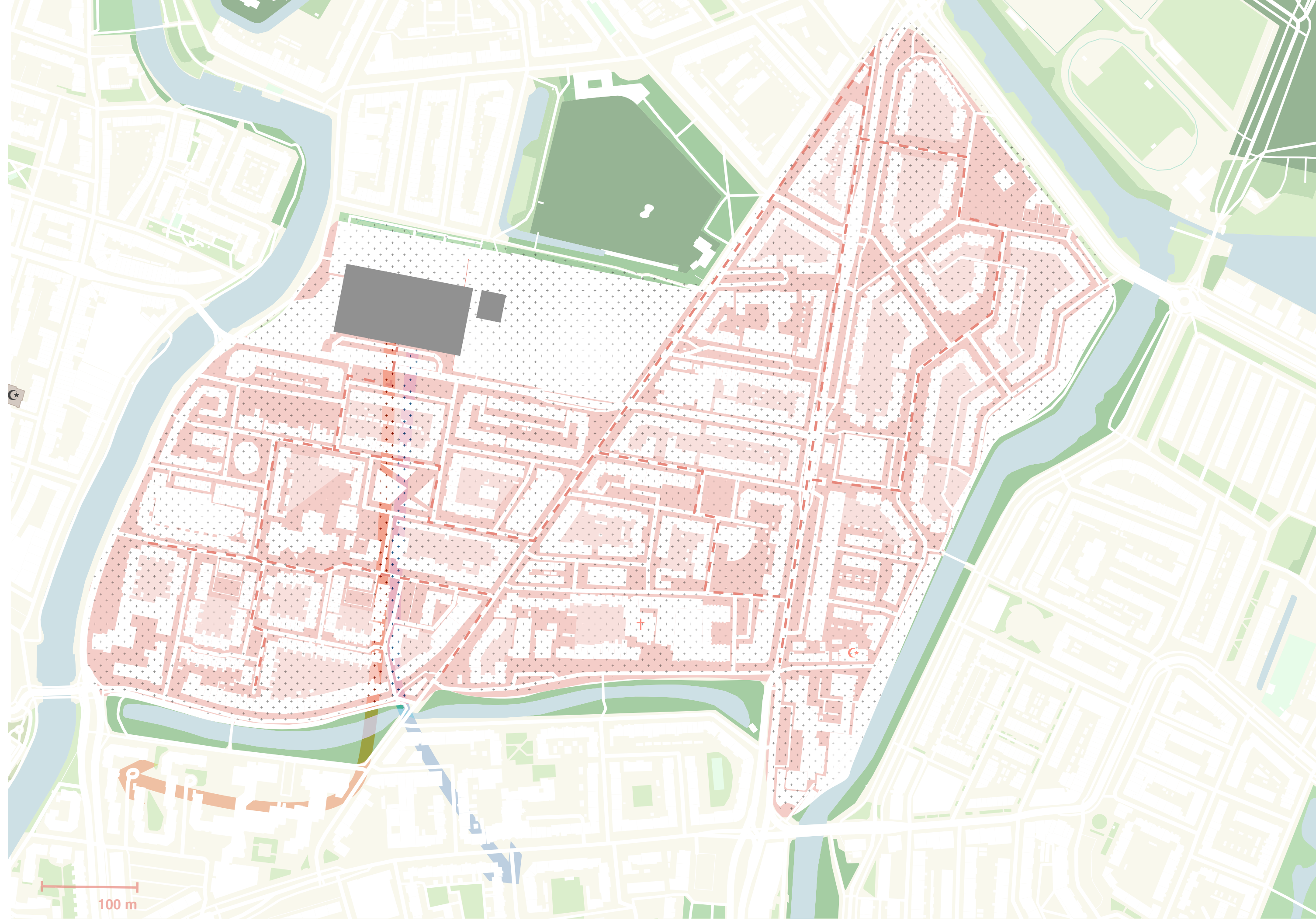


Figure 70: Geothermal heat potenital Oud-Crooswijk Source: Deltares, Syntraal, KWR en Mapgear B.V., met medewerking van STOWA, Rijkswaterstaat en Netwerk Aquathermie. (2021) programma: WarmingUP (https://warmingup.geoapps.nl/aquathermie?permalink=3076edd04a1c47a1bbd11dd985a4331d)

Potential:
194.553,99 GJ/Year

9.6 Solar fields

Method

Solar fields are solar panels placed in an open area. The field should not be in the shade so no obstacles, such as trees, can stand in the way. This method is mainly a solution that takes place outside the city.

Advantages

There is the potential to install solar panels in large numbers, so much energy can be generated in theory.
Another advantage is that the space under the solar panels can be used, for example, for urban farming. It can be an exciting form of mixed-use.

Disadvantages

There are few suitable locations in the city, especially in densely built-up areas. Besides, the open plains that are there are often green.
In Oud-Crooswijk, many trees would have to be felled to realise these solar fields. In total, due to the lack of space, the potential is not very significant.

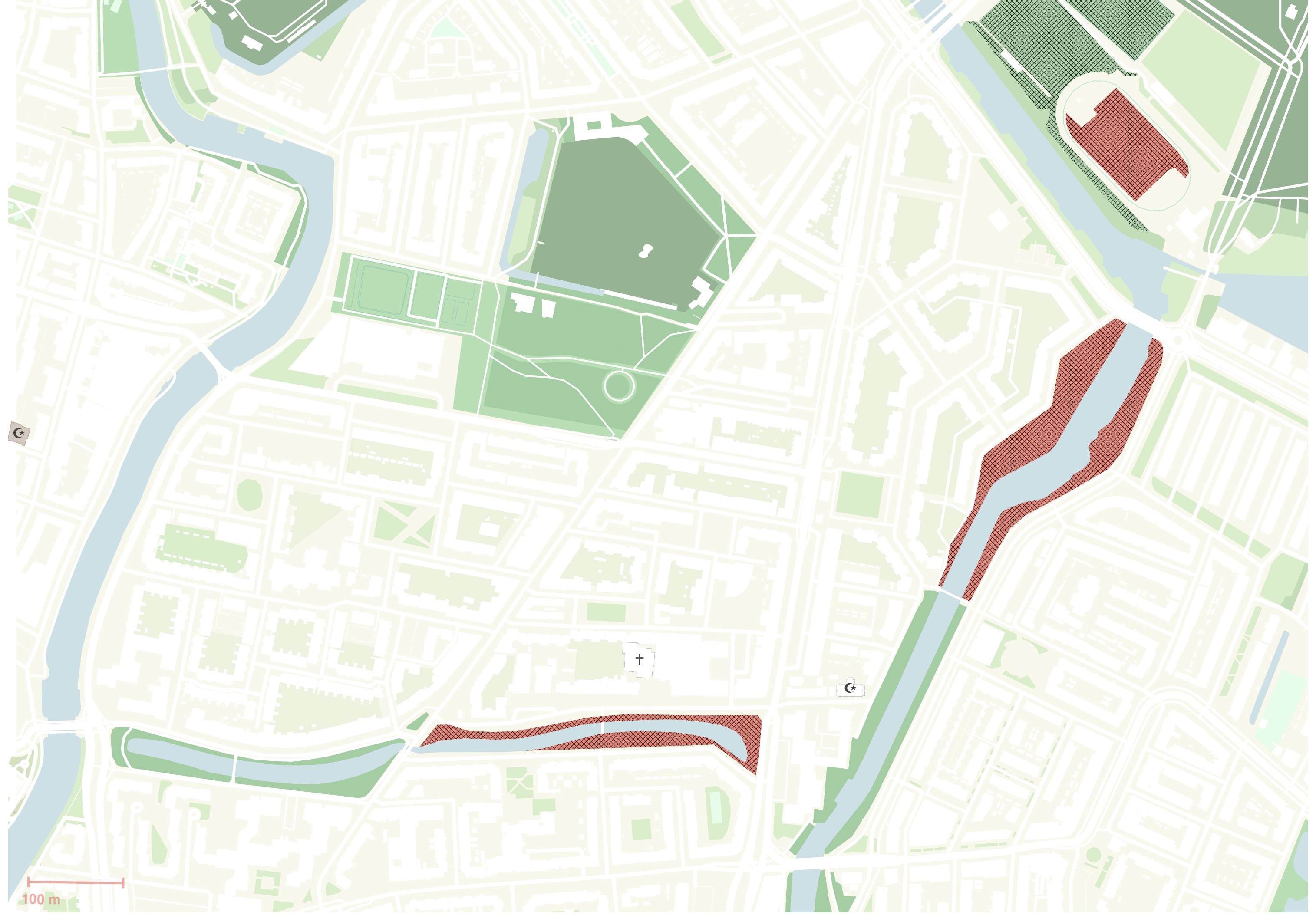


Figure 71: Energy potential solar field Oud-Crooswijk (Nationale EnergieAtlas, 2016)

Potential:
4.275 KWH

9.7 Solar rooftops

Method

It is possible to place otherwise place solar panels on rooftops. Not all roofs are equally suitable for this. The suitability has to do with the angle with respect to the sun. How big the roof is and how much available space there is on the roof. Solar panels work better when they do not get too warm, so a green roof can help.

Advantages

Many rooftops in the neighbourhood are very suitable and have much space for solar panels, so they can provide relatively much energy (Zonatlas). Consequently , the spatial impact is not too bad because it only takes place on roofs; it influences the public space less.

Disadvantages

Some buildings fall under a protected cityscape, and solar panels could disrupt this. Solar panels do not generate the same amount of energy all year round; considerably more is generated in the summer. Ownership can make this complicated as a large part of the neighbourhood consists of social housing, a small part is private rental housing, and a tiny part is privately owned.

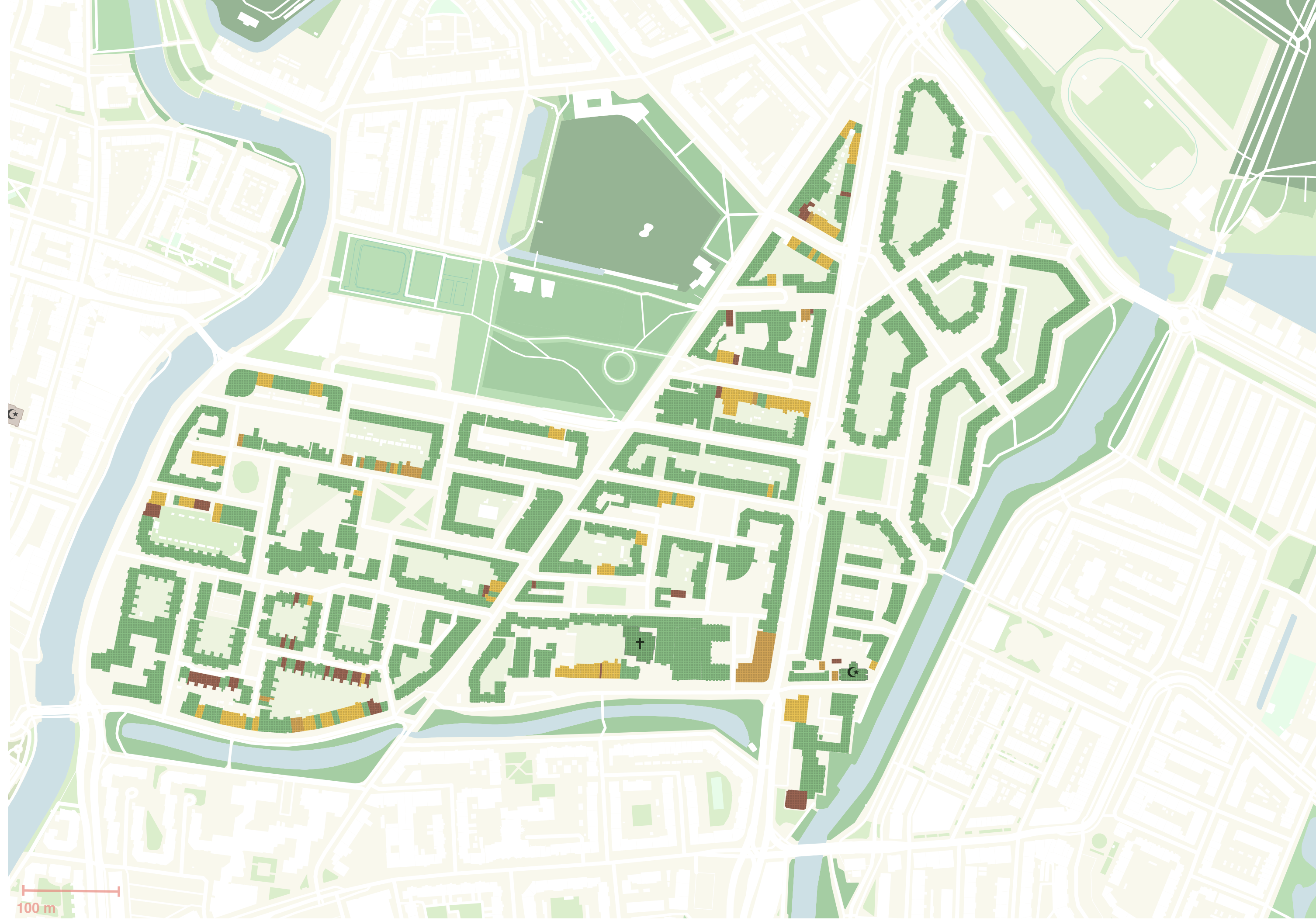


Figure 72: Energy potential solar rooftops Oud-Crooswijk (Zonatlas)

Potential:
7.598.315 KWH
max: 10.513.947,5 KWH

9.8 Wind turbines

Method

A wind turbine cleverly converts wind energy into electricity. There are different sizes, and the latest models can be 260 meters high (Kuijers et al., 2018). The oversized editions are about 120 meters high, and the medium types are up to 80 meters tall. It excludes urban windmills. Large wind turbines should not be less than 300 meters away from homes. The medium-sized turbines should be no closer than 100 meters from houses.

Advantages

Large wind turbines can produce an enormous amount of energy, especially in the colder months, and are, therefore, easy to combine with other sustainable production methods. Besides, since there is much wind in the Netherlands, this is a suitable form of energy production for the climate.

Disadvantages

It has many spatial restrictions, which means it cannot be placed in many places. In the context of Oud-Crooswijk, the only suitable places, far from residents, are in the cemeteries. It entails many complications. In addition, the spatial impact is significant. Even for people who live further away from it, it remains visible.

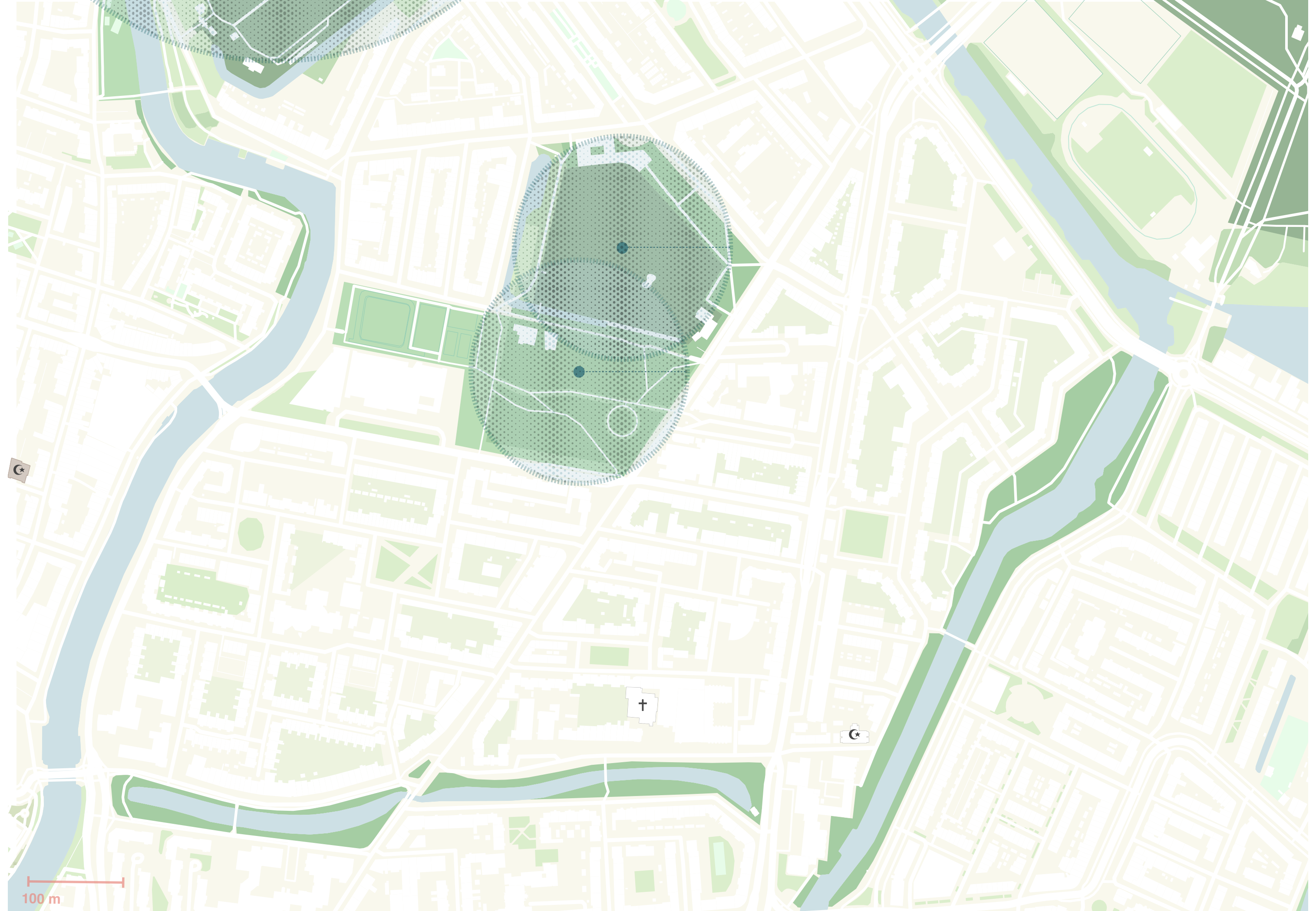


Figure 73: Energy potential wind turbines Oud-Crooswijk (Kuijers et al., 2018)

Potential:
8.200.000 KWH

9.9 Urban windmills

Method

Urban windmills are small wind turbines placed on top of built structures (Rezaeiha et al., 2020). The wind turbine itself is only a few meters high. Because they are built on top of existing buildings and structures, they can catch stronger wind. There are spatial restrictions in place. They can only be helpful when they are more than 20 m high because the wind is not strong enough closer to the ground (Rezaeiha et al., 2020).

There are also restrictions on their surroundings. There should not be any obstacles blocking the wind from the most common wind direction (south-west). The distance to the object must be 10 times the height of the obstacle, or the placement of the urban windmill must be higher than the obstacle.

Advantages

They have a minimal spatial impact, as they are only placed on existing higher structures. Thus, they are not apparent from eye level and are very suitable in an urban context.

Disadvantages

In theory, they are very suitable in an urban environment. However, they do have other spatial restrictions. In a densely built area, many obstacles block the wind. They are very inefficient if they do not catch enough wind. The potential of urban windmills in Oud-Crooswijk is not very high.

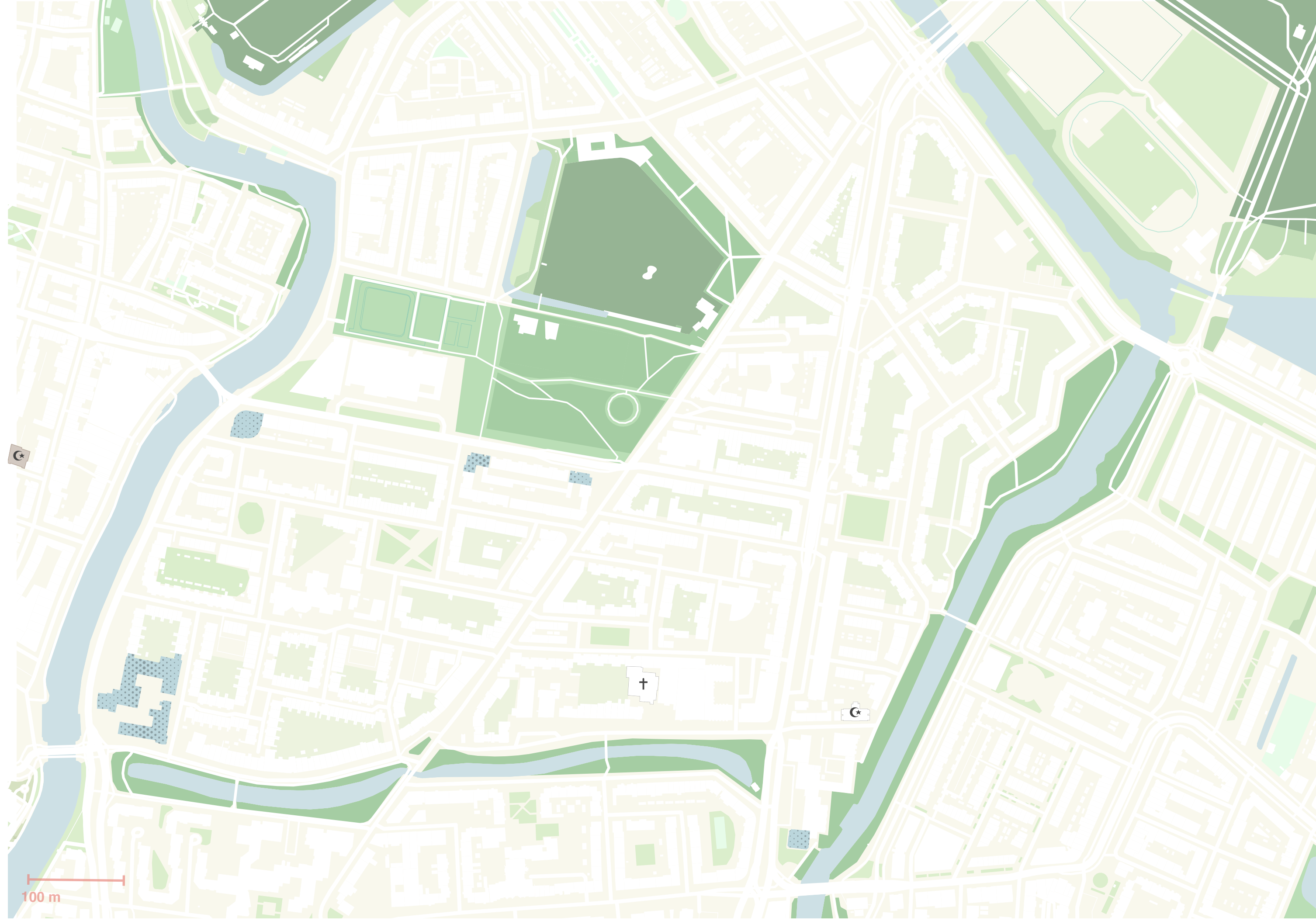


Figure 74: Energy potential urban windmills Oud-Crooswijk (Rezaeiha et al., 2020)

It is a densely built area with a majority of middle-rise buildings. Therefore only a few of the structures reach a height of more than 20 m. Of these structures, only a few do not have obstacles surrounding them. Consequently, there can be only a few urban windmills in the area, and the amount of energy they can produce is negligible, especially compared to the other energy potentials discussed within the chapter.

Potential: 65.600 KWH
max: 73.800 KWH
min: 57.400 KWH

9.10 Involvement matrix

Scale–involvement matrix

The different manners of energy production interact at different scales and requirements according to levels of involvement from the neighbourhood. For example, energy production on rooftops can be small-scale and would only require involvement from the people in the direct surroundings. In comparison, a wind turbine produces energy for a more significant part of the city and requires more involvement, as they can be seen from afar.
A residual heat network is interesting because it does not have a significant spatial impact, although it does contribute to a larger-scale energy network. The involvement is necessary because it does require citizen approval to be built. After all, the new network would need the whole area to be redeveloped. So the involvement and spatial impact are considerable at the start of the project.

The matrix differentiates between privately owned and corporation housing projects when it comes to solar panels, as ownership requires more involvement.

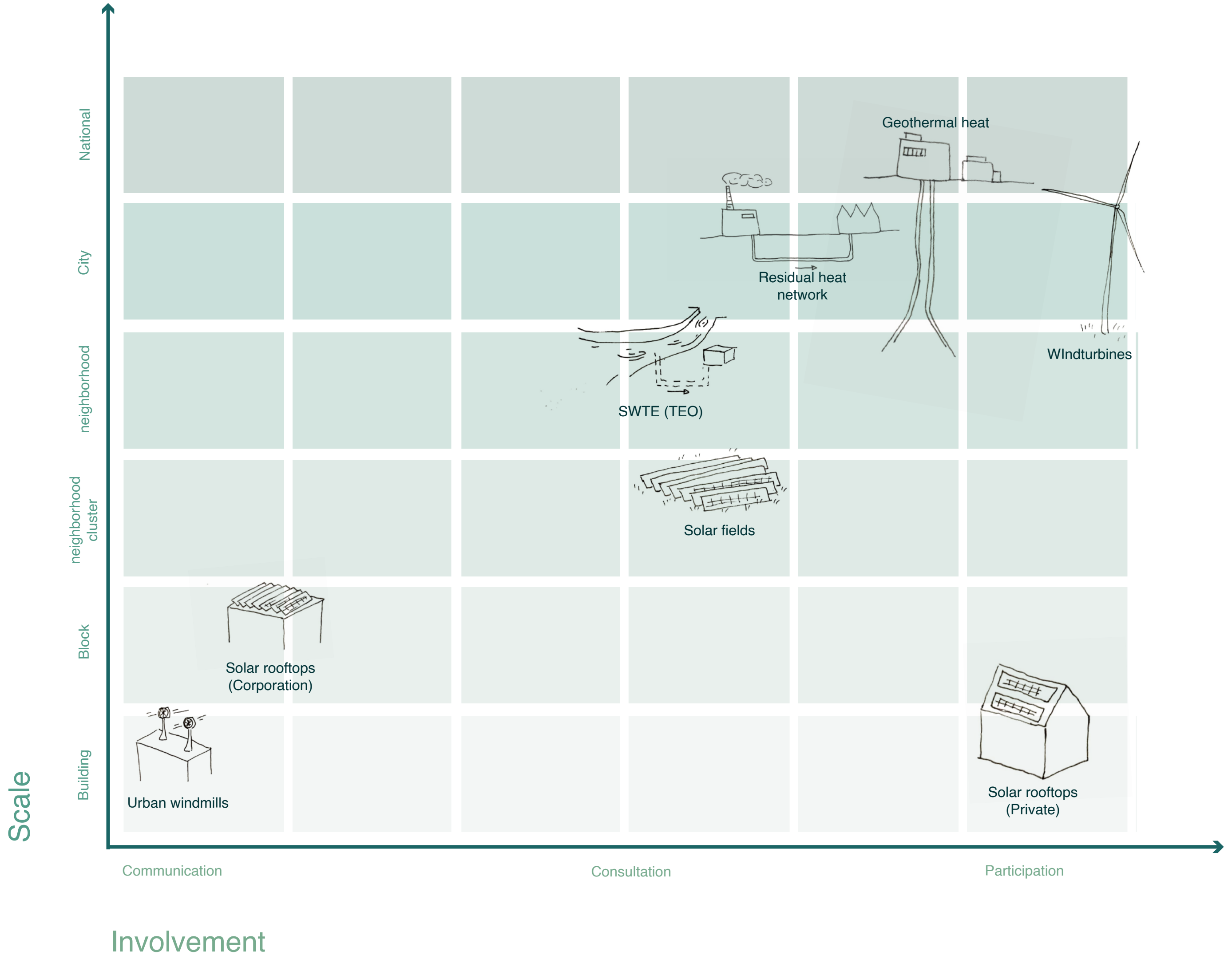


Figure 75: Scale-involvement matrix of all the energy potential studies

9.11 Conclusions

The graph shows the energy potential throughout the year compared to the energy demand. The energy demand is deficient in summer. In summer, people use less gas to heat their houses, but they also use less electricity. People spend less time at home, and it is longer light outside.

Solar panels will produce the most in the months with the most sun hours, mainly in summer and spring. It is a very effective way of energy production in these months.
The production is very ineffective in other months of the year. It is not a strong enough alternative to substitute fossil fuels; a combination with another type of energy production is always necessary.

Wind turbines, on the other hand, are most productive in colder months. In winter, the wind is more forceful, and wind turbines can run for more hours and produce more energy. In summer, they are less effective.
The combination of solar panels and wind turbines does create a potential solution for the current demand.

Monthly Electricity usage usage Oud-Crooswijk:

Month:	percentage:		Monthly electricity usage:	
Jan	10,5	%	841131,585	kWh
Feb	9	%	720969,93	kWh
Mar	9	%	720969,93	kWh
Apr	8	%	640862,16	kWh
May	7	%	560754,39	kWh
Jun	7,5	%	600808,275	kWh
Jul	7,5	%	600808,275	kWh
Aug	6,5	%	520700,505	kWh
Sep	7	%	560754,39	kWh
Oct	8,5	%	680916,045	kWh
Nov	9,5	%	761023,815	kWh
Dec	10	%	801077,7	kWh
Total	**100**	**%**	**8010777**	

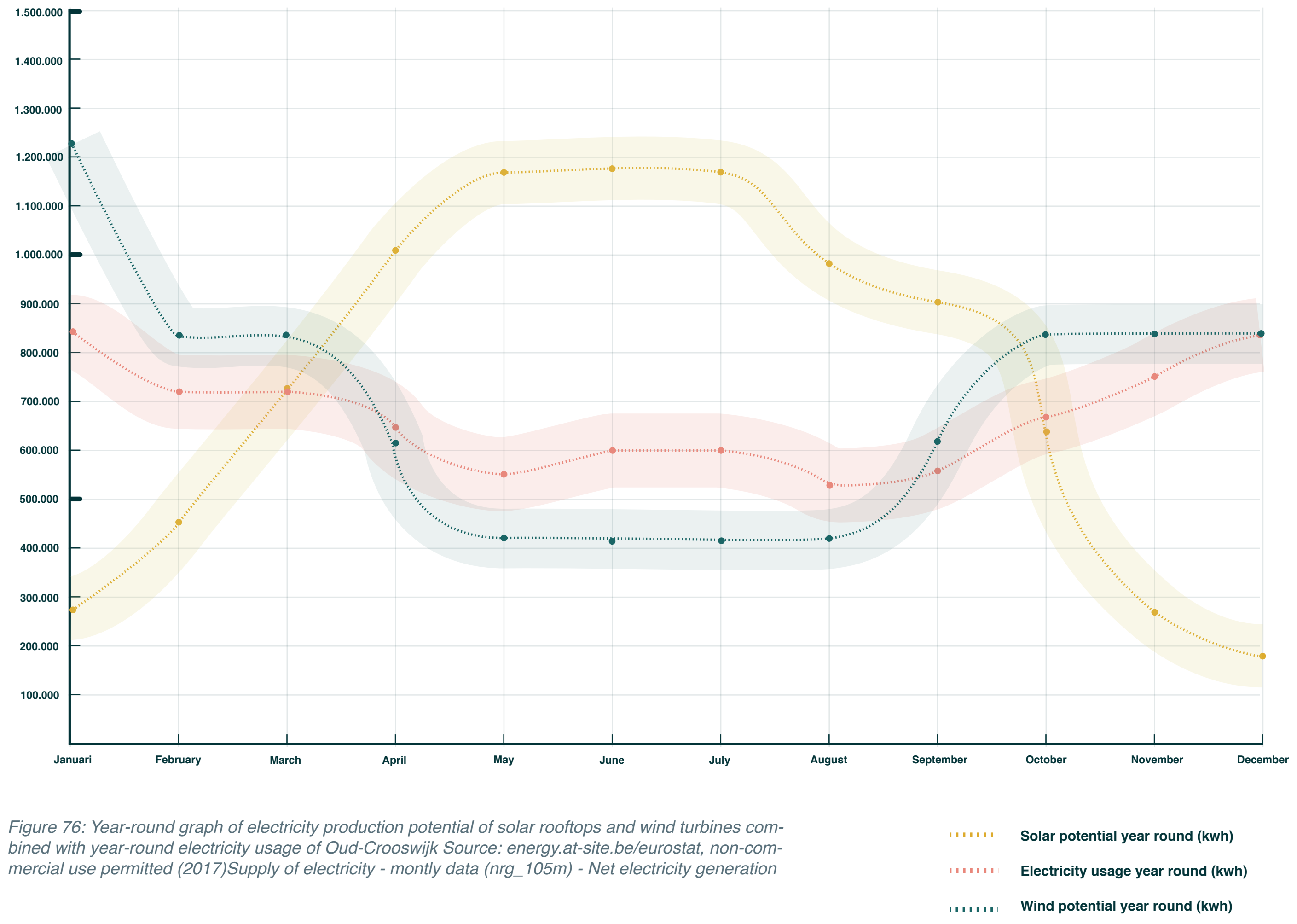


Figure 76: Year-round graph of electricity production potential of solar rooftops and wind turbines combined with year-round electricity usage of Oud-Crooswijk Source: energy.at-site.be/eurostat, non-commercial use permitted (2017)Supply of electricity - montly data (nrg_105m) - Net electricity generation

10. Scenarios

This chapter details the different possibilities of combining energy potentials in different scenarios. These scenarios are based on different levels of usage. The chapter will start with the scenario of current usage. The second scenario is the maximisation of production, so the maximisation of possible sustainable usage. The last scenario is an energy-saving possibility. All scenarios utilise existing built structures because this is the most sustainable solution.

Picture: 8: Power plant in the Netherlands at the border (Digitally enhanced by rawpixel)

10.1 Scenario of current usage

Scenario of current usage

The first scenario shows what sustainable energy potentials need to be utilised to meet the current demand. As mentioned in the last chapter, this is a combination of different modes of production to meet the electricity demand. Both solar panels and a medium-sized wind turbine are needed to achieve this. In addition, to fulfil the heat demand, a residual heat network is necessary. The current demand is met with all these new sustainable energy potentials. It does not consider future differentiation in demand, possible densification in the neighbourhood, or energy-saving methods and legislation.

Spatial impact

The scenario utilises three different methods of sustainable energy production. These methods exist in different locations on the scale-involvement matrix. This scenario will need higher levels of involvement for the wind turbine and the residual heat network. The neighbourhood needs to be on board with these plans. The solar panels are lower on the scale-involvement matrix. During the construction, most of the streets in the neighbourhood are opened up for the building of the residual heat network.

A consequence of this is that the spatial impact initially is considerable. Long term, the spatial impact will lessen. However, the wind turbine will define the view of many residents and the surrounding neighbourhood.

Figure 77: First scenario map of Oud-Crooswijk

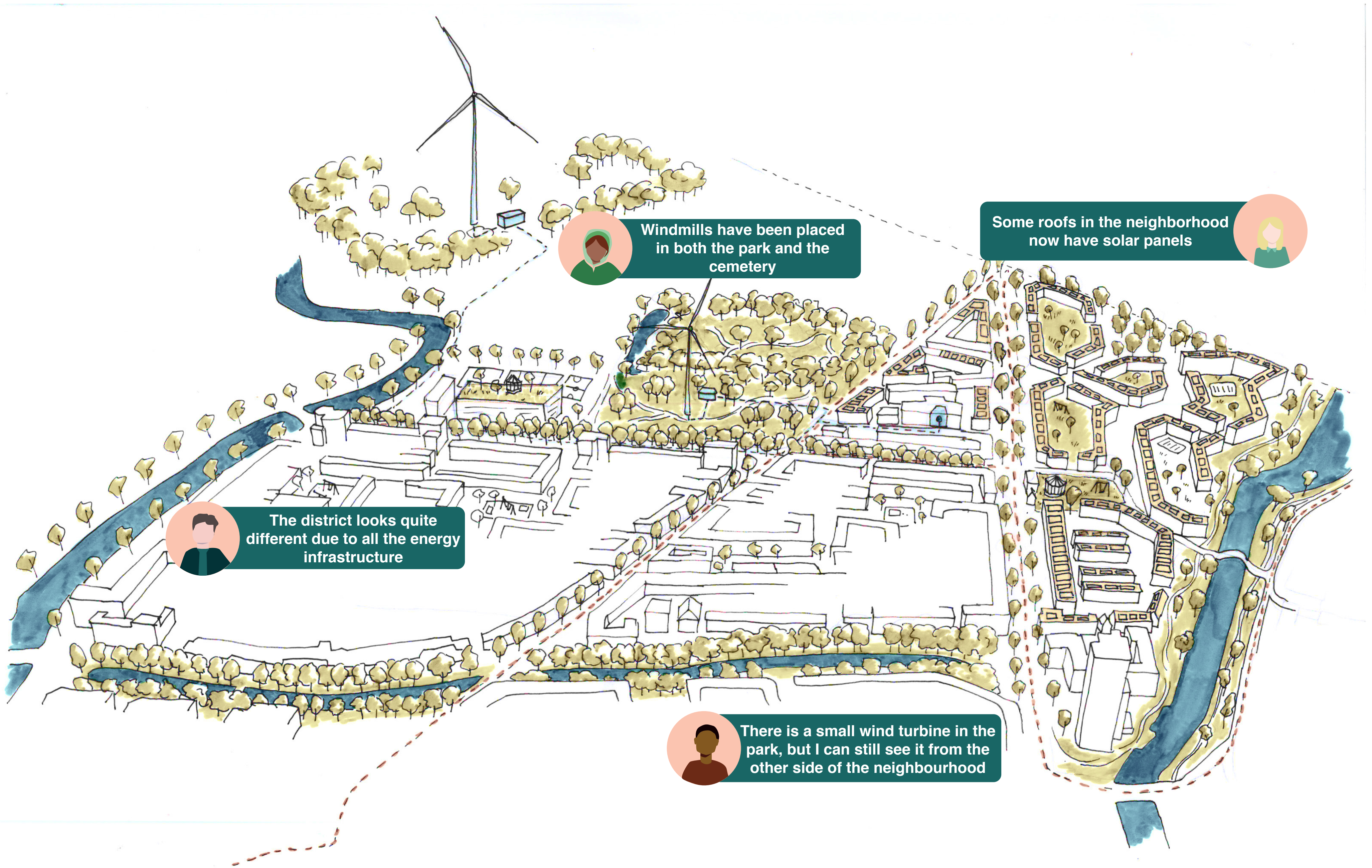


Figure 78: First scenario Bird's-eye view of spatial impact in Oud-Crooswijk

10.2 Scenario of maximum production

Scenario of maximum production

This scenario is based on maximising all the sustainable energy production methods. When all these methods are combined, more energy will be available than the neighbourhood currently uses.
It gives room for different possibilities in the neighbourhood. The unused energy can be sold, creating a financial benefit for the neighbourhood. The neighbourhood can densify, especially with the current norms of building. Newly built housing projects are all above A-label. It means a relatively large development is possible based on excess energy.

Spatially it is more challenging to densify in the neighbourhood, as it is already a dense neighbourhood. Currently, more than 80% of the area consists of built space.

Spatial impact

The spatial impact of this scenario is significant. Most of the neighbourhood will drastically change. In all parts of the neighbourhood, the energy transition will be visible, making it complex to get all residents on board with this change. Nonetheless, when it succeeds, it can have unforeseen benefits. When the transition is this visible, it can potentially have a trickledown effect on surrounding neighbourhoods.

Figure 79: Second scenario map of Oud-Crooswijk

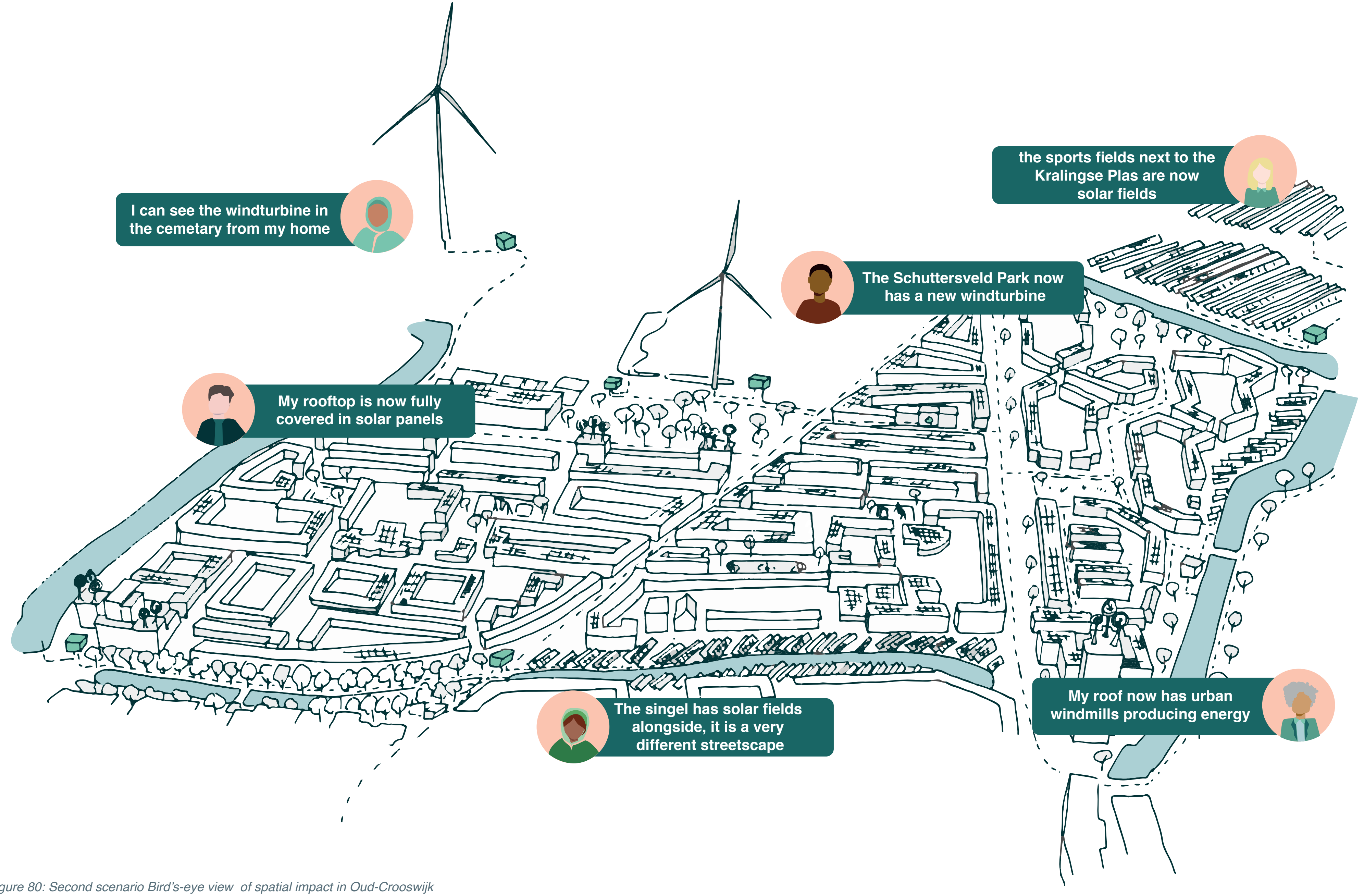


Figure 80: Second scenario Bird's-eye view of spatial impact in Oud-Crooswijk

10.3 Scenario of saving usage

Scenario of saving usage

The third scenario assumes a reduction in energy consumption in the district, accomplished through a combination of isolation improvement and behavioural change. In this scenario, the reduced demand for energy is generated sustainably by utilising a residual heat network and solar energy.

Spatial impact

The spatial impact of this scenario is dependent on the energy-saving strategy. If it is possible to save much energy, the spatial impact of energy production will be less than expected. The energy-saving plan has a significant spatial impact but takes place at a lower scale level. For example, it will mainly develop in people's homes and immediate surroundings at the block level. In the next chapter, the energy-saving plan is detailed.

Explaining the map

The next chapter explains this map, which is why no legend has been added yet. The chapter will name the different ways of saving energy and study what is needed in the neighbourhood to achieve this scenario.

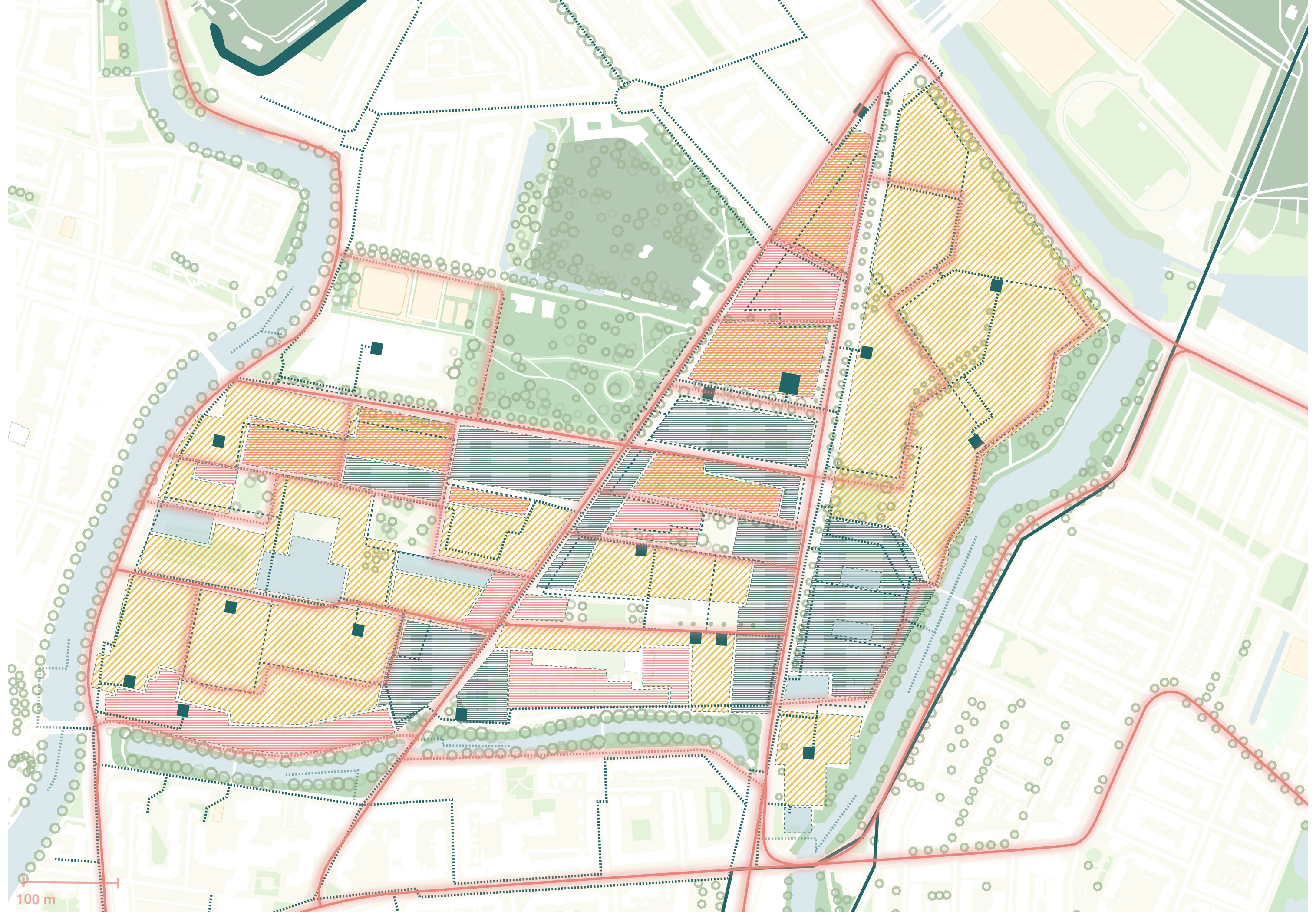


Figure 81: Third scenario map of Oud-Crooswijk

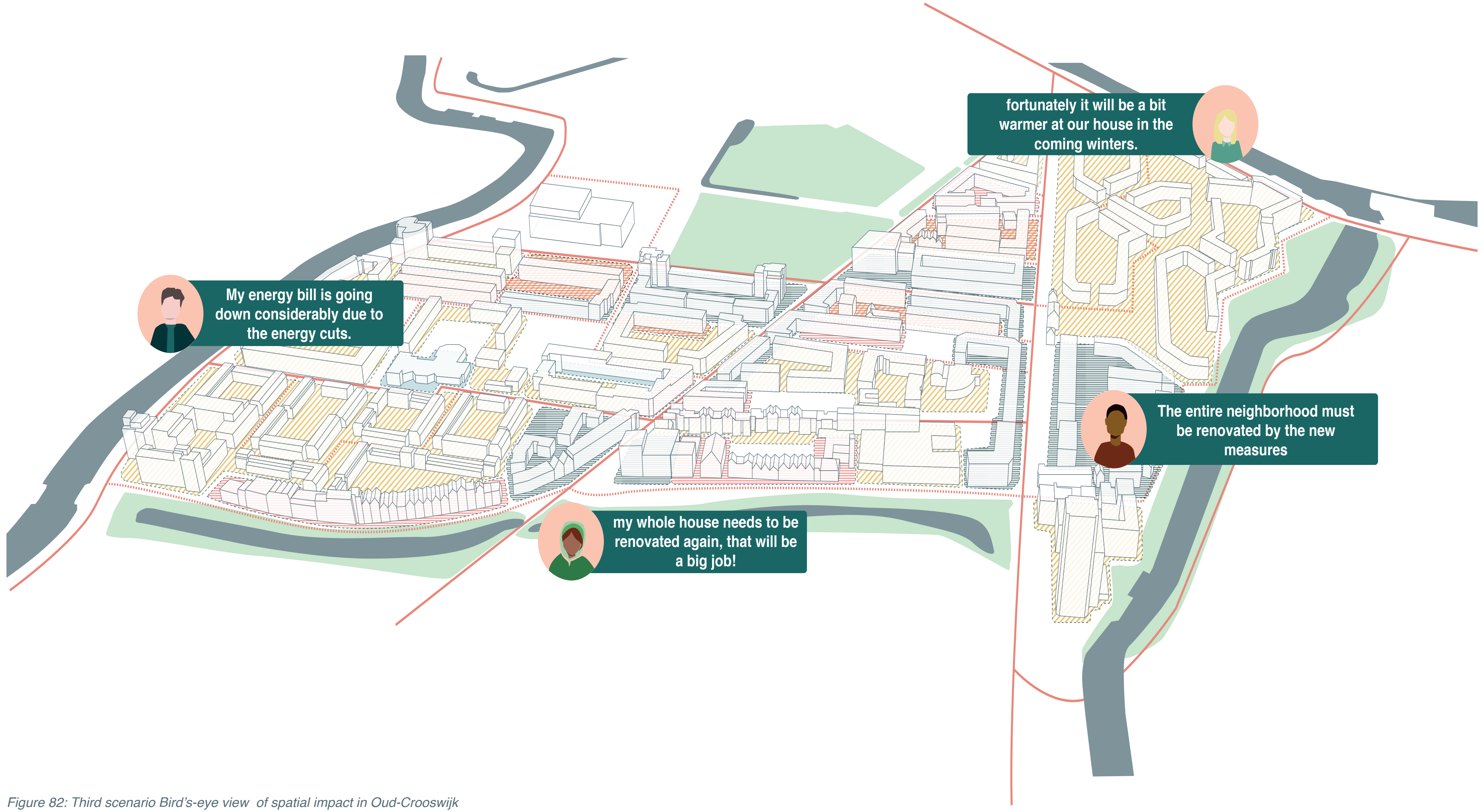


Figure 82: Third scenario Bird's-eye view of spatial impact in Oud-Crooswijk

10.4 Comparing the scenario's

Spatial Impact

The Current usage (CU) scenario and Using less (UL) scenario have a lower spatial impact than the Maximal production (MP) scenario. The MP scenario will change the whole neighbourhood. The CU and UL scenarios differ in the types of spaces they modify. The CU scenario occurs more in the public space, and the UL scenario is more in the private space. Thus the spatial impact of the UL scenario would seem less.

Redevelopment

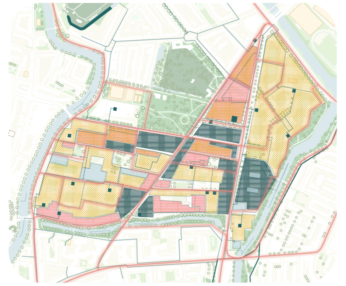
All three scenarios have the potential to alter the streetscape in the neighbourhood. The MP scenario also has the potential for densification. Because in this scenario, more energy will be produced than is currently used. as mentioned, in the UL scenario, the redevelopment will take place more privately than in the CU scenario.

Behavioural change

The CU and MP scenarios do not require significant behavioural changes beyond accepting the changing environment of the neighbourhood. On the other hand, the UL scenario requires much more from the behaviour of residents.

Scale of change

All three scenarios use a residual heat network, which plays out on a regional scale since the heat comes from the port. The CU and MP scenarios have wind turbines, which also impact the scale of the city/district. The UL scenario affects the private spheres the most.



	Space required	Redevelopment potential	Mentality shift	Location and scale of change
Current usage	• Part of all rooftops • Parks and recreational green spaces • Cemetery	• Main street axes • Parks and recreational green spaces • Cemetary	• Accepting changed environment	• Inside the neighborhood private spaces • Outside: Private space: cemetary • Outside neighborhood: Residual heat network
Maximal production	• All rooftops • Public spaces and green spaces • Cemetery	• Main street axes • Parks and recreational green spaces • Public spaces • Water bodies • Densifying • Energy mixed use (solar fields and urban farming) • Rooftops	• Accepting changed environment	• Inside the neighborhood private spaces and public spaces • Outside: Private space: cemetary • Outside neighborhood: Residual heat network
Using less	• All rooftops • Private courtyards	• Main street axes • Private courtyards • Communal spaces	• Change in way of using energy • Sharing energy production • Sharing space in communal courtyards • Sharing mobility	• Inside the neigborhood: communal space • Outside neighborhood: Residual heat network

Figure 83: Comparing the scenario's scheme

11. Energy saving plan

In addition to producing energy sustainably, it is also essential to be conscious of its use; this means saving energy. This chapter discusses current energy consumption and methods for saving on this.

Picture: 9: Oud-Crooswijk from rooftop of Heineken Gebouw

11.1 Current energy usage in the neighbourhood

Average energy usage

figures 84 and 85 visualise the current electricity consumption in the district. The colours show the amount of usage. Red stands for above average, and blue for below average. It shows where the most energy is used in the district at one glance. There are interesting similarities in the district. For example, there are several areas where gas and electricity use is very low. It is striking that the areas that colour red in gas use and therefore use much above average, actually colour light blue in electricity consumption. So use relatively little electricity. The same applies to the areas that colour red in the electricity consumption map; these are green, blue, and yellow.

Compared to national average

The maps in Figures 84 and 85 show the usage in comparison to the average of the neighbourhood. This is still well below the national average in both electricity and gas usage. The average national annual gas usage is 1.169 m3 gas (Hoebergen (CBS) et al., 2021). The average in the neighbourhood is 1.000,5 m3 gas (Hoebergen (CBS) et al., 2021). No part of the neighbourhood reaches the annual national average.

The average annual national electricity usage is 2.479 kWh (Hoebergen (CBS) et al., 2021). The average within the neighbourhood is 1.997.7 kWh annually (Hoebergen (CBS) et al., 2021).

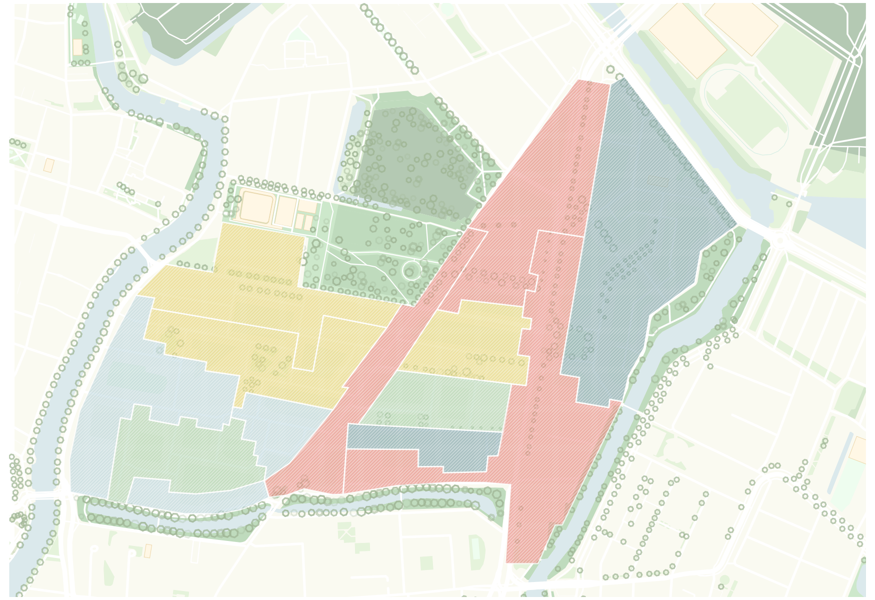


Figure 84: Electricity usage in kwh per pc5 zone in color showing below or above neighbourhood average per zone (Hoebergen (CBS) et al., 2021)

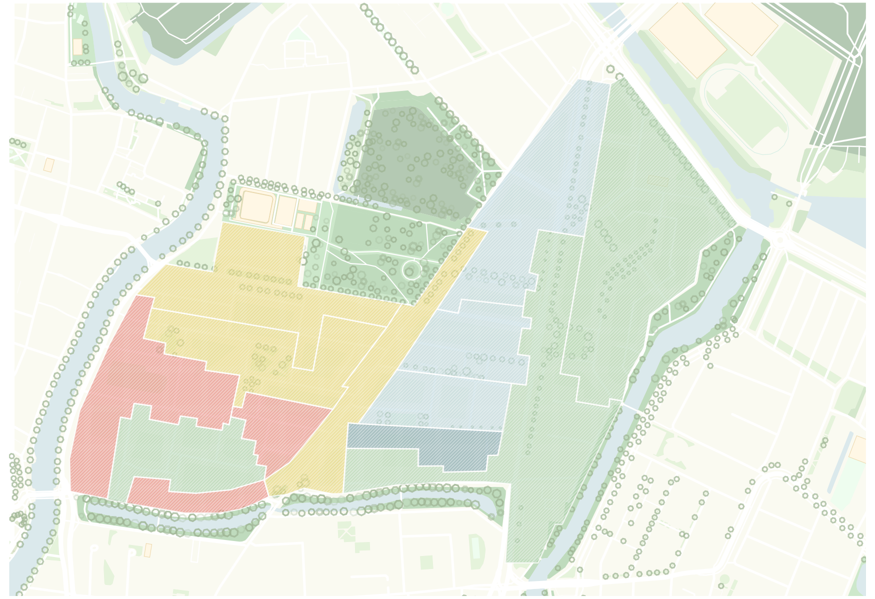


Figure 85: Gas usage in m3 per pc5 zone in color showing below or above neighbourhood average per zone (Hoebergen (CBS) et al., 2021)

Figure 86: Energy usage in electricity usage (kWh) and gas usage (m3) per pc5 zone (Hoebergen (CBS) et al., 2021)

Current energy labels

An energy label is a convenient tool to estimate the extent to which a home is energy efficient. However, it is a limited tool because it is a label that must be requested to be updated. For example, labels may be overdue compared to the current state of insulation of the home.

It does provide a picture to conclude from. For example, the label C is the most common, and it is also possible to see which neighbourhood clusters were built at once. Buildings before 1900 contain the most variation of energy labels, and these are also the only places that include label F. Many of the buildings built between 1970 and 1990 have an energy label C or B.

Current state of insulation

To estimate the state of insulation, this study looks at the current labels of the buildings in the district, the year of construction, and the current energy consumption.

Houses built between 1975 and 1983 often have a moderate wall and roof insulation (5-7 cm), double glass but not HR ++ and no floor insulation (Milieucentraal, 2022). When constructed between 1983 and 1992, there is most likely moderate roof, wall, floor insulation, and double glazing, but no HR++ (Milieucentraal, 2022).

In addition, a significant part of the district was built before 1930, most likely without insulation. Many of these buildings needed restoration over the years. The insulation condition in these homes depends on the restoration time (Milieucentraal, 2022). As a result, the energy labels of buildings from this time vary enormously.

Replacing single glass to HR++ can save 260 m3 of gas, insulating a pitched roof of an attic can save 420 m3 of gas, insulating the floor of a first floor can save 130 m3 of gas, insulating cavity walls can save 400 m3 of gas (Milieucentraal, 2022).

Figure 87: Energy labels per building (Rijksoverheid, 2022)

Figure 88: Map year of construction within Oud-Crooswijk (Atlas leefomgeving, 2018)

11.2 The insulation plan

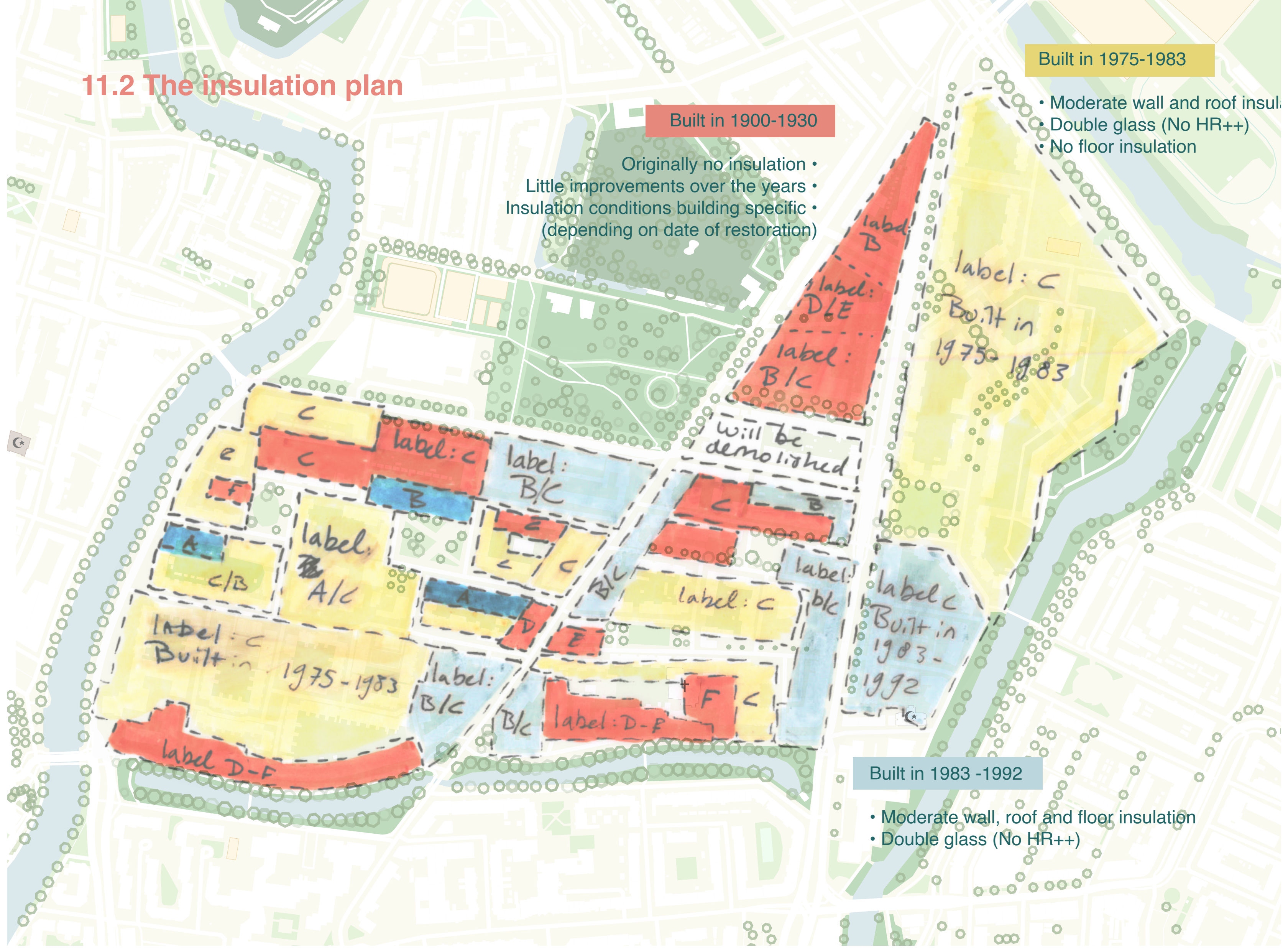


Figure 89: The current state of insulation based on building year and energy label (Rijksoverheid, 2022) (Atlas leefomgeving, 2018) (milieucentraal, 2022)

The insulation plan

An insulation plan is designed based on the analysis of the current state of the insulation and energy usage in the neighbourhood. The neighbourhood has four categories of the insulation plan. The first category is the buildings that already currently have an A-label, but these are not renovated and will remain. Then there are the buildings with a C-label built between 1975 and 1983. There the current insulation improves, with added floor insulation and a renovation of the current moderate roof insulation. The double glass will be replaced by HR++ glass. With these renovations, the new label of these buildings is an A-label.

The buildings built between 1983 and 1992, with mostly C and B labels, will have a renovation of the current moderate roof, wall, and floor insulation. The current double glass is replaced by HR++ glass.

The last category is the buildings from before 1930 with varying insulation levels. For this category, it is essential to investigate the current insulation state further and make a building-specific restoration plan.

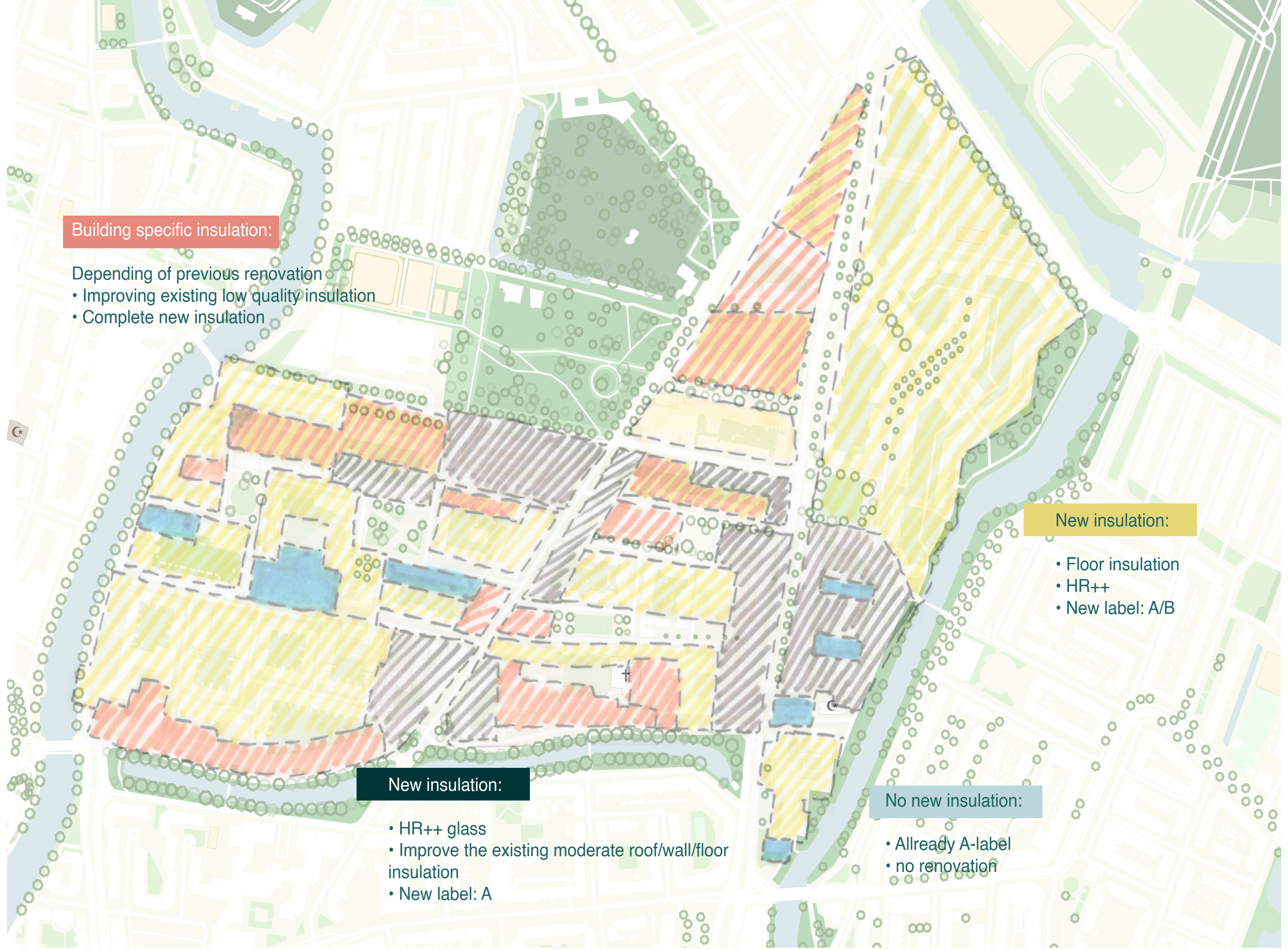


Figure 90: The new insulation plan (Rijksoverheid, 2022) (Atlas leefomgeving, 2018) (milieucentraal, 2022)

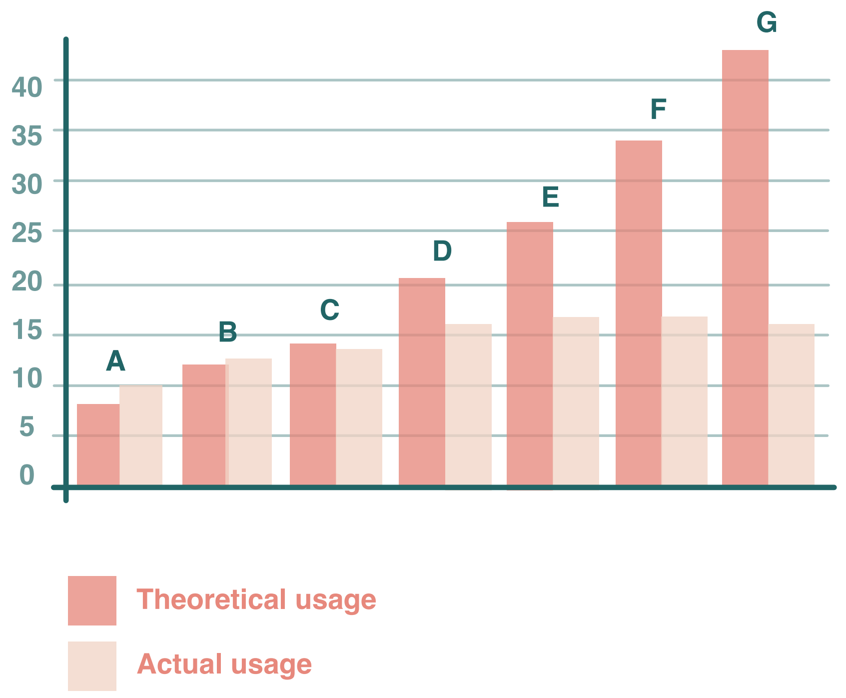
How much does the insulation plan save

As mentioned before, energy labels are a limited tool in estimating the insulation level. Therefore it is difficult to conclude how much this insulation plan could improve in saving energy usage.

There are key figures on which this calculation can be based; however, there is a big difference between the theoretical jump in energy consumption of labels and the actual (Majcen & Itard, 2014). Figure 91 shows that the estimated amount of energy saving is many times greater than the measured amount (Majcen & Itard, 2014). It is probably because, in the actual situation, other factors, such as money, play a role.

People who live in poorly insulated homes spend relatively more on their energy bills. And consequently have more motivation to save on consumption, so consumption will be lower than people who live in a well-insulated house. People in a well-insulated house naturally often need less energy. This levels itself out somewhat. As mentioned before, this district has relatively low energy consumption.

The calculations show that on the basis of the current data of the usage, the labels and the surfaces of houses in the district, combined with the research into the extent to which an energy label determines energy consumption, there is great potential in reducing energy consumption through better insulation.



Actual gas usage annually in m3/m2

Label A	10	m3/m2
Label B	13,5	m3/m2
Label C	14	m3/m2
Label D	15,5	m3/m2
Label E	16	m3/m2
Label F	16	m3/m2
Label G	15,5	m3/m2

Percentage of Energy labels in the Neighborhood

Label A+++	0,01%
Label A++	0,001%
Label A+	0,005%
Label A	0,07%
Label B	0,13%
Label C	0,63%
Label D	0,10%
Label E	0,02%
Label F	0,01%
Label G	0,02%

Average building size in m2

Label A	263,5	m2
Label B	84,5	m2
Label C	80,5	m2
Label D	99,5	m2
Label E	213	m2
Label F	174	m2
Label G	225	m2

Average building size in m2 of the total area: 102,5 m2

Current usage

1000,5 m3 on average per year
4.106 houses

Total usage is: 4.108.053,0 m3

G to A
total m2 of G label buildings = 12611 m2
Changing label will save (15.5-10) 5.5 m3/m2
Will save 5.5 m3/m2 * 12611 = 69.360.5 m3 per year

F to A
total m2 of F label buildings = 9236 m2
Changing label will save (16-10) 6 m3/m2
Will save 6 m3/m2 * 9236 = 55.416 m3 per year

E to A
total m2 of E label buildings = 15791 m2
Changing label will save (16-10) 6 m3/m2
Will save 6 m3/m2 * 9236 = 94.746 m3 per year

D to A
total m2 of D label buildings = 37677 m2
Changing label will save (15.5-10) 5.5 m3/m2
Will save 5.5 m3/m2 * 12611 = 207.223,5 m3 per year

C to A
total m2 of C label buildings = 190780 m2
Changing label will save (14-10) 4 m3/m2
Will save 4 m3/m2 * 12611 = 763.120 m3 per year

B to A
total m2 of B label buildings = 41295 m2
Changing label will save (13,5-10) 3,5 m3/m2
Will save 3,5 m3/m2 * 12611 = 144.532,5 m3 per year

Total m3 gas possibly saved:
1.334.398 m3 annually

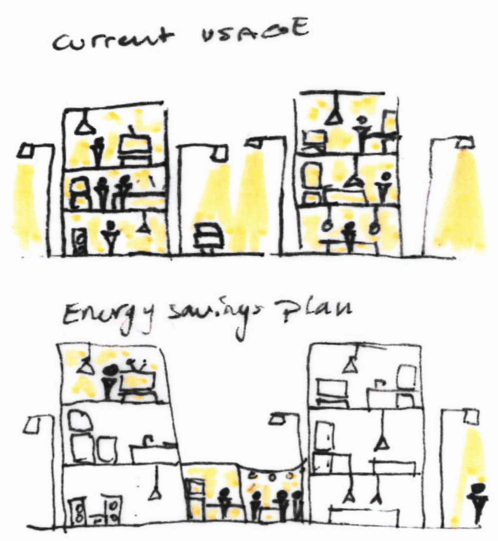
Figure 91: Graph and calculations how much the insulation plan will save in energy (Majcen & Itard, 2014) (Rijksoverheid, 2022) (Het Kadaster, 2022)

The energy saving plan

In addition to insulation, a technical solution, it is essential to look further into how we can reduce our energy consumption—for example, adjusting our habits regarding energy consumption. The current energy consumption habits are very individualistic. Residents all want a private warm house because this is pleasant, comfortable, and gives much space. Yet, it is not the most efficient way of using energy. Sharing energy is more efficient; fewer spaces need to be heated, and less energy is used per person. It is shown schematically in the energy-saving plan.

The map shows potential in the district for clusters for shared energy use. These are spaces where people can come together and share. It means sharing a part of their daily routine, cooking together, and spending time together. It can save money and stimulate the community spirit.

It takes many residents to adjust their habits because everyone has become accustomed to the conveniences of the individualistic society. It can also bring many benefits, it can stimulate togetherness and reduce loneliness. An excellent initial motivation for people to take this step may be that it saves money; later on, the qualities of the community are one reason people can stick with the habit.



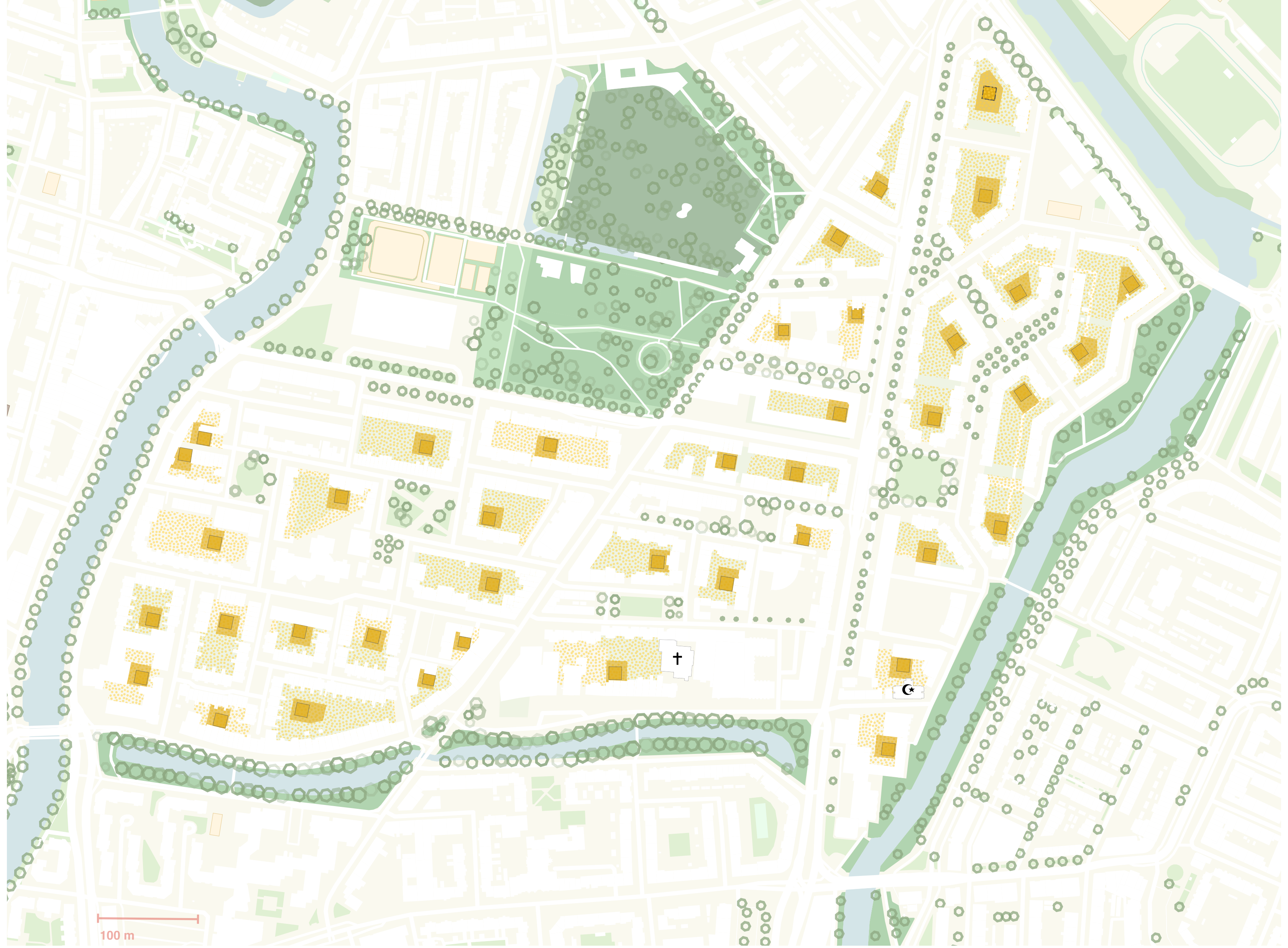


Figure 92: Energy-saving plan based on lifestyle choices

12. Design

The design brings all results of the previous chapters together; it combines spatial and energy potential. The design encourages change from a local to even national scale. It is a catalyst of transition, an example of what people can create together. It shows the importance of the human scale and that the transition starts with ourselves.

Picture: 10: Rene Passet, https://www.flickr.com/photos/passetti/8689548964

12.1 From transition to spatial quality

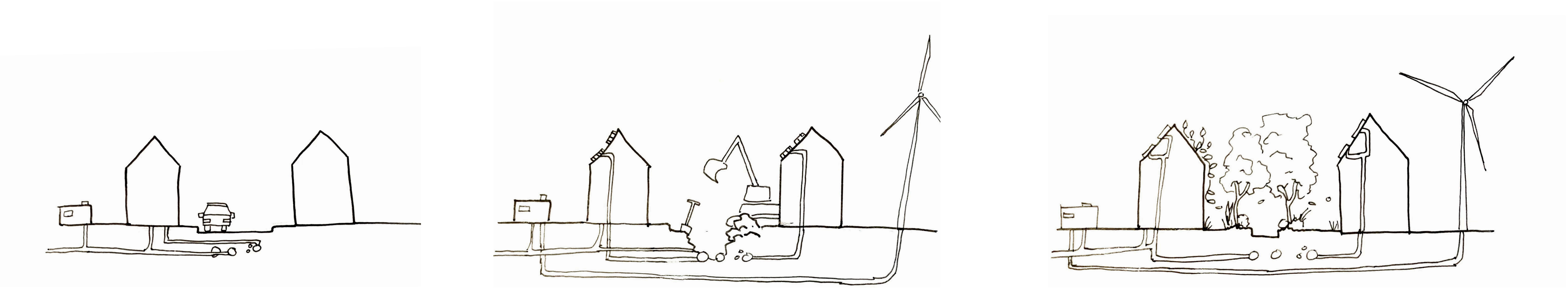


Figure 93: Illustration of changing streetscape because of redevelopment in the street due to new energy installations

The link between energy transition and spatial quality

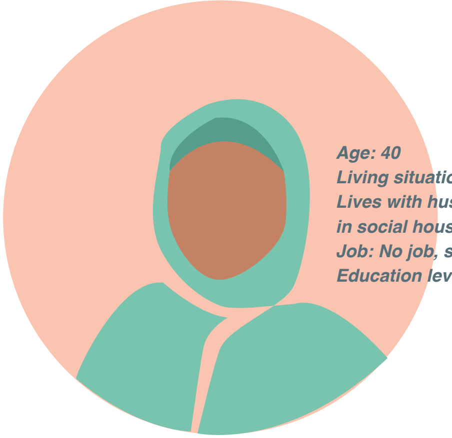
The link between energy transition and spatial quality is not immediately apparent. For example, many people associate energy transition with a reduction in spatial quality. Installing wind turbines or solar panels often negatively affects people's image of a neighbourhood or landscape. Thus, it is not about the direct consequences of the energy transition but the indirect spatial potential. This indirect spatial potential is created by constructing new energy systems, as shown in figure 93. Due to the construction of new designs, many existing structures in the neighbourhood must be broken open. When a road is already opened up, there is the possibility of developing the streetscape at the same time. With this, the street is broken open once, and the energy transition creates an opportunity to promote spatial quality in a neighbourhood.

It also brings added complexity that this research cannot overlook. As mentioned earlier in this research, the energy system operates on a national and even global scale. There are integrated and connected systems. The energy potential described on the district's scale is, to a greater extent, decentralised. But not autonomous, these systems continue to connect to larger national and global systems.
It means that adjusting structures in Oud-Crooswijk affects a much larger scale. The cables that run through Oud-Crooswijk do not only belong to Oud-Crooswijk. So changing this is very complex because not all these systems operate on the same scale. Some systems work more on a city scale, such as a heat network. But there are also systems, such as the electricity network, that are connected nationally and even internationally. These systems are integrated on different scales and combined in different ways. Adjusting these systems has far-reaching effects.

What makes it even more complex is the ownership of these systems. As mentioned earlier, these are private systems. The street that needs to be broken up may belong to the municipality, but the underground cables belong to different private parties. Sometimes these are outdated and poorly documented cable placements, and there is no good overview of precisely what runs where. In addition, the energy systems of private owners, such as the electricity network, also run under private land.

This research acknowledges this complexity but is limited in the extent to which it can take all these factors into account in creating the design. The design offers a possibility in this respect; it shows the spatial quality of a transformed neighbourhood. The design focuses on the outcome of the process and not the complexity of how this process could play out.

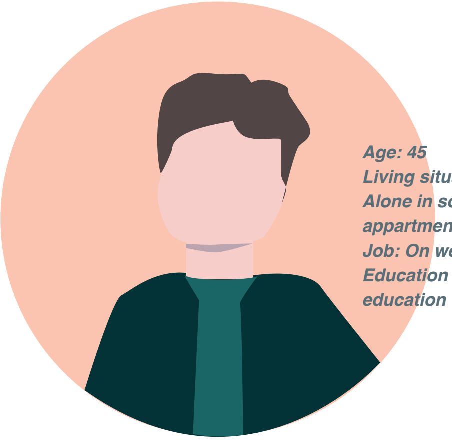
12.2 The people and their needs



Age: 40
Living situation:
Lives with husband and 4 children in social housing appartment.
Job: No job, stay at home mother
Education level: Lower education

Wishes for the neighborhood:
More connection within neighborhood.
Easy access to daily needs, such as grocery shopping.
Safe envrionment for the children.

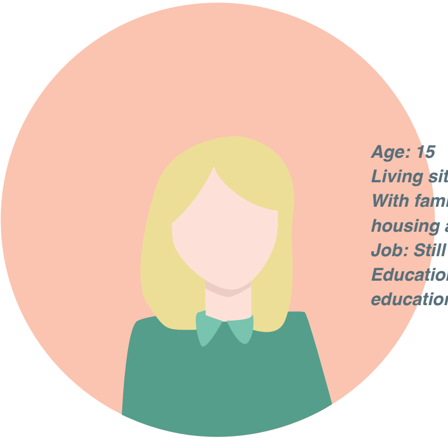
Struggles in the neigborhood:
Amount of income spent on fixed charges, due to quality of living.



Age: 45
Living situation:
Alone in social housing appartment
Job: On welfare
Education level: Lower education

Wishes for the neighborhood:
Safe and nice places to hang out with friends after school. Easy and nice route to cycle to school.

Struggles in the neigborhood:
Too few places to meet like minded peers. Little to do for her and friends in the area.



Age: 15
Living situation:
With family in social housing appartment
Job: Still in school
Education level: secondary education level

Wishes for the neighborhood:
Better homes and outdoor spaces with better views and isolation from noise from neighbors.

Struggles in the neigborhood:
Too much nuisance from groups of young people and noise. Too little participation from local residents, and a low co-reliance.

Age: 65
Living situation:
Alone in social housing appartment.
Job: Retired
Education level: secondary education level

Wishes for the neighborhood:
Nice places to walk during the day and to keep the neighborhood spots like the neighborhood cafe where he can meet his friends.

Struggles in the neigborhood:
Vandalism in the neighbourhood, waste on the street and how people deal with their living environment.

Age: 20
Living situation:
With roomates in private rental home
Job: Student
Education level: Higher education

Wishes for the neighborhood:
Safer entrances and streets with more social control, feeling safe to walk home at night.

Struggles in the neigborhood:
Safety on the street. High rate of traffic accidents and fear of intimidation in the evening.

Age: 35
Living situation:
With family in private rental home
Job: Electrician
Education level: Lower education

Wishes for the neighborhood:
Better quality of housing, better insulation. So that less of the money is spent on fixed costs.

Struggles in the neigborhood:
Nuisance from neighbors and would rather not have the children outside at night.

Figure 94: Imaginary residents of Oud-Crooswijk and struggles and wishes based on Neighbourhood data (Gemeente Rotterdam, 2022)

The people in the neighbourhood and their wishes

The district has a diverse palette of residents of all ages and origins. These people live in the neighbourhood differently and use the living environment diversly. As seen in figure 94, the wishes and struggles originate from the Municipality of Rotterdam neighbourhood profile research outcomes.

The security index

The neighbourhood has become increasingly safer over the years (Gemeente Rotterdam, 2022). Burglaries, theft, and vandalism are no longer as common as in previous years (Gemeente Rotterdam, 2022). Only nuisance in the neighbourhood has increased (Gemeente Rotterdam, 2022). The subjective and objective safety correspond well, and residents consider the area reasonably safe (Gemeente Rotterdam, 2022).

The physical environment index

There is a large discrepancy between the objective and subjective measurements (Gemeente Rotterdam, 2022). Residents are very pessimistic about the living environment, while the objective measures are usually positive (Gemeente Rotterdam, 2022).

The social index

Residents are not optimistic about, for example, participation or self-reliance in the neighbourhood; this corresponds to the objective measurements (Gemeente Rotterdam, 2022).

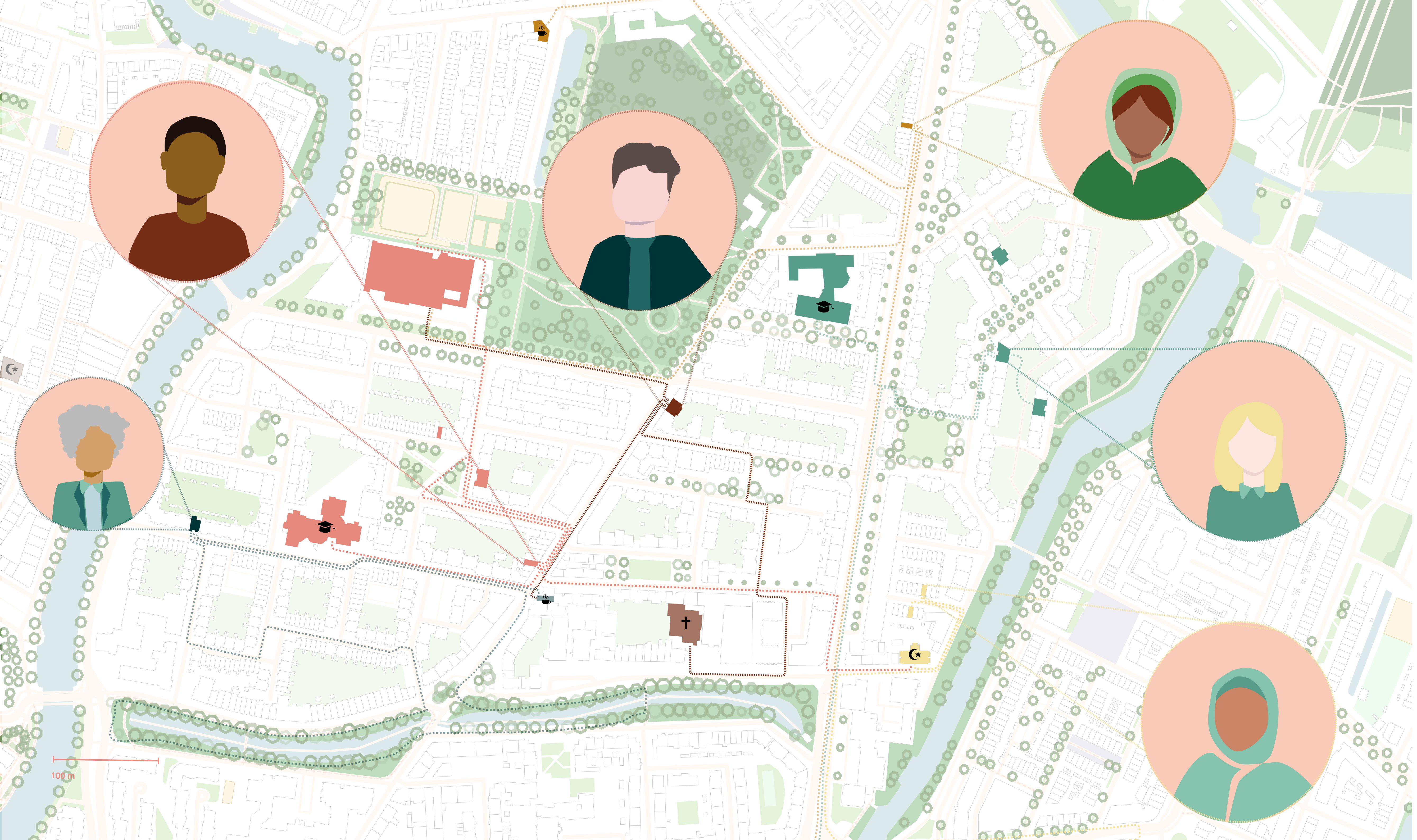


Figure 95: Movements of residents throughout Oud-Crooswijk

Movements throughout the neighbourhood

The neighbourhood is used differently by all residents. For example, 32% of residents have children, 15% of whom are single parents (Gemeente Rotterdam, 2022). These residents are more likely to use the neighbourhood's primary schools and play facilities. In contrast, 9% of the residents are students in the district (Gemeente Rotterdam, 2022). They study outside the area, and their social life will probably primarily occur in the city. Figure 95 shows these different movements based on various lifestyles.

12.3 The design in layers

12.3.1 Design in layers - sustainable energy production

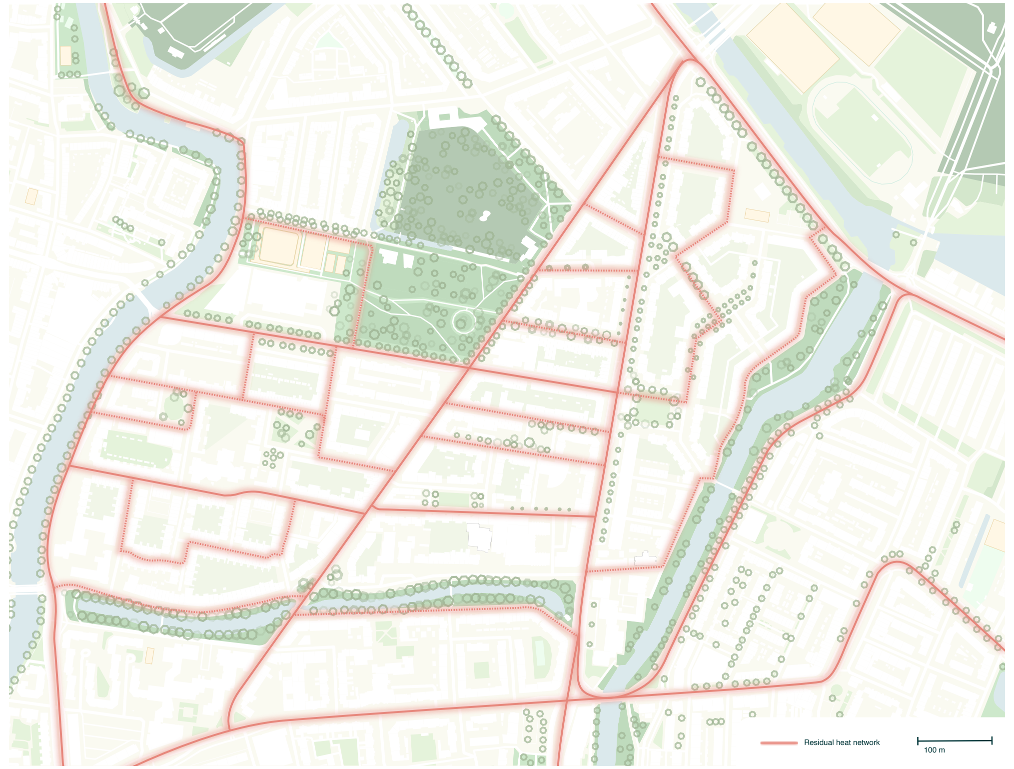


Figure 96: New residual heat network based on energy potential projected on map of Oud-Crooswijk

Residual heat network

The neighbourhood is connected with industries in the port and receives their residual heat. It will provide a sufficient amount of heat throughout the year. For this, the neighbourhood needs to install a new network; This is a significant restructuring in the district, and many roads have to be overhauled for this.

12.3.3 Design in layers - character and program

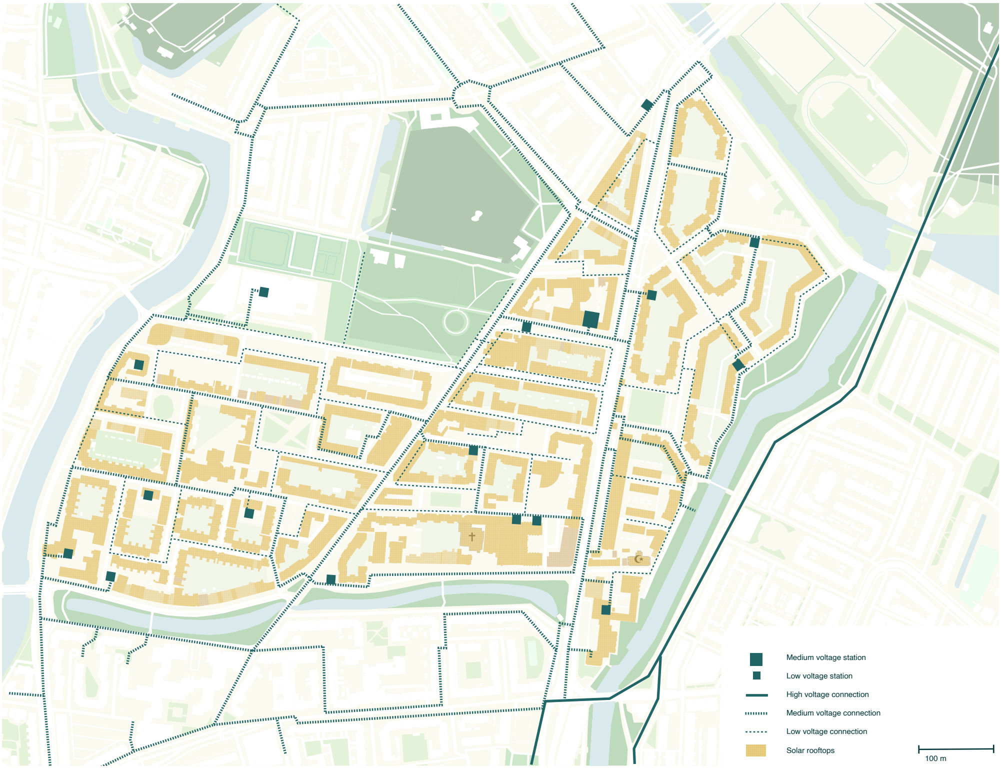


Figure 97: New solar rooftops and electricity network based on energy potential projected on map of Oud-Crooswijk

Solar rooftops

All suitable rooftops have solar panels installed. That covers a large part of the energy demand. In addition to installing the panels, it must connect to the district's electricity grid. It means that the residents of one house can use the generated energy from the roof of another house.

12.3.2 Design in layers - energy saving measures

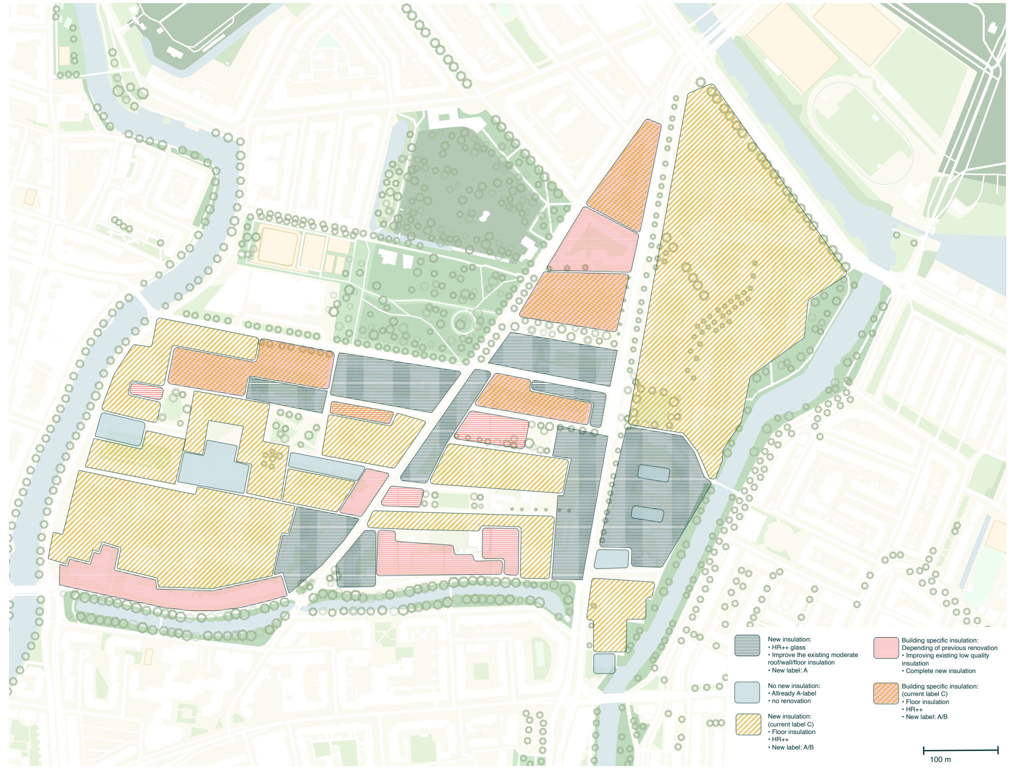


Figure 98: New insulation plan based on energy potential projected on map of Oud-Crooswijk

The insulation plan

In addition to sustainable energy generation, the district needs to save on energy consumption. Most homes in the community benefit from a renovation of the insulation. Many homes currently have a C label and have the potential to become an A label. Figure 98 shows the insulation plan. It states which parts of the neighbourhood can be better insulated and how.

Figure 99: New energy-saving plan based on energy potential projected on map of Oud-Crooswijk

Energy saving plan

In addition to better insulation, energy is saved by adjusting the lifestyle by using power more collectively. The energy-saving plan gives room for this lifestyle change. It offers a place to come together and save energy while improving community building and saving costs and energy.

12.3.3 Design in layers - character and program

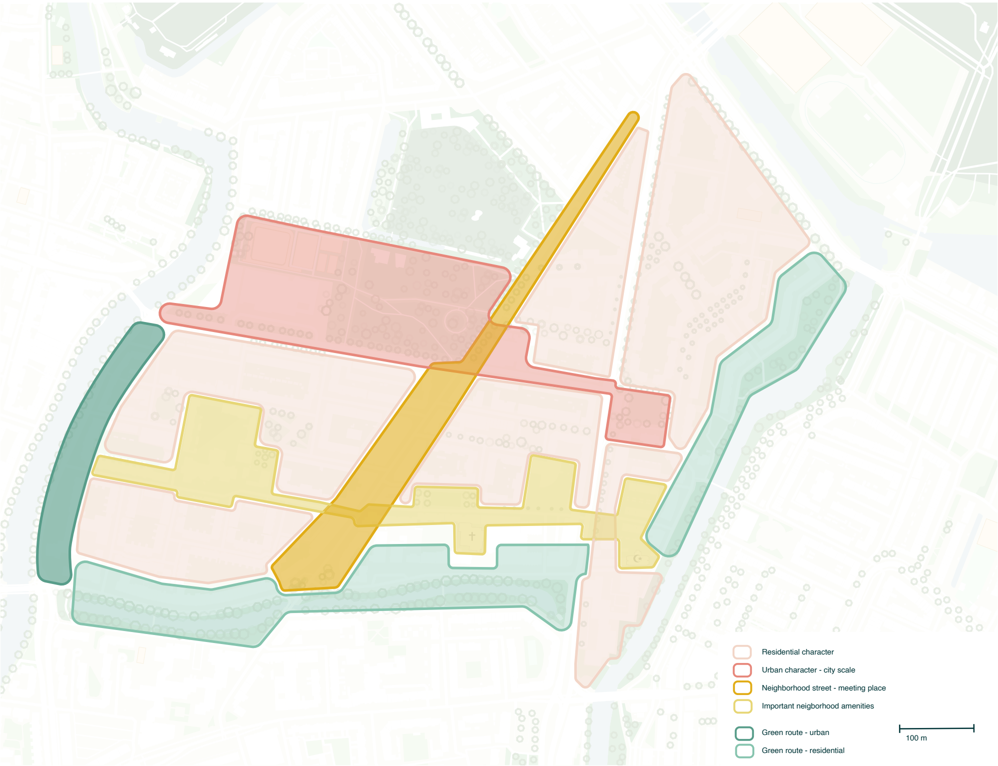


Figure 100: Stimulation of current characters in the neighbourhood projected on map of Oud-Crooswijk

Figure 101: New program in the neighbourhood projected on map of Oud-Crooswijk

Neighbourhood characters

The district mainly has a residential character. The sports complex and the new developments on the Crooswijksestraat create liveliness and an attraction on the scale of the city. The Crooswijkseweg is a neighbourhood street with a local bakery and a neighbourhood cafe. Walking routes along the water enclose the district, and each part of the neighbourhood has a different and unique atmosphere.

Program

The introduced function corresponds to the different atmospheres in the neighbourhood. As mentioned earlier, most of the district currently has a residential function. Amenities and meeting spaces are mainly on the important axes and public spaces. Newly developed functions will strengthen the existing atmosphere and stimulate more liveliness in the neighbourhood. It is traditionally a vibrant area. It used to have a cattle market, a slaughterhouse, and the Heineken Brewery. Over the years, an increasing part of the neighbourhood became residential program. It is an enormous quality for residents that the district regains its bustling character.

12.3.4 Design in layers - mobility

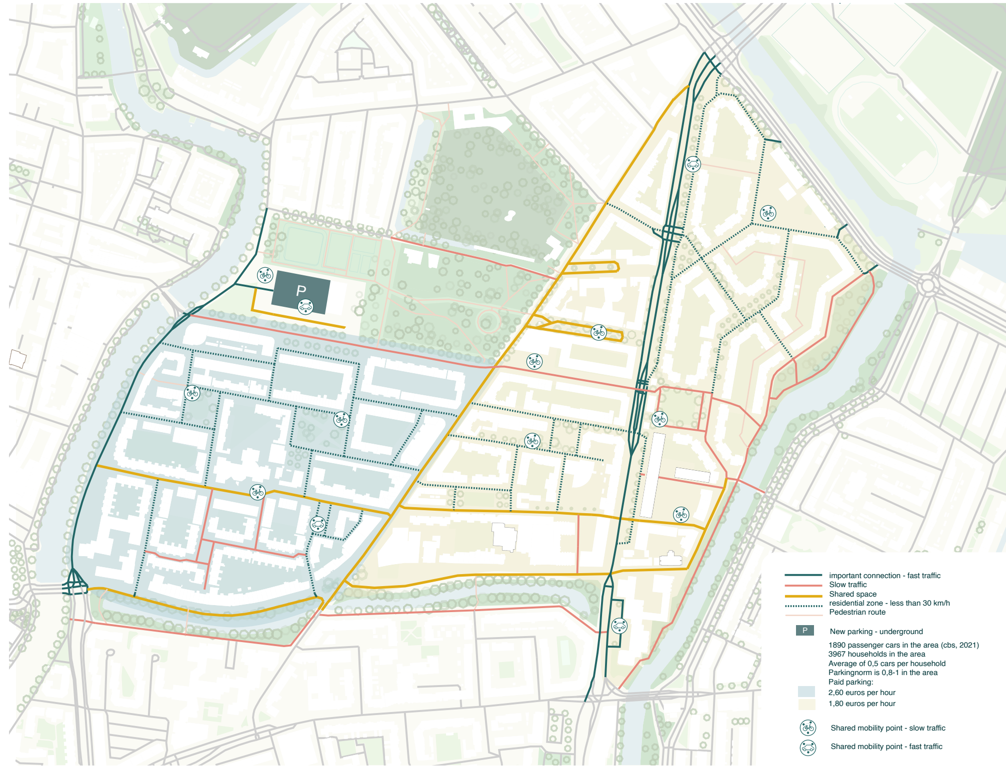


Figure 102: New mobility plan in the neighbourhood projected on map of Oud-Crooswijk

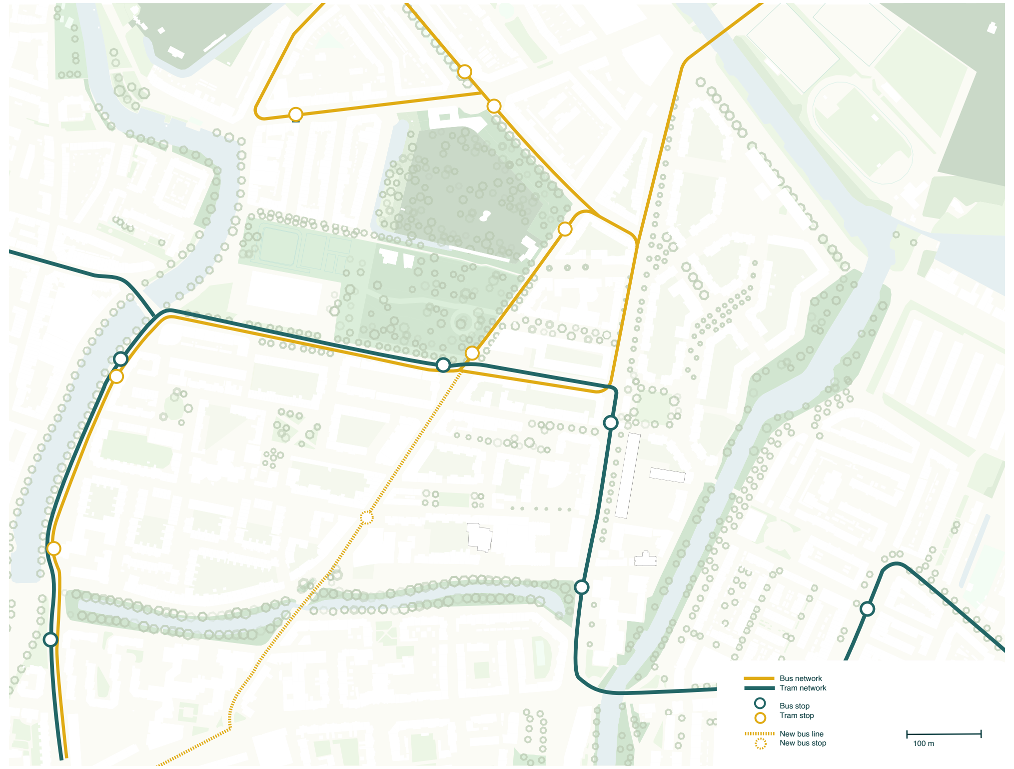


Figure 103: New public transport connection in the neighbourhood projected on map of Oud-Crooswijk

Mobility

The neighbourhood's walkability has improved, in addition to making essential bicycle routes safer and more accessible. The car is now a guest on streets mainly intended for residents to shop and meet each other. These roads are still passable for motorists but adapt to slow traffic. There is a new parking building under the new sports complex. And there are several car-sharing spots in the area. Current car ownership is approximately 0.5 passenger cars per household (CBS, 2022). In comparison, the parking standard in the district is 0.8 to 1. With more shared vehicles, the neighbourhood can redevelop quite a few parking spaces.

Residual heat network

The neighbourhood is connected with industries in the port and receives their residual heat. It will provide a sufficient amount of heat throughout the year. The new network will need to be installed. It is a significant district restructuring; many roads must be overhauled.

12.3.5 Design in layers - green structures

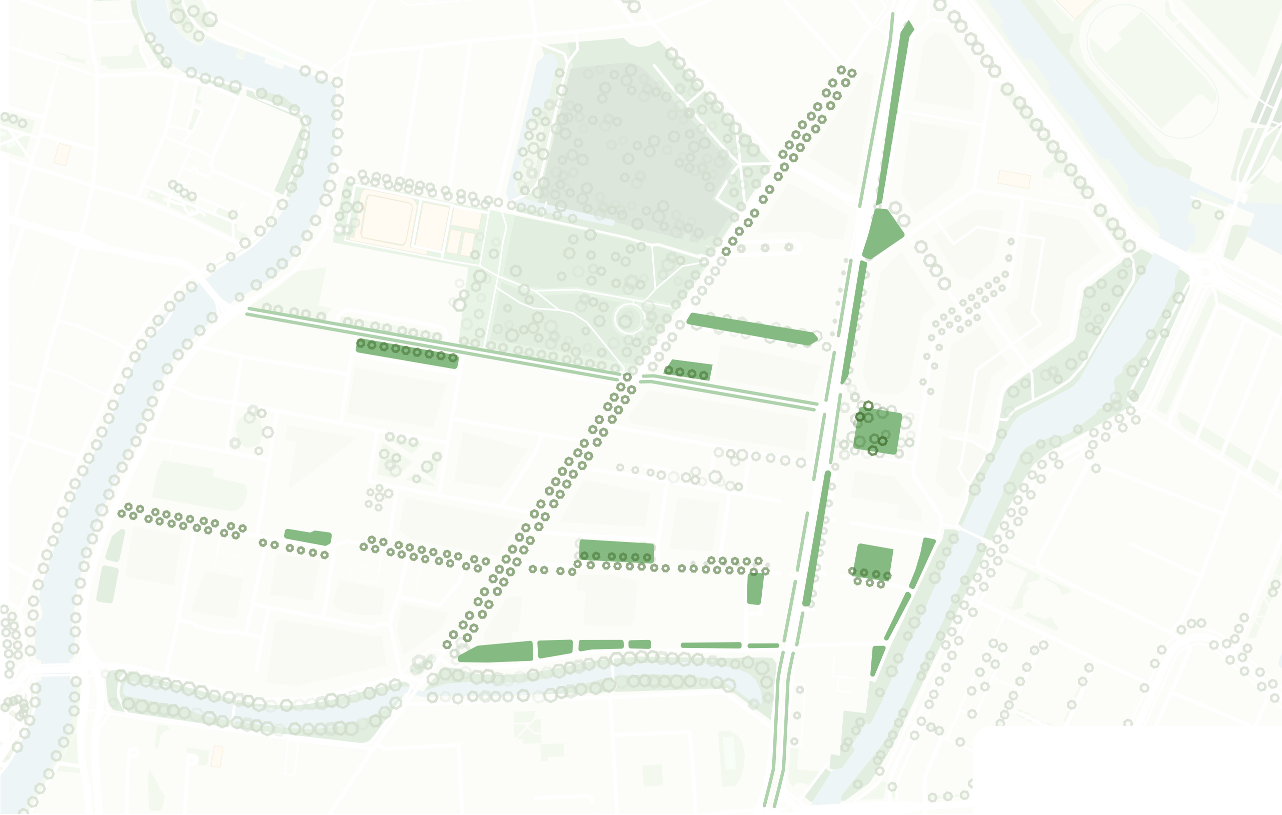


Figure 104: New green structure in the neighbourhood projected on map of Oud-Crooswijk

Green structure

The construction of the new residual heat network will give a chance to redevelop the principal axes. The streets will be redesigned to become more green and less car prominent. This new streetscape will encourage more street life and increase the district's quality of life and microclimate. The green structure consists of greening important axes and thus connecting to larger and existing high-quality green spaces in and around Oud-Crooswijk. These green connections will be discussed in detail in the following subchapters.

Figure 105: Bird's-eye of green structure in the neighbourhood

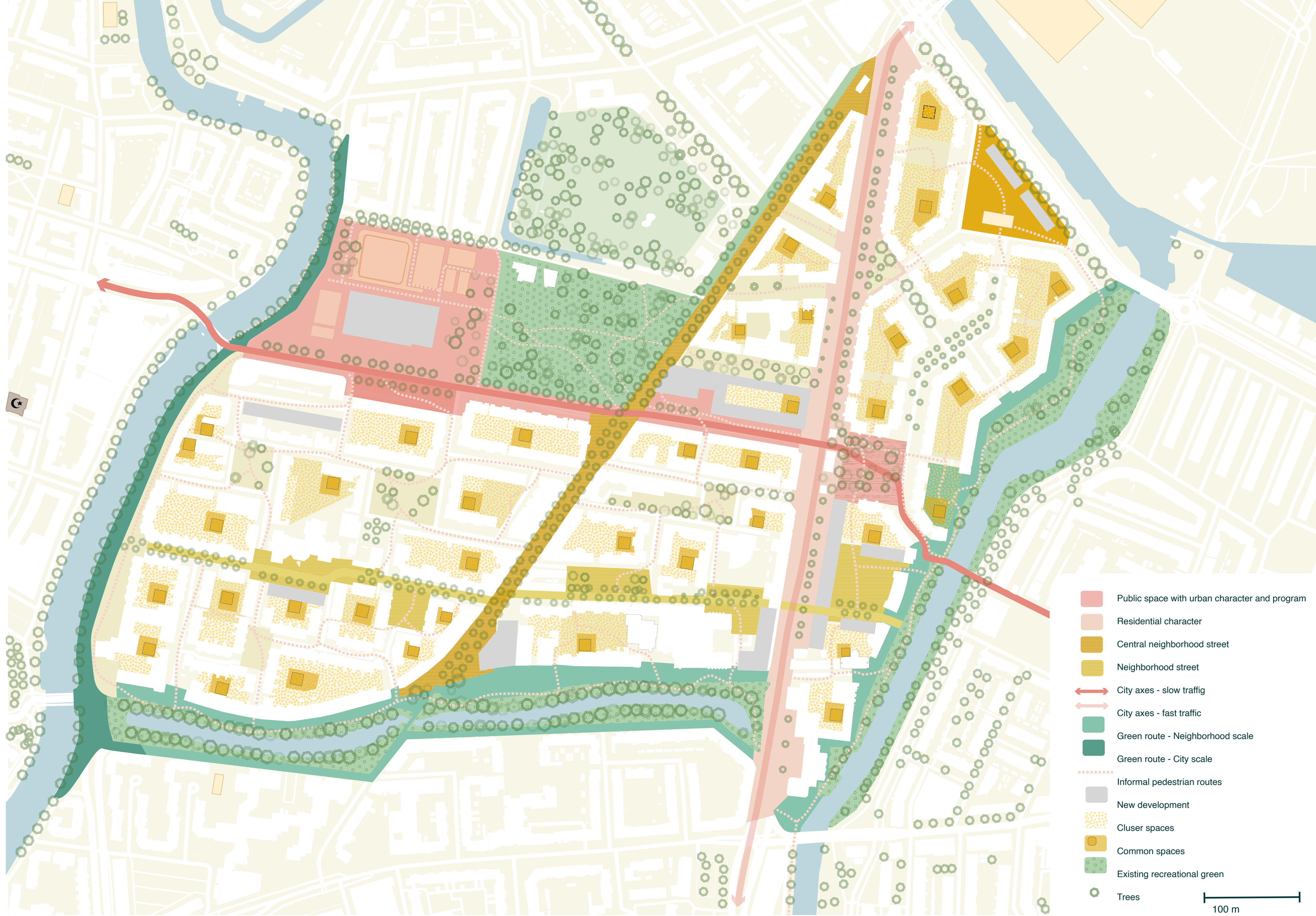


Figure 106: New public space network projected on map of Oud-Crooswijk

Figure 110: City connections in public space network

Figure 107: Neigborhood streets in public space network

Figure 108: Green routes in public space network

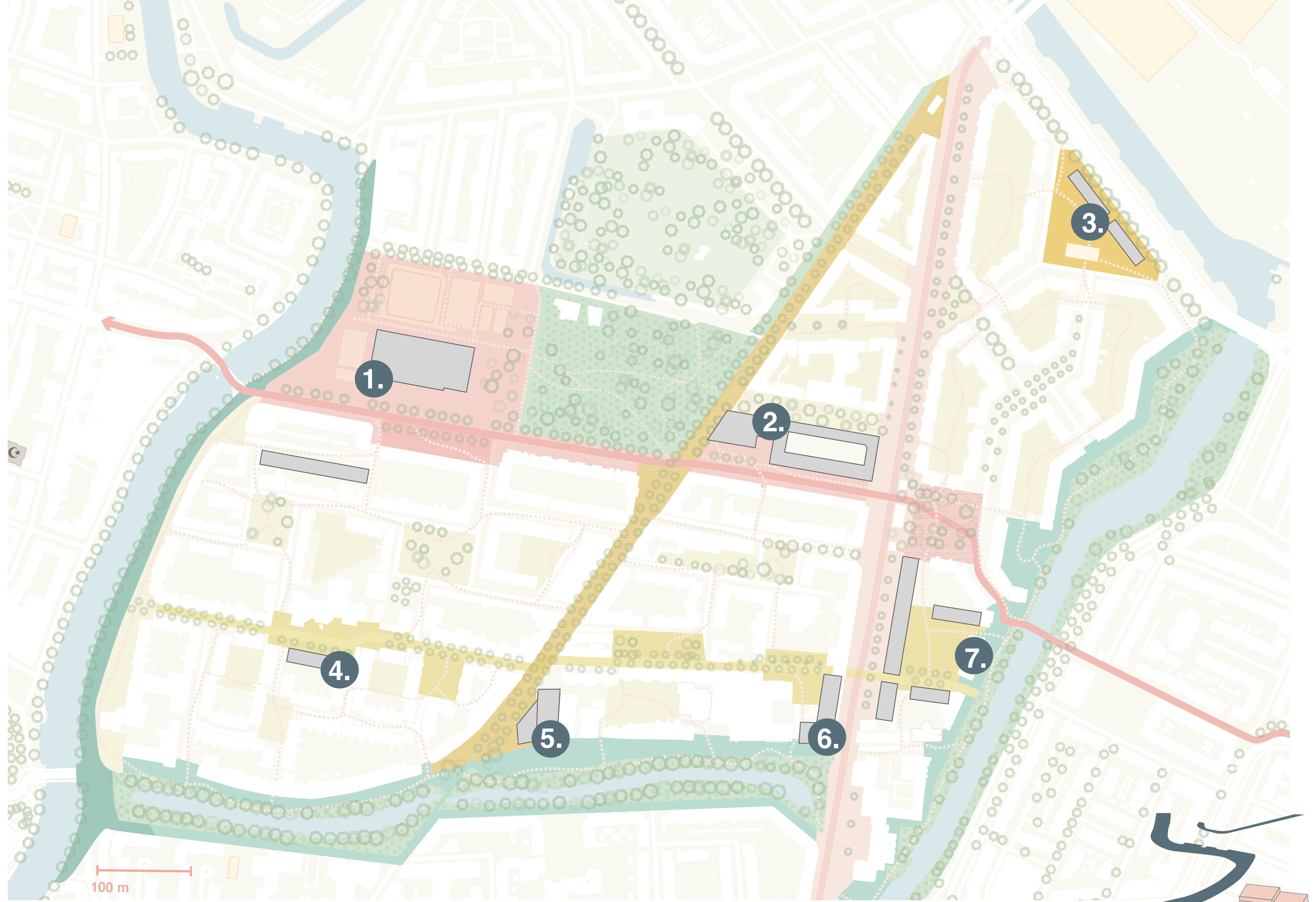
Figure 109: Informal routes and meeting spaces in public space network

Public space network

All these developments together create the new public space network of Oud-Crooswijk. It includes innovative sustainable energy production and a conscious lifestyle. It is a neighbourhood that allows residents to come together in cosy, hidden shared spaces and informal routes. Or on the markets and terraces of bustling neighbourhood streets.

The sports centre is a gathering place for people of all ages from all over the city. But there are also quiet walking routes in the green to escape the city's hustle and bustle of everyday life. Walking and cycling routes are safer and more pleasant, and the car has a minimal role in the neighbourhood and people's lives.

The neighbourhood is a more pleasant place to live, the public space is a nicer place to stay, the streets are a safer place to move, and the environment is a more social place to meet.



New development

There is development in the neighbourhood to create new high-quality spaces. The choice of where development takes place is based on the state of the current buildings, which no longer meet the new sustainable standard (In the cases of 1,2,5 and 6), and the qualitative value of the public areas. Or there is a new development to create new public spaces (3,4,5, and 7). In addition, there are locations where both reasons apply.

Figure 111: New development in the neighbourhood projected on map of Oud-Crooswijk

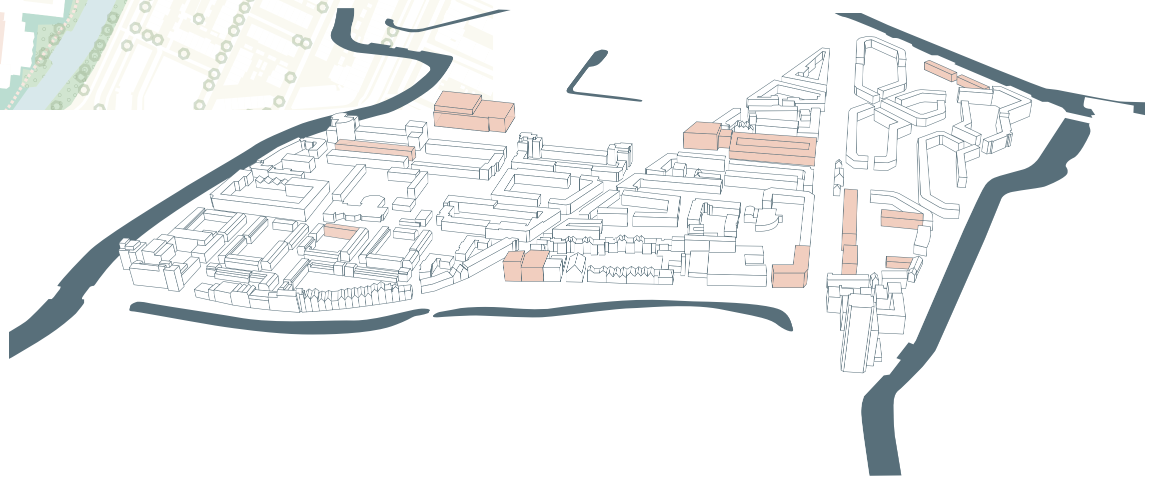


Figure 112: New development in the neighbourhood shown in birdseye view of Oud-Crooswijk

12.4 Cut out - sports hall Crooswijksestraat

Sports complex

The new sports complex is the main attraction point of the district. Many sports can be practised here outdoors and indoors. The existing fields of the current complex will be reused and even expanded. For example, on a beautiful sunny summer day, there can currently be queues for the tennis fields. In the future, people will have more space to pursue their hobbies. The complex, located at the district's entrance, used to be closed and hidden. But due to the redevelopment, the lively character of the neighbourhood is already clear upon entering.

The redevelopment does not affect the character of the sports complex but highlights its current qualities more clearly. It remains a place for residents, young people, and athletes to come together. It is meant to enjoy sports and see your friends in the meantime. In addition to the redevelopment of the Crooswijksestraat. As a result, this will be a more critical route for slow traffic, which has the potential for more interaction between street life and the sports complex.

For example, it might tempt someone who cycles by to put on their sports clothing and participate in a game.

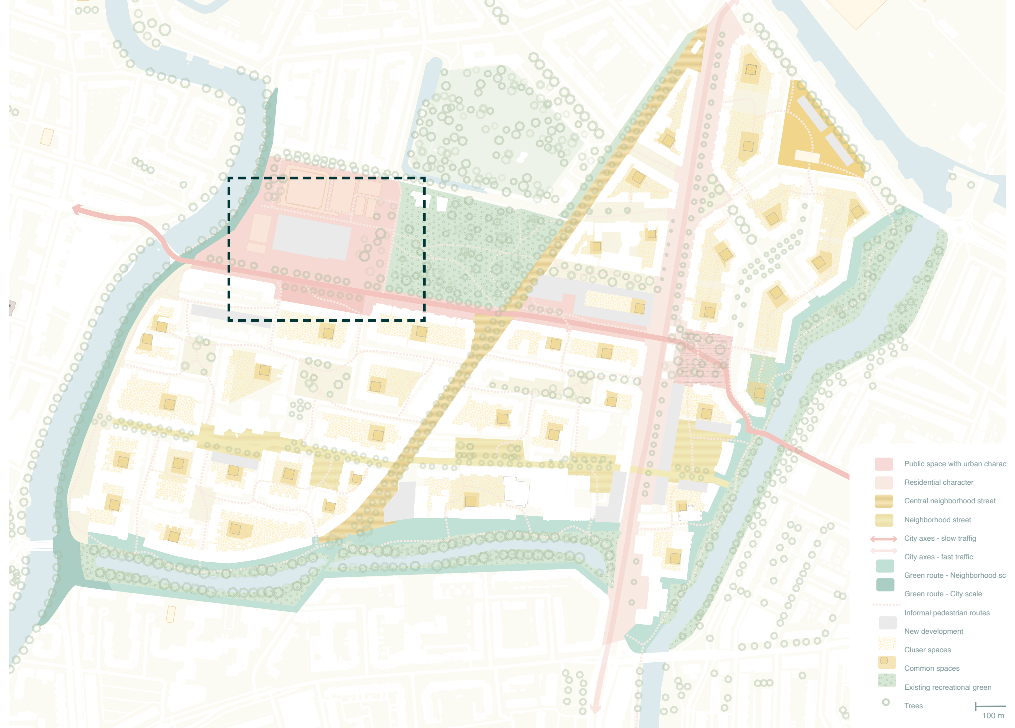


Figure 113: Location of zoom in sports hall Crooswijksestraat

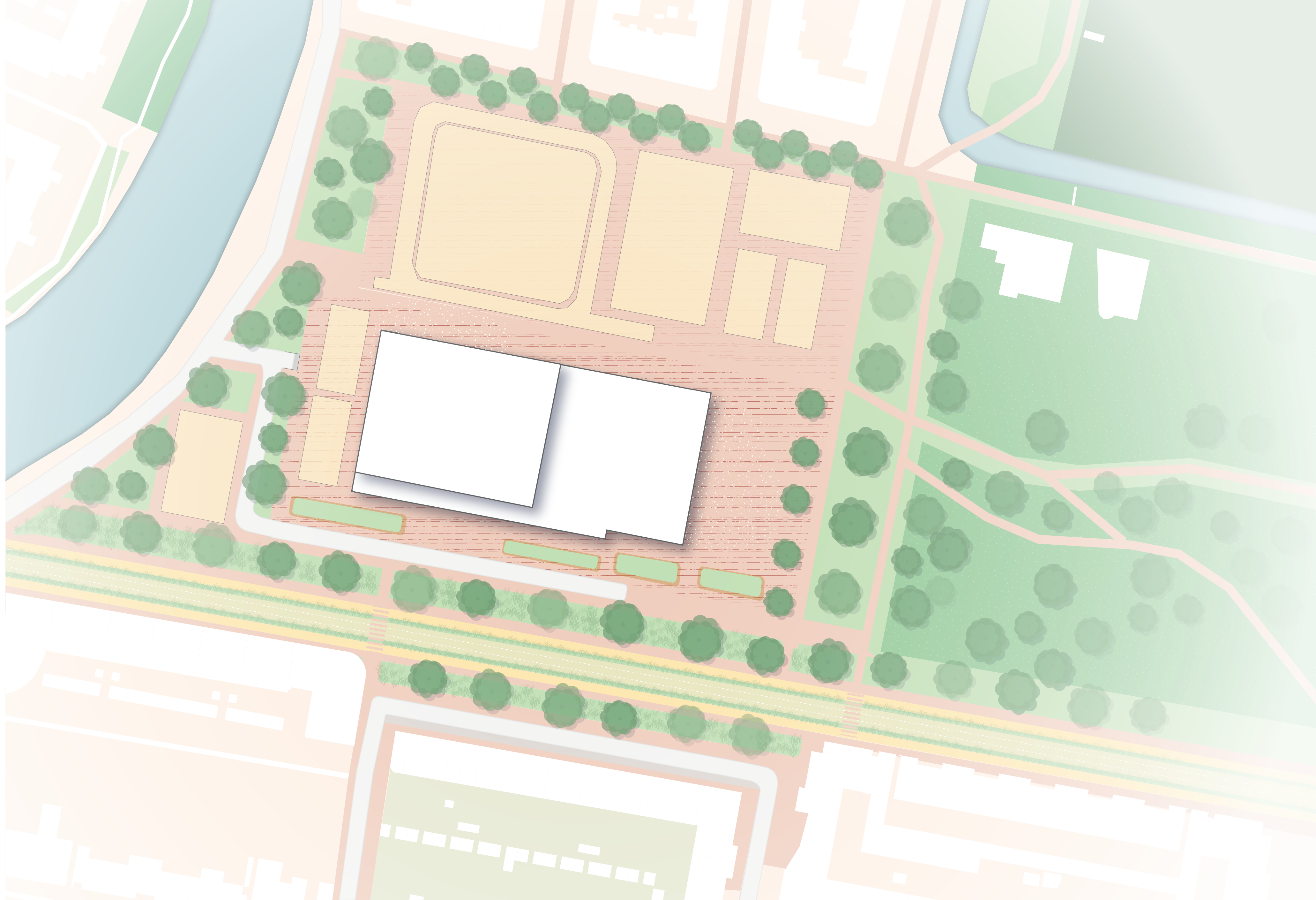


Figure 114: Zoom in of sports hall Crooswijksestraat

The streetscape of the Crooswijksestraat

The current profile is broad, and this is due to the prominent role of the car. There are two parallel streets and extra parking spaces on both sides. The street itself is busy with motorists, trams, and cyclists. It can create unsafe traffic situations. The road will be greenefied, which ensures a better microclimate and a nicer living space.

In addition, the broad street profile divides into various green user spaces. For example, cyclists cycle through a green corridor. The sports complex is more visible from the street, with more potential for interaction.

The water is collected and drained by wadis, which helps with the pressure on the water system for water collection during heavy rain. In addition, greening the street ensures more coolness. It is pleasant and needed during heat waves for commuters and residents (appendix 1).

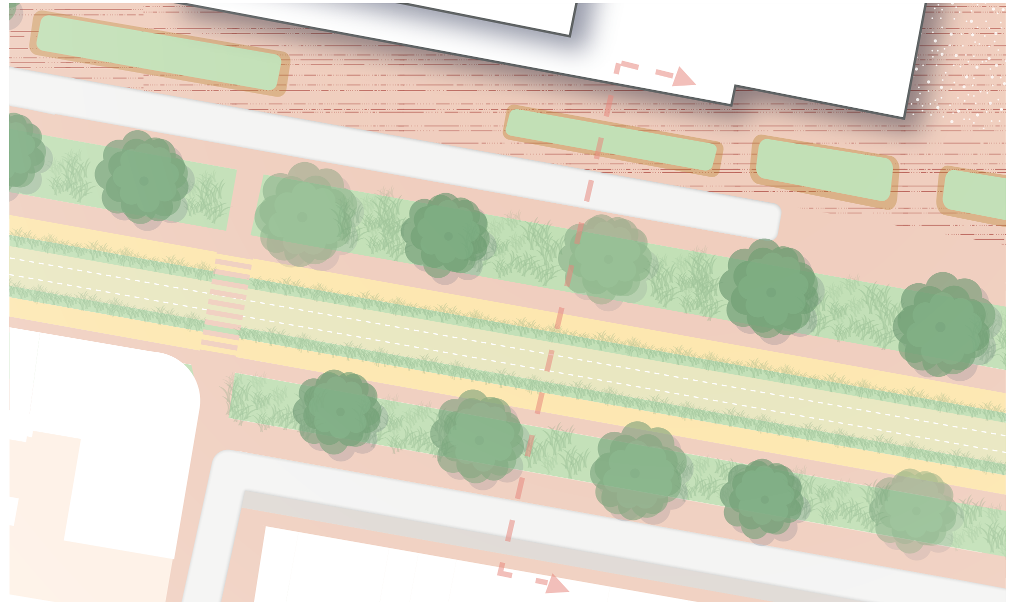
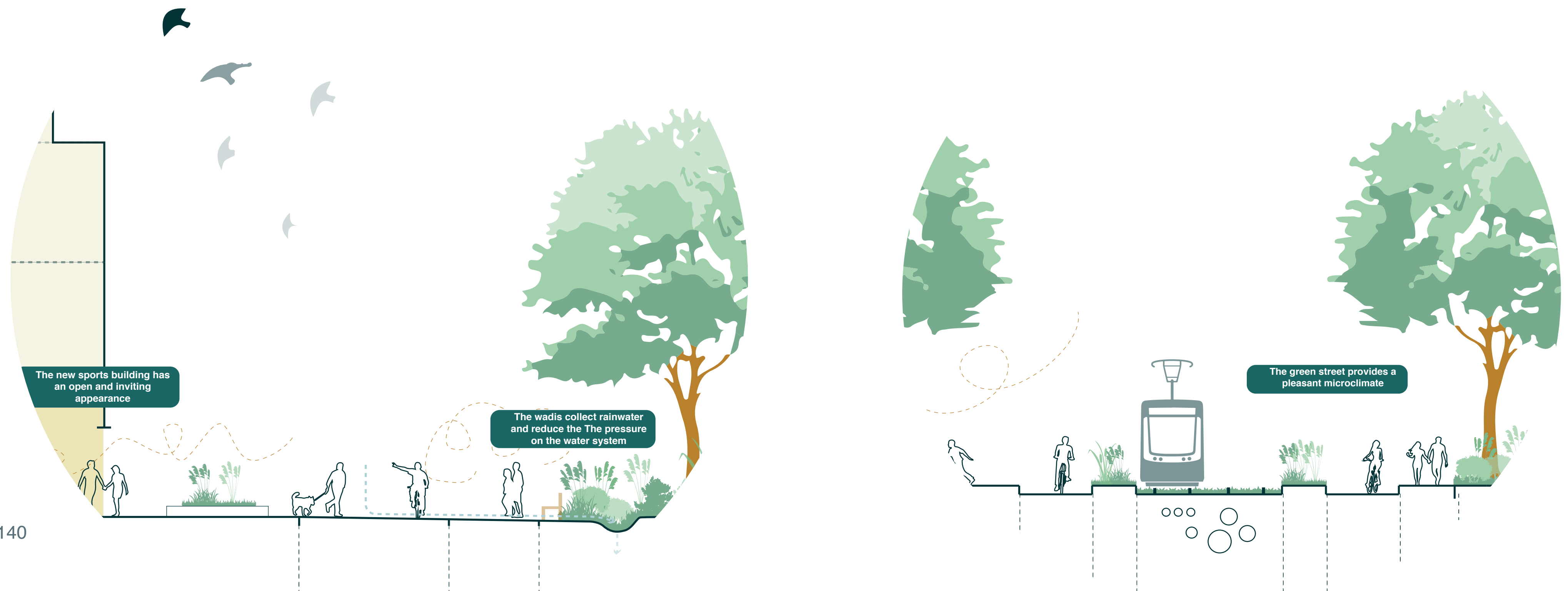


Figure 115: Location of section of sports hall at Crooswijksestraat



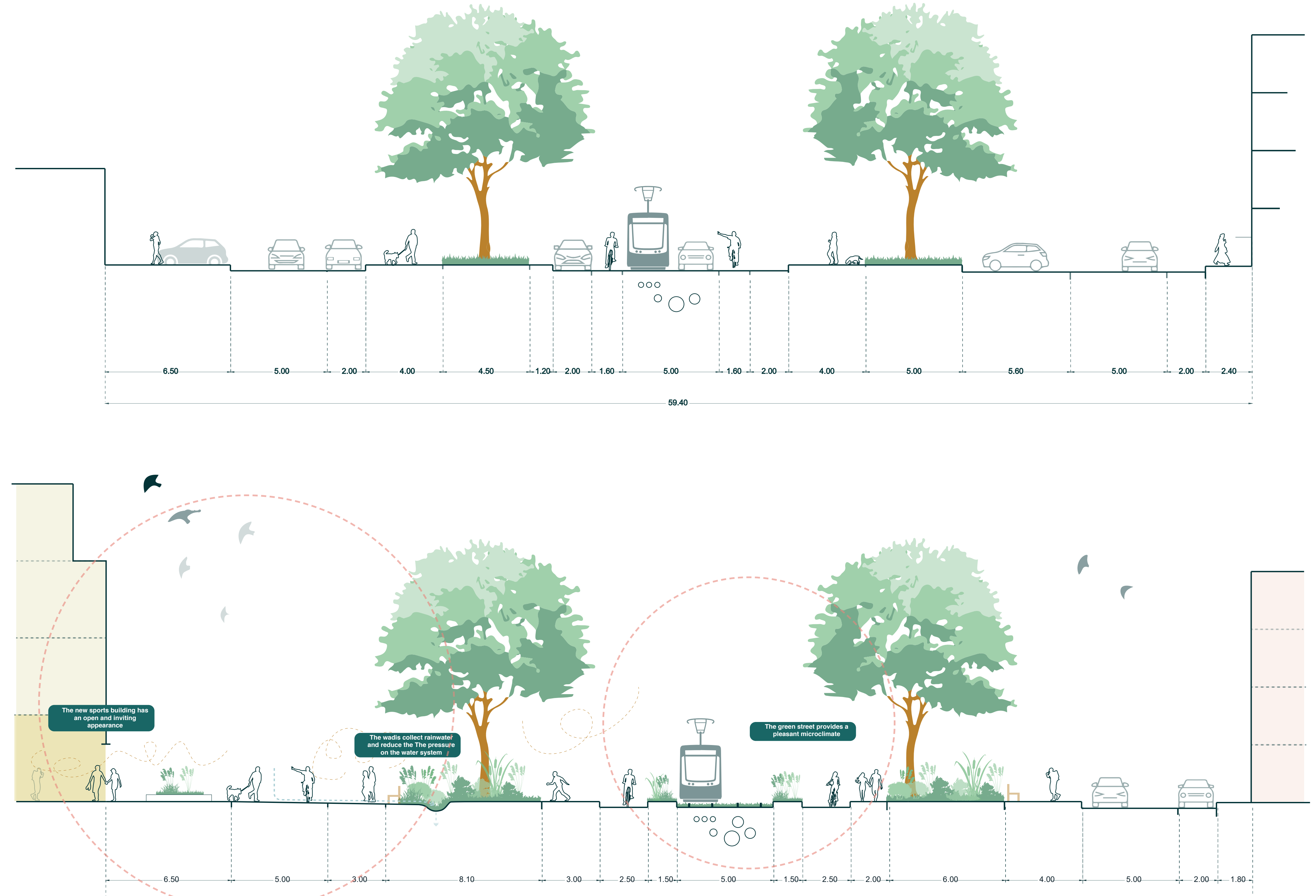


Figure 116: Sections of Crooswijksestraat at the location of the sports hall (Above: Current , Underneath: Within new design)

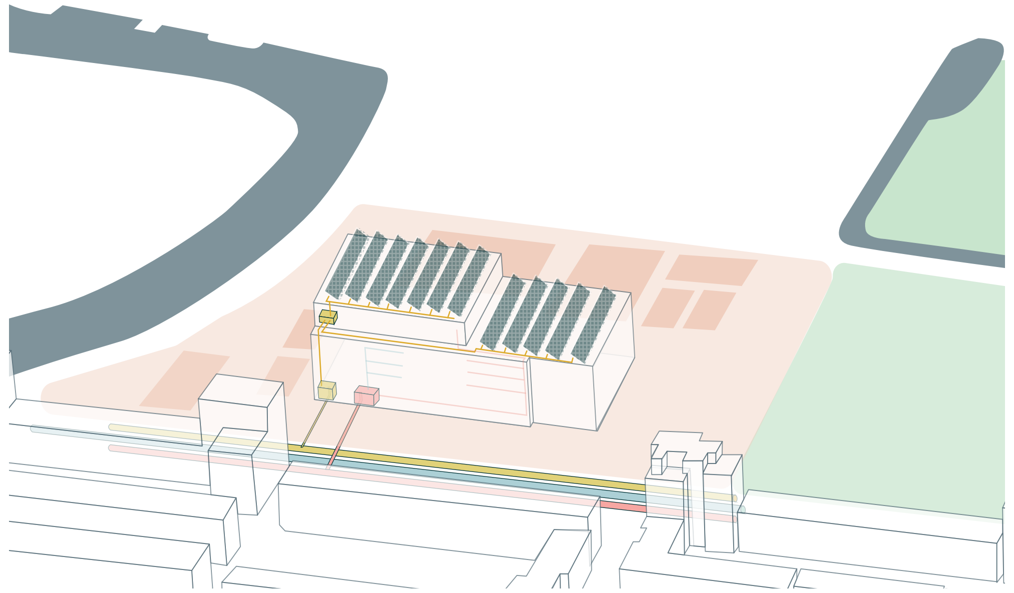


Figure 117: Axonometric view of new energy connections of the sports hall at the Crooswijksestraat

Energy at the new sportscomplex

This axonometry shows in detail the new connections of the new sustainable energy plan. It shows how the residual heat is used throughout the building, connected to the neighbourhood network, and discharged as cold water. And it visualises the connection of the new solar panels to the building and the power grid.

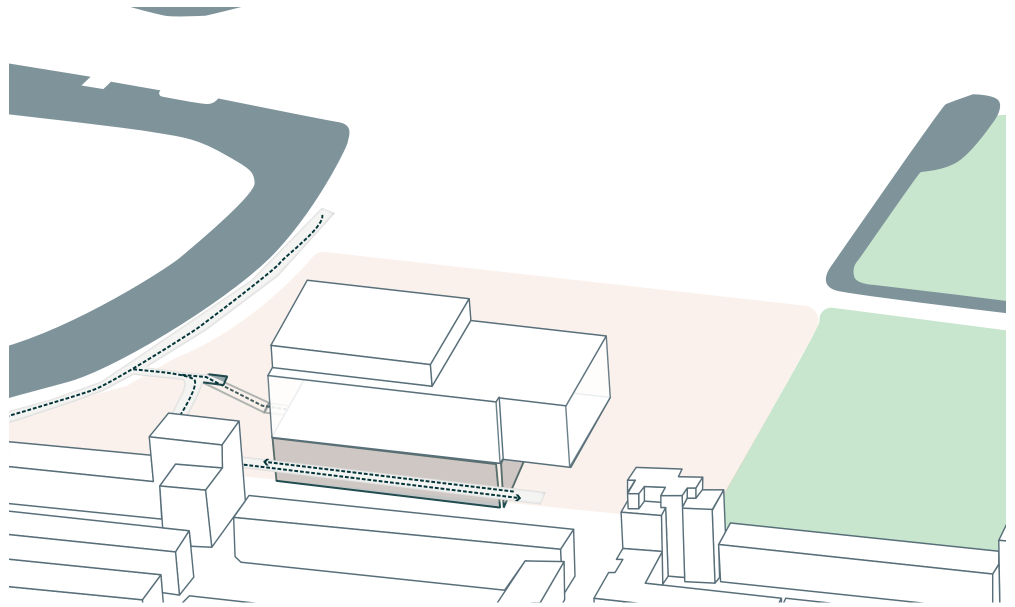


Figure 118: Axonometric view of new mobility connections of the sports hall at the Crooswijksestraat

Mobility of the sportscomplex

The street in front of the sports complex is accessible for loading, unloading, and other necessary traffic. The road is no longer continuous, and parking has been moved. The new sports complex has a parking garage in which users of the complex and residents can park, with many reserved places for shared mobility.

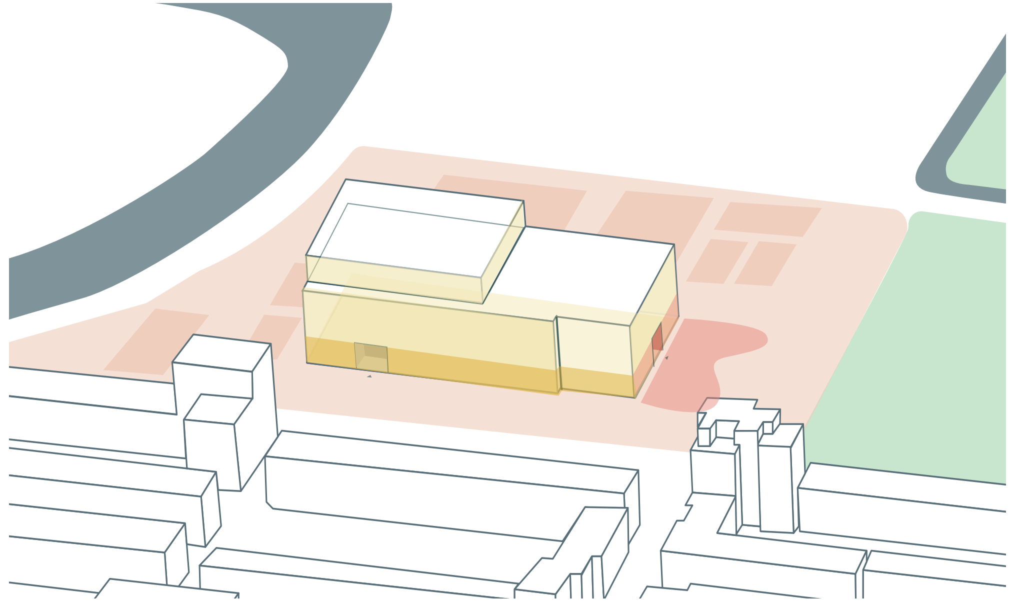


Figure 119: Axonometric view of new program of the sports hall at the Crooswijksestraat

Spatial quality of the sportscomplex

The axonometry shows the new spatial quality of the sports complex. It mainly shows how the interaction between the building and the street has improved. It is an attractive and vibrant complex. The greening of the road makes it an excellent place for residents to play sports and come and watch. It is the only sports complex in the area with a wide range of openly accessible outdoor sports fields. No tickets, reservations, or subscriptions are required. It makes the atmosphere of the sports complex different from others in the vicinity of the north of Rotterdam. The threshold of visiting and exercising is low, so the attraction is big.

Program of the new sportscomplex

The primary function of the sports complex, of course, is sports. Residents can sport both indoors and outdoors. As mentioned earlier, the complex will expand the sports fields outside, and as a result, these outdoor sports fields are less hidden behind the building. Inside, there is a broader range of sports and related functions, such as a sports cafe, and outside there is a terrace from which the sports can be viewed.

Figure 120: Axonometric view of new spatial quality connections of the sports hall

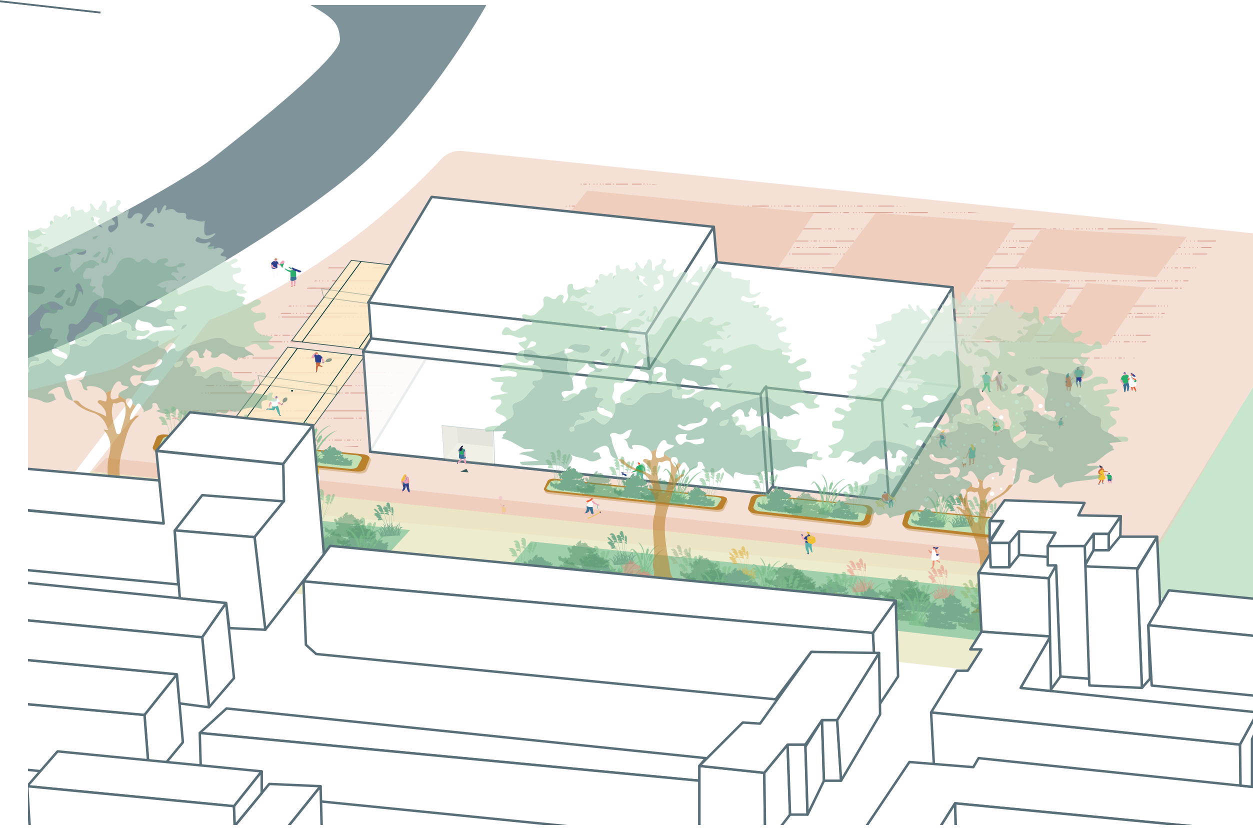


Figure 121: Impression of residual heat network infrastructure at eye level

12.5 Applicability of interventions

Applicability technical interventions

The interventions mentioned cause a lot of change in the neighbourhood. It can cause a lot of revolt and frustration among residents. The application of these interventions is complex, and the research will discuss this in more detail later. Some measures help integrate these new interventions in the neighbourhood; these are principles of applicability.

Residual heat network
The residual heat network construction is underground, but the entire district must be overhauled. Various infrastructure has to be built for it, from pipelines to heat exchange installations.
An advantage of this underground infrastructure is that people see less of it, which is also a disadvantage. The absence of the installation in people's living environment creates a disconnect. In comparison, this research has detailed why it is crucial that the connection between residents and the energy landscape needs to be stronger.

Transparency
The residual heat network comes above ground in several places, such as heat exchange stations. These are also built in the district. Unlike many other energy infrastructures, these stations are transparent. It allows people to see what is happening underground. Combined with a board with information about the plan for the entire neighbourhood, this can be a moment of education and wonder for residents and passers-by.
In addition, the process must also be transparent by involving residents and taking them along in what this can mean for the neighbourhood.

feedback
The visibility of action and reaction is also essential. It means that the effect of the measures must be visual and clear to residents. They need to see what they're doing it for. So visualizing how much energy is generated and used in the neighbourhood. How much residual heat comes in, and how much the panels generate.

12.6 Cut out - Pijperstraat

The Pijperstraat block

The block on the Pijperstraat is already on the demolition list, and the buildings are already empty.

It gives room for new development. The block is located at an important intersection and close to Schuttersveld park. The block stands at the meeting point between the Crooswijksestraat, an important slow traffic axis, and the Crooswijkseweg, the central neighbourhood street. In addition, behind the block is a large secondary school, the Rudolf Steiner college; a lot happens around the block.

The block connects these different streams of people and needs. For example, residents can go there to shop, and people on their way home from work can also do a small errand. The shops will be there mainly for food and other daily needs. Since there are few larger supermarkets in the area, this can be an addition to an area larger than the neighbourhood itself. In addition to developing these new functions, the site will create a new residential block. It is a mixture of private rental, social rental, and privately owned homes.

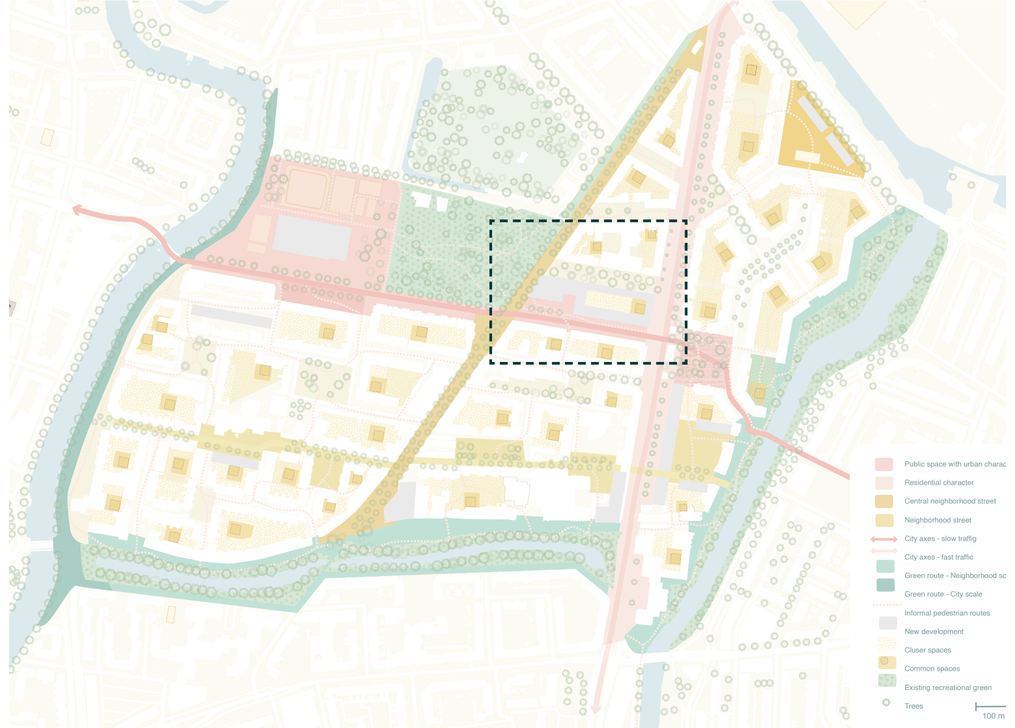


Figure 122: Location of zoom in new development at Pijperstraat

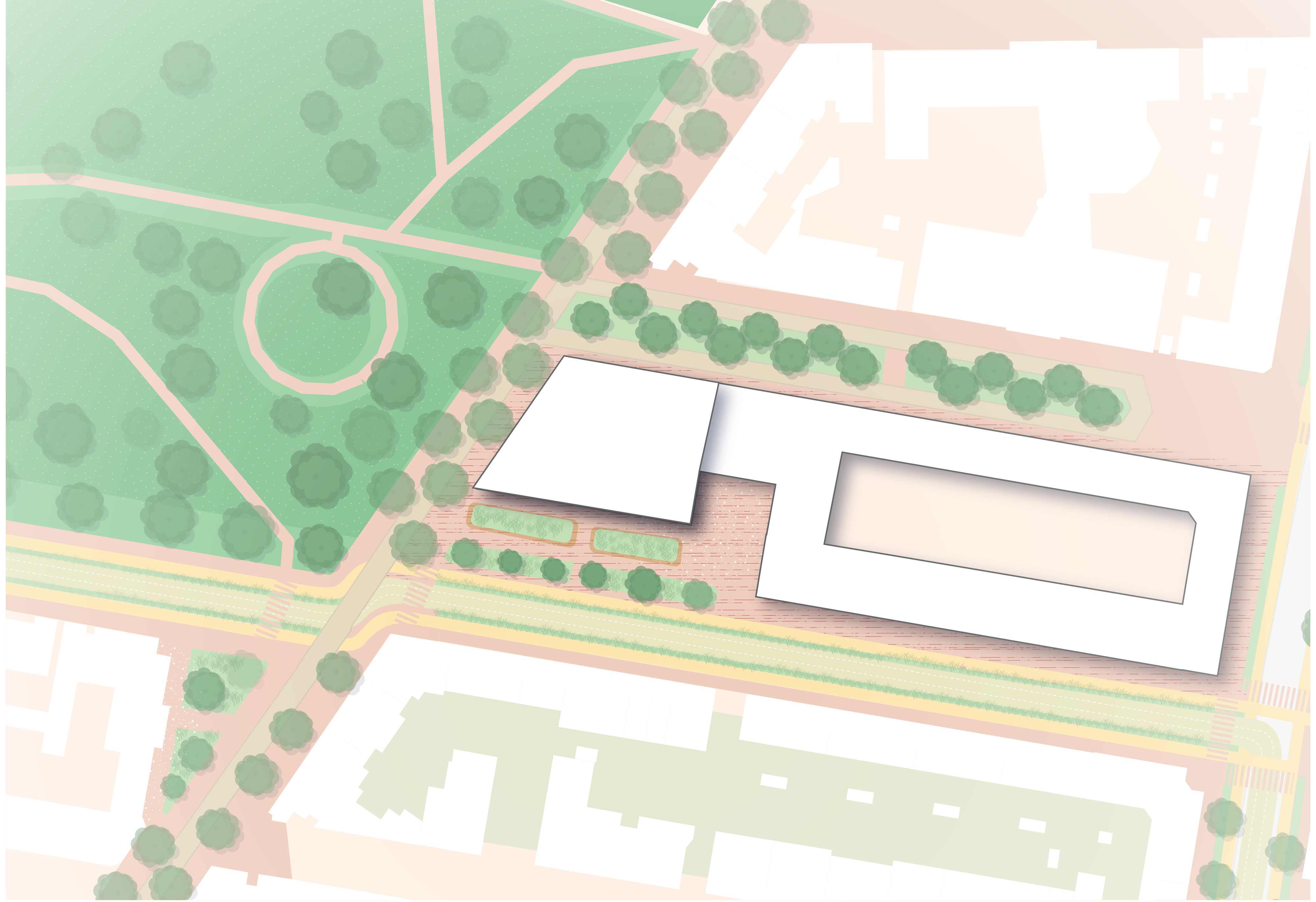


Figure 123: Zoom in new development at Pijperstraat

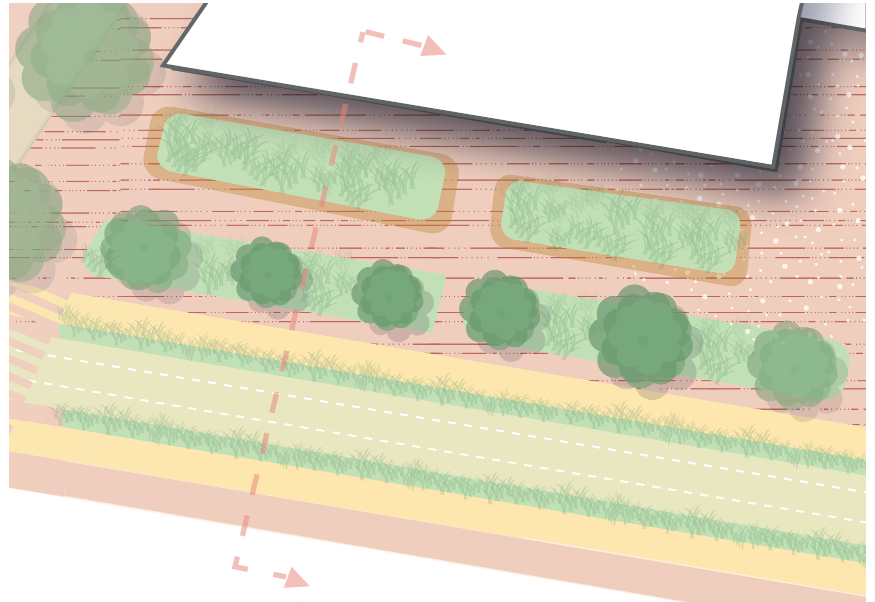


Figure 124: Location of section of new development at Pijperstraat

The Pijperstraat

The redevelopment of the block does a lot for the street profile. The current street profile is very tight and busy. The new development will provide more space for cyclists and pedestrians because it is no longer accessible by car. Cyclists no longer have to share space with the tram, which can prevent many accidents. In addition, the widening of the street profile gives room for greening. As a result, the street is almost unrecognisable from a traffic bottleneck to a lovely green slow traffic route.

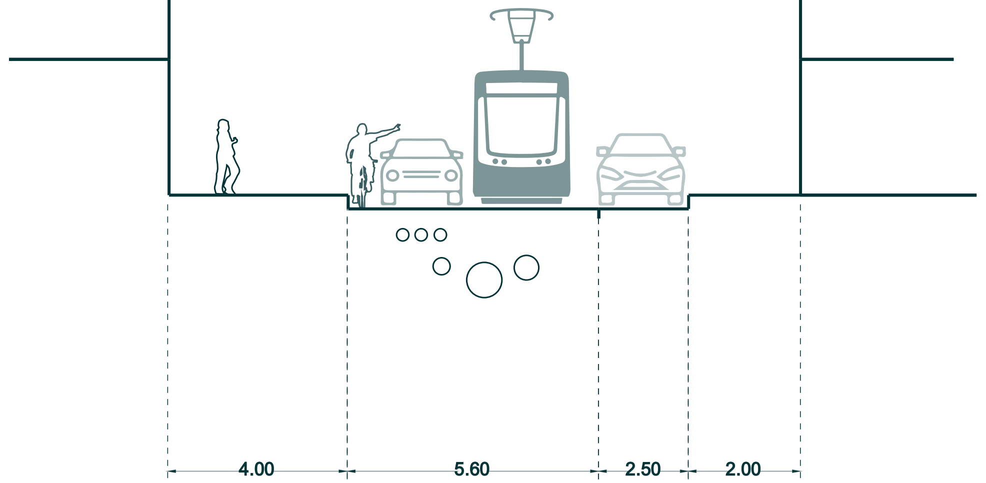


Figure 125: Section of the Pijperstraat current situation

Figure 126: Section of the Pijperstraat future possibility

12.7 Cut out - Koeweide

Figure 127: Location of sections of Koeweide

Figure 128: Historic picture of Koeweide in the time there was still a slaughterhouse. Source: Lex de Herder, Stadsarchief Rotterdam

Figure 129: Picture of Koeweide currently

The Koeweide

The Koeweide location used to be the district's slaughterhouse and traditionally had a critical area within the community. It is currently a pleasant green space and important for residents and children to come together and play outside.
It is one of the greater opportunities in the district because it is already a friendly place where residents like to come. That is why it is essential to make full use of the space. Currently, it is just a grass field and has little interaction with the surrounding buildings, which will change, the green area will transform into a green play wilderness, and the surrounding buildings will play a facilitating role. The place is suitable for a picnic, a neighbourhood celebration, or reading a book quietly.
Instead of ample open space, it becomes a space with more minor cosy spots. There is still enough space to play football in the grass or organise a local music event, but the area has more varied uses this way.
The historic building on the west side of the Koeweide houses a restaurant that pays homage to the original cattle market at this location. It is a fun way for residents to enjoy good food and learn something about the neighbourhood's history.

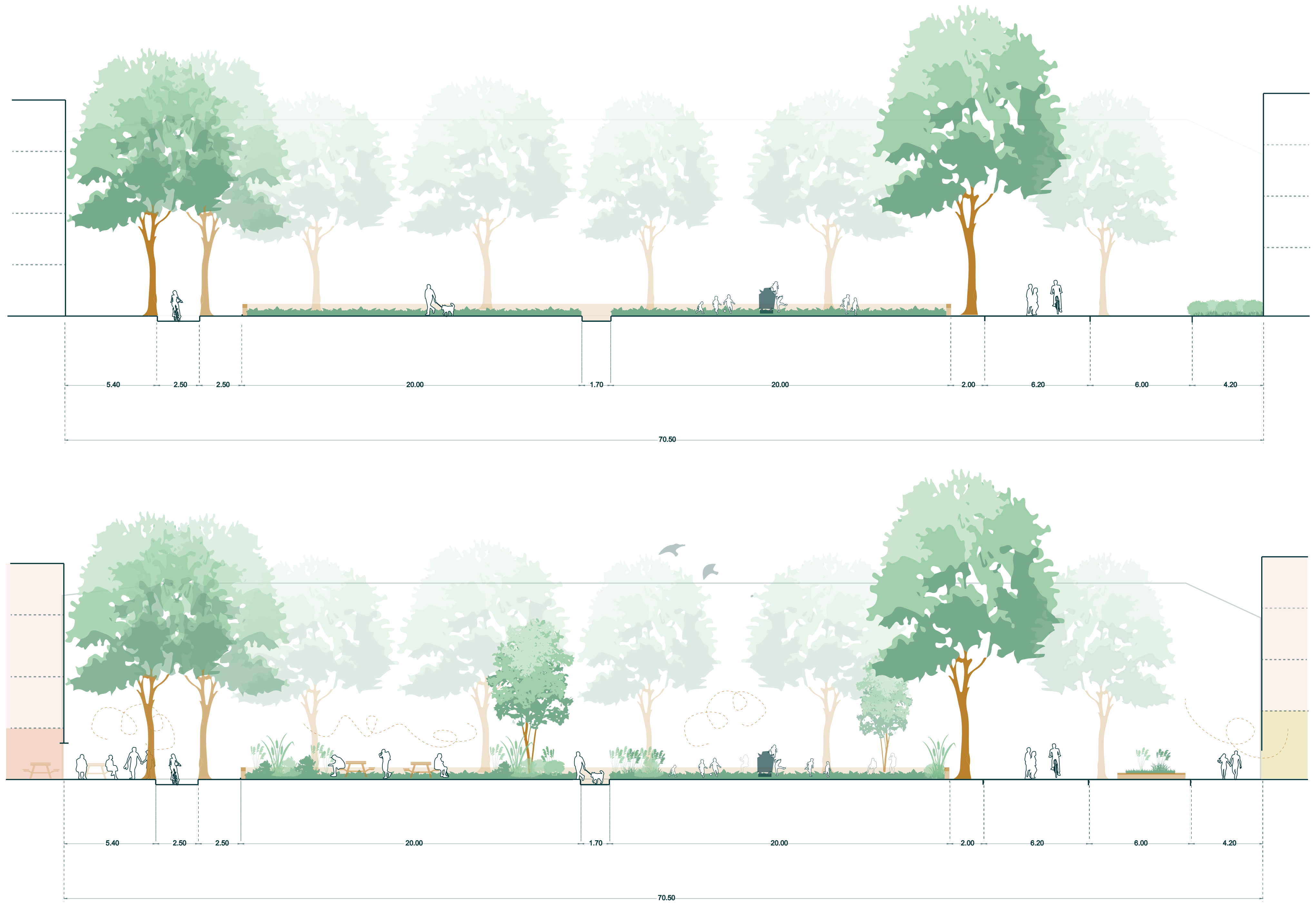


Figure 130: Section of the Koeweide
(Above: Current , Underneath: Within new design)

12.8 Energy community building block

An energy community building block

As explained in the energy saving plan, it is important to use energy differently. Energy has to play a different role in daily life. People need to adopt a less individualistic lifestyle. In the energy community building blocks, people work together towards a sustainable future. Energy is generated and used together.
Figure 131 shows an example of a possible design of such a shared energy space. The nice thing is that these spaces can be arranged in consultation with residents. As a result, the wishes of residents can be taken into account in the design. For example, some residents will enjoy growing their vegetables and other residents will enjoy having more play opportunities for the children. All these energy-saving community spaces have space for residents to come together in the evening, cook, and spent time together. This saves energy because the individual homes do not all have to be heated. And in addition, it can create a stronger bond between neighborhood residents, food connects people.
There may also be a financial motive because it can save costs for residents to heat in the shared space instead of at home. Eating together also saves on the cost of groceries.
Doing this in the right way requires a lot from residents, it requires a lot of good communication, more participation, and a greater sense of responsibility. This is a challenge, but the opportunities it offers spatially and for the community are enormous. With the rising trend of loneliness among people, this may be a necessary counter-reaction (CBS, 2020).

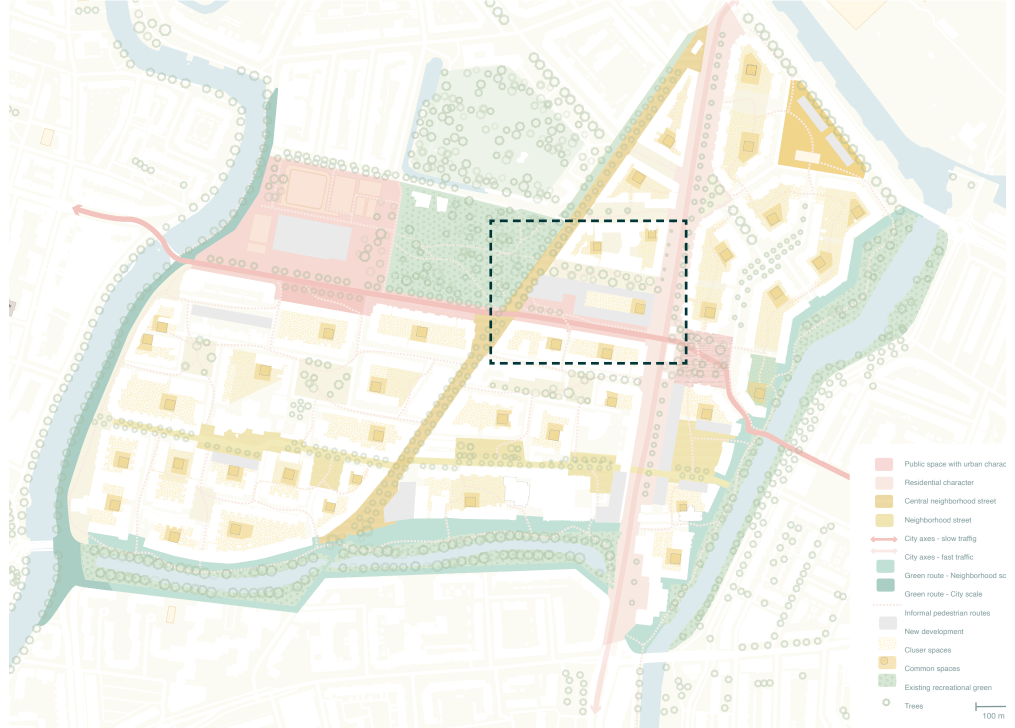


Figure 131: Location of zoom on energy community building block

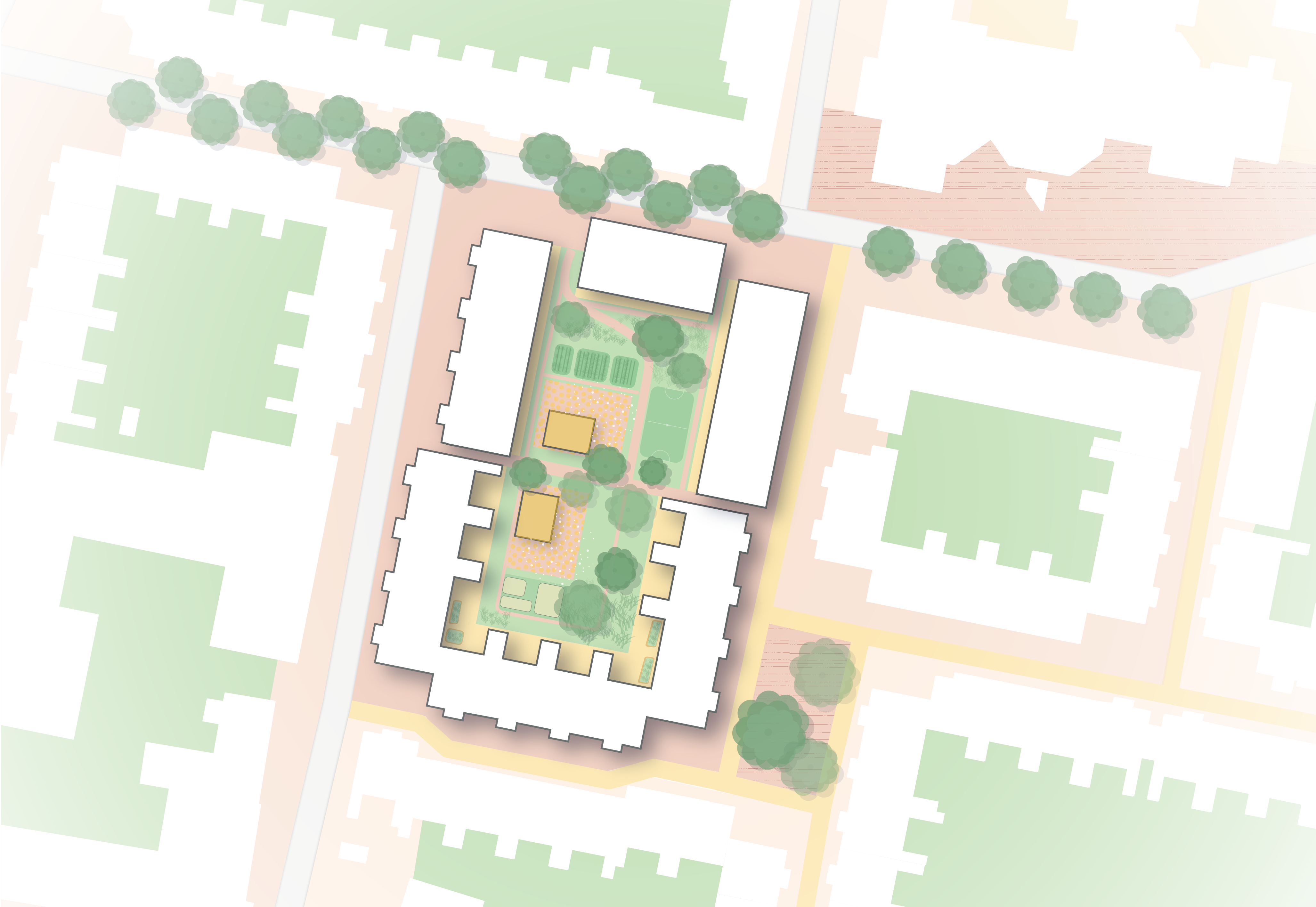


Figure 132: Zoom in of energy community building block

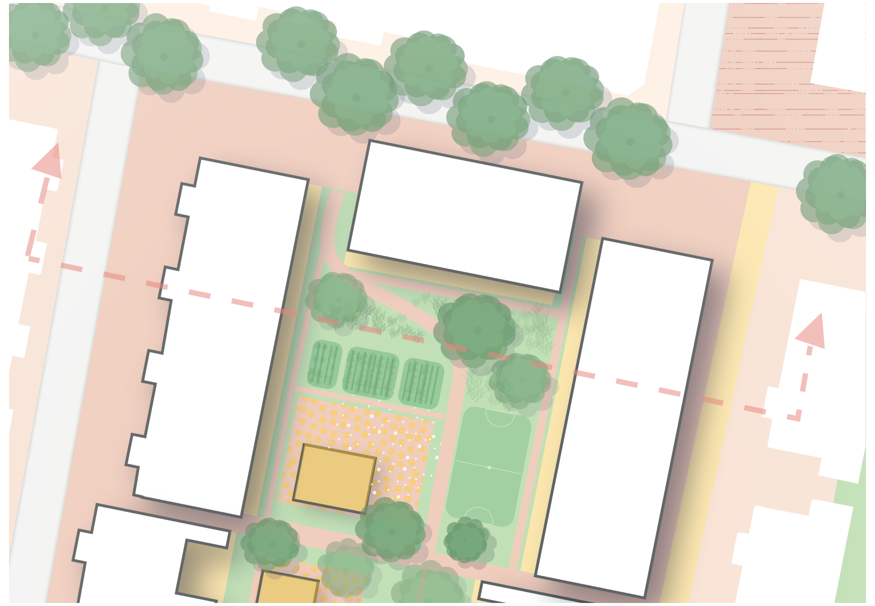


Figure 133: Location of Section of energy community building block

Figure 134: Picture of Albert de Boijhof in Oud-Crooswijk currently

Inside a community building block

As can be seen in figure 133, the original layout of a building block is much more individualistic. Currently, many courtyards facilitate parking or personal backyards. These are essential functions for residents.
That does not outweigh a communal space's qualities. Not only does the new plan look nicer, but it also has a more pleasant micro-climate. It counteracts trends in cities that significantly reduce the quality of life, such as; heat stress, water storage, and loneliness among the elderly.

Figure 135: Section of an energy community building block
(Above: Current , Underneath: Within new design)

Energy generating block

The energy generated using solar panels is used in the homes and connected to the power grid. The shared grid allows a neighbour to use energy from another neighbour if they can't produce enough. It makes it a joint energy production.

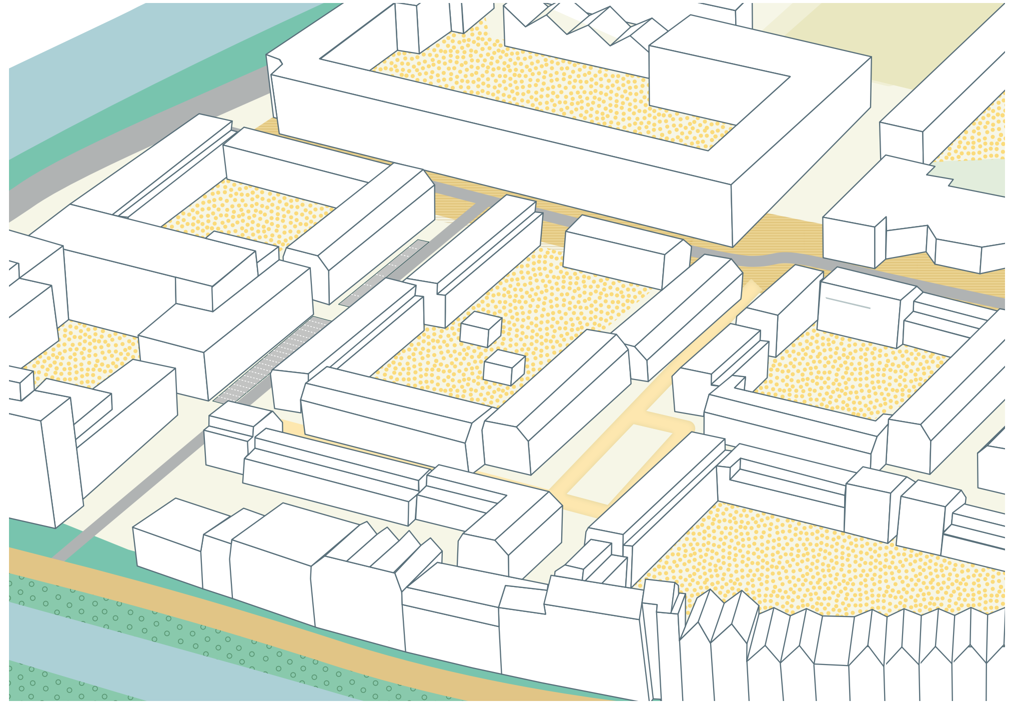


Figure 136: Axonometric view of new energy connections of the energy community building block

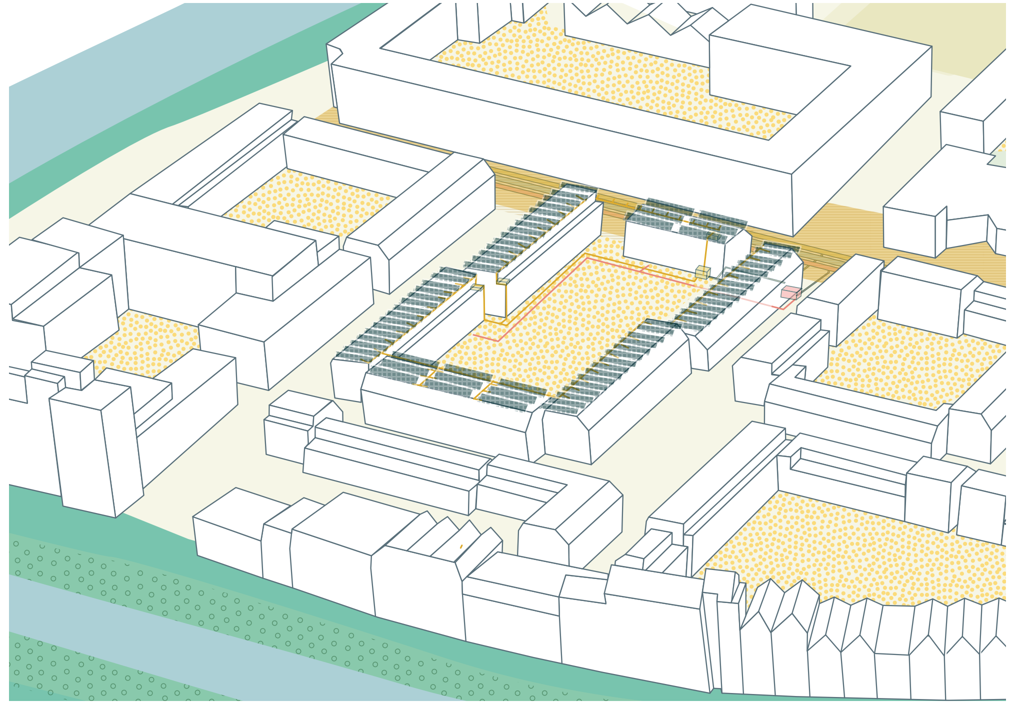


Figure 137: Axonometric view of new mobility connections of the energy community building block

Mobility

The common areas in the courtyards are not accessible by car. There is no place to park the car in the yard anymore. Residents can park elsewhere or may be more inclined to use a shared vehicle.

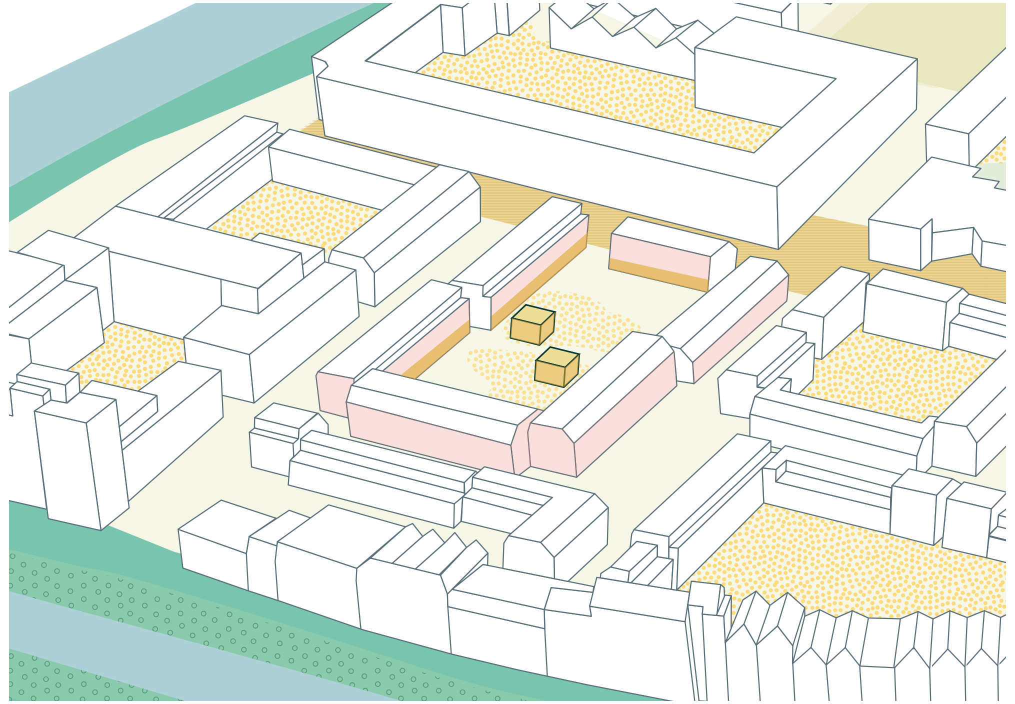


Figure 139: Axonometric view of new spatial quality of the at the energy community building block

The quiet quality

The hidden quality of the courtyard is a closed world that contrasts nicely with the noisy and busy urban world surrounding a residential block. From the street, it is not apparent to passers-by that a completely different life goes on behind the houses. Instead, it offers a place where no cars are allowed and where you can recognise every face on the street. It is a place with reasonable social control where children can play safely and freely.

Program in the block

In these community blocks, where people mainly live, this is, therefore, the main program. However, different forms of living occur here; community and individual living. This axonometry shows which spaces lead to communal living; thus, the areas facilitate and encourage other use.

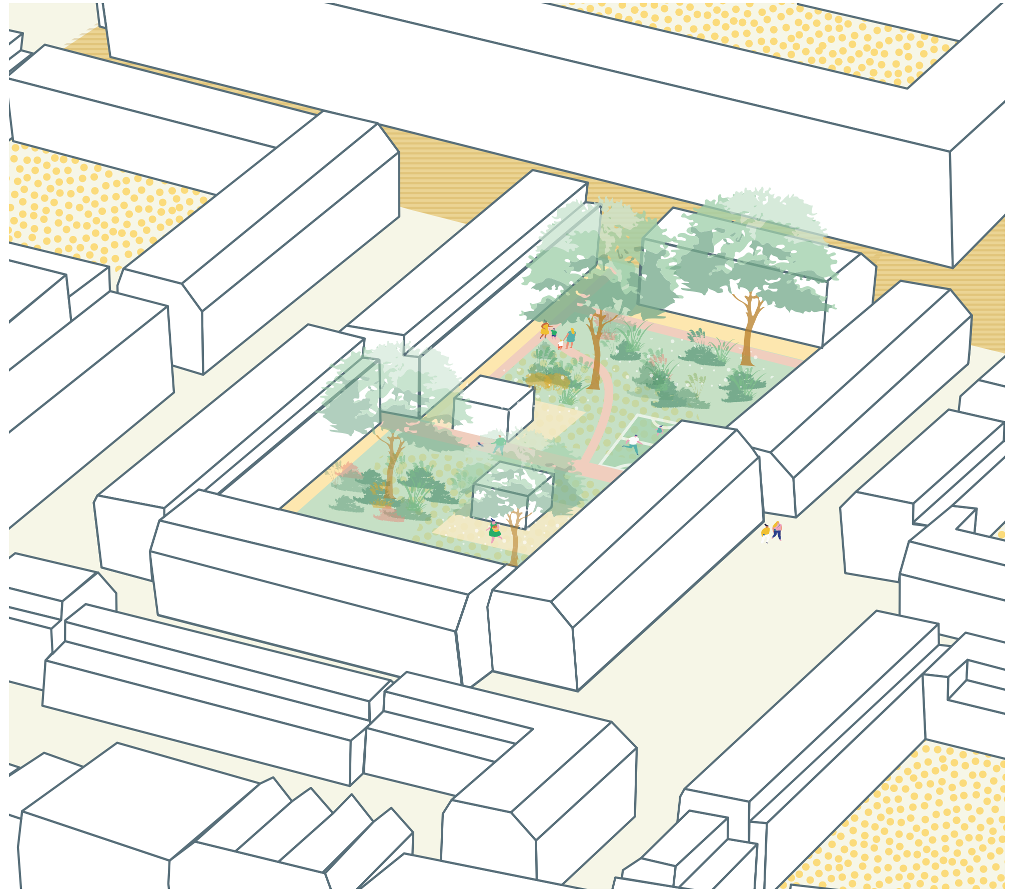


Figure 138: Axonometric view of new program of the energy community building block

Figure 140: Community building block birds-eye imrpession

12.9 Applicability of interventions

Applicability of social interventions

In addition to technical interventions, there are also social ones. These are even trickier to accomplish. These interventions affect people's privacy and habits. Again, measures help integrate these new interventions in the neighbourhood; these are principles of applicability. The energy-saving plan consists of shared energy-saving areas. That the following specific actions does it involve; cooking together and spending time together. It isn't easy to let people choose this instead of doing it at home in their own private space.

Saving money
Saving money is one of the easiest and most common incentives. For this, it must be clear to residents that this is a financially sensible choice for them.

Time
It is a lot of change to swallow, which takes some time for residents. That is why time is also an essential part of the change. The residents determine the pace at which these measures can be introduced. One way might be to redevelop one or a few blocks first. As a pioneer in the neighbourhood, show other residents the positive effect. It can create a domino effect that convinces more and more residents.

Participation
The inner spaces of the blocks are being redeveloped together with residents; this is complicated but can be very rewarding. It makes it easier for residents to get used to the change, and they feel more self-determined about it.

Visible effects
The connection between the interventions and the spatial quality that this produces must always be clear. It clarifies what residents are doing it for and is a permanent stimulating factor for forming new habits.

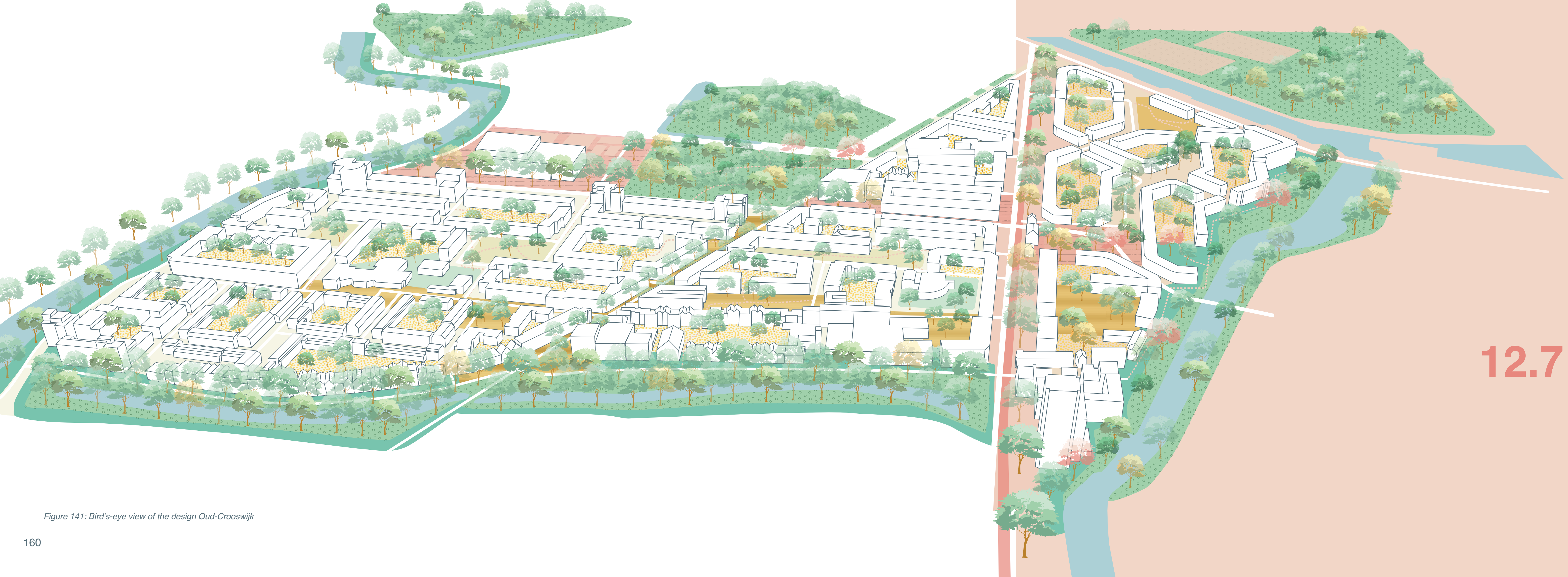


Figure 141: Bird's-eye view of the design Oud-Crooswijk

12.7 Behavioural change

Behavioural change

As mentioned earlier, redevelopment in the neighbourhood requires a lot from the residents. Behavioural changes are needed to achieve these qualities. Figure 142 lists the most extensive individual behavioural changes. Personal behavioural changes mean that people have to adjust their lifestyles.

It does not mean that the collective does not influence this, but it is not about social behaviour. Behavioural changes can be divided into accepting change and proactively encouraging change. When it comes to the construction of a residual heat network, residents are expected to take this change. Installing solar panels or insulating the house requires more cooperation with residents. Making other sustainable lifestyle choices, such as using the car less, requires a proactive attitude from residents.

It remains challenging to encourage behavioural change, but this study aims to show what the qualities are if this does happen. It shows that the benefits are great for the residents as individuals and as a community. The quality of life can improve, and it can reduce costs. In addition, residents are made aware of their individual and collective responsibility because they have a sense of ownership because of the decentralised energy generation.

Not all of these changes happen at the same time. Some mindset shifts must happen before others are possible. There is a kind of natural phasing in this process. First, the district will have to consult the technological solutions; for example, generating sustainable energy and insulating houses. Based on this, the spatial quality and the streetscape can be adjusted. This adjustment gives room for other uses, such as less car-oriented. This natural course of development will hopefully also stimulate a natural system of behaviour change. Finally, the extent of the relationship between our behaviour and our living environment has already been established, and through utilising this design, these developments should work together to achieve the intended qualities.

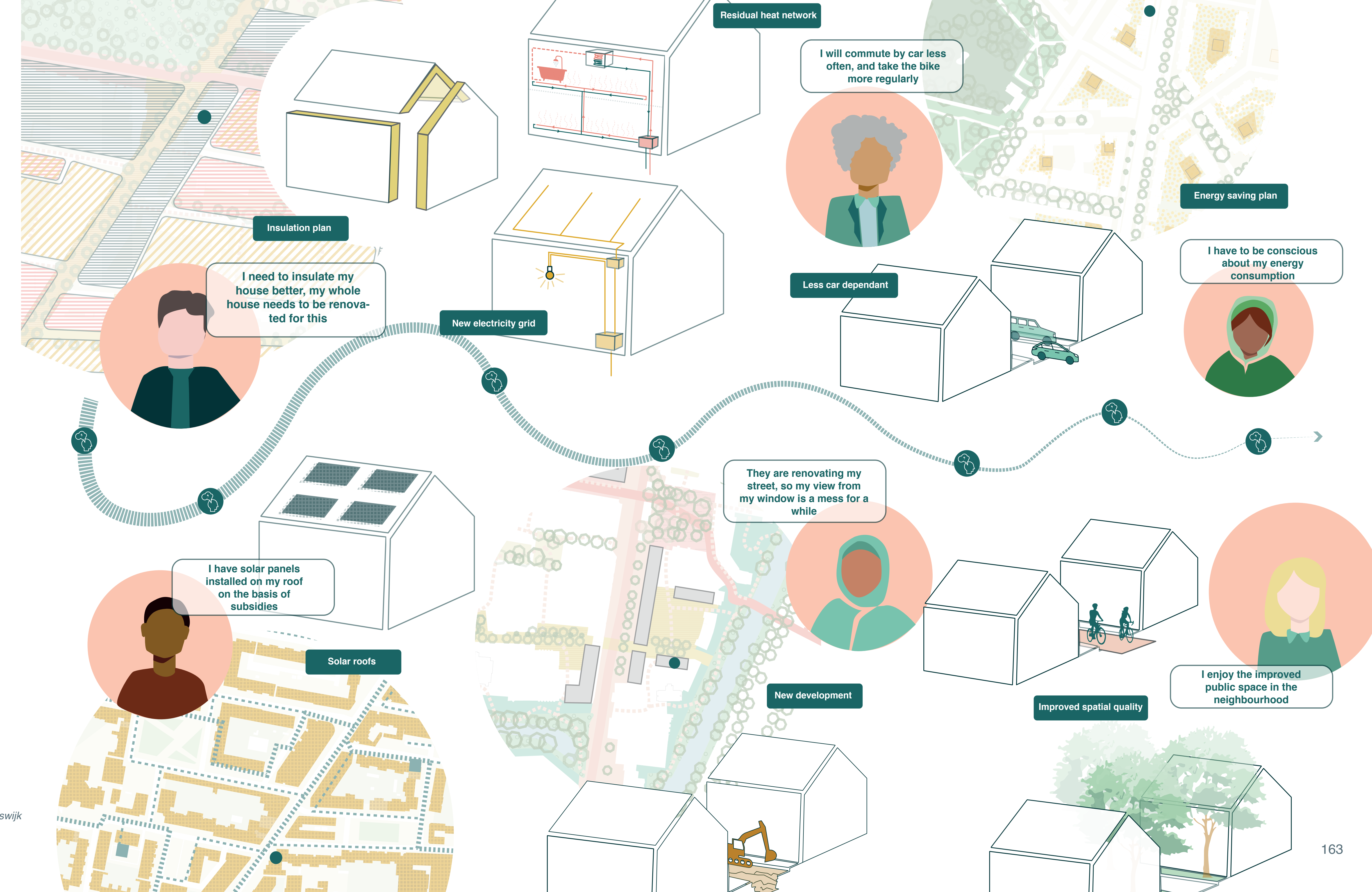


Figure 142: Scheme of behavioural change of residents in Oud Crooswijk

Social behavioural change

In addition to individual behavioural change, there is also social behavioural change. Social and behavioural change is about how the neighbourhood changes together. The design expects a lot from the interaction between residents. Residents need more from each other and have more to do with each other.

As mentioned earlier, this has a lot of potentials because it can stimulate a sense of community. The residents will have a different motivation to be prompted to change their behaviour in the first place. But the feeling of togetherness and society will be an excellent stimulant to make this a new habit. Humans are social animals who enjoy the company of others, a quality getting lost in modern cities, resulting in large groups of people who feel alone (CBS, 2020).

The design asks residents to share more. Where residents used to have their backyard, there is now a communal one. Residents first all had private cars and are slowly making way for shared vehicles. It isn't easy because owning property is an essential human good that many people value very much. The benefits of community or other financial factors must transcend this drive of possession.

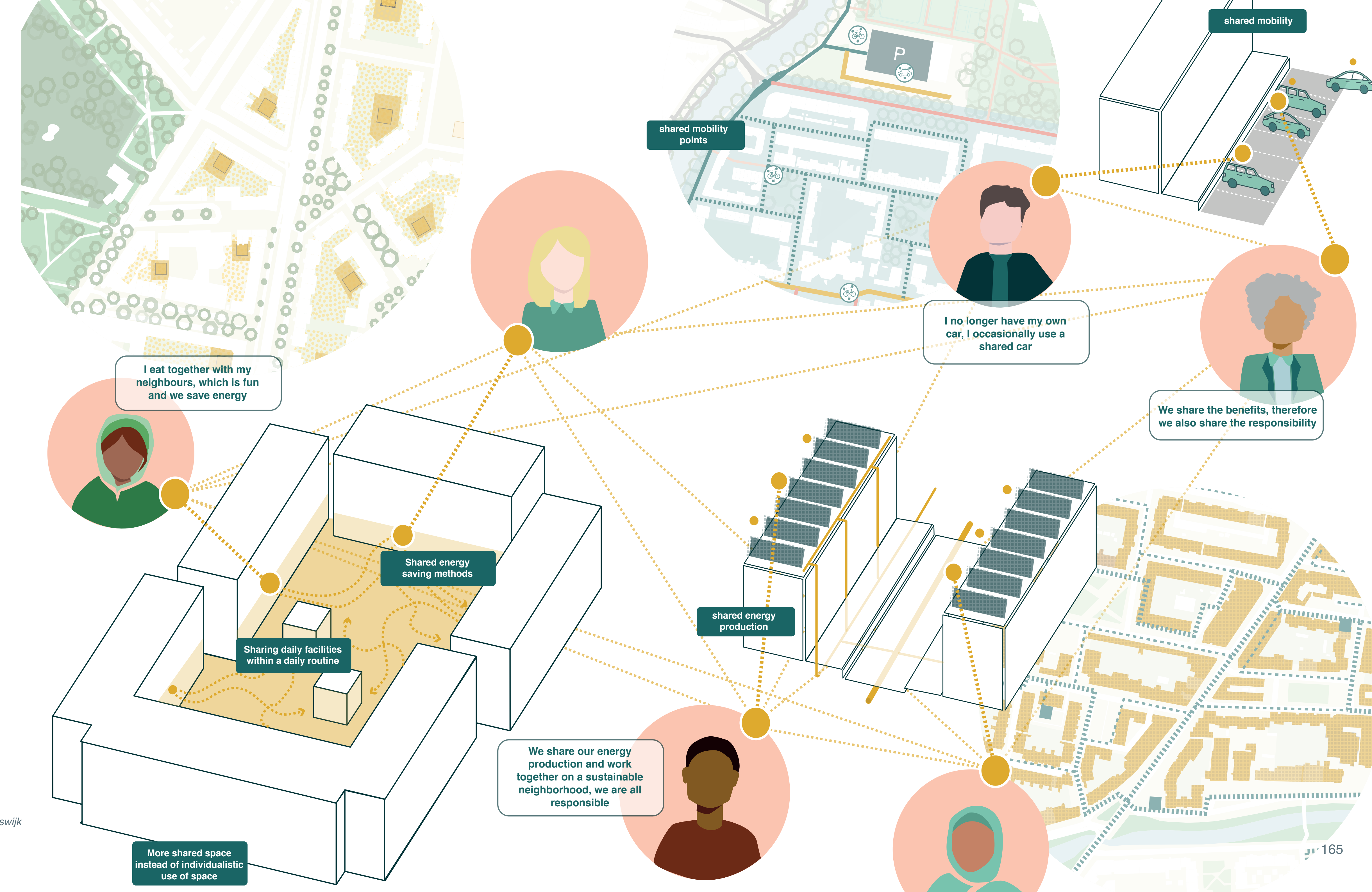


Figure 143: Scheme of social behavioural change of residents in Oud Crooswijk

12.9 Contribution to energy transition

Contribution to energy transition

The changes in Oud-Crooswijk cannot be viewed separately from a larger systemic change. The low-scale modifications can affect the energy system on the national scale or even beyond. An earlier chapter detailed the key locations of the current national energy system. These key locations are the city, the port, and the extraction site. The design focuses on the role of the city in this.
The design has decentralised energy production and conscious use of energy. Energy generation first took place as far as possible outside the inhabited world, but it now mixes with urban life.

It affects the more significant central production locations. Such as the gas extraction sites in Groningen. This way, they can become almost superfluous when the decentralised urban energy production can be supplemented, when necessary, by regional sustainable energy sources.

The relationship with the port will also changes. Currently, a lot of energy transportation takes place in the port as part of the import and export. In addition, the port uses a lot of energy.
In the new urban decentralised energy landscape, the port plays a different role; it will help supply residual heat. Other energy-related functions in the harbour are partly no longer necessary in this new system. It creates room for new developments in the port.

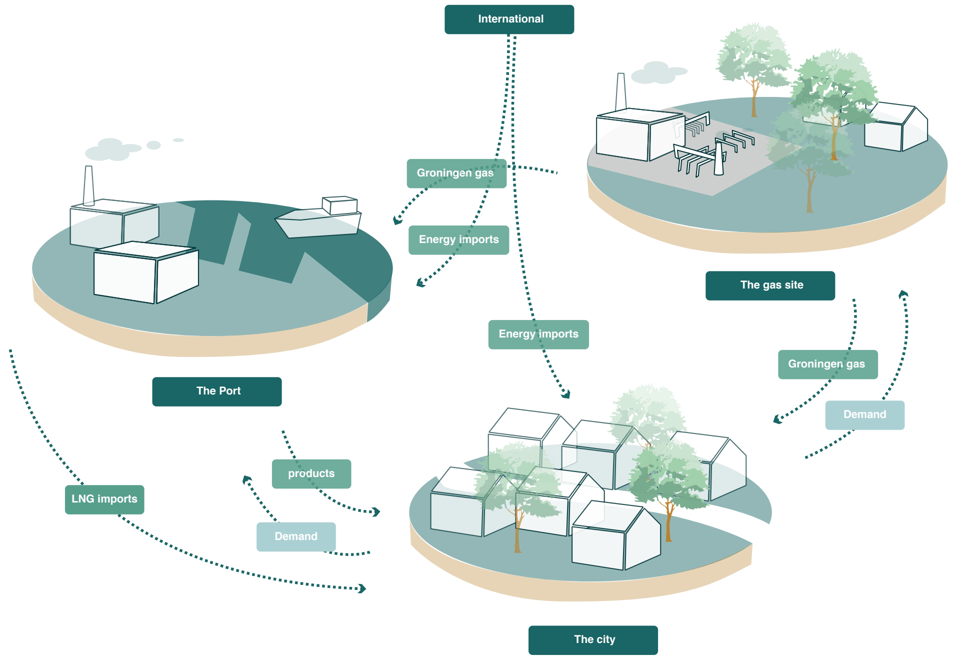


Figure 144: Scheme of key points of the current energy system

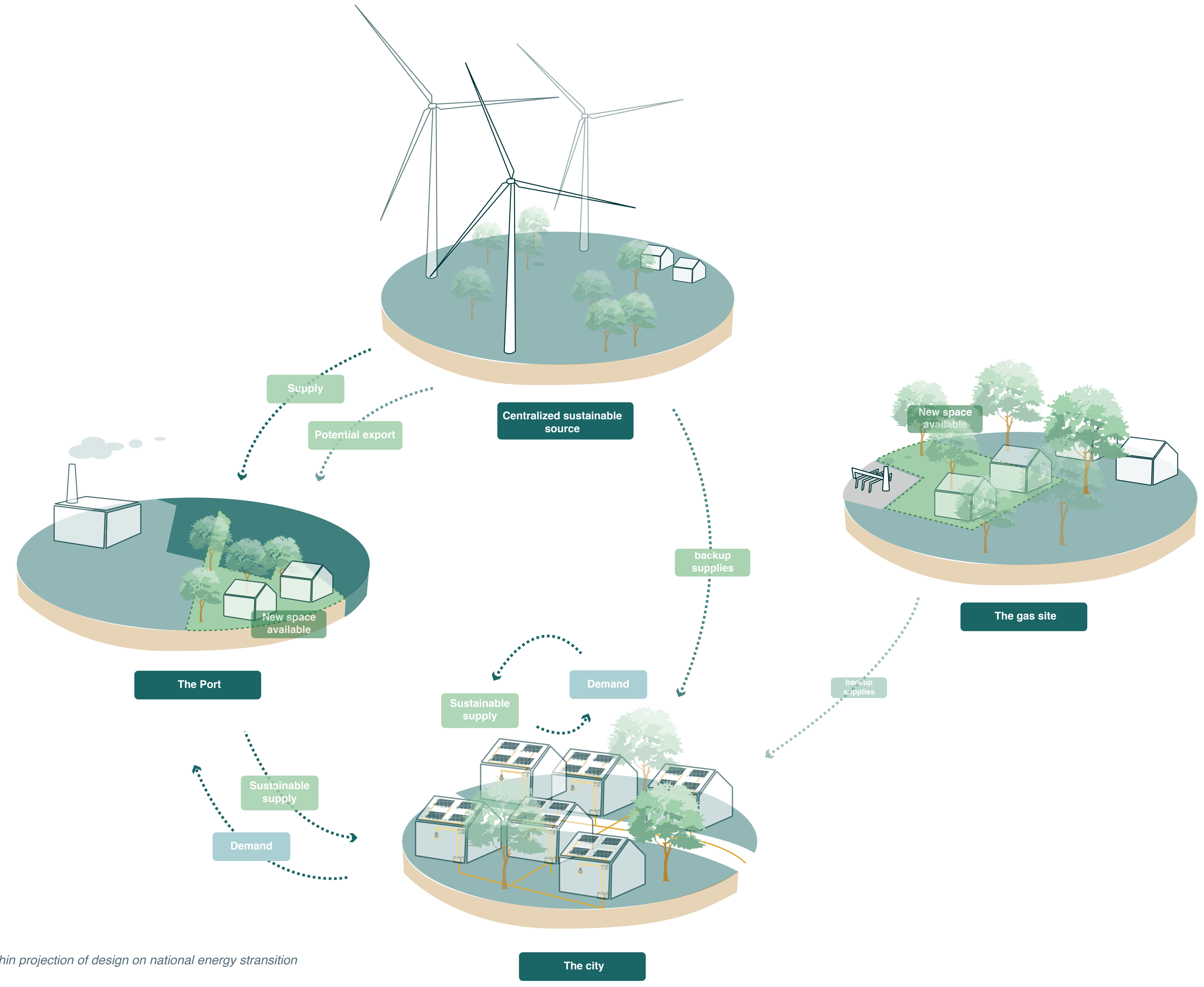


Figure 145: New key points within projection of design on national energy stransition

Contribution to energy transition national scale

Even though it is a highly decentralised system, it is not autonomous. It remains interconnected on a national scale. It makes for a less efficient but much more conscious system. People are closer to energy production and are aware and responsible for their behaviour and contributions.

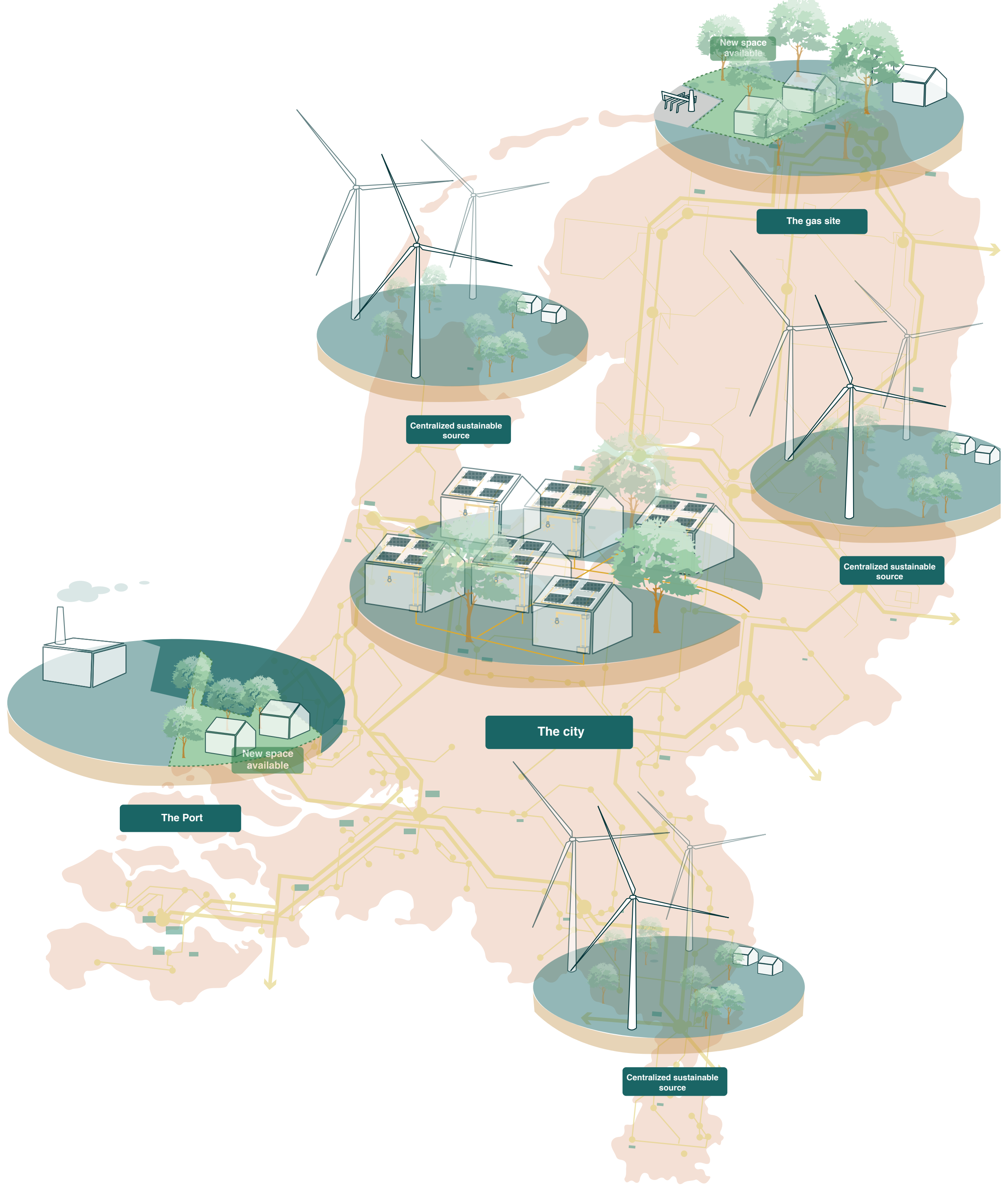


Figure 146: New key points on a national scale connected to national electricity grid within projection of design on national energy stransition

Contribution to other key points

For the port, this means that space will become available. The areas previously used for storing, processing and transporting fossil fuels will be available. It means more space in the port to produce sustainable energy or other urban developments. Lack of space is a significant problem in the Netherlands, so more area in the port can be of excellent quality.

Figure 147: Potential free space within the port of Rotterdam available for new development

13. Conclusion and reflection

13.1 Conclusions

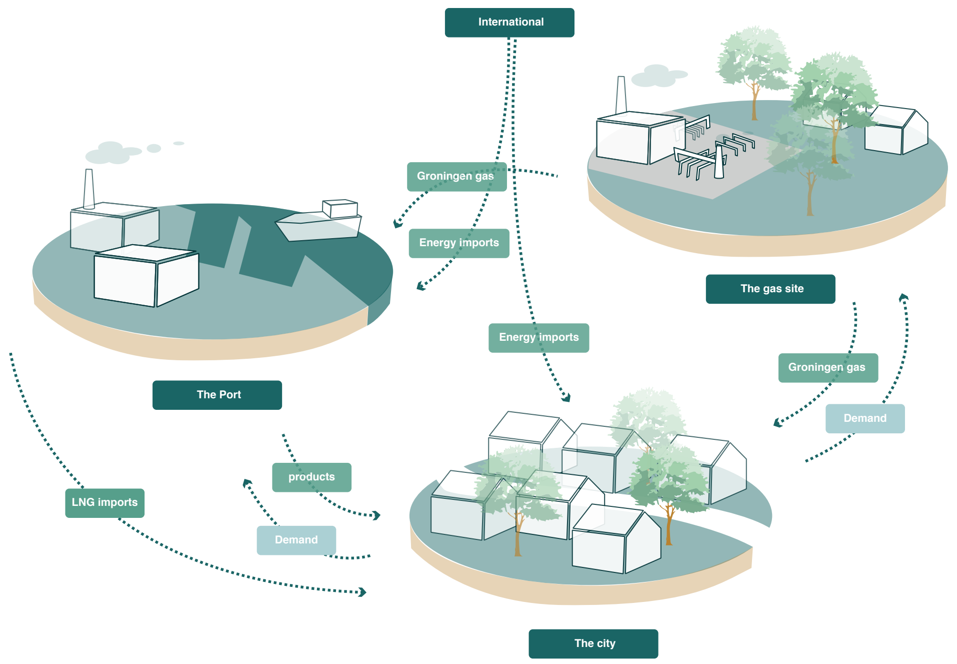


Figure 148: Scheme of key points of the current energy system

Where do the flows of the current national energy system create spatial bottlenecks, and what are the critical locations for transition within the national energy system?

The primary energy flows used and transported throughout the Netherlands are Gas and Electricity; the research focuses on these flows. Gas is used in the majority of dutch households to heat and cook. The mapping of these flows shows that the gas network has two primary connections. The connection between Groningen and the Randstad/the port, and the relationship between Groningen and the east of the Netherlands. The connection between Randstad/the port exists because both areas use a lot of gas. The link along the eastern Netherlands is due to gas export abroad.
The electricity network is very similar to the gas network because a lot of electricity in the Netherlands is generated by burning gas. Forty-four of the approximately 70 power plants run on gas.

The role of the port is essential because it is where the LNG imports enter the country, and the oil pipelines all pass through the port of Rotterdam. In addition, a lot of oil is used in the harbour, and there is also a lot of storage and exchange with other countries. The key locations in the energy system of the Netherlands are, consequently, the port, the city, and the gas extraction sites in Groningen.

In both Groningen and the port, the energy network creates pressure on space. In Groningen, due to the related earthquakes. In the port because of the space required for storing, processing, and transporting various forms of energy. The city is an exception because it is one of the main contributors to the problems related to the energy system due to the created demand. The issues related to our current energy system are not directly felt within the city's borders. Instead, a relatively large amount of energy is used here, and little of the effect on the living environment is noticed.

These key locations have the potential for change, but the most significant potential lies in the city because there the cause and consequences are the furthest from each other.

The indirect consequences of the current energy system can be felt in the city. For example, the use of fossil fuels causes global warming due to greenhouse gas emissions. Global warming is particularly noticeable in the city due to air pollution and the urban heat island effect (appendix 1).

This research focuses on Rotterdam because of the connection between two key points, the city and the port. Oud-Crooswijk is a neighbourhood in Rotterdam with a high risk of energy poverty. These people have less to spend and contribute an elevated part of their monthly income to their energy bills. It is an exciting target group because the disadvantages of the current system are more noticeable in this neighbourhood. Thus, the potential to make the community more sustainable and change the residents' attitude is very significant. And therefore, Oud-Crooswijk is the destination for the continuation of the research.

What is the energy potential of a key location, and what is the spatial impact of this?

The energy potential of Oud-Crooswijk is the potential production of sustainable energy sources and the possibility of energy that can be saved compared to current use. For each energy source, it is calculated how much of this can produce in the district and to what extent this is a suitable source for this location.
The focus here is on existing users and proven methods of energy sources. Not all forms of energy production are discussed; choices were made based on a pre-selection of ways that seemed most appropriate in this urban context.

The sustainable energy production methods covered in this study are Thermal energy surface water, waste heat network, geothermal heat, solar fields and solar rooftops, wind turbines (large and medium size), and urban windmills.

The general conclusion is that the district's renewable energy production potential is high. Based on the amount of energy that can be produced and the minimal spatial impact, the best options are solar rooftops and the residual heat network. By analysing the pro-

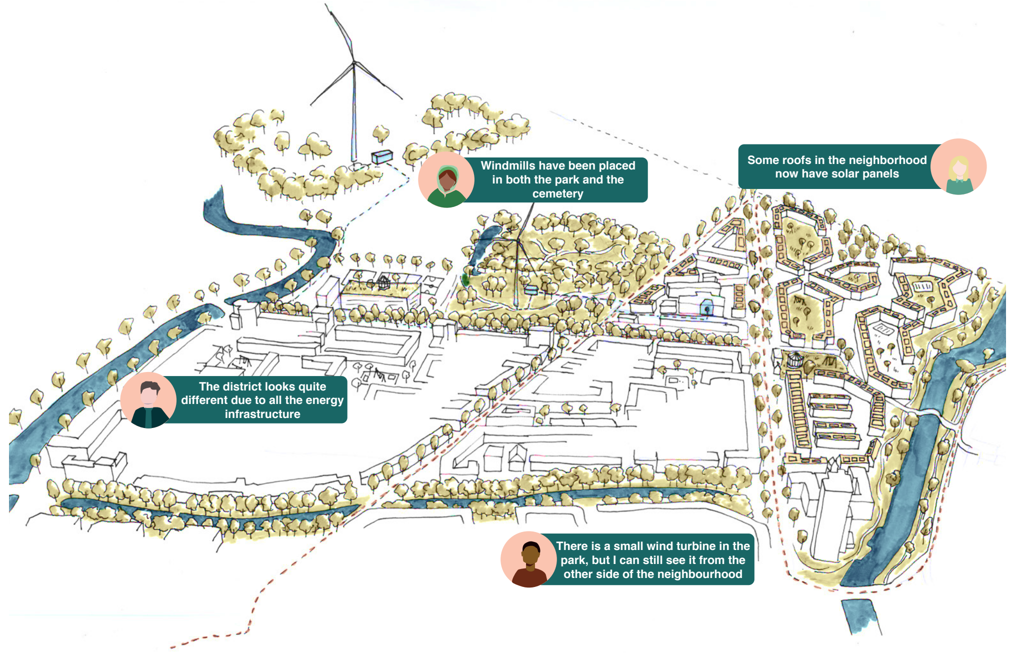


Figure 149: First scenario Bird's-eye view of spatial impact in Oud-Crooswijk

duction throughout the year, it can be seen that the combination of these two methods is insufficient for current use. It also requires the installation of a wind turbine to meet the demand. Finally, the spatial impact of wind turbines is greater and more participation from the residents is needed. In figure 149, this spatial impact is shown from a birdseye perspective.

It is not necessary to assume the current energy usage because the energy potential in the district is also based on the extent to which savings can be made on the use. An insulation plan allows for better insulation from the existing buildings. This plan includes the current energy labels, construction time, and typology to estimate the insulation state. In addition to better insulation of the houses, behavioural change of residents save energy. The energy-saving plan stimulates a different attitude towards energy use and promotes energy sharing. For example, it could save a lot of energy because it is more economical to heat a room than all different individual apartments.

Relatively little energy is used in the district. One reason may be that a relatively high share of income goes toward the energy bill. The percentage that energy-saving measures can contribute is limited. It is uncertain how much the energy-saving plan will save in total. It is necessary to determine which methods of energy production in the district are required to meet the demand.

How to encourage people to make a shift in their behaviour to live more sustainably and can thus contribute to community building?

It is difficult for people to change habits; we like to stick to what we know (Sijmons & van Dorst, 2014). Residents identify with their environment and what it looks like. Consequently, a change in this environment also affects their self-image (Sijmons & van Dorst, 2014).
A big mental step is required to achieve the intended savings. Residents must make individual adjustments. For example, their houses will have to be insulated again, a residual heat network will have to be installed, solar panels will have to be placed on the roofs, and all these networks will have to be reconnected to the existing grid.
So there is a lot of construction and changes in the neighbourhood. In addition, residents are asked to be more aware of the energy they use. In addition, other lifestyles must also change; for example, residents are stimulated to make more use of more conscious alternatives in the field of mobility. All these changes are listed and shown in figure 150.

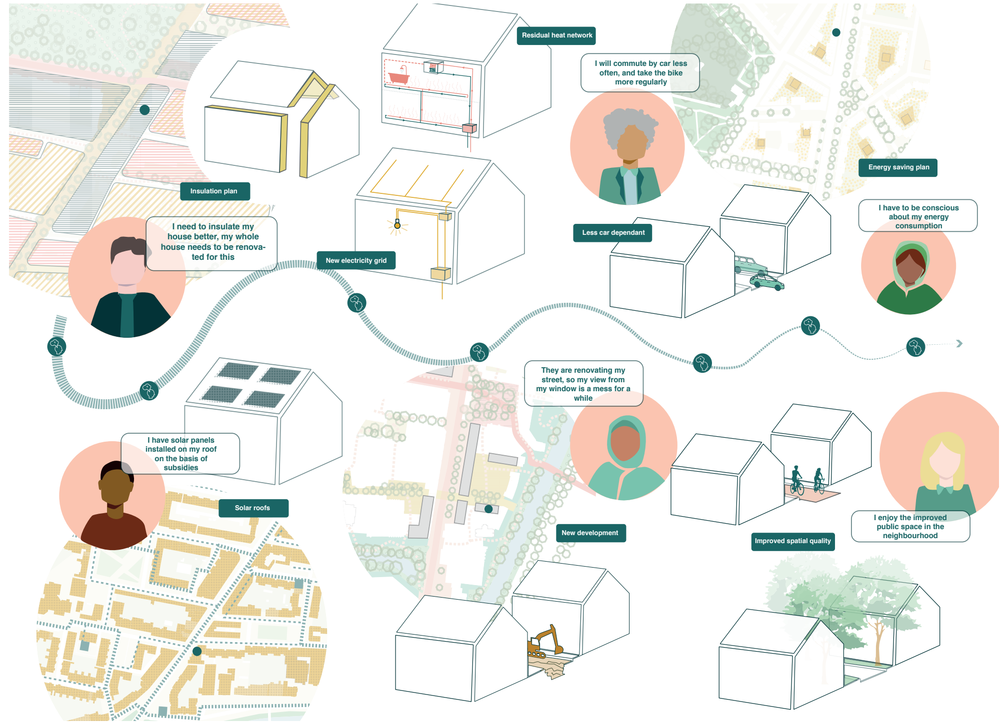


Figure 150: Scheme of behavioural change of residents in Oud Crooswijk

In addition to these individual steps, residents must work together more for this change to occur. The idea of saving energy together is not that easy. For this, people must make a profound change in their daily routine. It impacts people's daily habits and the spaces in which this takes place. The residents of this neighbourhood are not used to seeing their neighbours daily, let alone having to share a space. The individualistic attitude of residents is encouraged to change to a more social perspective with a sharing mentality

The energy produced should also be seen as a shared good, something litigated together, a shared responsibility, and therefore something fairly distributed among everyone. It will be easier for people living in cooperative rental properties, as they have no sense of ownership of the property they live in and, thus, no sense of the energy that can be produced on the roof.
Private owner-occupied homes are a more challenging aspect because it is personal property. The differences in ownership have not been included in the design of this plan; this is a limitation of the research. However, owner-occupied homes are only 8% of the total 4,393 addresses, around 351 homes (Gemeente Rotterdam, 2022).

In addition, the energy-saving plan requires the residents of a building block to share their courtyard. Currently, these courtyards are occupied with individual backyards or private parking. Giving up a personal backyard for a community space is difficult because ownership is important to people.

All these changes together are a massive shift in mindset. There are several motivations for residents. First, it saves money. For example, residents can get rid of their cars and use a shared vehicle, saving costs generally spent on privately owned cars. In addition, by insulating a home, less heating is required. Further, due to the decentralised energy generation, the energy price is not dependent on geopolitical tensions. As a result, it cannot suddenly rise as much as we are now experiencing in gas prices due to the war in Ukraine.

In addition, sharing the energy will save money on heating, and money can also be protected by, for example, cooking together. Another indirect motivation is the improvement of spatial quality and the stimulation of community building.

How can we redesign a key location that stimulates spatial quality and community spirit?

The design for Oud-Crooswijk goes beyond the energy potential. Due to the redevelopment necessary for the neighbourhood to construct these energy potentials, a lot has to be redeveloped. Based

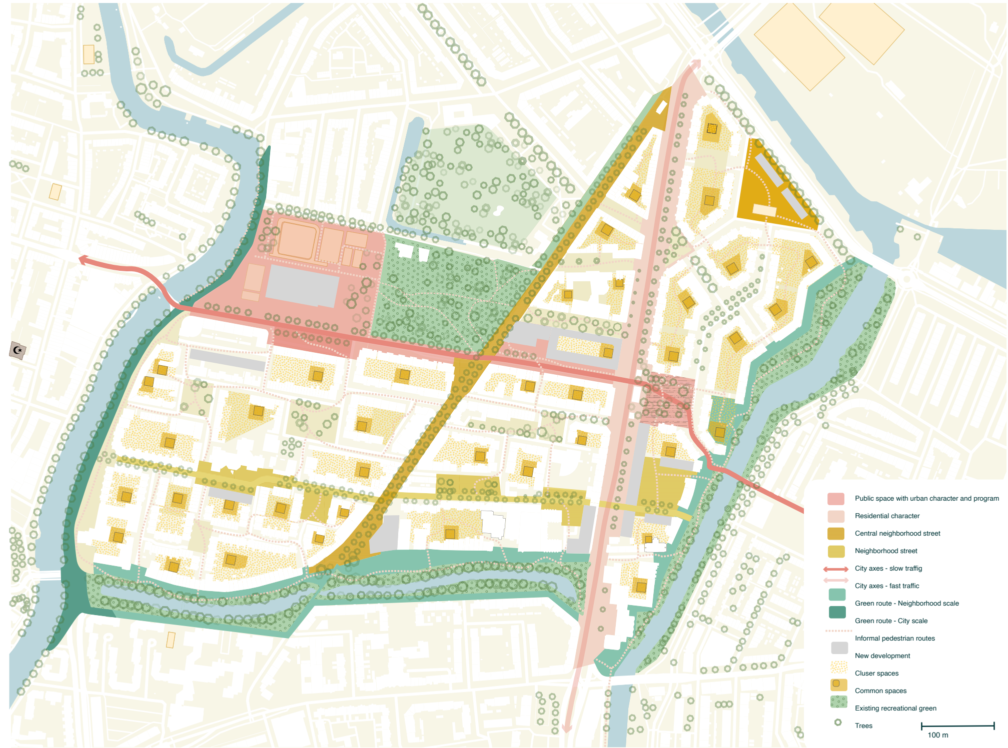


Figure 151: New public space network projected on map of Oud-Crooswijk

on all this redevelopment that is taking place, there is a potential to redevelop the neighbourhood on other fronts as well. Figure 151 shows the new public space design.

The streets that are already being opened up can be designed differently. For example, these streets can become more green. In addition, there is also more space in the neighbourhood due to the trend towards the sharing economy, of which shared cars are a part. This advancement frees up space that was previously dominated by the car.
In the new spatial plan for Oud-Crooswijk, the public space is a place that residents reclaim. Slow traffic connections are becoming more important; this will create pleasant bicycle connections and more pedestrian-friendly walking routes. In addition, the character of existing functions and spaces is enhanced by strengthening the interaction between the public space and the surrounding buildings.

The district has a wide variety of lovely places with different characters. The neighbourhood is surrounded by luxurious green structures, perfect for strolling along, walking the dog, and clearing your head. In addition, the district has bustling neighbourhood streets with fun local cafes and shops, a locality that is quickly disappearing from cities and must be adequately safeguarded. In addition, the district has a large sports complex that is extremely popular among residents. These existing qualities are better connected and strengthened, and protected.

In addition to the spatial quality, the relationship between residents is encouraged to change from the current individualistic attitude to a communal attitude in which there is a lot of sharing. It has the chance to provide community building. Residents have to do more with each other, and this allows for developing a stronger bond.

The design thus combines the energy potential with the promotion of spatial quality and community building. This significantly impacts Oud-Crooswijk, and the residents who will live in a much more liveable neighbourhood. The design also contributes to the national energy transition.

Can this redesign contribute to the national energy transition?

The redesign of Oud-Crooswijk consists of decentralising a large part of energy production. It changes the proportions of the current central efficient energy system. As mentioned earlier, the port and the gas extraction sites in Groningen are vital in the current system.

In this redesign, the emphasis on energy production is on people's living environment. As a result, the current gas extraction sites are less important. The role of the port is also changing; it is still important because of the supply of residual heat. It means that the connection between the city and the port stays strong. A lot of

Figure 152: Potential free space within the port of Rotterdam available for new development (Lisa data : bedrijven; PDOK Dataset)

space currently used for the processing, storing, and transporting of fossil fuels will become accessible in the port. Figure 152 shows those spaces, now available for redevelopment. The decentralised energy generation in the city will not always be enough, and a more central generation of sustainable energy will most likely prove necessary as a supplement.

What are the potentials of the shift towards a decentralised energy system to facilitate a sustainable neighbourhood design while stimulating community building in the context of the national energy transition?

The redevelopment on the district's scale ensures a better microclimate and a nicer and safer living environment: better spatial quality and a more varied program. In addition, the neighbourhood is better suited for the diverse group of residents and their needs.
In addition, the role of the neighbourhood in the city is changing. The district is a more pleasant place to cycle and walk through and also has functions with great appeal. The lifestyle of residents is more based on sharing. It can stimulate more sense of community in the neighbourhood, which has a positive effect on the district as a whole, as well as the mental and physical health of residents.

Furthermore, the district is a lot more sustainable, which not only has an effect on a local scale but also helps with the national energy transition. Due to the decentralised generation of sustainable energy, current national energy structures and relationships are unnecessary. The spatial impact extends many times beyond the boundaries of the district. The benefits are endless, the possibilities abound, and now it's just a matter of flipping the switch.

13.2 Phasing

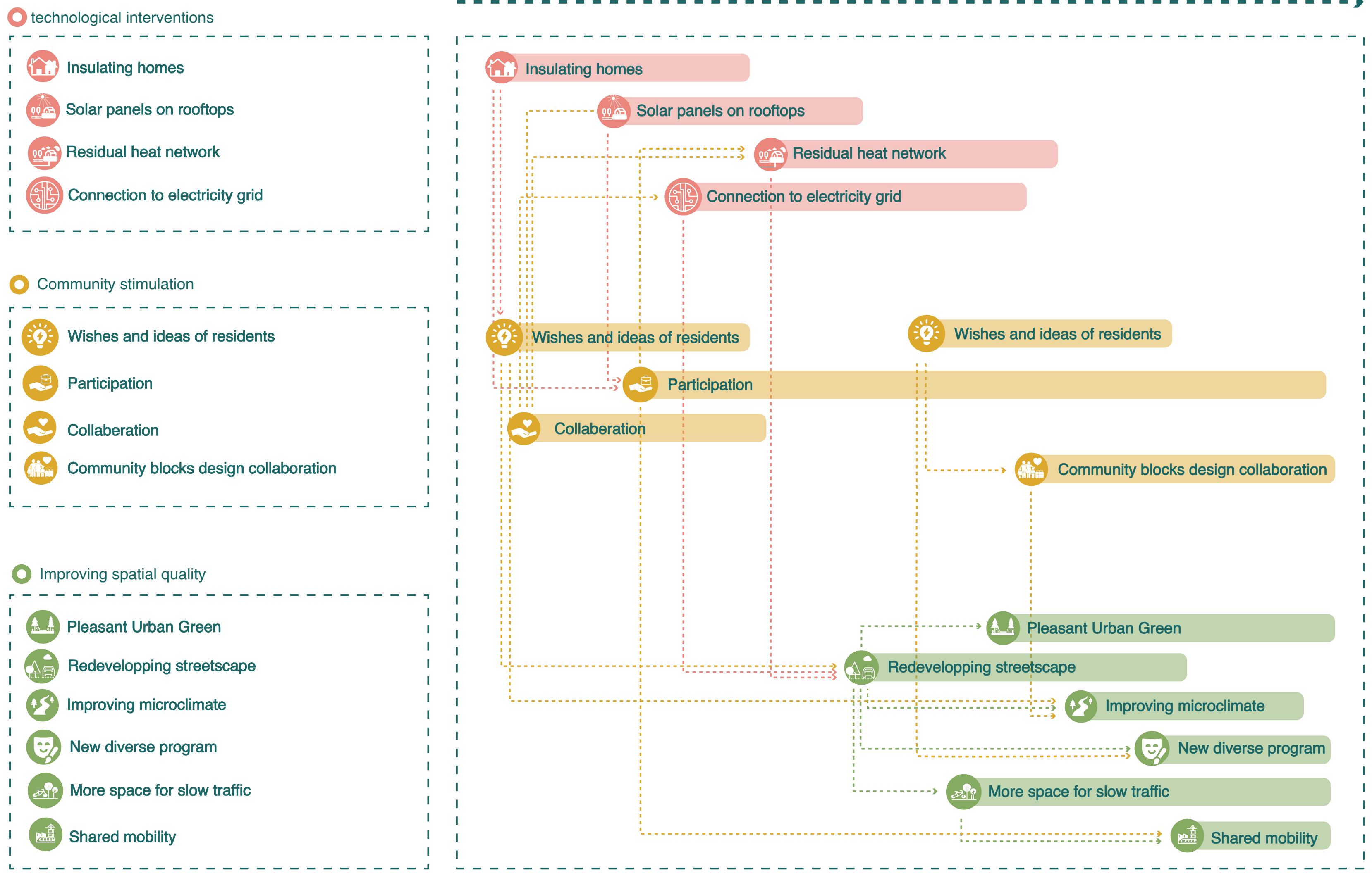
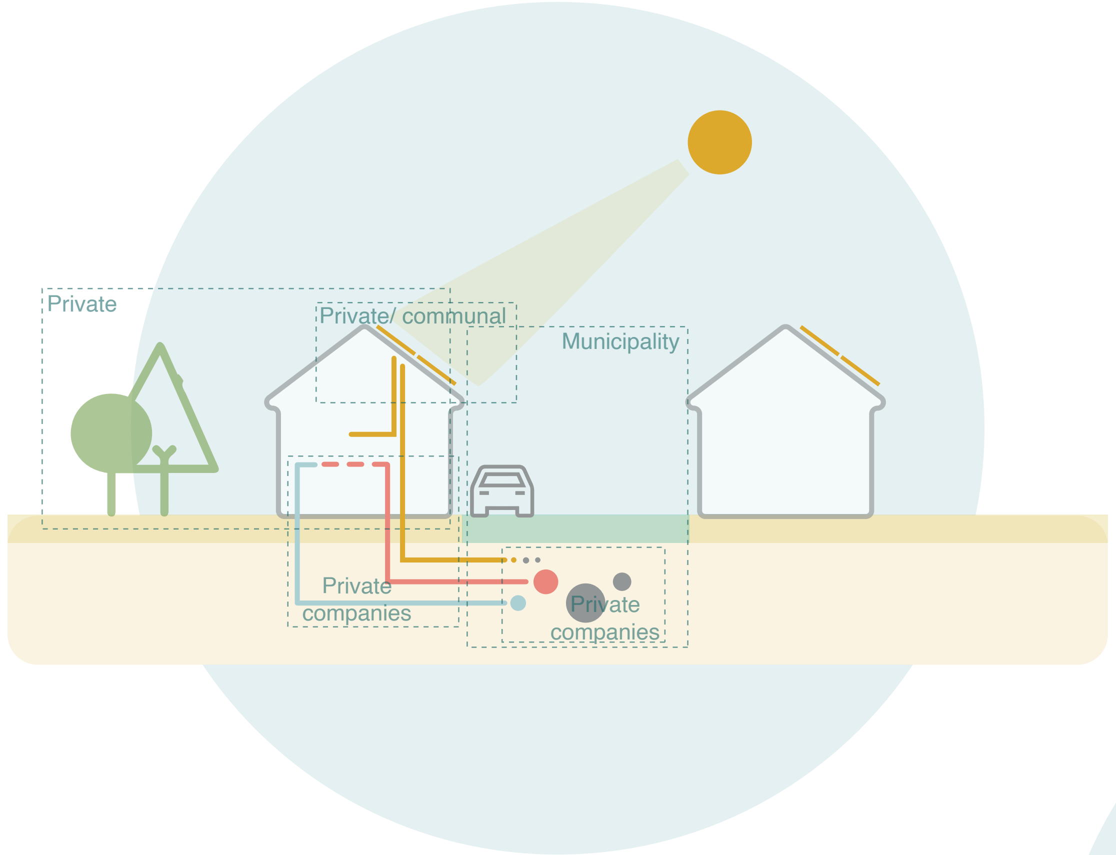


Figure 153: Phasing of interventions in Oud Crooswijk and connection between the interventions

Phasing is a crucial aspect of any project that has been touched upon in this study but has not yet been fully addressed. The figure shows the natural progression of the interventions. These are not time-bound but offer a sequence of events because the interventions are connected. Some interventions can only take place after another intervention.

In addition, some changes in Oud Crooswijk depend on the degree of participation and collaboration. That is why the precise timing of this process is challenging to make. A large part of the plan is about stimulating behavioural change, which can only be encouraged but not forced. Hence there is a natural progression.

13.3 Ownership and complexity



It has been mentioned and explained that achieving the intended qualities is a complex task. That is partly due to the different systems, their scales and ownership that are affected. The research considers this complexity and is aware that it is almost impossible to grasp completely.

Figure 154 shows when people connect solar panels to the electricity grid; it intertwines with many systems. These systems belong to different owners. The land is sometimes private and sometimes owned by the municipality. The underground cables belong to private corporations, and the solar panels belong to residents. If these are connected, this requires a lot of communication and cooperation.

It illustrates another complex problem related to ownership. Who owns the energy when it runs through so many different systems?

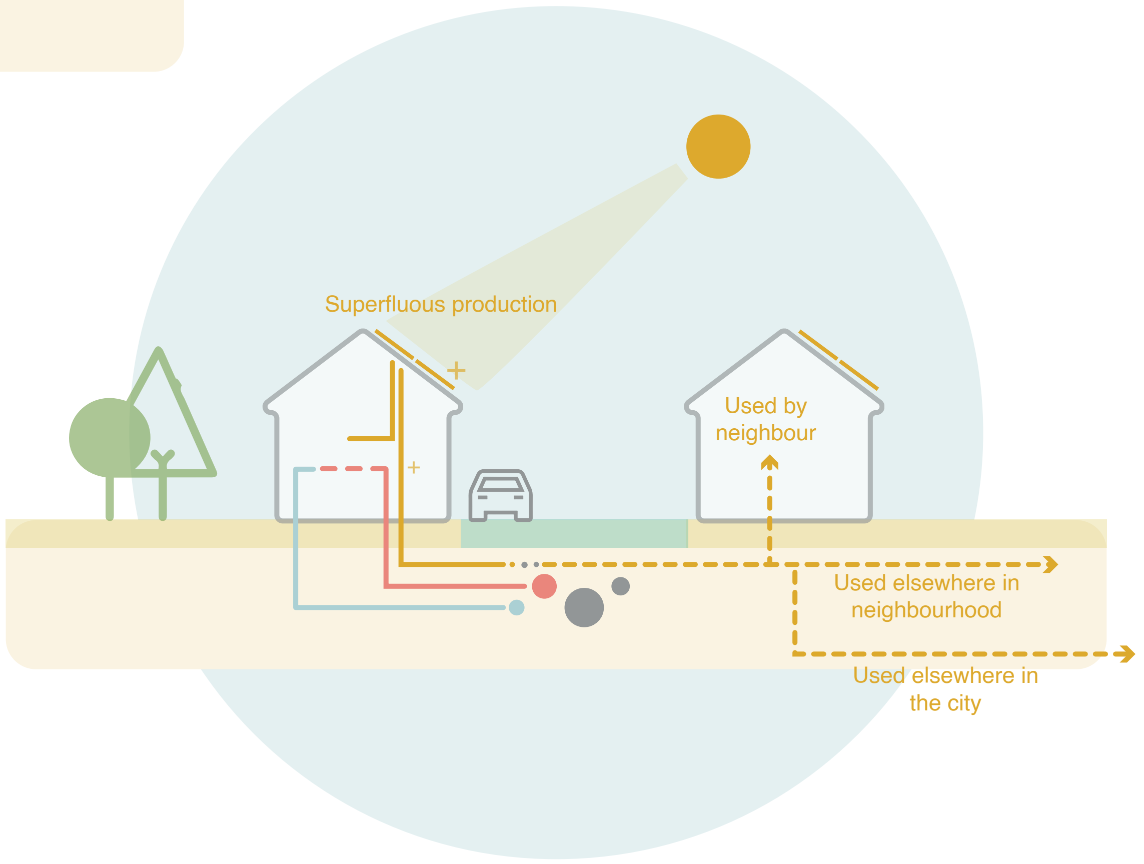


Figure 154: Phasing of interventions in Oud Crooswijk and connection between the interventions

The power is generated and used locally in the design. But the energy can also be distributed across the district. And by being connected to the electricity network, the energy can also be used elsewhere in the city or even the country. The excessive energy could also be sold. It is a crucial question to whom this energy belongs.

Those different systems can have varying effects. It can affect the participation of residents. For example, if a resident can resell the electricity they do not use, this could be a motivator to use less of it themselves. On the other hand, this can promote an individualistic and competitive character. When the power is generated and used as a block, this can provide a greater sense of togetherness.

13.4 Reflections

The relationship between research and design

There is a strong connection between research and design. The analysis starts with an exploratory and descriptive study. In this part of the research, the current national energy system is examined to see where there are problems and opportunities for transformation. Based on this conclusion, the design assignment is defined.

The design assignment is set for Oud-Crooswijk because the exploratory study shows that this is both an important and a good location for the transformation. The design assignment includes using local opportunities and improving the living environment and the significant energy challenge for a decentralised solution. The design assignment is then linked back to the larger research question, which looks at the design's effect on the energy transition on a national scale.

The relationship between the graduation topic and the Urbanism master track and the master programme

The energy transition is a question that can be handled from many different disciplines and is also much needed. This research focuses on the spatial challenge that the current national energy system creates. It is how energy is made spatial; it goes beyond the numbers and the flows land in an environment. It makes the transition tangible and visual.

The design task arises from the spatial bottlenecks defined in the spatial analysis of the current national system. The design focuses on improving the quality of life and has landed in the complexity of the urban environment. In which other trends, possibilities and constraints play a role.

This is also one of the limitations of this research, to grasp the completeness of the complexity. The study points out the various factors that are taken into account in the choices regarding the design assignment. But not all of these factors have been worked out in equal depth.

It successfully shows what this complexity consists of and how the energy task relates to other urban developments. These cannot be seen separately, and there is a lot of potential in linking them.

The research is closely related to the other master tracks through the covered themes and scales, such as Building technology in the insulation plan, which states how the houses can be better insulated. The research is also relevant to landscape architecture because of the potential opportunities for the Dutch landscape if a large part of the energy demand in the city is solved.

Research methods and approach

Literature study

Literature formed an essential basis for this research. The literature on How our behaviour shapes our energy landscape in the theme, environmental psychology gave insight into the relationship between people's behaviour and their environment. The insights from this study are used later in the research to form the energy-saving plan and the design. The role of behavioural change, the task, and the constraints have been developed based on the literature discussed in this subchapter.
The literature on Urban Metabolism is leading in forming the flow analysis. The theory gave the dimensions of which the flow analysis should consist and how it should be investigated. The third theme within the literature study is the relationship between people, technology, and the earth.

It is literature that helped put the energy transition into a bigger picture. To understand where the more significant movement is going. It is essential during a study to zoom out to understand how the research is positioned in relation to spatial and temporal dimensions to understand the distinction between short movements and deeper-lying trends.
The theory has made an essential addition to the awareness of the connections between technology and limitless individual actions in centralised systems. However, the direct relationship with the design is difficult to pinpoint.

Flow analysis

Based on the theory about the flows, a flow analysis of the current energy network of the Netherlands has been carried out. The gas network and the electricity network are highlighted in this.
These are important energy sources and infrastructure in the Dutch energy system.
This analysis does not cover other essential energy networks, such as the oil pipelines. It did, however, provide a good insight into the flows and formed a sound basis for developing a conclusion about what the spatial bottlenecks were and the key locations for transition.

Systemic sections

In addition to the flow analysis, the systemic sections made the flows spatially transparent and the places between which these flows were located. Finally, it allowed the relationship to these places to be concluded, forming the basis for the critical locations for transition.

Spatial analysis

Based on the selected key points, Oud-Crooswijk emerged as a suitable location for the design task. Here, a spatial analysis was first carried out to understand the district better. It clarified what kind of neighbourhood it was, who lived there, and what the spatial structures were. Opportunities and challenges were formulated from this.

Energy potential mapping

Energy potential mapping is a method used to see the possibilities of sustainable energy production in the area. Per method of production, the map shows the production location, and it is calculated how much this will produce in that scenario. Spatial constraints are taken into account for each energy source.
This makes it possible to decide what the spatial consequences of energy production are in the district. Here a choice has been made as to which sources are suitable for the district; not all methods can be included.
Only existing and proven used methods of sustainable energy production are considered. In addition, the energy potential also consists of the potential for energy savings. It looked at construction solutions and lifestyle changes. The study would be examined similarly to the district's energy storage potential. This could be an essential addition to the scenarios.

Scenario study

The scenario study compares different combinations of energy potentials and their spatial effects. The scenario study in this study is based on three stages of use, current, maximum, and minimum. The scenarios are then compared in terms of spatial impact, the scale of the interventions, and what they can mean for residents. From this, it can be concluded in which scenario or scenarios the most significant potential lies.

Research by design

In the research by-design stage, the spatial assignment in the neighbourhood is the starting point. In this, the spatial analysis of the community is used as well as the energy potential and scenario study. It is determined which prospects in the neighbourhood can be used and what this can look like. In this, the district's energy and spatial tasking are combined to arrive at a design.

Scientific relevance of the work

The energy transition is an urgent issue and, therefore, an important subject that is discussed and tackled from many sides. This research builds on existing research into the relationship between energy and space. There are also many studies into making neighbourhoods more sustainable. This study aims to make the connection between the energy issue and environmental psychology, and community building. Many case studies of eco-villages or net zero neighbourhoods are new construction projects in suburban areas. This study attempts to project the findings of existing studies onto an existing inner-city neighbourhood with a high risk of energy poverty, with all the complexity that goes with it. To show the human side of the energy transition and the importance that everyone should be included in a shift.

Ethical issues and dilemmas

Relative to other neighbourhoods in Rotterdam, little energy is used in Oud-Crooswijk. Thus, it could be argued that it is unfair to start looking at energy-saving measures here because relatively less can be won.
On the other hand, it is an excellent place to start because it is also a neighbourhood that feels the consequences of the current energy system. Additionally, it is a neighbourhood that could use an investment.
The study's social aspect and approach are also more challenging aspects when it comes to ethical dilemmas. In this way, the design does two things, improving the living environment and expecting a change in behaviour from residents. It includes the assumption that this is better for the residents and that they will benefit from this change. Some of the changes in the neighbourhood are for the greater good, the greater transition of which it is part.
In addition, the social complexity is challenging to grasp. For example, there are signs of residents' dissatisfaction with developments in the neighbourhood. For example, the text "money wolves" was written on the windows of a block that will be demolished for new growth.
In addition, residents are critical of the plans of the municipality. Havensteder, the owner of a large part of the social rental homes in the district, also receives protests from residents. The protest is that rents are rising, and the original residents of Crooswijk can no longer live in the area. Residents are afraid of gentrification and have seen how the target group in Nieuw-Crooswijk has changed completely.
Improving the living environment in the district requires a significant investment in the neighbourhood. This will inevitably increase the property value. Consequently, the question is whether the community's existing residents would support this.

The relationship between the graduation project and the broader social, professional, and scientific framework

The research shows, through the combination of the energy transition issue, human behaviour, and urban complexity, that these are necessary aspects to be highlighted. The main conclusion relevant for further studies is the interaction between these themes and how important it is. There is a lot of potential to do this the right way. In addition, the research brings the energy question among the people. It shows that behavioural change is inevitable and essential to the transition.

Potential applications of the results in practice

The research shows the feasibility of decentralised sustainable energy production and ensures many qualities in the living environment. On the contrary, the research results show that it is a process that requires a lot of collaboration between residents and designers. Participation in the needs of residents is critical. The actual application of the study results requires deep cooperation, many consultations, and further studies of the residents.

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15. Appendix

Apendix

Appendix 1 Climate change effect

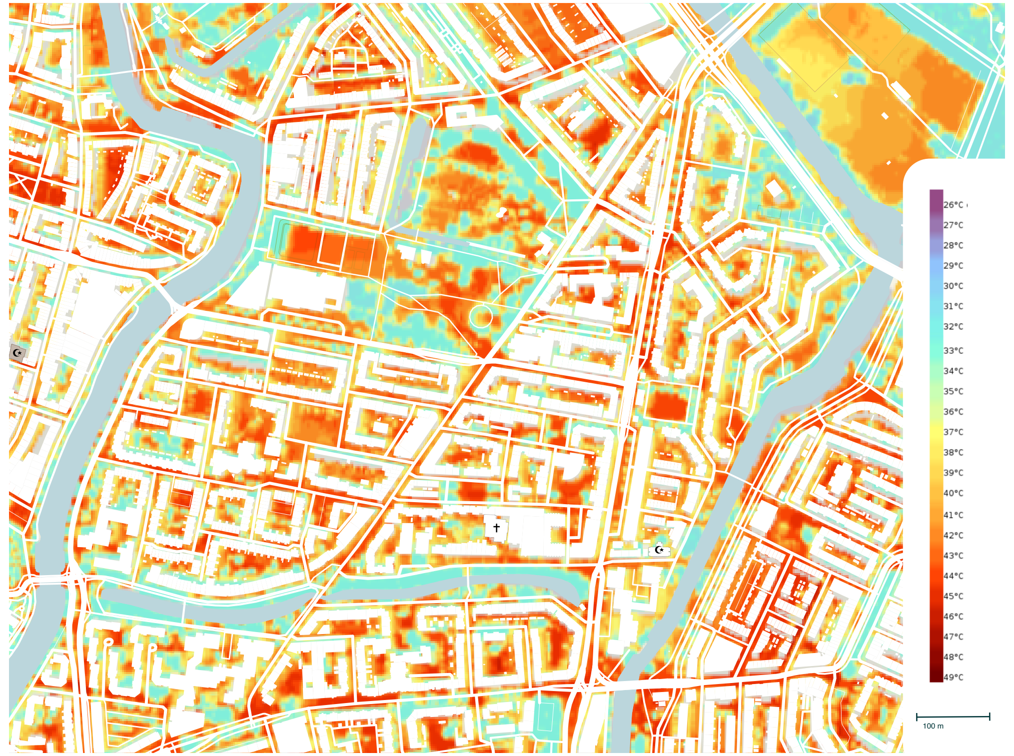


Figure 155: Feeling temperature in heat wave currently (Witteveen+Bos, 2021)

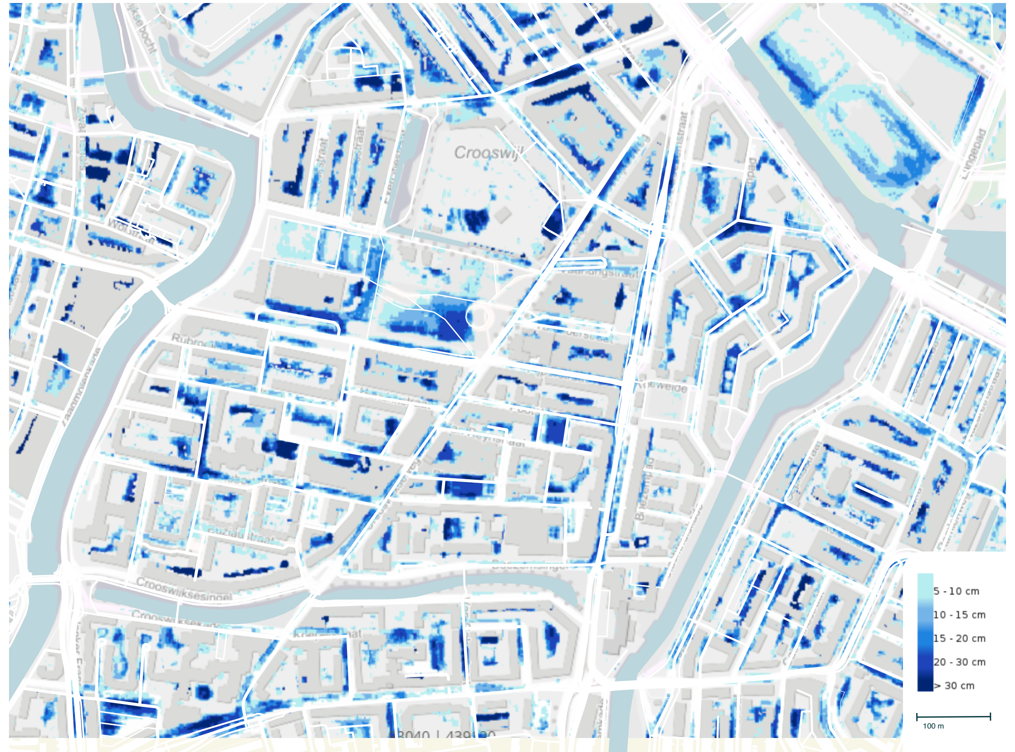


Figure 156: Pluvial flooding risk by heavy rain (70 mm in 2 hours)

Feeling temperature in heat wave currently

Pluvial flooding risk

Appendix 2 Gas and electricity usage - Rotterdam (city)

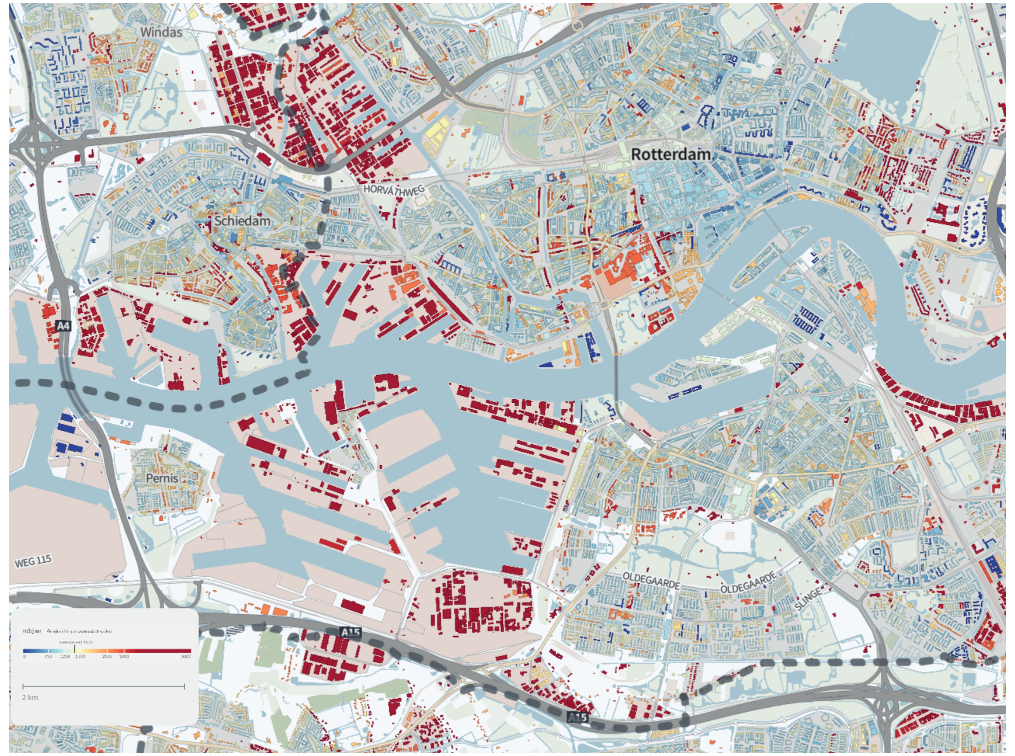


Figure 157: Gas usage in the city of Rotterdam 2019 (Datavoorziening VNG Realisatie, 2019)

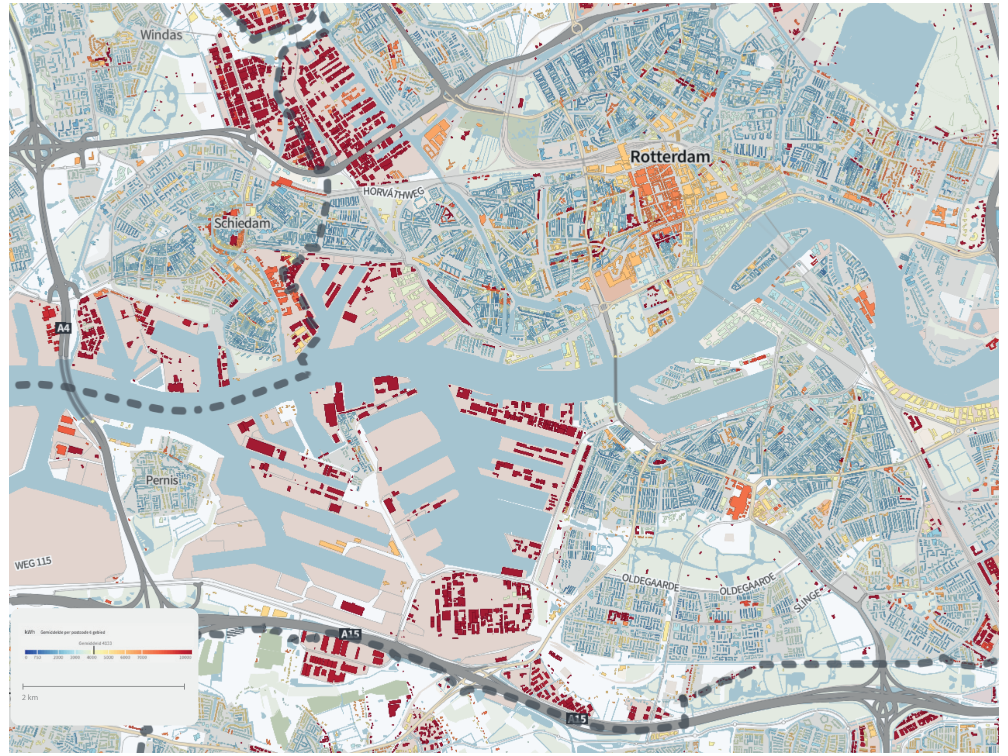


Figure 158: Electricity usage in the city of Rotterdam 2019 (Datavoorziening VNG Realisatie, 2019)

Gas usage in the city of Rotterdam

Gas consumption differs greatly per district. This has to do with the year of manufacture and function. The center has a relatively low gas consumption. Residential areas around the center with older buildings have a higher gas consumption, such as in Kralingen or Rotterdam-west. Industries rise above all residential areas and consume by far the most gas.

Electricity usage in the city of Rotterdam

Electricity consumption is comparable to gas consumption. So is again a big user in this. There are also differences in residential areas and residential areas with old buildings once again score. However, a big difference is a center itself. This color is a lot darker in electricity consumption than in gas consumption.

Appendix 3 Gas and electricity usage - Rotterdam (Botlek)

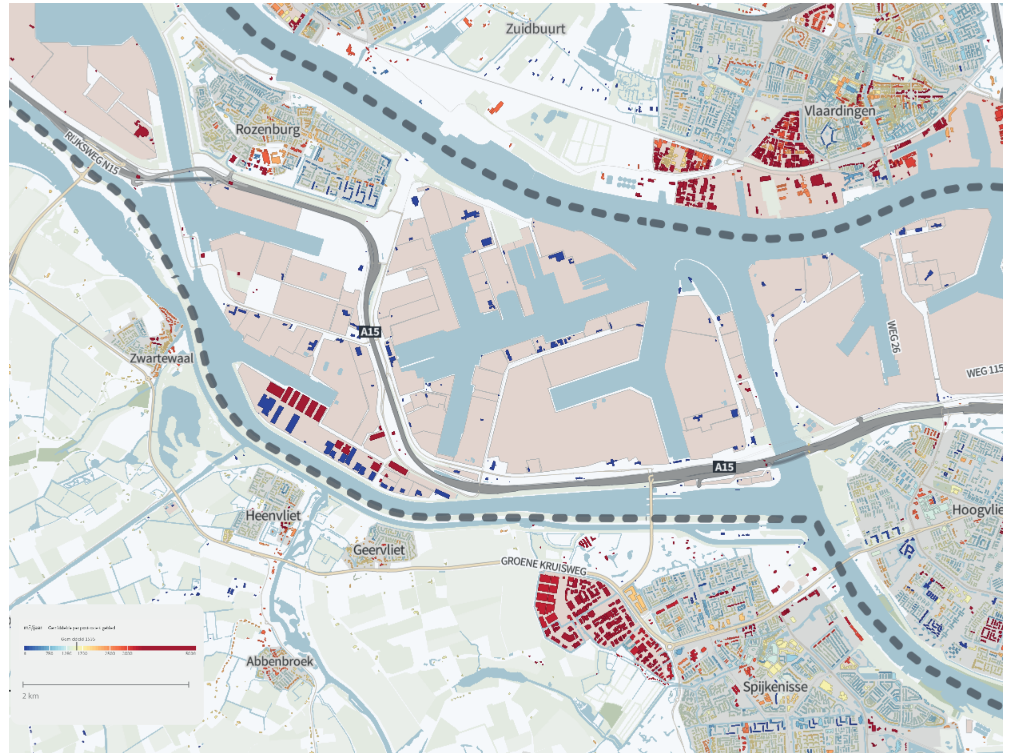


Figure 160: Gas usage in the city of Rotterdam 2019 (Datavoorziening VNG Realisatie, 2019)

Gas usage in the Botlek

Curiously, many of the industries have relatively low gas consumption in the Botlek area. Much of the industry in the Botlek is using 0 m3 per year. Industries in the Botlek area have a lot lower gas usage than in surrounding residential areas. This is the other way around the center of Rotterdam.

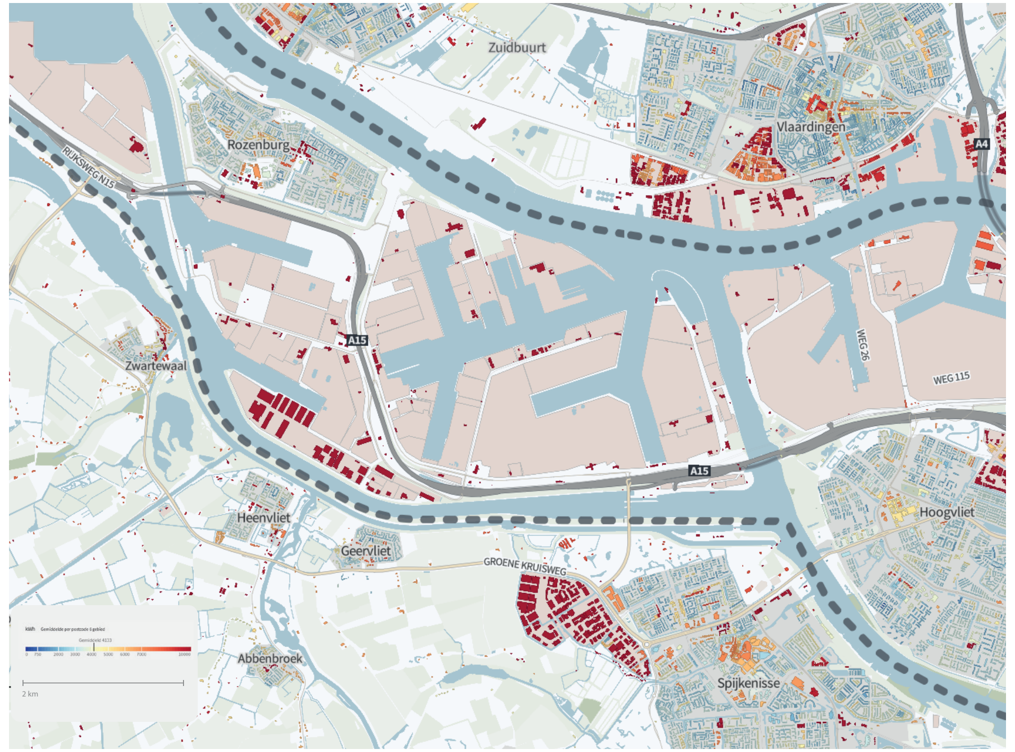


Figure 159: Electricity usage in the city of Rotterdam 2019 (Datavoorziening VNG Realisatie, 2019)

Electricity usage in the Botlek

The electricity consumption, on the other hand, is very high. As shown in figure 159, all industries in the Botlek show the highest percentage of electricity usage.

Appendix 4 Gas and electricity usage - Rotterdam (Maasvlakte)

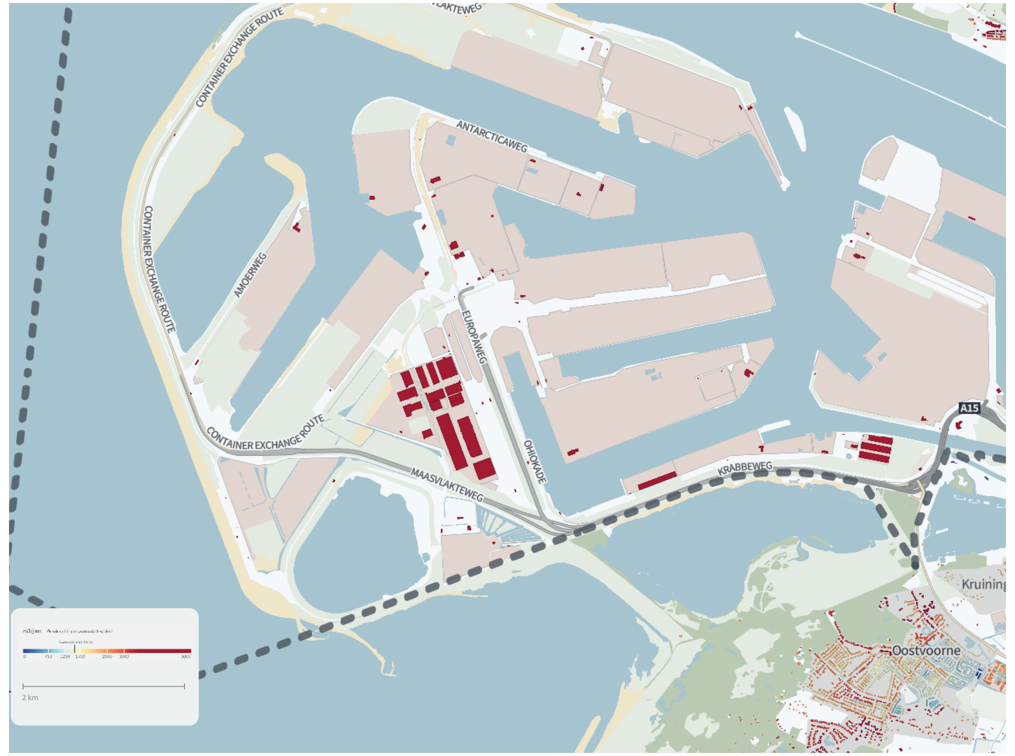


Figure 162: Gas usage in the Maasvlakte port area of Rotterdam 2019 (Datavoorziening VNG Realisatie, 2019)

Gas usage in the Maasvlakte

Gas consumption on the Maasvlakte is alike for every company. The industries have the characteristic of high gas consumption. There are no companies that do not consume gas like the Botlek area.

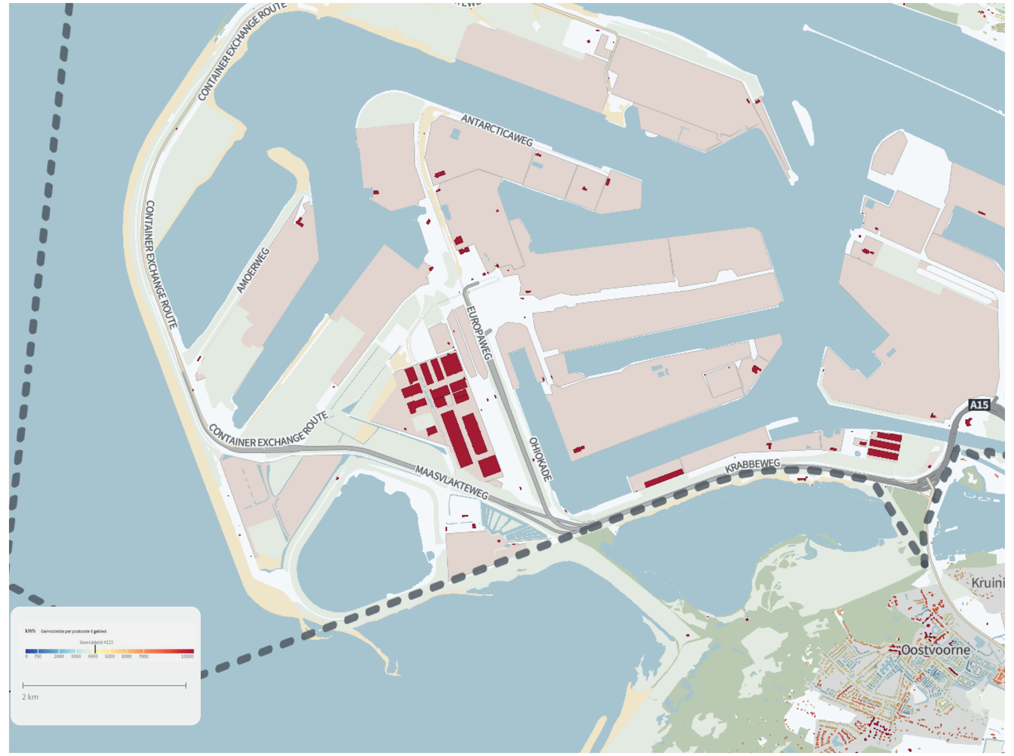
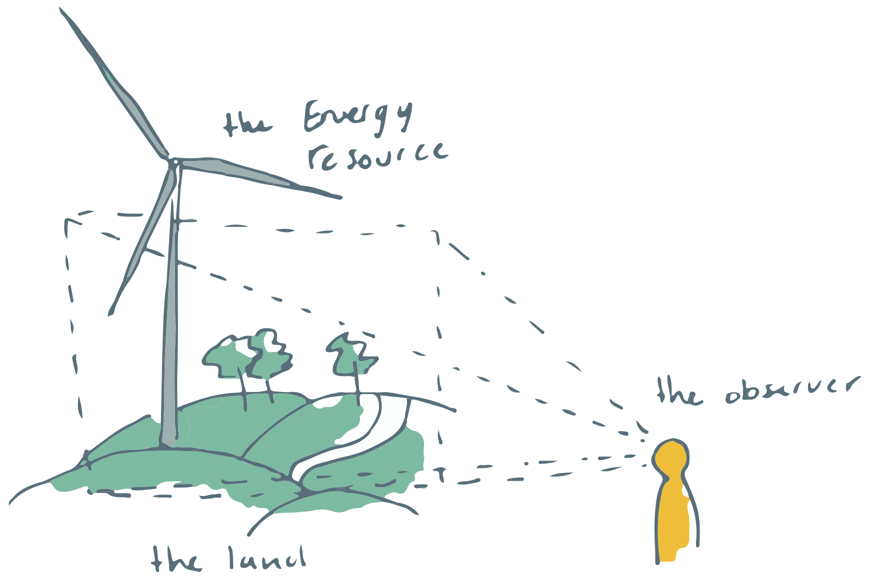


Figure 161: Gas usage in the Maasvlakte port area of Rotterdam 2019 (Datavoorziening VNG Realisatie, 2019)

Electricity usage in the Maasvlakte

The same applies to electricity consumption in the Maasvlakte area, here too, the average is high.

Appendix 5 Defenitions of energy landscape



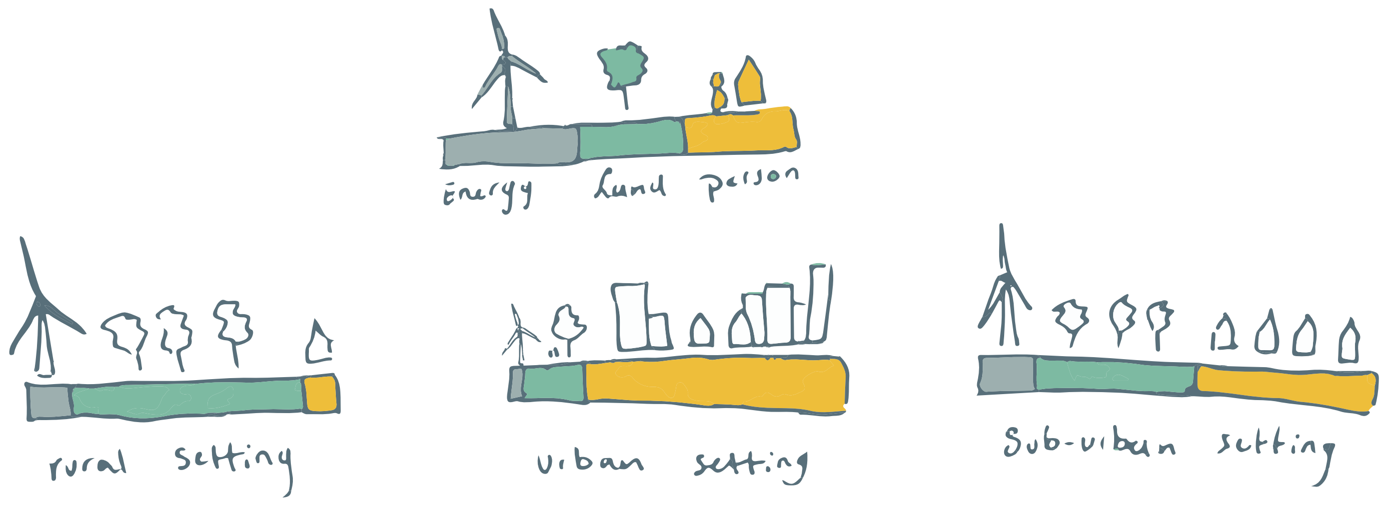


Figure 163: Schematic illustrations of definition energy landscape

Definition Landscape
“The landscape is part of the land, as perceived by local people or visitors, which evolves through time as a result of being acted upon by natural forces and human beings.”
- The European Landscape Convention (Florence, 2000)

Definition Energy Landscape

“Observable landscapes that originate directly from the human development of energy resources” M. Pasqualettia,b & S. Stremke (2018)

My definition of Energy Landscape
The tree elements of the energy resource, the land and the observer
exist in different compositions.

Sites containing these elements in varying compositions are Energy Landscapes. Therefor different settings from rural to urban can be or become Energy Landscapes.