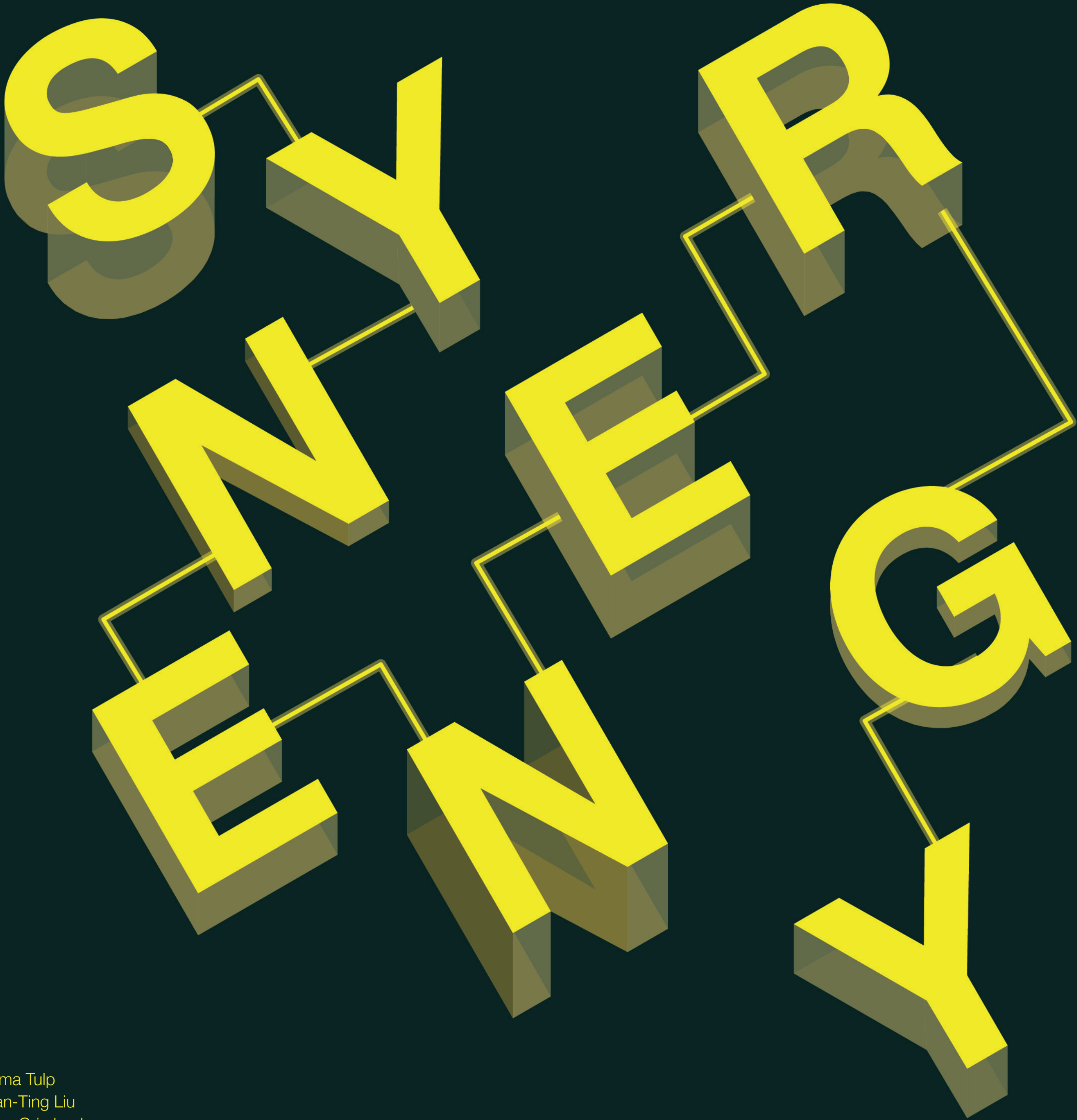

Emma Tulp
Kuan-Ting Liu
Elena Grimbacher
Mariana Bobadilla García

TU Delft

Delft University of Technology - MSc Urbanism (Architecture, Urbanism and Building Sciences)

Quarter 3
AR2U086 R&D Studio - Spatial Strategies for the Global Metropolis
AR2U088 Research and Design Methodology for Urbanism

Authors:
Mariana Bobadilla García 5669480
Elena Grimbacher 5626536
Kuan-Ting Liu 5582911
Emma Tulp 473948

Tutors:
Alexander Wandl
Caroline Newton
with inputs from Roberto Rocco de Campos Pereira and Marcin Dabrowski

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Sources for additional data in the maps are mentioned in the caption of the maps.

Preface

Hereby we present you our strategy for a just and fair energy transition towards a fossil fuel free province of South Holland.

We would like to express our gratitude to our supervisors Alexander Wandl, Caroline Newton, Roberto Rocco de Campos Pereira and Marcin Dabrowski for helping us through this project. The lectures certainly added to this, in these we learned a lot of crucial insights about the topic.
The learning experience was not always easy, but we certainly learned and enjoyed it a lot!

We hope that this report can offer you new insights and a fresh look on current issues.

Mariana Bobadilla García
Elena Grimbacher
Kuan-Ting Liu
Emma Tulp

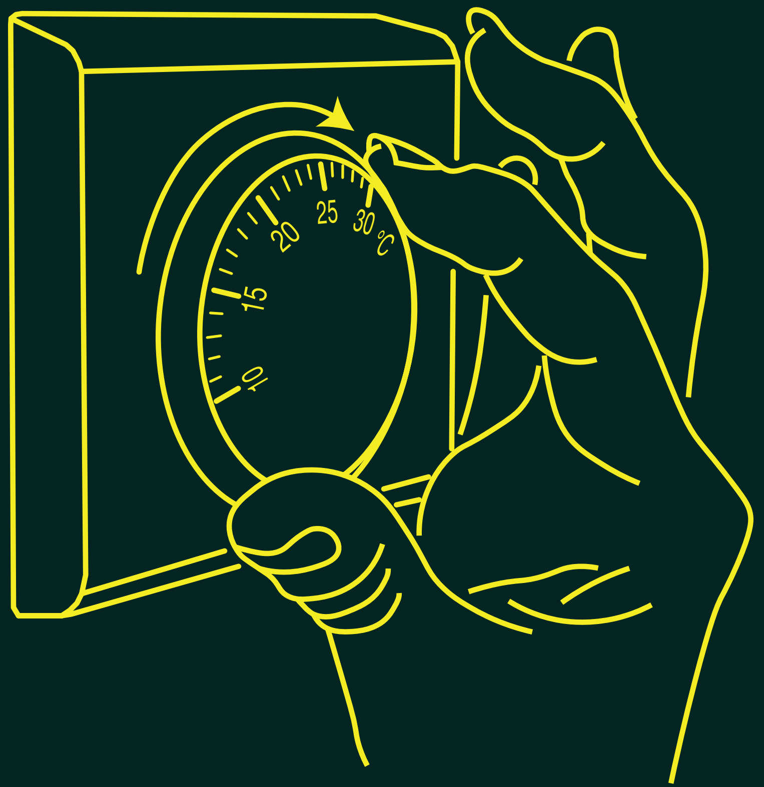
Our society is dealing with multiple wicked problems: the Climate Crisis, poverty, inequality and our need for a sustainable and healthy environment to live in. The Climate Crisis increases the urge to reduce the dependency on fossil fuels and requires a structural transformation to our management and distribution of space, economy and community. More than 8% of the Dutch population faces energy poverty, and this percentage will increase with the rising natural gas prices. The Province of South Holland, in the Netherlands, is a region thriving from an economy based not only in the biggest port in Europe, the Port of Rotterdam, but also thriving design, technologies and innovations in the cultural centres of cities like Delft, Leiden, Rotterdam and The Hague. This region has a great potential to strategically change the energy generation towards alternative, renewable sources, as well as the energy consumption of the region to tackle social inequalities such as energy poverty.

This report will elaborate on the question of how a just energy transition towards 100% renewable energy of the Province of South Holland can be created through synergising and adjusting the spatial distribution. Through research by design, approached through the school of urbanism of Bouwkunde in TU Delft, the scope and application of regional planning for energy development will be illustrated to facilitate an adaptive, inclusive and collaborative energy transition in the Province of South Holland.

This systemic change creates the opportunity for the Port of Rotterdam to evolve from the current petrolscape to a renewable energyscape and to become a leading role model in the energy transition towards regional renewable energy generation and distribution, and a global hydrogen hub. A fair system without energy poverty, accessible, affordable and efficient energy and mobility, a repurposed energyspace for diverse renewable energy systems and a recycling system, and a local energy production will enable a just transition towards a fossil fuel free future for the Province of South Holland.

Keywords: energy transition - sustainable development - regional planning - renewable energy - energy poverty - inclusive - social justice

Abstract



Turn down your energy (demand). How the Province of South Holland can achieve an affordable and just energy transition, can be discovered in this project.
An explanation is given in the Appendix.

Table of Contents

Figure 1 (Tulp, 2021a)

01. Introduction

01. Introduction

The region has been a national power even before the construction of the Nieuwe Waterweg in Rotterdam in 1863, which laid the foundations for its global relevance on the industries of transportation and energy. The most populated province in the Netherlands and home to national and international institutions at the Hague, as well as incubators for innovation such as TU Delft, the Province of South Holland is a pool for convergence, synergy and development, with its industrial power concentrated in the Port of Rotterdam, fueled by the more than 500 billion euros generated annually in the region (Port of Rotterdam Authority, 2022), which is -20% of the national gross domestic product.

Bordered by the North Sea and fed by the mouths of the Rhine-Meuse-Scheldt Delta, the Port of Rotterdam is the largest and busiest seaport of Europe, across its 40 kilometres of length. Its two main industries are the petrochemical industry and the business of cargo transshipments, which cover the greater area of the port. This later activity connects most of Europe with cargo transport throughout the rest of the world. This regional relevance implies a widespread infrastructure of logistics with Rotterdam at its core. Its four oil refineries and over 35 chemical companies (Port of Rotterdam Authority, 2022) are key not only to the economy of the 2.6 million inhabitants of the province. With the oil, gas, electricity and heat they produce, they also keep south hollanders warm and their lights on, their cars running.

In response to the Climate Crisis and its escalating effects on the environment, the province has vowed to reduce its carbon emissions to zero by 2050, a task only achievable by drastically reducing the role of fossil fuels in its dynamics, since only the port emits over 30 million tons of CO_2 annually (Samadi et al., 2016).
How does the Province of South Holland transition towards energy sources that are not as CO_2 intensive as fossil fuels?

The convergence of technologies, institutions, private and public interests, as well as a natural potential to harvest energy from renewable sources, enable the region to extend its energy scape beyond the petrochemical industries of the port, into its grasslands, its agricultural lands, its cities and the North Sea. The port's industrial and logistic relevance also makes it a candidate for the export of these technologies and energies and to become a global leader in energy transitions and management of renewable energies and hydrogen.

Another setback of the fossil fuel-centreed energy system is the region's dependence on great energy industries that control the energy market and prevent citizens from engaging with the energy of their houses, both the one they consume and the energy they receive. Since reducing consumption is key to reducing CO_2 emissions, a just energy transition that diverts power from the great global players into local producers and citizens with energy agency and no energy poverty, is the way to go.

Figure 2: Province Map (pictures (Biesbosch, 2020), (Den Haag, 2022), (Faculteit Bouwkunde, 2022), (Gouda, 2022), (Het Groene Hart, 2020), (Kinderdijk, 2022), (Leiden, 2022), (Maassluis, 2022), (Maasvlakte, 2021), (Noordwijk, 2022), Ouddorp, 2022), Rotterdam, 2013), (Scheveningen, 2016) & (Westland, 2022)).

01.1 What is Energy?

Energy is the ability to work. It can change from one form to another. Energy has different forms, and they can be divided into potential energy and kinetic energy. The sources for the energy we use in our cities can be divided into renewable and non-renewable sources.

Since the Paris Agreement of 2015, there has been a lot of discussion about the 'energy' transition. The meaning of the term "energy" can also be divided into primary energy sources and secondary energy sources.
Primary energy includes both renewable and non-renewable energy sources, such as the sun or oil, and they generate secondary energy sources, such as heat, electricity and petrol.

These 3 main units were used in this project. Here is the simple translation:
1 PJ= can supply electricity use for 21* hours in the Netherlands
I GJ= washing laundry 100 times
100 kWh= 7 euros

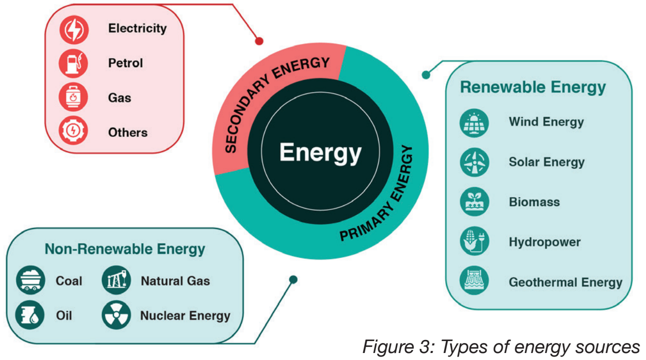


Figure 3: Types of energy sources

*The total electricity consumption of the Netherlands in 2020 is 114.8 TWh, which is equivalent to 413.28 PJ. That is, 1 PJ can only supply the Netherlands with electricity for 21 hours and 12 minutes.

International Trends

In 1979, the first World Climate Conference, held in Geneva, called on all countries to support the proposed World Climate Programme and recommended the immediate development of strategies to facilitate better use of climate information by governments planning their social and economic development (WMO, 2009). Several subsequent world climate conferences followed this conference. Still, it was not until the signing of the Paris Agreement in 2018 that people began to realise the urgency of the energy transition to face the worsening Climate Crisis. The goal of the Paris Agreement is to limit global warming to well below pre-industrial levels by 2 degrees, preferably 1.5 degrees (UNFCCC, 2022). In order to achieve this goal, member states must reduce their greenhouse gas emissions to 40% by 2030, making it possible to achieve a carbon-neutral world by 2050.

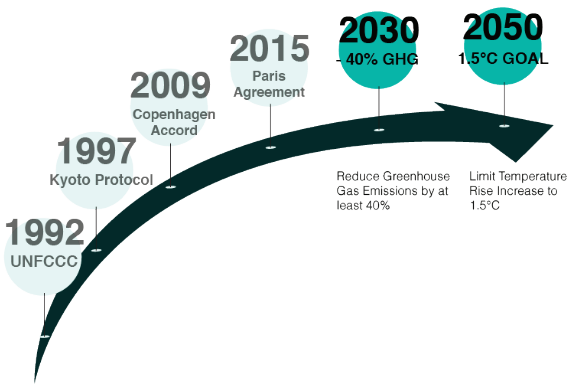


Figure 4: Timline of energy agreement and goals

The Netherlands' Goal

The Netherlands is more ambitious in the energy transition process than the international trends. In 2015 however, 93% of its energy still came from fossil fuels. To realise the goal set in the Paris Agreement, limiting temperature rise below 1.5 degrees compared to the pre-industrial level, it could not succeed by only reducing greenhouse gas emissions. As a result, the Dutch government closed five oil refineries in 2015. However, three new oil refineries were also opened after a while, which caused public outrage. To regain the support of the people, the Netherlands became one of the members of the Powering Past Coal Alliance initiated by Canada and England in 2017 at COP23.

The Energy Agreement is an agenda signed in 2013 by 47 parties such as governments, companies, civil society, etc. It aims to make a more sustainable energy supply to attain the EU goals and boost the economic development at the same time. In 2019, the Dutch government merged the Energy Agreement into the Climate agreement, which focuses on the reduction of CO_2 emissions, for a better integration. That is to say, the national goal right now is to reduce greenhouse gas emissions to 49% by 2030 and 95% by 2050 (compared to the 1990 level); renewable energy generation has to

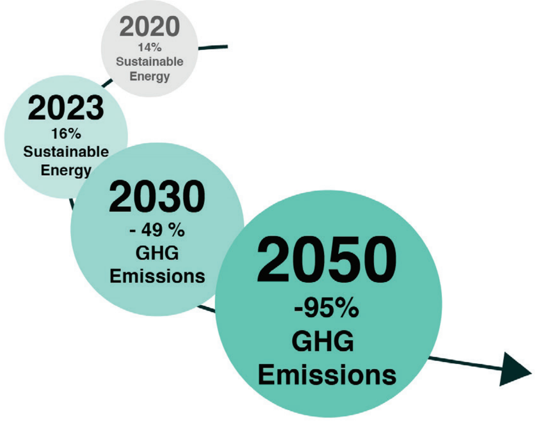


Figure 5: Types of Ducth energy goals

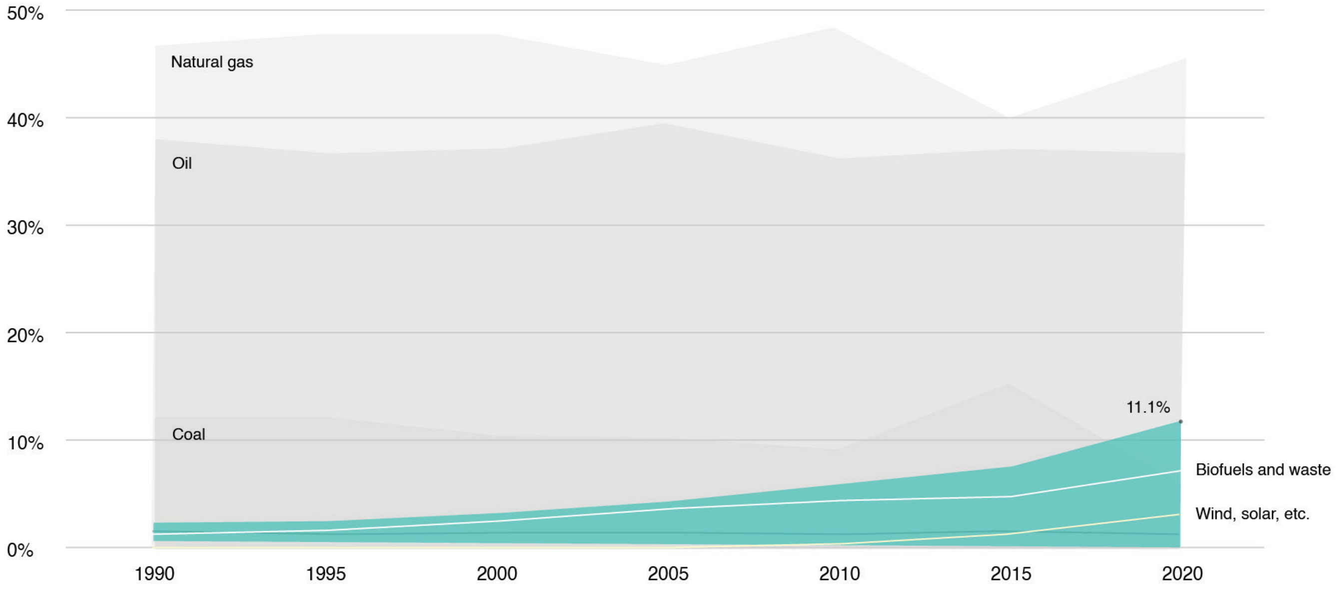


Figure 6: Total energy supply (TES) by source, Netherlands 1990-2020

reach 16% by 2023, and by 2050, 100 percent of the energy will come from renewable sources (Energieopwek.nl, 2022 and IEA, 2021).

In 2020, total national greenhouse gas emissions were 164.4 Mton, a reduction of 8.8% from 2019. It was a 25.4% reduction compared to 1990, meeting the target set in the UNFCCC. However, the greenhouse gas emissions in 2021 are 167.8 Mton, a slight increase compared to one year ago. The sharp reduction in 2020 and the slight increase in 2021 are due to the pandemic postponing many economic activities and a colder winter in 2021, which led to a rise in natural gas consumption in the built environment.

According to the Energy Report, three main principles were mentioned (Ministry of Economic Affairs of the Netherlands, 2016):

(1) focus on CO_2 reduction
(2) make the most of the economic opportunities that the energy transition offers
(3) integrate energy in spatial planning policy

Drawing together the above discussion, it is worth noting that most of the existing planning and discussion focuses more on economic development.

The Province Of South Holland

In response to the national goal, the province of South Holland highlighted that ‘the transition needs to be addressed by reducing final energy consumption, generating renewable energy, storing or using CO_2 in products and materials, and saving energy in companies ‘(The Province of South Holland, 2019). This ambition can be also seen in the Energy Agenda that the goal is to reduce CO_2 emissions by increasing the efficiency of energy production and infrastructure.

The province of South Holland is a high density area with 8.2% attribution of land area and 21% of population of the Netherlands. As an area with higher energy demand, only 5.9% of South Holland’s energy consumption came from renewable energy sources in 2019. Compared to the Dutch average of 8.8%, which is already left behind the goal, renewable energy generation in South Holland is facing a pressing situation.

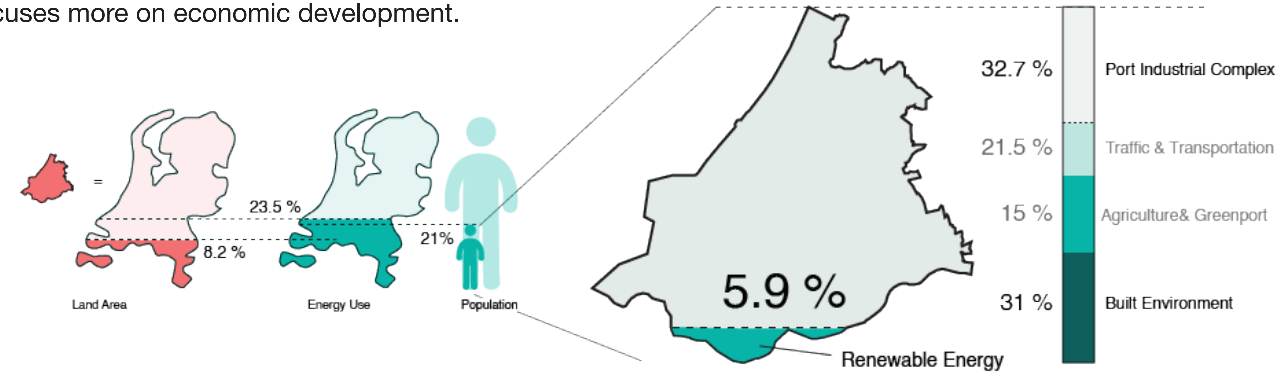


Figure 7: Comparison of the province of South Holland with the Netherlands

Up to 64% of the population of the province of South Holland is concentrated in the region of Rotterdam and The Hague. However, if taking a look at the total energy consumption in this region, even though it accounts for 77% of South Holland’s energy use, the vast majority of that percentage is still used in the port area. More specifically, in 2019, despite the fact that the total energy consumption in industry has decreased, it still accounts for 61% of the Province of South Holland. This underlines the imbalance in the distribution of energy in South Holland.

The Port Of Rotterdam

The Port of Rotterdam is seen as an economic engine in South Holland, yet it is the largest CO_2 emissions area. In 1990, the Port of Rotterdam released more than 20 Mton of carbon dioxide. This amount increased to more than 30 Mton in 2016 due to the expansion and new companies entered. Even with the closure of old coal-fired power stations in Maasvlakte in 2017, it still accounted for 61% of Rotterdam’s CO_2 emissions and 16% of the Netherlands in 2018.

However, although the Port of Rotterdam is still responsible for a sizeable attributable number of CO_2 emissions in the province of South Holland, the port’s carbon emissions have been on a steady downward trend since 2016. By 2020, emissions have been reduced to a level close to the total of 30 years ago. Remarkably, during this period, the port has increased its area by 20% and its annual throughput by around 50%, which means that there is still significant growth in the results of energy efficiency transformations. Still, this result can not be ignored because there was an inevitable economic contraction due to the pandemic.

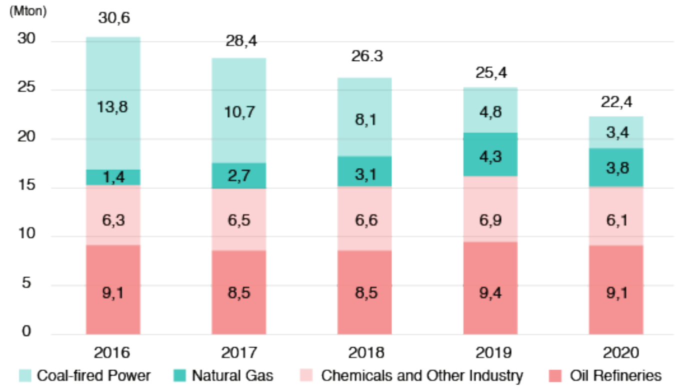


Figure 8: CO_2 emissions of the Port of Rotterdam

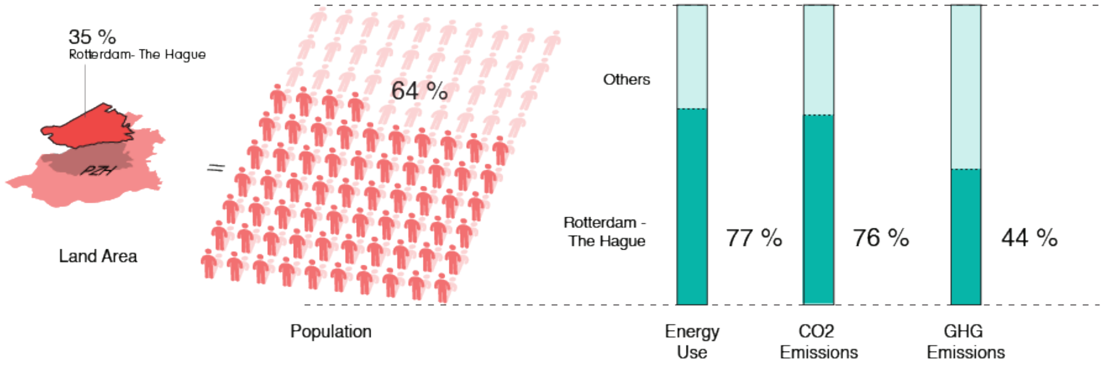


Figure 9: Key numbers of Rotterdam- The Hague

01.2 Problem Statement

The Increasing Price Of Energy Bills

In February 2022, CBS released an energy report predicting that energy bills will increase by 86% in 2022 compared to the previous year. The average annual energy price in 2022 will be €2,800 per household, €1,264 higher than in 2021. These dramatic increases in variable delivery charges have led to higher energy prices. Variable gas delivery costs have increased by €1,096 and electricity by €625, both rising by nearly 350% in one year (CBS, 2020).

Besides, there is a significant difference in energy bills between households due to the differences in housing type, construction years, degree of insulation, household size, and appliances' efficiency. For example, in January 2022, a multi-person family living in an older, larger detached home will have to pay 96% more for energy than in the previous year, compared to the 70% for a single-person home with a new, smaller apartment (CBS, 2020).

Average energy consumption has been declining due to improved home insulation, more energy-efficient appliances, and self-generated energy such as solar. Still, a 4% reduction in the average energy consumption has a minor impact on the balance of energy costs, which still totaled an 82% increase compared to 2021.

High Dependency On Imported Energy

The Netherlands is a central energy hub for the Northwest European market - not only for oil but also for natural gas, coal, and electricity (der Linde & Stapersma, 2018). In addition, the Netherlands used to be a net exporter of natural gas, yet gas production has declined by 72% from 2013 to 2020. A key turning point was the unexpected earthquake in Groningen, which had

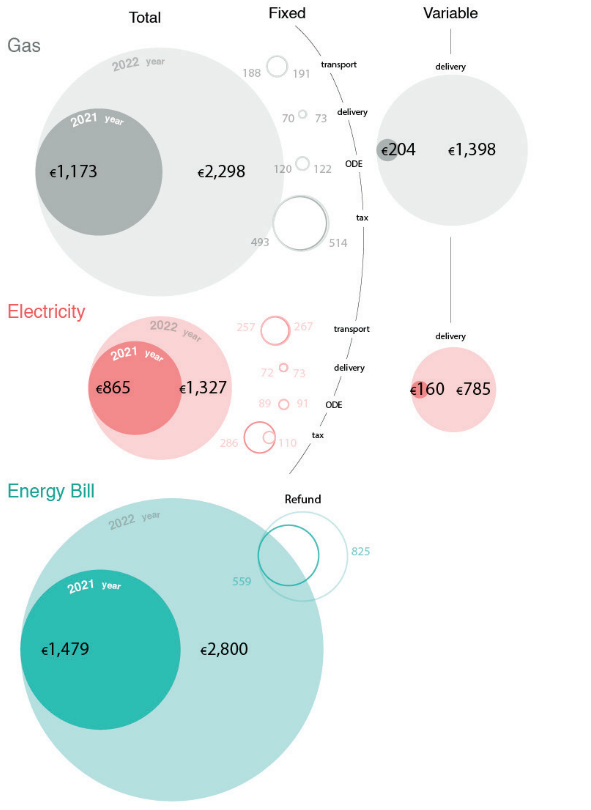


Figure 10: Energy bills in 2021 and 2022

significant social pressure on safety issues and led to the government's decision to shut down extraction by 2022. From 2023 onwards, Groningen gas production will only have emergency access. Moreover, because domestic energy production has decreased, the Netherlands became an energy importer in 2018. Specifically, the dependence on imported energy grows from 23.7% in 2013 to 68% in 2020. Moreover, the expectation of national production will supply less than a quarter of domestic demand by 2025 (PBL, 2020).

On the other hand, with the increased awareness of the urgency of the energy transition, natural gas has clear advantages over coal and oil in terms of calorific value, combustion efficiency, and carbon emissions, driving the global demand for the natural gas market (Nesta,2022). Based on this and the current massive demand for natural gas in the Netherlands, this has led to unexpectedly significant energy costs for society. From this perspective, we must realise that countries highly dependent on imported energy must face the uncertainty of energy shortages and market price fluctuations, not to mention even facing unpredictable wars in the world, which will create even greater instability.

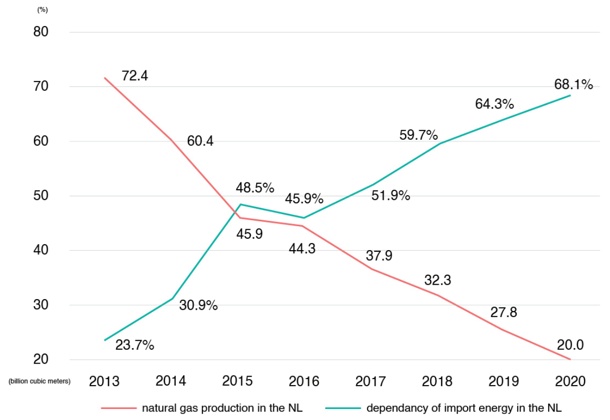


Figure 11: Energy production and import energy rate in the Netherlands

The Energy Poverty Issue Is Being Neglected

Energy poverty is a global problem. In the Netherlands, about 8% of households live in energy poverty- more than 650,000 households. In the face of a growing energy bill crisis, that number could increase by another 25,000 (NECP, 2019). The situation in the Province of South Holland is also urgent. Assuming the UK definition of energy poverty, more than 10% of a household's income is spent on energy costs (EU, 2019). In this scenario, about 100,000 households in the Province of South Holland are energy poor. However, if different indicators are used, such as comparing low-income households with high energy costs or low energy quality, then the energy poverty crisis in South Holland becomes even more severe than the Dutch average. In particular, if energy quality is taken into account, then more invisible energy-poor households emerge. Most of these households are unnoticed because they will use as little energy as possible because of high energy bills or they even barely have reliable appliances (TNO, 2021).

In line with the Dutch energy transition targets, the current government plans to transition 1.5 million households from natural gas to alternative energy sources for heating and cooking by 2030 (NECP, 2019). There are 50 pilot sites that started the transition experiment to move away from natural gas use in 2018. However, after two years of intervention, the transition process is more complicated than expected. The average actual expenditure per household during the transition process was at least twice as much as the subsidy. In addition, construction delays and a lack of enthusiasm among residents resulted in only 206 households completing the natural gas-free program. Not to mention, for many municipalities, it was more motivating and realistic to use the money invested to help address energy-poor households pay their energy bills (Feenstra et. al., 2021).

It is evident from the above cases that the government is more invested on how to achieve the goal of energy transition without acknowledging that the severity of the energy poverty crisis is beyond the statistics. Currently, nearly 90% of households still rely on natural gas for heating and cooking (PBL, 2018). This means that to achieve the goal of being gas-free by 2050, the issue of energy poverty should not be ignored, as those households suffering from the energy crisis will certainly not be able to cooperate with the government.

In other words, the challenge for the Netherlands is not only to achieve the goal of carbon neutrality but to realise that underlying problems at a more fundamental level may affect the possibility of achieving the long-term goal. 'The Netherlands is a country with a rich social welfare state legacy. The national government mistakenly believes that energy poverty is addressed through existing social welfare policies' (Freenstra et al., 2021). In the absence of an official definition of energy poverty and a national framework for addressing energy poverty, this problem will be even more dangerous for multi-level governance in the Netherlands. The governance of energy poverty can be seen as a fundamental underlying issue of the energy transition, which may have a greater impact on the energy transition as a whole, and is, therefore, an urgent issue that can no longer be ignored.

Energy Poverty	High Energy Rate (more than 10%)	Low Income, High Energy Bill	Low Income, Low Energy Quality
All Neighbourhoods			
% in the Netherlands	8%	4%	6%
% in South Holland	6%	3%	8%
Total number of dwellings in South Holland	99,791	49,895	133,054
Districts in South Holland where Energy Poverty is higher than the Netherlands			
Number of neighbourhoods	240	244	532
% of all neighbourhoods in South Holland	11%	11%	24%
Total number of dwellings in South Holland	48,135	28,117	116,626

Figure 12: Energy poverty in the Netherlands and South Holland

Historical development of the Province

The Port of Rotterdam is an important economic factor and the petroleum landscape is an important part of the development. Not only spatially, but also culturally, the development of the port in cooperation with the development of oil has influenced the current identity of the Rotterdam and The Hague region.
Socially, the development of the oil landscape in the port and also worldwide has changed the way society lives.
In 1864, the port of Malle was built (Hein, 2018). This area is now in the immediate vicinity of Rotterdam city centre, but on the south side of the Niewe Maas. In 1872, the Nieuwe Waterweg was developed, which made the waterway more efficient and was an important change for the creation of the present port (Hein, 2018). In 1906 the Waalhaven was developed and a few years later the airport. It should be mentioned that airports were also only made possible by oil production. Between 1923 and 1933, the port of Pernis was developed after the Pernis oil refinery was located on the site of the port - the oil industry flourished. In the meantime, the first offices were established in the city centre of The Hague to represent the industry in the cities. In 1974, the Maasvlakte project, an expansion of the port, was completed and in 2013, Maasvlakte II was completed, representing a large part of the Port of Rotterdam's economic hub with 8,436,240 containers per year, EUR 551 billion before taxes in 2021 and 180,000 employees and 180,000 employees (Havenbedrijf Rotterdam, 2021). This historical development shows that the energy supply of the port not only had a spatial impact on the province, but also changed the entire way of life and social structures. When planning the energy transition, which in this case aims at energy production without fossil fuels, the associated changes at the governmental and social level as well as in the way of life are taken into account.

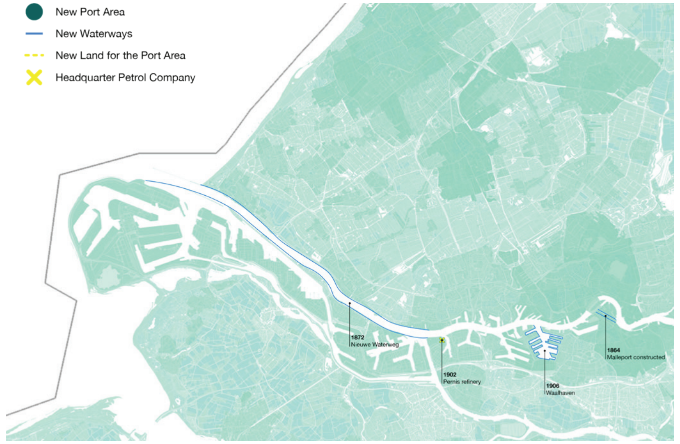


Figure 13: Historic development port 1850-1910 (after Hein, 2018)

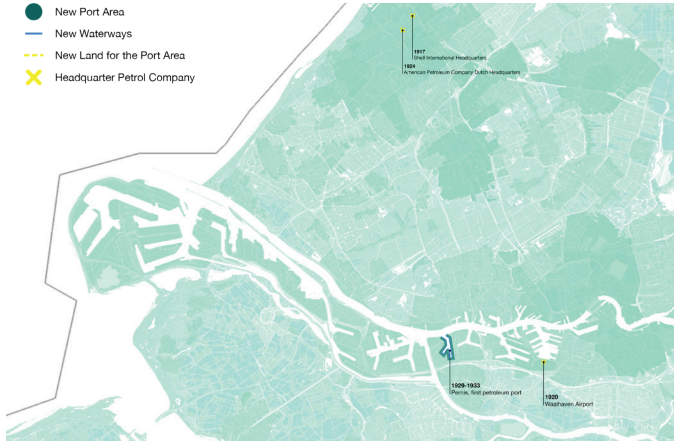


Figure 14: Historic development port 1910- 1950 (after Hein, 2018)

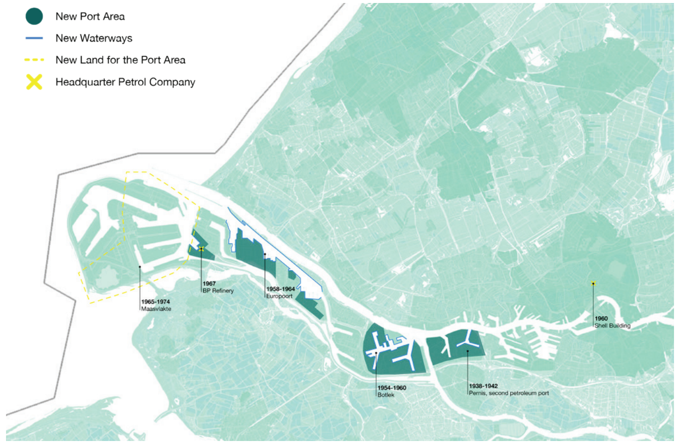


Figure 15: Historic development port 1950-1970 (after Hein, 2018)

Figure 16: Historic development port 1970-2000 (after Hein, 2018)

Figure 17: Sustainable Development Goals addressed in this project (European Commission, 2022)

01.3 Sustainable Development Goals

The Sustainable Development Goals (SDGs) are an agenda developed by the United Nations with an action plan for sustainable development. There are 17 goals focused on people, planet and prosperity to be achieved by 2030. Their conception of development integrates social, economic and environmental sustainability (United Nations, 2022). In the systemic change proposed by the project “A just and fair energy transition towards a fossil fuel free province of South Holland”, the SDGs are taken into account and form the framework for the goals that this project tackles.

Back in 2015, the agenda was set for a 15-year timeframe, but in 2022, it is just eight years away from the end of the timeframe for which these goals were set (United Nations, 2022). However, the first step in addressing global injustice was to set an agenda with hard and equitable goals.

The agenda recognised the immense challenges that needs to be faced in our world today. Rising inequality, poverty, unemployment, health problems, the Climate Crisis, and all the uncertainties of the future are just some of them.
In some areas, the agenda itself and the way it is structured can already address some inequalities, such as through the application of international law by which all participating nations are bound.

For the agenda to work, all nations involved in it should first be on the same page and have the same worldview and beliefs. Defining the problems and recognising the same way - a universal, insightful way to overcome differences between different nations after much debate - must be overcome to create a universal agenda. Through the drafting of the SDGs alone, many structural changes and improvements have already been made to create a plan with 17 goals to be achieved by 2030.

One value of this agenda is that the goals are not set just for one nation, but as an overall outcome for the United Nations, so the approach of leaving no one behind also underlies the system (according to Declaration No. 4 of the SDG agenda). Participating nations have committed to prioritise the progress of countries that are furthest behind in achieving the goals.

However, changes must be made within each country, and in the Netherlands in particular, the financial resources and structures are in place,so there is great potential to achieve the SDGs by 2030.

This 2015 manifesto of the Heads of State and Government and the High Representatives of the United Nations is very ambitious in perspective and in view of the current state of the problem. However, it is all the more important that this manifesto is discussed, outlined and acknowledged by all states represented. This is because the urgency of solving poverty and hunger is critical to the foundations for sustainable development as a whole. It is also important to emphasise that most human needs and necessities for human life and human rights are found in a nation like the Netherlands. However, looking at the definition of energy poverty, according to TNO, about 8% of the Dutch population suffers from energy poverty (TNO, 2021).

01.4 Research Questions

There are three domains considered in this project, physical, social, and economic.
Based on the subquestions under different perspectives, the main research question is:

How can a just energy transition
towards 100% renewable energy
in the Province of South Holland be created,
through synergising and adjusting
the spatial distribution and generation of renewable energy?

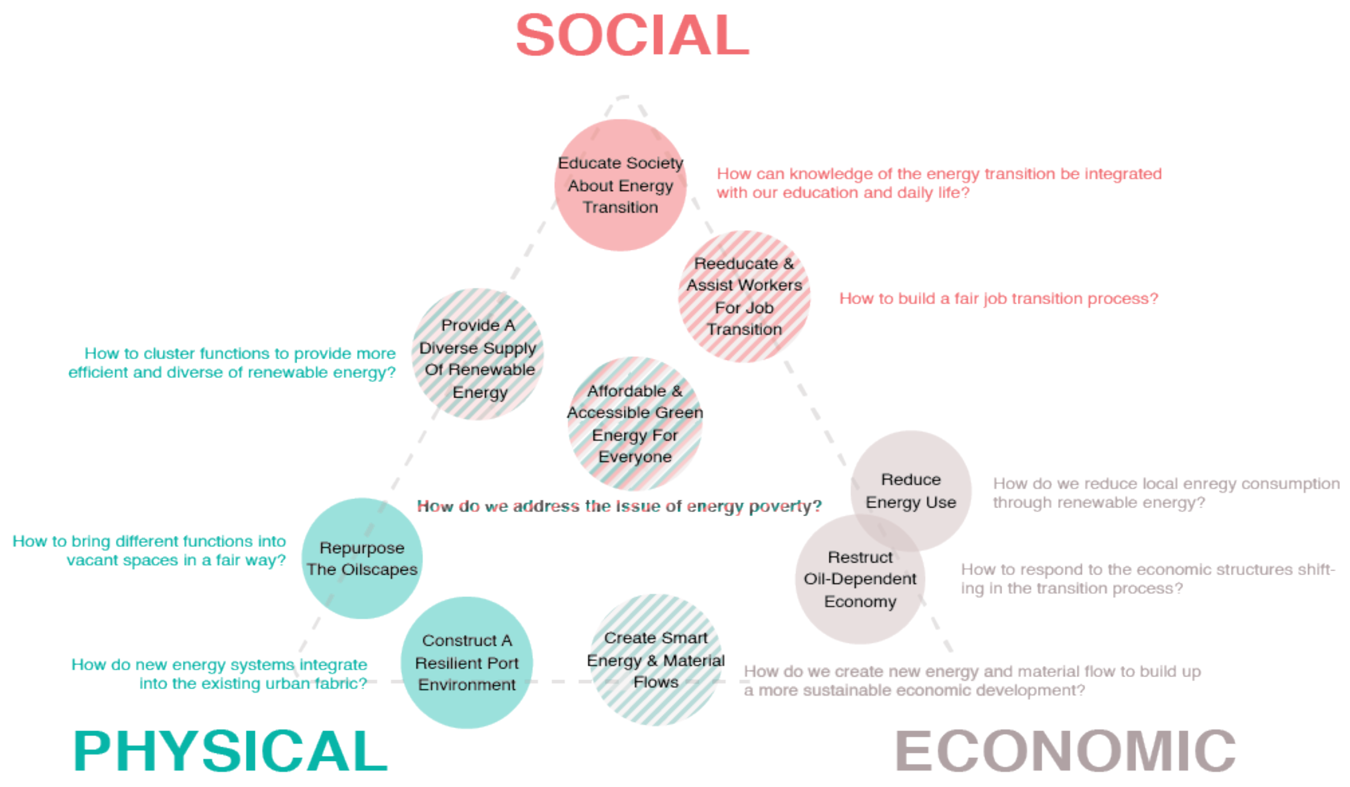


Figure 18: Research question and sub-goals

01.5 Conceptual Framework

First of all, the physical domain represented the whole area in the Province of South Holland. Secondly, the social domain is the area that considers all the activities. Last, the economic domain focuses more on the Port of the Rotterdam area. The physical environment is the most extensive collection in this project, including the social and economic domains. The social domain is the second, and the economic sphere is the smallest collection. Three arrows are defined as tools cooperating and following three core values: just, sustainability, and digitalisation, to achieve the final goal.

From the physical perspective, a synergistic environment is built up by reallocating spatial functions, reorganising social structure, and redefining economic policies. In the social view, stakeholders' opinions and expectations are included and integrated. Social assets will be realigned to create a fair and affordable system. In the last part, the economic domain, energy, and material flows are redistributed to assist the transformation into a more sustainable and circular network.

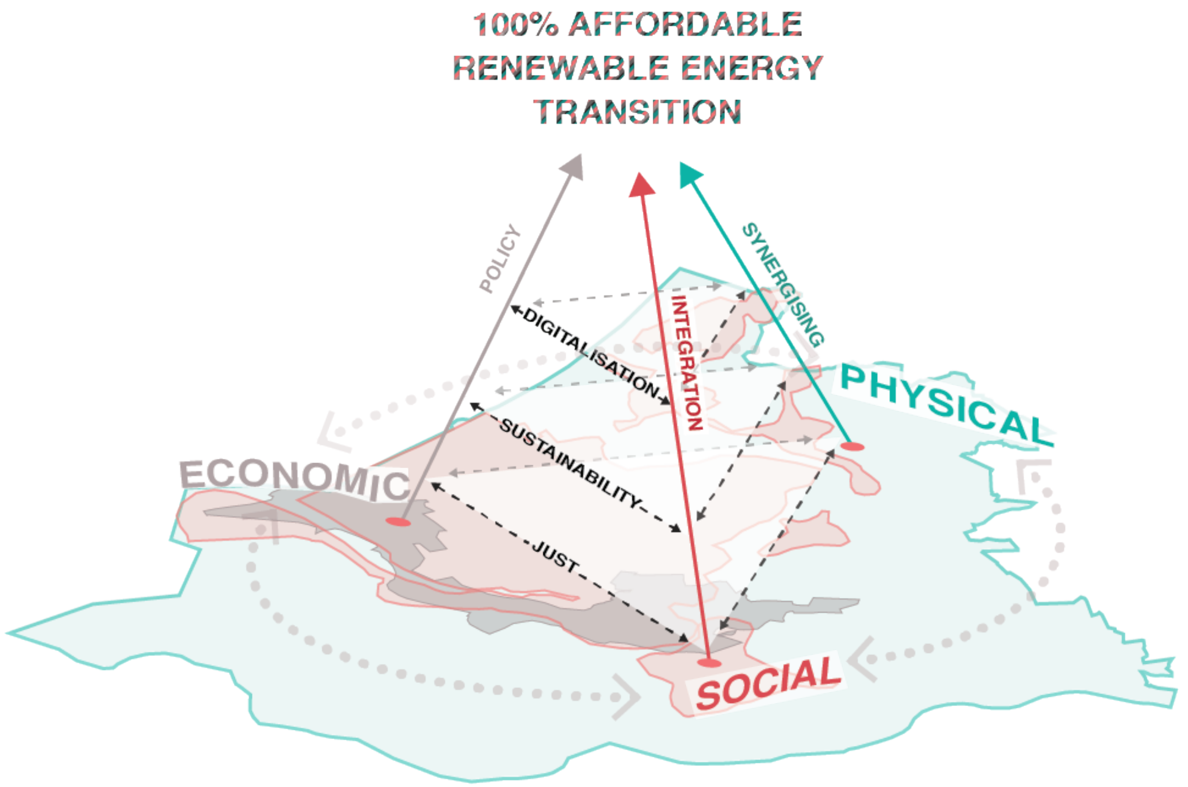


Figure 19: Conceptual framework

01.6 Methodology

The project presented in this report was developed through a combined methodology of research and research by design, as presented in these pages.
All analysis and reflections on the outcomes of the research and following proposed solutions were carried out through iterative group discussions and follow-up research.

The methods of literature review and mapping provided the foundations for following steps in the research and design process.

Literature review consisted in the analysis of strategies, visions and meta-analysis of existing and future projects for the Province of South Holland, its industries and its society.

Spatial analysis was carried out through two key methods: a visit to the Port of Rotterdam and mapping through digital tools. The second method consisted of the crossing of diverse geographical information about the province through maps, aided by the QGIS software, illustration tools and existing maps.

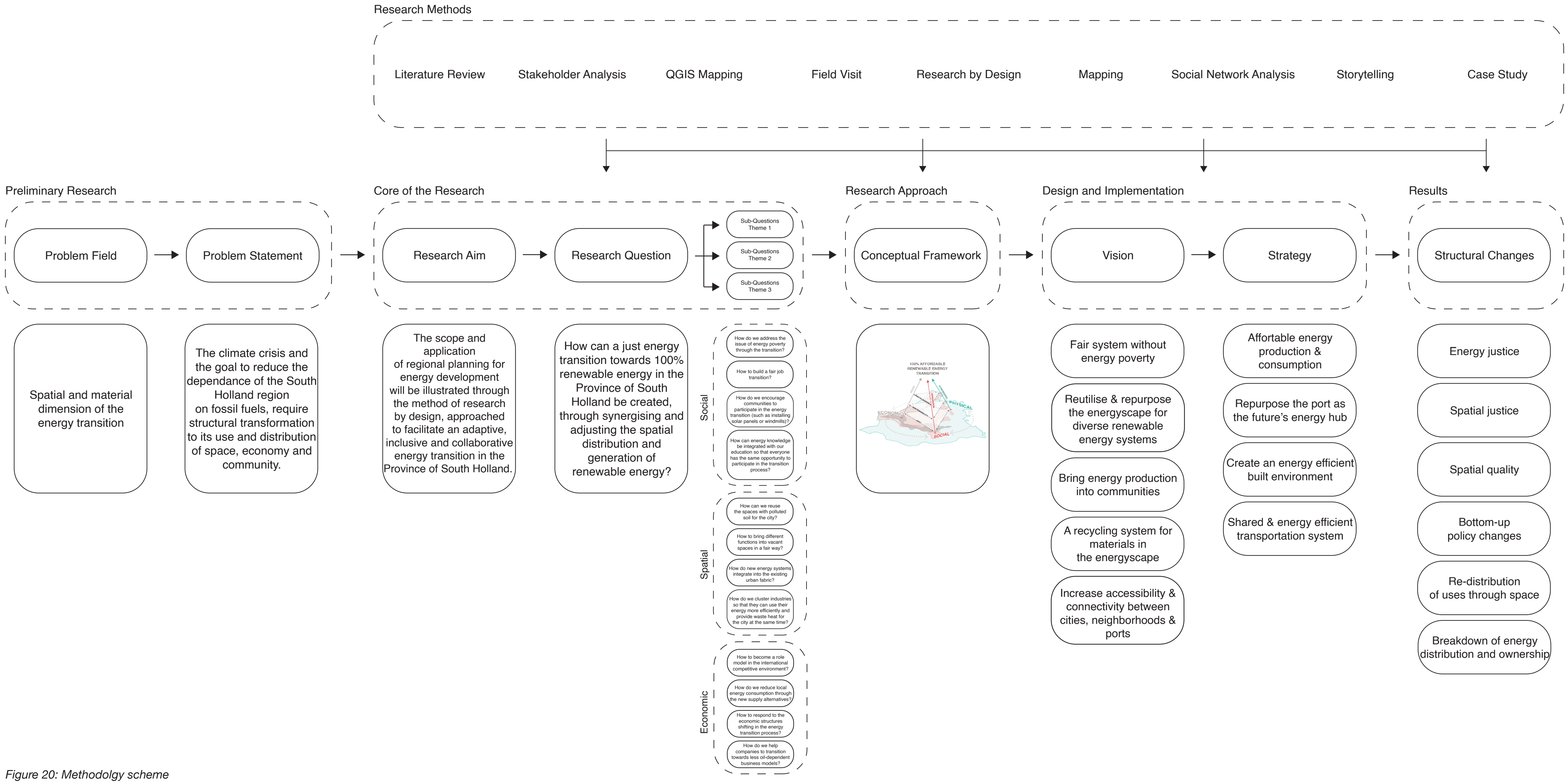


Figure 20: Methodolgy scheme

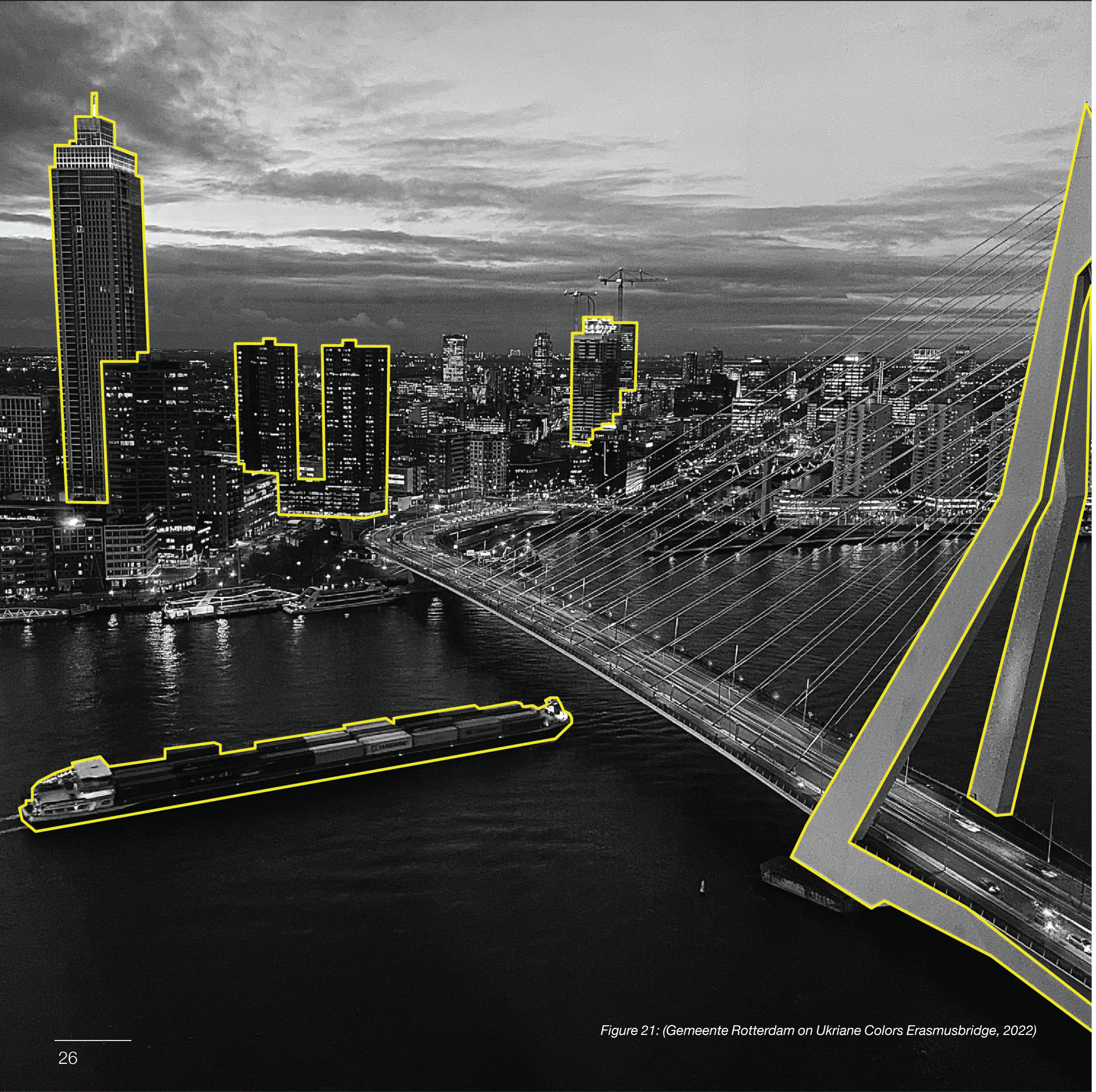


Figure 21: (Gemeente Rotterdam on Ukriane Colors Erasmusbridge, 2022)

02. Understanding the Province

02.1 Socio-Spatial Analysis

Low Income

In the Province of South-Holland the average percentage of low income households per neighbourhood is between 30-40%. For the clarity of the map, this layer is filtered out.
The lowest percentage of low income households can be identified in the region of the Hague. These are surrounded by a great number of low income households. In the city of Rotterdam, almost all neighbourhoods have a high share of low income households. Both the allocation of the low income neighbourhoods in the Hague and Rotterdam overlaps with a high number of social housing in these neighbourhoods (see the map on the right).
In the East and South of the province low income neighbourhoods can also be identified, as well as lower house prices in these regions.

Figure 22: Low income households (Nationaal Georegister, 2019)

Social Housing

As seen in figure 22, the city of the Hague and Rotterdam have a large number of social housing projects, both in the city centres and the neighbourhoods around them. Besides this, the cities around the port can also be identified as neighbourhoods with a large number of social housing, such as on Goerree-Overflakkee.

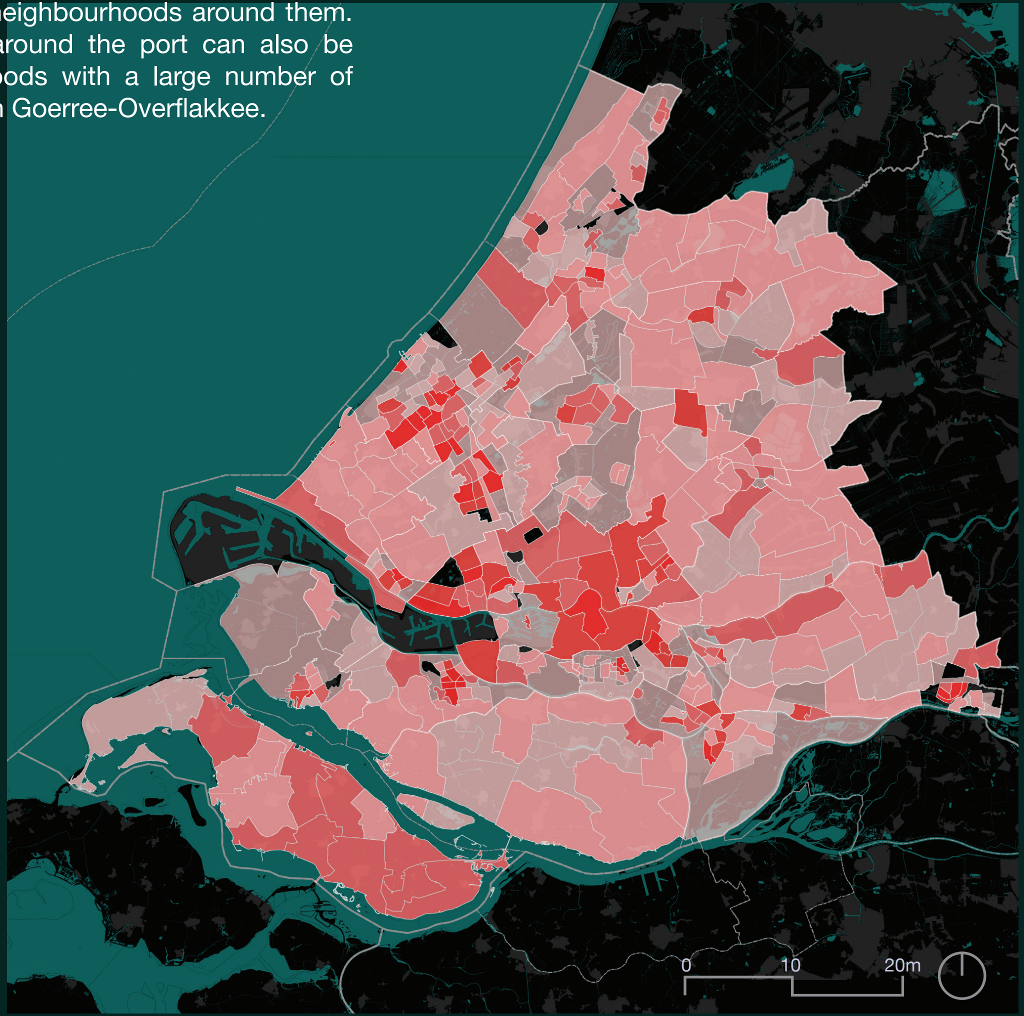


Figure 23: Percentage Social Housing (Nationaal Georegister, 2020)

Cars per Household

As can be seen in the map, households in the city centre have, generally speaking, less than one car per household (the lightest colors). This can probably be explained easily because they live closer to facilities and, most of the time, public transport is better in these areas. Another reason can be that the percentage of social housing and low income households is higher in these areas.
The brighter yellow colors are the households with more than 1.5 cars per household, these neighbourhoods are spread across suburban areas.
For the visibility of the map, neighbourhoods with households with 1 to 1.5 cars are turned off.

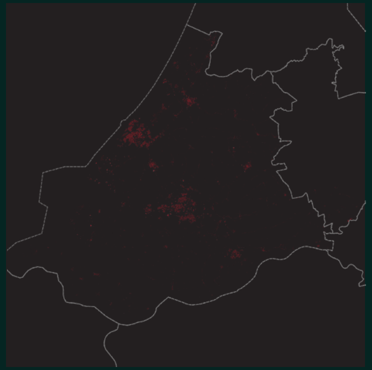
Figure 24: Cars per household (Nationaal Georegister, 2019)

Educational Institutes

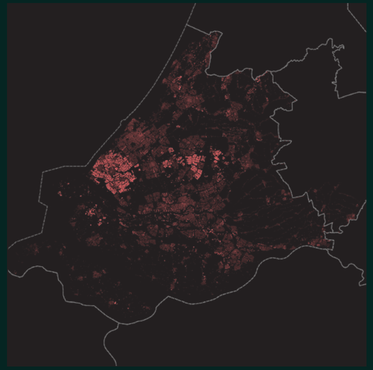
The Province of South-Holland has a number of educational institutes. The universities and 'Hogescholen' are located in Leiden, the Hague, Delft and Rotterdam. These are the main cities in the province.
The 'MBO'-schools (vocational secondary education) are more spread around the province, located also in smaller cities across the province. Around the port area, a couple of technical schools are located. These schools might educate students for jobs related to the industries of the port. In the Westland (where most of the greenhouses are located), the local 'MBO'-school is mainly dedicated to train students for work in the greenhouses.

Figure 25: Educational Institutes (Google Maps, n.d.-a) & (Google Maps, n.d.-b) & (Google Maps, n.d.-c)

Buildings before 1950



Buildings between 1950-2000



Buildings since 2000

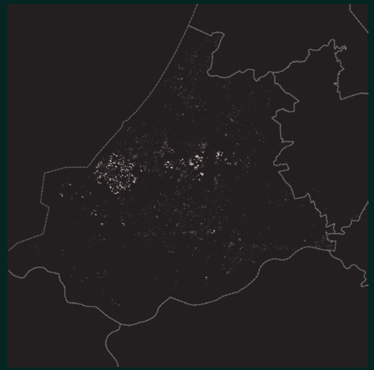


Figure 26, 27 & 28: Building age (Nationaal Georegister, 2018)

Building Age and Energy Poor Neighborhoods

In developing the transition to a renewable energy system, reducing energy demand is an important starting point. This is because 30% of energy is consumed by the built environment (Provincie Zuid-Holland, 2020). It is important to look more closely at the current energy standards of our built environment and there is potential to reduce consumption in this sector. With new technologies, buildings can be converted to be energy neutral and save a lot of energy through retrofitting and integrating smart technologies. However, 84% of the buildings in the province of South Holland were built before 2000 (Héél véél informatie over de provincie Zuid-Holland, 2022). Figure 29 shows the combination of building age and energy-poor neighbourhoods in the province. This combination shows areas that have the potential to serve as a starting point for short-term improvements.

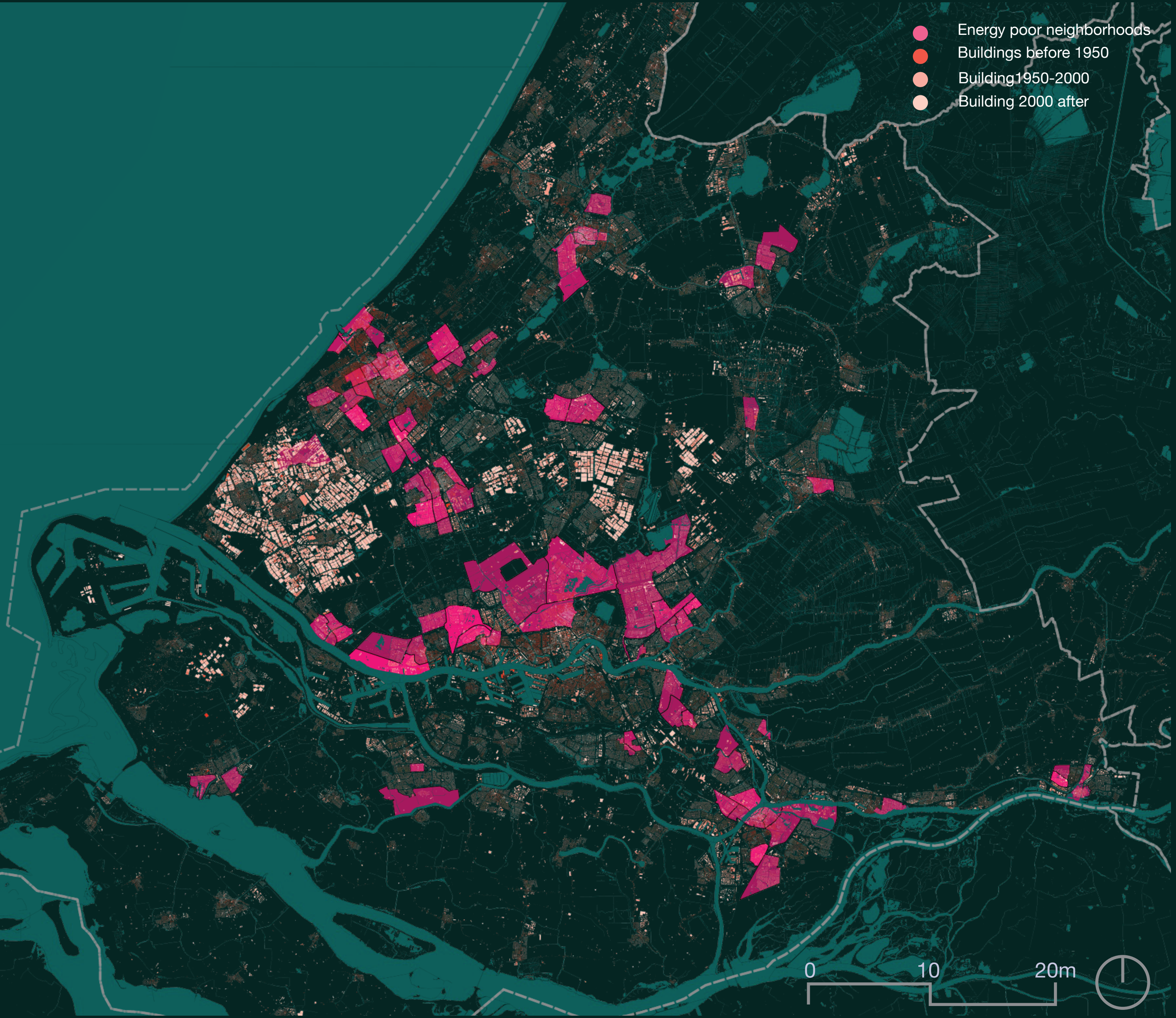


Figure 29: Building age and energy poor neighborhoods ((Nationaal Georegister, 2018) & (TNO, 2021))

02.2 Current Energy Systems

Industries in the Province of South Holland

Across the province, several industries populate its cities through their factories, refineries, transport networks and headquarters. The map shown in these pages presents the distribution of economic units that identify as industries, most of them related to the extraction of fossil fuels and minerals.

It is worth noting that there is an abundance of these units in The Hague and the interior of the city of Rotterdam, while the port seems deserted. This does not mean that factories, refineries and mines cluster in The Hague, but that their headquarters are rooted in there and they have little to no administrative bindings in the port, so even if the infrastructure is spread beyond the cities, it is managed from within them.

The companies that populate the province are the current stakeholders of the energy industry and the fossil fuel industry, as the later is one of the key imports of the Port of Rotterdam and it supplies up to 85% of the region's energy.

The industries that do bother to plant their administrative locations in the port are those related to storage and bulk transport services, which are the light, white dots that populate the port.

In this and the following pages it will be noted as well, that pollution does appear to cluster around the port and its industries, particularly those related to fossil fuels and chemicals.

Industries are not only a great economic driver but also great energy consumers and polluters. In 2015, the fossil fuel industry accounted for over 27 megatons of CO_2 emissions per year (Mton CO_2/y) (Samadi et al., 2016) and consumed over 230 PJ of energy, 30% of the region's energy demand. The transition towards renewable energies will depend strongly on an industrial transition, both because of their relationship with fossil fuels, and due to their relevance to the economy and lives of the province's inhabitants. They will be key stakeholders that can aid a faster transition through their technologies and can also become energy producers, both as co-operatives and as providers through the distribution of their residual heat and materials.

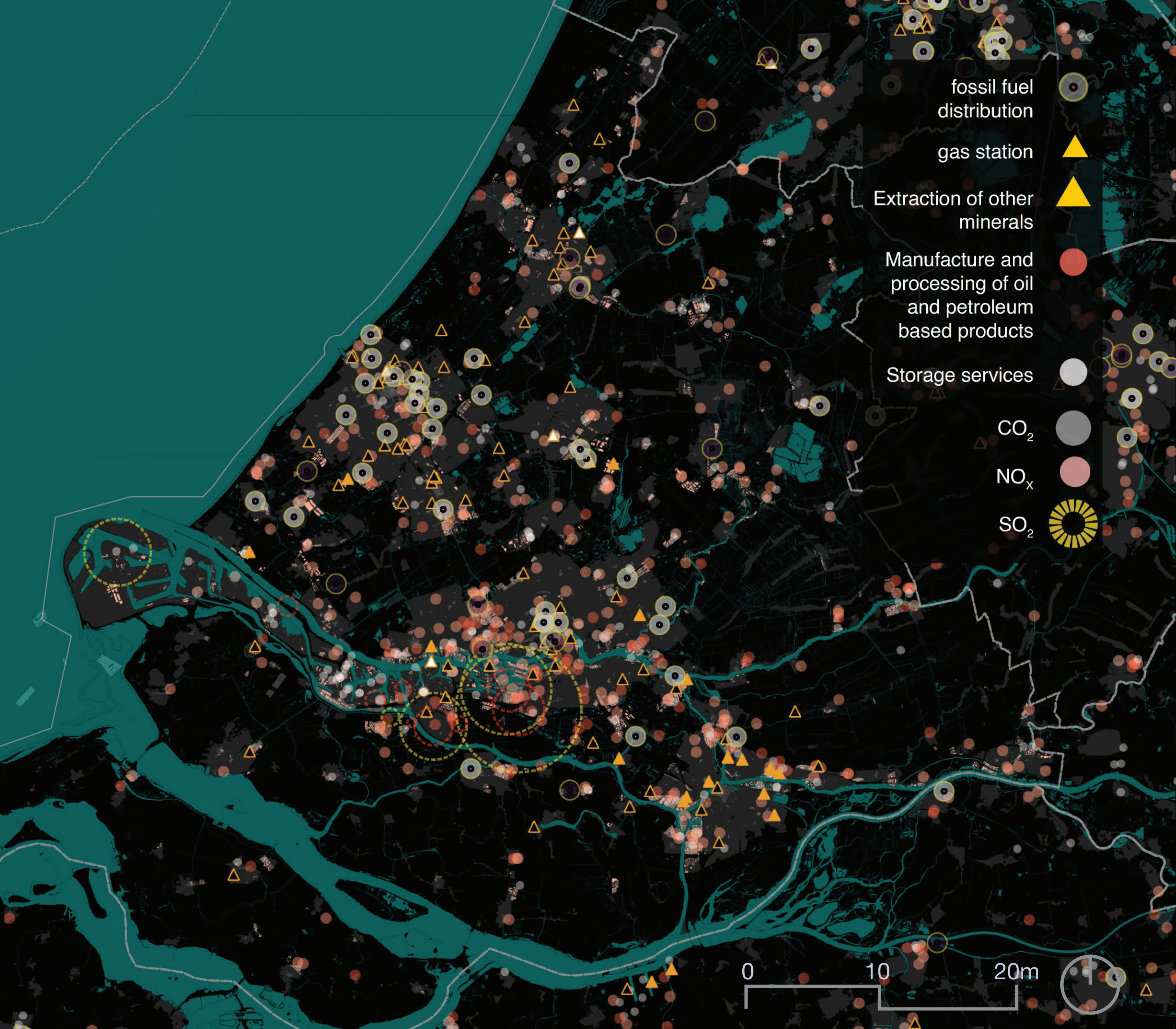


Figure 30: Petrochemical industries and infrastructure in the Province of South Holland (LISA, 2014)

Energy Supply across the Province

The province distributes its energy through a variety of networks. Electricity is currently distributed through a grid run by the companies Tennet and Stedin, while gas, natural gas, heat and oil, run across sub-terrain pipelines that run parallel to each other through energy corridors and diverge according to specific needs of the grid.

The underground service that is the most extended across the province is gas, natural gas and heat distribution, since it spreads across cities and greenhouses. Up to 90% of homes depend on natural gas (PBL, 2018), which means that the region is heavily dependent on fossil fuels, but also that it could easily transition towards another source if it can make use of the existing infrastructure.

Oil, on the other hand, seems to spread through a more limited corridor that touches on settlements but doesn't spread into them as gas and heat networks do.

The spread of this infrastructure across the province does not respond only to local demand, but to that of consumers outside the country and outside the Netherlands, that have for decades depended on the gas, heat and oil that comes from the Port of Rotterdam. It is this extension after all, what has aided the extension and spread of the pipelines and gas stations throughout the province, in the way of the corridors that supply the rest of the market.

Renewable energy is a rising industry in the Province, with wind parks across and around the port and extending into the North Sea, and three of the main biofuel producers of the country (Khandenwal, van Dril. 2020). While experimental technologies and incentives for new energy sources rise in the Province, there is limited connection to the overall grid for alternative suppliers, which translates in limited options for energy consumers.

Going back to the relationship between the industries and pollution, there is an unfortunate overlap of major urban centres in the region with the greatest concentrations of greenhouse gasses such as carbon dioxide, nitrogen dioxide and sulfure dioxide. Exposure to these compounds contributes to the development of chronical health conditions (Cole et al., 2020) and the area around the Port of Rotterdam is not only the most polluted of the Province but the most polluted one, nationwide. This is a direct threat to the health of inhabitants and a direct reminder of the importance of the transition, to our own health.

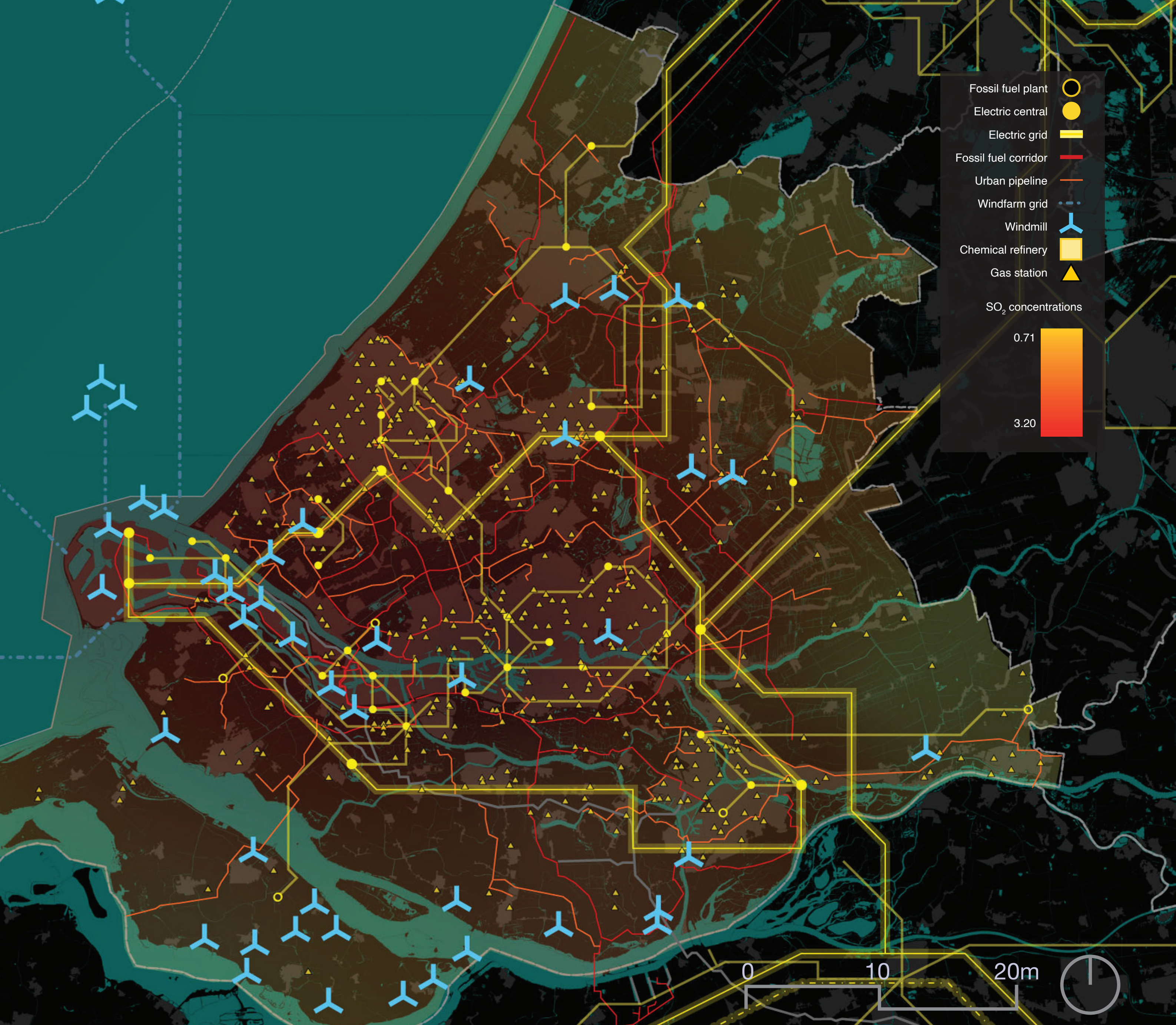


Figure 31: Energy supply across the province ((Tennet, 2022),(Hein, 2018), (Cole, Ozgen & Storbl, 2020))

The Port of Rotterdam can be called the core of the Province of South Holland. The opening of the Nieuwe Waterweg in 1863, that connected Rotterdam to the North Sea along with the beginning of oil imports, jump started the spread of new logistical infrastructure that connected the imports of the port with the rest of Europe. Private and public interests in the development of the oil industry led them to invest in the communities that would provide its workers, which translated in the development of the towns and cities around the port (Hein, 2018).

In its 40 kilometres of length and 7, 903 hectares (Port of Rotterdam Authority, 2020), it provides over 20,000 jobs and at least 460 tons of bulk cargo transited through it in 2020, within 15 million containers.

Across its 1,500 kilometres of pipeline corridors, gas, oil, natural gas and heat are transported, with current plans to lay infrastructure for new networks along them, such as hydrogen and biofuels.

Even as the port tries to incorporate these renewable energies into the cluster however, oil refineries (0.65 ha), oil storage units (1.43 ha) and chemical plants dependent on oil (0.98 ha) cover the greater part of its landscape.

As a major polluter (30.3 Mtons of CO_2 emissions in 2015), the port has committed to reducing them by 60% by the year 2030 and by 95% in the year 2050. The scenario of a transition towards 100% renewable energy sources by 2050 would entail a drastic shift in the composition of the port, beginning by phasing out fossil fuel-centreed industries.

Figure 32: Structure of the Port of Rotterdam ((LISA, 2014), (Port of Rotterdam Authority, 2021) & (Hein, 2018))

Current Energy Flows

In 2020, the Province consumed 731 PJ of energy, between its industries, its transport networks, greenhouses and the built environment. This demand was supplied mostly by fossil fuels, with small assistance from nuclear energy (5%) and the emerging biofuel industry (6%).

Most of the fuels (72%) needed to power the region were imported from other countries (IEA, 2018).

The yellow bars in the scheme at the left show the proportions of energy that end up dedicated to fossil fuel production, most of which is exported outside the province.
How to achieve a transition towards renewables is a tricky question, when energy production is not only a great consumer but a great economic driver. The fossil fuel infrastructure, particularly gas pipelines, has great potential to host alternative processes, such as hydrogen storage and electrolysis (Port of Rotterdam Authority, 2020). A transition towards renewables does not just require the chemical industry to assimilate renewable sources into their production. Eliminating the fossil fuel industry can drastically reduce the province's overall consumption and thus its emissions. The vacant oilscape can be then repurposed for alternative, cleaner, more local uses.
The second greatest consumer is our built environment, which accounts for cities, services, houses, train stations.
As for the chemical industry, fossil fuel production and the chemical industry are the greatest energy consumers. 99% of the coal demand comes from petrochemical industries, from which only 33% ends up in energy for houses (MSR, 2007).

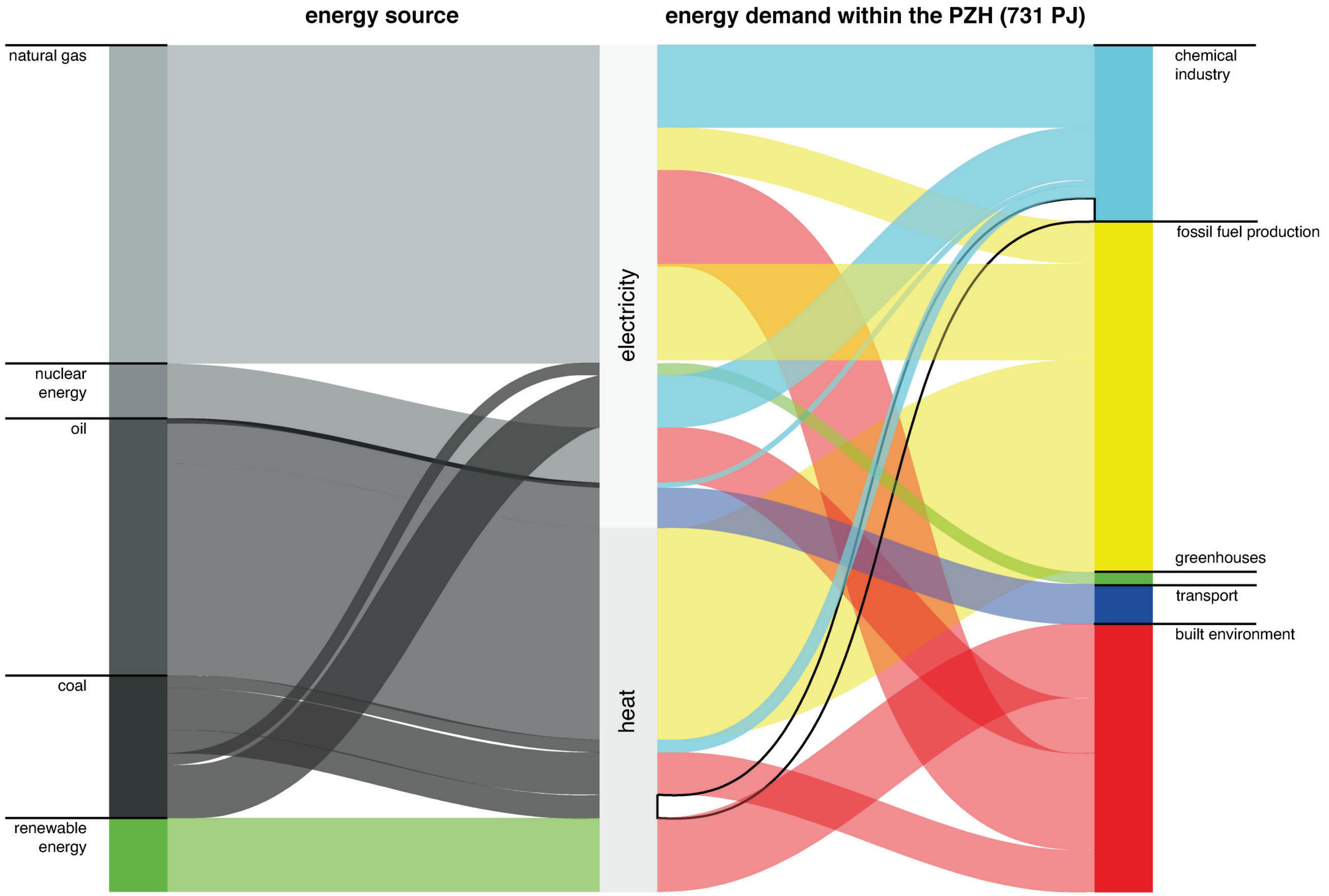


Figure 33: Current energy flows (MSR, 2007)

Current Fossil Fuel Scape

Today's petrol station landscape in South Holland has developed over the years and established itself in the everyday scenery of our lives.

As can be seen in Figure 38 (of the petrol stations) and Figure 41 (of the harbour), it is spatially dominant in the province, although all the administrative buildings in the city centres must also be taken into account. According to the findings of the February 2022 field trip, the customer-oriented administrative buildings tend to be located in the city centres and represent an affluent and exclusive image of the oil industry.

However, the closer one gets to the port area, the actual industry and refineries, the harsher the spatial scenery becomes. Not only the space that are perceive develops along the lines of the oil landscape, but also the space below ground, the pipelines that serve to supply the built environment with energy based on fossil fuels.

So the distribution of pipelines and the distances to be covered need to be rethought, because renewable energy can be produced in a more decentralised way and does not need pipelines, but cables, for example. 72% of energy is imported, making South Holland reliable and dependent on other nations (Provincie Zuid-Holland, 2018).

The transport to import these raw materials then also relies on tankers with fossil fuels. The driving force for the historical development of the port was the establishment and expansion of the oil industry and the generation of profits from fossil fuels. This has not changed until today. According to Carola Hein, the Port of Rotterdam is one of the "last man standing" ports for fossil fuels (Hein, 2022).

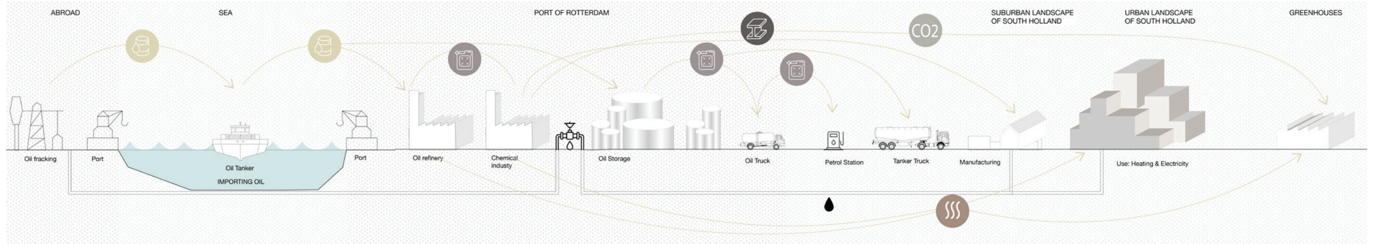


Figure 34, Section of current petrolscape in South Holland


Figure 35: (Auto Report Africa, 2020)


Figure 36: (Green, 2021)


Figure 37: (Demidova, 2020)


Figure 38: (Filling station, 2022)


Figure 39: (Runway Girl Network,


Figure 40: (Trillions, 2020)

Figure 41: (Jungerius, 2020)


Figure 42: (Chepkemoi, 2017)


Figure 43: (De Ingenieur, 2017)

Current Petrolscape

This is the spatial distribution of petrol stations in the province of South Holland, and petrol storage, processing and refineries are mostly spatially located in the port area. The petrol stations are a major spatial outcome of the fossil fuel facilitating landscape today and provide the retail for the residents of the oil. Petrol stations are mostly located near transport infrastructure: motorways, regional roads, airports, railways, waterways and railways.

Current Petrolscape in South Holland

Petrol Station

Petrol Storage and Processing

Figure 44: Petrol stations (Hein, 2018)

Current Wastescape

This map focuses on parts of the material flow - more precisely on the areas where materials end up at the end of their life cycle: the waste areas. The map shows the current recycling stations in the province of South Holland. It can be seen that the collection points are usually located in the outskirts of the urban settlements and that there are several recycling stations in the harbour area. The current waste landscape is the result of our linear economy, which leads to the spatial consequences of linear flows (Amenta & Timmeren, 2018).

Collection and storing waste

Recycling stations

Recycling South Holland

Figure 45: Recycling and Waste stations (Provincie Zuid-Holland,2020) & (Recycling, 2022)

02.3 Current Material Flow

This is the overview of the supply chain of the most important products needed for the energy transition. The material flow that needs to be considered when planning the introduction of more renewable energy systems for the energy transition. From the mining location to the raw material, through electrochemical production and manufacturing, to the end of use and end of life. It is shown where reuse, reassembling, re-manufacturing and recycling can be integrated into this linear flow to introduce a circular material flow in South Holland.

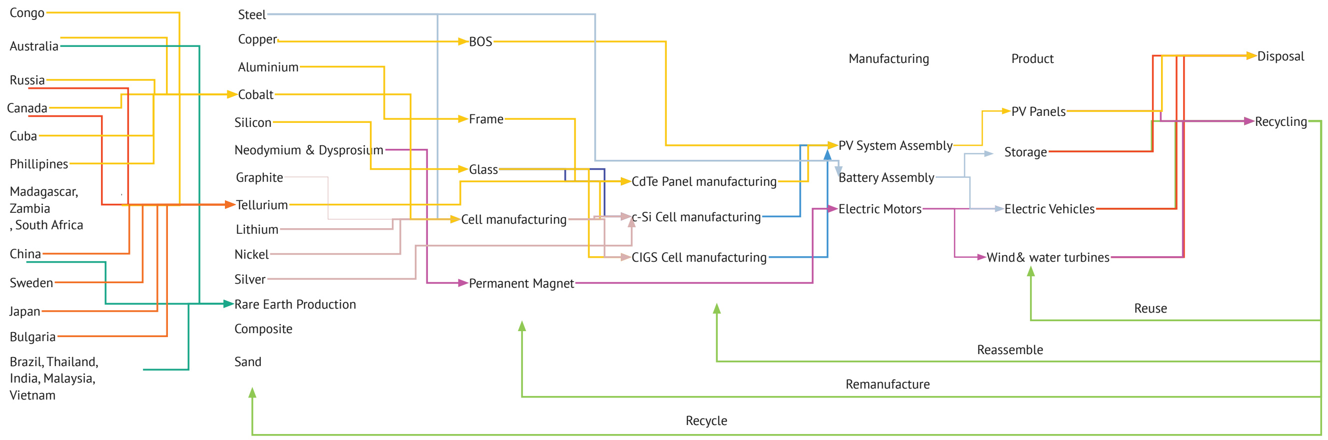


Figure 46: Interpreted from Responsible Minerals Sourcing for Renewable Energy

Crucial Materials that are needed for making the energy transition happen are (IRENA, 2021):

Copper, 6 USD for a long time. But in 2021 increased to 10 USD

29 **Cu** Copper

27 **Co** Cobalt

Cobalt, strong price fluctuations over the years

Nickel, prices are continuously rising

28 **Ni** Nickel

66 **Dy** Dysprosium

Dysprosium, is a rare earth metal: just in October 2021 20% price increase

Lithium, prices rising quickly

3 **Li** Lithium

60 **Nd** Neodymium

Neodymium, is a rare earth metal: just in October 2021 20% price increase

How South Holland can deal with the demand for critical raw materials (IRENA, 2021):

As the result of large scale mining projects is not always guaranteed, an important step to deal with the dependency is diversifying. The Netherlands as a country and the Province of South Holland can take action now in expanding national supply. And subsidies of critical materials can be exchanged with other, less critical materials. Stockpiling and long-term supply contracts for critical materials can also decrease the dependency. Most importantly, the recycling of critical materials has to take place. And research and development of products that limit the need for critical materials - e.g. fewer permanent magnets materials other than silver in PV panels in the production process can improve the demand for raw materials. This redesigning of products can be funded by the government, and TU Delft is already an exemplary university doing research and developing projects for the energy transition.

Raw metals are a dominant material, which is needed for the transition. Thus developing a circular material flow in the province of South Holland will not only financially pay off and create a stable market for those valued raw materials, but also enhance a more sustainable environment.

Global Import of Materials

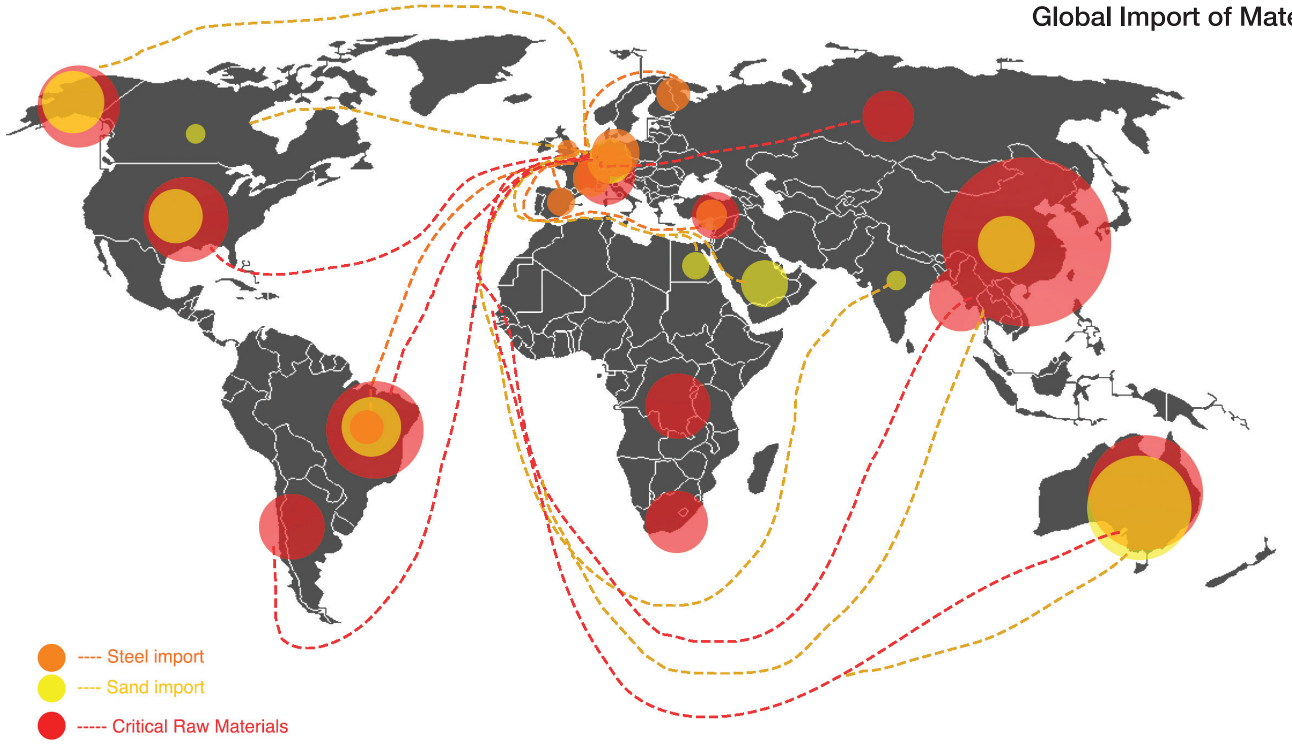


Figure 47: Global Import of Materials (Global Trade Atlas, 2019) & (International Renewable Energy Agency, 2021)

This flow shows which materials are needed at the end of the life cycle of a solar module. 95 % of the glass and 100 % of the metal can already be recycled with today's technology in the first processing step. In order to recycle the cell modules and the plastic, the discarded solar modules must be processed in the facilities at the port. There, 80 % of the cell modules and 85 % of the silicon can be recovered and there is a high recycling potential for raw materials such as indium, silver and tellurium (GreenMatch, 2017).

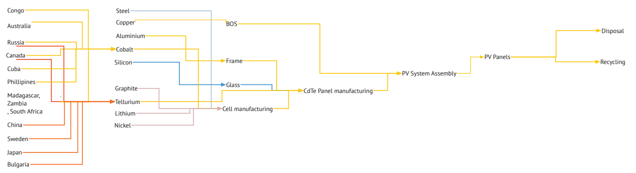


Figure 48.1, Material supply chain for PV panels (International Renewable Energy Agency, 2021)

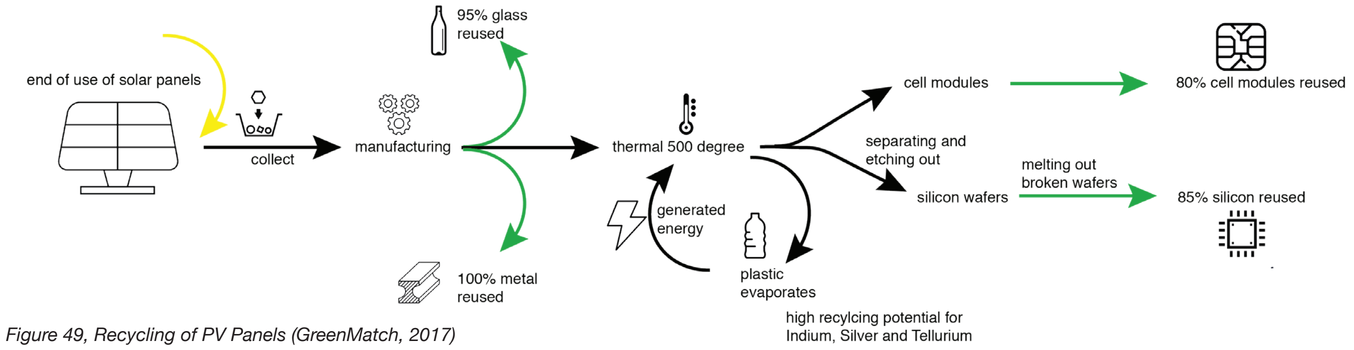


Figure 49, Recycling of PV Panels (GreenMatch, 2017)

This flow outlines the end-of-life cycle of wind turbine blades. Through the manufacturing process, epoxy resin and fibre fraction can be dismantled, and through chemcycling, a new process, and existing recycling processes, new epoxy resin and recycled fibres are generated (Durakovic, 2021).

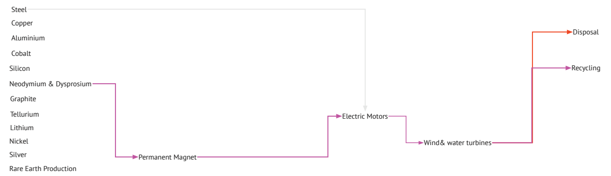


Figure 48.2, Material supply chain for wind turbines (International Renewable Energy Agency, 2021)

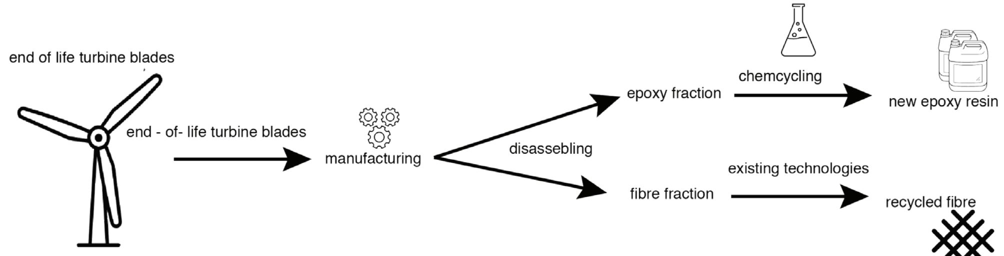


Figure 50, Recycling of Windtrubine blades (Durakovic, 2021)

The main renewable energy products are batteries, cables that require metal and plastic, wind turbines and some hydro turbines, as well as solar panels and pipes for the heat grid. Critical raw materials here are cobalt and lithium. The raw materials are used for the production of materials needed for the transition to renewable energies. Therefore, there is a high potential for recycling most of these materials (as shown in table 52).

	Li-ion	Li-S	EV	c-SI	CIGS	CdTe	PMG	Non-PMG
Aluminium	X	X		X	X	X	X	X
Cadmium						X		
Cobalt	X							
Copper	X	X		X	X	X	X	X
Dysprosium			X				X	
Gallium					X			
Indium					X			
Lithium	X	X						
Manganese	X							
Neodyinum			X				X	X
Nickel	X							
Silver				X				
Selenium					X			
Tellurium						X		

Figure 51, Potential re-use of materials (International Renewable Energy Agency, 2021)

	Current	Potential	Current	Potential	Current	Potential	Current	Potential
Aluminium	70%	95%	-	-	77%	81%	80%	95%
Cadmium	-	-	-	-	77%	81%	-	-
Cobalt	90%	95%	-	-	-	-	-	-
Copper	70%	95%	-	-	34%	81%	90%	95%
Dysprosium	-	-	0%	95%	-	-	0%	95%
Gallium	-	-	-	-	0%	81%	-	-
Indium	-	-	-	-	0%	81%	-	-
Lithium	0%	95%	-	-	-	-	-	-
Manganese	0%	95%	-	-	-	-	-	-
Neodynium	-	-	0%	95%	-	-	0%	95%
Nickel	90%	95%	-	-	-	-	-	-
Silver	-	-	-	-	0%	81%	-	-
Selenium	-	-	-	-	0%	81%	-	-
Tellurium	-	-	-	-	77%	81%	-	-

Figure 52, Material use in batteries, solar panels & wind turbines (International Renewable Energy Agency, 2021)

02.4 (Potential for) Renewable Energy

Renewable energies, which come from replenishable sources, are an appealing alternative to the energy from fossil fuels in the Province of South Holland, as its land has a natural potential to harness them across its fields, its sea, its cities and even its subsoil.

The North Sea holds potential not only for the emerging technologies that seek to harness tidal energy, but also to extend wind farms further into it. It is also key in the offshore production and electrolysis of hydrogen, sourced from sea water. Wind energy has its best potential to be harvested in the sea and then along the coastline, where wind reaches up to 65 km/h. Agricultural and grass land across the Province, where average wind speed still reaches 43 km/h, can also host wind turbines.

The yield of kilowatts per hour across the Province varies between 11 and 35 kWh (van Sark, 2016), but except for the area around the port, there are no clear differences that render some areas more or less fitting for photo-voltaic farms, than others. The roofs and walls of buildings have the greatest potential for placing new panels, as they require the least occupation of virgin land and they can feed energy directly to its consumers. Greenhouses can also display panels across their roofs, however this, as the extension of solar farms across agricultural land, must be a decision made by producers which would need to reduce agricultural production for energy production.

There are more surfaces facing the sun, than just fields and buildings. New technologies allow communities to harvest energy from photo-voltaic tiles, that have the potential to cover roads, streets and sidewalks. These can serve to power public infrastructure and public lighting.

One key setback to solar energy production is the decrease of solar hours during the winter months. Unless exceptional production and storage technologies enable producers to harvest enough solar energy for the entire year during the sunniest months, those who seek to rely mainly on solar energy will need to count on alternative sources.

Geothermal energy is a promising source for heat, that happens to be abundant in the region. Up to one GJ can be extracted per metre at some areas of the Province. It can heat houses and greenhouses, and it is a great alternative supply for the industry. There are already 17 active extraction points that provide 3 PJ to greenhouses, and the Province is said to be able to generate over half of the country's 230 PJ geothermal potential.

Biofuels are another growing sector of renewable sources in the Province, but they have the downside of the unavoidable release of carbon after their consumption. They remain a sustainable end for residue of forestall and agricultural practices and for handling the waste from livestock. Biogas, as well as geothermal energy, can both be transported through existing gas corridors.

The development of policy for individuals and independent corporations to acquire and display infrastructure for renewable energy production will allow these emerging stakeholders to generate alternative income within their land, offer new energy supply alternatives to their neighbors, power their own ventures, thus reducing the carbon footprints of the agricultural sector, and finally, they take pressure off the grid and heat supply networks.

Other sources, such as tidal energy and energy extracted from algae, can provide further forms of diversifying local energy production and its market.

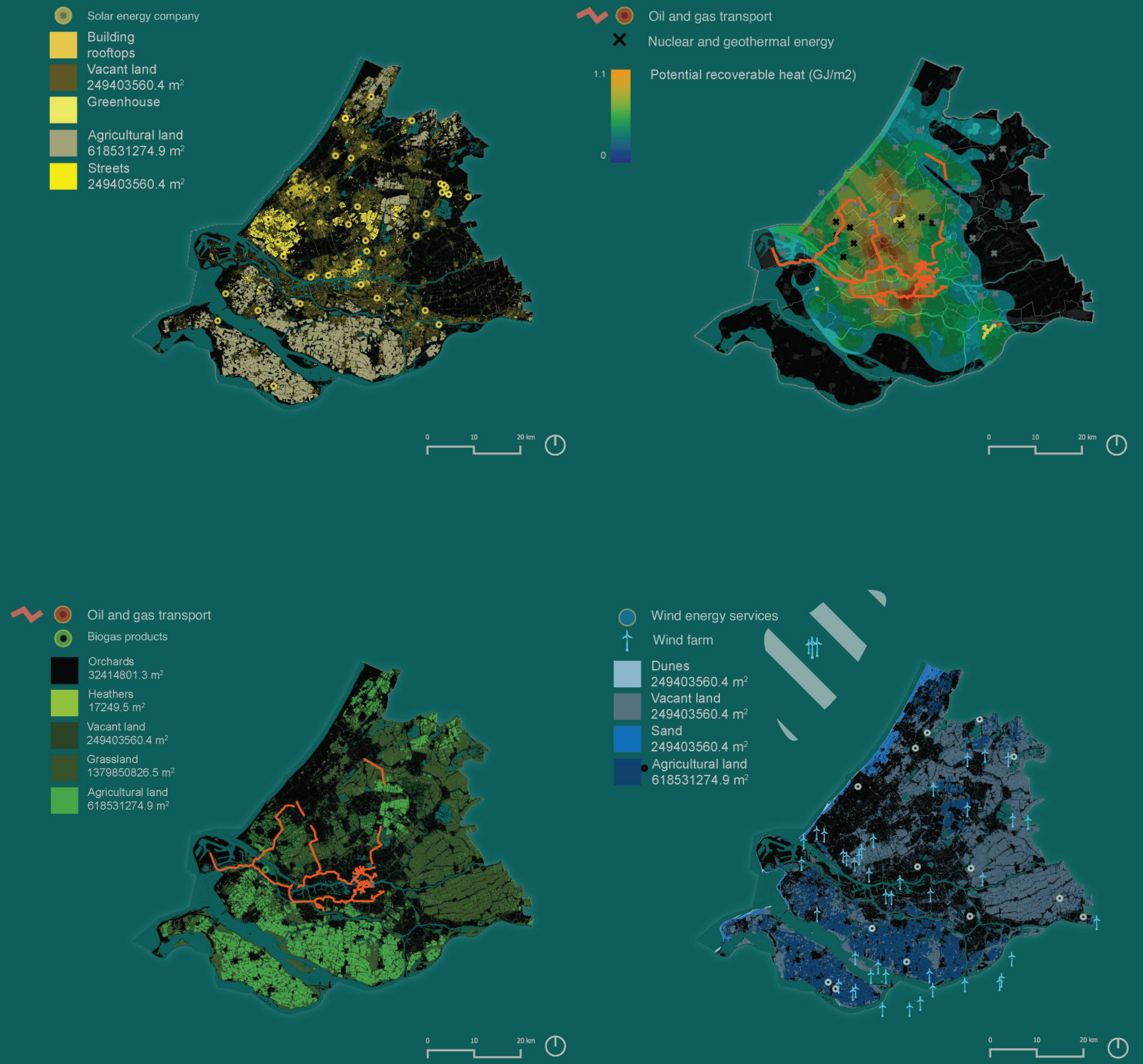


Figure 53: Potential of renewable energy across the land ((LISA, 2014), (Hein, 2018), (Basisregistratie Topografie, 2022))

There are diverse interests in the uses of the land, as well as its potential for renewable energies. There cannot be an unilateral decision to repurpose it for the generation of renewables and owners cannot be forced to do so themselves. Other limitations such as size, environmental restrictions and geographical limitations, narrow even further the possibilities of the land, for renewable exploitation. In the current map, the areas with the greatest potential to integrate at least one renewable energy system are shown.

Windmills are by far the most adaptable equipment, as they can be displayed across all land with limited obstruction. Photo-voltaic panels, aside from covering streets, can be surely displayed on buildings and on fields with limited potential for other uses.

Geothermal energy will require the display of wells over the land with the greatest potential for heat harvesting, and this practice is best kept away from buildings, due to the uncertainty of potential yet minor earthquakes.

Tidal energy, just as windfarms offshore, depends on the distribution of surface between these and other uses, but the development of the technologies to collect it will define the role it plays in the transition before 2050.

Biofuels are expected to increase production in the following decades, but this will happen mainly because the collection of organic waste will be more efficient, as there is limited interest in intensifying agricultural production exclusively for plant based fuels.

The greatest potential to secure the energy transition and the role of individual consumers and landowners in energy generation, remains in their interest to become producers and to learn the benefits of installing their own panels and mills. Areas like the ‘Groene Hart’ might only be suitable for wind mills, to preserve their agricultural value, but agricultors can still become independent from the energy grid if they choose to install their own wind mills or solar panels on the surface of their houses.

The areas of the Province with the greatest potential to generate two or more of these renewable energies have been marked as “Energy Parks”.

Figure 54: Combined potential of renewable energy across the land ((LISA, 2014), (Hein, 2018), (Basisregistratie Topografie, 2022))

02.5 The Involved Stakeholders

Taking a closer look at the key stakeholders playing a role in the energy transition in the Province of South Holland, striving to be generating renewable energy locally as much as possible, the main actors can be divided in three sectors.

The public sector

The public sector are governmental and national institutions, being responsible for providing a just base for regulations, subsidies and laws. Engaging an active and strong civil society that is included in the development of the projects to provide a sustainable and just transition. The public sector currently holds a lot of 'power' as seen in figure 56.

The private sector

One of the most important factors for the growth of the Port of Rotterdam was the petroleum industry - the private sector, including all the major petroleum companies, is one of the main players in our energy transition. Social housing associations and construction companies are also key to a just energy transition and to fighting energy poverty.

Public transport services like NS ('Nederlandse Spoorwegen') are organised under the Dutch Act and the Dutch government is the only shareholder of this company. Nevertheless, it is a company of the capitalist economy, striving for profit and dependent on consumers. The research sector has a lopsided role as it profits from research, but it is needed to deliver technical innovation, but this should be supported by the government to create better integration and opportunities to involve civil society in energy transit.

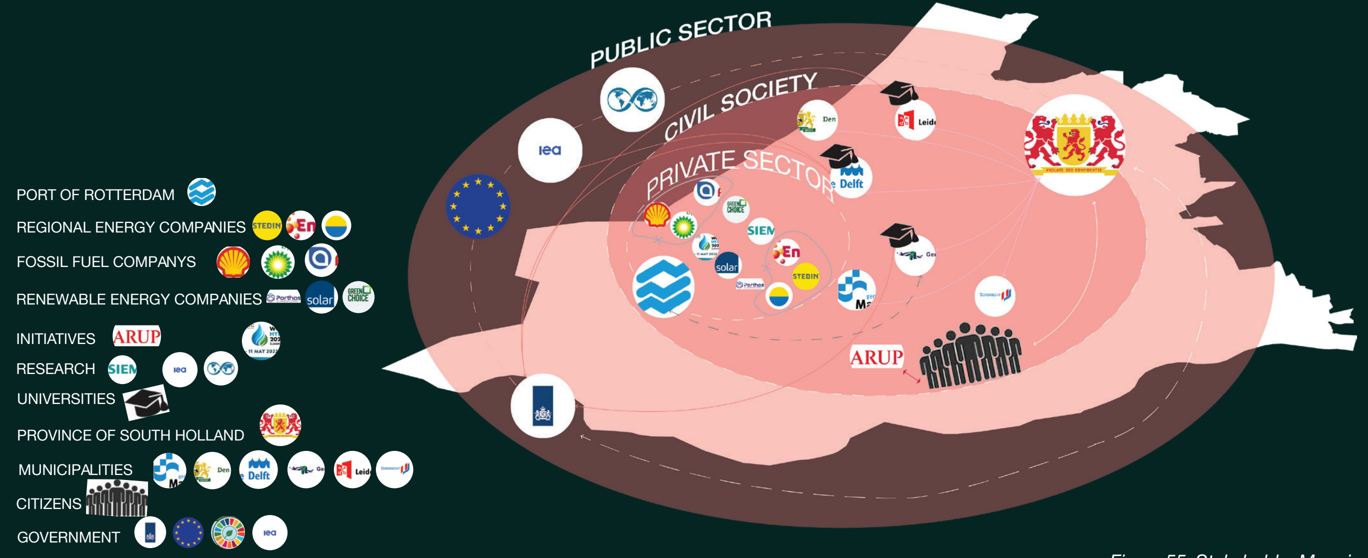


Figure 55: Stakeholder Mapping

Civil society

Civil society is the part of the stakeholders that has the greatest interest in the energy transition, but also the one that has the least power. However, for workers in the fossil fuel industry, in the manufacturing industry, in the automotive industry and for workers in the port as a whole, their work will change with the energy transition. It will be important to create co-operatives and involve civil society in such a way that they can be an active part of the transition. Educational institutions play an important role in this. An educated society is the basis for a thriving society that is integrated and part of the change so that the transition is sustainable. Future generations are the most important stakeholder for whom this energy transition is being planned, and how today's civil society with its ethical values can bring about change so that future generations can have a good life in the future.

Power-Intrest Matrix

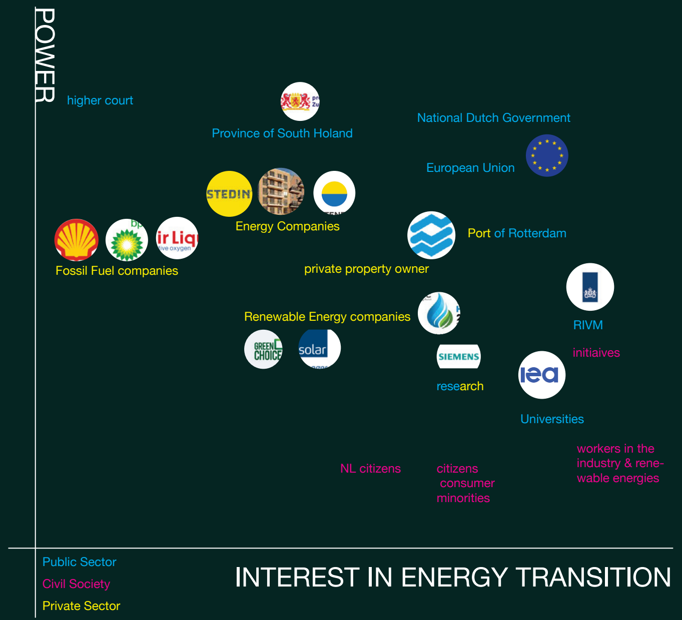


Figure 56: Power-Interest-Matrix

Multilevel Governance

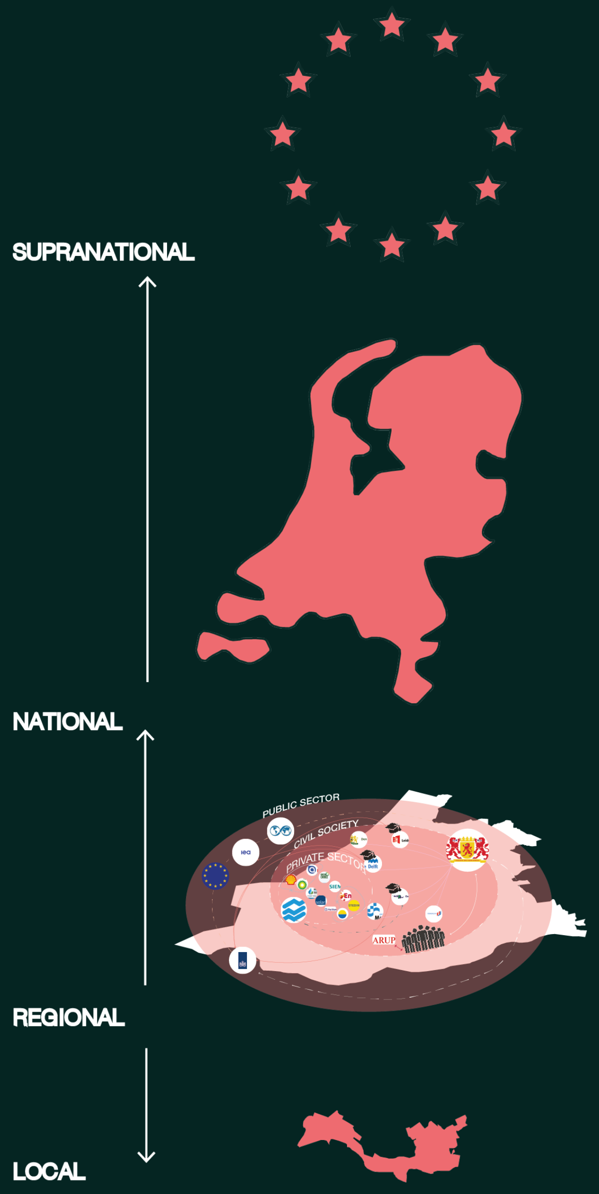


Figure 57: Multilevel Governance

02.6 Making Use of the Strengths and Weaknesses

In the process of analysing the province, a SWOT analysis has been done. During this analysis the Strengths, Weaknesses, Opportunities, and Threats are identified. These are then combined to define potential interventions.

02.5.1 Strengths & Opportunities

Using empty oil scape for renewable energy storage

Once the fossil fuel industry is phased out in the future, these areas (in the port) will become vacant. These can be repurposed, for example for the generation and storage of renewable energy.

Providing a heat hub for other building functions

The industry (in the port) has a lot of residual heat which isn't useful for them. At the same time, the greenhouses in the 'Westland' need a lot of heat. These two can be synergised and more efficient in the future. If the greenhouses have excess heat this can be transported to the housing in the cities.

Role model as renewable energy port

At this moment, the Port of Rotterdam, is one of the main global ports. When transitioning to renewable energy, it is crucial for the port's economy, to preserve its relevance, this can be achieved by the transformation of the Port of Rotterdam into an example for the rest of the world.

Synergising functions according to available energy

To accomplish an efficient energy transition, the energy demand of the province needs to go down. This can be done by synergising functions and sharing the heat and electricity between different building functions. For example, a store needs electricity from 9.00 to 17.00 while housing needs electricity from 17.00 to 9.00.

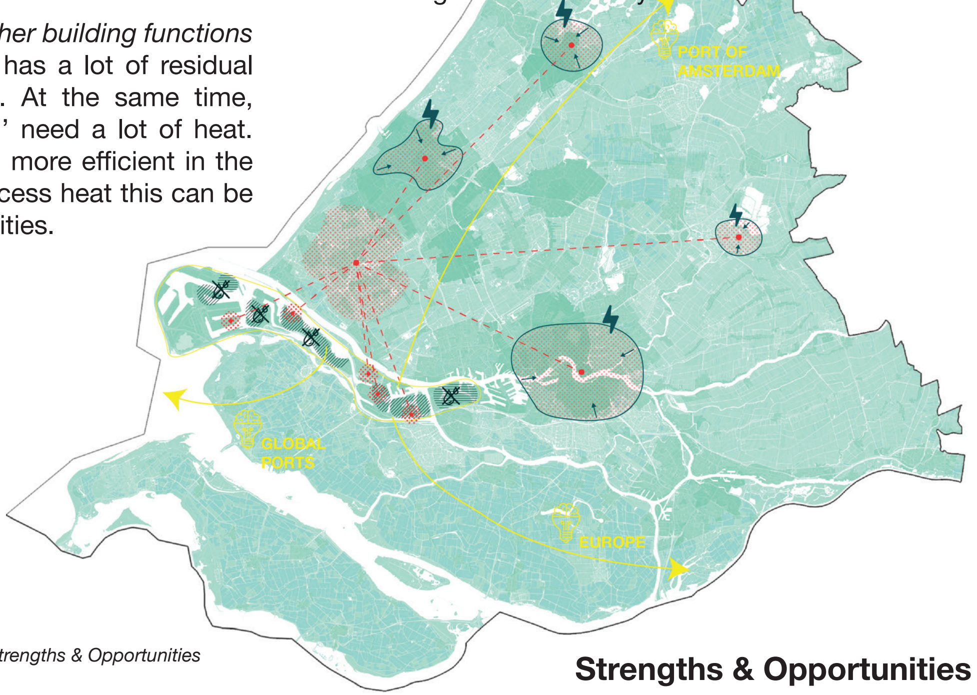


Figure 58: SWOT - Strengths & Opportunities

Strengths & Opportunities

02.5.2 Strengths & Threats

Stimulating (big) companies to clean their image

(Big) companies use a large proportion of the generated energy. At the same time, they often want to have the biggest profit margin. They use a lot of fossil fuel and don't usually pay for the effect it has on Crisis. If companies change their image and do their share, the consumption of energy can go down and it can be generated more sustainable. Since the grid and the infrastructure that transports the energy of the province is already managed by these companies, there is also a window of opportunity for them, in transitioning along with their infrastructure, towards a renewable-based industry and economy.

Finding alternative energy to replace fossil fuels and decrease the reliance on other countries

Besides the generation of renewable energy through solar and wind, innovations in new alternative sources of energy, such as tidal or algae, help to tackle this challenge even faster. The province hosts industries and universities that are already invested in the research of these technologies that can bring production home, not only to reduce our reliance on other countries, but to keep the province as a global leader in the sector.

Generating energy locally and independently

A great part of the Province of South-Holland is urbanized. This urban area can be used efficiently to generate local, renewable energy. This can be done by putting solar panels on roofs and facades or adding small wind turbines on roofs. The heat from some infrastructures, such as data centres and factories, can also be reused locally through cascading.

In recent years, farmers and agricultors have found an alternative source of income in the display of wind farms or photo-voltaic farms across their fields, as well as collection of organic material for biofuel. This not only reduces dependence on fossil fuels but also diversifies the market and brings consumers closer to the production of their own energy.

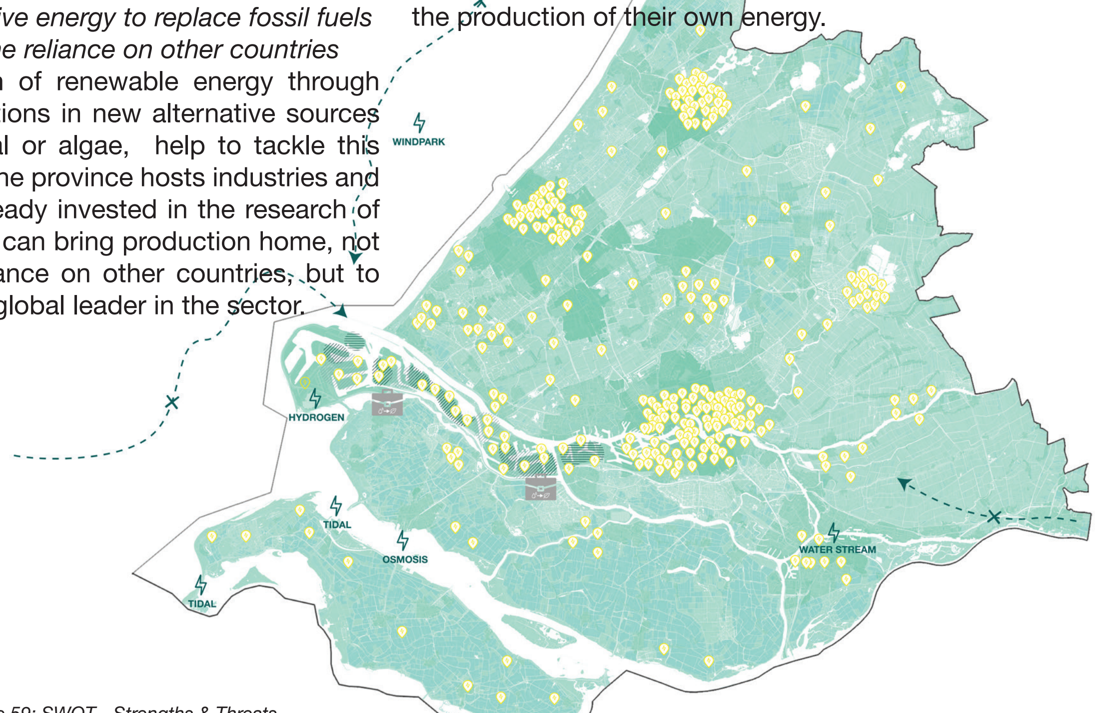


Figure 59: SWOT - Strengths & Threats

Strengths & Threats

02.5.3 Weaknesses & Opportunities

Reducing job loss through training employees in the oil- to the renewable energy sector
To prevent people losing their jobs because of the phasing out of fossil fuel companies, they need to be re-educated to fulfill the newly available jobs. Educational institutes can take a big part in this.

Making logistics more (energy) efficient through digitalisation
If all logistics systems are digitized, they can better interact with each other. As a result, as little time and energy as possible is lost.

Creating a healthier environment by lowering the oil production and CO_2 emission
At the moment the industry in the port is a great emitter of gases such as: NOx, SO2, CO_2, because of the use of natural gas and coal. In the future, industries will phase out the use of fossil fuels. This means that the neighbourhoods around the port can breathe in healthier air.

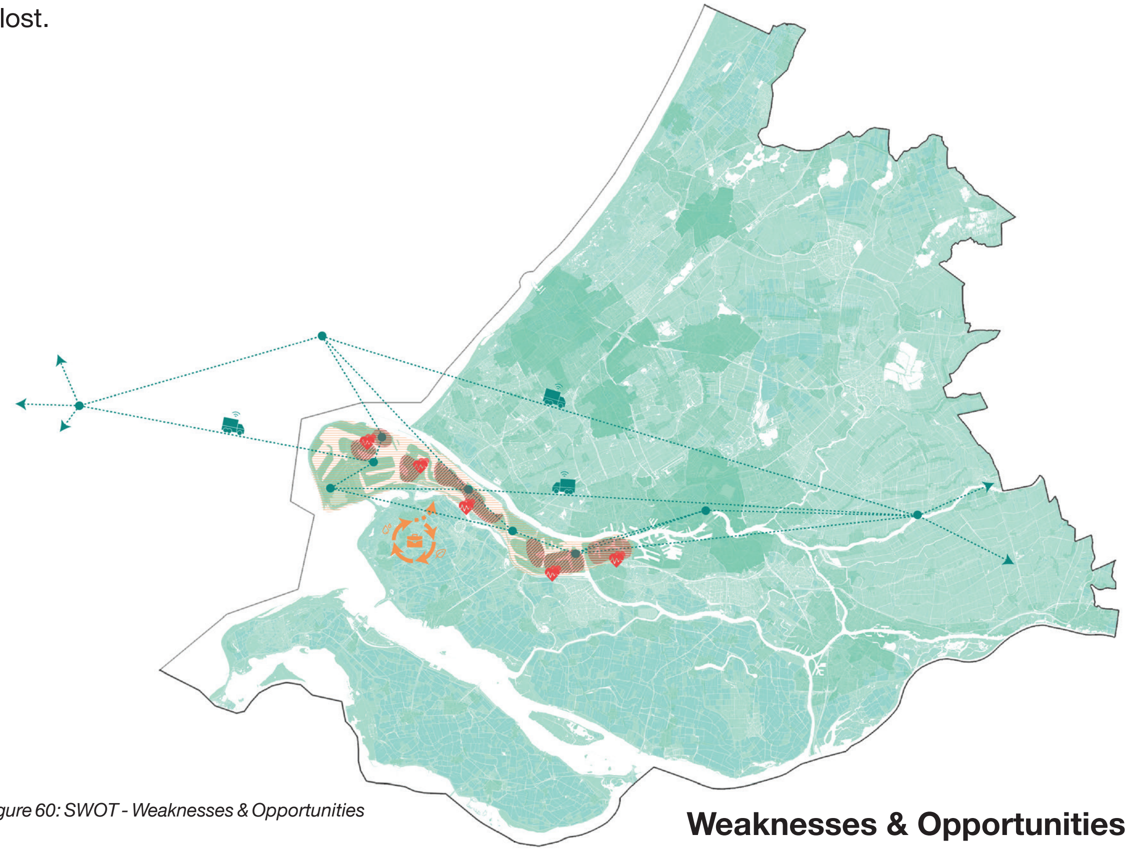


Figure 60: SWOT - Weaknesses & Opportunities

Weaknesses & Opportunities

02.5.4 Weaknesses & Threats

Making the port resilient for Climate Crisis
Sea level rise and rising temperatures due to the Climate Crisis, will make the coast, the port and the cities vulnerable to floods and heatwaves. Any plans for future successful settlements in the province will need them to be resilient to these rising threats, as well as to other unforeseen consequences.

Stimulating companies to do their share through policy & tax advantages
Because companies are often only focused on profit, there is little incentive to invest in sustainable ways of producing energy. Policy and tax advantages can help to stimulate them to do so.

Educating society to reduce energy demand and emissions
To reach a renewable energy system in the Province of South-Holland, every person needs to do their part. This means that people need to be aware of the importance of the energy transition and what they can do themselves to reduce their energy demand.

Reducing energy poverty through more diverse energy providers and subsidies
Currently there are not many energy providers where you can choose from. This means that these companies don't have much competition, and don't need to lower their prices.

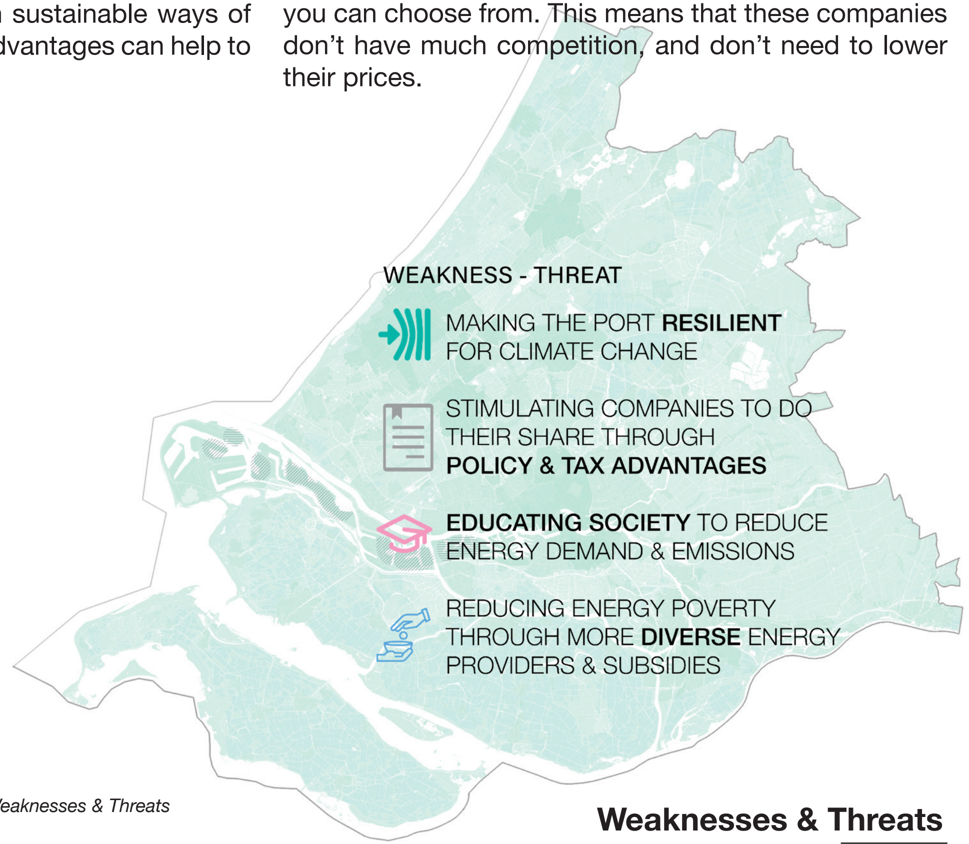


Figure 61: SWOT - Weaknesses & Threats

Weaknesses & Threats

02.6 What Can We Learn From This?

Fossil fuels are found in the small actions of everyday life, for example, using gas for heating and cooking. Alternatively, commuting to work, taking the train, or even flying on holiday, the plane, all means of transport are fueled by oil. The daily street scene and the definition of the street are also controlled by fossil fuel-powered cars. In a larger picture, it is evident that the entire infrastructure has been developed according to the space required for fossil fuels.

Based on the analysis mentioned above, the current situation relies on fossil fuels so much that it influences daily life people might not even notice. However, the current distribution of resources is seriously unequal. While most planning discusses maintaining a stable and sustainable economy in the energy transition, more unnoticed fundamental structural issues need to be addressed urgently. The current way people perceive space and the everyday actions people take for granted need to change to achieve a just energy transition for a sustainable environment for future generations.

Finally, the following chapters will explain how this project vision the future and how all these changes can achieve a province of South Holland without fossil fuels by 2050.

This part concludes with the problematic issues that need to address but also addresses the unseen potential that can be redesigned:

How can different potentials be reused strategically and spatially?

How can fundamental issues be redefined and redeveloped by policy-making?

How can energy production and conservation currently existed be reorganised?

How can society be reeducated?

How can the linear market be redefined and recreated with circular flows?

How can the multi-layer governance be re-collaborated?

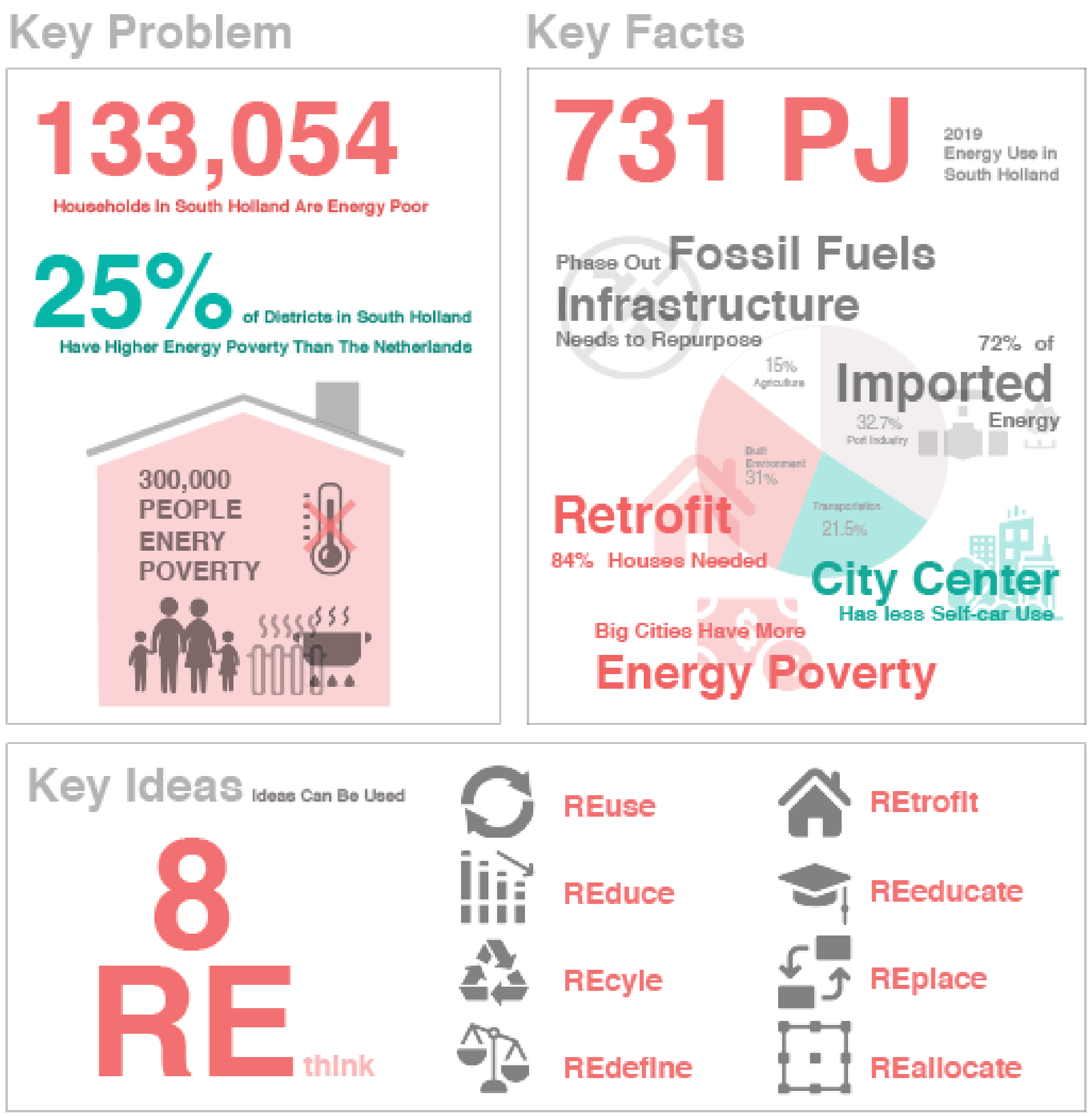


Figure 62: Conclusion Diagram for Analysis

WE NEED A SYSTEMIC CHANGE

Figure 63: (RPPC Port Call, 2021)

03. A Fair, Renewable Transition

03. A Fair, Renewable Transition

03.1 A Syn-Energisied South Holland 2050

In 2050, the Province of South-Holland will be powered by 100% renewable energy, that will be local, accessible and affordable.
Society will become a major stakeholder as the synergy of functions and the intervention of the built environment reduce energy poverty and energy consumption.
The expansion of renewable energy infrastructure through the existing oilscape will transform the region's economy and identity.

Figure 64: Vision Map

03.2 Hierarchic Explaination of the Vision

As previously stated, in the ‘conceptual framework’ part, the vision is built up from three dimensions:
- the economic,
- social,
- and spatial.

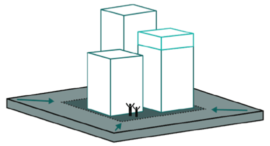
Three values were set up:
- educate society in terms of the energy transition,
- reorganise in an efficient clustered manner,
- and policies for a feasible transition for everyone.

These were used to navigate through the three layers:
- just,
- sustainability,
- and digitalisation.

This eventually led to the goals which the vision and strategy need to include.

In chapter 04, ‘Strategy for a Systemic Change’, this scheme will be further extented with main aims, interventions, and outcomes.

educate society in terms of the energy transition



reorganise in an efficient clustered manner

policies for a feasible transition for everyone

Figure 65, 66, 67: Diagrams Values

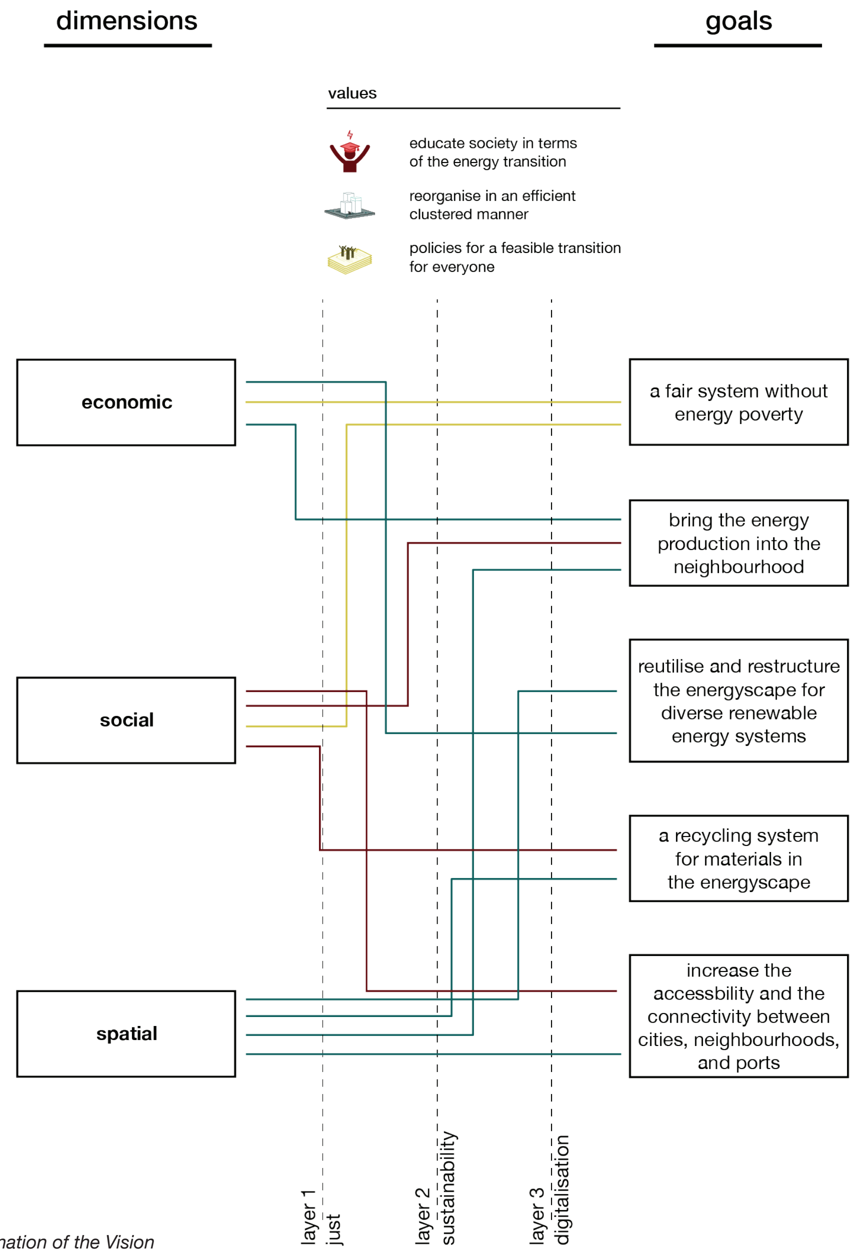


Figure 68: Hierarchic Explanation of the Vision

03.3 Synergy Sections

To illustrate the synergy and complexity of the systems that are part of our vision, these sections explain the flows of visionary South Holland.

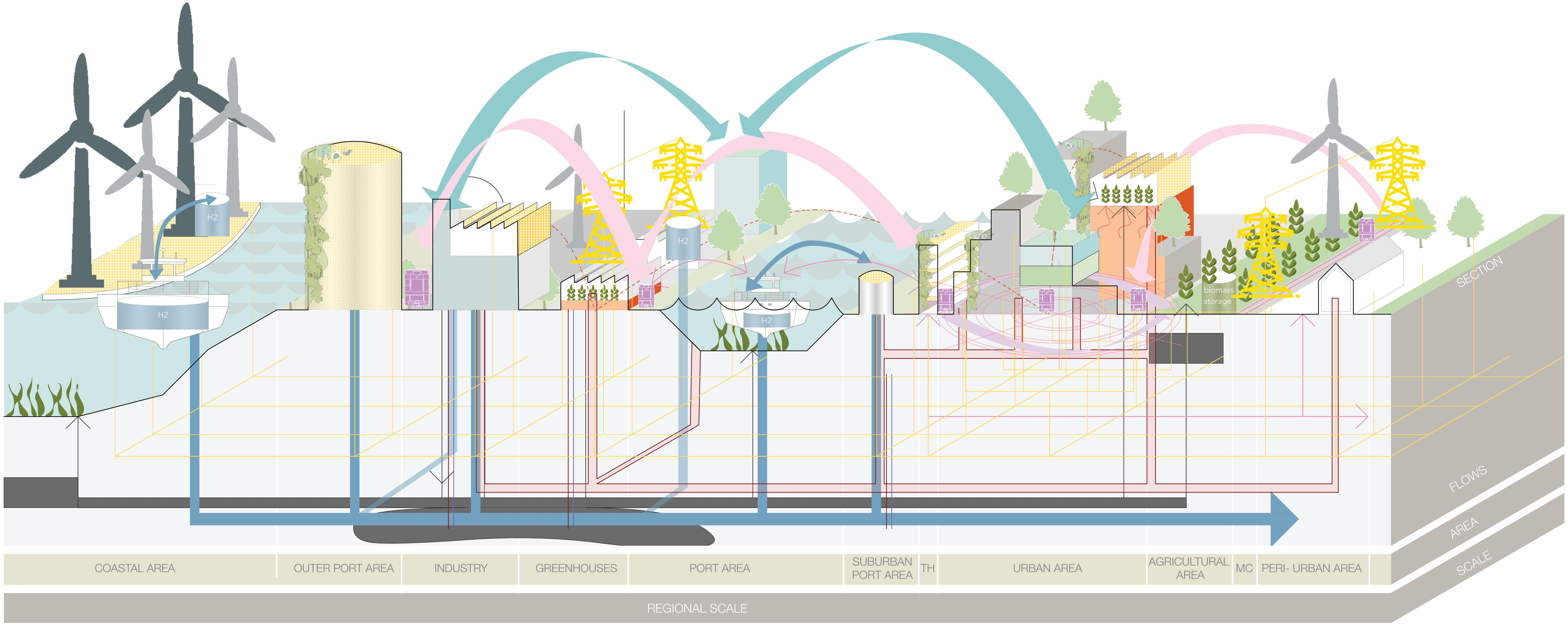


Figure 69: Combined section of all synergies

MC : MOBILITY CORRIDOR

TH: TRANSPORTATION HUB

Heat Flow

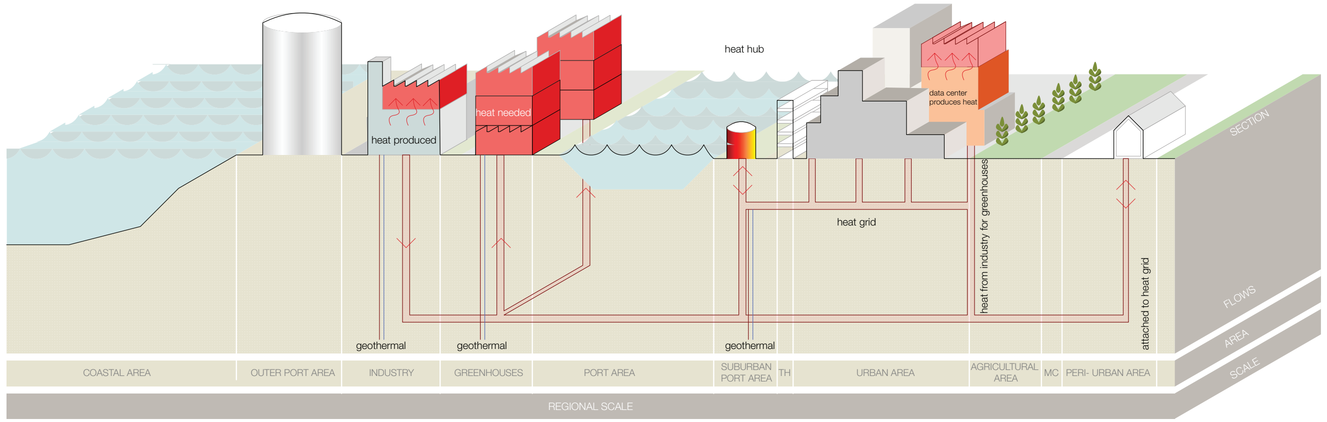


Figure 70: Heat Flow Section

MC : MOBILITY CORRIDOR
TH: TRANSPORTATION HUB

Electricity Flow

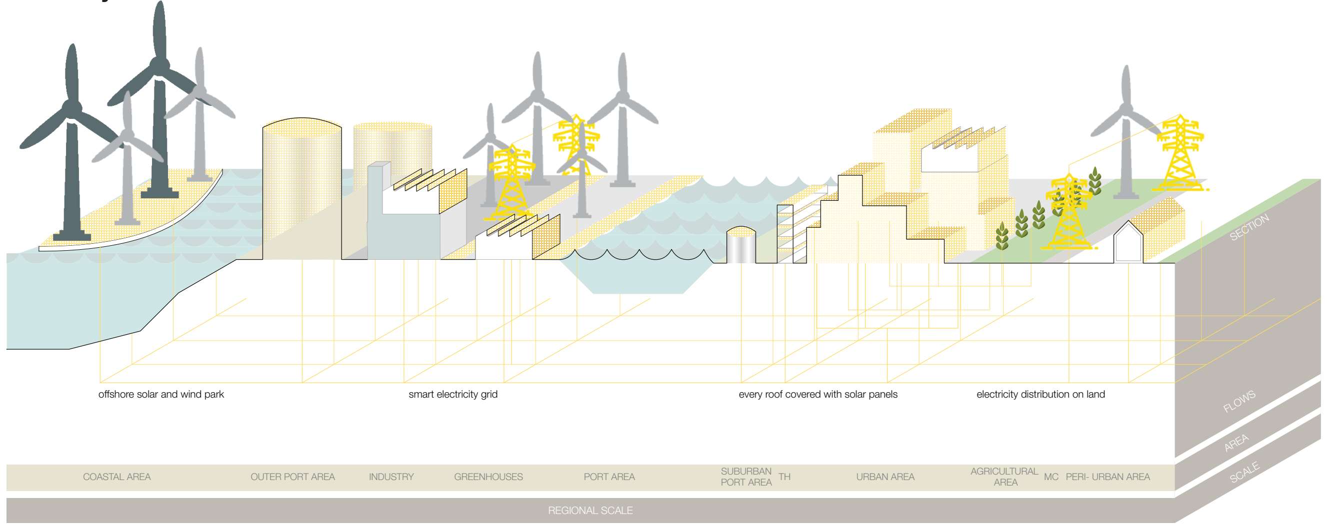
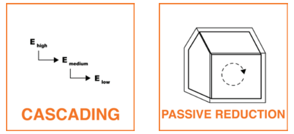


Figure 71: Electricity Flow Section

MC : MOBILITY CORRIDOR
TH: TRANSPORTATION HUB



Heat is another energy source, and industry produces a lot of heat but also needs a lot of electricity. Urban areas can use this extended heat (a low energy form) and take advantage of the cascade principle. There is already a heat network between the city and industry, but this network needs to be expanded intelligently and efficiently and will then form a large part of the equitable distribution of heat. A heat centre in the harbour suburb, balancing and storing heat and using the high geothermal potential in South Holland, can enable a balanced distribution through vertical synergy effects that can cascade the use of heat and enable a smarter heat distribution. For example, a greenhouse can be built over an industrial building, a swimming pool that needs to be heated can be built over a data centre, or a residential building can be built over an office building, as the time of energy use is balanced.
Synergy of heat and power generation and demand through grid expansion and distribution.

Solar and wind generation is a major opportunity to generate 100% renewable electricity for South Holland. Potential offshore wind and solar farms and rooftops in urban and industrial areas can support these renewable energy sources. Roads also play an important role in electricity generation when solar paved or with a second layer of solar panels over the paved surface. All these generators are connected through a smart grid that ensures an even distribution between generation and demand of these renewable energy sources.

Hydrogen Flow

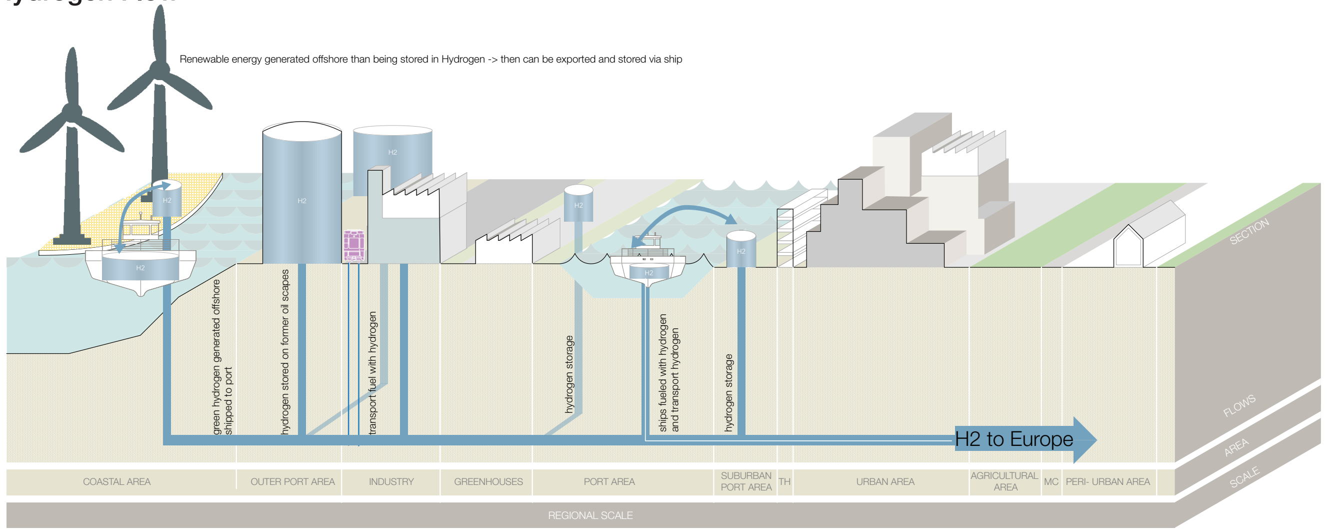


Figure 72: Hydrogen Flow Section

MC : MOBILITY CORRIDOR
TH: TRANSPORTATION HUB

CO_2 Flow

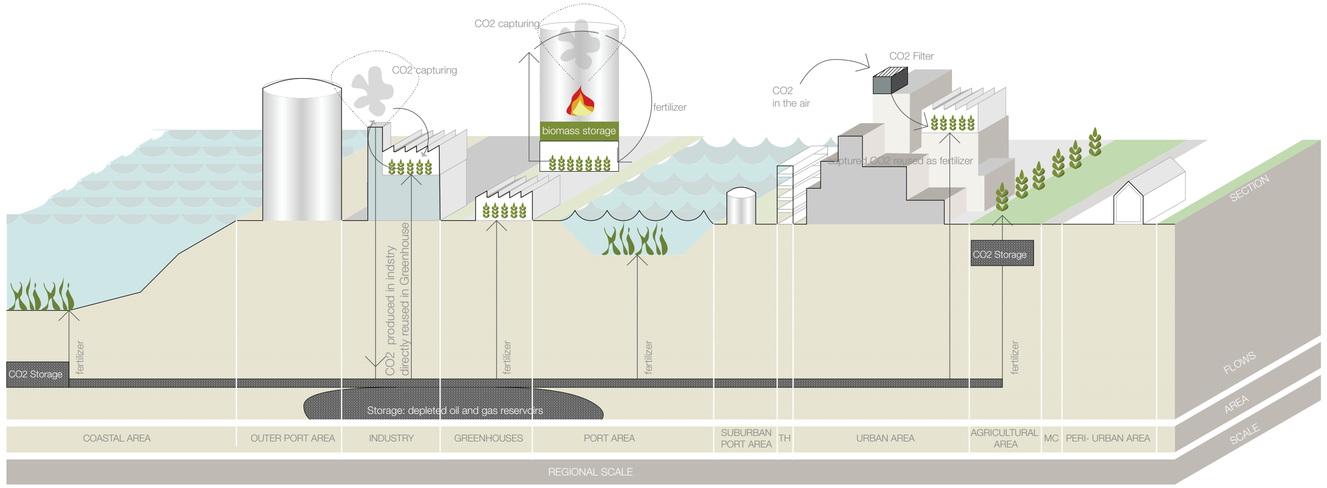
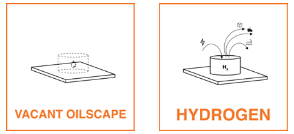
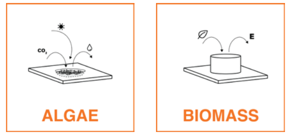


Figure 73: CO_2 Flow Section

MC : MOBILITY CORRIDOR
TH: TRANSPORTATION HUB



The Port of Rotterdam has set itself the goal of becoming “The Hydrogen Port”. Hydrogen holds great potential for storing and transporting energy. The empty fossil fuel pipelines in the port, but also the gas pipelines that have yet to be laid, can be repurposed for hydrogen use. The infrastructure on the water will then also rely on hydrogen, and the Port of Rotterdam will be a leading role model for managing Europe’s largest port powered by hydrogen. And to export hydrogen to Europe and even the whole world, as the port and its infrastructure are perfectly suited for the distribution of hydrogen.



Consider CO_2 as a gas that damages the environment when it is in the atmosphere, but also as a potential when it can be captured before it leaves the system. CO_2 can be reused to fertilise agricultural products in South Holland. In this way, carbon can be seen as a product that serves a positive purpose and is part of a cycle, rather than just waste that is stored underneath the sea. Capturing CO_2 is currently very energy intensive, but if there is a way to generate this energy in a renewable way, it would be a green turnaround.

Transportation Flow

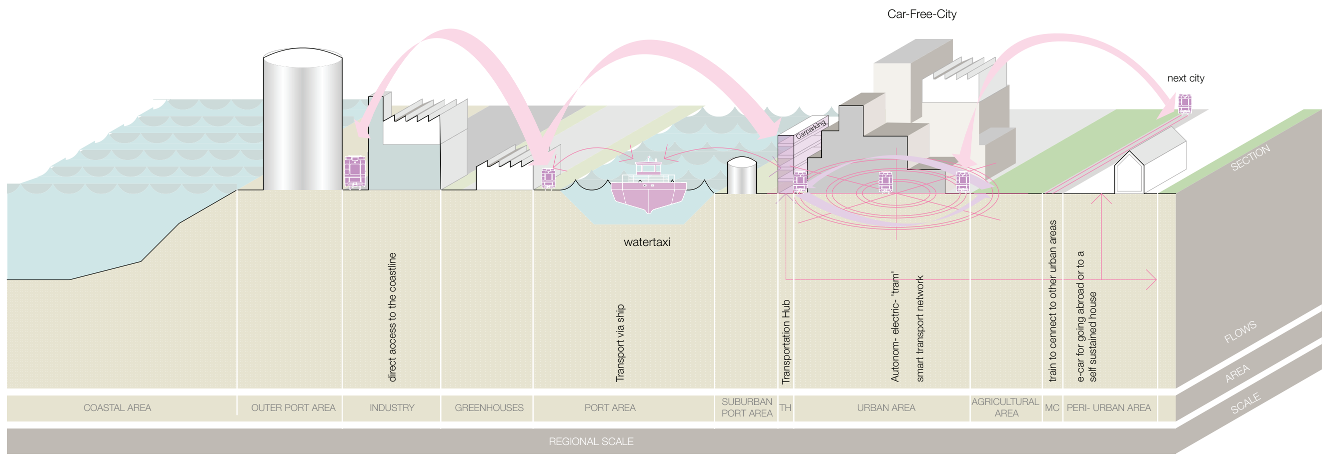


Figure 74: Transportation Synergy Section

MC : MOBILITY CORRIDOR
TH: TRANSPORTATION HUB

Data Flow

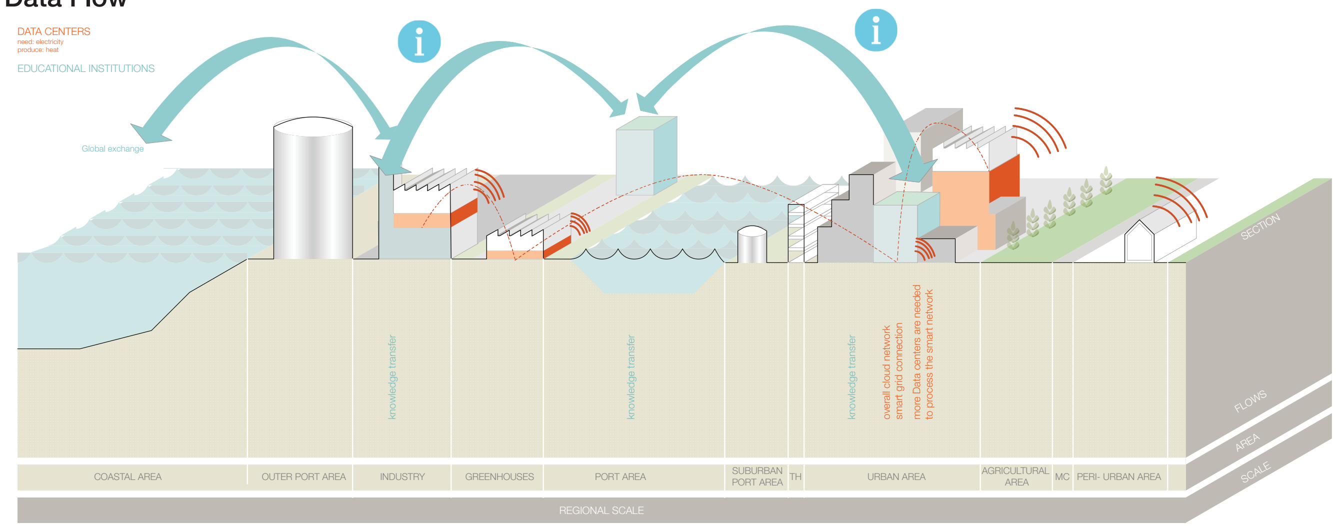


Figure 75: Data Flow Section

MC : MOBILITY CORRIDOR
TH: TRANSPORTATION HUB

In 2050, there will be car-free city centres. Inner-city streets and car parks will be opened up to green the built environment, improve passive energy systems and counteract urban heat islands. Cycling and walking will become more attractive, and an autonomous, electric-powered community tram can pick up residents in front of their homes when there is a longer distance to cover or it is physically easier for some people, such as the elderly. Parking towers with shared mobility hubs are located in the outer districts and offer the possibility to get into the city by alternative means of transport. Everything is well connected as public transport systems are improved and traffic is regulated and controlled by a smart grid. This way, everything is optimised and energy and time wasted in transit is minimised.

Smart data, knowledge and research exchange is one of the main goals, which will be the basis for accessible, equal and efficient energy production, but especially for energy distribution. It is expected that technologies will improve and energy production will become more efficient. This means that a global exchange of knowledge is needed to make this energy transition possible.

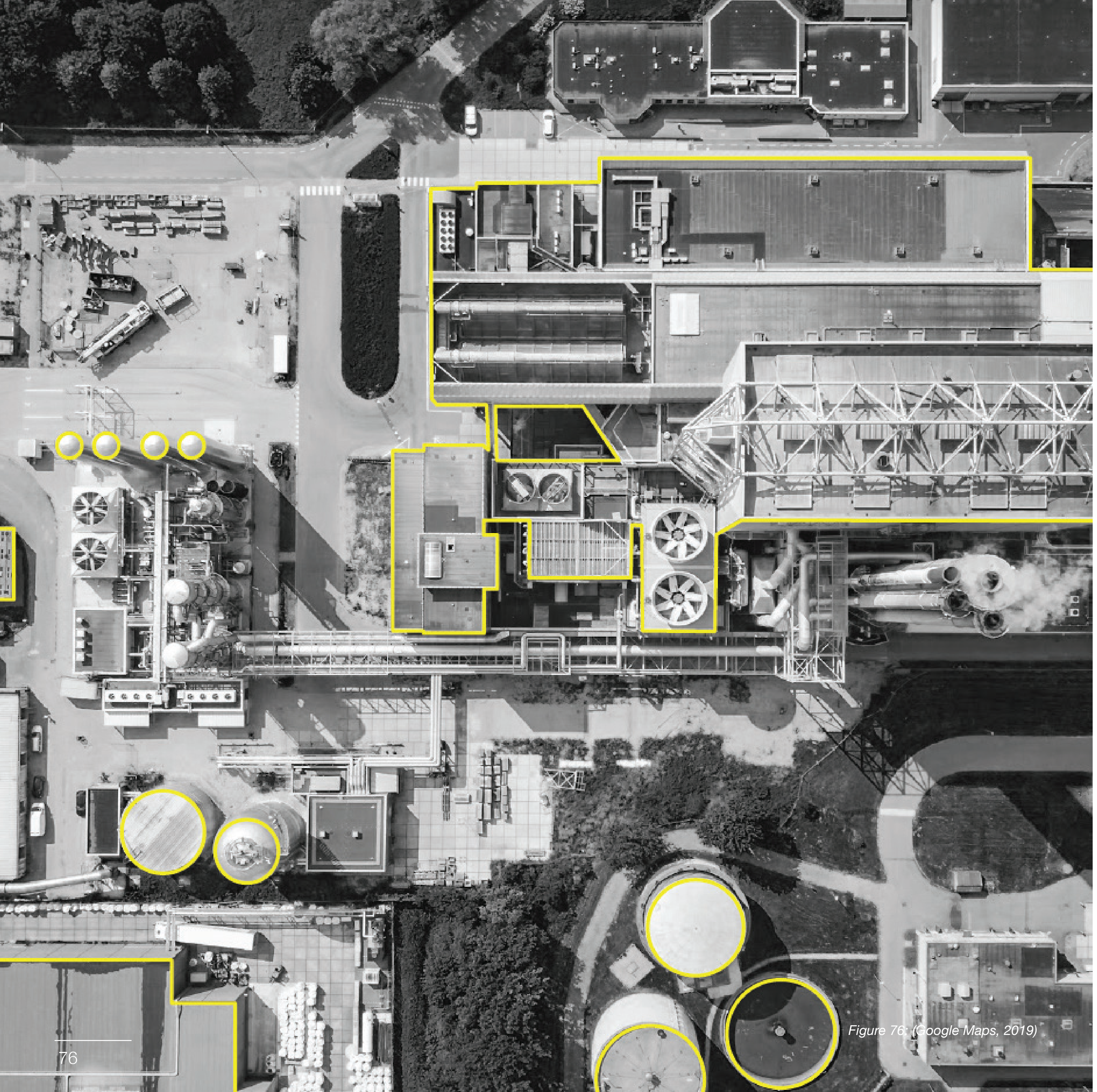


Figure 76: (Google Maps, 2019)

04. Strategy for a Systemic Change

04. Strategy For A Systemic Change

04.1 Hierarchic Explanation of the Strategy

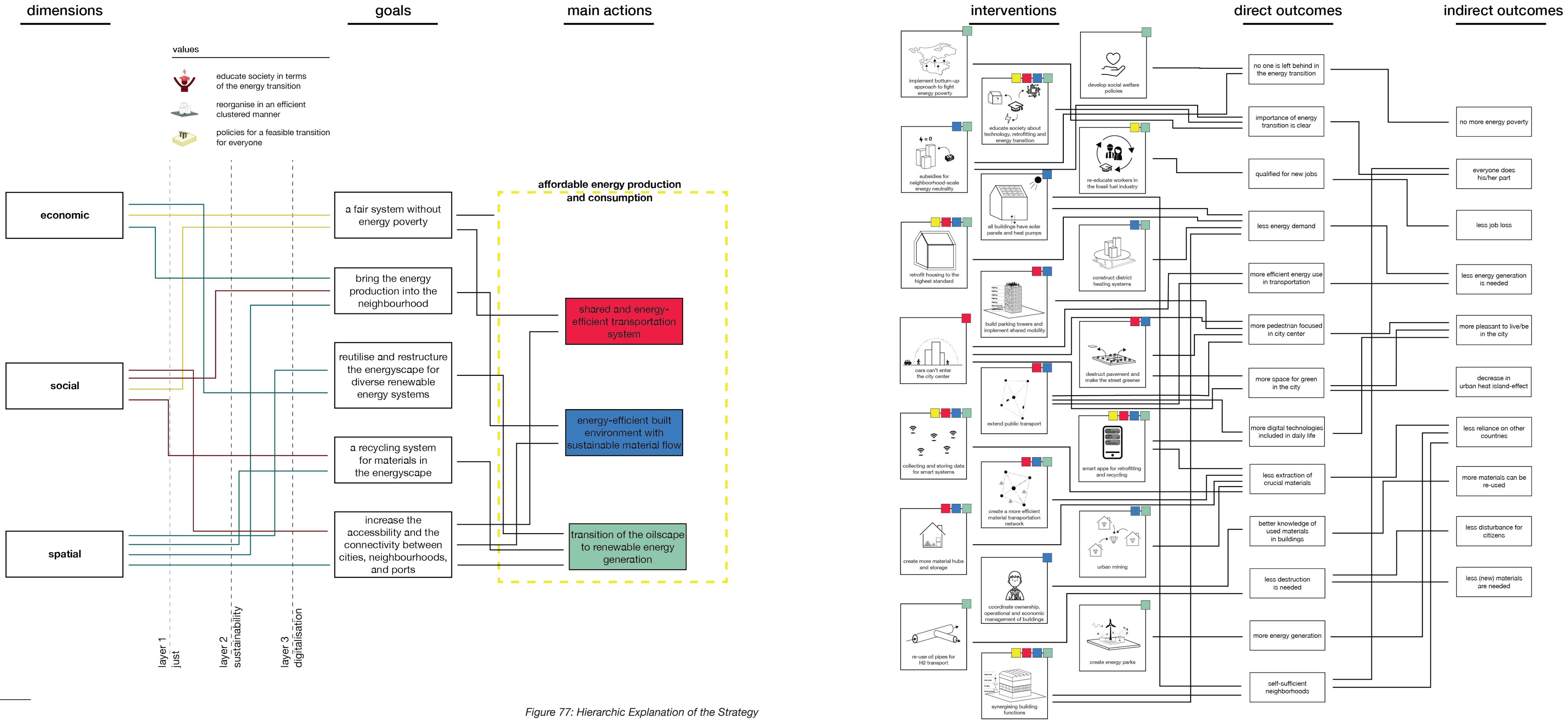


Figure 77: Hierarchic Explanation of the Strategy

04.2 The Toolbox

This is the toolbox which is used to accomplish the strategy. How the toolbox is implemented, can be seen more detailed when the pilot projects will be explained.

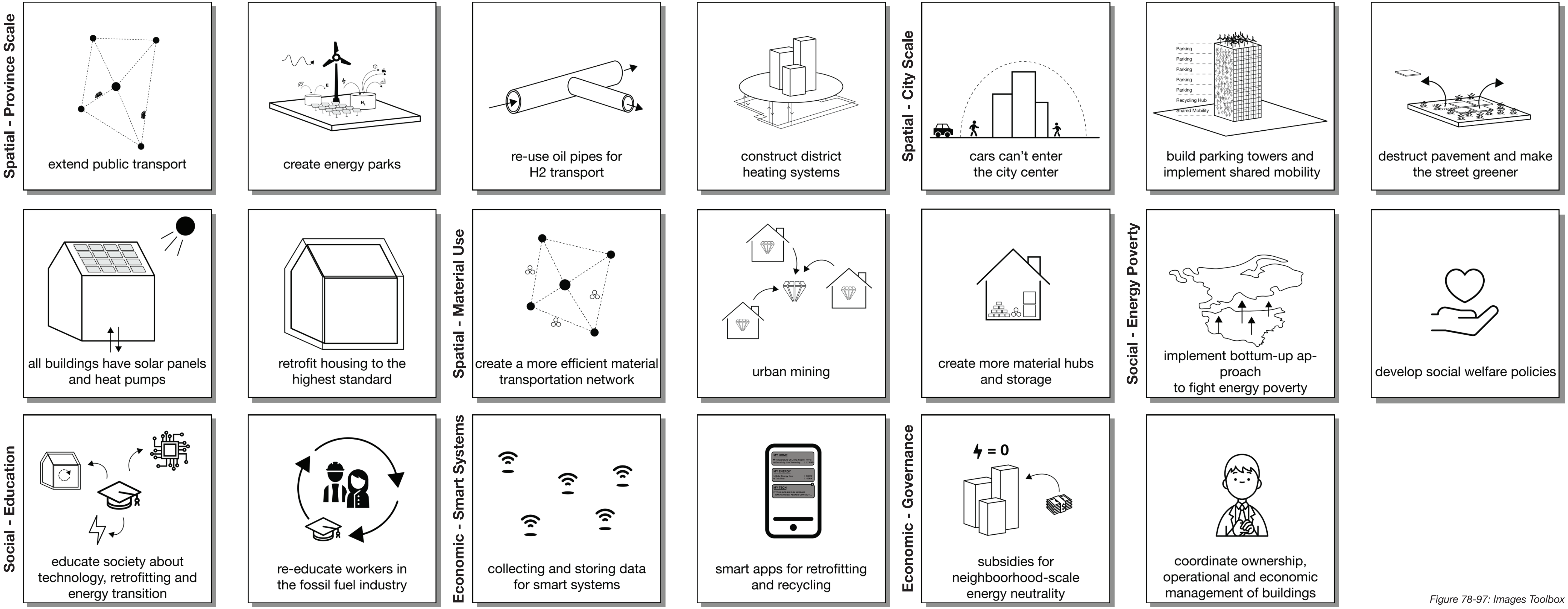


Figure 78-97: Images Toolbox

04.3 Synergising Stakeholders

In order to bring about a systematic change in the Province of South Holland, all stakeholders need to interact and participate in the energy transition. First of all, it must be acknowledged that the energy transition involves many more actors internationally and relies on technological developments. For example, the European Union is an important player in this field with the Green Deal.

However, it is also a crucial point where local, provincial actors need to take a bigger role in the transition. As Roberto Rocco states in his text “It’s a deal”, the Netherlands relies too much on technological change to drive the transition (Rocco, 2022).

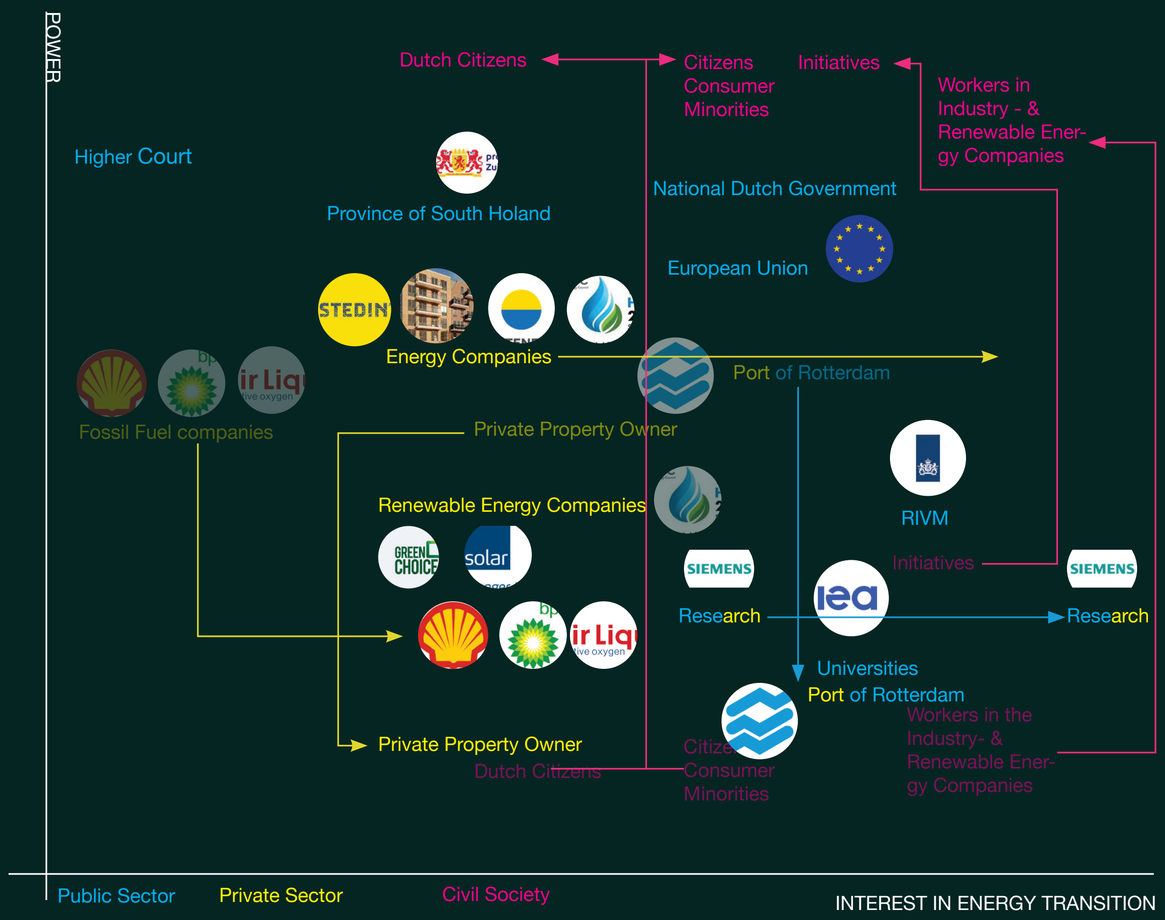


Figure 98: Changed Power-Interest Scheme

However, to achieve a just energy transition, citizens must be empowered and there must be interaction with civil society. Communicative planners and process planners will be needed in the public sector by 2050. These public sector planners then integrate all relevant actors to establish a democratic process to achieve common planning outcomes (Rocco, 2022). This management will involve civil society in planning. However, the public sector needs to engage and recognise that this change and shift in power relations can only be beneficial for sustainable long-term planning, as only change will be accepted by society and not contested. The research sector can make an important contribution to realising this goal and linking the public sector with civil society, as technology and intelligent systems can help the public sector - not just the private sector - to understand the needs and aspirations of society and shape the transition accordingly.

Participatory planning and processes are key to an equitable energy transition. Encouraging society to engage and participate is a prerequisite for a fruitful process and a sustainable end result of the energy transition. A good communication basis and a platform for exchange between the public sector and civil society are crucial for this development. Digital platforms, public engagement and education for the future generation in the form of engaged participation and overall good knowledge for productive exchange in provincial decision-making are the first steps towards citizen integration. However, the public sector, together with the research and education sectors, should provide an exchange platform for communication to enable equitable exchange at eye level.

The Port of Rotterdam and the transport systems (such as NS) and also the energy suppliers (like Tennet) are important actors, as these companies are state-owned but still make profits and rely on the consumer. A lot can be changed in the transport sector and in the hard infrastructure for energy supply to achieve the strategic approaches and major systematic changes that need to be made in a short time.

Education and knowledge are a crucial point for how active and effective the ‘voice’ of civil society is. The Netherlands has an active and strong civil society. Society challenges the ideas of the government, this is a good thing because it keeps the government alert and focused in this way. This is an excellent basis for shifting the power-interest matrix with regard to the energy transition.

For the development of networked governance, it is crucial to overcome the difficulty of integrating all stakeholders to the same extent. It is likely that some stakeholders feel it is unfair that the others get their way and they do not.

An active civil society already shows that the structure of planning offers the possibility to take into account the different needs and concerns of most minorities in society, and that an equitable decision-making process follows from this. More and better alternatives and solutions to conflicts. And planners only learn that there is a conflict in the first place when civil society is active. Therefore, civil society must be involved in planning.
Moreover, an active civil society supports a fair and equitable political structure in the planning and design process and maintains the basic structure of a democracy. An active and aware society is able to voice its concerns and its opinion is heard.

Stakeholder Synergy

The stakeholders are divided into four sectors: public, private and civil, plus the educational institutions that play a crucial role in the management of the energy transition. In figure 99, the current and potential synergies between the stakeholders are outlined, according to our strategy.

Type of Stakeholders

- Private sectors
- Civil Societies
- Education institutions
- Public sectors

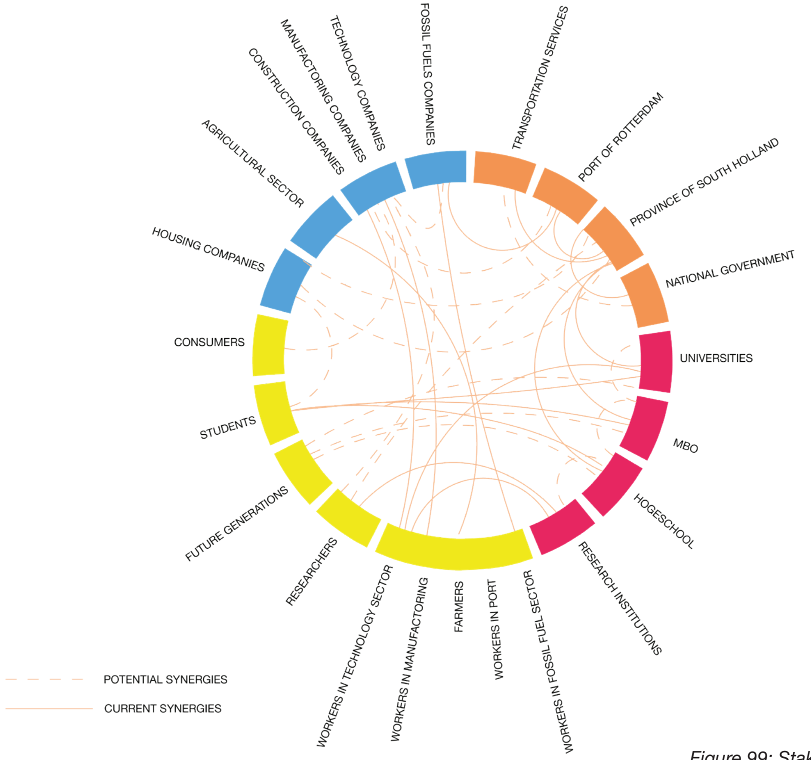


Figure 99: Stakeholder Synergy

Stakeholder collaborations according to strategic approach

4.3.1 Affordable energy consumption and production

Those potential collaborations between the stakeholders will affect the shift to the affordable energy consumption and production. The Private sector, especially the technology, manufacturing and construction companies will be collaborating with all other sectors very closely to provide an affordable energy production. Research institution, students, future generations and universities will be part of that collaboration. The Province of South Holland will collaborate with all sectors closely and develop an participatory and multilayer planning to make energy affordable for everyone involved.

Figure 101: Stakeholder Collaborations Affordable Energy

4.3.2 Shared and energy efficient transportation system

The public sector , especially the transportation services will be a main collaboration partner in developing a shared and energy efficient transportation system. In collaboration with the Province and the National government and research instations, the transportation network can be improved.

Figure 102: Stakeholder Collaborations Shared Transportation

Stakeholder Collisions

In Figure 100, the current and potential coalitions between stakeholders are outlined according to our strategy. Educational institutions play a rather neutral role but act as managers of the transition.

Stakeholder Sectors

- Private sectors
- Civil Society
- Educational institutions
- Public sector

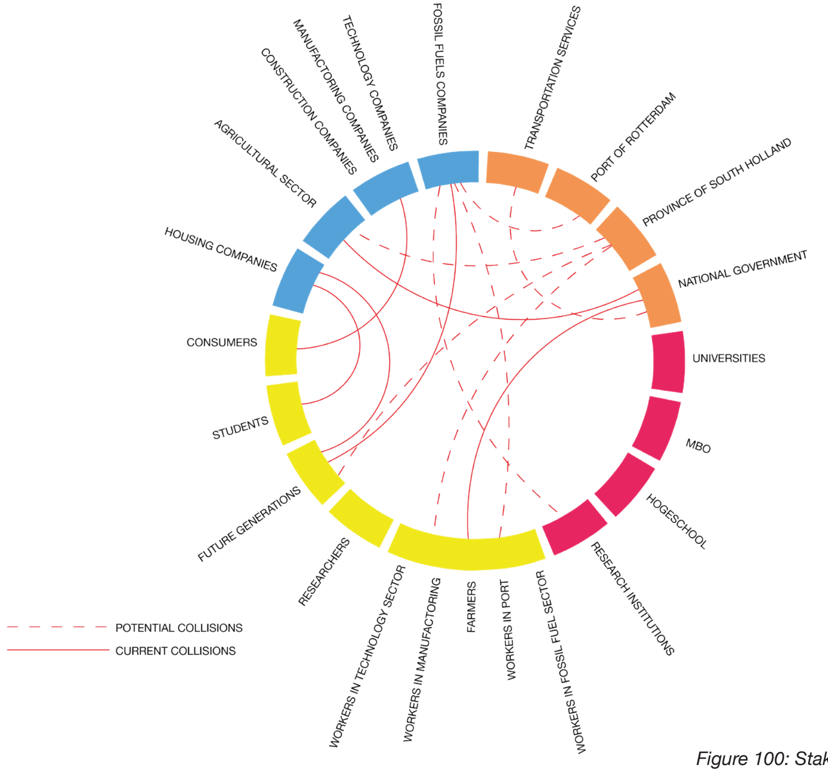


Figure 100: Stakeholder Collision

4.3.3 Energy efficient built environment with sustainable material flow

To sustain a fair energy transition in the built environment the collaboration between private and public sector a plays role here. However the collaboration between the private sector such as construction companies and the research institutions must be strengthens to create a good synergy between new technologies to improve efficient and developing those products.
The consumers should also be a strong partner in the transition, as the private sector follows the demand . Main stakeholders however is the public sector responsible to create attractive subsidies for private and civil sector.

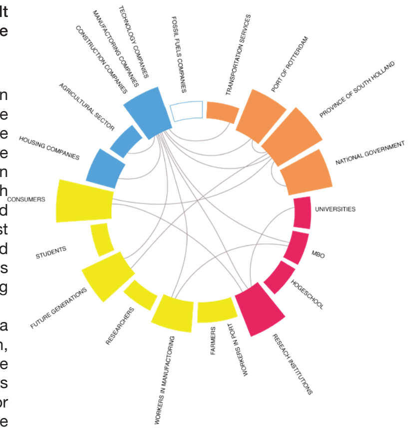


Figure 103: Stakeholder Collaborations Efficient Energy

4.3.4 Transition of oil scape to renewable energy generation

Here the collaboration between the public sector and the civil society is crucial. Moreover the private sector collaborated with the Port of Rotterdam and the civil society to implement the products and changes needed for the transition of the oil scape to renewable energy generation systems. Research institutions and future generations will drive and strengthen the synergies.

Figure 104: Stakeholder Collaborations Renewable Energy

04.4 Timeline and Phasing

This timeline is a combination of four key actions. Affordable Energy Consumption and Production, Shared and Energy Efficient Transportation Systems, Energy Efficient Built Environment with Sustainable Material Flows, and Transition from Petroleum Landscapes to Renewable Energy Generation.
Based on these four main actions, we grouped them into four types of approaches: spatial strategies, technology implementation, policy, and social interventions.

Figure 105: Phasing of all main actions

04.5 The Layers of the Transition

On the right side of this page, the four different layers are combined in a map, allowing to see the development of the province in three phases.

This sub-chapter describes the different layers of our strategy individually. For each layer, the timeline, stakeholders and phasing is presented.

04.5.1 The Social **SYNERGY**
Affordable Energy Production And Consumption

04.5.2 The Transportation **SYNERGY**
Shared And Energy-efficient Transportation System

04.5.3 The Circular Material **SYNERGY**
Energy-efficient Built Environment With Sustainable Material Flow

04.5.4 **SYNERGISING** Renewable Energies
Transition Of The Oilscape To Renewable Energy Generation

Figure 106: Strategy Map - Phase I

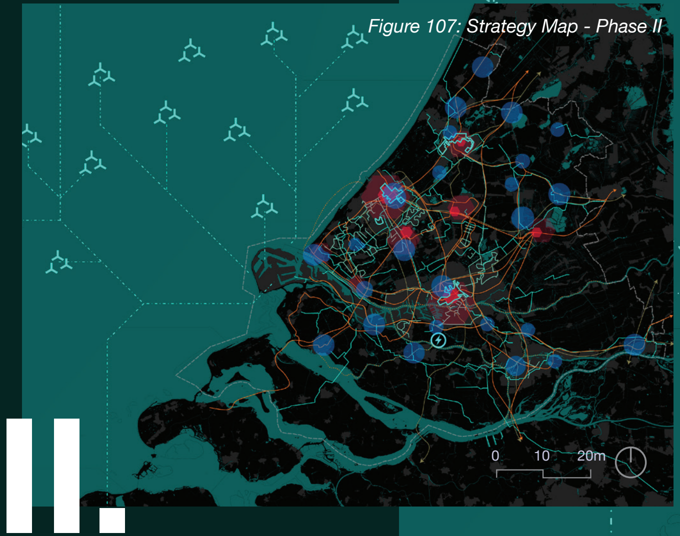


Figure 107: Strategy Map - Phase II

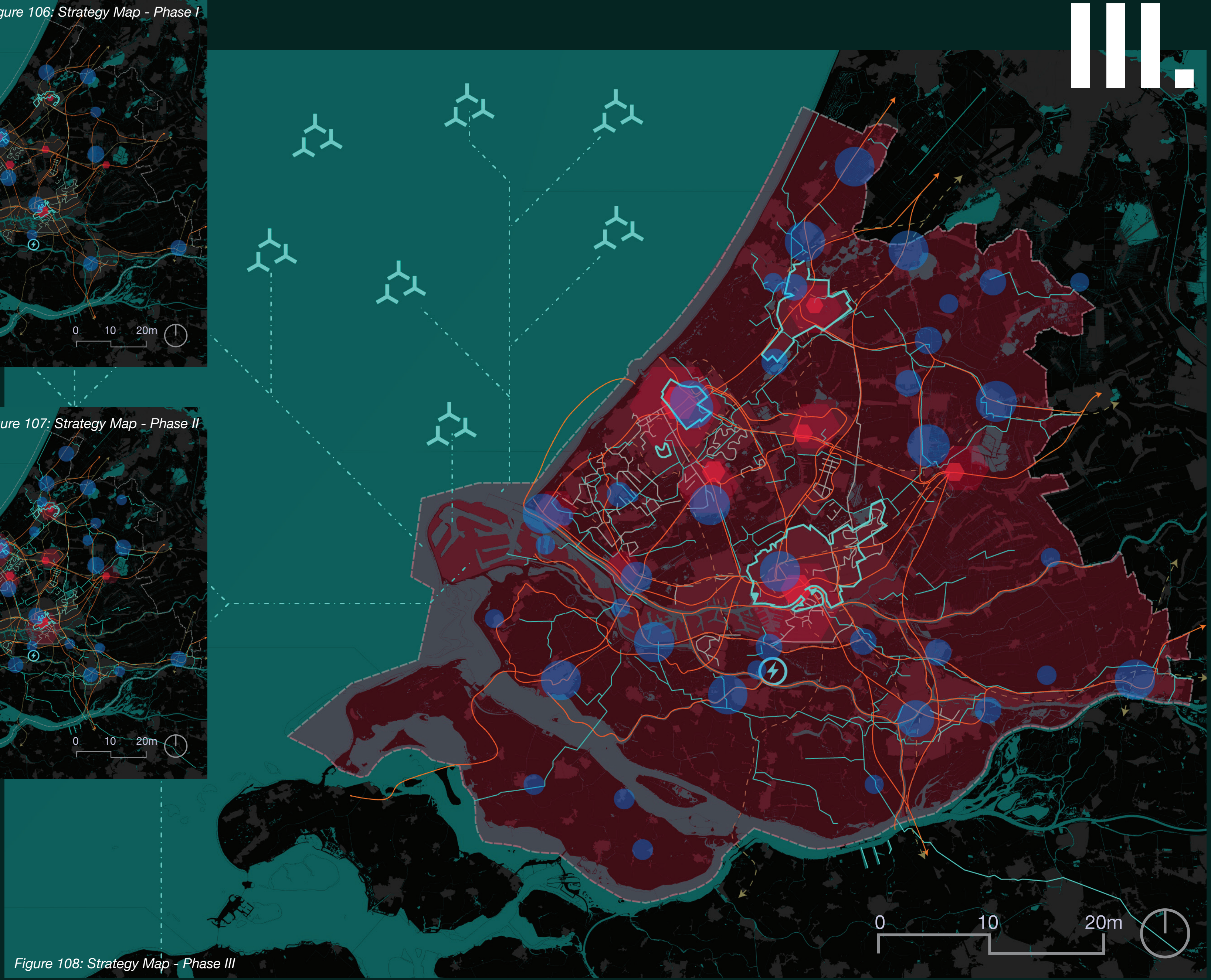


Figure 108: Strategy Map - Phase III

04.5.1 Timeline and Phasing - The Social SYNERGY

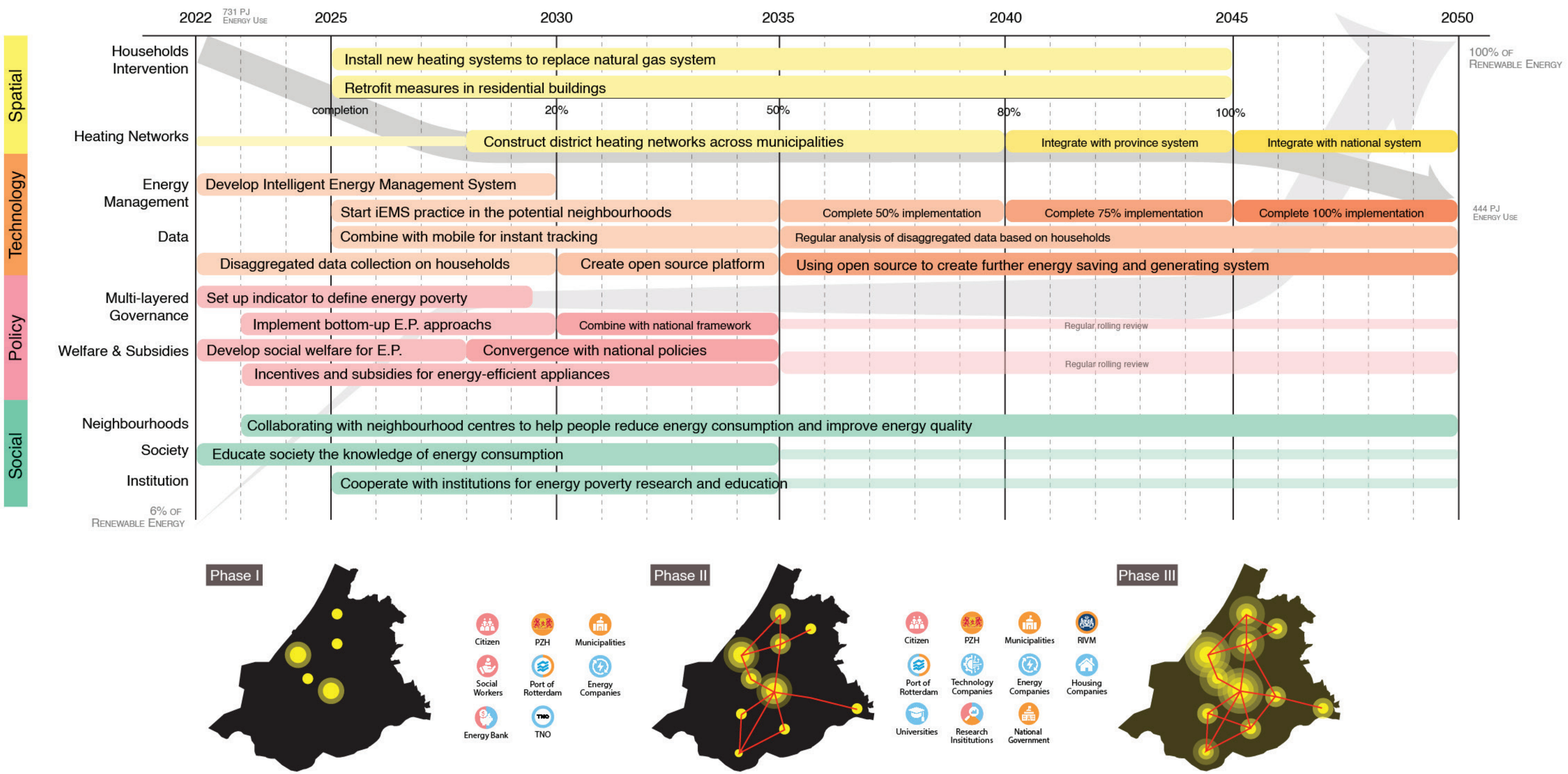


Figure 109: Phasing of main action I - Affordable Energy Production And Consumption

04.5.2 Timeline and Phasing - The Transportation SYNERGY

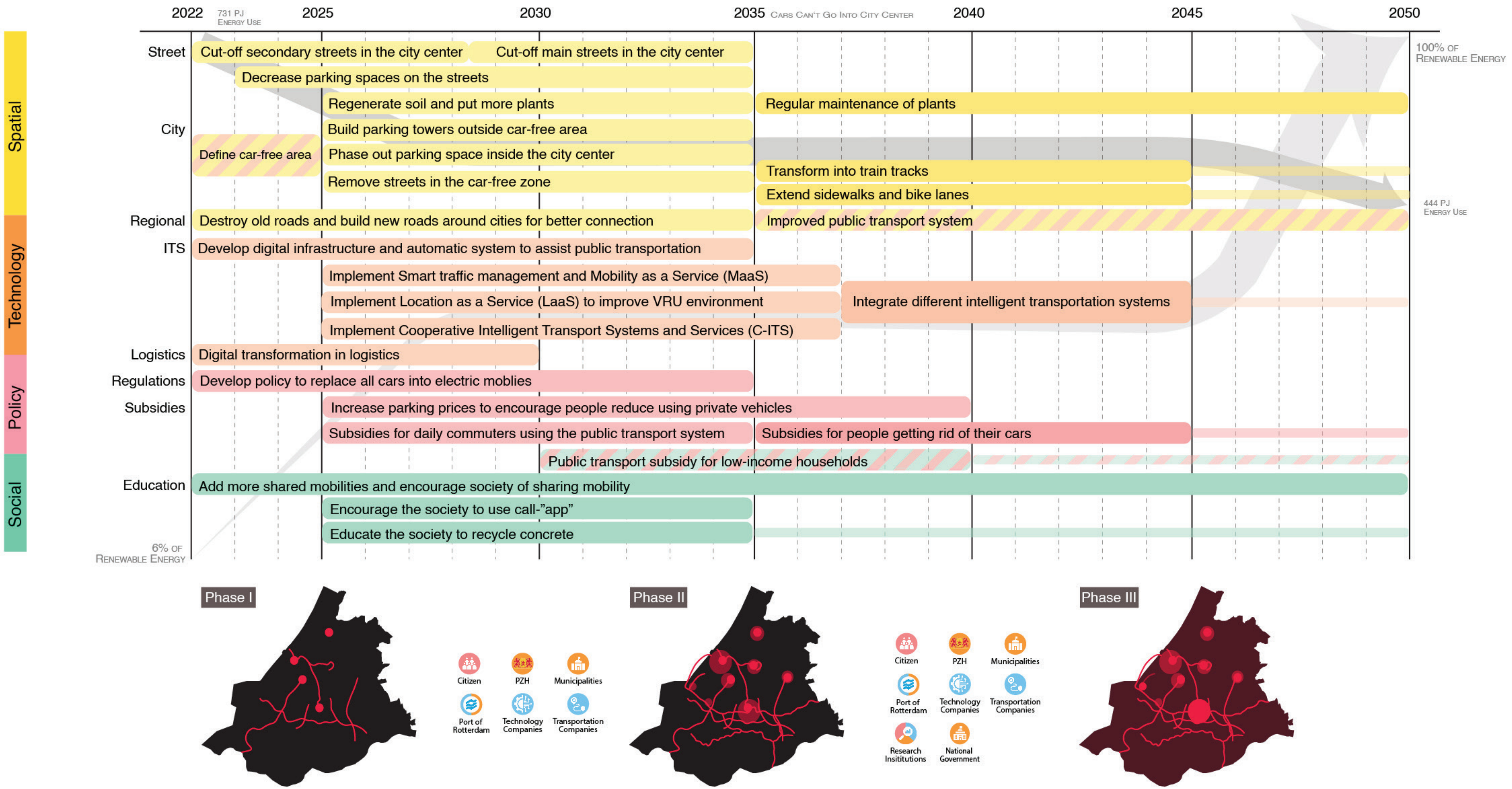


Figure 110: Phasing of main action II - Shared And Energy-efficient Transportation System

Figure 111: Shared And Energy-efficient Transportation System - Phase I

Phase I

In this first phase, the centres of Rotterdam, Den Haag, Delft and Leiden will become car-free. One component of the car-free centre is the fact that cars can't be parked in the streetscape anymore. Parking towers will be built in order to provide space for the parking of cars.
To decrease car use, the public transport system will be more extensive and efficient. In phase one, new train and fast tram tracks will be built. On the city level, some roads will be cut-off and eventually be destroyed. The soil in these streets can be regenerated and plants will be planted.
To support this transition, subsidies will be written to make car ownership less attractive, such as taxes on parking and a subsidy for daily commuters to use public transport; and society will be educated on using shared mobility.

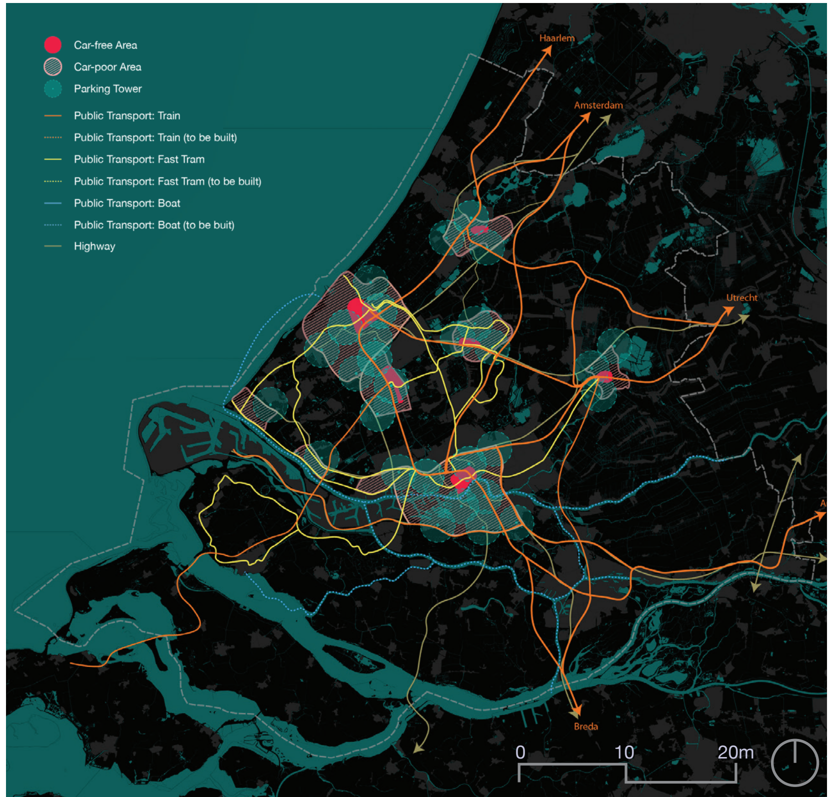


Figure 112: Shared And Energy-efficient Transportation System - Phase II

Phase II

In phase two, the neighbourhoods around the city centres as well as other towns in the province will be car-poor. In these areas, it is possible to deliver groceries to your door, or drop off your grandma but you can't park there. To accomplish this, more parking towers will be built around these areas. Beside this, a new public transport system by boat will be realised.
In the car-poor areas the roads will be narrower and more green will be planted. This will improve the urban heat island effect and the general healthiness of living in the city. The streets in the car-free area will be transformed into train tracks.
In the cities, an app will be implemented which can be used for 'calling' a tram.
More subsidies will be implemented for people without a car.

Figure 113: Shared And Energy-efficient Transportation System - Phase III

Phase III

In the last phase, the centre of Zoetermeer and Gouda will also be car-free. Next to this, the whole province will be car-poor. Lanes for private vehicles will be reduced on highways, and public transport will be promoted.

In all of the phases the public transport systems will be maintained well and made more efficient where possible; public transport will be promoted; and the greenery will be maintained well to create an attractive city life.

Phasing - The Transportation SYNERGY

04.5.3 Timeline and Phasing - The Circulair Material SYNERGY

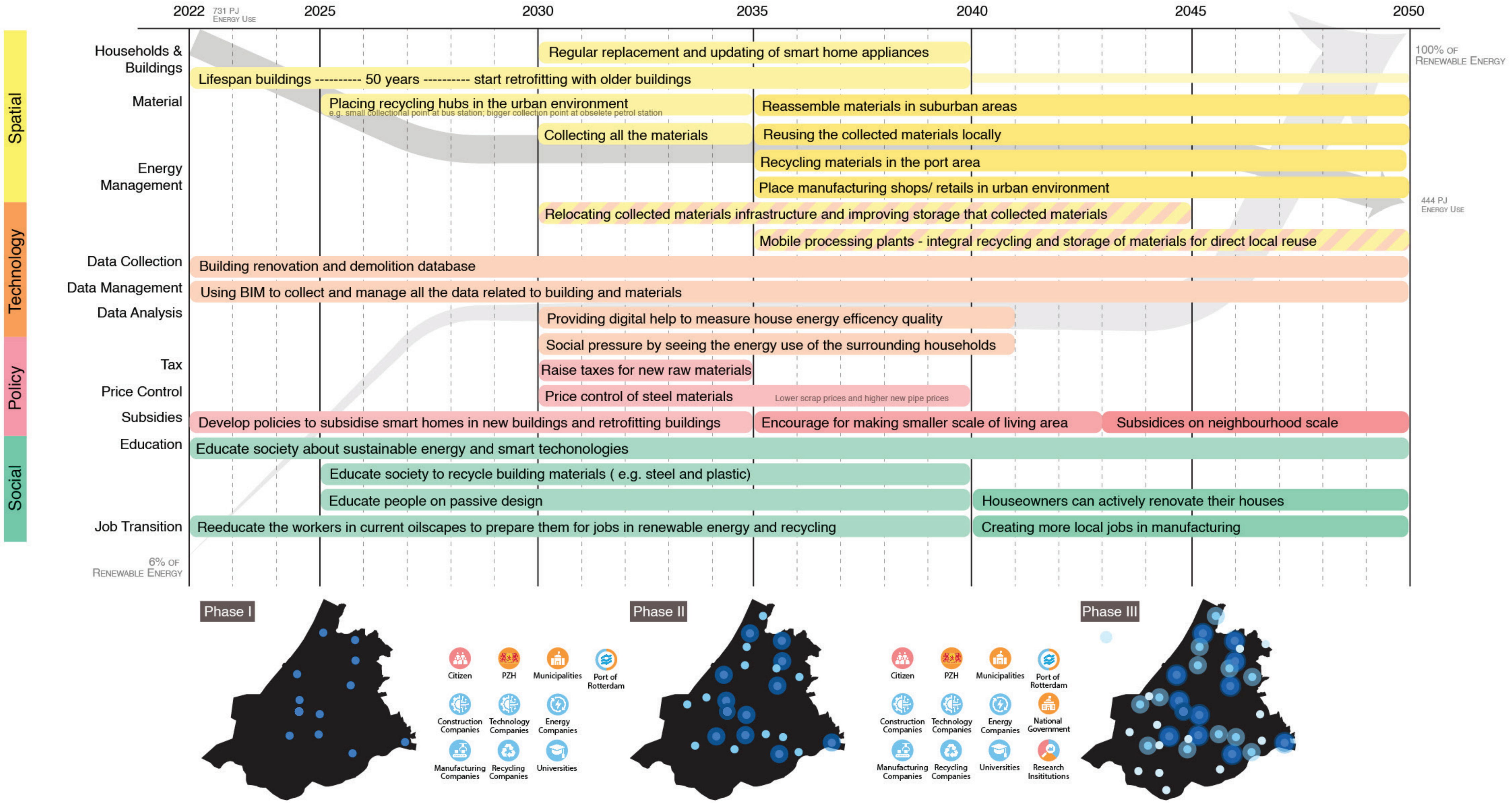


Figure 114: Phasing of main action III - Energy-efficient Built Environment With Sustainable Material Flow

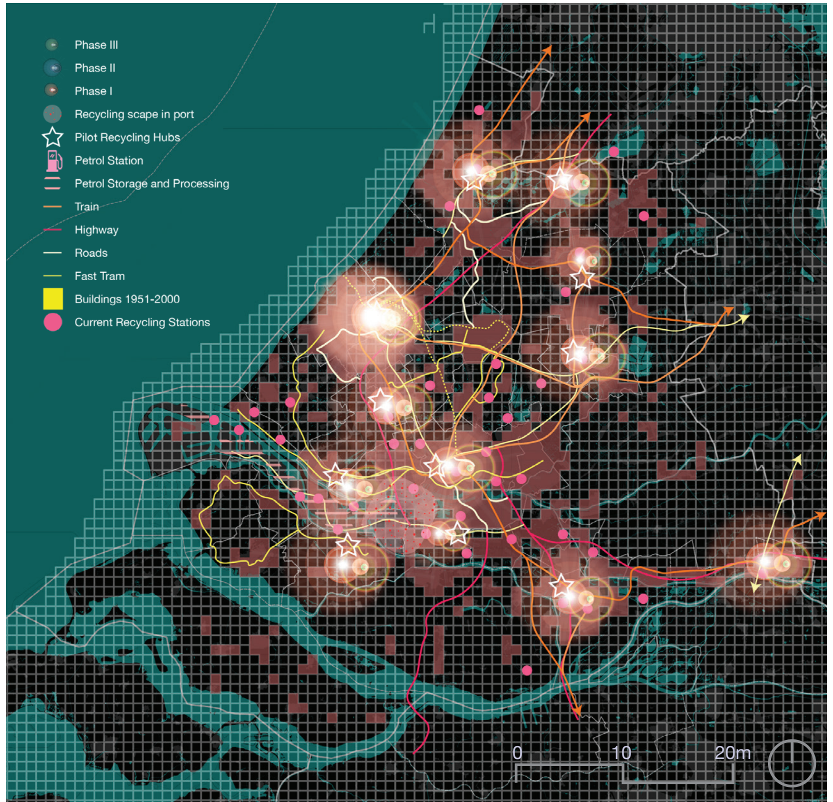


Figure 115: Energy-efficient Built Environment With Sustainable Material Flow - Phase I

Phase I
To kick-start the transition, the pilot sites for starting a circular flow of materials, taking into account the energy transition, focus on strengthening the already existing recycling stations. This is done by improving the existing infrastructure, as it has already been outlined in the analysis that the current recycling stations are located close to highways and railway tracks, which can be proposed as infrastructure for the efficient distribution of materials.
In addition, the neighbourhoods with older building structures that require more refurbishment and energy poverty are strategically targeted first, so that a short-term improvement can be achieved for the South Holland population.
The recycling infrastructure strategically improves the material flow of passive energy systems, such as retrofitting homes to save energy and reduce energy bills, but at the same time retrofitting and expanding

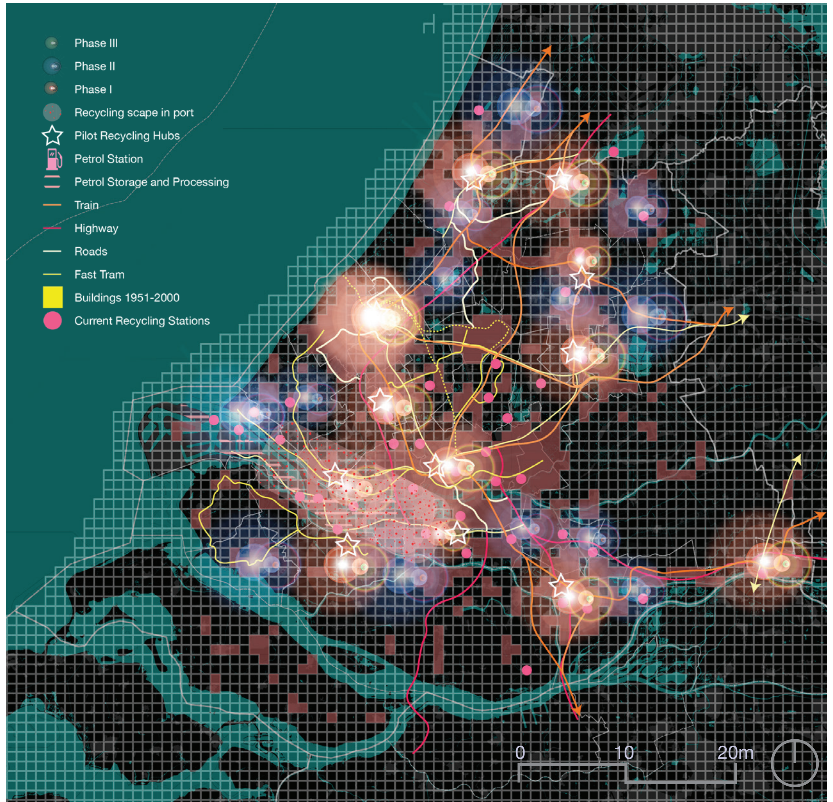


Figure 116: Energy-efficient Built Environment With Sustainable Material Flow - Phase II

them with new technologies and renewable energy generation systems that can then also be recycled at the pilot sites, as retrofitting will strategically start in the areas with older building structures first.

Phase II
In the second phase, the recycling stations will be extended to areas that are less accessible in terms of infrastructure, but still in neighbourhoods with older buildings that still need to be retrofitted to be energy self-sufficient and reduce energy demand. The Port of Rotterdam will increase its capacity to recycle the materials needed for the renewable energy systems in a chemical, energy-neutral way and without CO_2 emissions as they are captured. Reuse the space of the oil refineries in the port that will slowly be phased out.

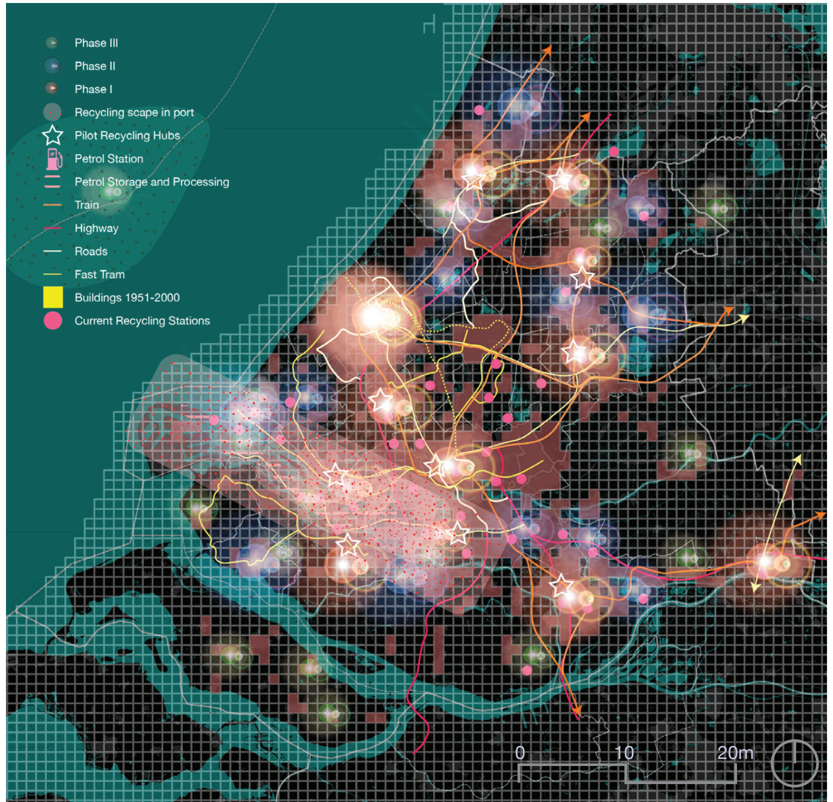


Figure 117: Energy-efficient Built Environment With Sustainable Material Flow - Phase III

Phase III
In the final phase, all buildings will be upgraded to an energy-neutral or even positive energy standard, and a circular material flow infrastructure will be created so that even if retrofitting has already taken place, repair and reassembly of components is more likely to take place on site. Only short and smart distances connect the districts of South Holland to a network of recycling stations across the province and intelligently link it to the main recycling facilities in the Port of Rotterdam.

Phasing - The Circular Material SYNERGY

The Circular Material Synergy

This map shows how the material flow for the development of critical materials, which can then be assembled and used and subsequently reused, recycled, remanufactured and reassembled, takes place spatially in the province of South Holland. The Port of Rotterdam plays an important role in this process, as the materials arrive at the port, but also the chemical recycling and the main storage take place and find space in the port.

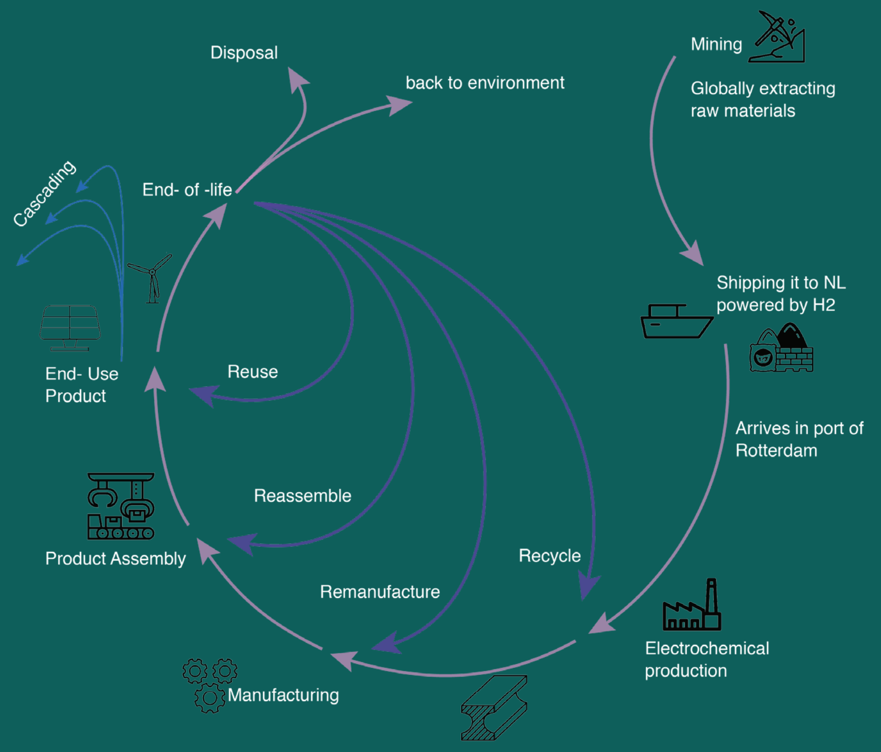


Figure 118: The Material Circle

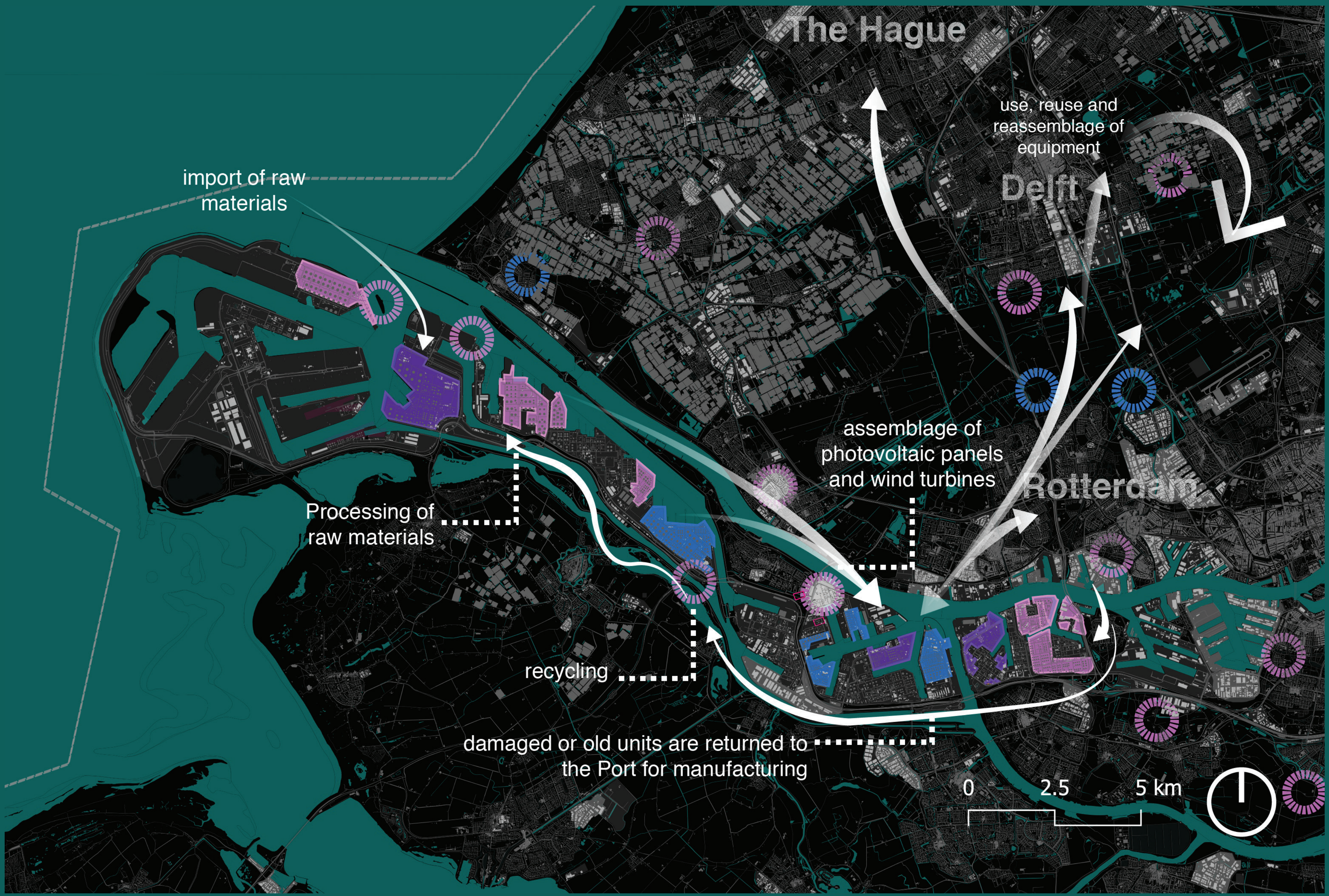


Figure 119: Recycling and Waste stations (Provincie Zuid-Holland,2020) & (Recycling, 2022)

04.5.4 Timeline and Phasing - SYNERGISING Renewable Energies

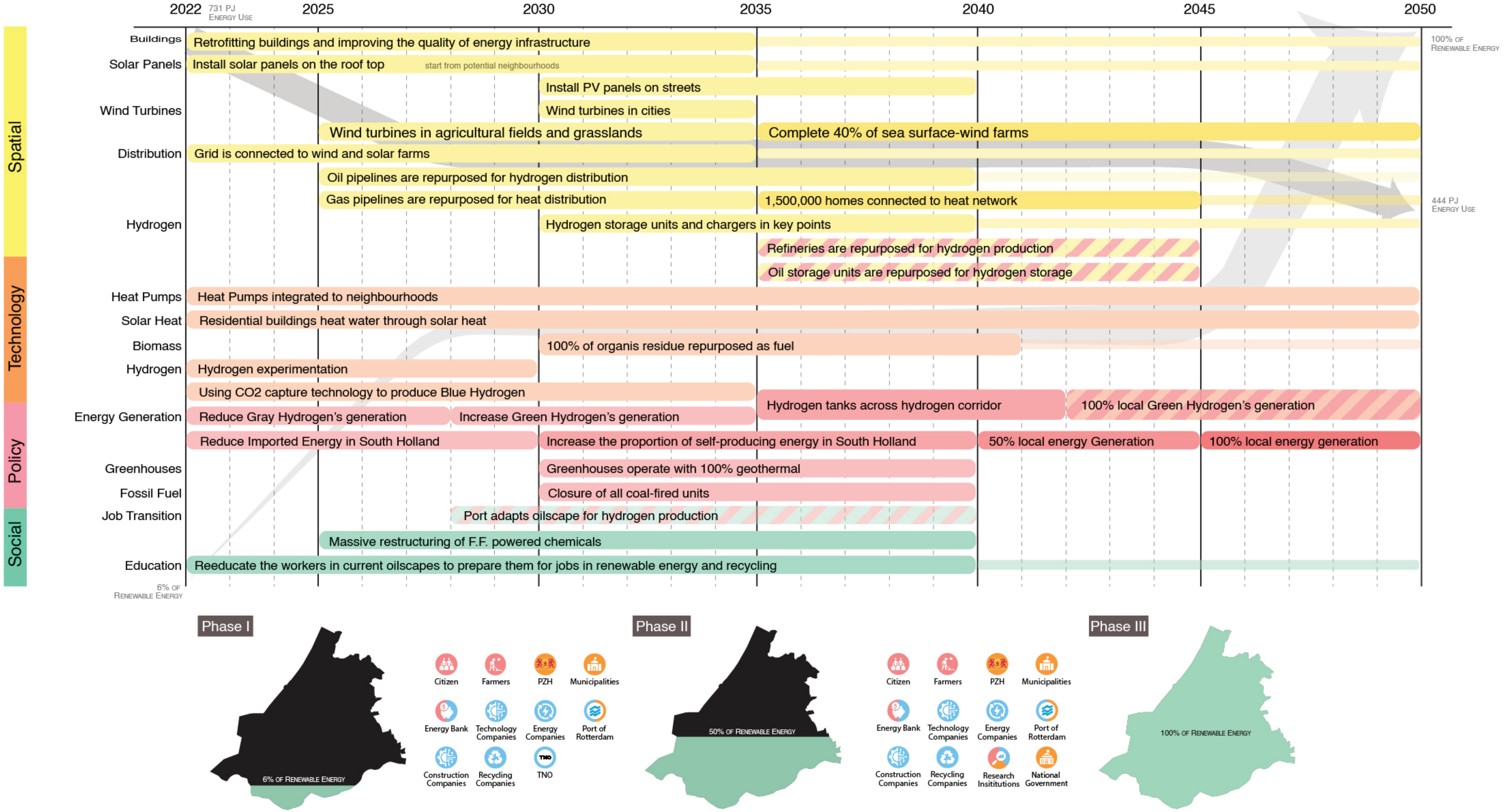


Figure 120: Phasing of main action IV - Transition Of The Oilscape To Renewable Energy Generation

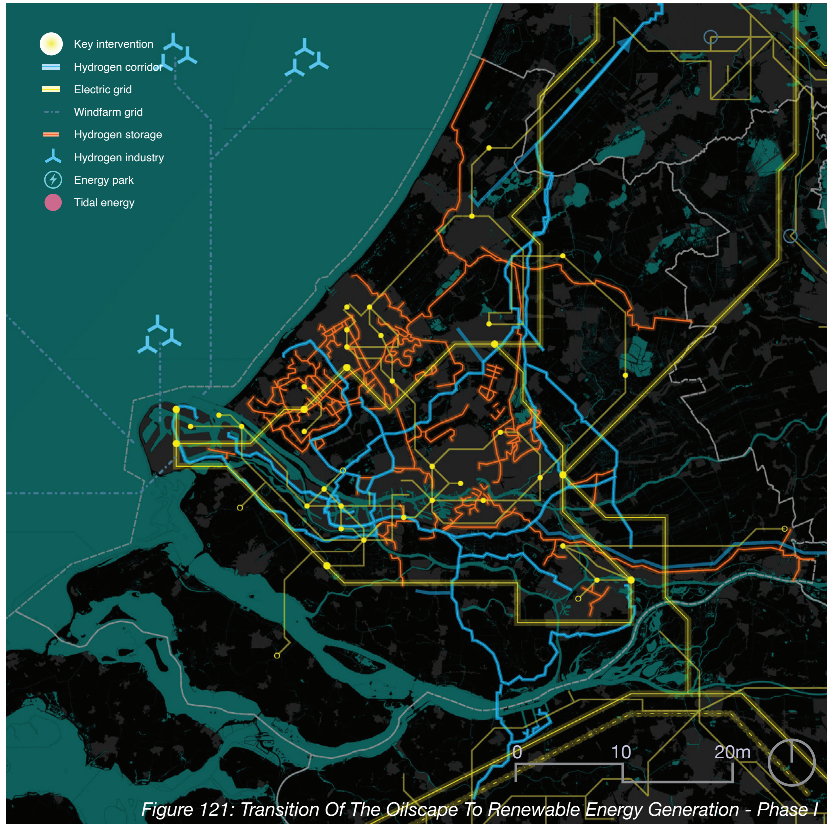


Figure 121: Transition Of The Oilscape To Renewable Energy Generation - Phase I

Phase I
During the first phase of the transition for renewable energy infrastructure, the Port of Rotterdam repurposes the refineries and storage units destined for oil and gas. It must be noted that oil storage and pipes are not suitable for hydrogen, but gas and natural gas pipelines can be adapted (Port of Rotterdam Authority, 2020). The initial network will be dedicated to exports of hydrogen, to develop the networks for local use via private funding.
At the same time, greenhouses, closest to existing subsoil heat extraction wells, will be fully connected to the renewable energy system. Offshore wind farms will continue to extend to cover 20% of the province's coast.
Domestic gas appliances will begin to be traded by electric appliances, in order to begin phasing gas out of neighbourhoods and to leave space for geothermal heat.

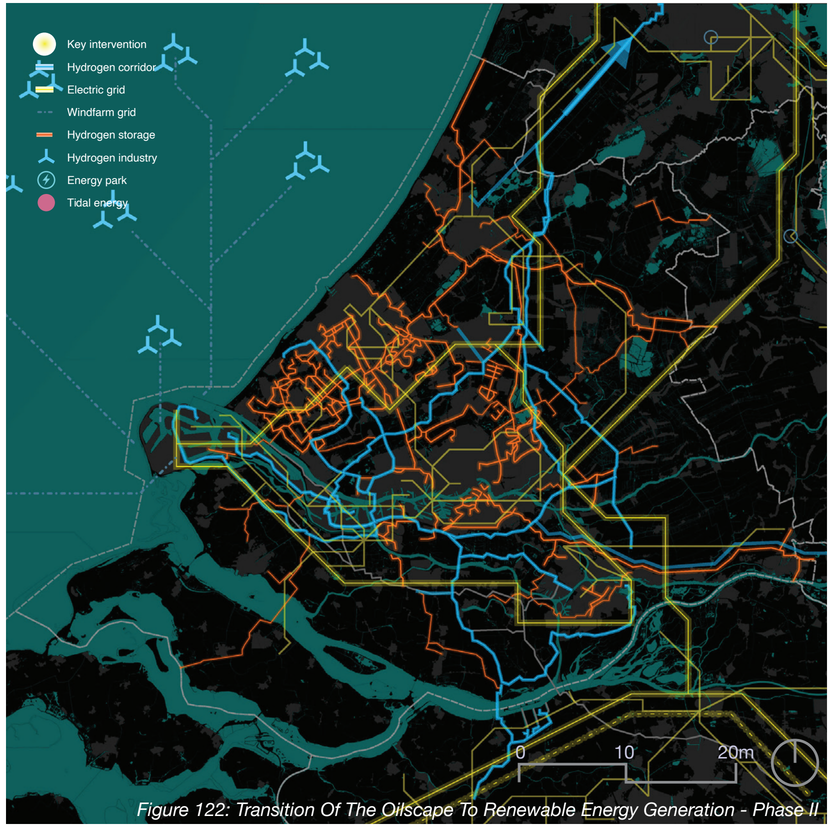


Figure 122: Transition Of The Oilscape To Renewable Energy Generation - Phase II

Phase II
During the second phase of the transition, the heating network will reach cities through the completely repurposed heat and natural gas grid, and the networks across towns, suburbs and cities will begin connecting to local wells for subsoil heat extraction. These wells are to be dug up at a pace of five wells per year.
The fully repurposed hydrogen corridor will begin feeding local outlets for electric transport systems and local industries, and energy hubs and parks will begin feeding and storing hydrogen with locally sourced, renewable energy.
Offshore windparks will extend over 30% of the coast.
Transportation will be 100% reliant on renewable energies and biofuel.

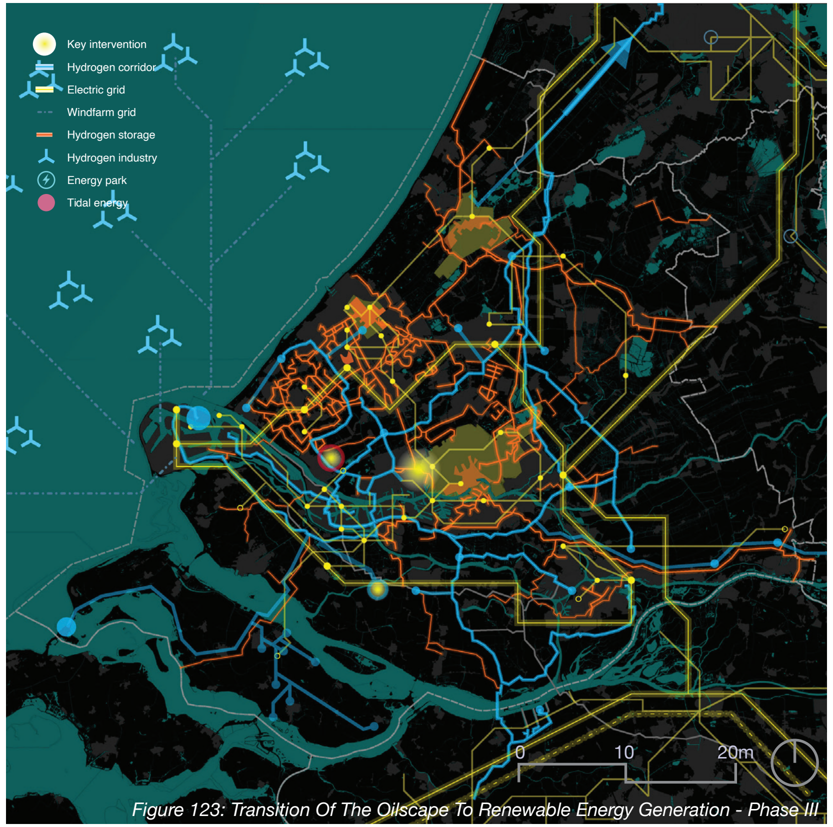


Figure 123: Transition Of The Oilscape To Renewable Energy Generation - Phase III

Phase III
By the end of phase three, the hydrogen corridor will have connected to energy parks and hydrogen parks across the province.
The heat grid will have expanded into all neighbourhoods and communities.
Offshore wind farms will cover 40% of the province's seas and solar farms and onshore wind farms will completely feed the electric grid.

Phasing - SYNERGISING Renewable Energies

New Energyscape, the Backbone of the Transition

The distribution of energy across the Province in 2050 has to rely on the existing remnants of the oilscape that shaped it, but its sustenance will now be diversified energy sources that will no longer concentrate on refineries, but are spread across the land and the sea.

Extensive wind farms across land stripes and corridors inland, and the occupation of 40% of the sea of the Province will feed hydrogen hubs and the electric grid, while they also give a new look to the landscape.

The facades and roofs of all buildings facing the sun, as well as sidewalks and roads, will collect energy through photo-voltaic cells during sun hours.

Geothermal heat wells will be spread across, and their network will take over the local heat and gas pipelines, to feed houses and buildings with renewable heat, aided by the widespread use of heat pumps.

Great Key inter-systemic changes will take place, specially around the Port of Rotterdam, where refineries and oil storage units will be phased out to leave place to hydrogen storage and management, which will also take over regional portions of the existing gas networks, to be fed into local hydrogen hubs and tanks, and towards the national and international market.

Energy Parks will be developed in areas with high potential for harnessing two or more types of renewable energy and they will be connected to local communities and the hydrogen corridors, to either store energy or sell it.

Finally, experimental resources such as tidal wave energy will connect into the new grid with the potential for new producers to feed it.

Figure 124: New Energyscape ((Tennet, 2022), (Hein, 2018), (Cole, Ozgen & Strobl, 2020))

Energy Flow in 2050

At the end of the energy transition, when local renewable energy industries have reached their greatest calculated potential according to current estimates and existing technologies, the Province of South Holland will not be just able to provide 100% local, renewable energy for its local demand, but it will also foster a renewable energy market.
The focus of electricity and heat demand on wind, solar and geothermal energy, as well as the cascading of heat from the remaining industries in the port, will allow for local biofuels production to be exported mostly, since only a small part is required to assist in the transportation industry (Strengens & Elzenga, 2020).

However, this is only half of the bargain, since the key point to the success of this market without aid from imported energy or biofuels, will be the reduction of the demand. The industry of the port will be able to reduce its demand by over 50% (Samadi, 2020) by the phasing out of the fossil fuel industry and through optimization of remaining industries.

The more efficient and specialised transportation routes as well as the "car-poor city" strategy, will reduce the demand of energy for transportation, which will be aided nonetheless by local hydrogen and biofuels.

The built environment, finally, will reduce its energy demand by the education of the population, retrofitting strategies and the exchange of high-energy consuming appliances for more efficient ones, along with other widely discussed strategies.

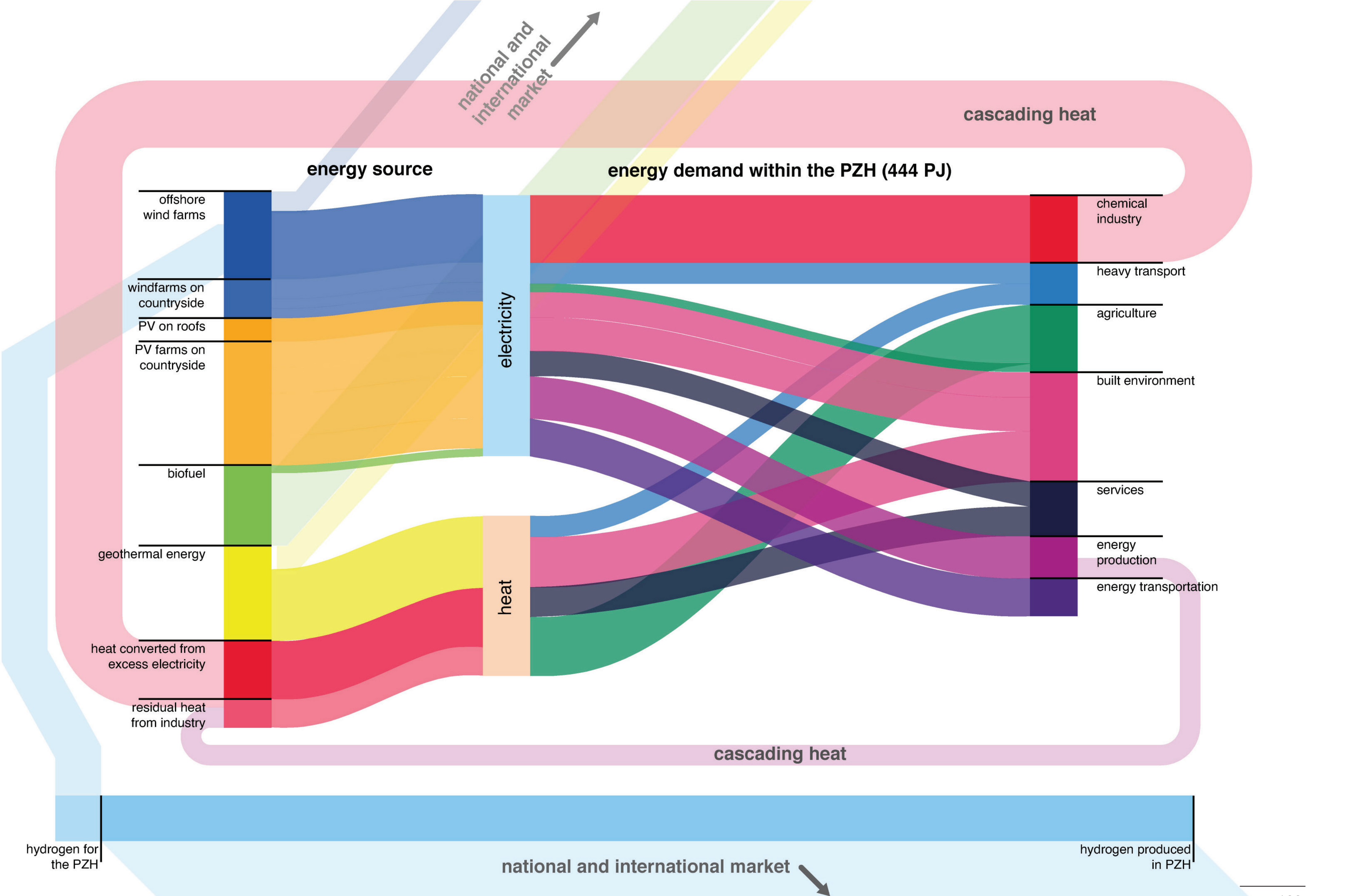


Figure 125: Energy Flow ((Bilius, 2007), (Bosman et al., 2018), (DNV, s.f.), (Elzenga & Strengers, 2020), (Hydrogen Core Team, 2020), (International Energy Agency, 2020), (Jepma et al., 2019), (Kadaster, 2022), (KIVI section Electrical Engineering, 2017), (McKinsey & Company, 2018), (Port of Rotterdam Authority, 2020), (Port of Rotterdam Authority, 2021), (Rijk & van Dinther, s.f.), (Samadi et al., 2016), (Schejigronf, 2015), (Stork et al., 2018), (Netbeheer, 2021), (van Sark et al., 2016), (van Steekelenburg et al., 2019), (van Vlimmeren, 2021), (Visman, 2019), (Wierling et al., 2018))

Phasing of the Port of Rotterdam

Renovations to the Port of Rotterdam will begin with the shut down of fossil fuel-powered electric centrals starting from the exterior of the port inwards, so they can be gradually adapted to supply by renewable wind sources.

Adjoining storage facilities and refineries will begin refurbishment in the same order with priority for storage units, to become hydrogen storage facilities. Refineries will be repurposed to become electrolysis facilities. As electric centrals begin to function on renewable energy, the surrounding industrial complexes will be also required to connect to their grid.

The transitioning oilscape will become available for new industries to settle in the port, but two will have preference.

1. Manufacturing, recycling and storage of energy appliances such as solar panels and windmills.

2. Alternative, emerging technologies for renewable energy generation, such as tidal energy.

The greatest requirements to adjust industries to the energy transition revolve around enforcing it through tighter regulations for energy consumption, developing a long term vision for competitively priced renewable energy and the restructuring and increasement of funding and investments in digitalization, development of new technologies and the development of the new grid.

The steel industry will be key in the task of refurbishing the oilscape for new technologies and energy systems.

Figure 126: Phasing of the Port of Rotterdam ((Lechtenböhmer, Arnold, Fischedick, 2016), (Jepma, Spijker & Hofman, 2019))

Thus, greater subsidies and an intersectional plan that engages its transition with that of the oilscapes, is key.

By the year 2050, all the industries of the Port of Rotterdam will rely on renewable energies and will be connected to the local heat grid, to provide their excess heat to neighbouring communities.

Hydrogen and geothermal energy will power feedstock while renewable energy will provide electricity.

Policy for the transition of industries in the Port of Rotterdam.

The policy required for the transition will revolve around energy generation and its storage, which will require existing law to allow the shifting of uses among diverse typologies of infrastructure.

The plan for restructuring energy distribution will be developed by industries, the Port of Rotterdam Authority and energy providers, to allow an organised transition where no industry faces shortages.

A second key policy framework will be the one that enables energy research and the development of new technologies around the port, where research is already underway but where most industries need the development of more efficient energy technologies to ensure their transition.

Companies will be enabled to form energy co-operatives so they can develop their own technologies and harness renewable energy through them, among sectors that share similar demands of energy. They will also become private providers with financial and legal stimuli to engage further with communities around the port by sharing their energy with them.

Figure 127: Phasing of the Port of Rotterdam ((Lechtenböhmer, Arnold, Fischedick, 2016), (Jepma, Spijker & Hofman, 2019))

Hydrogen will be a carrier of the transition not only because of its properties as potential energy carrier but because of the Port of Rotterdam's potential to import, produce, store and export it, which will create an economy to replace the current fossil fuel led economy.

Chemical conglomerates will develop a green hydrogen facility that will produce 250 MW at the beginning and grow to 1 GW by 2050. Its heat will be distributed among these industries and neighbouring communities.

By 2030, local production of green hydrogen is set to become as profitable as grey and blue hydrogen, when local production will also increase. This will depend on the investment in upscaling renewables and in the improvement of water electrolysis technologies.

The facilities for storage and transport of hydrogen will also be destined for its import. The competition between domestic and imported hydrogen will balance out for the local market as the port improves its capacity to produce it, but the greater share of imported hydrogen will be destined for other European markets.

On the regional level, hydrogen will become a buffer that balances the varying influx of energy from wind and solar power and it will also power regional transport networks.

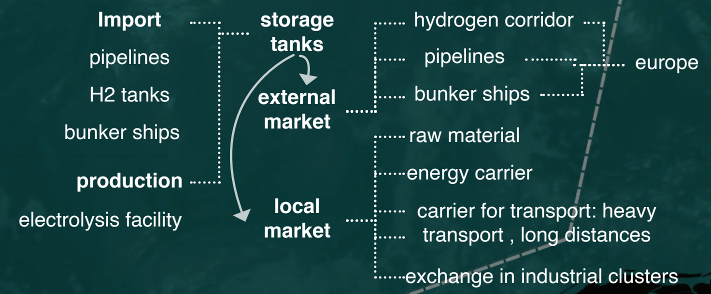


Figure 128: Phasing of the Port of Rotterdam ((Lechtenböhmer, Arnold, Fischedick, 2016), (Jepma, Spijker & Hofman, 2019))

04.6 The Key Interventions

This sub-quarter will elaborate further on the six interventions where our four main actions come together. Three phases are explained: the current situation, the intermediate stage and the final stage.

Synergising building functions

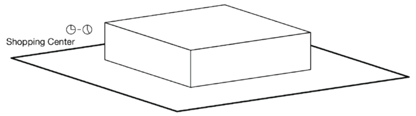


Figure 129

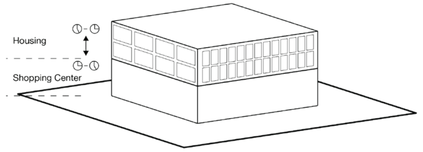


Figure 130

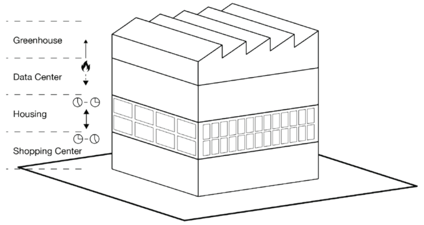


Figure 131

Current situation

In 2022, functions are not synergised efficiently. To make use of the principle of cascading, vertically synergized functions in the built environment decrease the energy demand. When levels with different uses are synergised in one building or block, the heat can be transmitted from the lowest level to the highest levels naturally, as heat drives to the top, so energy waste can be minimised. To show the transition, a shopping centre has been used as an example.

Intermediate stage

Housing will be placed on top of this shopping centre. When connected to the same grid, the two functions can share their energy. By synergising functions with different timeframes in the energy demand - like housing and offices, or housing and shopping centres, the energy demand can be managed quite stable over a day. To create an even energy demand throughout the day. A shopping centre uses its main energy from 9.00 to 17.00, while housing uses its main energy from 17.00 to 9.00. Also the transportation is synergised here, as the building inhabitants have a short distance getting their groceries or other living essentials downstairs.

Final stage

On top of this, a data centre and greenhouse are placed on top. The data centre produces excess heat, which can be repurposed for the greenhouse (or housing). Here also the principle of energy cascading is smartly extended vertically. Moreover, the outcome of the functions itself provides a more synergised urban environment, as the grown products in the greenhouse can be sold to the inhabitants living in the same building. By synergising the transportation of goods, less energy is needed, and in the meanwhile excess energy can be reused, electricity used to different timeframes and the overall energy demand goes down.

Parking Towers

Figure 132

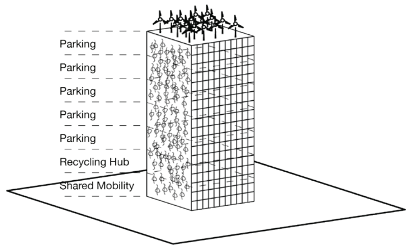


Figure 133

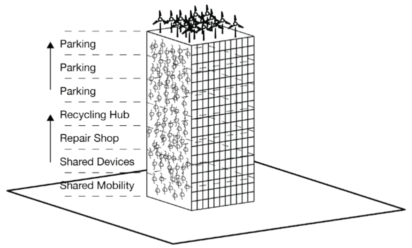


Figure 134

Current situation

Parking lots tend to be on street level, in sight, on ground level and using space that could be used by pedestrians or other slow traffic. This is not the best use of that space and as one main goal is to maintain the current urban footprint, virtual functions like parking will be re-used to densify the housing stock and to improve transportation networks. Parking towers are placed in key locations, so drivers can park right outside their neighbourhoods and practice shared mobility. This will trigger a shift towards car-poor neighbourhoods

Intermediate stage

More towers with shared uses are created. They have parking spaces and host local recycling hubs and shared mobility spots, such as shared bike hubs. These towers will generate energy through solar panels on the facades and small wind turbines on the roof. Facades with no direct sunlight will be covered by plants, to decrease the effect of urban heat islands.

Final stage

As cars will be used less often, parking spaces will be phased out. The ownership of cars will decrease, as the public transportation system is networked and efficient. The parking spaces will move to the top of the tower. Shops for repairing and sharing devices will be added to the tower.

Urban mining

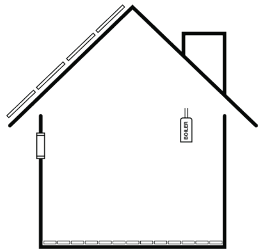


Figure 135

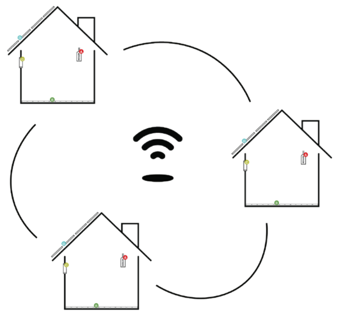


Figure 136

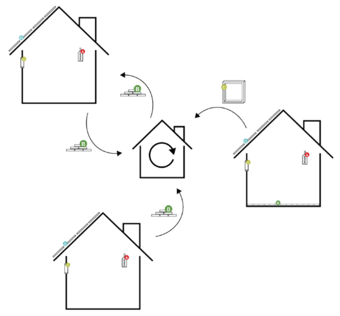


Figure 137

Current situation

Currently available materials/ systems are not mapped and registered well. Especially when demolished or refurbished. So urban mining is difficult to coordinate and manage. However there are a lot of important raw materials in our built environment that should be included into a circular system. So in the 1st phase an accountable BIM system should be established.

Intermediate stage

In this phase that is the case, a smart system is created which knows where all available materials are located and what the state of these is. A CIM dataset connects all the BIM datasets in the city to coordinate smart urban mining and retrofitting processes to achieve a low energy demand by efficiently managing construction processes.

Final stage

In the final stage, materials and systems can be exchanged between buildings. This results in a system where all materials are used as efficiently as possible. The CIMs are connected to a regional dataset coordinating the construction processes efficiently and the exchange and transportation of materials are smartly organised over the whole province connecting the recycling potential of the port with the cities.

Smart systems, connected to an app

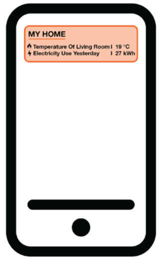


Figure 138

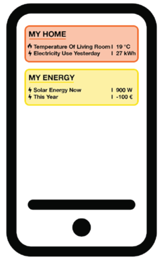


Figure 139

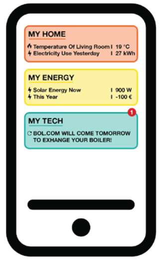


Figure 140

Current situation

A lot of houses in the Netherlands are not smart at the moment, but a small amount can monitor the temperature in the house and the energy use. The goal is to integrate a smart energy system to all newly built and retrofitted buildings. To integrate the single person in the energy transition, the management of energy demand of their own building and their own lifestyle by integrating smart systems to save energy where it is possible.

Intermediate stage

In the next phase, the energy generation through the (newly placed) solar panel can be monitored. Besides this, as Dutch people want to keep an eye on their wallet, the savings are also mentioned in the app. The smart energy systems in buildings and on the individual smartphone extends and shows results in energy and financial savings.

Final stage

When all the smart systems are installed and the materials in the house are registered, the app on your phone will tell you when for instance your boiler needs to be changed. The smart system of the building communicates not only with the user but also integrates the data of the CIM and future digital twin to make material flow and energy process more efficient and through that also saving energy. The implemented infrastructure will then provide easy options to keep the building’s energy demand as low as possible.

Retrofit housing

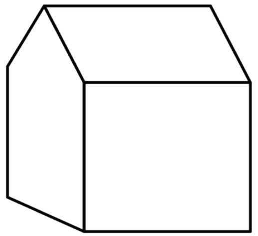


Figure 141

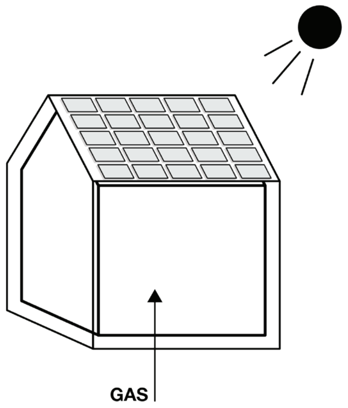


Figure 142

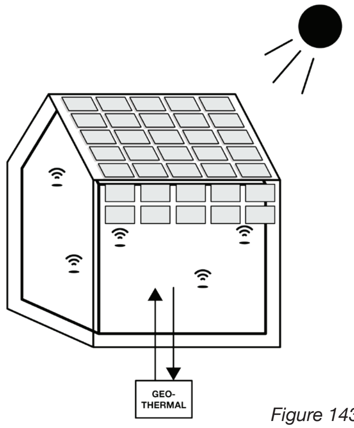


Figure 143

Current situation

Currently a lot of housing in the Netherlands is badly insulated and is connected to gas. For an efficient energy transition, the energy demand of current housing needs to be reduced, renewable energy needs to be produced locally and the house needs to be gas-free. Alternative energy generation systems will be installed and the buildings will be insulated.
Including technology and sustainable materials are crucial.

Intermediate stage

The first step of this process is to better insulate the housing, and place solar panels on the roof. Self-sufficient electricity generation. Shared and stored via a communal smart electricity grid and storage system. The energy demand will go down, while renewable energy is produced.

Final stage

Next, the gas is cut-off and a geothermal connection will be realised. Besides this, smart systems will be installed to use the energy and heat more efficiently and sustainably. And to connect the buildings with the surrounding environment.

Educate society

Figure 144

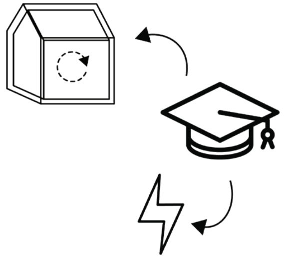


Figure 145

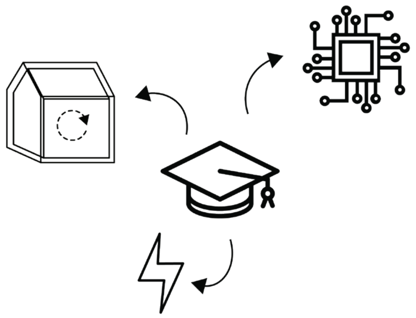


Figure 146

Current situation

At this moment, quite some people are aware of the consequences of Climate Crisis and the importance of changing to renewable energies. However, the importance must be recognised by everyone, so there is still work to do.

Intermediate stage

In this phase a lot of housing needs to retrofitted and solar panels need to be put on roofs of housing. To accomplish this, society needs to be aware. Both about the importance of this, as about the way this can be accomplish and for example what subsidies can be granted.

Final stage

In the last stage, society also needs to be educated about all the smart systems which will or already are in their houses. They need to know what these systems are for and what these can do.

04.7 Pilot Projects

Energy Poverty Analysis

This project used the reference based on TNO's research (2021), about the energy poverty in the Province of South Holland. There are three indicators, High Energy Quote (EQ), Low Income and High Energy Costs (LIHK), and Low Income and Low Energy Label (LILLE), with different measure standards. None of these can show the whole picture of the energy poverty issue in South Holland (TNO, 2021).

However, potential areas can be picked out as low-income families with high energy bills, yet energy quality is not in the worst situation at the same time by combining Indicator 2 and 3. From this perspective, these potential areas have more capability as starting points for further improvement references.

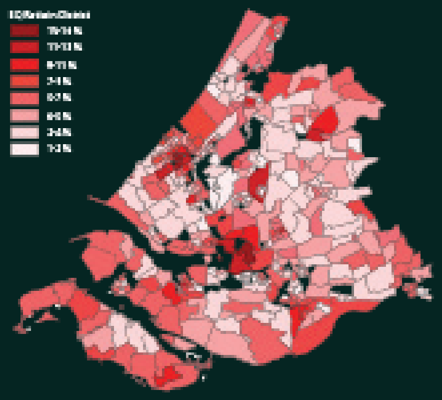


Figure 147: EQ in South Holland (TNO, 2021)

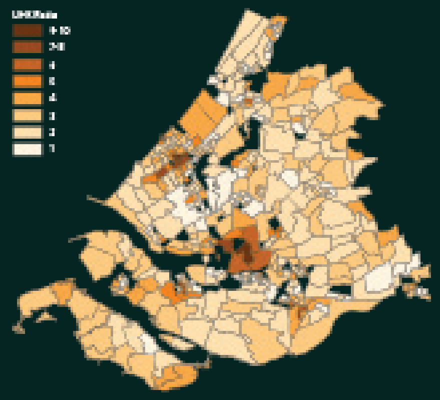


Figure 148: LIHK in South Holland (TNO, 2021)

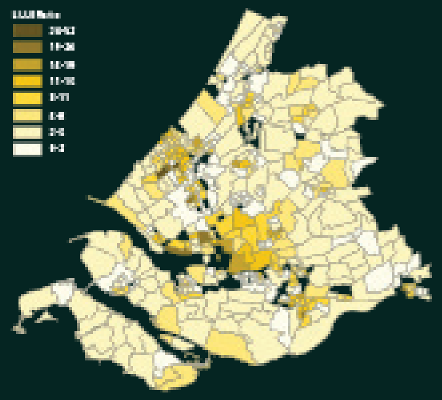


Figure 149: LILLE in South Holland (TNO, 2021)

High Energy Quote (EQ)

This indicator considers a household to be in energy poverty if it spends more than 8% of its income share on energy costs. This standard figure is not the most commonly used figure of 10% as household financial assets are taken into account.

Low Income, High Energy Costs

This indicator measures low-income households with high energy costs. It is defined as households with a disposable income in the lowest 25% of the Netherlands and energy costs in the highest 50% of the Netherlands.

Low Income, Low Energy Label

This indicator measures the low income households with low energy quality. The definition of low energy quality means the energy label of a household is D or lower.

Three sites were selected as pilot projects based on Indicator 2 and 3. When selecting the projects these four steps were followed:

Step I	based on Indicator 3: Low-income areas with low energy quality proportion less then 11%
Step II	based on Indicators 2: Low-income areas with high energy costs proportion more than 4%
Step III	mapping the results from step 1 and step 2 to define potential areas
Step IV	defined 3 locations: City centre, suburb, and port area, to be pilot projects of key the interventions

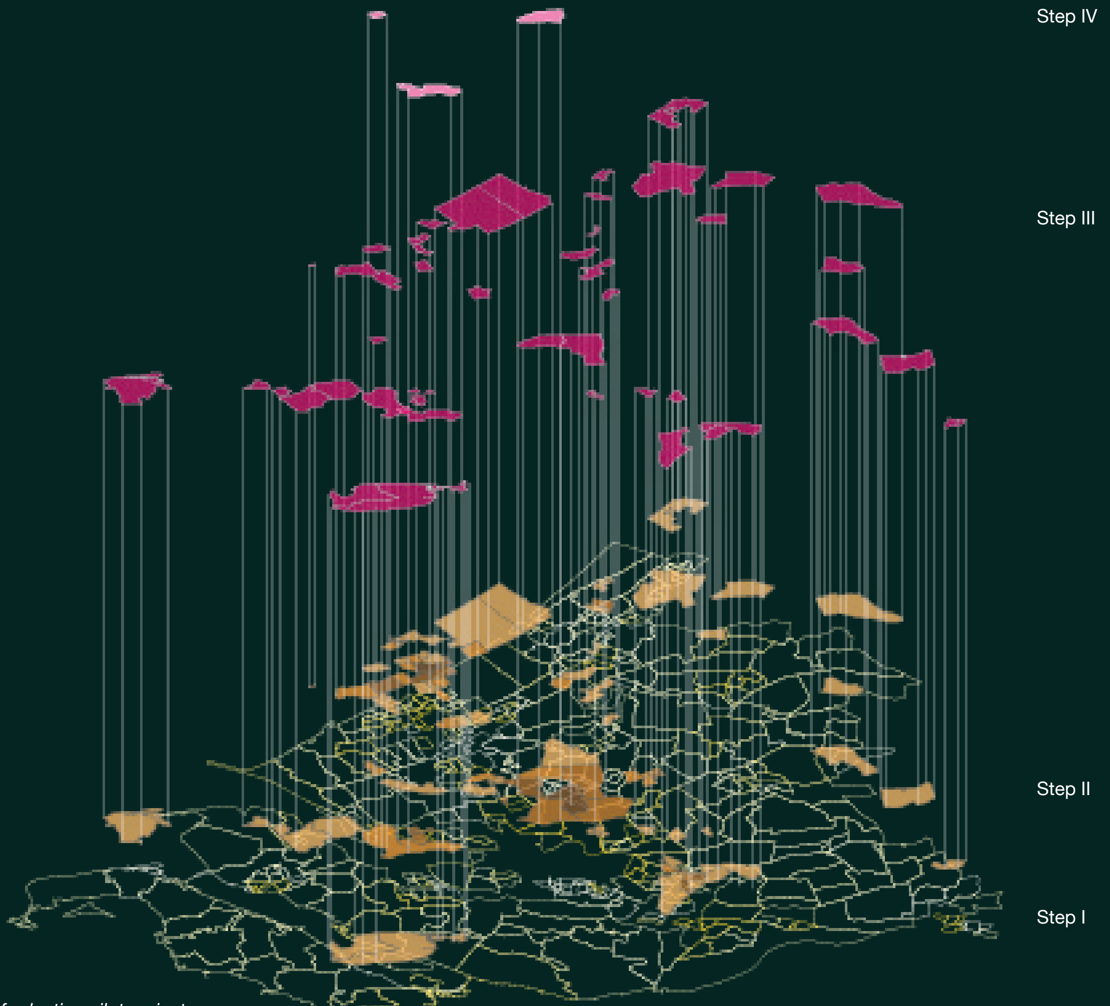


Figure 150: Steps of selecting pilot projects

Socio-Spatial Information

General, socio-spatial information about the three pilot projects can be found on these pages. The most important information will be highlighted.

Noord, Rotterdam

The neighbourhood, right next to the centre of Rotterdam, is quite dense, with 6.669 addresses per km^2. In this dense area, the car use is quite low compared to other neighbourhoods, so it is relatively easy to phase out the cars that don't really park there.

Sluispolder, Maassluis

Most housing was built around the same time, with probably similar lay-outs and building materials. The retrofitting in this neighbourhood can be specialized and realised in a short time frame.

Hekelingen, Nissewaard

This neighbourhood is in a suburban area of the province and has a low density of households. This means that it has great potential to be self-sufficient. There is quite some (free) space is available and there is a low energy demand. The neighbourhood can be energy generator for surrounding neighbourhoods.

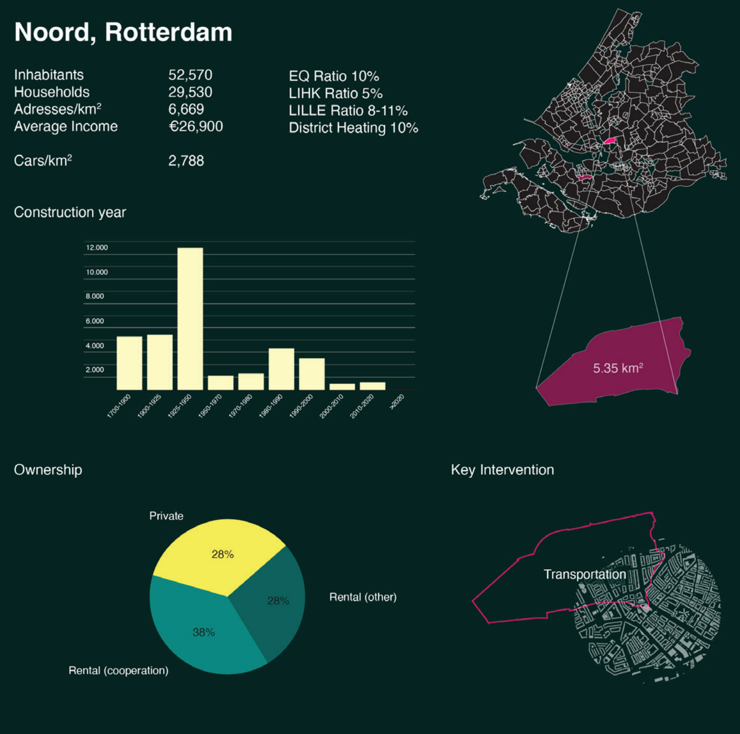


Figure 151: Diagram Rotterdam Noord (Héél véél informatie over wijk Noord, 2022)

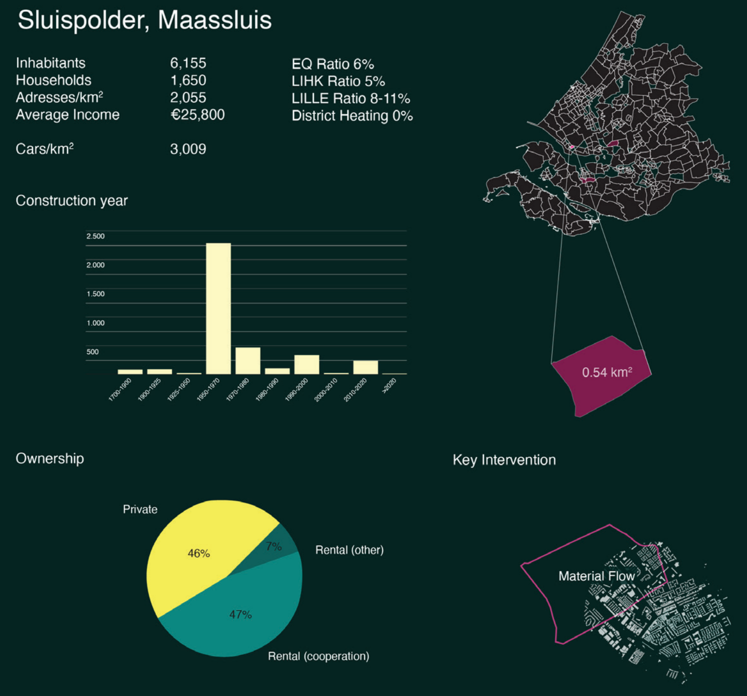


Figure 152: Diagram Maassluis (Héél véél informatie over wijk Sluispolder, 2022)

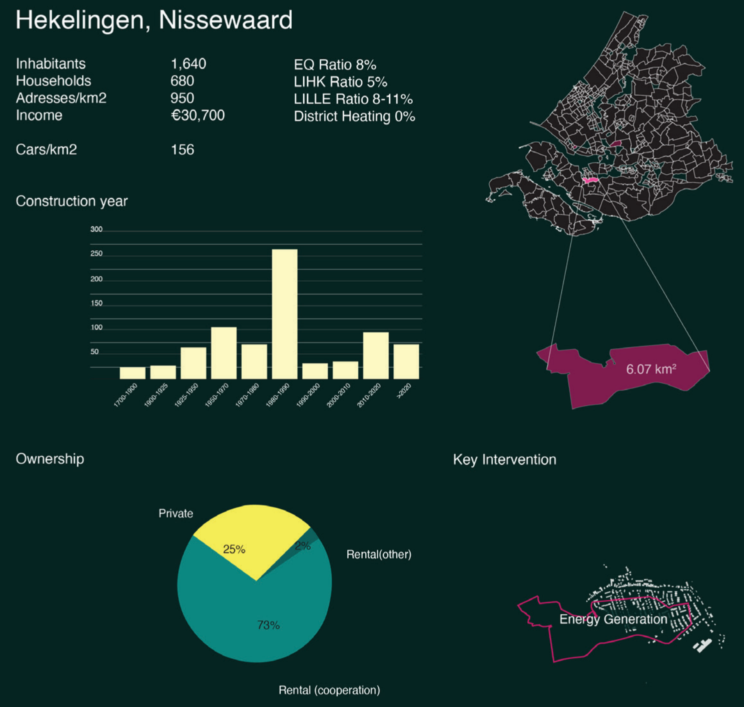


Figure 153: Diagram Hekelingen (Héél véél informatie over wijk Hekelingen, 2022)

4.7.1 Smart City Centre

Rotterdam is a key location for strategic change and improvement of the mobility network towards a sustainable and smart car-free region. Rotterdam Noord has a high population density, if you look at Rotterdam Noord it has 6.669 addresses per square kilometre.

Rotterdam Noord has great potential to tackle the current energy poverty, as improvements are already underway. There is already a tram line, car ownership per household is not that high compared to other areas, so phasing out cars is quite realistic, and the proximity to Rotterdam Central Station and the city centre is very accessible on foot and by bike. Besides this, part of the housing is already connected to an alternative heat network. In Rotterdam itself already some grassroots innovations are in place that provide the sustainable basis for a just transition and governance, making change permanent and thriving and providing good communication for the development of such a transition.

Involved stakeholders: *biking shops, NS, public transport, recycling hubs,recycling companies, educational institutions, small energy companies, innovations, grassroot initiatives, greenery, maintenance, city of Rotterdam, hydrogen company, residents, new mobility companies*

Scale 1:5000

Figure 154: Map of Rotterdam Noord

On the right page Stijn's journey to school, through Rotterdam, can be seen.
If you want to listen to Stijn's story, scan this QR code.

join me on my way to school

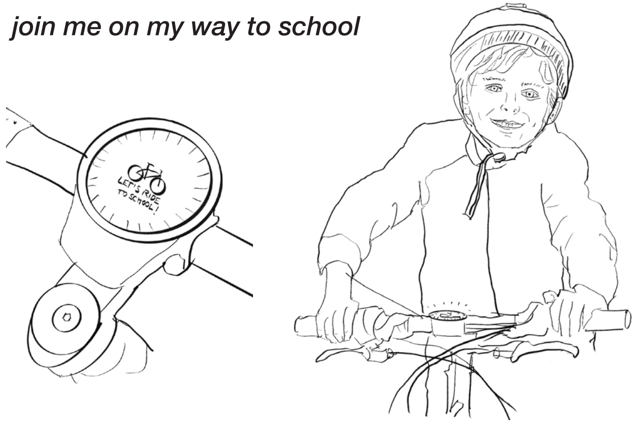


Figure 156: (Afanasyev, 2016)

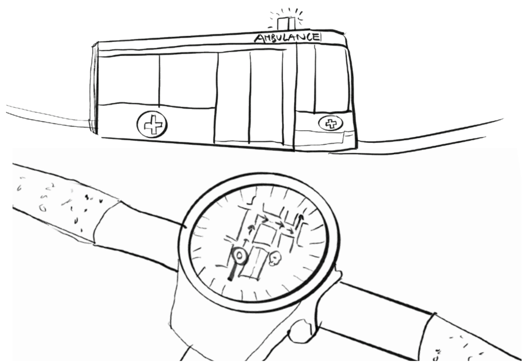


Figure 157: (My Suitcase Travelling,

Figure 158: (Croxford, 2021)

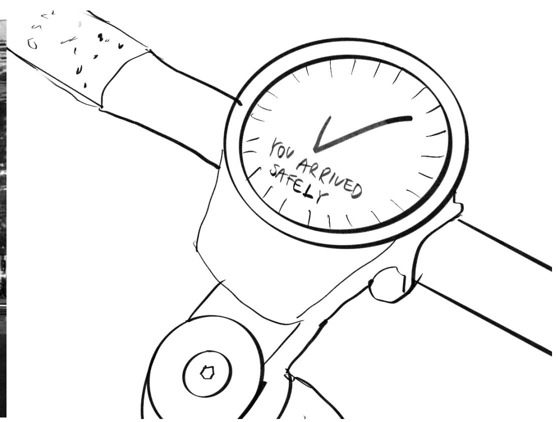


Figure 155: Stijn's route through Rotterdam on his way to school

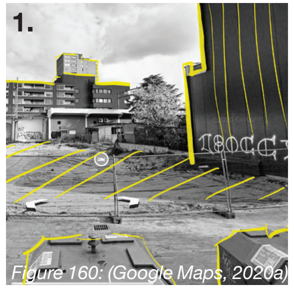
Figure 159: Intervention Map Rotterdam Noord
Scale 1:13.000

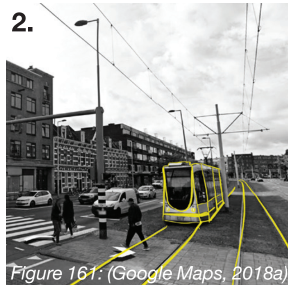
An important first step in the transition, especially in a densely built environment like the city centre of Rotterdam, is to reduce the energy demand through a passive energy system. Biophilic design can improve air quality and the general health of residents as plants provide shade and make the environment more resilient to the extreme weather changes we will face in the future due to Climate Crisis, making the city centre not only more resilient but also more liveable through urban greenery. Greening the area is therefore a starting point for reducing the energy demand and thus the energy bill for the citizens of Rotterdam Noord. To achieve this, more space will be dedicated to green and the current street space will be restructured and redefined by opening up the currently paved streets to open ground and plants.

In this way, the streets will be narrowed and perhaps even closed so that car traffic in this neighbourhood will be phased out. By introducing a better connected and smarter public transport system in the neighbourhood, residents will be given the opportunity to give up their cars. To encourage this process, parking garages will be built at key points of car infrastructure, allowing residents to leave their cars at the edge of the neighbourhood and switch to another form of public transport. Shared mobility can be introduced very well in this densely built environment and will also enable further densification in this area, as this will positively influence the energy distribution and maintain or even reduce the urban footprint of South Holland.
To enable this process, the general use of technology is a foundation for this change. The individual smartphone is used to coordinate and plan the individual transport needed in the city and offers attractive and efficient mobility models to move through it. Fewer cars, more green spaces and weather protection when cycling, will improve the cycling and walking experience in the neighbourhood.

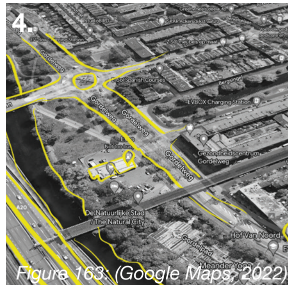
In improving the flow of materials in the city, existing gas pipelines can be repurposed as hydrogen pipelines, integrating hydrogen into the overall energy network. A heat network connecting the city centre of Rotterdam with the port area, which has a large surplus of heat, will also enable smarter energy use and is already under development.

An important step to reduce energy demand is to retrofit houses with new insulation technologies, preferably with renewable building materials such as sheep's wool or horsehair, which have a high U-value and last about 100 years, longer than the plastic insulation that most new buildings are equipped with today. With better insulation, the heat in buildings can be regulated more efficiently. Especially when combined with current smart technology to include it in retrofitting, so that energy use and demand can be linked to the whole neighbourhood, the city and also the port. For example, the excess heat for the port from buildings in the city that need more heat but can generate electricity via renewable energy systems can be self-sufficient by installing solar panels and using the large solar potential in the city centre of Rotterdam. The transformation of housing will also be used to install the necessary technologies to control energy distribution, but also to generate energy via heat pumps and the installation of solar panels on the roofs and facades.


1.
Figure 160: (Google Maps, 2020a)


2.
Figure 161: (Google Maps, 2018a)


3.
Figure 162: (Google Maps, 2020b)


4.
Figure 163: (Google Maps, 2022)

Interventions in Rotterdam Noord

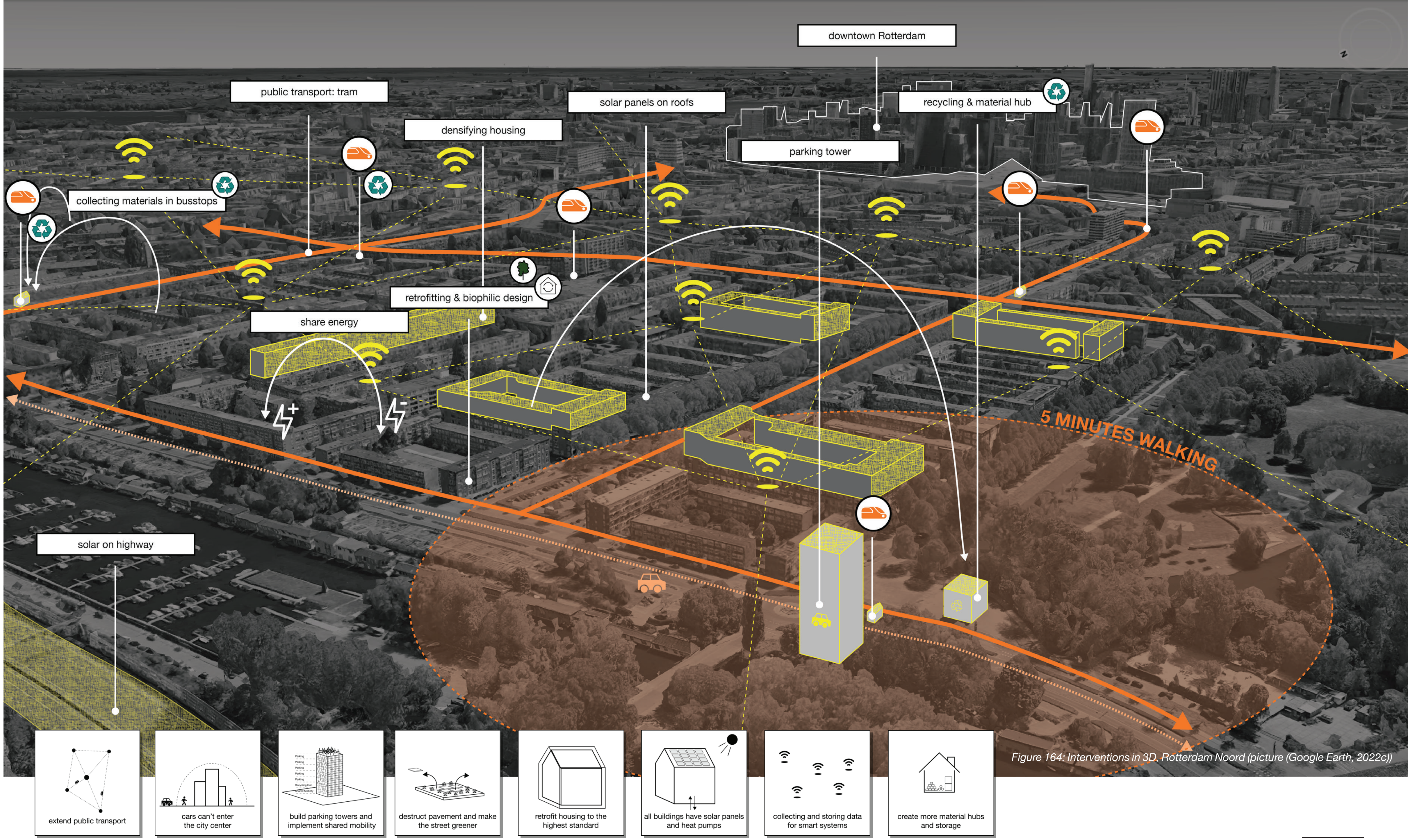


Figure 164: Interventions in 3D, Rotterdam Noord (picture (Google Earth, 2022c))

Bergweg, Rotterdam Noord

Figure 165: Eye-level Bergweg, Rotterdam Noord (base layer (Google Maps, 2021e))

Current Situation

Figure 166: Bergweg, Rotterdam Noord (Google Maps, 2021e)

4.7.2 The Circular Material Port Area

When considering the circular flow of materials used to enable the transition from fossil fuels to renewable energy systems, there is a lot of space that needs to be considered.

Maassluis is a town/village in the port area of Rotterdam. Originally Maassluis was a fishing village, but with the construction of the new canal it is now directly on the main transport river of the Port of Rotterdam and has a nice view of the other side of the river with its industrial landscape/ skyline of a waste treatment plant, the oil storage unit of an oil refinery and also Rozenburg, another small town in the port area. It has great potential to serve as a model for the energy-efficient material flow of recycling and reprocessing materials. In terms of the changes needed for an energy-neutral built environment, the material flow of building materials is crucial. Maassluis already has great potential as an exemplary location.

Involved stakeholders: *manufacturing, industry, recycling companies, agricultural sector, workers, residents, craftsmen, education, chemical industry, Port of Maassluis, Port of Rotterdam*

Scale 1:5000

Figure 167: Map of Maassluis

On the right page Anna's journey to and from the material hub in Maassluis, can be seen.
If you want to listen to Anna's story, scan this QR code.

join me for a day

Figure 169: (Grimbacher, 2022b)

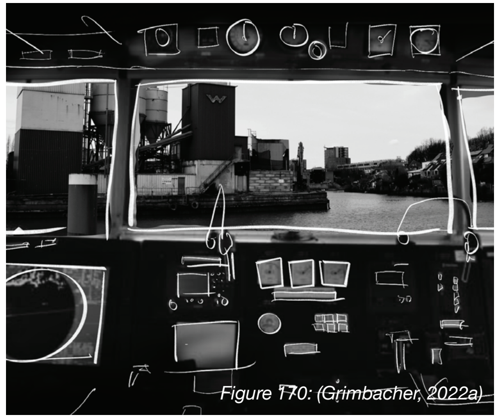


Figure 170: (Grimbacher, 2022a)

Figure 171: (Vertraco, 2019)

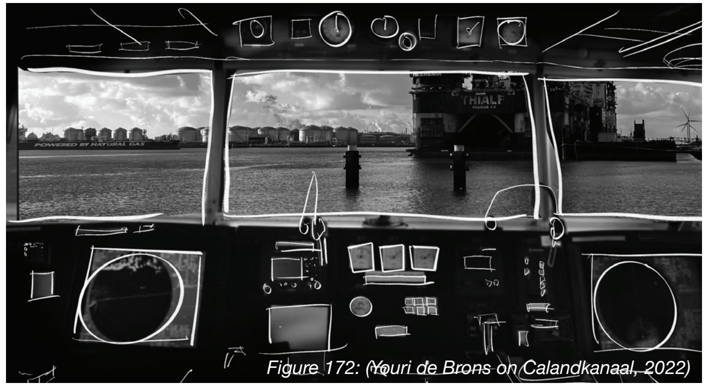


Figure 172: (Youri de Brons on Calandkanaal, 2022)

borrel in the bar at the wasteplant

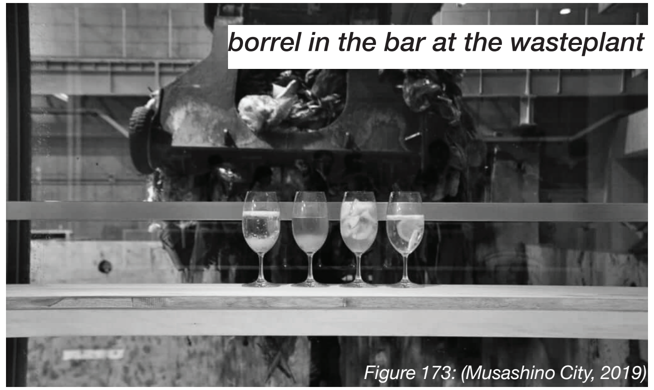


Figure 173: (Musashino City, 2019)

Figure 168: Anna's route on her way, to and from the material hub in Maassluis

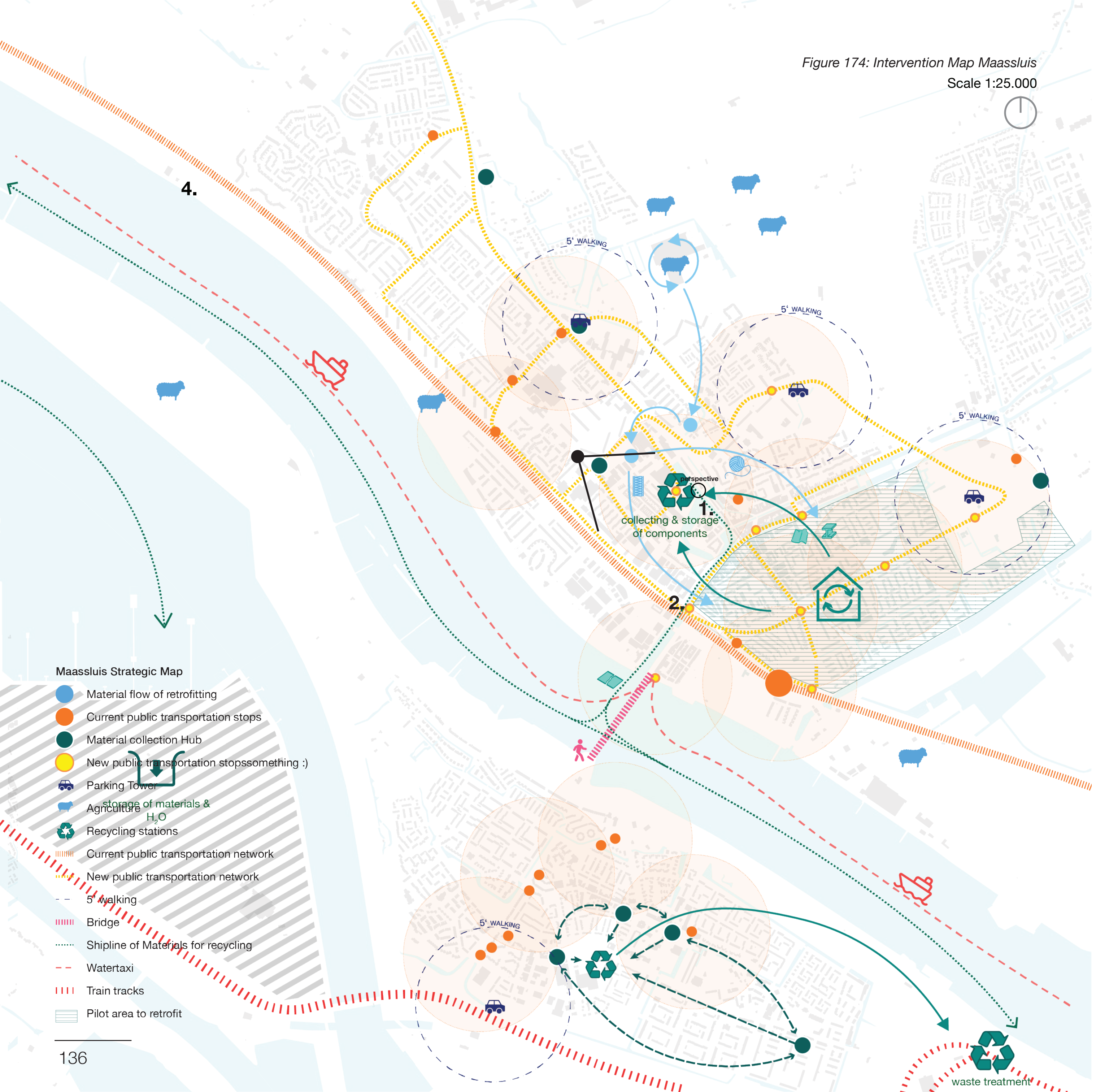


Figure 174: Intervention Map Maassluis
Scale 1:25.000

The city centre of Maasluis already has a materials collection point, a concrete company, direct access for these manufacturers to the port via a smaller city harbour and an industrial zone in the heart of the centre. So there is a direct waterway connection to the waste incinerator across the river and the freed up oil storage can be used to store materials waiting to be chemically recycled.

The transition to a more circular flow of materials for the materials needed for energy retrofitting of houses can be demonstrated very well in Maassluis. The concrete company can transform into a sustainable building materials company, supplying biodegradable building materials to the construction companies and being responsible for the rehabilitation of the neighbourhoods.

Let's start with the Sluispolder neighbourhood, where a high percentage of residents are energy poor, but the built environment also offers a higher energy standard, so improvements can be made whose results are visible in the fairly short term. Time for the transition to a more circular flow of materials and the switch to sustainable building materials taking place in Maassluis. Integration of current craftsmen and industries and support for the transition by providing workshops and educational opportunities to make the transition sustainable.

The current typology of single-storey warehouses in the city offers great potential for the synergy of production functions and the integration of processes for the collection, reuse and recycling of components. But also for the production and recycling of renewable energy technologies such as solar cells, small wind turbines and heat pumps. As the available space in the province is used in a resource-saving way and in a smart energy cascade, the functions have to be stacked vertically.

As a result, a whole new economy is developing in the area, and jobs in Maassluis are taking over from current jobs in the fossil fuel industry. A new agricultural innovation company called "Ieyl" has also set up on the outskirts of Maassluis, creating potential for innovative change in the agricultural sector, but also offering the opportunity to use the surplus sheep's wool as a material for sustainable and renewable insulation, which can be produced in Maassluis itself and then used to retrofit houses in the city to reduce energy demand and combat energy poverty. All of this happens in Maassluis and provides a circular flow of materials on the way to a future without fossil fuels.

1.

Figure 175: (Grimbacher, 2022a)

2.

Figure 176: (Grimbacher, 2022b)

3.

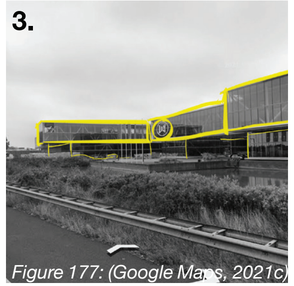



Figure 177: (Google Maps, 2021c)

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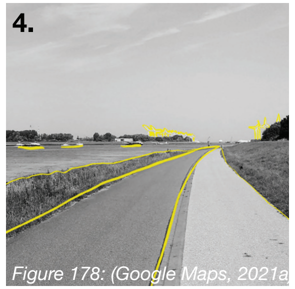


Figure 178: (Google Maps, 2021a)

Interventions in Maassluis

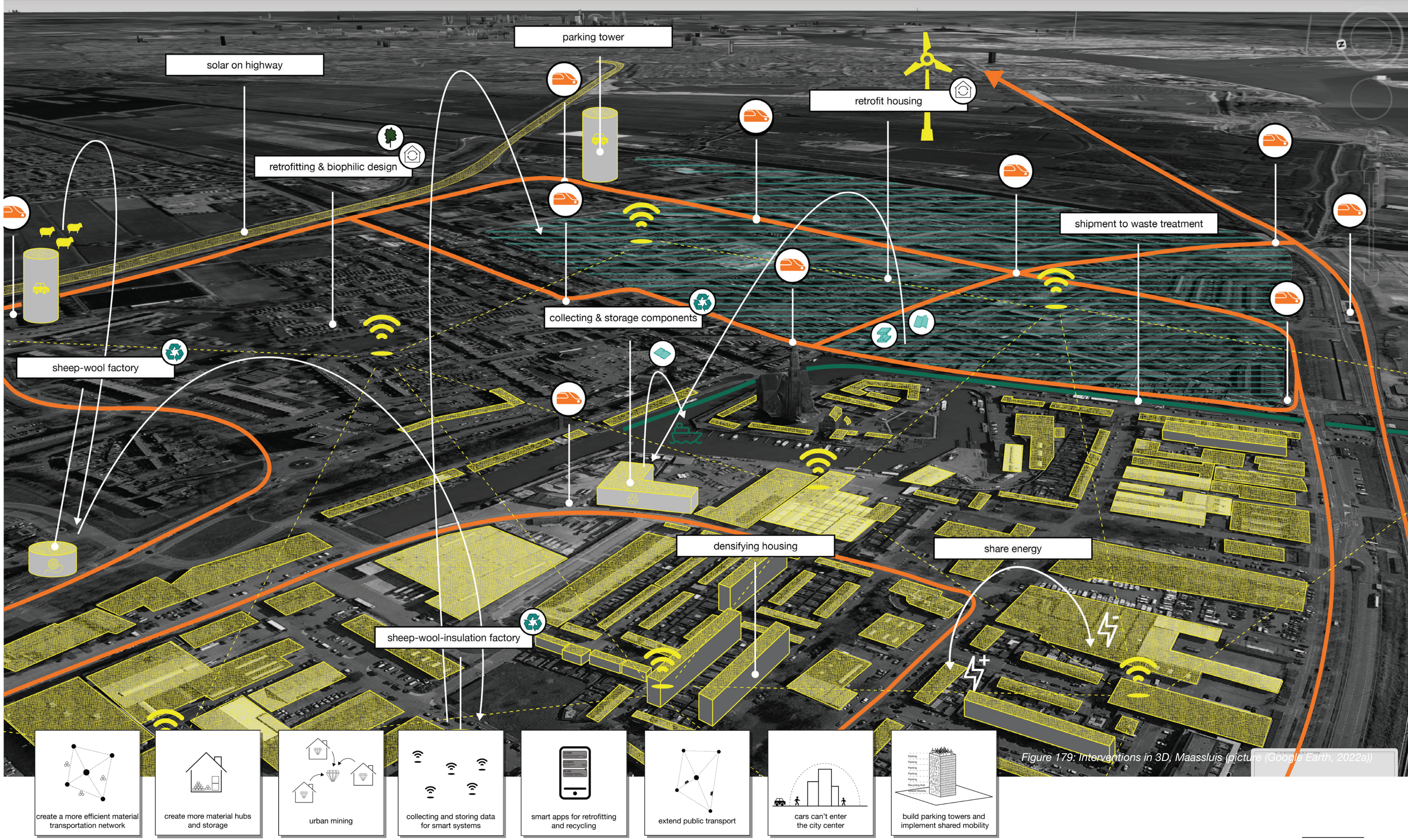


Figure 179: Interventions in 3D, Maassluis (picture (Google Earth, 2022a))

Geerkade Oostzijde, Maassluis

Figure 180: Eye-level Geerkade Oostzijde, Maassluis (base layer (Google Maps, 2015))

Current Situation

Figure 181: Geerkade Oostzijde, Maassluis(Google Maps, 2015)

4.7.3 Self-Sufficient Neighbourhood

One of the main goals of this project is to transition to self-sufficient energy production from renewable energy sources and to integrate energy production into the neighbourhood. Considering the renewable energy potential in the province and the simultaneous fight against energy poverty, the village of Hekelingen has the potential to be a leading role model for renewable energy production in the more suburban areas of the Province of South Holland. Hekelingen is part of the municipality of Nissewaard and today has 1640 inhabitants on 18 m2.

Involved stakeholders: *residents, agricultural, energy companies, public transport, recycling companies, greenery, maintenance, city of Rotterdam, hydrogen company, residents, new mobility companies*

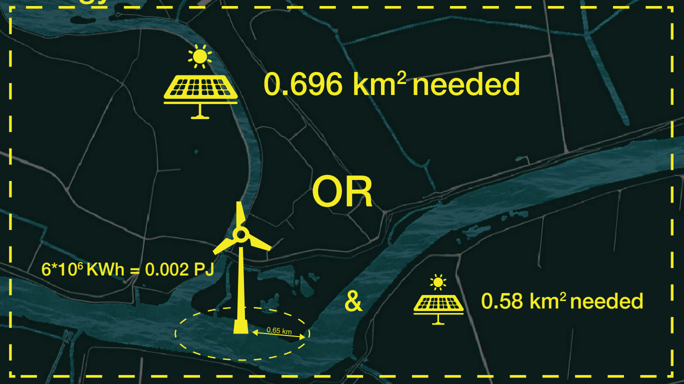
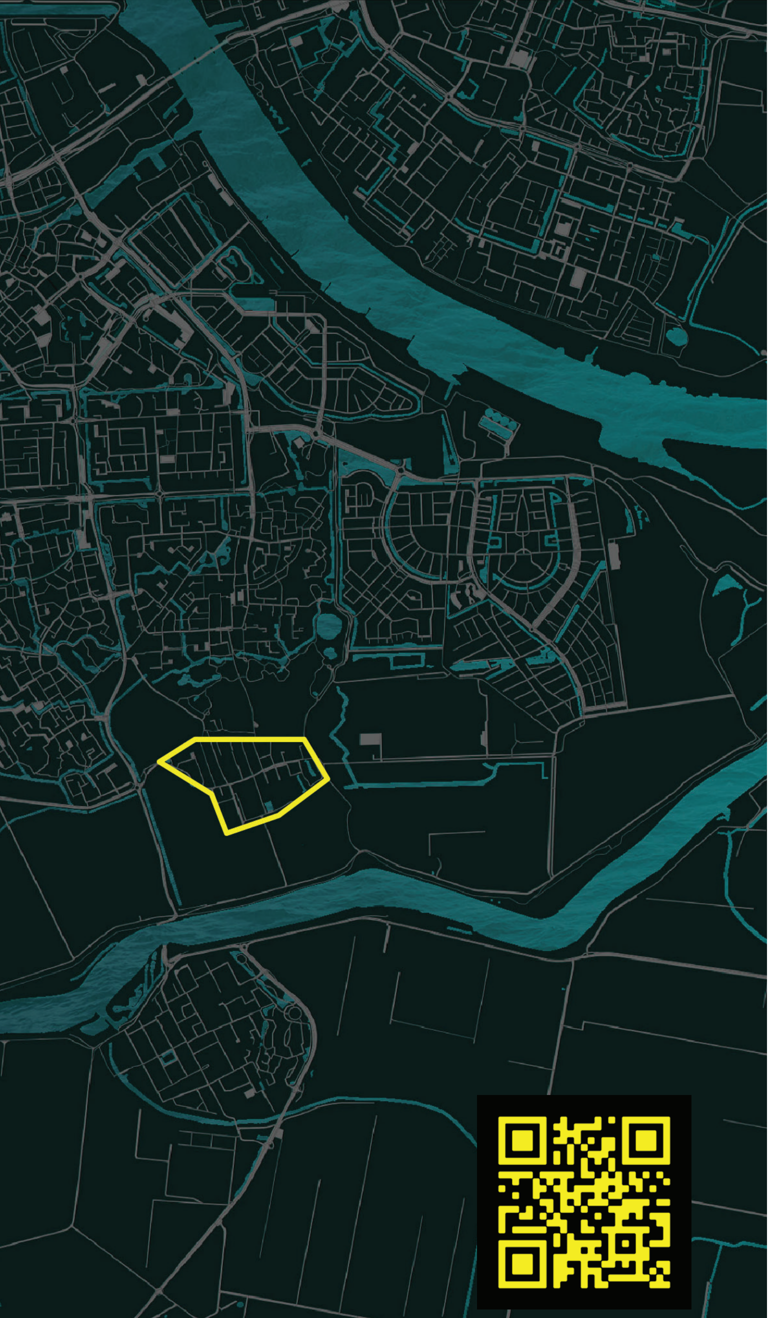


Figure 182: Energy Diagram


Scale 1:5000
Figure 183: Map of Hekelingen

On the right page Daphne's bike ride through the energy scape, can be seen.
If you want to listen to Daphne's story, scan this QR code.

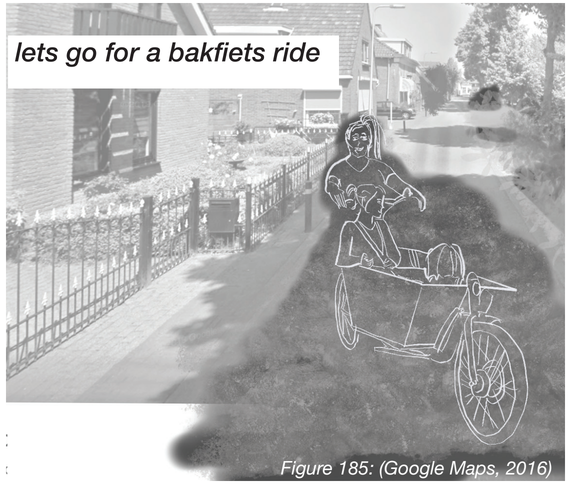


Figure 185: (Google Maps, 2016)


Figure 186: (Google Maps, 2014)

Figure 187: (Google Maps, 2021b)

look - thats where we get our green energy from!

Figure 184: Daphnes 'bakfiets' ride with her kids through the energy scape

Figure 188: Intervention Map Hekelingen

Scale 1:10.000

Most of the buildings were constructed between 1980 and 1990. The average electricity consumption in the village is 3,310 kWh and consists mainly of residential buildings that are not yet connected to district heating. The development of a heating network in the town itself, but also the connection through the whole area of Nissewaard and especially the connection of the heating network with the harbour. The Hekelingen area has great potential for the production of electricity from renewable energy sources, even beyond what is needed for the functions on site. For example, it can be stored and distributed via hydrogen to the port area where it can be used, and in return the excess heat can be used for the residential buildings.

In addition, solar potential can be harnessed by placing solar cells on the roofs of buildings in the city, but also by using the current road infrastructure to generate energy by placing solar cells as a second vertical layer above the road or integrating them directly into the "paved" surface. A small solar farm next to the hydrogen storage facility also provides electricity all year round. When the sun does not provide electricity, wind turbine power generation kicks in, and just one wind turbine can generate approximately more than 6 million kWh of electricity and already produces more electricity than is actually needed. So the potential of Hekelingen to become an energy self-sufficient district can be achieved with some crucial infrastructural changes and existing technologies. Then, the interconnection and synergy with the harbour and its surroundings is crucial to put the city in a sustainable overall picture. The direct connection to the waterway ensures that Hekelingen becomes part of the hydrogen network in the Province of South Holland.

Figure 189: (Facebook, 2022)

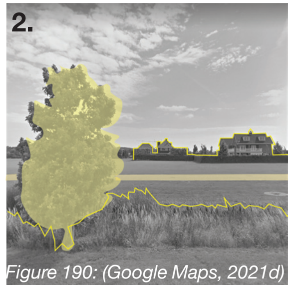


Figure 190: (Google Maps, 2021d)

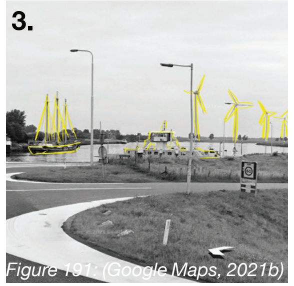


Figure 191: (Google Maps, 2021b)

Figure 192: (Hekelingen, 2022)

Interventions in Hekelingen

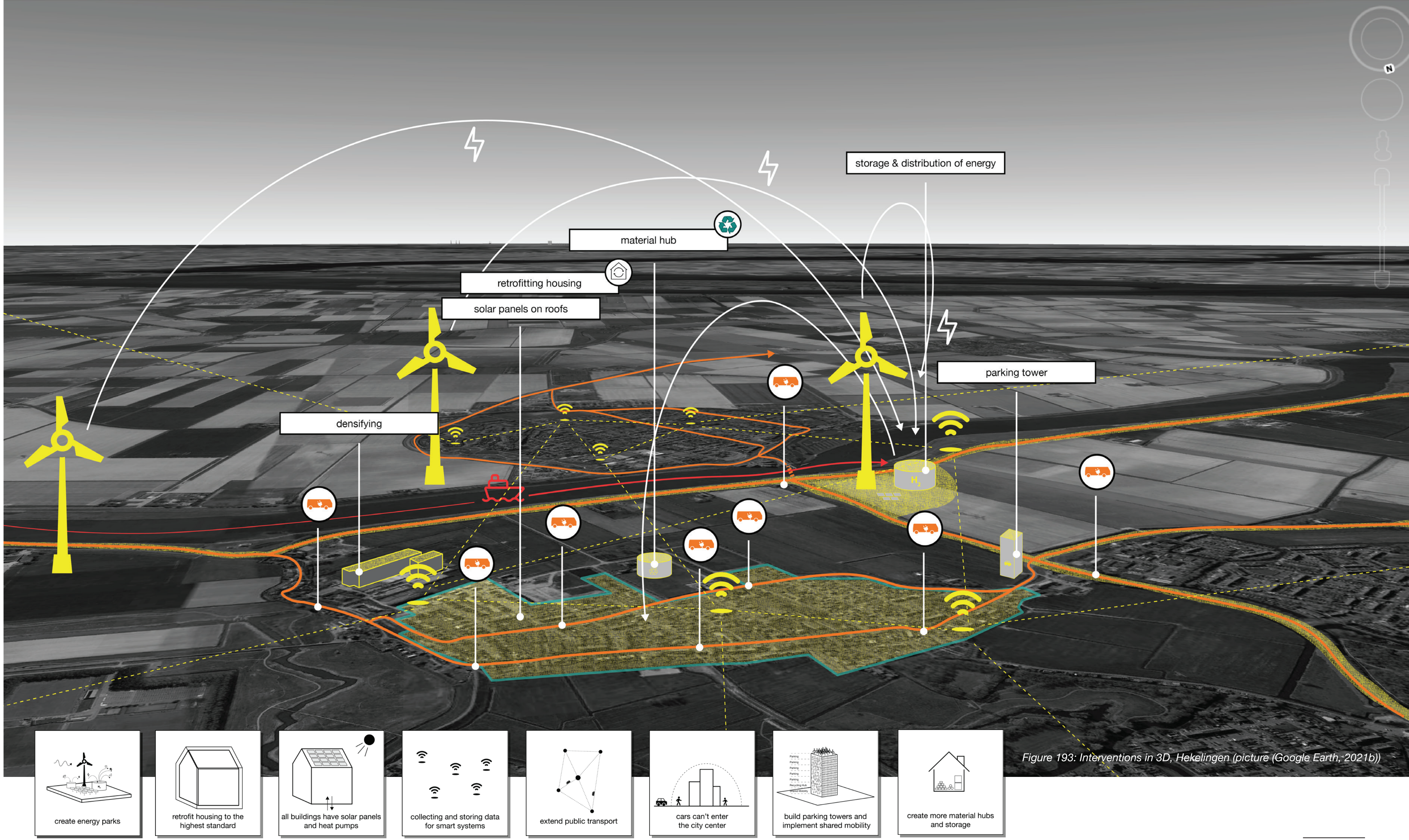


Figure 193: Interventions in 3D, Hekelingen (picture (Google Earth, 2021b))

Groede, Hekelingen

Figure 194: Eye-level Groede, Hekelingen (base layer (Google Maps, 2018b))

Current Situation

Figure 195: Groede Hekelingen (Google Maps, 2018b)

4.8 SYN-ENERGY

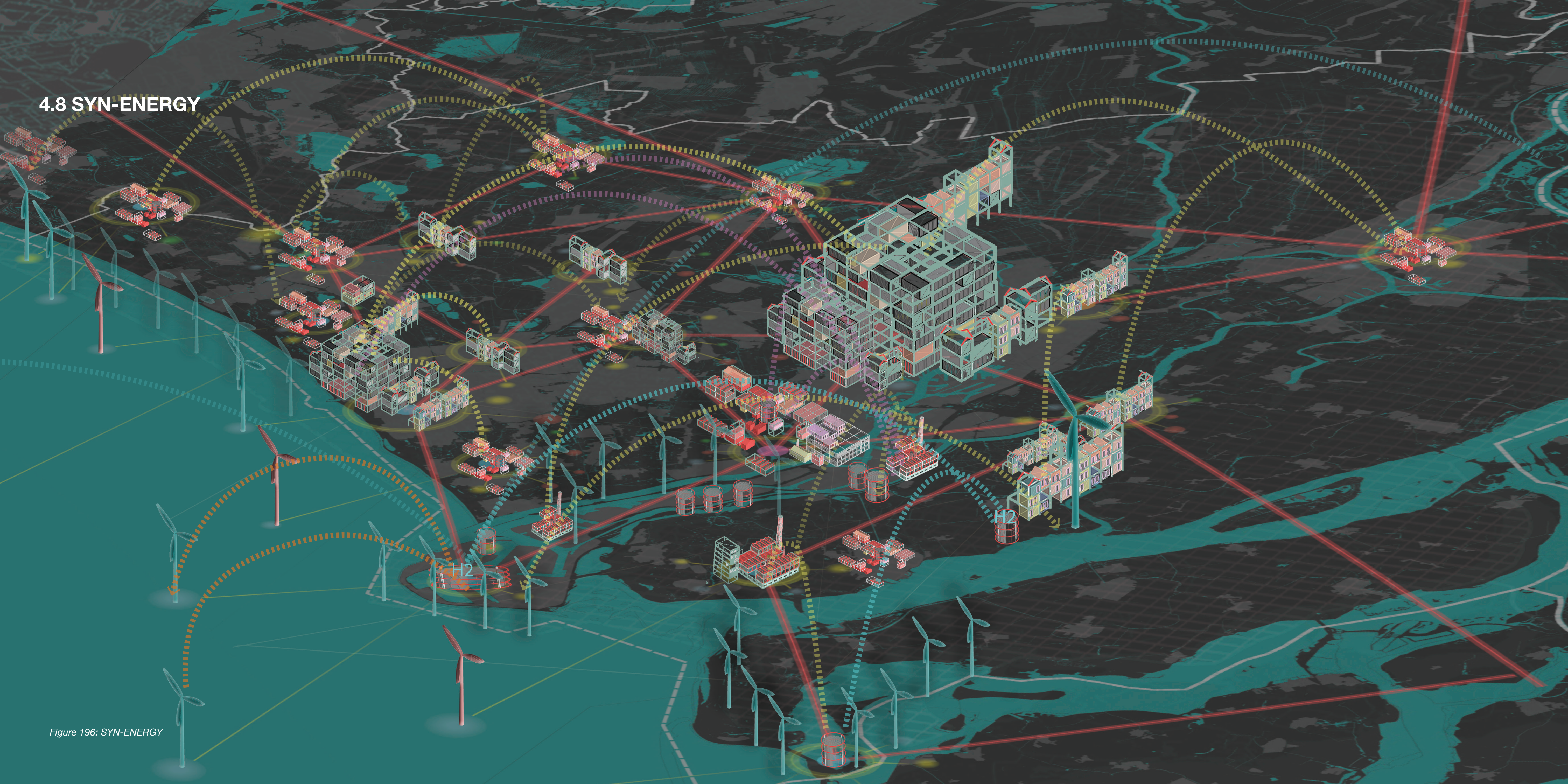


Figure 196: SYN-ENERGY

Figure 197: (Blanken, 2021)

05. Conclusion & Discussion

05. Conclusion and Discussion

05.1 Conclusion

This project was set in motion with the purpose of discovering and proposing a new approach to the energy transition and the goal of the Province of South Holland, to reduce their carbon emissions beyond 95% by the year 2050.

As the group dived into the possibilities of sustainable and “green” transitions towards renewable or locally produced energies for the region, the concepts of fair and just energy distribution, along with the clear role of households and the built environment as energy consumers, the project turned towards the problematic of energy poverty as a systemic driver of social injustice that could connect directly to the energy transition, as its small scale, system-wide implications, throw out of balance the relationships of producers and consumers with literal power.
The prospect of locally generated, renewable energy remained as a main driver of the research-design, as this path kept the potential of engaging consumers with production as it gets closer to them, and it enables them to become producers themselves.

Existing analysis of pathways to follow towards the 2050 goal (Samadi et al., 2016, van Vlimenen, 2021) suggested that the transition towards renewables could only be achieved by reducing the energy demand of the general population, a goal that requires all households to have access to energy efficient appliances and passive and active technologies as those displayed in our Toolbox. Thus, a transition towards locally generated renewable energy depends on tackling energy poverty.

The role of the government as planner and policy maker must also be addressed and discussed, as the recent COVID-19 pandemic showed worldwide, that emergency situations can enable them to take drastic measures for the public good. There can’t be anything more urgent than enforcing the policies and strategies that will help the Netherlands achieve their goal to reduce emissions, in response to the escalating Climate Crisis. Since policy documents and visions tend to have a top-down approach to the transition and the role of energy companies and the government is crucial but not central to the transition, a middle ground where their interests and the needs of the stakeholders meet, must be achieved.

The evolution of the energy flows between current and future demand showed that, while reducing demand is fundamental to enable the transition, in the end it is the systemic transformation of the energy industry, which can really make a decarbonised Province of South Holland possible by 2050. Citizen empowerment and education are key not only to help reduce demand by individual action but also, and maybe most importantly, because their education will allow them to realize their role as stakeholder consumers and how critical energy is to their survival.

The pilots in Hekelingen, Rotterdam North and Maasluis showed how different urban settings can adapt and engage with the energy transition across systems, with Maasluis focusing on synergies between energy, industry and community, Rotterdam focusing on urban synergies between people and energy and Hekelingen, as an example of community-led energy independence.

05.2 Further Research

The topic of energy poverty in policy, research, analysis and visions for the transition was overlooked in general, and those papers that mention the strategies that could reduce it, fail to make the connection, let alone with the role of citizens in the transition, but with the measures, steps, policies necessary to put those strategies in play, unlike strategies developed for the petrochemical industry and the Port of Rotterdam.

Only further interdisciplinary approaches to the energy transition from the point of view of social justice will support the goal of such a titanic task, which is already falling behind.

There are limited sources and research on the topic of raw material recycling as this is still a young industry. Its growth and development are crucial to the transition and to the growth of solar and wind energy, especially if the Netherlands aims to depend less on external sources of materials.

Most documents regarding the potential of renewable energies in the province focus on mainstream technologies whose potential has been proved and is currently being exploited and improved. While wind and solar energy are set to become the main energy sources of the future, other experimental technologies such as algae biofuel and tidal energy, have unexplored, unquantifiable potential, that could diversify local energy production even further. Their research and investment in their growth can be a relief to other production systems. The systemic changes required for the industry will demand a mindset shift not only in consumers but also in the financial dynamics of industries,whose profits will reduce during the transition and have no guarantees of exceeding their current figures, since production would also be lower. The structural challenges of a slower economy must be taken into account in all future research for a just transition.

05.3 Discussion

One great obstruction to the research and development of the project was the combination of limited information directed to the general public and the discrepancies between specialized documents and publications from private, public and academic parties. Information regarding the actual yearly production, demand, supply and consumption of energy in the region does not have unified measures across providers and supervisors. Inaccuracies in measurements and scales made the task of pinning down basic facts extremely time consuming and led to the assumption of estimates. While academia and the Research & Design Studio are institutions dedicated to this type of research, the process has proved to show how difficult it is for the general public to access general information about such an elemental matter.

On the topic of the material flows, it became difficult to define which side of them, if the flows of energy production components or the flows of materials for the efficientization of the built environment, would be more relevant to the transition. While the recycling of raw materials and components is mentioned in literature constantly, it is an underdeveloped industry and in the meantime, the strategies and technical information required to support and fuel the energy demand reduction of the built environment are overlooked and left out of mainstream publications and policy. Again, this calls for more, interdisciplinary looks into all the dimensions of the transition.

05.4 Assessment SDG

This project's main mindset is followed by SDG Goal 1, no poverty, and Goal 7, affordable and clean energy. Everyone should have the right to access energy equally and affordably. Three pilot projects were chosen with the energy poverty crisis and the interventions were addressed with three different perspectives, which are also followed by the other goals set in SDGs, to build up our final vision " Syn-Energy, A just and fair energy transition towards a fossil fuel-free province of South Holland." See the detailed explanation below.

Directly connected and used in three pilot projects:

Figure 198: SDG Rotterdam Noord

Goal 1 NO POVERTY: refer to the definition from TNO, pointing out energy poverty neighbourhoods for further approaches and intervention so that South Holland can go toward a no energy poverty province in the future.

Goal 7 Affordable And Clean Energy: "Ensure access to affordable, reliable, sustainable, and modern energy for all," which is the main objective of this project. This project underlines the possible reasons which could lead to a more severe energy poverty crisis, and the consequence is pointed out with further potential intervention.

Goal 11 Sustainable Cities And Municipalities: Increased the cooperation in multi-layer governance. Three pilot projects are set based on this goal for future cooperation with other layers' planning as a reference. Besides, urban settlements are sustainably included in local energy production and integrated into an intelligent energy distribution network, as shown in pilot project three.

Figure 199: SDG Maassluis

Goal 12 Responsible Consumption And Generation: The present project approaches this goal through not only the responsible use of energy and participation in energy generation but also through the flow of materials in the energy landscape by creating more local recycling stations, as shown in the pilot project two.

Goal 9 Industry, Innovation, And Infrastructure: Research institutions in South Holland play substantial roles in developing and promoting innovations to create and improve renewable energy production. Besides, infrastructure in the province is strengthened and made more inclusive and efficient—for example, repurposing oilscape areas and pipelines; improving transportation systems in the city centre, as shown in pilot project one.

Figure 200: SDG Hekelingen

Other linkages in this project in strategies:
Goal 4 Quality Education: Creating quality education is the foundation for any intersystem change. This project's emphasis on educating society in intelligent technologies, sustainable architecture, retrofitting, and retraining workers in the fossil fuel industry to transition to various renewable energy jobs is critical to development.

Goal 8 Decent Work And Economic Growth: this project will ensure a sustainable transition away from the fossil fuel industry while recognizing economic stability and the importance of the province's agricultural and chemical industries. The transition will provide work for all in an inclusive manner.

Goal 13 Climate Activity: This project addresses an urgent action is to phase out fossil fuels to reduce greenhouse gas emissions in the Province and create a sustainable material flow.

Goal 16 Peacefulness And Strong Institutions: An inclusive, strong, and active society in South Holland is critical for a fair and inclusive transition.

Goal 17 Partnership For The Goals: Collaborations and partnerships between companies, local and national governments, as well as citizens and housing corporations, is the key method to the swift transition in energy governance, as shown in chapter 4.

05.5 Individual Reflections

Mariana Bobadilla García

This process has taught us a lot about energy and energy systems and now I'm aware of how crucial the energy transition is to the survival of humanity, but it also seems like a far-fetched dream for a very particular section of the world's population and its industries. The topic of how achieving 0% emissions by 2050 nationally will not affect the emissions of the rest of the world directly is not ever mentioned throughout the paper, because the regional vision is intended to concern only the Province of South Holland. While the Port will become a global leader in alternative energy and hydrogen production, and it will lead research, development and knowledge to be transferred into other regions of the world, it will be one of the next decade's greatest challenges, to translate the strategies from such a privileged, specialised area to other energy hubs across the world, to ensure the survival not only of the world's population but even just of the Dutch people.

The challenge of acquiring the information for this project is worrisome when considering the common belief that inhabitants of the Netherlands can become producers if so they desire -or so I believed- however information dissemination about the sector and the transition seems still reserved for medium to large energy producers. One last problem is how sectorized and specialised the transition looks, so disconnected from any other institution that will be affected by it, without which the transition seems unlikely.

Back to "How do we achieve an energy transition?," we achieve it, for as cheesy as it may be, together. I am critical of strategies that begin with individual change but I agree that structural change, especially in systems reticent to it, requires public pressure that can only happen through an informed, concerned society. As energy poverty affects our quality of life directly, informing citizens of its close proximity to their realities can trigger them to engage with climate action and finally with the societal compromises and challenges that the Climate Crisis demands of us to survive it.

Kuan-Ting Liu

During the research, I was really shocked by the fact that the energy bill is getting so high that it almost doubled prices. And at the same time, realizing that one of the tenth people in the Netherlands is suffering from energy poverty, I never thought of how much proportion they could be and never thought of this thing happening around our lives. In the midterm, our group goal was to generate 100% renewable energy, which means before we started to research the energy poverty crisis, I had not noticed that most existing planning focused too much on economic development. And even though there is a discussion from a social perspective, they are only related to the outcomes of phasing out the fossil fuel industry. To be more specific, there is no national framework to follow is another shocking point that underlines how this inequality is being neglected in society. Indeed, economic growth in a country will directly influence ordinary people's daily life. But if the ambitious goal set in 2050 is to reduce 95% of greenhouse gas emissions and phase out 100% of natural gas heating in households, how could we ignore the fact that society cannot be fully involved in the transition process because not everyone has the same ability to invest their household transition without considerate subsidies and policies supported.

There are some questions I was thinking about in this whole planning process. First, I wonder how much our project can input to this unseen crisis in the energy transition process. This large-scale strategic planning seems like a principle for more detailed planning to follow, but how far we should push is not clear. Also, when the social issue becomes the whole core, it is hard to set up how much spatial intervention could change this "structural" problem. And maybe because of these two questions that might also come from the situation without a top plan (national framework) that we can refer to. So it also links to another question, wouldn't this plan (top plan) also come up by us, "the planner," first so that others like policy-makers can follow?

Finally, during the whole digging data and number process, I found out that the information on energy transition is not friendly for ordinary people. For example, many reports and websites misused "energy use" to describe energy consumption and supply. Besides, energy consumption can also be divided into primary energy consumption and final energy consumption. And a bunch of units used in the energy terms is complicated for people who do not understand the realm. Even if we who might have more experience and privilege in learning are being confused by unspecific terms used in energy planning, how could we expect that ordinary people would have the enthusiasm to understand it?

Elena Grimbacher

How can a just energy transition be developed? That was the question that accompanied me throughout the project, and more questions arose during the project.
For me personally, it was difficult to create a visionary vision based on the current state of research. I know that a lot of research has already been done in the field of energy transition and many different strategies and plans, regulations and visions have been developed. However, when looking at the current figures of increasing energy demand and the growing urgency of the climate crisis, all these goals and approaches do not yet become clear. In Renee Rotmans' presentation on the Port of Rotterdam, it was noted that the port has already started many projects dealing with the energy transition and digital transformation, but that the social transformation is still pending (Rotman, 2022). There is no overall strategy on how to actively involve civil society in the transformation, but I think a participatory planning process would be crucial to make the transformation fair. However, how this activation could be concretely implemented remains a big question mark for me, because when I discuss this topic with friends and fellow residents, I find that they don't want to give up the privileges and lifestyle that the "fossil energy supply" offers them. Cooking with gas, driving a fast car, taking long hot showers. It is clear to me that in order to realise our vision and implement our proposed strategy, not only is a systematic change in politics and administration required, but also our current lifestyle needs to change. My lifestyle and the way I perceive my environment should also change. But then I also think about changes in regional planning and how my small changes and actions can make a difference in the big picture. Also, Carola Hein mentioned in her presentation that the port of Rotterdam will be one of the last ports to trade fossil fuels (Hein, 2022).

When I think about this 'just' change in the energy transition, I ask myself at the same time about my role as an urban planner and as a student - what is my individual role in the energy transition? While researching, I realised how much TU Delft is already doing for the change, especially in technological and digital terms. As mentioned in the brochure "It's a deal" of the methodology course, the Dutch government is currently focusing more on these potentials than on social change (Rocco, 2022).
During the development of this project, the war in Ukraine started. Russia is violating basic human rights and values and borders that until a few weeks ago I believed formed a stable and common basis for a just and global energy transition. How can we plan for the future when nations like Russia don't even consider human rights? Who develops these rights? If human rights are a common right - isn't affordable and accessible energy also a human right? What right is currently being violated by the non-provision of energy? And why is there no common definition of energy poverty? How come this issue is not addressed in the SDS and Capita Selecta presentations? I realised once again how finely everything is interwoven and how strongly it is connected, how there are synergies. Regarding the energy transition, however, I think that the war and the crisis can bring about great leaps in change. When gas prices go up and the current dependence on fossil fuel countries, like Russia, becomes more obvious to everyone than ever before. It is the already energy-poor households that will suffer the most from this crisis, and this is a systemic problem that needs to be addressed urgently. All these big questions were triggered by the start of the war and linked to the problem statement in this regional strategy project.

Emma Tulp

Let me start with the fact that I really enjoyed the project! I really liked the fact that we designed on a bigger scale than before. This more conceptual way of thinking really interests me.

I will start this reflection discussing the sketches, thoughts, and frameworks we did as a group which later proved to be crucial in developing the vision and strategy. In the first weeks of the project, we were a little lost, we talked a lot, had nice ideas but it didn't really get us somewhere. On Alexander's recommendation, Elena and I drew sections for all the separated layers of which we could think of. This can be seen as the first step, Remon Rooij described in his lecture on February 7th, of making a generic framework for regional development, 'exploring and deciding on regional design alternatives, or experimenting' (Rooij, 2022). This resulted in the base of the vision we presented in the midterm presentation.

I, and I also think the rest of my group, were very happy about what we presented in the midterm presentation. However, we struggled a bit on how to proceed after this. We didn't know what our goal was in the project and had a small identity crisis. But after a reminder in one of the tutorings, we remembered we wanted to accomplish a just energy transition. Marcin underlined this idea in his lecture about vertical governance. If you want to change something in society, it needs to be in the public sector, private sector, and the civil society. A change is needed in both the policies of the government, as in the participation of the citizens (Dabrowski, 2022).

We researched the accessibility of energy and looked up the term 'energy poverty'. We discovered that we are also energy poor. This fact became crucial in our strategy after that. If we wanted to accomplish a just energy transition, we needed tackle the problem of energy poverty.

A big part of this project is working in a team. Before we started as a group, in the first talk we had with each other, each one of us stated what our strengths and weaknesses were. As Remon Rooij stated in his lecture on February 22 (Rooij, 2022a), this helped a lot in functioning well as a group. Not only because we knew the strengths and weaknesses of each other, but also because we created a safe atmosphere where it was okay to show your weaknesses, ask for help and support each other.

During this quarter I discovered that there is more fundamental problem than "only" the transition to renewable energies, the problem of energy poverty. When thinking of the Netherlands, poverty doesn't often come up, but this depends on the definition you use. Perhaps it is not quite in the nature of the average Dutch person, but I think that giving the Dutch Government more power in making her own decisions, can be beneficial in this case. It can result in a fast shift towards no more energy poverty, with changes in policy and more subsidies.

Figure 201: (de Brons, 2022)

06. References

06. References

06.1 Annexes

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Figure 202: (Minderhout, 2005)

07. Appendix **172**

07. Appendix

07. Appendix

07.1 Interesting Numbers

1 PJ= 10^{12} J ; 1 GJ= 10^{6} J ; 1kWh= 0.0036 GJ

1 wind turbine onshore (2.5-3 W)
=6000000 kWh/year =0.028PJ/ year

1 PJ needs
solar energy= 4km²
wind energy=26.2km²;
biomass=47.5 km²

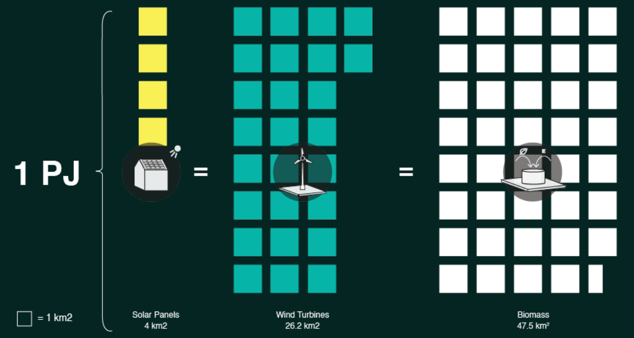


Figure 203: 1 PJ Renewable Energy

Energy consumption in South Holland in 2019 =731 PJ Needs
=9 times of Rotterdam area only by solar energy
=60 times of Rotterdam area only by wind energy
=107 times of Rotterdam area only by biomass energy

Figure 204: Supplying PZH

Total energy consumption per household is almost 97 GJ. If including all the production and distribution processes then the average energy consumption per household is 257 GJ.

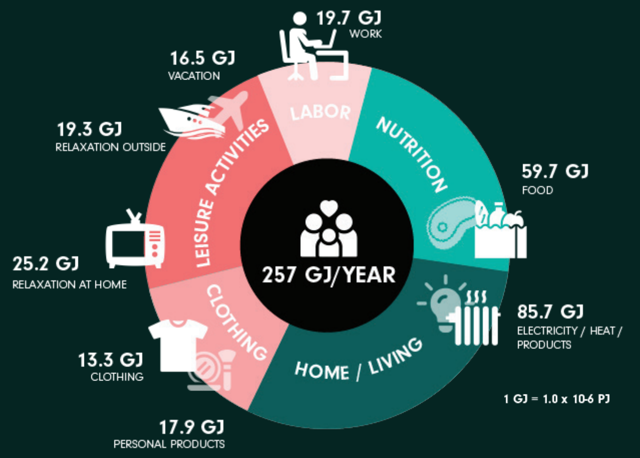


Figure 205: Energy Use Family

If every household reduces 8% of energy consumption, then it can reduce 10% of energy consumption in South Holland a year; 8% of energy consumption per household is around 20GJ.

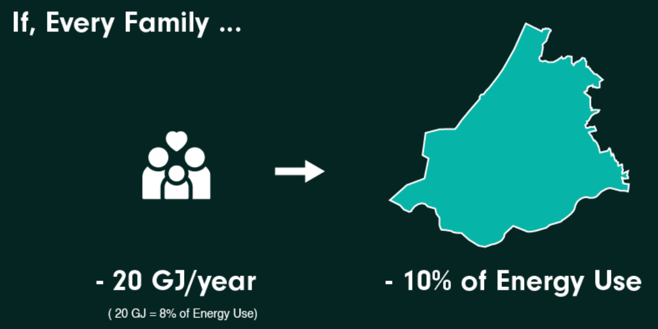


Figure 206: Decrease in Energy Use Family

The energy bill can be divided into two main parts, one is electricity bill, and the other one is gas bill. And inside each part included fixed transportation costs, fixed delivery costs, variable delivery costs, ODE costs, and an energy tax. The largest change is in the variable delivery costs, for example, the variable delivery cost in 2022 increased by 346.2% in gas and 347.6% in electricity.

	January 2022 (euro)	Price change compared to January 2021 (euro)	Price change compared to January 2021(%)
Gas, transport costs (fixed)	191	3	1.60%
Gas, delivery costs (fixed)	73	3	4.30%
Gas, delivery costs (variable)	1398	1096	346.20%
gas, ODE	122	2	1.60%
Gas, energy tax	514	21	4.20%
Total annual gas amount	€ 2,298	€ 1,125	93.80%
Electricity, transport costs (fixed)	267	10	3.90%
Electricity, delivery costs (fixed)	73	1	1.40%
Electricity, delivery costs (variable)	785	625	347.60%
Electricity, ODE	91	2	2.10%
Electricity, energy tax	110	-176	-59.80%
Total annual amount of electricity	€ 1,327	€ 462	51.50%
Energy tax refund (-)	825	266	47.60%
Total energy bill	€ 2,800	€ 1,321	86.00%

Figure 207: Energy Bill

The average energy bill per household in the Netherlands in 2020 was 1,574 euros. And the average energy consumption of natural gas per household in South Holland is 1080m³; the average consumption of electricity is 2690kWh. If using this number as the assumption[1)], then reducing 8% of energy in electricity and gas can save around 126 euros a year. It is to say, the average time for households needs to reduce 40 minutes a day of electricity, and reduce 3 m³ of natural gas a day (2.5kWh/day).

		Average Consumption of Natural Gas (m3)	Average Consumption of Electricity (kWh)
the Netherlands	2016	1300	2910
	2017	1240	2860
	2018	1270	2790
	2019	1800	2730
	Average	1402.5	2822.5
South Holland	2016	1120	2770
	2017	1080	2730
	2018	1100	2670
	2019	1020	2590
	Average	1080	2690

Figure 208: Energy Price

This number is based on average natural gas use per household, but the different sizes of households use different amounts of natural gas per hour. To be more specific, one 10 m² room needs approximately 1kWh to warm up at a suitable temperature in the room while a 30m² room needs approximately 3 kWh[2)].

[1)] the energy bill in 2022 has many different influence factors that the price increase 86% compared to the previous year, number to calculate the approximate saving price could be in a household.
[2)] Calculation Part

1. Formula:
    1)BTUs needed per hour= (desired temperature change in Fahrenheit) x (cubic feet of space) x 0. 133
    2)Temperature conversion formula: °C x 9/5 + 32 = °F
    3)1 m3 = 35.3146667 cubic feet
    4)1 BTUs =0.000293 kWh
2. Based on a 10m2 room:
    1)Change 12 degrees Celsius needs 3045 BTUs needed an hour, approximately 0.89 kWh
        3,045 BTUs = 21.6 x 1060 x 0.133 ; 3,045 BTUs ≈ 0.89 kWh
    2)Change 15 degrees Celsius needs 3806 BTUs needed an hour, approximately 1.11 kWh
        3,806 BTUs = 27 x 1060 x 0.133 ; 3,806 ≈ 1.11 kWh
3. Based on a 30m2 room:
    1)Change 12 degrees Celsius needs 3045 BTUs needed an hour, approximately 0.89 kWh
        9,130 BTUs = 21.6 x 3178 x 0.133 ; 3,045 BTUs ≈ 2.68 kWh
    2)Change 15 degrees Celsius needs 3806 BTUs needed an hour, approximately 1.11 kWh
        11,413 BTUs = 27 x 3178 x 0.133 ; 3,806 ≈ 3.34 kWh

07.2 Starting the Conversation

Explanation of Figure 'Turning Off the Heat'

This image represents a number of things what the project is about. By turning off the heat,

energy poverty will be reduced.
the energy demand will be reduced.
society will be more aware about
the Climate Crisis.

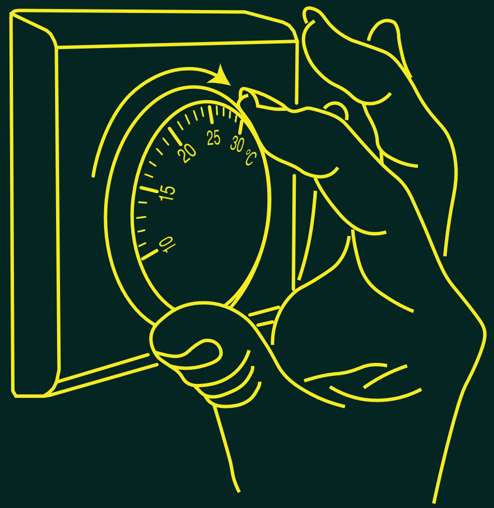


Figure 209: Turning Off the Heat

Figure 210: Energy Poverty

'What Will Happen If We Do Nothing?'

By putting ourselves in the situation in a funny way, the problem is more relatable. When showing this picture to fellow-students, they laughed at the picture but the message came across.

Visionary Instagram Story

During the Methodology Course, these Instagram stories were made. These show a visionary image of 'How change can look like?'.

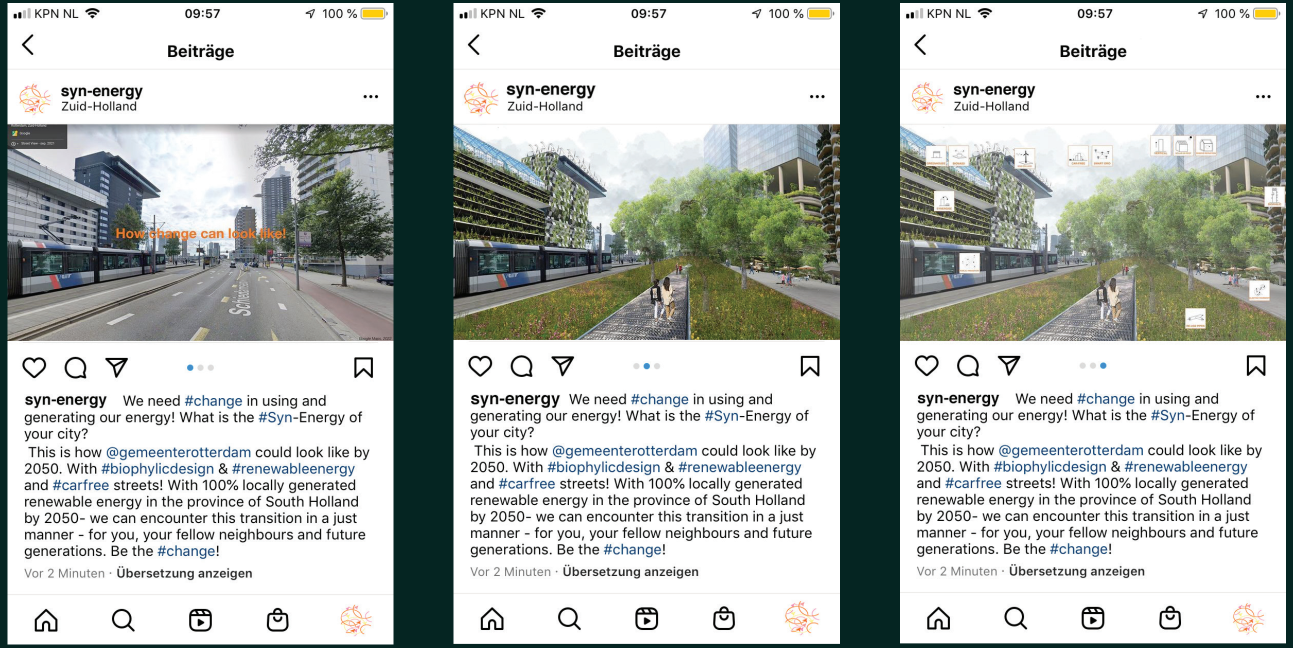
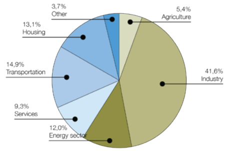


Figure 211, 212 & 213: Visionary Instagram Stories

07.3 Assessment of Vision

During the development of the vision, thematic sections were made which eventually led to the vision. In the chart on the right, the main outcomes of the different layers are stated.



	Vertical farming	Automated industry	100% renewable energy	Clustered services	Car-free city	A++++ insolation
Green	- No more greenhouses -> a greener 'Westland'	- Less commuter roads needed -> industry is surrounded by green	- Less green	- Biophilic design (better microclimate & less heat)	- Green in the city	- Green facades & roofs
Transportation	-	- Industry: Boats & trains - City: logistic hub underneath the city?	- Solar in & above roads	- Connect the port better through public transport	- Parking towers around the city - Everything on tracks with cover (for water & solar)	- Better train connections; no cars
Energy flow	- More diverse	- Industry need big batteries - Windturbines in the forest, ex. Schwarzwald	- Small circles connected to grid	- Synergy: service 9h-17h, housing 17h-9h - Different energy circles in clusters	- Making methanol for the industry with CO_2 & energy	-
Energy generation & storage	- Biofuel generation - Heat synergy: data center -> greenhouse -> housing - Heat synergy: industry -> greenhouse	-	- Solar panels above roads; roads generate $E_{kinetic}$ - Storage in car batteries - Production in other countries (with more sun & wind)?	- Energy storage in car batteries	- Batteries (for electric cars) - H_2 for trucks, train & boats - Biomass production with greenhouses - H_2 in current gaspipes	- Production with algae - H_2, sun & wind
Building density	- High buildings- Greenhouses on top of buildings & industry; - Smaller, more local groceries stores	- Industry is clustered - Some houses can be off-grid, but need to be self-sufficient	- Lower buildings	- Densify city for efficienty - Mixed functions - People living in the industry - Parking under the city?	- High density in the city	- Renewable materials -> maximum 10 story building (building with wood); insulation (ex. sheep wool) - Clustered city
Smart grid	-	- Data center under the city (for the heat & data) - Big data center in port area (for the heat & data)	-	- Interconnected!!	- Smart public transport system	-