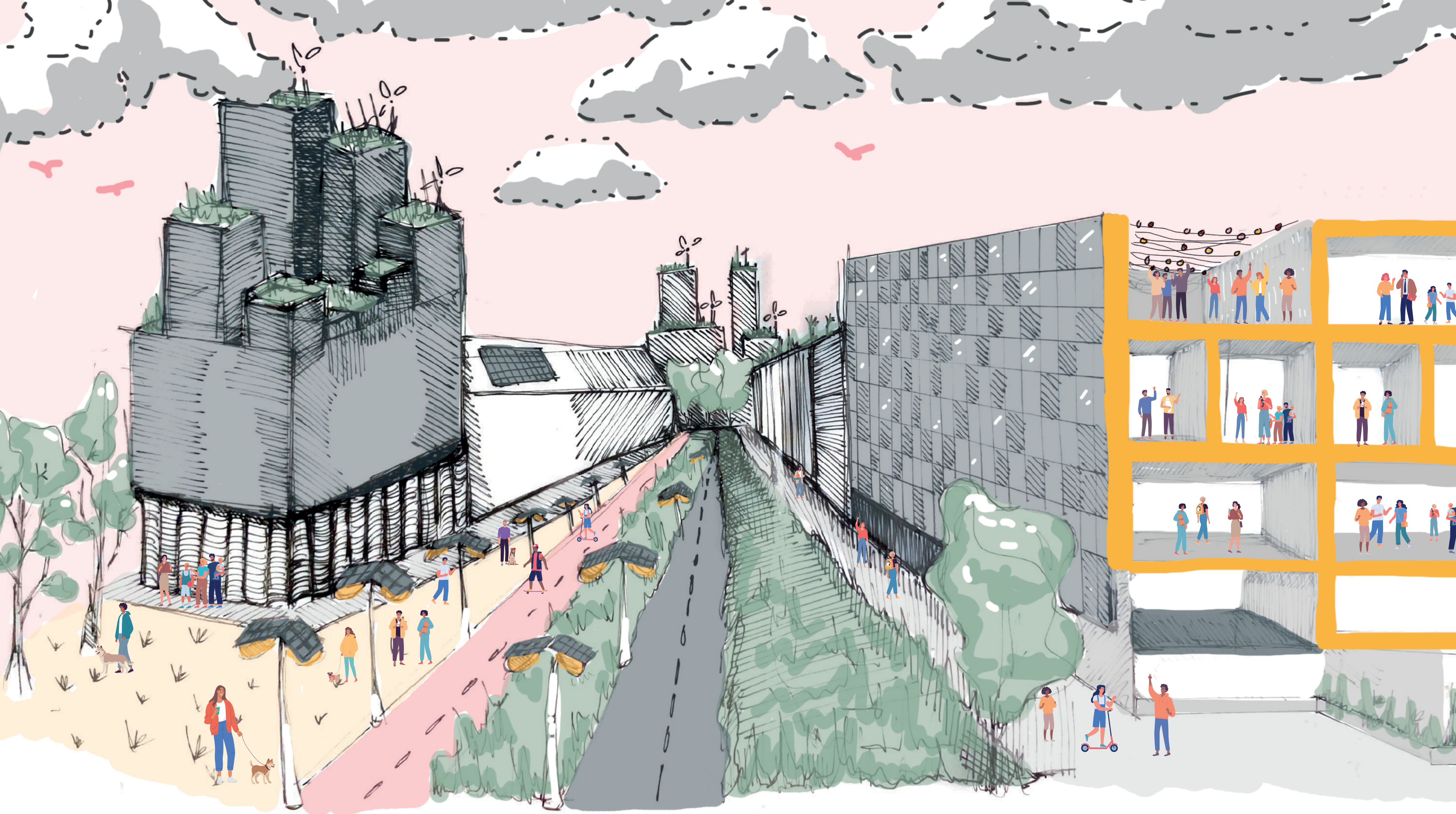


A SOLARPUNK ENERGY LANDSCAPE

DECENTRALIZING THE ENERGY TRANSITION TOWARDS SUSTAINABLE ENERGY COMMUNITIES

„ Solarpunk is a movement in speculative fiction, art, fashion, and activism that seeks to answer and embody the question “what does a sustainable civilization look like, and how can we get there?”

The aesthetics of solarpunk merge the practical with the beautiful, the well-designed with the green and lush, the bright and colorful with the earthy and solid.

Solarpunk can be utopian, just optimistic, or concerned with the struggles en route to a better world ,but never dystopian. As our world roils with calamity, we need solutions, not only warnings.

Solutions to thrive without fossil fuels, to equitably manage real scarcity and share in abundance instead of supporting false scarcity and false abundance, to be kinder to each other and to the planet we share.

Solarpunk is at once a vision of the future, a thoughtful provocation, a way of living and a set of achievable proposals to get there.”

- A Solarpunk Manifesto

Authors:
5219159 Annika van der Nat
6028187 Emese Nagy
1391380 Esmée de Ruiter
5789281 Jan Osusky
5010039 Tijmen Boot

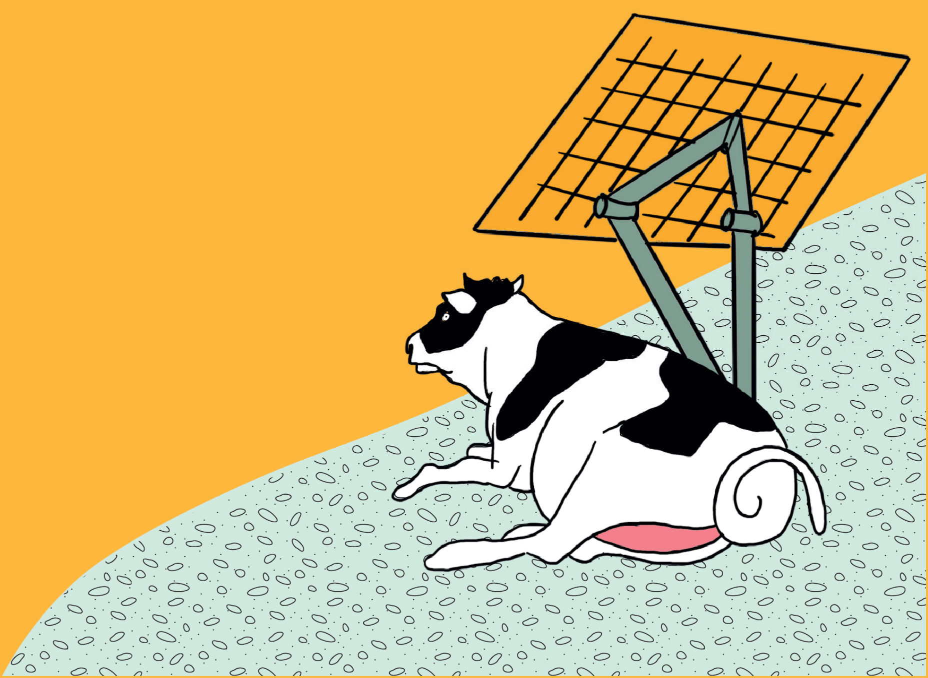
Tutors:
Nikos Katsikis & Rodrigo Cardoso

Delt Univrsity of Technology
MSc Urbanism (Architecture, Urbanism, Building Sciences)

Quarter 3

AR2U086 R and D Studio: Spatial Strategies for the Global Metropolis
AR2U088 Research and Design Methodology for Urbanism

February 2024 - April 2024



Abstract

The EU Green Deal aims to ensure a socially just energy transition, but the shift towards renewable energies often replicates the centralized, top-down approach of traditional fossil fuel systems, negatively impacting rural areas. This report reimagines this paradigm by advocating for decentralized energy communities, particularly in regions experiencing the neglect often seen in 'shadow agglomerations.' It argues for a shift where decentralized energy production empowers both cities and rural areas, enabling them to attain energy self-sufficiency and ownership. The research uses a multicriteria analysis to explore the Eurodelta and Zeeland regions, forming a vision that supports the strategic development of energy communities in Zeeland and Rotterdam. This approach aims to facilitate a more spatially equitable and just energy transition, enabling regions overshadowed by major urban centers to become essential in achieving sustainable energy production, thereby reshaping the energy landscape towards a more distributed and participatory model.

Key words: Renewable energy, Decentralized, Shadow agglomerations, Borrowing size, Energy communities, Energy landscapes, Toolbox

Contents

List of Figures

Chapter 1

Introduction: The Issue with the Current Energy Transition

Since the advent of the industrial revolution in the early 19th century, the ramifications of CO^2 emissions on global climate dynamics have been profound. The combustion of fossil fuels has sparked a surge in environmental pollution, with emissions from various sectors including industry, energy production, transportation, and even routine household activities. Without decisive intervention, the cumulative impact of these emissions poses an existential threat to our ecosystems, potentially precipitating irreversible ecological damage.

The industrial revolution marked a paradigm shift towards radical gains in efficiency, albeit at the expense of exacerbating environmental pollution. Over the past two centuries, fossil fuel energy has diffused into virtually every aspect of modern life. Nonetheless, historical precedent illustrates a reliance on locally available energy sources such as wood from forests, hydroelectric power, and wind energy. This prompts a fundamental question: Can we envision a future where such renewable sources once again assume the center stage in energy production?

In light of the multifaceted nature of CO^2 emissions, we recognize the prevailing energy landscape as a principal contributor to the problem. Our objective, therefore, is to undertake a (partial) reconfiguration of the energy industry, with a view towards mitigating pollution in an ecologically sustainable and socially equitable manner.

To elaborate further, this objective necessitates a comprehensive overhaul of existing energy infrastructures, predicated on the adoption of renewable energy technologies and sustainable practices. This entails transitioning away from fossil fuel dependency towards greener alternatives, such as solar, wind, and hydroelectric power generation. Additionally, fostering community engagement and promoting inclusivity are imperative to ensure that the transition is both environmentally sound and socially just.

Furthermore, the envisioned redevelopment of the energy sector must be underpinned by robust policy frameworks and strategic investment initiatives. By incentivizing innovation and facilitating the deployment of clean energy solutions, governments and stakeholders can catalyze the transition towards a more sustainable energy landscape.

In summary, the endeavor to address CO^2 emissions mandates a holistic approach, encompassing technological innovation, policy reform, and societal engagement. By recalibrating the energy industry to prioritize environmental stewardship and social equity, we can strive towards a more resilient and sustainable future for generations to come.

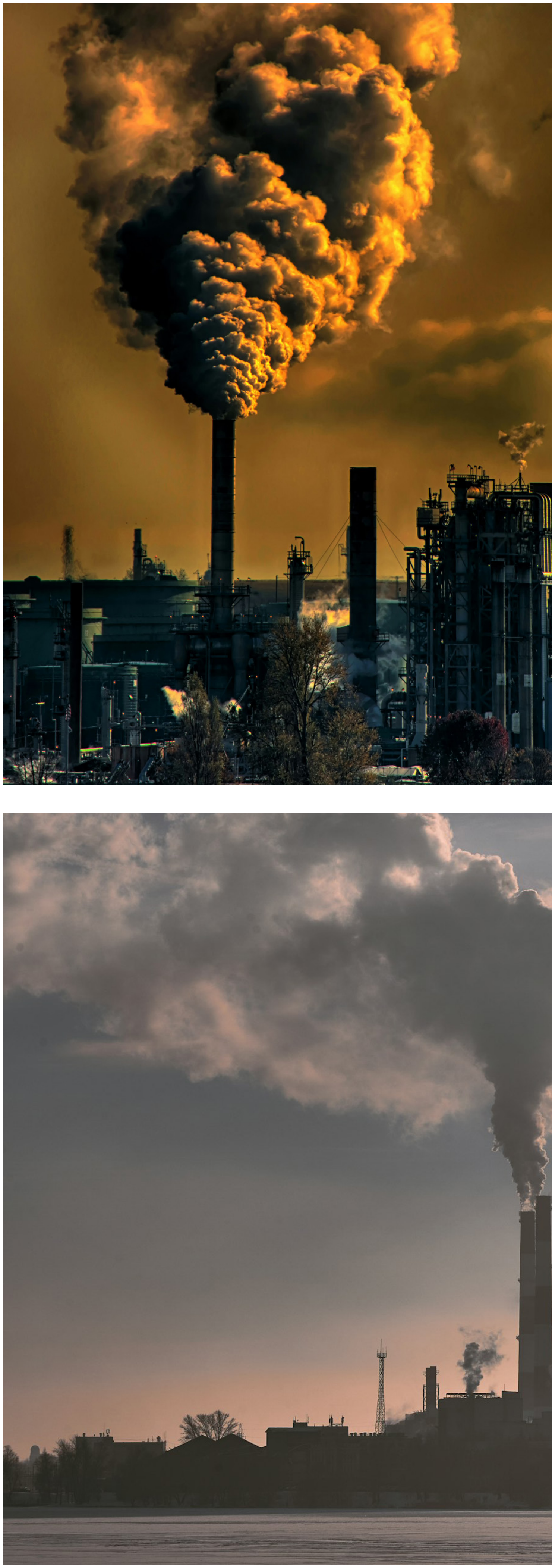


Figure 1: This is how energy production looks like today

Historic Perspective: Energy has Always been Part of the Landscape

Throughout history, the configuration of energy landscapes has changes a lot. Across most eras, these landscapes have been intricately tied to local characteristics, encompassing the indigenous flora, climatic conditions, and geographical features. The evolution of energy dynamics in the Netherlands over the past century is presented in the figure below.

Pre-Industrialization

During the medieval period, societal energy demand was primarily fulfilled with locally available resources. Timber for heating, the Sun, and human and animal power where the energy sources. Towards the end of the Middle Ages, inhabitants of the Low Country begann burning peat for energy. However, this exploitation lead to habitat degradation. Consequently, renewable energy sources such as wind and water became important again. This period witnessed the introduction of windmills in the Dutch landscape, and renewable energy became essential components of everyday life. Even now, the dutch cultural landscape is shaped by this form of renewable energy production.

Industrialization

The industrial revolution marked a turning point in history, transforming the energy landscape drastically. The discovery of fossil fuels as sources of energy revolutionized energy dynamics, enabling the widespread adoption of coal, oil, and gas for powering industry. This paradigm shift resulted a drastic enhancement in energy efficiency, as smaller areas could now generate large amounts of energy, thereby increasing productivity on a vast scale. Nonetheless, this new efficiency came at a considerable environmental cost, as the combustion of fossil fuels has devastating environmental consequences such as pollution, impacts on public health, and global warming. Moreover, the centralized control exerted by a handful of energy conglomerates further led to concerns regarding energy security and justice.

Future Era

Presently, society stands at the cusp of the next transformation, characterized by a renewed emphasis on sustainability and environmental stewardship. The renewble energy sources such as wind and the sun are once again in the center of this transformation. Leveraging technological advancements, contemporary renewable energy technologies exhibit remarkable efficiency. However, the renewable energy infrastructure requires a large footprint. Consequently, energy production is once again interacting with inhabited areas. The same technology of harnessing wind power, that is an essential part of Dutch culture, is also leading the energy transition into the future.

Figure 2: Historic time axis of energy production

Current Situation: Energy in the Netherlands

The energy landscape in the Netherlands is still dominated by fossil fuel power plants, producing 90% of all the energy that is consumed in the country (EBN, 2023). Figure 3 shows the production of energy per source used in the Netherlands. The largest parts of the energy grid is produced with gas and oil, followed by renewable sources, coal, and nuclear only takes up 1% of production. In the Netherlands itself there are fourteen fossil fuel power plants (European Commision, 2024) producing a third of the energy that is consumed by the country (EBN, 2023). The energy produced by the majority of these power plants run on gas and are located in the vicinity of the highest urbanized areas. The only exception are the two power plants in the northeast corner, producing in rural areas of the country.

Renewable Energy

The renewable sources in the Netherlands mostly consist of biomass, wind power, and solar power. Even though the share of energy by renewable sources is increasing each year, the country still ranks the lowest in percentage of energy from renewable sources amongst the EU, besides Luxembourg (EBN, 2023).

With the current technologies the difference between space used for energy production between renewable sources and fossil fuels is immense. Both wind and solar need an area upwards of 5000 km2 (Lumify Energy, 2023) to produce all the energy consumed in the Netherlands, whereas fossil fuel plants only take up 12 km2 (European Commission).

Energy Business

The energy sector is a large business for the Netherlands; The majority of the energy consumed here is imported, two thirds from the countries surrounding the Netherlands; Norway, Denmark, the UK, Belgium, and Germany. The latter two are the largest energy exchange partners of the Netherlands. Coal is imported from Germany and oil from Belgium (Energie Nederland, 2024). Both Belgium, with the port of Antwerp, and Germany, with the Ruhr-gebiet, have energy regions which play a significant role in the Euro Delta area.

Moreover, the largest consumer of energy is the industry sector with 44%. Followed by households, transport, the energy sector itself, and agriculture (EBN, 2023).

Focus

As the energy sector is such a large business, with this project our focus will lie on the energy consumed by households, agriculture and their accompanied road traffic. The goal of this new energy landscape is to balance the consumption and production for these sectors. The industry, due to its unique circumstances, as economic value and benefits with a centralized situation, will not be part of the balancing of production and consumption.

Households, agriculture, and transport total 34% of the entire energy consumption in the Netherlands (EBN, 2023). Most of which is through electricity and gas, but also other fossil fuels to power the vehicles. In a future where households become more dependant on electricity, also for their heating and transportation, renewable energy sources could have a big impact on the total energy consumption.

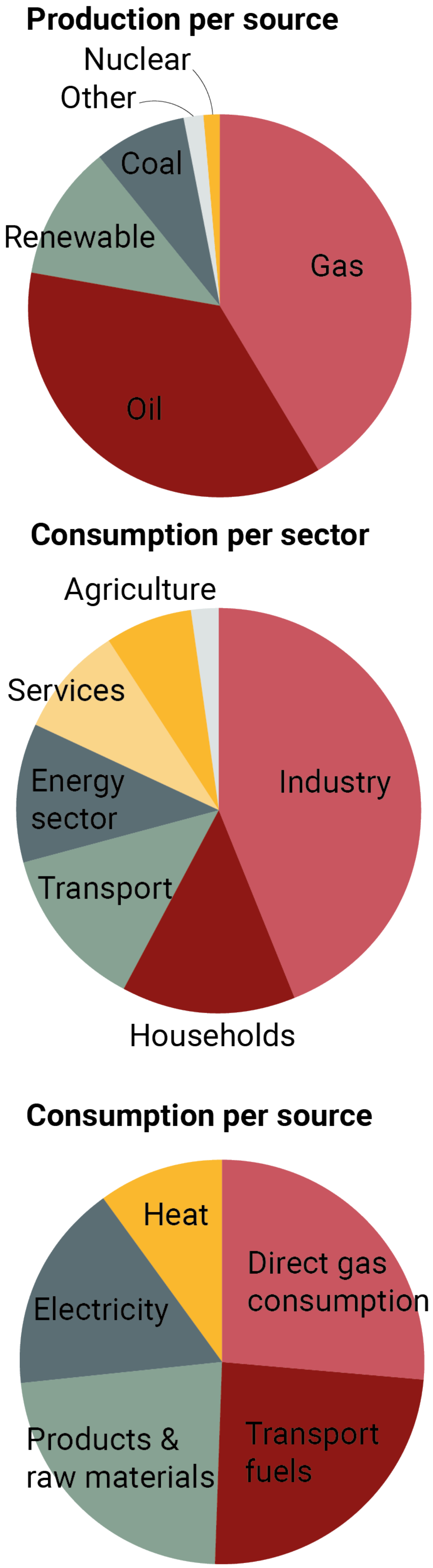


Figure 3: Overview over production and consumption of energy (EBN 2023, CLO 2022)

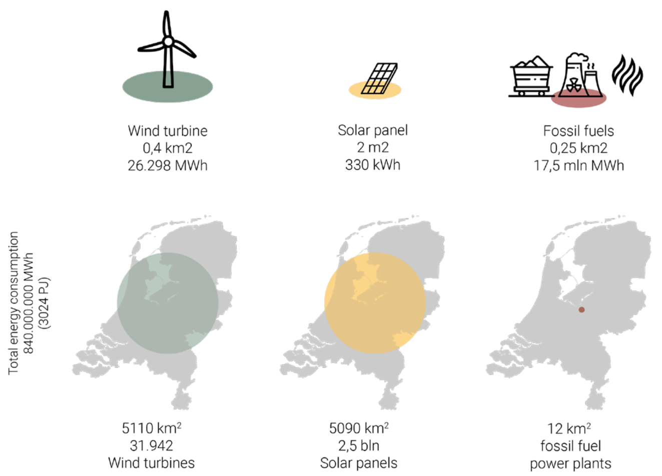


Figure 4: Space use of different energy production modes, including the space needed to supply the whole of the Netherlands with energy

Problem Statement: the Current Energy Transition is Unjust

At the heart of this project is the urgent need to address the harmful CO2 emissions plaguing our environment. If left unchecked, these emissions will fuel drastic climate change, posing a grave threat to our ecosystems.

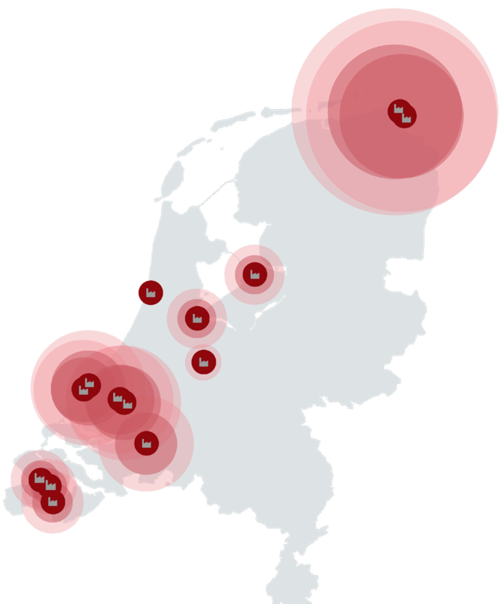
We've honed in on the energy sector as a major culprit in emitting CO2. Tackling this issue head-on can make a significant difference in the global efforts to combat climate change.

There are a few key aspects of the current energy landscape that have been identified as major contributors to the problem. Firstly, energy production is heavily centralized. Just a handful of big actors control most of the energy production in the world. The Netherlands count fourteen fossil fuel power plants, which are owned by only eight organizations. This setup leads to an unfair distribution of the negative impacts of energy production. The areas around these power plants suffer from high levels of pollution, yet the benefits of energy production mostly line the pockets of these organizations, leaving locals uncertain about where the energy ends up.

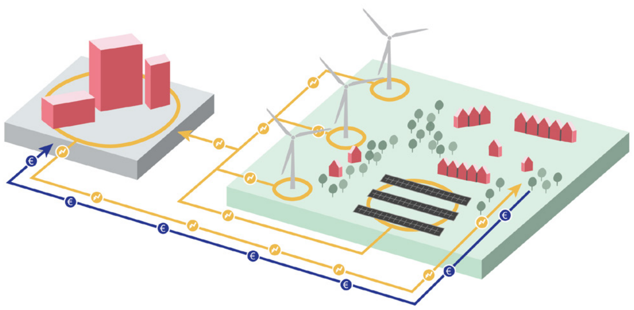
Secondly, even with the rise of renewable energy sources, the structure of the fossil-fuel era industry remains. A few large conglomerates still hold most of the power over energy decisions. While wind turbines and other renewable installations may be dispersed in the landscape more evenly, the benefits tend to flow back to these corporations, leaving local communities by the wayside. Without societal acceptance, these renewable energy sources risk remaining disconnected from our cultural fabric.

Lastly, the physical distance between energy production sites and local communities exacerbates this disconnection. Wind and solar farms, while symbols of progress, often feel like distant entities, fenced off and inaccessible to nearby residents. This spatial separation creates a barrier rather than fostering a sense of community engagement with the energy sources that will shape our future. Bridging this gap and fostering community involvement in energy initiatives is crucial for creating a sustainable energy landscape that is embraced and supported by all stakeholders.

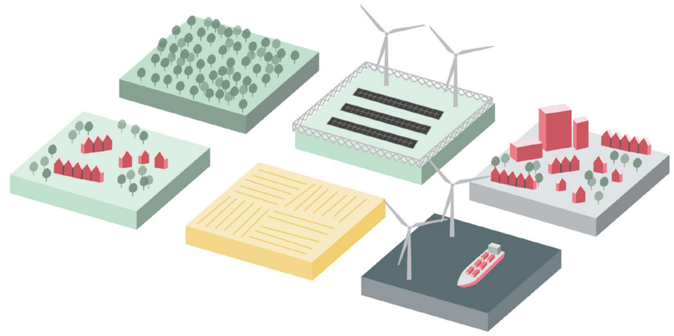
Problem: centralized energy production



Problem: profits don't benefit local communities



Problem: energy production is spatially separate form the landscape



from left to right:
Figure 5: Current centralized energy production system
Figure 6: Current system of renewable energy production and profits
Figure 7: Renewable energy production is separated from other landscapes

Research Questions

How can the energy transition be reimagined through a just implementation of renewable energy production in collaboration with the landscape and communities?

RQ1 How is energy transition regarding fossil fuels currently constructed and which problems occur?

RQ2 What does renewable energy production include and how can it be implemented effectively?

RQ3 In what way can different landscapes, from rural to highly urbanized, be part of a decentralized energy landscape powering households, agriculture and transportation?

RQ4 How can various communities of society be included in the energy transition?

Vision Statement: Energy as Part of the Community...

Vision Goal 1: A decentralized energy system

Vision Goal 2: Energy communities

Vision Goal 3: An integrated energy landscape

In almost all aspets of our everyday lives, energy is present – from the emissions rising from factories to the movement of vehicles, and the web of power lines traversing our landscapes. However, amidst this pervasive presence, we often fail to contemplate its origins. Over the course of the past two centuries, since the industrial revolution, our energy landscape has undergone profound transformations. While advancements in efficiency have been noteable, the reliance on fossil fuels has exacted a toll on the environment, impacting our climate and affecting our habitats.

Our vision is to tackle the major contributors within our energy system through the decentralization of energy production, ensuring equitable distribution of its benefits, and seamlessly integrating renewable energy solutions into the fabric of our society.

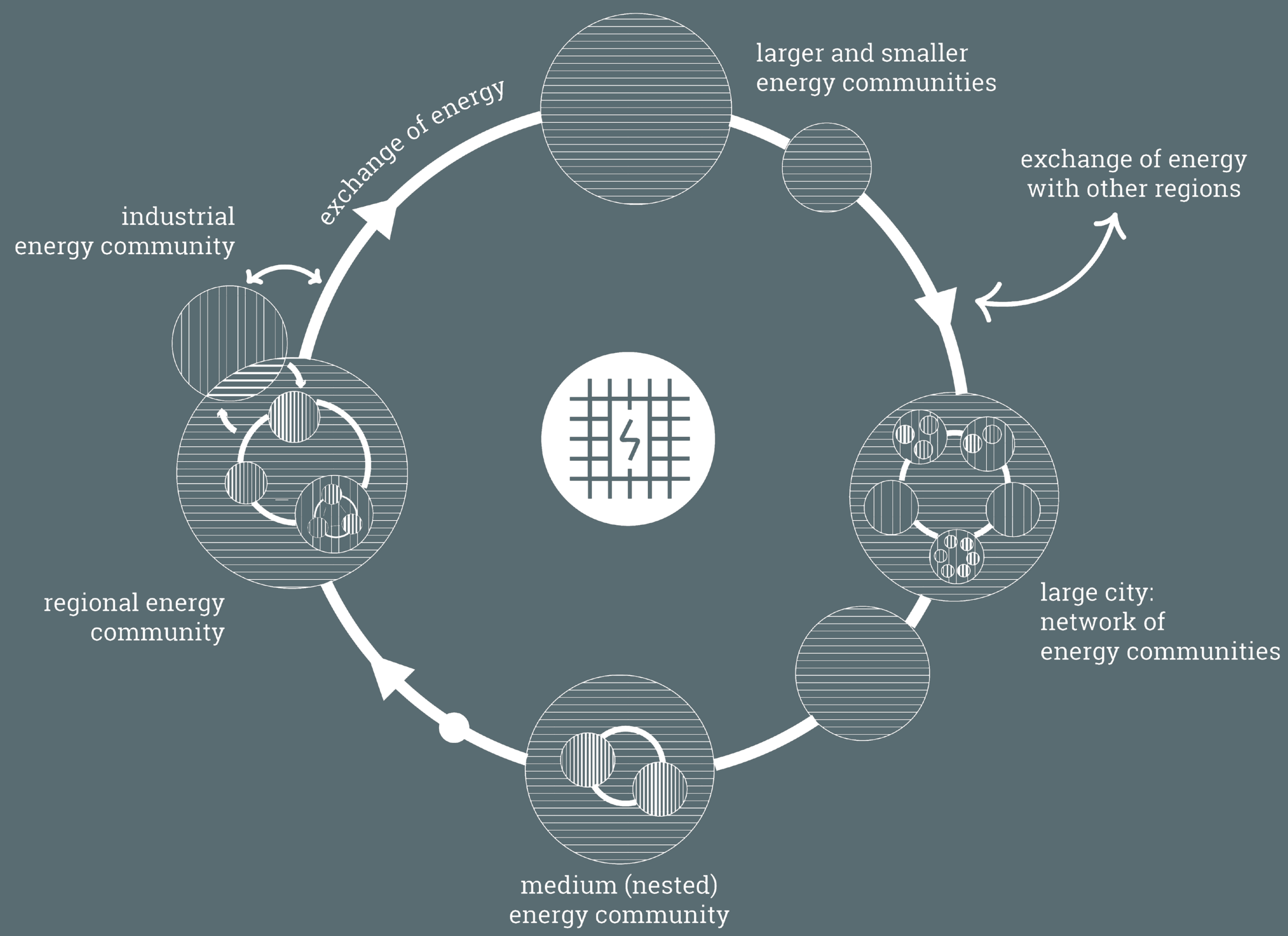
Firstly, we advocate for a decentralized paradigm in energy production, harnessing the characteristics of diverse regions to exploit renewable sources such as wind and solar power. Rural aresa, characterized by their expanse of open land, offer fertile ground for the deployment of wind turbines, while the roofs of urban centers present ideal areas for the installation of solar panel arrays. This decentralization not only diversifies our energy portfolio but also involves local communities by affording them a substantive role in energy production.

Furthermore, we advocate for equitable distribution of energy benefits. Our principle is simple: energy produced in a certain area should primarily benefit the local population. This localized approach ensures that residents residing in proximity to energy production sites directly reap the rewards, fostering a sense of ownership and empowerment. In instances where certain communities may face challenges in meeting their energy demands, collaborative arrangements for energy importation from neighboring regions ensure a fair and balanced distribution of benefits across communities.

Lastly, we aim to reintegrate energy production into the fabric of everyday lif. Drawing inspiration from historical precedents where society coexisted harmoniously with their energy sources, we aim to interweave energy production seamlessly into daily activities. By embedding energy infrastructure within the fabric of our communities, we aspire to cultivate a sense of ownership and connection, thereby fostering a more sustainable and cohesive society.

In essence, our vision encapsulates a holistic reimagining of the energy landscape, one characterized by decentralization, equity, and societal integration. Through collaborative endeavors and innovative initiatives, we seek to forge a path towards a future where energy serves as a catalyst for sustainable development and societal well-being.

... with energy communities



Energy communities have long been a fixture in human societies, but in recent years, this concept has gained traction as an alternative to the prevailing energy landscape. Drawing inspiration from the European Union's definition, an energy community is characterized as an association that produces and shares renewable energy, with a focus on generating and managing cost-effective green energy autonomously, thereby mitigating CO2 emissions and curbing energy wastage (European Commission, 2024).

Our conceptualization of energy communities is underpinned by three overarching vision goals. Firstly, these communities serve as integral components of a broader initiative to decentralize energy production, thereby fostering greater resilience and sustainability within the energy grid. Secondly, they aim to engender a democratic dispersion of benefits, ensuring that the fruits of energy production are equitably distributed among community members. Finally, energy-producing installations are seamlessly integrated into the landscape, embodying a harmonious coexistence between human activity and the natural environment.

Chapter 2

Our Approach and Methodology

Theoretical Framework

Urban living areas, as complex systems, manifest the convergence of energy generation, distribution, and consumption. The current urban energy paradigm as stated in the introduction is heavily reliant on centralized fossil fuels, resulting in inefficiencies and high greenhouse gas emissions (UN-Habitat, 2011). Urban planning researchers and designers criticize this model for its lack of energy efficiency and sustainability, advocating for a transition to integrated and compact city designs that promote sustainable energy use (European Commission, 2011). This transition involves rethinking urban spaces to facilitate efficient and renewable energy use, aligning with the broader goal of climate mitigation and a net-zero emissions economy (UN-Habitat, 2011; IEA, 2016).

Rethinking goes beyond merely replacing fossil fuel-based systems with renewable energies; it necessitates transforming urban areas from passive centers of demand into active participants in energy management. In other words, a new approach to applying renewable energies is essential, where decentralization is key. Dispersing renewable energy types offers benefits like climate and environmental friendliness, efficiency, resilience, reliability, affordability, and higher energy security (Coaffee, 2008).

However, decentralization comes with its challenges. As discussed in the introduction (see Figure 4), the shift to decentralized energy production necessitates a larger spatial footprint than fossil fuels. Renewable energy technologies (RETs) require more space due to their lower energy density compared to fossil fuels (Pasqualetti and Stremke, 2018). Accommodating these RETs within the current landscape, demands an understanding of how they can be integrated while creating a new layer of interaction in the landscape, whilst taking into account the environmental and social integrity. Here, 'landscape' refers to an area as perceived by people, shaped by the interaction of natural and human factors (ELC, 200 0, art. 1, a).

Furthermore, a fairer and more sustainable energy transition must consider the human dimension. It is critical to recognize the diversity among residents in different cities and not perceive them as a homogeneous group. For instance, farmers are more concerned with the implications for food production when implementing PV fields and energy crops, unlike urban residents (Picchi et al., 2019).

Policymakers currently tend to seek passive consent from residents, but engaging people in energy projects requires more than that. Active acceptance involves their willingness to integrate these technologies into their homes and environment, necessitating the provision of installation sites, the covering of up-front capital investments, or behavioral changes (Sauter & Watson, 2007). This brings us to the concept of active and social acceptance, where residents actively contribute to the implementation of renewable energies in their living spaces. Promoting this involvement necessitates achieving three psychological needs: competence, connection, and autonomy . Without this, enabling self-determined and intrinsically motivated behavior cannot be done (Deci and Ryan, 2002).

Early research on energy autarkic regions shows that increased interactions among people, for example, within neighborhoods or regions, are desirable and can drive the implementation of decentralized energy systems (Müller et al., 2011). Giving space to enable these interactions strengthens interpersonal relationships, contributing to the integration and enhancing the social capital of local populations

.

In our project, 'energy communities' are collectives of residents in a certain area that represent the shift from passive to active roles in the energy transition, showing the decentralized, participatory approach required for sustainable urban energy systems.

In 2019, the European Union embraced the Clean Energy for all Europeans package, designed to provide a roadmap for the energy transition, particularly in achieving the objectives of the Paris Agreement. This comprehensive package comprises regulations aimed not only at attaining net-zero targets but also at fostering environmental benefits, enhancing societal well-being, and strengthening economic resilience. The regulations primarily concentrate on enhancing the energy efficiency of buildings, establishing targets for exclusive reliance on renewable energy sources, and implementing a regulatory framework to facilitate the EU's transition. In this package the EU introduced the concept of renewable energy communities, alongside establishing a support service for citizen-led renovation efforts, which encourages citizens to spearhead the formation of such communities. Additionally, they established the energy communities repository, showcasing successful existing initiatives. (European Commission, (n.d))

According to this document, an energy community empowers collective citizen-led energy initiatives, crucial for advancing the transition to clean energy. They enhance public acceptance of renewable energy projects, attract private investments, and effectively reconfigure energy systems. This empowerment enables local citizens to drive the transition and directly gain from benefits such as improved energy efficiency, reduced bills, decreased energy poverty, and expanded opportunities for local green employment. (European Commission, (n.d))

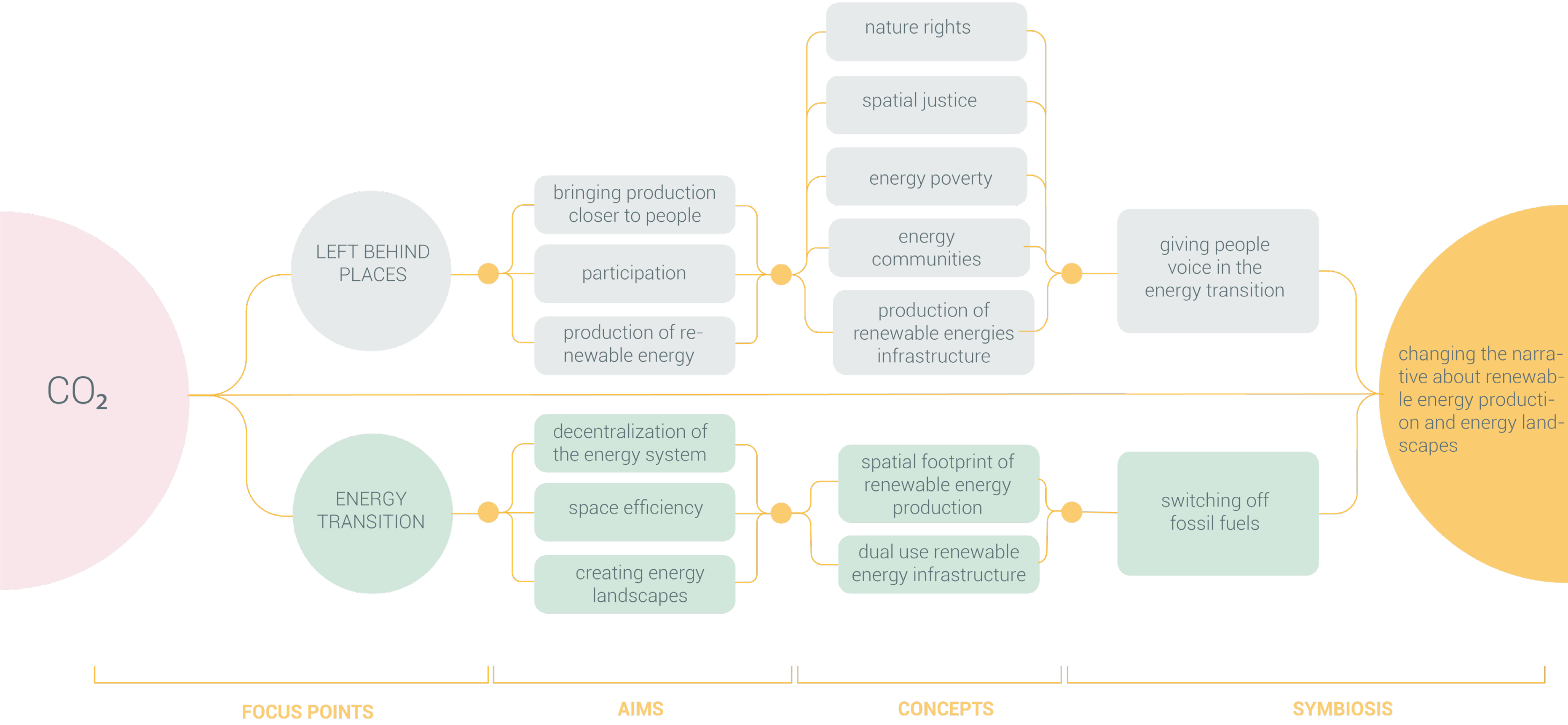
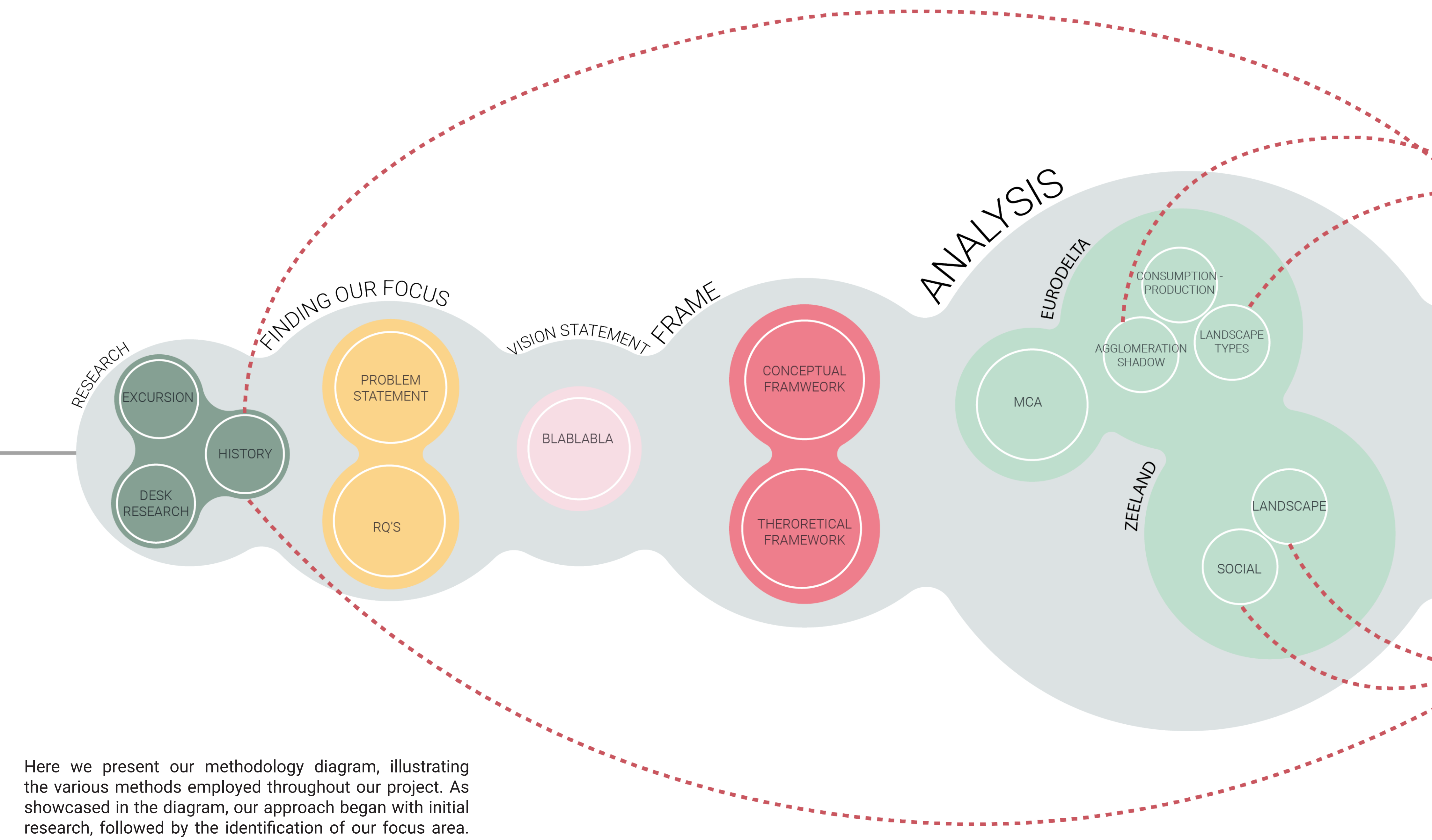


Figure 8: Our conceptual framework

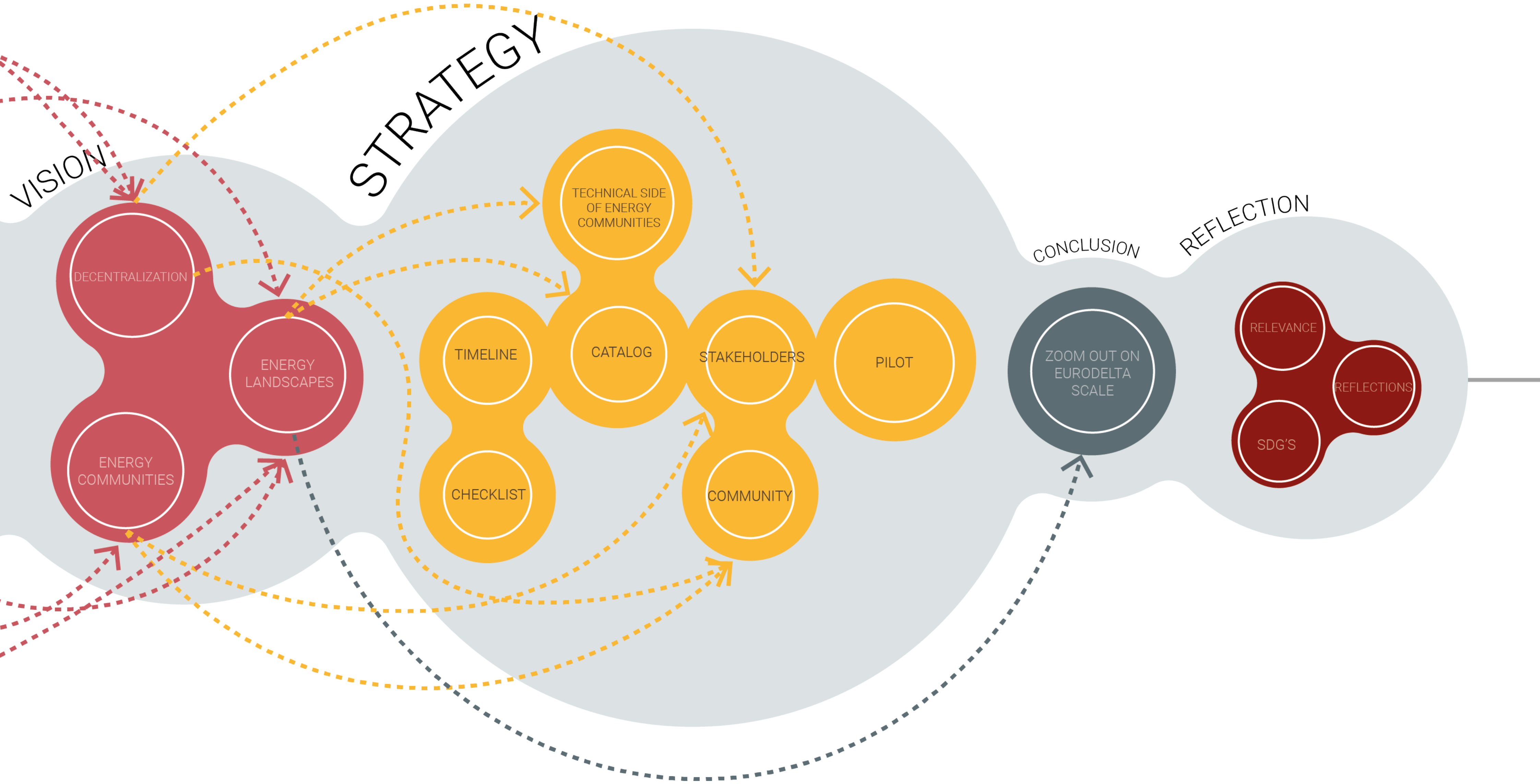
Conceptual Framework

Our conceptual framework centers on lowering CO2 emissions by targeting areas impacted by 'Agglomeration Shadows' and incorporating the process of energy transition. We address these focus areas through both a social and technical lens. The horizontal axis illustrates the timeline and intricate components that build the overarching concepts of energy transition and agglomeration shadows. Our project's objective is to empower residents living in areas that have the potential to evolve into energy communities, ensuring their active participation in the transition to these communities. By aiming to construct a more spatially efficient, decentralized narrative for renewable energies, we will put specific strategies into practice. These include weaving energy systems into the urban fabric and designing a new layer in the cultural landscape: the renewable energy landscapes. In doing so, we use a multidisciplinary approach that consists of environmental, social, and technical aspects of reducing reliance on fossil fuels and cutting CO2 emissions. Anticipated results are the achievement of spatial justice in energy distribution, promoting equitable access to energy and enabling citizen ownership over various forms of production, thus mitigating energy poverty.

Methodology



Here we present our methodology diagram, illustrating the various methods employed throughout our project. As showcased in the diagram, our approach began with initial research, followed by the identification of our focus area. Afterwards, we crafted our vision statement and conducted analyses utilizing QGIS, multi-criteria analysis, and desk research. With a well-defined vision, we set our vision goals and embarked on comprehensive strategic planning. This encompassed creating a timeline, conducting stakeholder analysis, crafting a toolbox for energy communities, visualizing the design through illustrations, and executing a pilot project to illustrate our approach. As a result of this strategy phase we zoomed out again on a bigger scale. Finally, we concluded our work with a comprehensive summary and reflection on our findings.


VISION
STRATEGY
CONCLUSION
REFLECTION
DECENTRALIZATION
ENERGY LANDSCAPES
ENERGY COMMUNITIES
TECHNICAL SIDE OF ENERGY COMMUNITIES
TIMELINE
CATALOG
STAKEHOLDERS
PILOT
CHECKLIST
COMMUNITY
ZOOM OUT ON EURODELTA SCALE
RELEVANCE
REFLECTIONS
SDG'S

Chapter 3

Understanding the (Social) Energy Landscape

In both the European and global contexts, the Eurodelta region emerges as a nexus of considerable power and influence, owing to its dense urbanization and extensive infrastructure (SURE Eurodelta, 2023). Spanning across the Netherlands, Belgium, and regions in northern France and eastern Germany, this delta encompasses the major rivers; the Rhine, Meuse, and Schelde.

Within the energy landscape, the Eurodelta region hosts several centralized production hubs. Along its coastline, the ports of Rotterdam and Antwerp serve as significant energy producers, primarily through the extraction and refinement of gas and oil. Further inland, the Ruhrgebiet region dominates energy production, largely fueled by coal.

These areas constitute primary contributors to the issue of CO_2 pollution within the energy sector. Our analysis seeks to delve into the roles played by the spaces between these major production centers, shedding light on their current contributions and untapped potential within the envisioned energy landscape. Through comprehensive data analysis, we aim to identify opportunities for leveraging these intermediate areas to foster a more sustainable and environmentally responsible energy landscape.

Eurodelta overview map

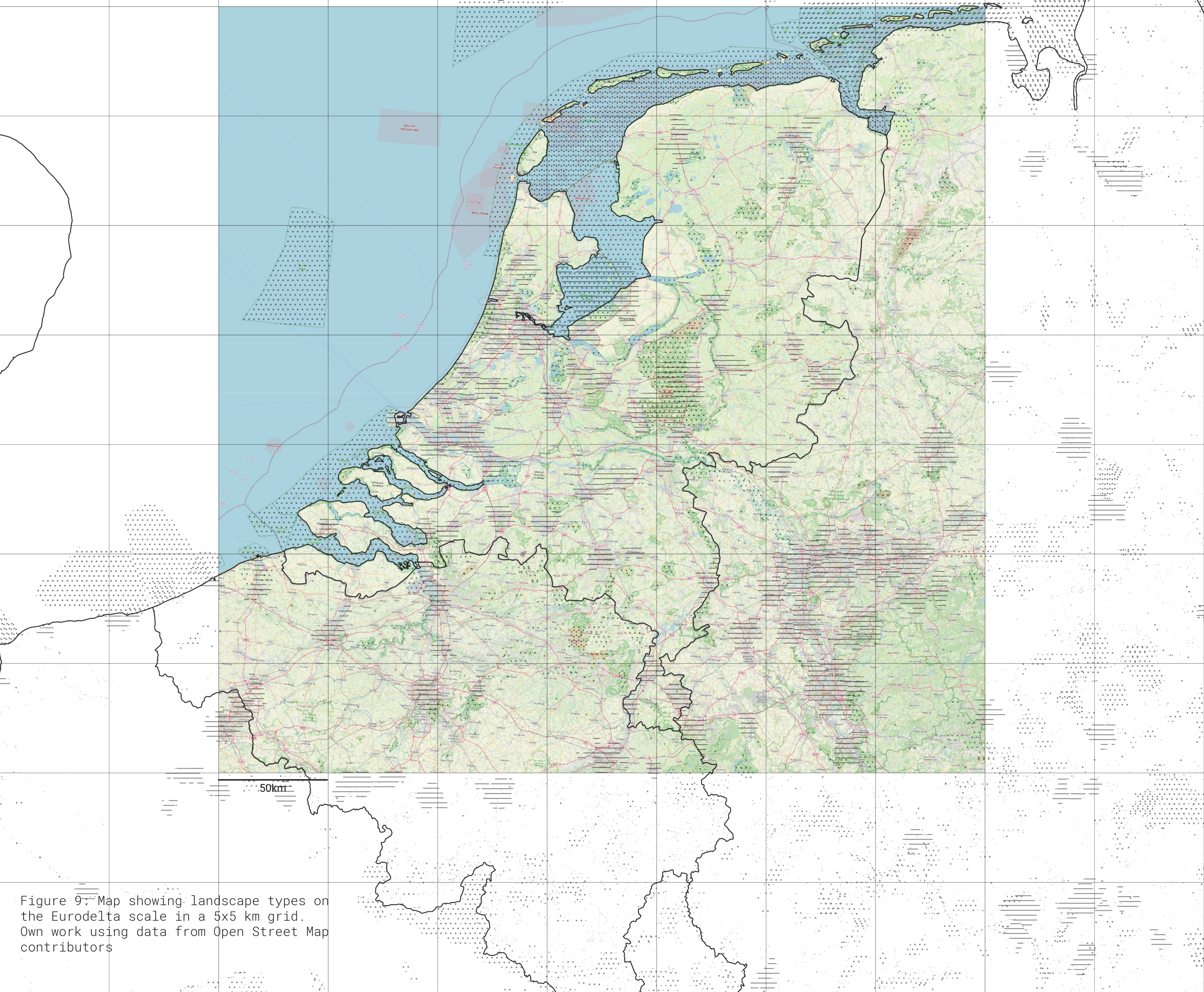


Figure 9: Map showing landscape types on the Eurodelta scale in a 5x5 km grid. Own work using data from Open Street Map contributors

Identifying Energy Landscape Types in the Eurodelta

To understand the landscapes of the eurodelta, we performed this analysis to identify different types of energy landscapes. Seeing how these landscapes are laid out helps us identify interactions and tensions between different types. Locating similar landscapes is also helpful for an eventual transfer of place-based policies.

To find these landscape types, we based our analysis mainly on factors concerning human and economic activities, renewable power potential, and current land uses.

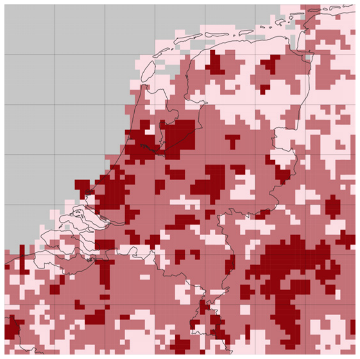
The first two datasets used are the 'Degree of Urbanization' and 'Electricity Consumption', with the former classifying municipalities either as urban, suburban or rural, and the latter spatializing electricity consumption in the landscape. Using these datasets, we can gain an understanding where there is a lot of activity, and also where gaps and inequalities exist.

Secondly, to incorporate potential for renewable energy generation, we used the 'Wind Power Potential', which provides a measure for efficiency of wind turbines. In principle it makes sense to also inclue solar power potential, but looking at the data revealed only minimal differences in the study area, so we didn't include it.

Finally, 'Natura 2000 areas' and 'CORINE Land Use' give us an understanding of the land uses in the eurodelta. The former also poses as a restriction zone, where the implementation of renewable energy infrastructure is difficult.

These layers are generalized into a 5x5 km grid, because in this step readability is more valuable to the overall project than precision. They were calculated together using K-medians clustering which resulted in seven clusters as seen in Figure 10, five of which are based on land and thus of most concern to the project. The characteristics of each cluster can be seen in Figure 11.

Data Sources

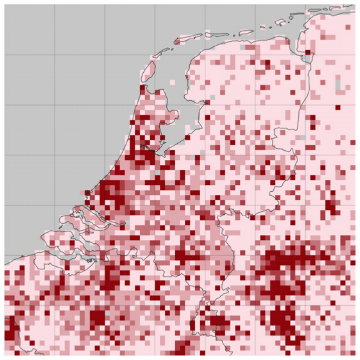


Degree of Urbanization

Classification of all municipalities in the EU into three categories urban, suburban, and rural.

Data source: eurostat 2024

- urban
- suburban
- rural

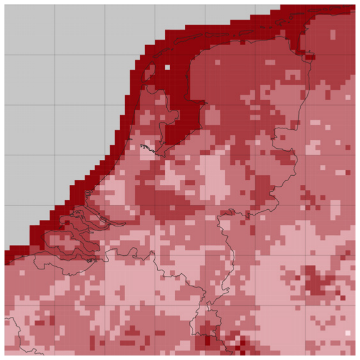


Electricity Consumption

electricity consumption of all sectors, aggregated by square kilometer. Index values.

Data source: European Commission 2024

- > 1000
- 750 - 1000
- 500 - 750
- 250 - 500
- < 250

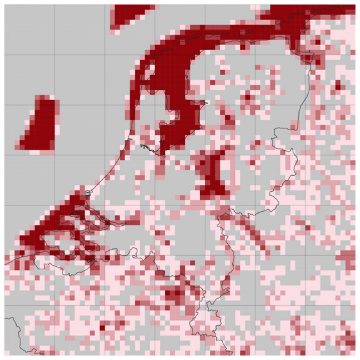


Wind Power Potential

Mean wind power density at 100m height. This is a measure to quantify the resource wind.

Data source: Global Wind Atlas 2024

- > 700 W/m^2
- 520 - 700 W/m^2
- 400 - 520 W/m^2
- 150 - 400 W/m^2
- < 150 W/m^2

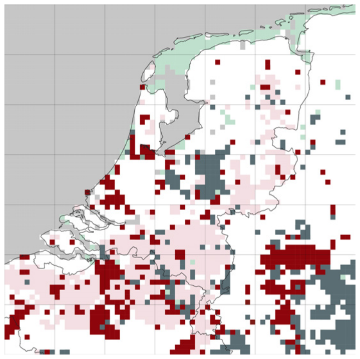


Natura 2000 Areas

The amount of Natura 2000 area is aggregated in the grid. One cell has an area of 25km^2.

Data source: European Environmental Agency 2021

- > 20 km^2
- 13.5 - 20 km^2
- 7 - 13.5 km^2
- 2 - 7 km^2
- < 2 km^2



Land Use

This is not based on the standard level 1 classification, rather a custom classification was chosen.

Data source: European Environmental Agency 2021

- urban and industrial
- complex agriculture
- other agriculture
- forest
- other natural areas

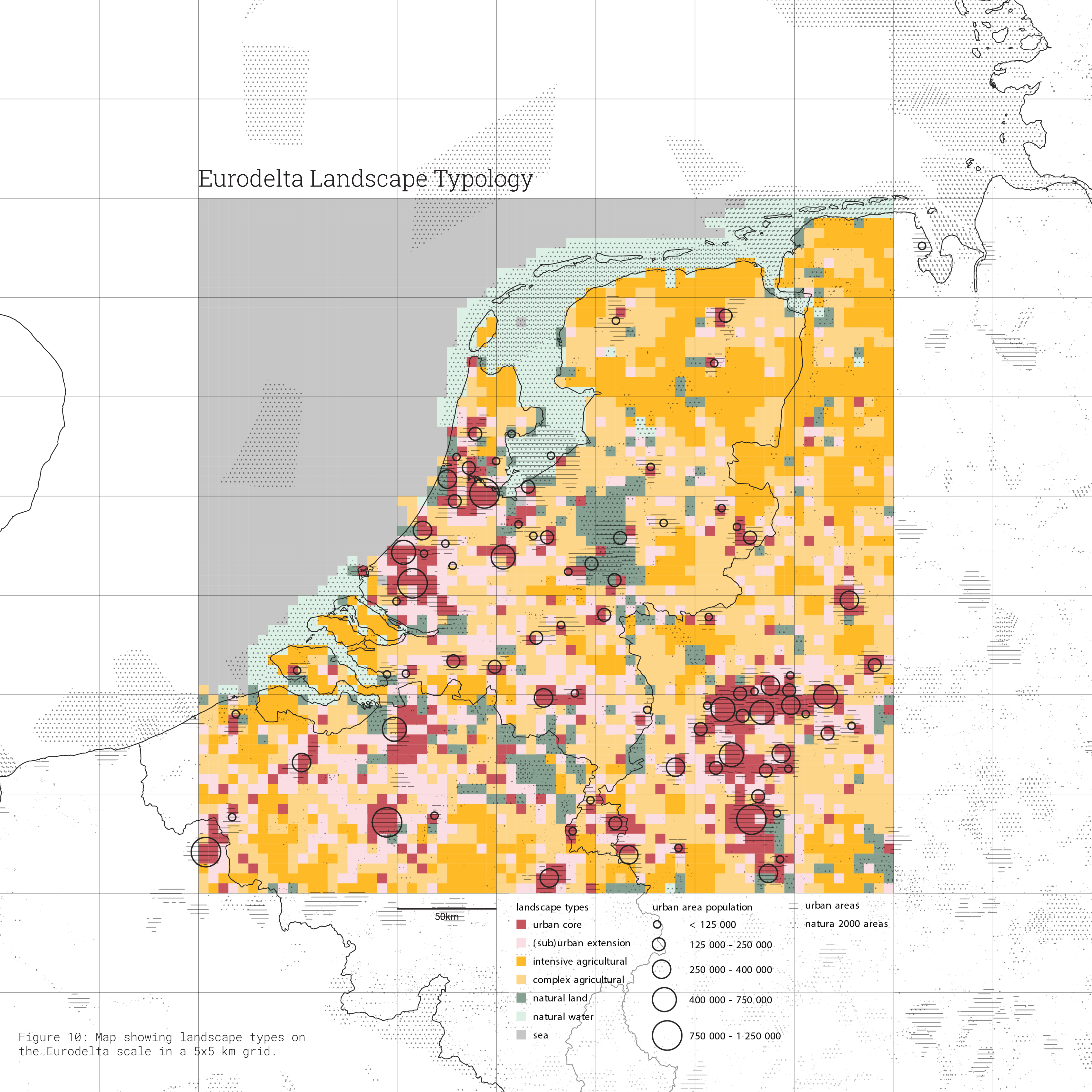


Figure 10: Map showing landscape types on the Eurodelta scale in a 5x5 km grid.

Five Energy Landscapes in the Eurodelta

These five landscapes types emerged from the analysis. They differ in the degree of urbanization and the homogeneity of the land uses. In order to make Figure 10 more readable, we generalized it into a so-called potato plan, shown in Figure 12. This plan also acknowledges that the localities of these landscapes are not precise, because the underlying data is stored in a 5x5 km grid. Also the edges between the landscapes are not sharp, but gradual.

The potato-plan allows us to understand, which places are similar to each other, and thus are able to transfer solutions from one place to another. Landscapes that are different from each other create connections between them to restore the imbalance.

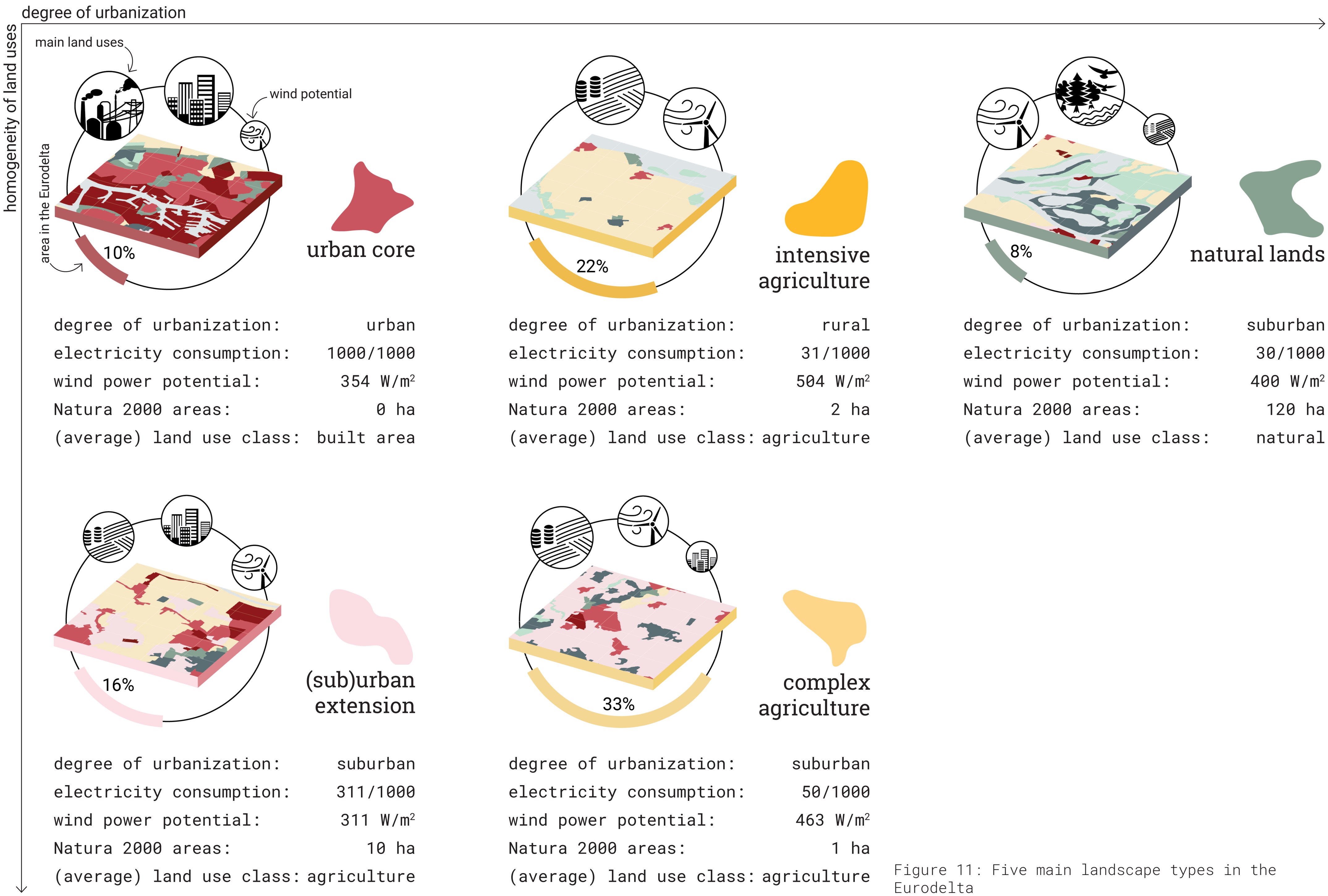


Figure 11: Five main landscape types in the Eurodelta

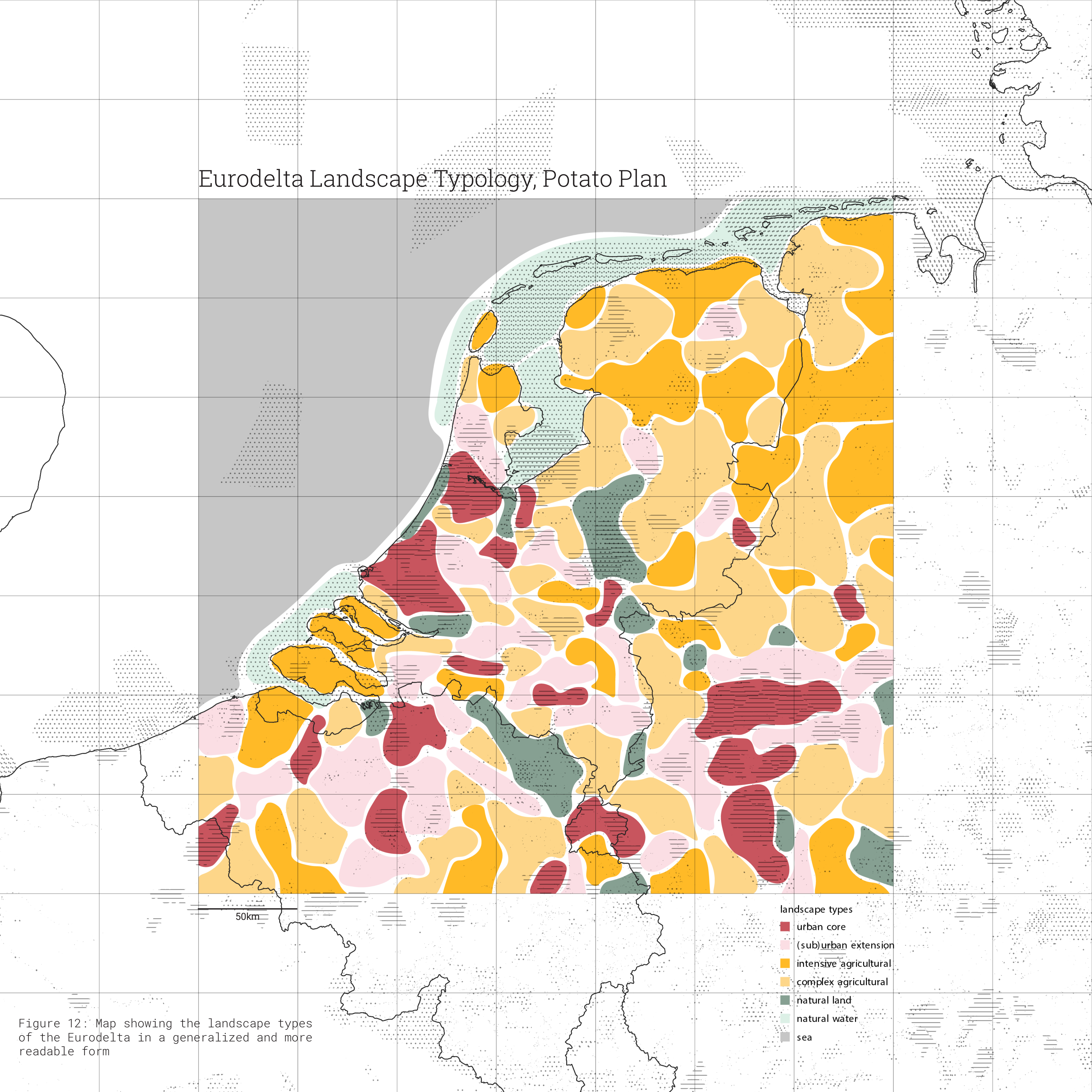


Figure 12: Map showing the landscape types of the Eurodelta in a generalized and more readable form

Understanding the Energy Relationships Between the Landscapes

Energy consumption across regions varies significantly, reflecting diverse demographic and economic factors. Urban centers such as Rotterdam, The Hague, and Leiden emerge as notable consumers, attributable to their dense populations and thriving industrial sectors. Similarly, cities like Amsterdam, Utrecht, Arnhem, Nijmegen, and Eindhoven also contribute substantially to the nation's energy demand, reflecting their urban vitality and economic activity.

In contrast, rural areas, particularly those in the northeastern expanse of the country, exhibit relatively lower energy consumption per hectare. These regions, predominantly characterized by agricultural land use, boast expansive open spaces and fewer residential clusters. Interestingly, this spatial abundance presents an intriguing opportunity for these rural locales to pivot towards energy production. With minimal investment in renewable energy infrastructure, they could potentially attain self-sufficiency and even export surplus energy, leveraging their ample land resources.

Visual representations of energy consumption patterns underscore a marked concentration of energy use in select urban and industrialized zones, mirroring the prevailing centralization evident in the energy production landscape. However, it's imperative to note that our project isn't geared towards decentralizing consumption per se. Rather, our focus lies in establishing robust interconnections between energy production and consumption centers, fostering a harmonious equilibrium within the national energy grid.

Total consumption:

790.527 TJ

Households

47%

Road transportation

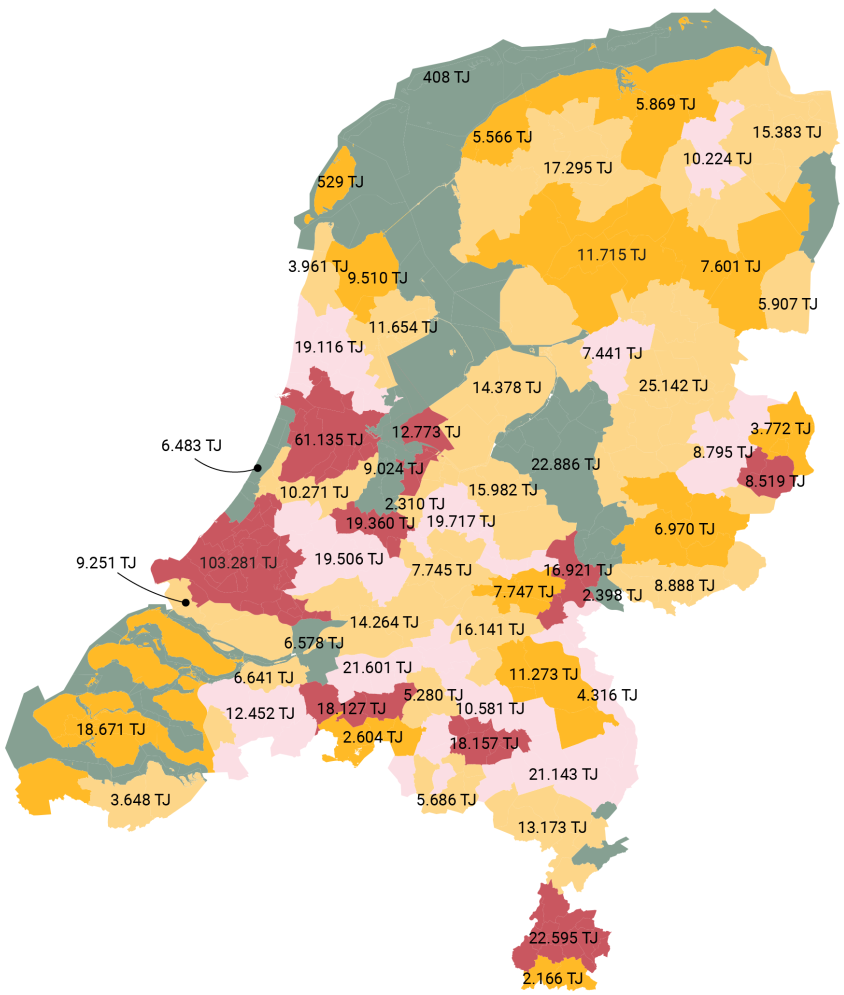
45%

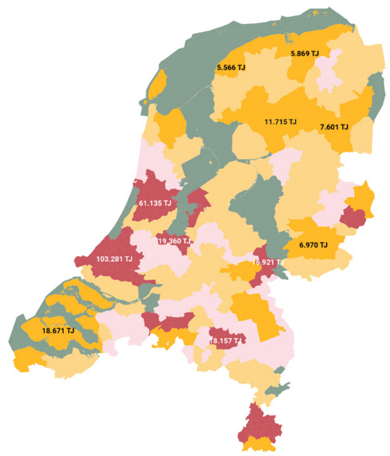
Agriculture

7%

Average consumption in West-Netherlands

Rotterdam, The Hague, Leiden	Zeeland
1090 GJ/ha	**120** GJ/ha





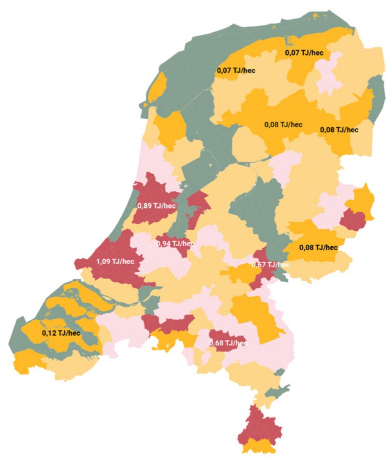


Figure 13: consumption per energy landscape

Agglomeration Shadows in Zeeland

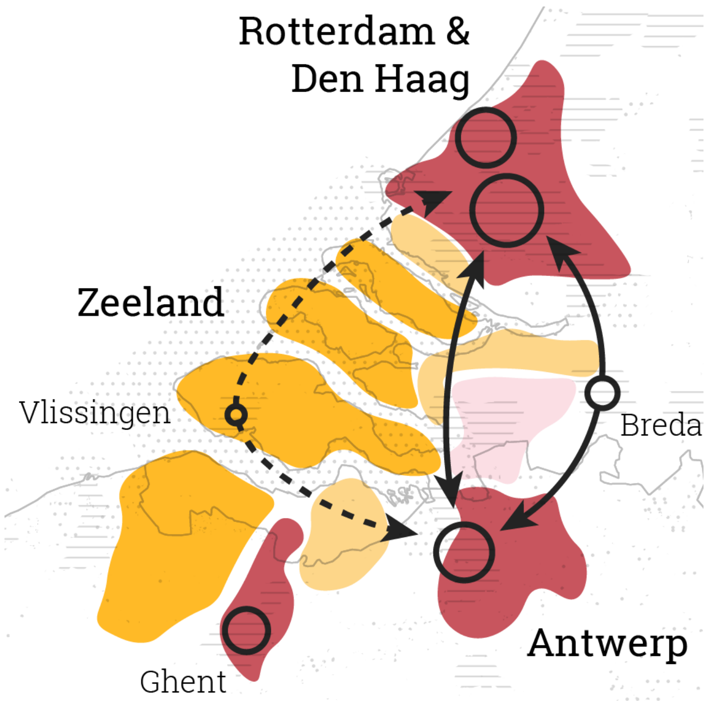


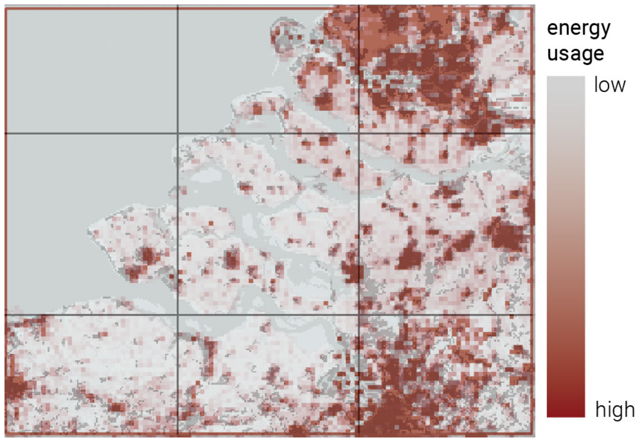
Figure 14: Connections between Rotterdam and Antwerp. Even through Zeeland lies close to both, it is passed by the important transportation routes.

Cities and regions are interconnected not only by national borders and shared economies/climates but also through their mutual interactions. This interaction justifies the choice of Zeeland for our study. Zeeland is situated between two large cities, Rotterdam and Antwerp, and a medium-sized city, Breda. Rotterdam and Antwerp, in particular, exhibit significant economic activity, unlike the cities within the Zeeland province. Research refers to the relationships between these kinds of cities and regions as "agglomeration shadow" and "borrowing size," with the former being particularly applicable to Zeeland (Source, NEG: TBF). The concept of the agglomeration shadow concerns how larger urban areas can negatively influence surrounding regions in various aspects, such as business activity, population growth, and urban functions (Cardoso & Meijers, 2021). Larger cities may undermine the need for equivalent functions in nearby areas, leading to a concentration of high-end cultural amenities and urban functions within these larger cities, casting a "shadow" over smaller towns and cities in close proximity. This dynamic prevents surrounding areas from reaching their full potential. Given Zeeland's spatial position relative to Rotterdam and Antwerp, coupled with significantly less urban and economic activity and urban functions—as investigated through the CORINE dataset—the likelihood of Zeeland experiencing an agglomeration shadow is prominent. According to Cardoso and Meijers (2021), it is possible to transform this shadow into borrowing size, where regions can benefit from their proximity to first-tier cities.

Energy Landscapes in Zeeland

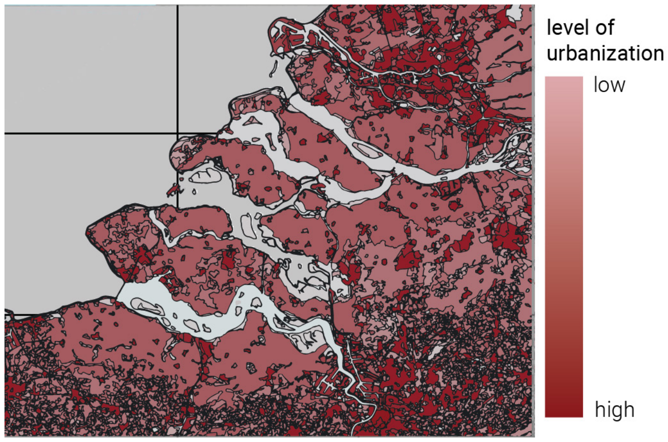
To understand Zeeland better and to see if this is a left behind space, where we can base our vision off of, we performed a similar landscape analysis as we did on the Eurodelta. Using K-medians clustering, we identified seven landscape types, which serve as the base to locate possible interventions in.

In the next step, we also analyzed the social structures in Zeeland, and finally overlaid them on each other to understand the region.



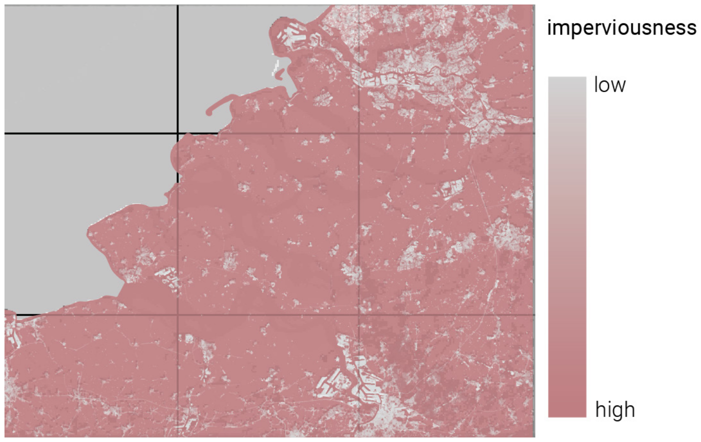
Energy Usage

Analyzing electricity on the scale of Zeeland helps to understand the region's economic activity. Although Zeeland has residential areas and cities, it is notable that the area has relatively low electricity consumption. Additionally, most activity occurs near water bodies, where industrial zones are located. However, there is higher electricity usage between the major cities of Rotterdam and Antwerp, suggesting these areas benefit more from their location between the port cities, leveraging the so-called 'borrowing size' advantage.



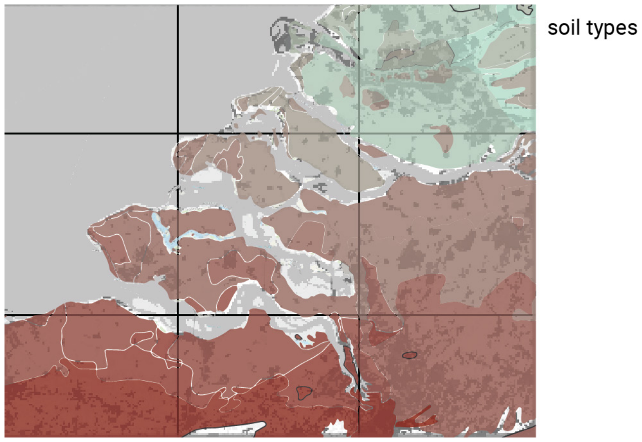
Urbanization

This analysis compares the urbanity of the region with the surrounding areas, with a particular focus on the eastern side between Rotterdam and Antwerp. The findings indicate that the differences in urbanity are relatively minor compared to these areas. This is surprising, given that other analyses have shown significantly lower activity levels in Zeeland. Furthermore, the relative distance between these areas is also quite small. The body of water between Zeeland and Brabant might have a significant effect on this, effectively increasing the perceived distance. This could also be one of the reasons Zeeland experiences more of an agglomeration shadow, while the cities on the other side of the water seem to reap the benefits of their location. These cities form a more polycentric network than those on the opposite side, thereby enhancing each city's competitive power.



Imperviousness

Zeeland has little paved surface area. However, there are regions with significantly higher imperviousness, corresponding with areas of higher population density. This is evident in the electricity analysis, which shows higher consumption in these areas. Notably, roads can be distinguished between the major port cities, passing through Breda, but not through Zeeland. This could contribute to Zeeland's 'agglomeration shadow' while accordingly Breda benefits from the 'borrowing size' effect.



Soil

The analysis reveals that Zeeland consists of various soil types and is not homogeneous. This leads to diverse energy applications since a solar field, for example, can have different effects depending on the specific application in the area.

Trees

It is noticeable that Zeeland has fewer trees compared to the surrounding areas, despite the low level of impervious surfaces in the region. This suggests that the area primarily consists of large grass fields, likely dominated by a specific grass type. This species has low biodiversity and is used to feed the cattle that farmers raise in the area. Consequently, the region has significant potential for biodiversity and energy development due to the ample space available for potential dual-use applications.

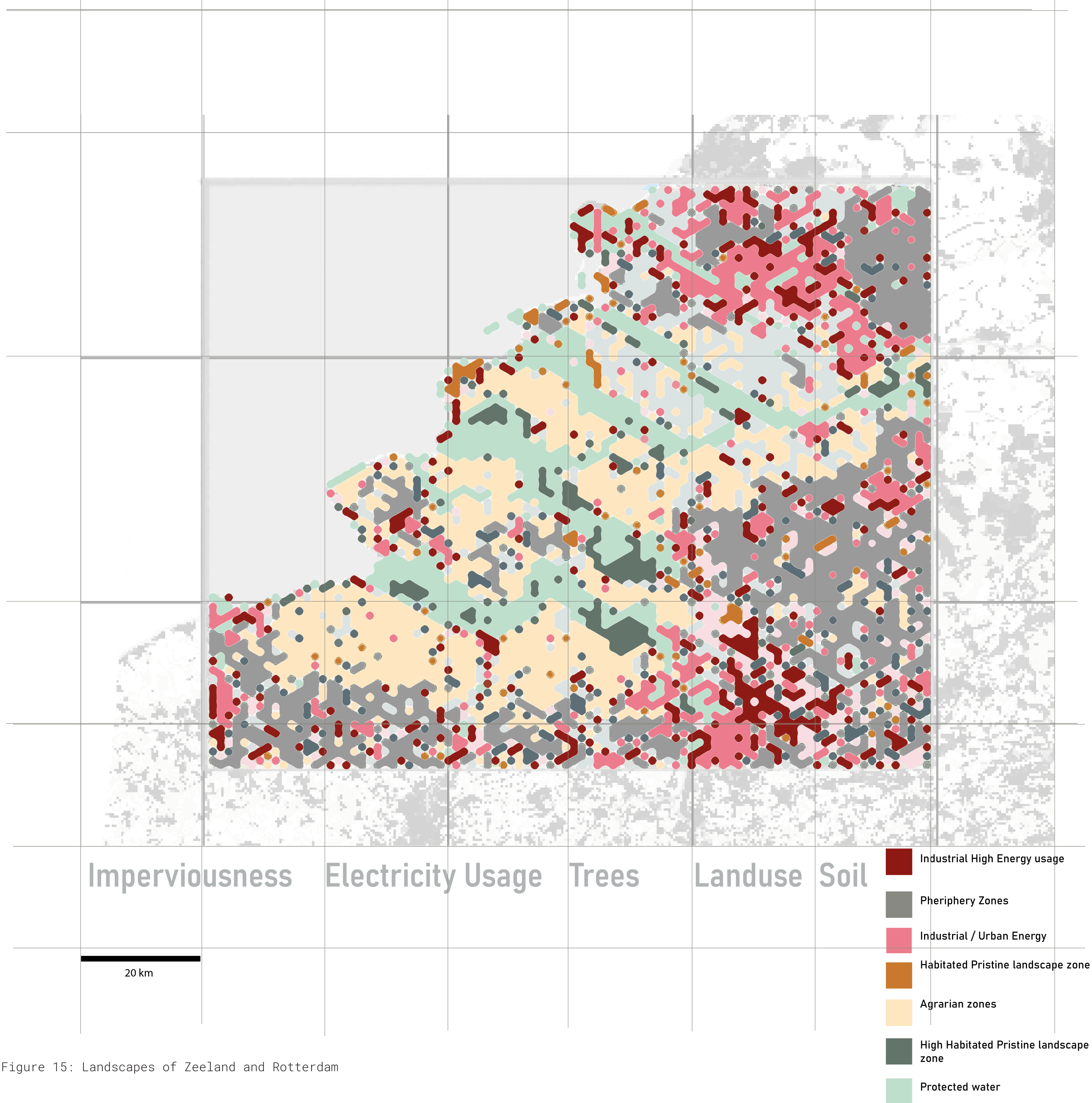
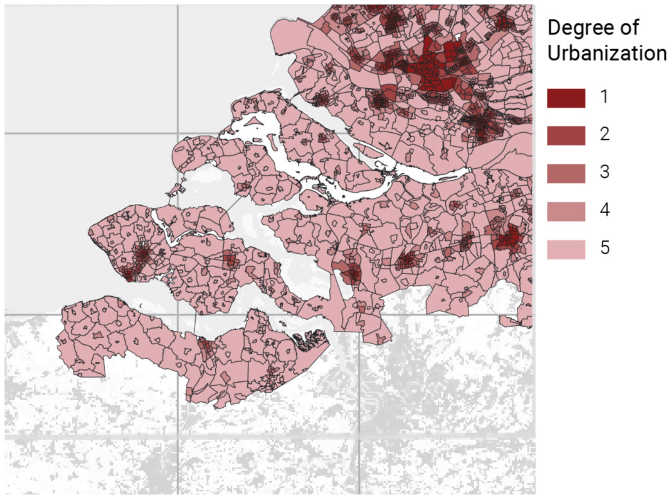


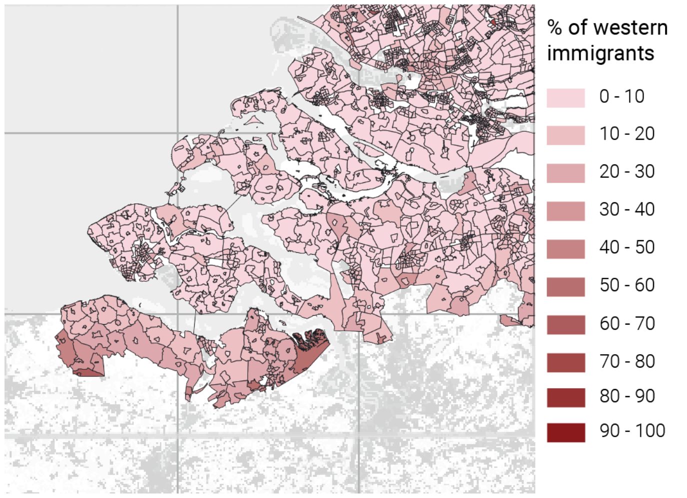
Figure 15: Landscapes of Zeeland and Rotterdam

The Social Layer of Zeeland



The degree of urbanization helps understanding where more densely urbanized areas are and how the urban fabric is dispersed. This analysis goes from 1 to 5, with 1 being the most urbanized level en 5 the least urbanized level. From this analysis areas like Rotterdam ans Vlissingen are emphasized.

Datasources for all datasets: CBS 2022



This analysis shows the percentage of Western-immigrants. It is notable that these percentages are at its height in areas with a lot of heavy industry or greenhouses. This is probably true due to the high amount of Polish and other East European immigrants providing cheap labour for these sectors.

These analysis were used in a Multi-criteria analysis using a cluster analysis with the K-median in GeoDa.

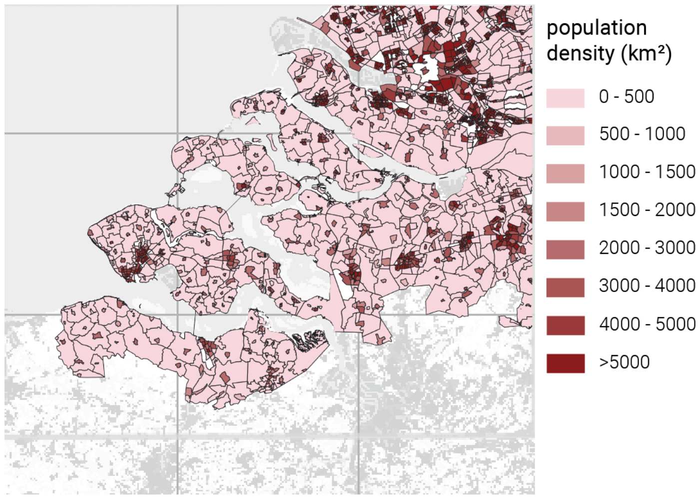
5 clusters were created, with one being natural areas where the population density was 0, thus this cluster is not shown in the map nor was it included in making the conclusion for the different communities.

The data used for this analysis came from a dataset from CBS (2022), this dataset provided data per neighbourhood, which is why the data is shown per neighbourhood. The data input where the following:

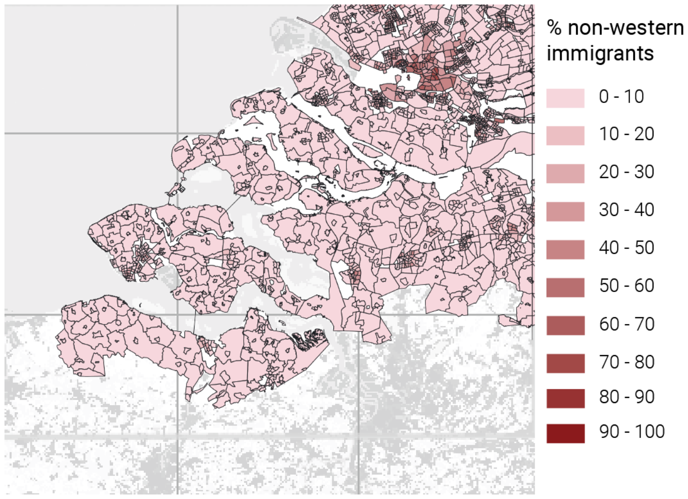
% divorced citizens
% married citizens
% western immigrants
%Non-western immigrants
urbanization level
population density
%owner occupied houses
% rental houses
average household size
housing value
age groups

The results of this analysis is shown on the next page.

The four clusters represent four different communities. Their characteristics are shown on the next page, and can be further used when creating new Energy Communities.

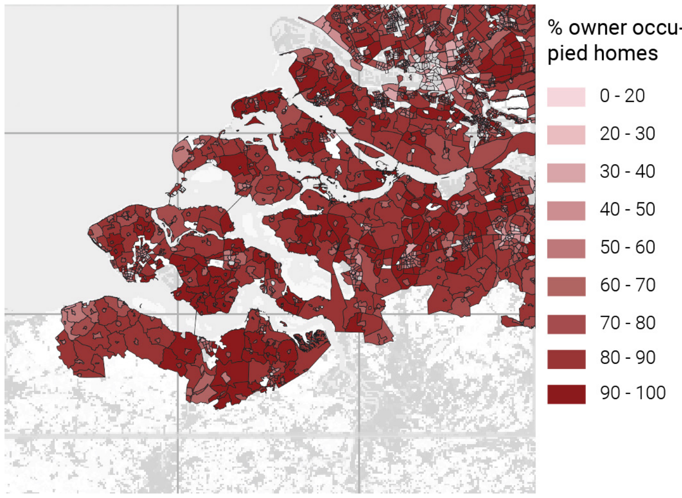


This analysis shows the population density. This follows nearly seamlessly the trend in the analysis about urbanization. This is due to the high density of houses in those areas. Again the more rural areas are the least densely populated.

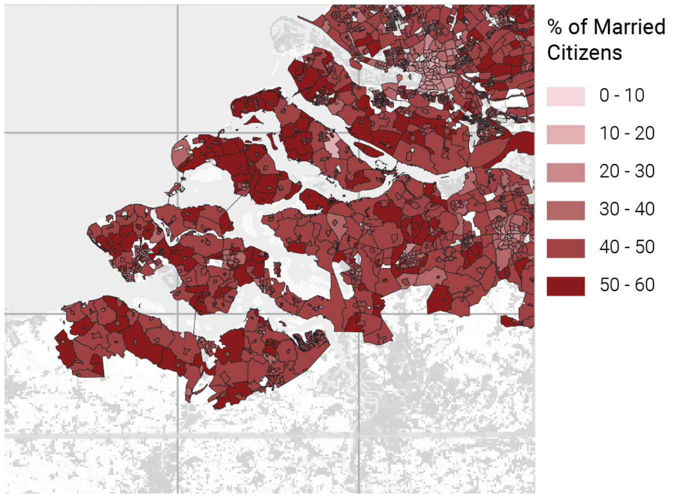


This analysis shows the percentage of non-western immigrants, like Turkish and Maroccan people. These people are mainly concentrated in the bigger cities, like Rotterdam. This is in contrast to the western immigrants, and is important for assessing the diversity of these bigger cities.

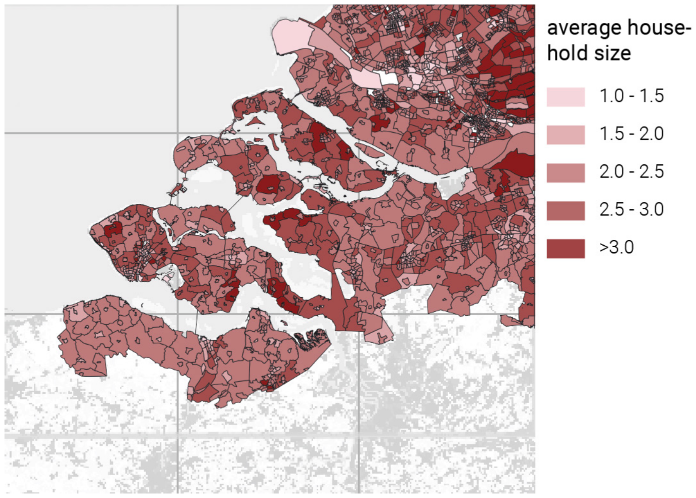
Figure 16: (combined) datasets about the social layer of Zeeland



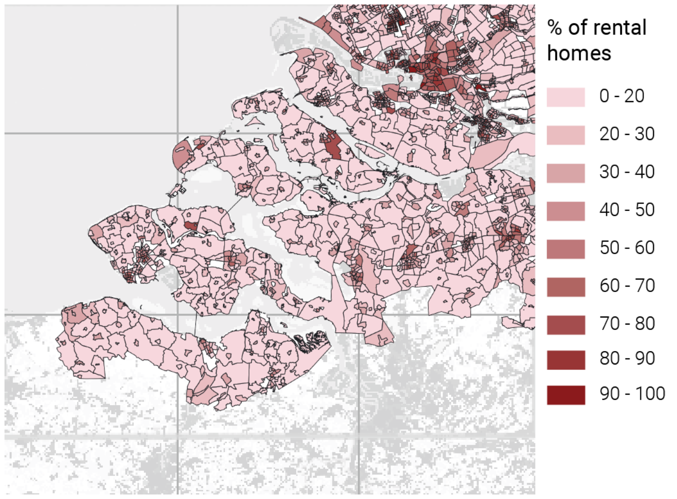
This analysis shows the percentage of owner occupied houses. As is shown here, rural areas in Zeeland are mainly owner occupied. These are large areas and according to the urbanization level the least urbanized.



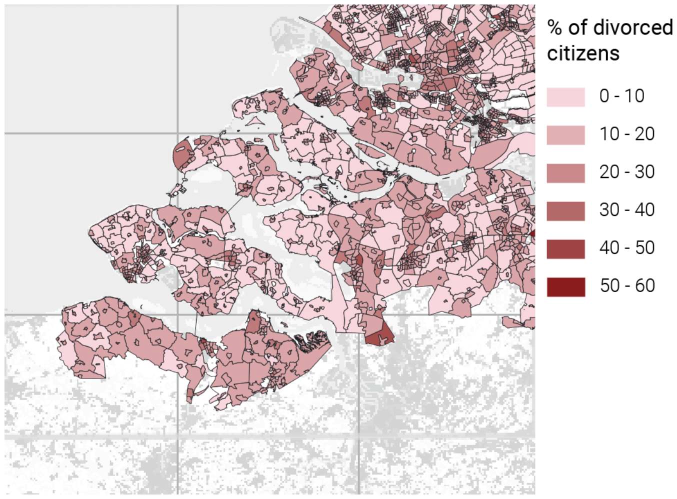
This analysis shows the percentage of married people. In most of Zeeland, this percentage is higher than average. In comparison, Rotterdam has a very low percentage. This is correlated to the amount of religious people living in these two areas, where there are less living in Rotterdam and more living in rural areas in Zeeland.



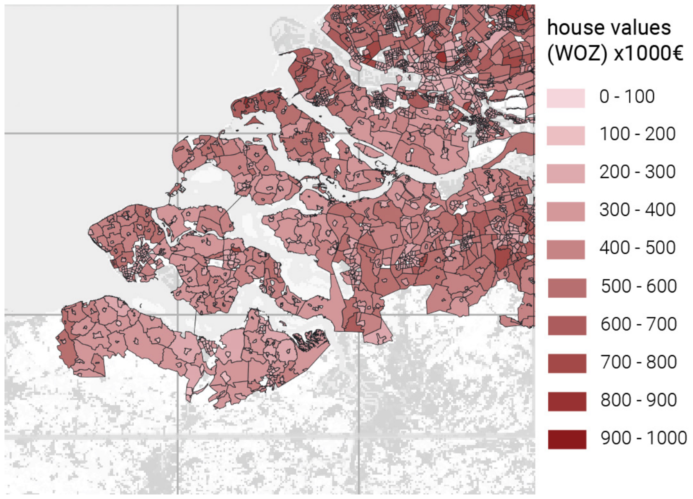
This analysis shows the average household sizes. Most of these are closely linked to age and household types, for exaple the difference between a young family, an old couple and a student. As is shown here, again the rural areas in Zeeland have the highest household sizes, while Rotterdam has the smallest.



This analysis shows the percentage of rental houses. It is clear that mostly in bigger cities, such as Rotterdam, people rent their homes. This analysis helps in identifying how people use their homes, how they get maintained and what the financial situation of most people in an area is



This analysis shows the percentage of divorced citizens. This analysis is an addition to the analysis about married people, and supports the conclusion about religious prevalence in rural areas.



This analysis shows the housing value, this helps with assessing where it is more likely for people to live with a higher income, since data about income was not available for this analysis. As is expected, the urbanized areas are more expensive than rural areas.

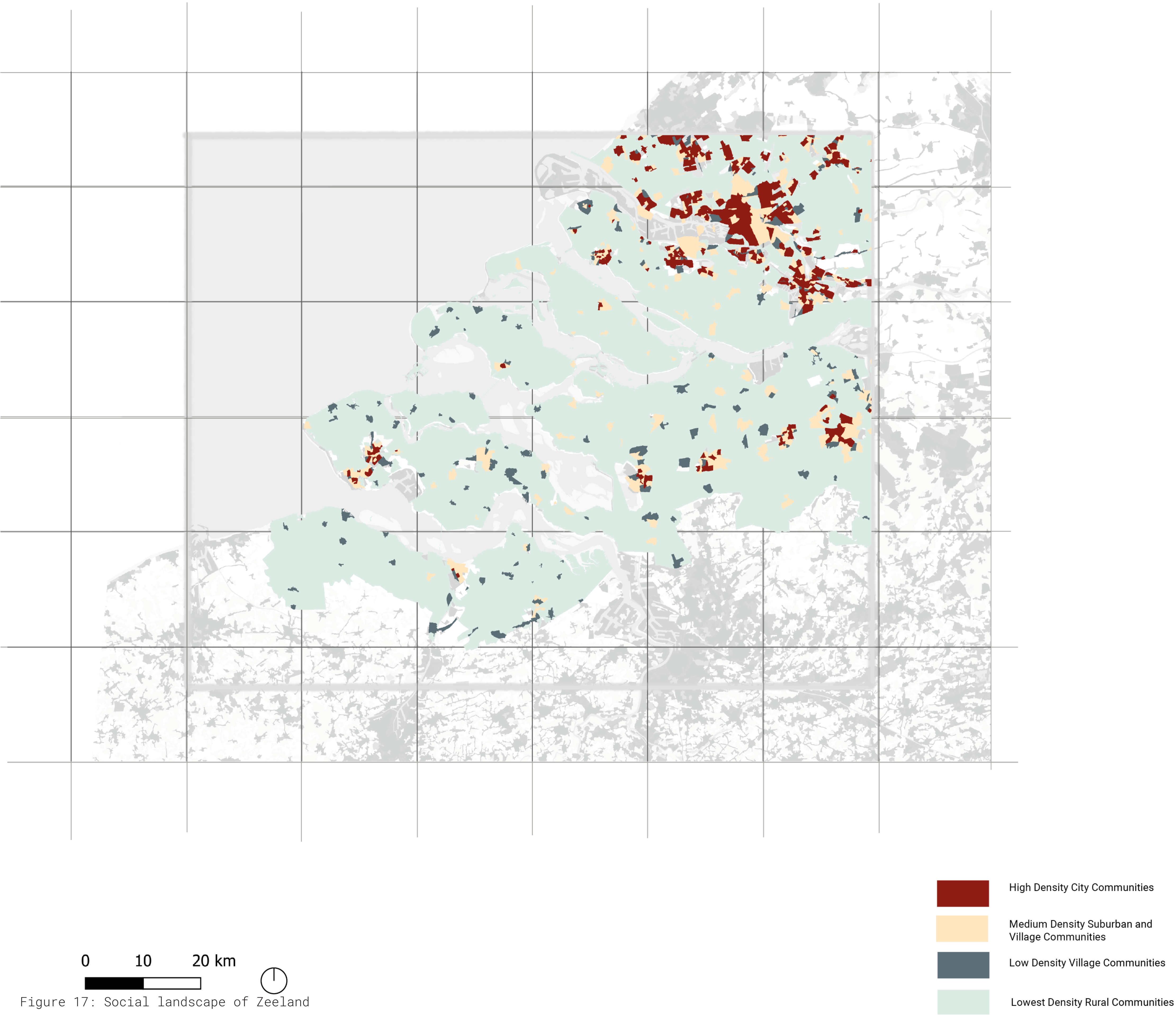


Figure 17: Social landscape of Zeeland

Hello, we are the Visser's,
We live in a small village and love our quiet life and occasionally talking to our neighbour Herman.
Our children went away after school and now have their own families near the big city.

Hi, my name is Nisrine,
I live and work in the city and like to be busy.
I left Turkey with my parents when I was a child and still like to visit my family there.
In my pasttime I like to hangout with friends or my roommates.

Hey, we are the family Maas,
We live on a farm in a rural area and like to get our hands dirty while working.
The children bike to school for an hour every day, so they get plenty of excercise!
On sunday we like to go to church and relax.

Hi, we are Froukje, Joep and Little Jelle,
After living in the city in our 20s, we decided to start our family in the sub-urbs.
This is the first house we bought and we work parttime and commute to work 2 days per week, the other days we work from home to watch this litlle guy.

Low Density Village Community

Urbanization level: 2
Population density: low
Amount of immigrants: low
Main age group: 65+
Marriage rate: high
Divorce rate: low
Household size: 2,3
Mainly bought houses
Housing value: 354.000

High Density City Community

Urbanization level: 1
Population density: highest
Amount of immigrants: high
Main age group: 20-40
Marriage rate: low
Divorce rate: higherst
Household size: 1,8
Mainly rented houses
Housing value: 301.000 euro

Low Density Rural Community

Urbanization level: 5
Population density: lowest
Amount of immigrants: lowest
Main age group: 0-16 & 40-65
Marriage rate: highest
Divorce rate: lowest
Household size: 2,5
Mainly bought houses
Housing value: 432.000 euro

Medium Density Village and Suburban Communities

Urbanization level: 2
Population density: medium
Amount of immigrants: medium
Main age group: 20-40
Marriage rate: medium
Divorce rate: low
Household size: 2,2
Mainly rented houses:
Housing value: 307.000 euro

Figure 18: The four types of people living in Zeelnad

Zeeland Analysis Conclusions

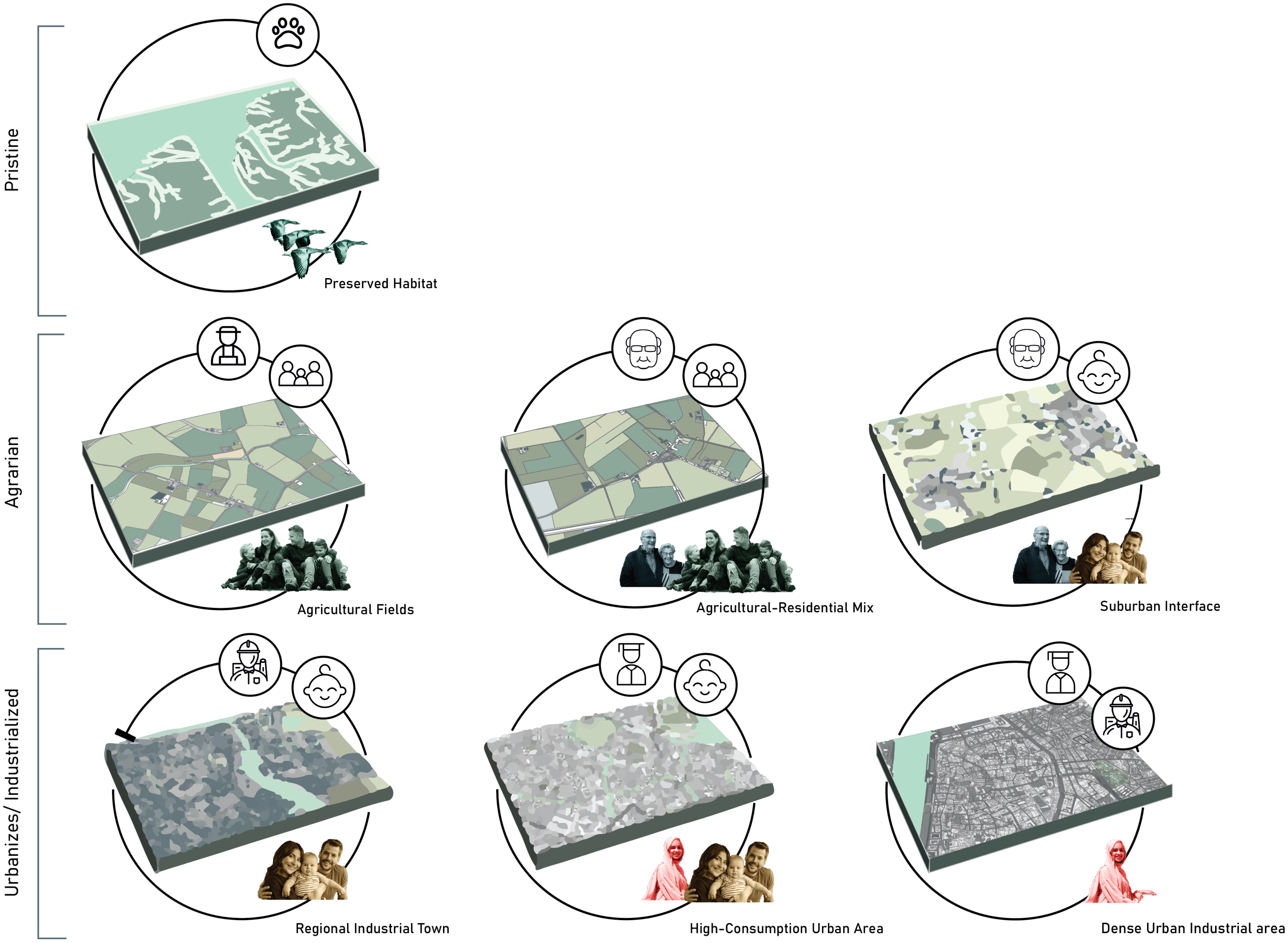


Figure 19: Landscape and social types in Zeeland

The analysis of Zeeland indicates that its geographical position within the Netherlands has adverse effects, contributing to the negative impacts associated with 'shadow agglomeration' and leading to its perception as a peripheral rural area. This isolation not only obstructs physical and economic connectivity but also results in diminished economic activity, manifesting in the decline of services, culture, and accessibility (as illustrated in the 'Electricity and imperviousness' figure). Despite its advantageous coastal location, Zeeland faces challenges as people and resources tend to gravitate towards larger urban centers like Rotterdam and Antwerp, which offer more services and employment. The roads surrounding Zeeland, providing direct access to these cities, bypass the region, further intensifying its isolation.

To mitigate these challenges, ensuring improved connectivity between Zeeland and major urban centers is important to establish mutually beneficial relationships. Although economic flows have routinely excluded Zeeland, this scenario has allowed the region to evolve as a natural resort, enjoying a rich diversity of wildlife, including birds, marine life, and amphibians. This natural abundance is supported by the Natura 2000 sites, dunes, mudflats, salt marshes, and polder landscapes, coupled with the region's extensive water bodies that provide essential nutrients for the ecosystem. In conclusion, despite the economic bypass, Zeeland has cultivated a rich natural environment due to its very low urban density.

Populated areas in Zeeland range from small village communities with limited diversity to more vibrant city communities with younger, diverse populations, and from rural communities primarily engaged in farming to suburban areas with young families and commuters. The proximity to major cities like Antwerp and Rotterdam, as well as the appeal of dune areas, influences settlement patterns. The inner parts of the islands tend to harbor rural communities reliant on agriculture, while areas closer to the dunes benefit from tourism, attracting more suburban-type communities. Therefore, the factors of urbanization, employment opportunities, and even soil type are intricately connected to settlement patterns and the demographic profile of the residents. Historically, urban and community development focused on trade and production, which during the Industrial Revolution evolved to separate production from urban leisure spaces. However, the populated areas of Zeeland reflect a reversion to pre-industrial urban concepts, where production and consumption are intertwined and visible.

In light of these findings, it is crucial to recognize nature as a key stakeholder, integrating ecosystem services into regional planning and development significantly, to ensure a balanced and sustainable growth for Zeeland.

Chapter 4

Vision: A Just Energy Transition

In our vision statement we set out to create energy communities, to correct the injustice that will happen if the renewable energy transition is organized centrally. We analyzed the landscapes in the Eurodelta and uncovered the tensions between urban core landscapes and intensive agricultural landscapes. In the region of Zeeland, which shows signs of a left behind place in the agglomeration shadow of Rotterdam, we found out which communities of people live there and that they differ significantly from surrounding regions.

Specifically in the region of Zeeland, together with Rotterdam, we develop this vision. Energy communities come together to incorporate many different stakeholders in small and medium towns. They connect to each other to create an integrated energy landscape. This landscape will be able to produce energy in a decentralized manner. These points will be expanded further on the next pages, they culminate in one vision statement, and we will reflect on the vision through the lens of a SWOT analysis and it's relevance in the sustainability triangle and the sustainable development goals.

Figure 20: a potential future energy landscape, where renewable energy is simply part of the existing landscape.

Vision Goal 1: Decentralized Energy System

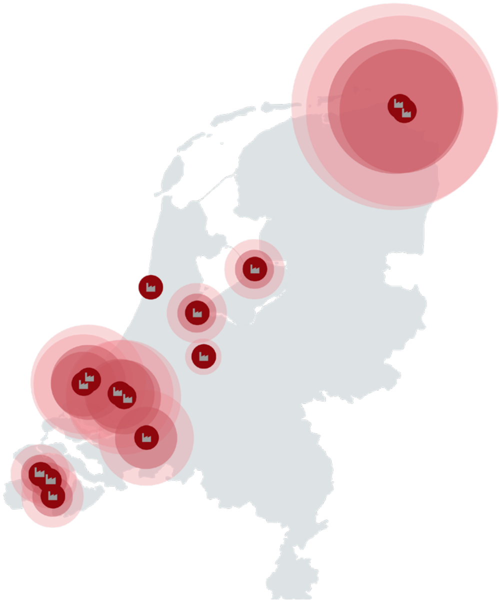


Figure 21: Current centralized energy production system

Current System

Energy production is centralized in just a few places, and then exported to the rest of the country. With most of the energy production infrastructure situated in the urban core landscapes, this effectively leads to a wealth transfer from the peripheral regions into the core. On the flipside, much of the pollution has to be endured by the urban core region, which is also unjust.

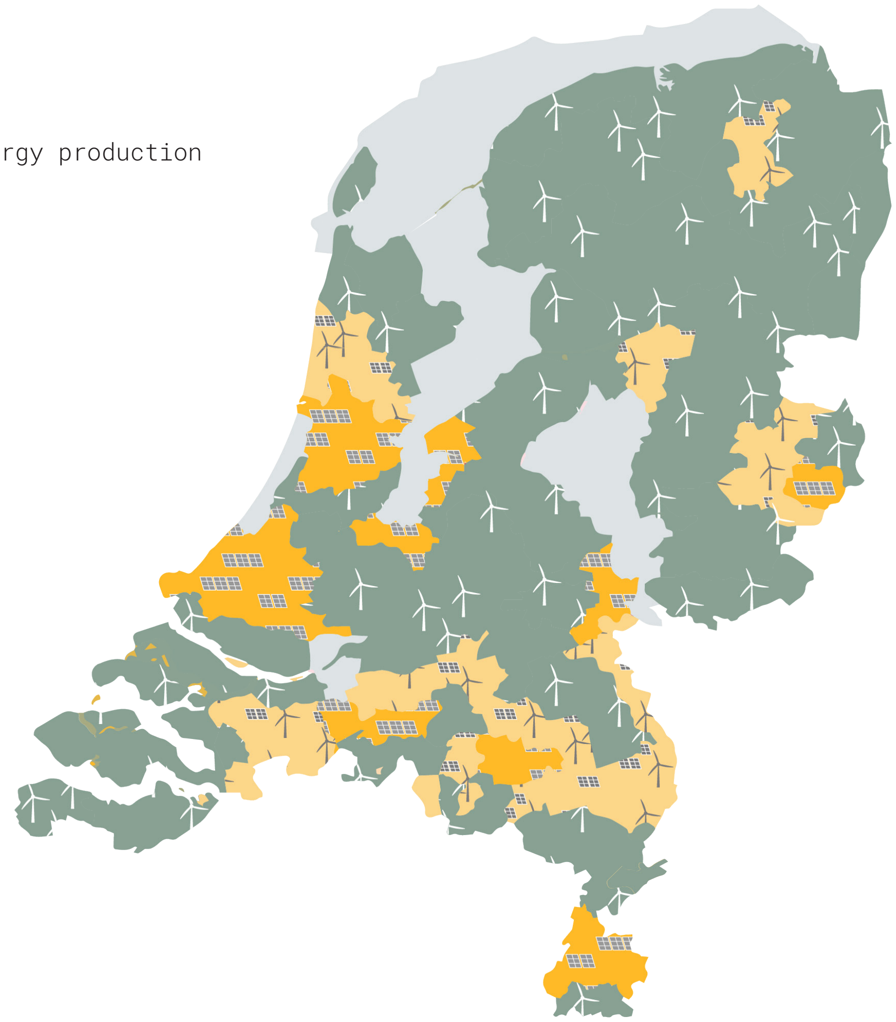


Figure 22: Renewable energy production is decentralized

Vision: Decentralize energy production to make use of the land, and to spread out benefits and impacts

Renewable energy production needs a lot of space. This can be harnessed as a strength if we think not only of decentralizing production, but also benefits and impacts. If the money earned from wind turbines and solar panels doesn't just flow into the urban core regions, but actually becomes productive capital for the agricultural landscapes, these left behind places have new opportunities and value.

Vision Goal 2: Energy Communities

Current System

The dominant large energy corporations, who until now produced energy centrally, now expand into the rural landscapes to build renewable energy production, as we explored in the problem statement.. While the production physically isn't in the urban cores anymore, the profit and other benefits are still centralized there. We have shown on the example of Zeeland that the places where those infrastructures are set up are economically disadvantaged.

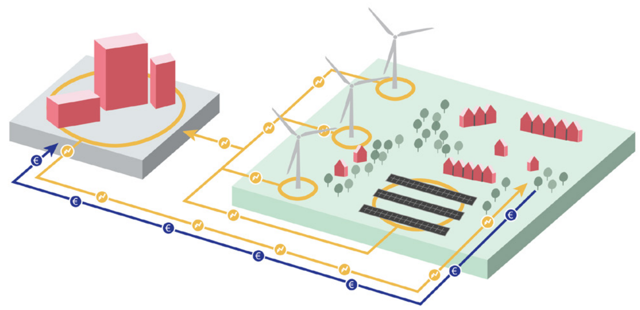


Figure 23: Current system of renewable energy production and profits

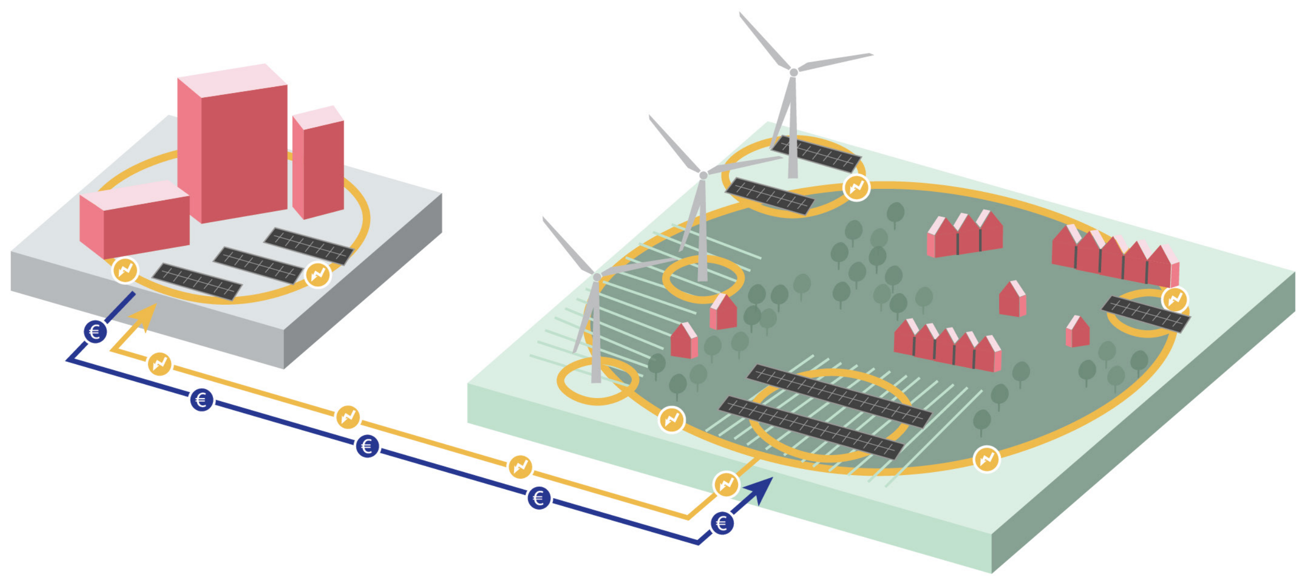


Figure 24: Energy communities producing renewable energy themselves and trading with consumers

Vision: Spatial justice through energy communities, who come together to produce their own renewable energy and profit from it.

While it is difficult for a single household to build a wind turbine, if the local communities start cooperating, it becomes possible to connect land owners with consumers, regulators, financing and grid operators to make renewable energy projects possible. If the people are involved in the energy production, they don't just have the negative externalities, but also feel the benefits and profits.

Vision Goal 3: Integrated Energy Landscape

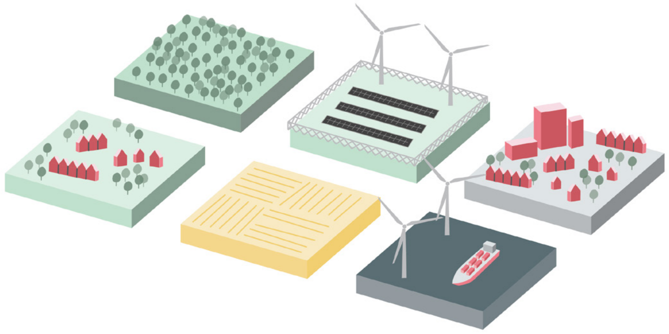


Figure 25: Renewable energy production is separated from other landscapes

Current System

Renewable energy production is being built as wind and solar parks superimposed on the landscape, often physically separated from other land uses and not accessible to the public. Thus they are like foreign objects that in the best case are invisible, and in the worst case antagonize adjacent residents and communities.

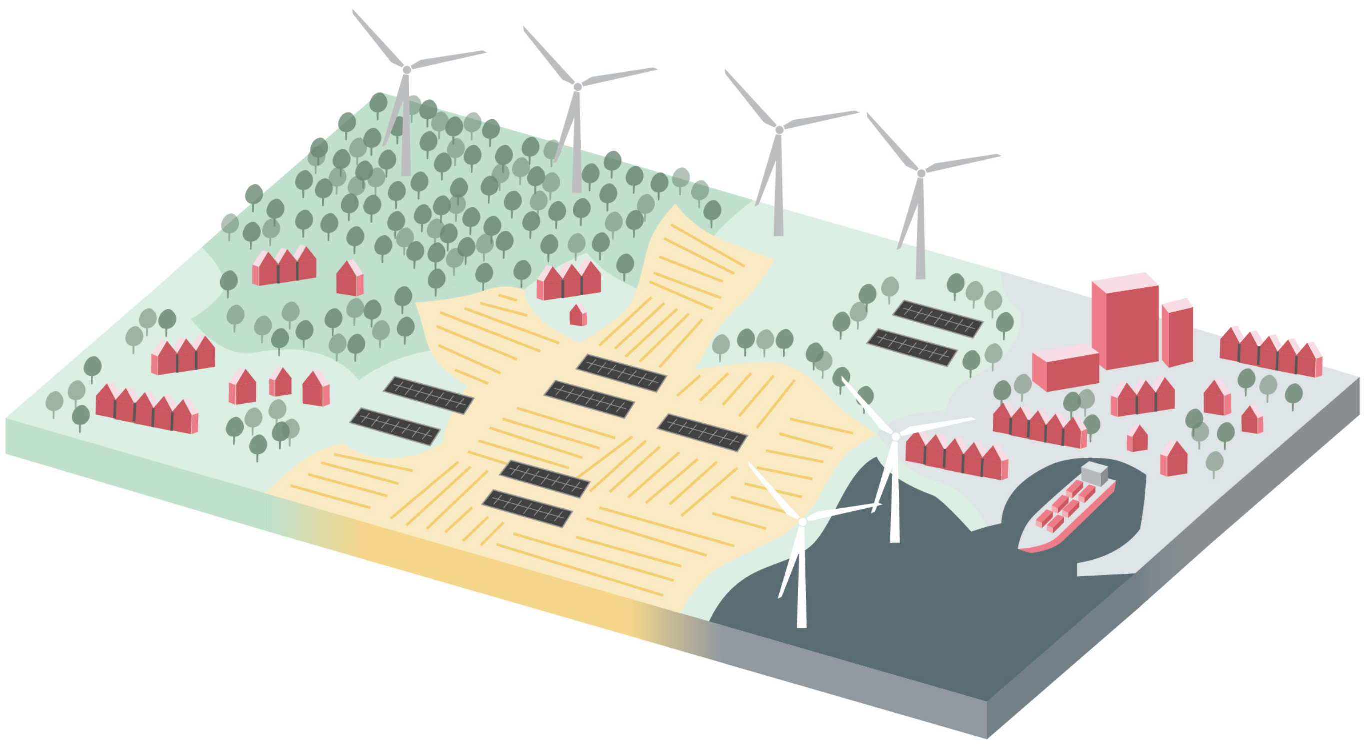


Figure 26: Renewable energy is seamlessly integrated in the landscape

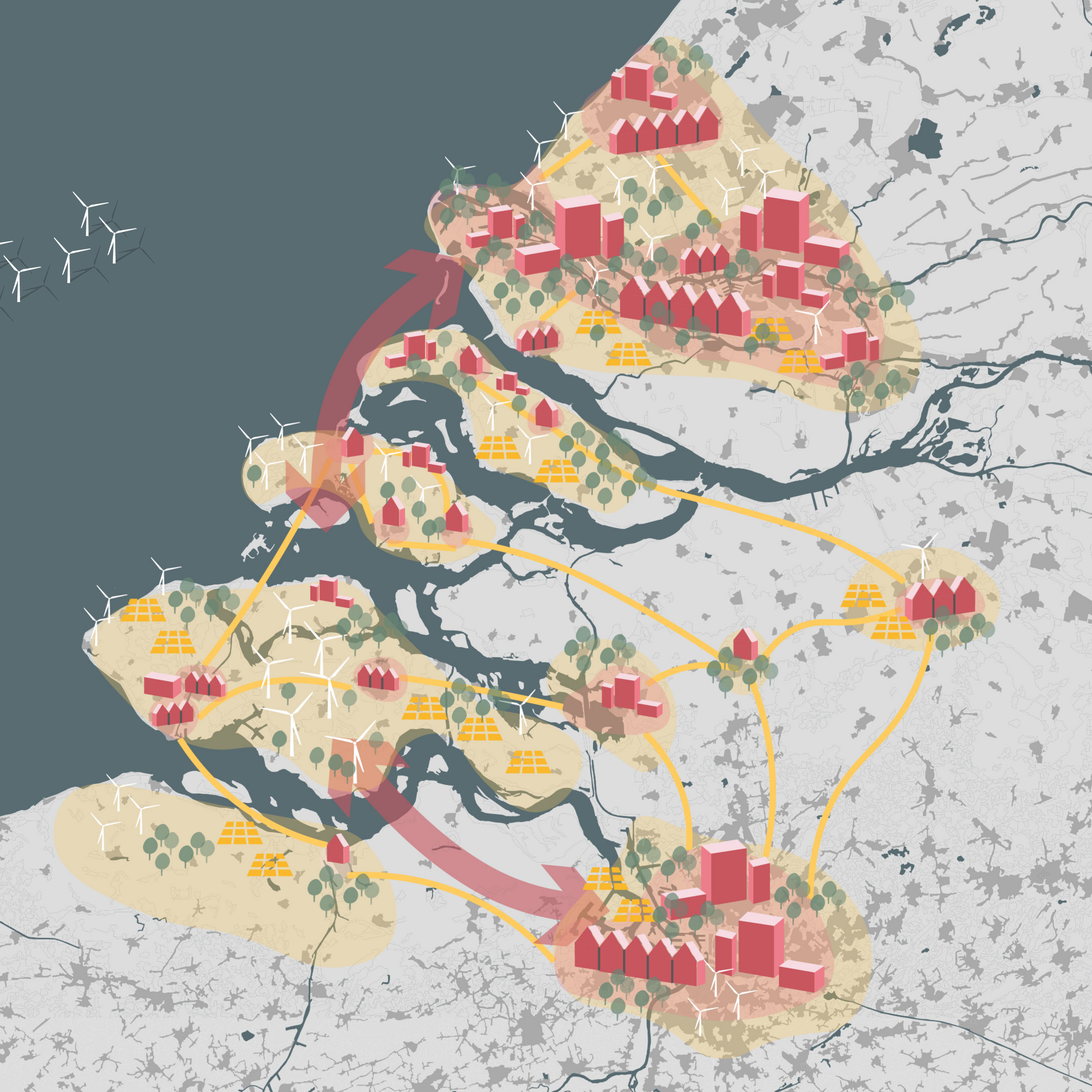
Vision: Integration of renewable energy in the culture and existing landscape.

A careful placement of renewable energy production, reacting to existing landscapes and integrating themselves into current land uses leads to a responsible usage of space and also preserves and enhances said landscape. Multifunctionalism and co-location are controlled by the energy communities, which have an interest in a nice environment to live.

Our Vision

Reenvisioning the energy transition, by designing sustainable energy landscapes and creating new energy communities.

Figure 27: A network of energy communities forming an integrated energy landscape



Putting our Vision into Context

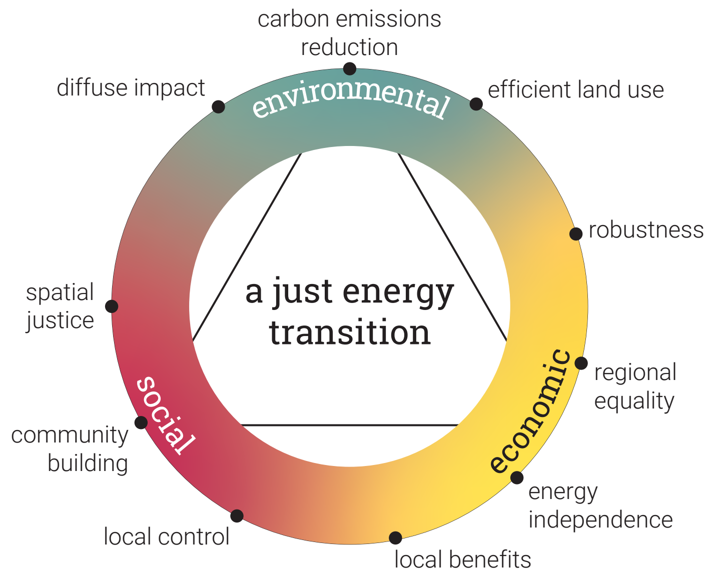


Figure 28: Sustainability triangle of our vision

Sustainability

Our vision aims to address all sides of the sustainability triangle, realizing that the three dimensions of environmental, social, and economic sustainability are not separated, but intertwined with each other.

SWOT Analysis

strengths

- co-location of renewable energy with other land uses
- people feel connected to power sources
- wind energy is engrained in Dutch heritage
- less dependence on a few energy providers
- increased robustness of the energy system
- less pollution
- pioneer project

weaknesses

- less control because of decentralization
- set-up costs money and resources
- impacts of renewables on the local environment
- existing jobs in fossil fuel industry vanish
- grid typology and capacity needs to be changed

opportunities

- securing our future against global warming
- re-use of existing infrastructures
- opportunities for left behind spaces
- new jobs in the renewable energy industry

threats

- potential local opposition, NIMBYism
- disruption of the current system requires carful implementation
- houses in the open landscape need to be considered
- current energy companies may oppose
- complacancy
- potentially green washing

Figure 29: SWOT analysis of our vision

An analysis of the strengths (S), weaknesses (W), opportunities (O) and threats (T) can help us identify how the vision can be improved, and what needs special attention.

Major threats to consider are potential opposition of local residents, and how the change in the energy system needs to be implemented carefully. The first concern will be addressed by a focus on the stakeholders and the community, and by involving them in the project from the start. The second concern is addressed with a gradual implementation, and a pilot project, from which learnings can be applied to scaling it up.

Impact on the SDGs

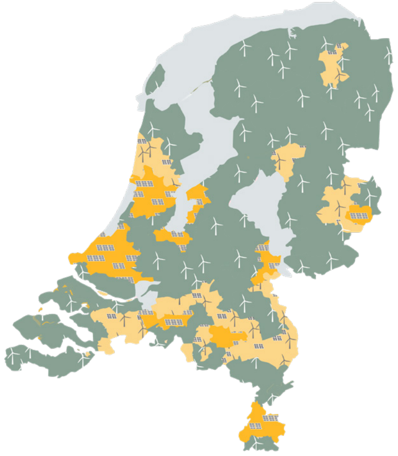
SDG	Decentralizing the energy production	Spatial justice in energy through energy communities	Integration of energy in the cultural landscape	
7 AFFORDABLE AND CLEAN ENERGY	○	●	○	The downside of the current centralized energy production is that only a few companies control energy generation. Moreover, like many other European countries, the Netherlands is somewhat dependent on other nations, which makes them vulnerable. According to our concept, production occurs within communities, thus keeping ownership local
8 DECENT WORK AND ECONOMIC GROWTH	●			The downside of the current centralized energy production is that only a few companies control energy generation. Moreover, like many other European countries, the Netherlands is somewhat dependent on other nations, which makes them vulnerable. According to our concept, production occurs within communities, thus keeping ownership local
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	●	○	●	Rethinking energy production requires the implementation of new technologies, which in turn necessitates a large workforce for their creation and implementation. According to our project, surplus energy produced will be sold, which contributes to boosting the economy.
11 SUSTAINABLE CITIES AND COMMUNITIES	○	●	○	The transition away from fossil fuels requires the development of new infrastructure. To ensure the efficient and environmentally friendly operation of renewable energy sources, continuous monitoring and the integration of innovative technologies are necessary, along with collaboration with developers and researchers.
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	○	●	○	Our project's primary aim is to decentralize energy production, making it not only physically accessible to communities but as a way to raise awareness. When renewable energy production takes place nearby and people understand the processes involved, it prompts us to reconsider our consumption habits, not just in terms of energy but also in other aspects.
13 CLIMATE ACTION	●			The threat of climate change is evident worldwide, hence the aim is to establish an energy production system that promotes sustainability on social, environmental, and economic fronts alike. The energy-producing communities envisioned in our project seek to achieve these goals collectively through community collaboration.
17 PARTNERSHIPS FOR THE GOALS	○	●	○	For a sustainable future to emerge in the long term, it is essential for decision-makers and civil society to collaborate and intertwine their efforts. This same collaborative approach is crucial for ensuring energy provision. Therefore, our project is founded on the cooperation of rural and urban stakeholders

based on: United Nations, 2023

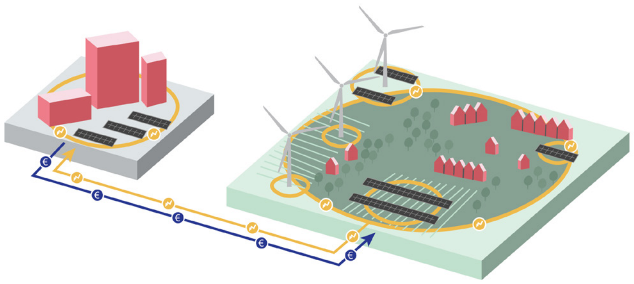
Chapter 5

Strategy

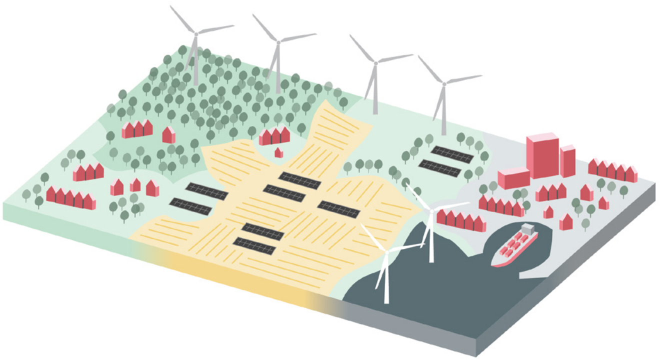
Vision goal 1:
Decentralized energy production



Vision goal 2:
Energy communities



Vision goal 3:
Integrated energy landscape



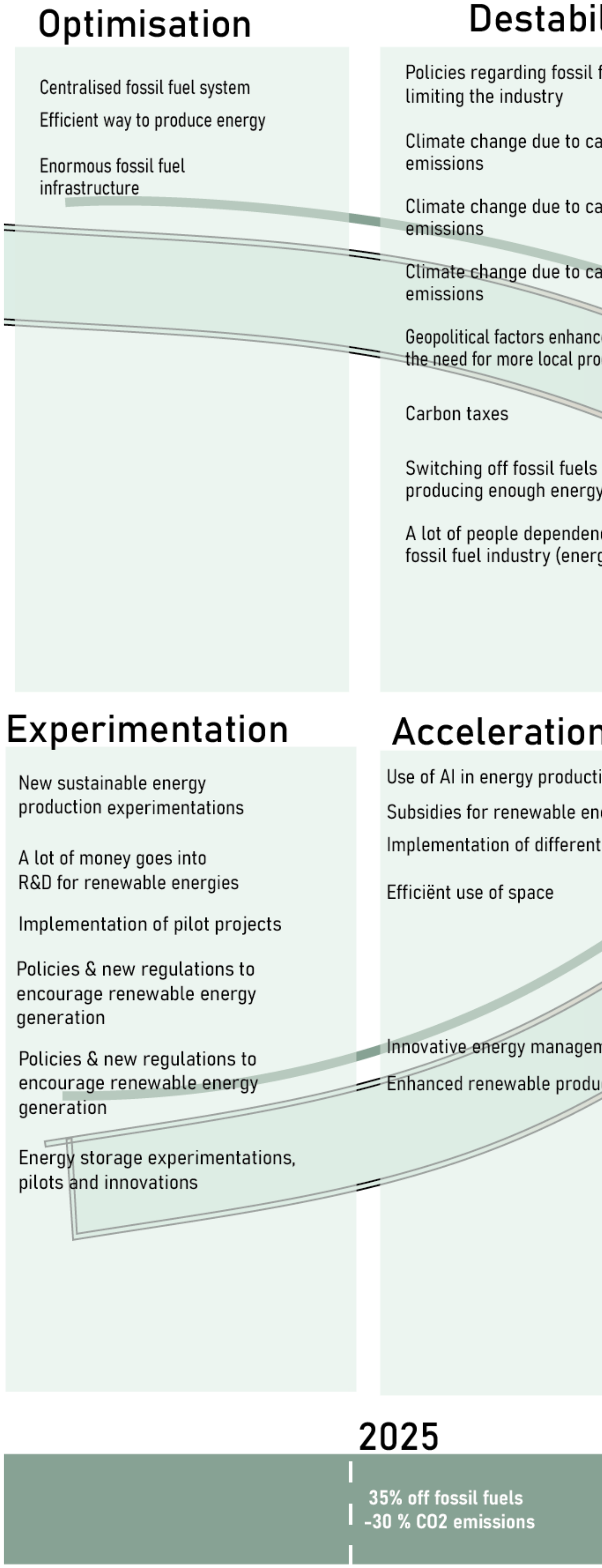
In our vision we are focusing on reimagining the living environment and the energy transition. In this reimagined scenario, a cultural energy layer is added on top of the built environment, where transparency is a key pillar. The primary principle in integrating this new, visible energy infrastructure layer is that energy communities are able to exchange energy, store it for later use, or feed it into the electricity network, supporting each other and creating an environment where the collective within an energy community becomes significant.

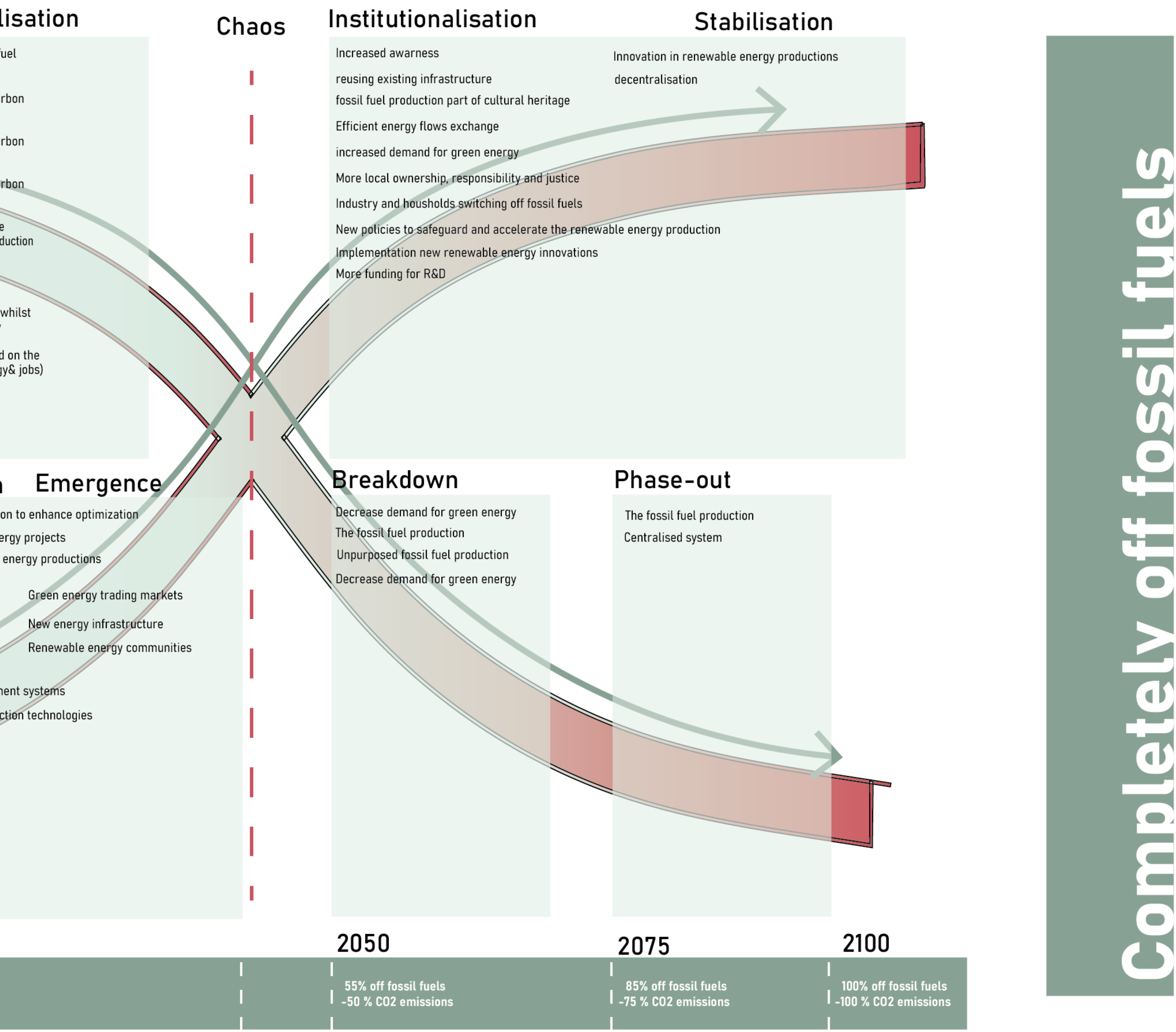
In the strategy, we explore the essence of an energy community from technical, social, and policy perspectives. This aims to bring together the various aspects of creating an energy community and achieve our vision goals in a fair, transparent, and sustainable manner. Ultimately, our goal is to create a fair energy transition that introduces a purer form of democracy.

The strategy begins with the timeline to provide a clear and comprehensive overview of the different interventions involved in creating an energy landscape. Next, we discuss the technical aspects of implementing an energy community, showing the various energy systems and their relative sizes to each other to explore the spatial footprint of these systems in an area. Additionally, the technical principles upon which an energy community is designed will be explained.

Subsequently, we discuss the catalog that presents diverse energy system options within the landscape, which was devised following analyses from the vision. In alignment with this, we tackle the implementation of an energy community within the context of policy formulation. To this end, we propose a new system advocating for an improved, more transparent democratic process, one that brings people closer to the heart of decision-making and clarifies their role in the establishment of an energy community.

Thereafter, we intend to use maps and visual examples to demonstrate potential appearances of energy landscapes and communities, exemplified by a city and a village in Zeeland—Klaaswaal and Oud-Beijerland—and Rotterdam.These areas were deliberately chosen to address and incorporate all the landscapes analyzed in our strategy and due to their proximity of each other, which will be elaborated upon in the technical section. In the final part of the strategy, we illustrate what an energy community might look like from a resident's perspective.




lisation
Chaos
Institutionalisation
Stabilisation
Increased awarness
reusing existing infrastructure
fossil fuel production part of cultural heritage
Efficient energy flows exchange
increased demand for green energy
More local ownership, responsibility and justice
Industry and housholds switching off fossil fuels
New policies to safeguard and accelerate the renewable energy production
Implementation new renewable energy innovations
More funding for R&D
Innovation in renewable energy productions
decentralisation
Emergence
on to enhance optimization
ergy projects
energy productions
Green energy trading markets
New energy infrastructure
Renewable energy communities
nent systems
ction technologies
Breakdown
Decrease demand for green energy
The fossil fuel production
Unpurposed fossil fuel production
Decrease demand for green energy
Phase-out
The fossil fuel production
Centralised system
2050
2075
2100
55% off fossil fuels
-50 % CO2 emissions
85% off fossil fuels
-75 % CO2 emissions
100% off fossil fuels
-100 % CO2 emissions
Completely off fossil fuels

Timeline

In the timeline, we outline the progression of our project from the present day to the year 2100. The upper section illustrates the evolution of energy production in accordance with our vision. Our primary objective is to diminish reliance on fossil fuels. Initially, we aim to phase out coal, followed by a gradual increase in renewable energy production. Furthermore, we highlight the significance of geothermal energy and anticipate technological advancements.

In the lower section of the timeline, we present a detailed plan for establishing energy communities. We provide an example featuring the processes for three distinct energy communities. Regardless of the commencement year, each community undergoes identical phases. We have categorized the actions into five distinct phases, which may vary for each community. Subsequently, we further categorize these actions into policy, social, technical, and spatial layers, arranging them accordingly.

based on: International Energy Agency n.d., Rural Energy Community Advisory Hub 2022.

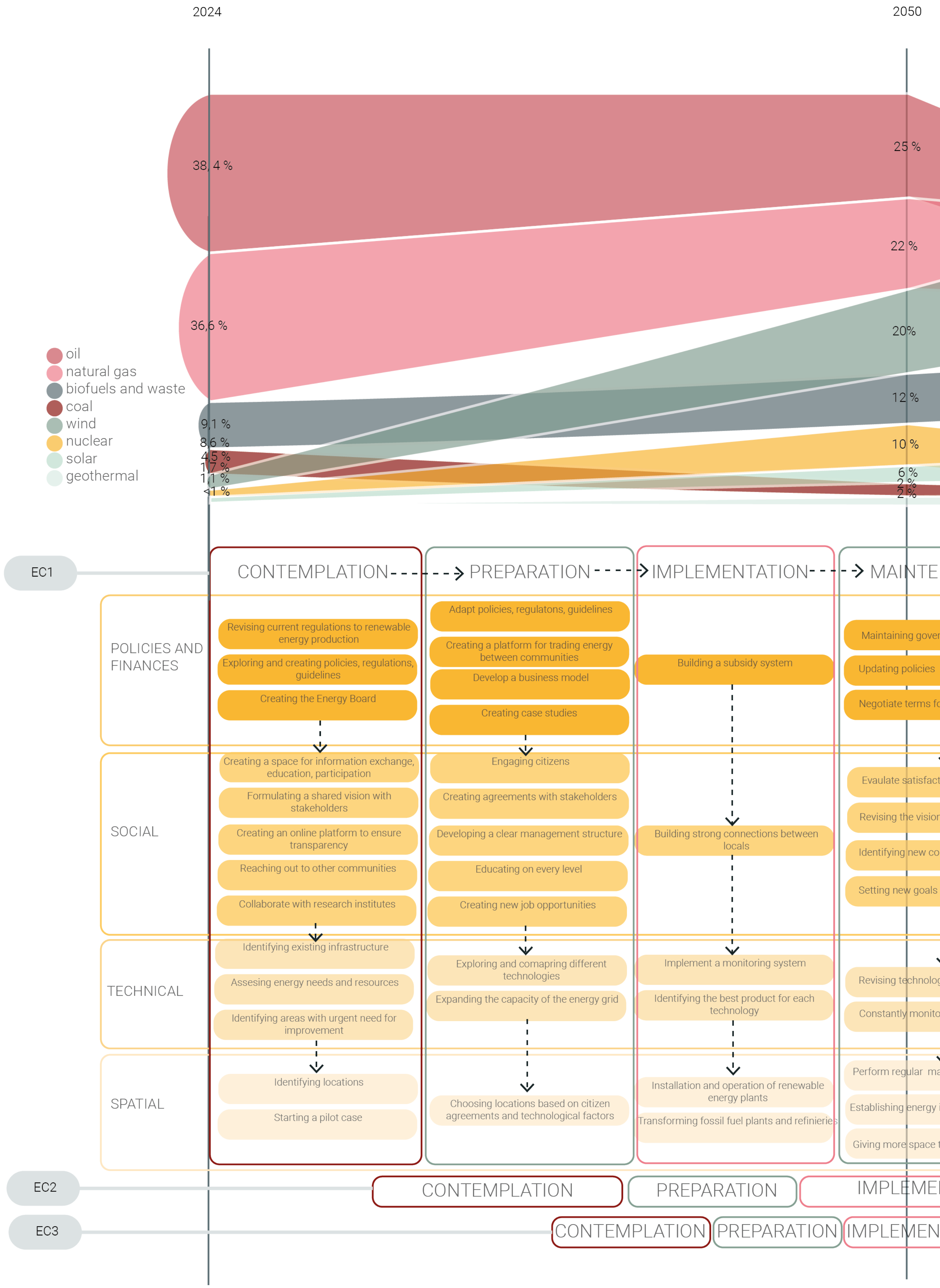
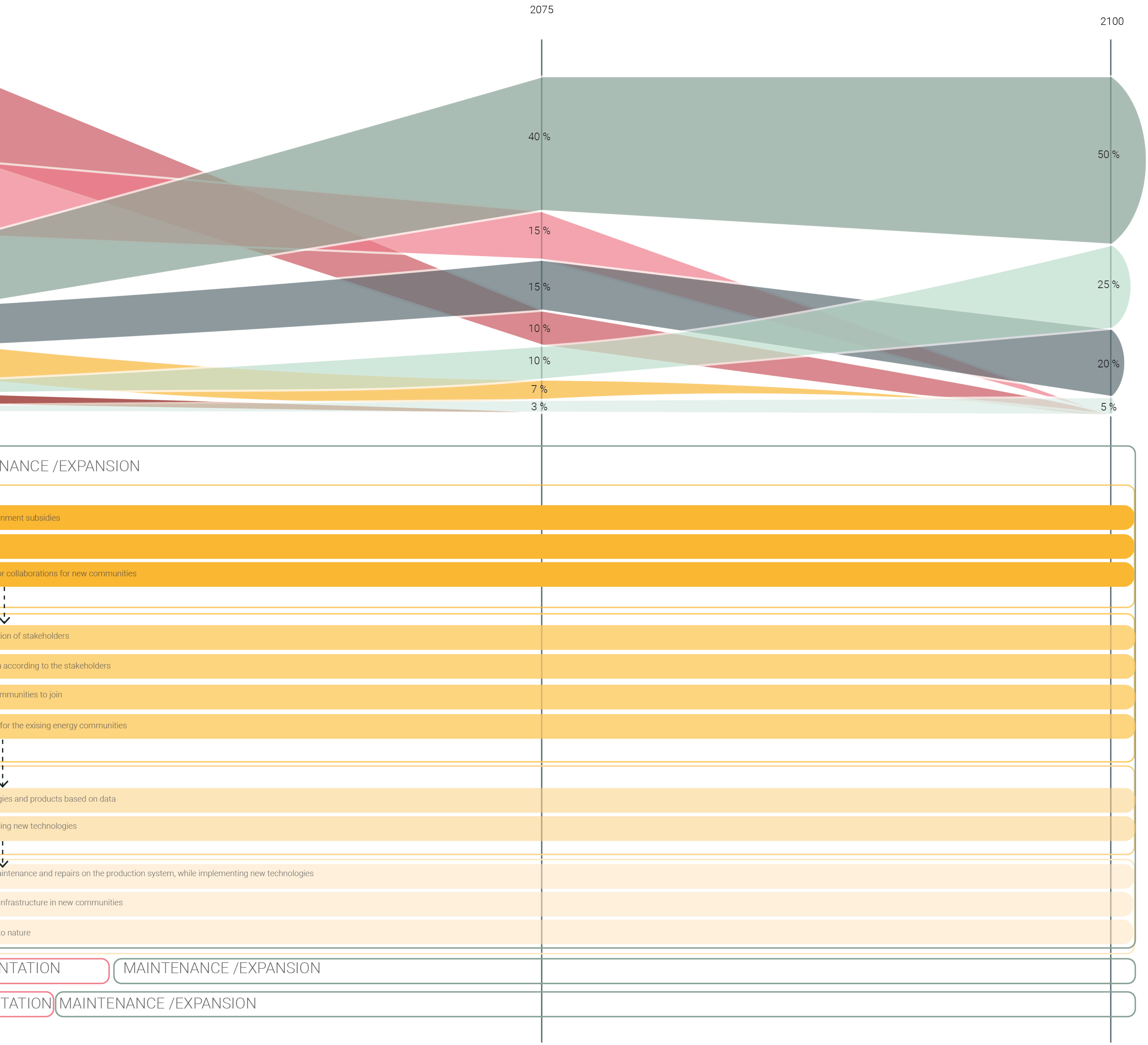


Figure 30: The timeline of how to implement the strategy


2075
2100
40 %
50 %
15 %
15 %
25 %
10 %
10 %
20 %
7 %
3 %
5 %
NANCE /EXPANSION
nment subsidies
r collaborations for new communities
ion of stakeholders
according to the stakeholders
mmunities to join
for the exising energy communities
gies and products based on data
ing new technologies
intenance and repairs on the production system, while implementing new technologies
nfrastructure in new communities
o nature
NTATION
MAINTENANCE /EXPANSION
TATION
MAINTENANCE /EXPANSION

The Technical System of the Energy Community

To achieve sustainable energy generation in urban areas, it is crucial to understand the different energy systems and how they need to be integrated into the environment and cities. Various energy systems have different applications and uses. It's important to distinguish between energy and electricity; energy is a collective term for various types of energy, including electricity. Besides electricity, heat is another significant form of energy.

Our current energy system encompasses different levels of electricity: low voltage, medium voltage, and high voltage. This distinction is vital for spatial planning since low voltage typically occurs underground, while high voltage is transmitted through overhead power lines. Transporting electricity incurs losses, so it's wise to minimize distances and consider the proximity of different areas. This principle underpins the technical aspect of creating an energy community. By forming smaller sub-networks that exchange energy among themselves, the energy has to travel shorter distances, thereby increasing efficiency. The size of these sub-networks depends on the size of the cities/neighbourhoods/towns and surrounding area. For example, Rotterdam might consist of multiple sub-networks, while three smaller nearby villages could share one.

The technical side of an energy community is closely linked to the location of the areas. Within the sub-networks, there can also be clusters, allowing streets and buildings closer to each other to exchange energy more rapidly than those farther apart. This way, smaller energy communities within the larger ones emerge.

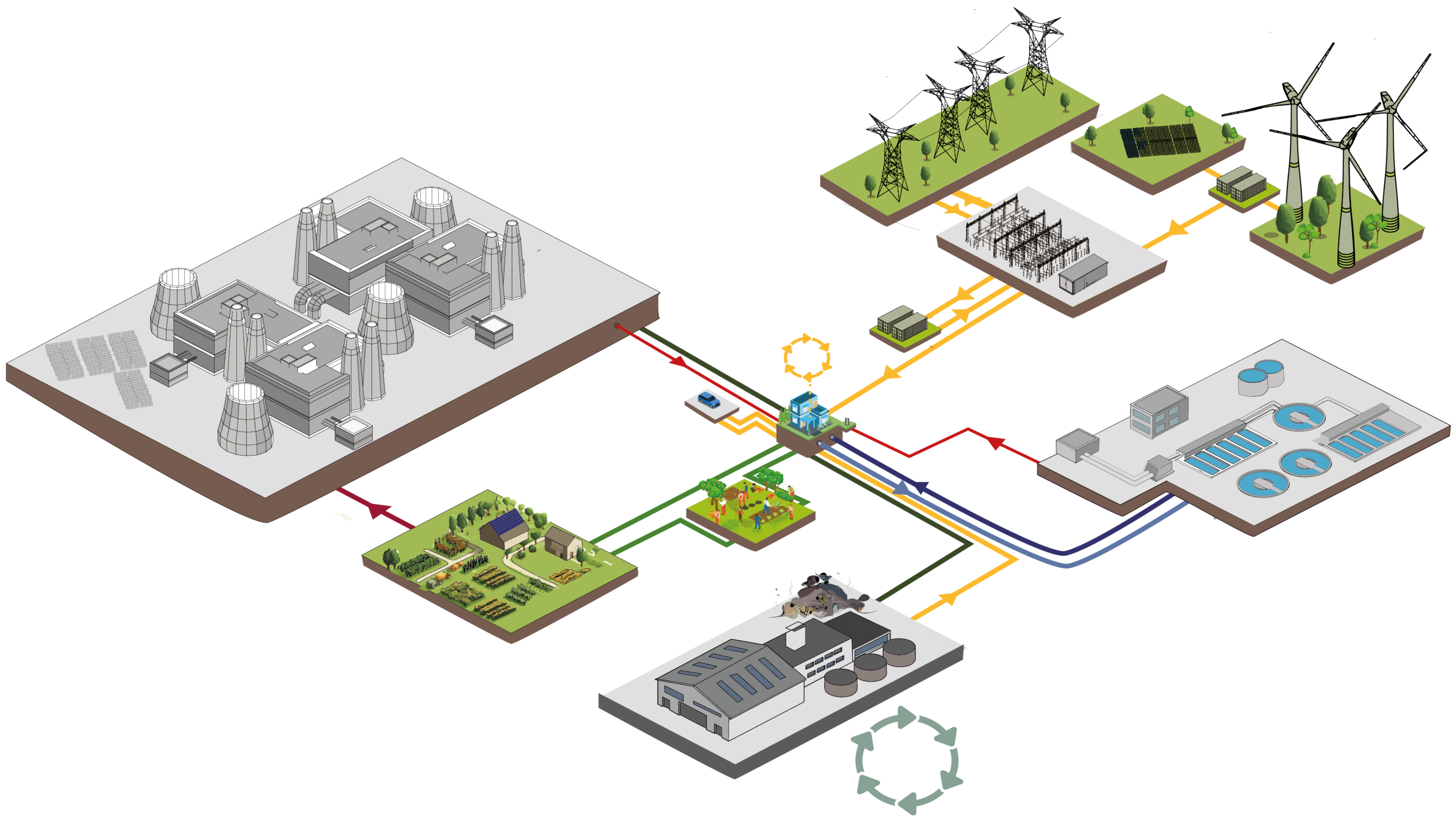
Storage

A crucial pillar for the successful implementation of renewable energies is the use of storage. Both consumption and production have peak moments. Ensuring that supply and demand are balanced and the electricity grid is stable requires the ability to store generated energy for later use.

Households and Energy

In our project, we focus on households, as residential buildings are responsible for a significant percentage of CO2 emissions. By concentrating on homes, certain energy systems become more crucial than others. The emphasis will mainly be on solar panels, wind turbines, in-house energy systems (e.g., heat pumps), and sources that generate heat, such as energy from sewage, surface water, and biofuel. In Figure 31, we show the complete energy system relevant to the households.

Besides switching to sustainable energy sources, reducing consumption is also vital. We have reviewed the loops leading to higher energy use, such as waste, water, and energy, in order to close them, as shown in the diagrams. It is essential to acknowledge that closing these loops requires collaboration with other communities. The varying sizes, diversity of populations, locations, and dominant sectors (like agriculture versus industry) result in different needs that are complementary to each other, see Figure 32.



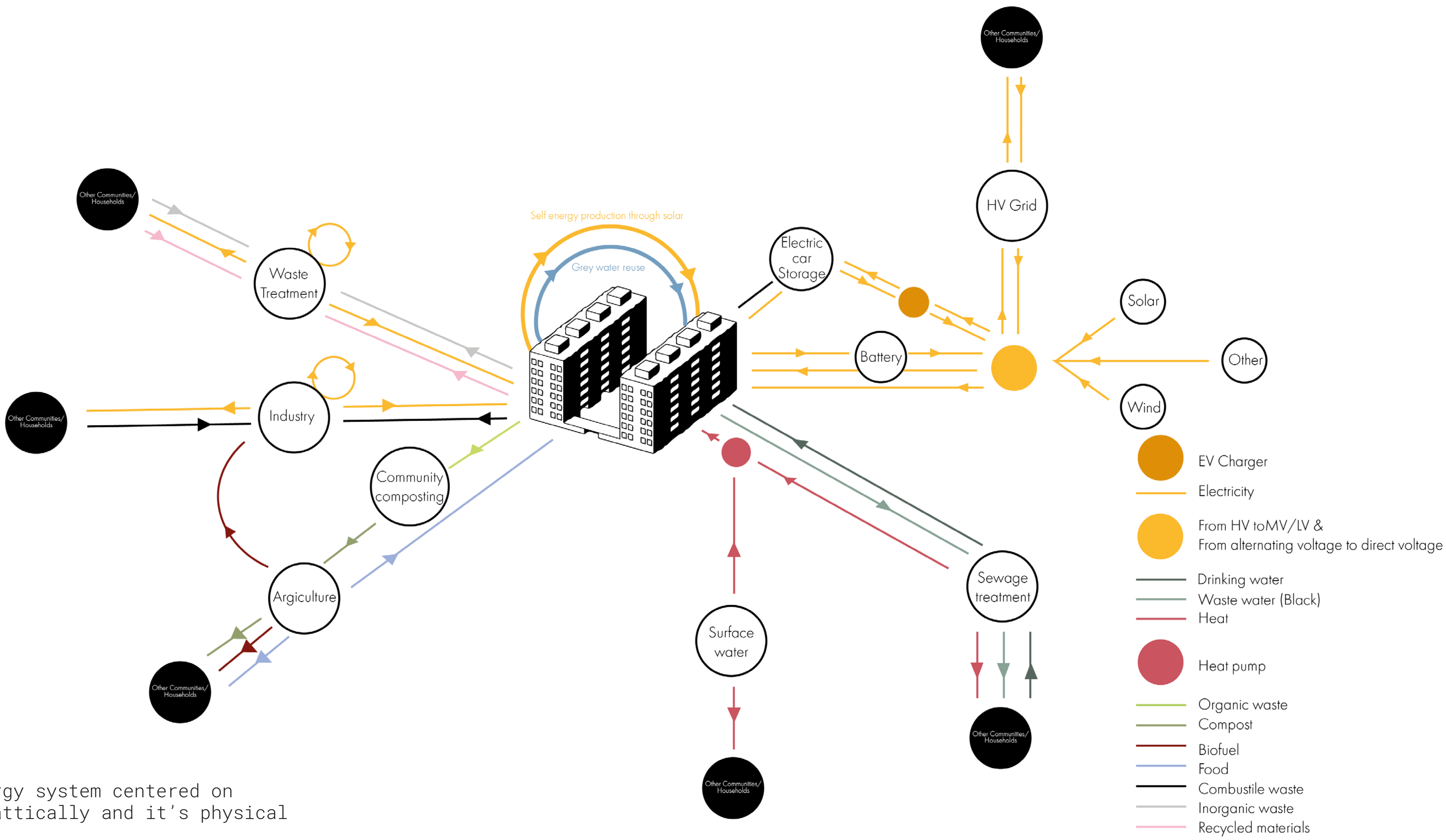
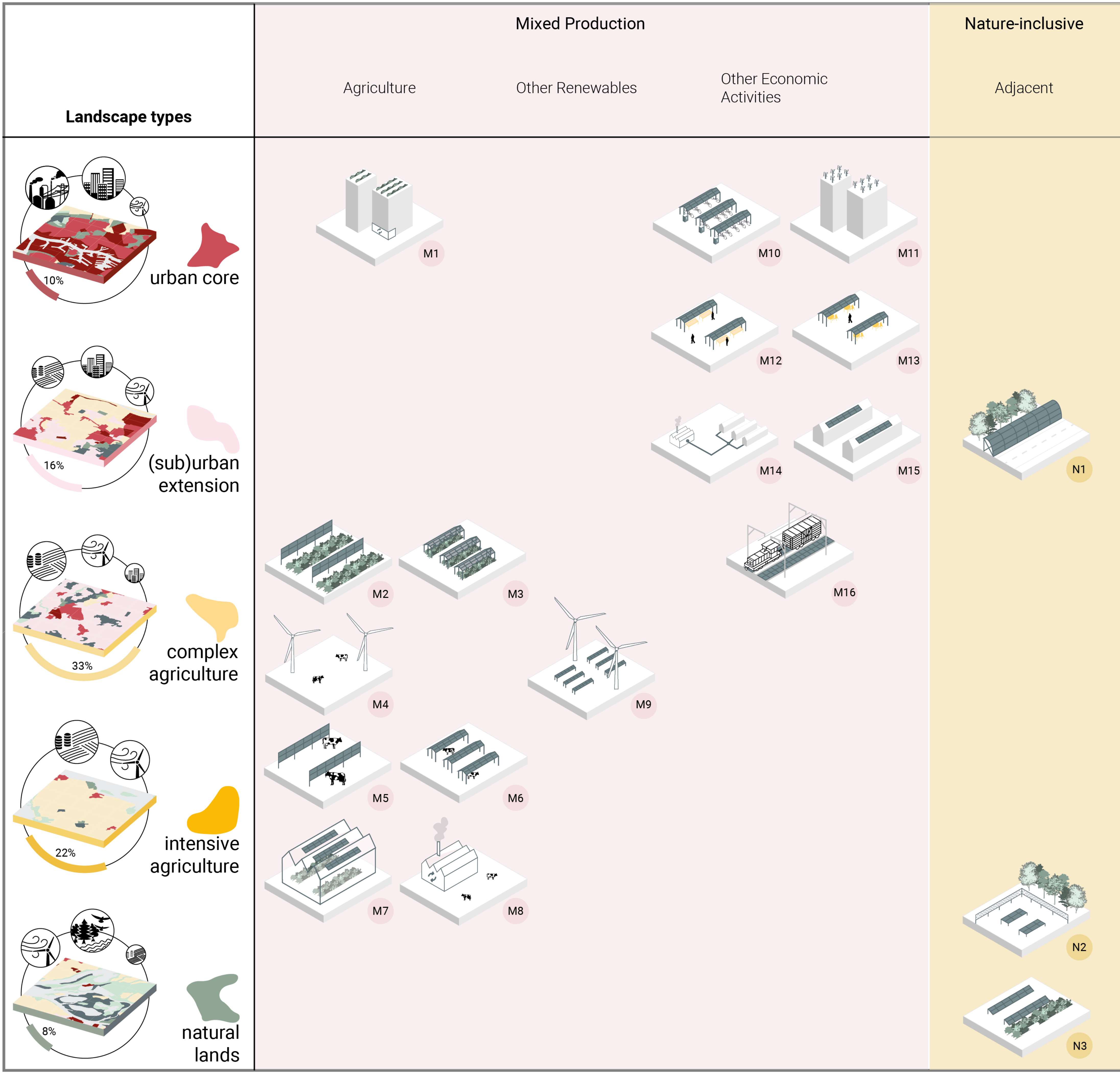
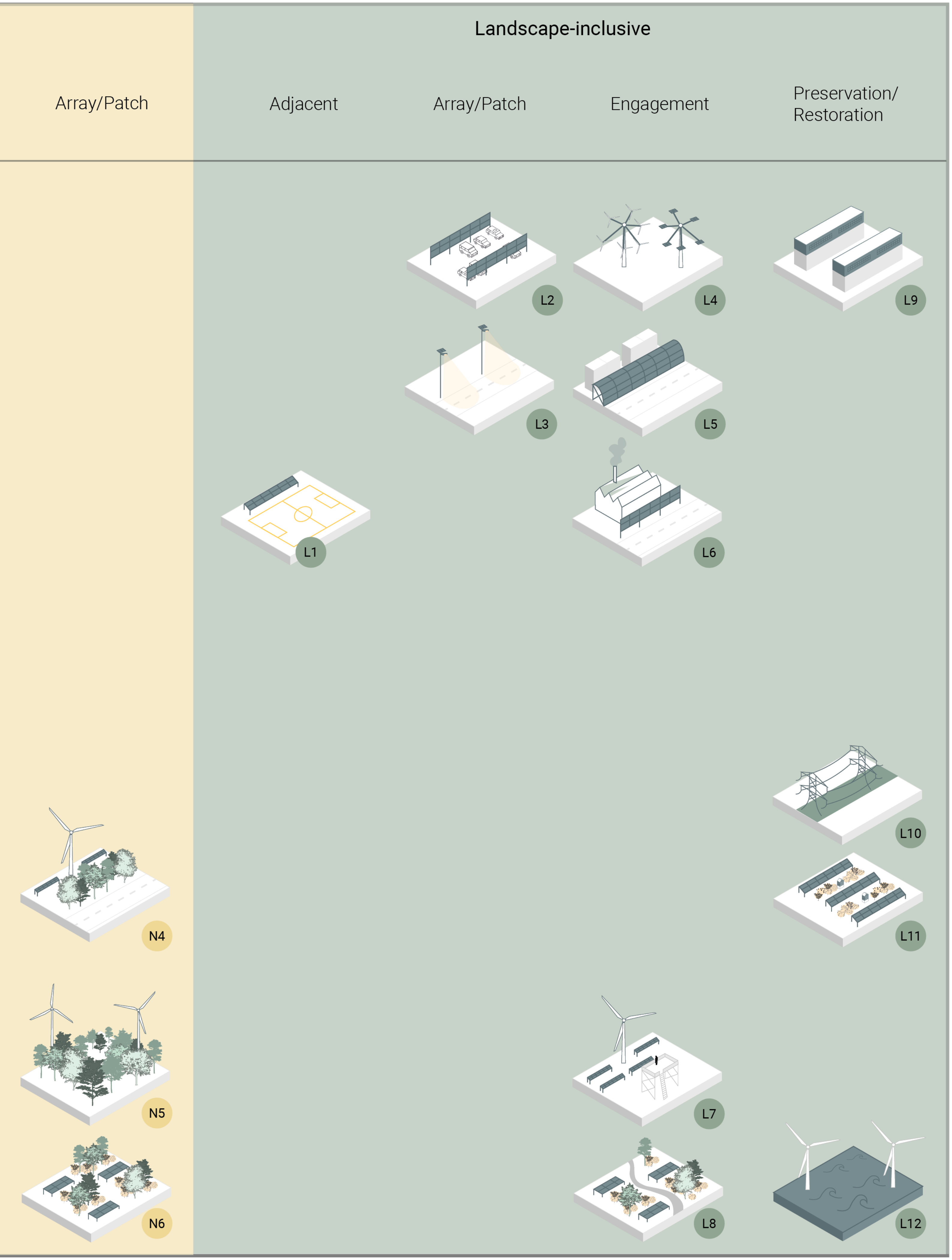


Figure 31: The energy system centered on households, systemattically and it's physical implementation


Mixed Production
Nature-inclusive
Landscape types
Agriculture
Other Renewables
Other Economic Activities
Adjacent
10%
urban core
16%
(sub)urban extension
33%
complex agriculture
22%
intensive agriculture
8%
natural lands
M1
M2
M3
M4
M5
M6
M7
M8
M9
M10
M11
M12
M13
M14
M15
M16
N1
N2
N3

Catalog



This catalog is based on the research of Oudes (2022). Using their systematic approach to examine the different spatial configurations of multifunctional SPPs, a distinction between different types of multifunctional sustainable energy landscapes was found. In addition, the analysis of the different landscapes in Chapter 3 was used to specify in which landscape type a certain energy landscape type might fit. This does not exclude a certain energy landscape from the other landscape types, it is meant as a suggestion where these might fit best. The different energy landscape types were found through literature and are based on multiple case studies.

Following, this catalog will be used in a case study of Rotterdam, Oud-Bijerland and Klaaswaal.

- M1 City composting
- M2 Crops between solar
- M3 Crops underneath solar
- M4 Lifestock between wind
- M5 Lifestock between solar
- M6 Lifestock underneath solar
- M7 Solar on greenhous roofs
- M8 Agricultural waste incineration
- M9 Wind and solar
- M10 Direct solar use in EV's
- M11 Small wind turbines on roofs
- M12 Market underneath solar
- M13 Terraces underneath solar
- M14 Waste heat
- M15 Solar on roofs
- M16 Solar integrated in railway tracks
- L1 Solar next to sportfields
- L2 Parking between solar
- L3 Direct solar use in streetlights
- L4 Renewables as art
- L5 Solar as sound shield
- L6 Solar as sight shield
- L7 Look out
- L8 Walking path between solar
- L9 Restoring homes with solar in facade
- L10 Green corridors in infrastructure
- L11 Pollinators between solar
- L12 Preservation/ Restoration
- N1 Solar shielding nature
- N2 high accesibility for nature
- N3 Low solar visibility
- N4 Nature as sight shield
- N5 Wind and forests
- N6 Porous path of solar in nature

Figure 32: Catalog of measures combining renewable energies with land uses.

Stakeholder Analysis as a Base to Create Energy Communities

Objective of the Stakeholder Analysis

In order to build an energy community, we have to connect many different stakeholder with diverse logics and (sometimes) competing interests and opinions.

As a first step we need to understand those stakeholders. The start is formed of desk research to identify relevant stakeholders of differing types (see Figure 33). Next we estimated how interested and powerful each stakeholder is and what their attitude towards the project is (see Figure 34). In a real-life context this can be done through surveying the stakeholders (stated preference method) or analyzing their behavior (revealed-preference method).

For each stakeholder we identified their goals, potential benefits they can get from the energy community, and how they are addressed in the project, see Figure 35.

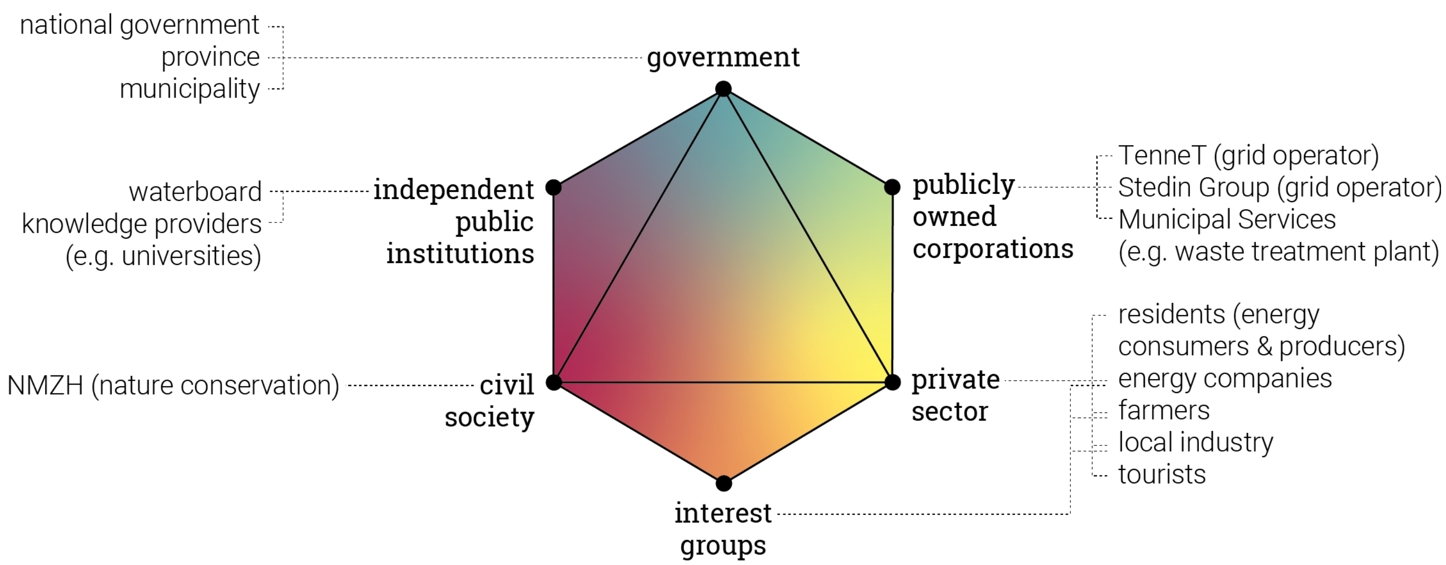


Figure 33: classification of the relevant stakeholders into six types, adapted from (Rocco, 2024)

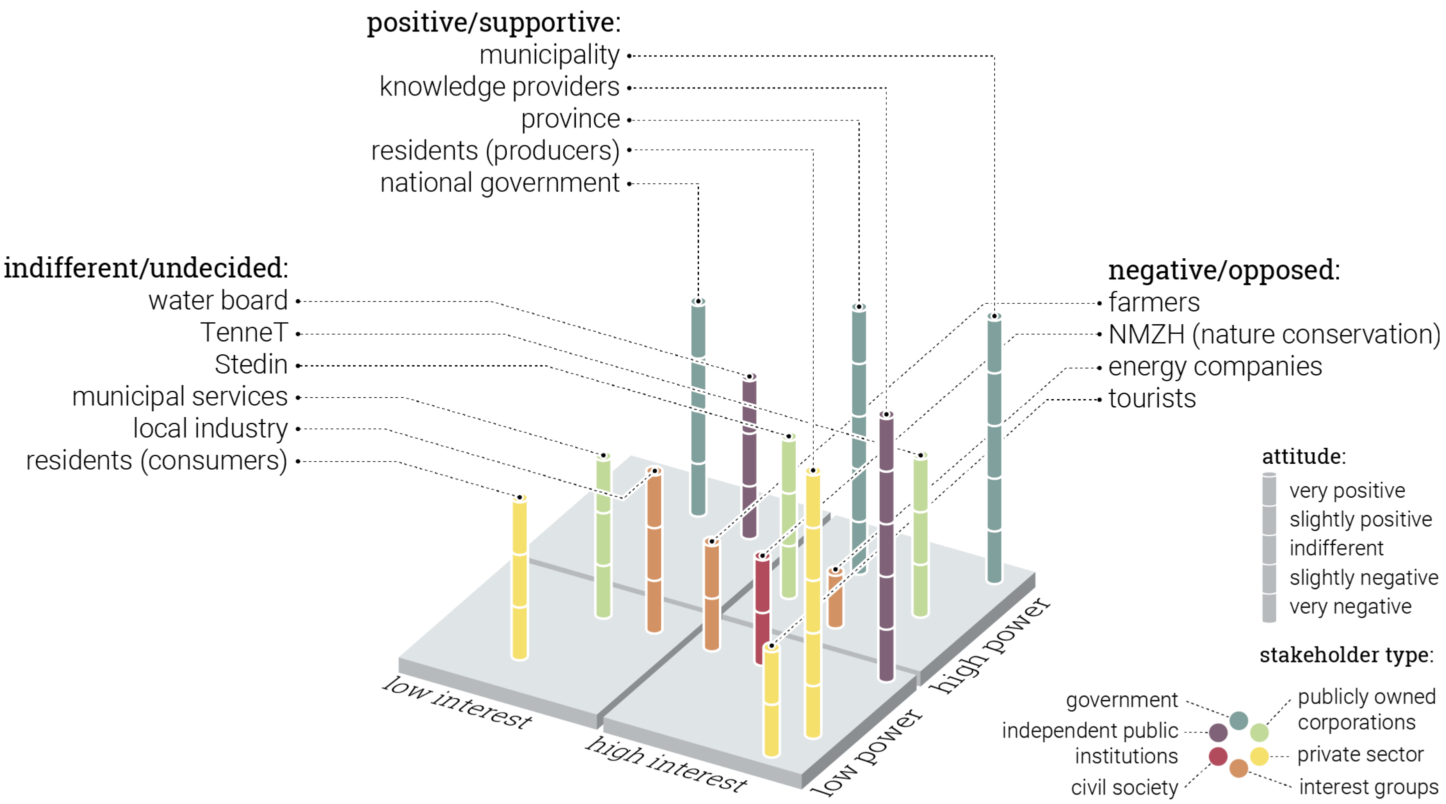
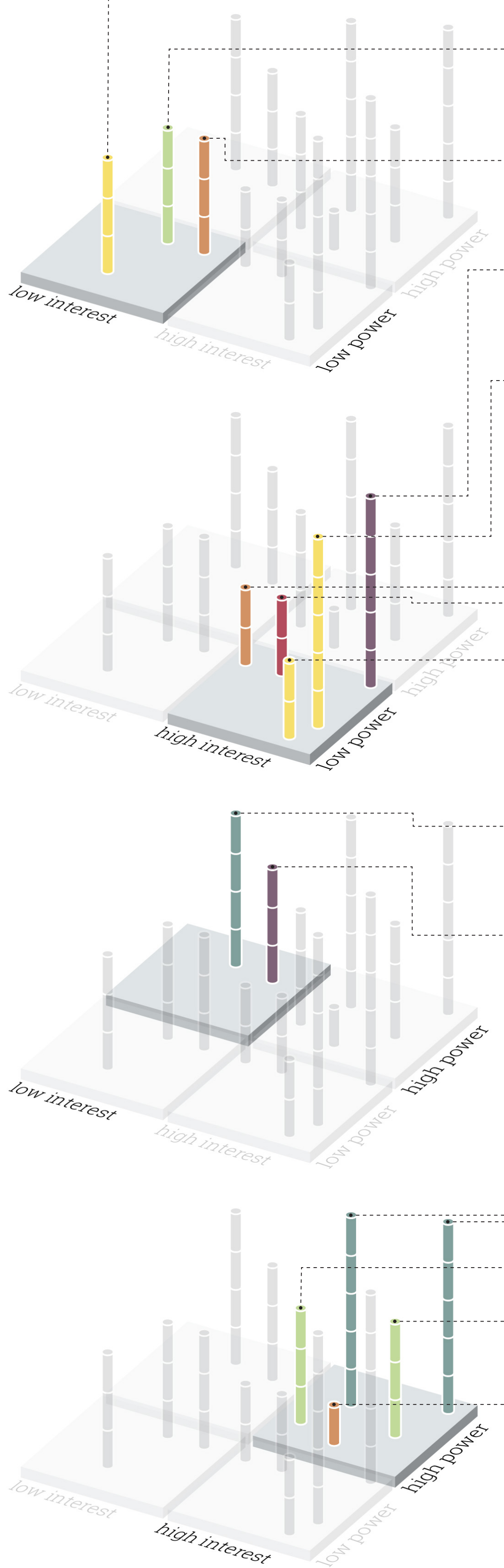


Figure 34: stakeholder matrix, adapted from (Rocco, 2024)



Stakeholder	Interest	Role in the energy community	Engagement Strategy
Residents (Consumers)	Affordable energy, employment opportunities, a comfortable place to live	Democratic base, employment, become energy providers	engage, convert to producers, keep informed
Municipal Services	Provide residents with services, within budget, implement policies	Provision of services, implement municipal projects	consulting group, find production opportunities
Local Industry (organized in a trade group)	Remain local, profitable, and competitive, innovate	Economic opportunity, become energy provider	engage, form partnerships
Knowledge Providers	Research & Innovation, knowledge transfer, education	Consult energy community, research, legitimize ECs	consulting group, maybe project management, observation & reflection
Residents (Producers)	Self-sufficiency, profit, cooperation with grid operators	Democratic base, individual agency, ambassadors	form partnerships, coordinate efforts
Farmers (organized in a trade group)	Remain profitable, keep farming, be part of the local community	Provide land, become energy producers	form partnerships, keep informed
NMZH (Nature Conservation)	Protect nature, wildlife, fight against pollution, get local support	Consult as environmental experts, legitimize ECs	consulting group, keep informed
Tourists	Relaxation, nature experience, cultural experiences	Raise awareness of renewable energy, experience the community	focus groups, communication, advertisements
National Government	Carbon neutrality, energy independence, innovation, economic growth	Provide policy framework, funding, transfer of policies, protect nat. infrastructure	consulting group, engage for funding, persuade for transfer of the pilot
Water Board	Manage & protect water flows, fresh water, flooding, fiscal responsibility	Allow implemention of ECs on water bodies, consult as water experts	consulting group, accomodate interests
Province	Implement national policies, energy affordability, regional equality	Provide policy framework, funding, implement infrastructure	accomodate interests, engage for funding, consulting group
Municipality	Wellbeing of their citizens, economic opportunities, fiscal responsibility	Provide policy framework, funding, potential project lead, local communication	potentially project lead, or consulting group, funding, coordination
Stedin (grid operator)	Energy availability, grid capacity, infrastructure maintenance, end-consumers	Consult as energy experts, coordinate infrastructure, facilitate energy transport	consulting group, potentially funding, form partnerships
TenneT (grid operator)	Energy availability, grid capacity, infrastructure maintenance, energy prices	Consult, coordinate infrastructure	consulting group, coordinate efforts
Energy companies (organized in a trade group)	Profitability, high sale prices, growing production, low production costs.	Consult as technology experts, invest	find investments, consult as technical providers

Figure 35: table of the interests, roles and engagement of each stakeholder

Energy Communities Coming Together

The organizational chart in Figure 36 shows the proposed coordination of the energy system. A new governing body is created: the Energy Board. These boards are meant to manage and control the new energy system, making sure the surplus of energy is fairly distributed among the Energy Communities, on a national level through policies. The Energy Communities can decide in collaboration with the municipality and advisory institutions what type of energy landscapes they would like to include in their community. The Energy Board also has a direct effect on the Energy Communities through regulation and by providing each other with feedback. Both the energy Boards and the Energy Community Coordination Hubs are chosen democratically through an election. The Energy Boards operate on a provincial level and are meant to operate similar to the already existing Water Boards. The Energy Communities operate on a more local level, where the local residents, farmers and industry can partake in discussions concerning their community.

The map to the right in Figure 37 shows a proposed future for the town of Oud-Bijerland. Using its existing landscape, the Energy Community has chosen multiple energy landscapes to fit in their existing structure. This map shows where local actors have a spatial influence and it shows the reaction of these actors on this transition and the impact it has on their lives. The interventions were based on the Catalog on page page 51 and on the masterplan for this area following on page page 63.

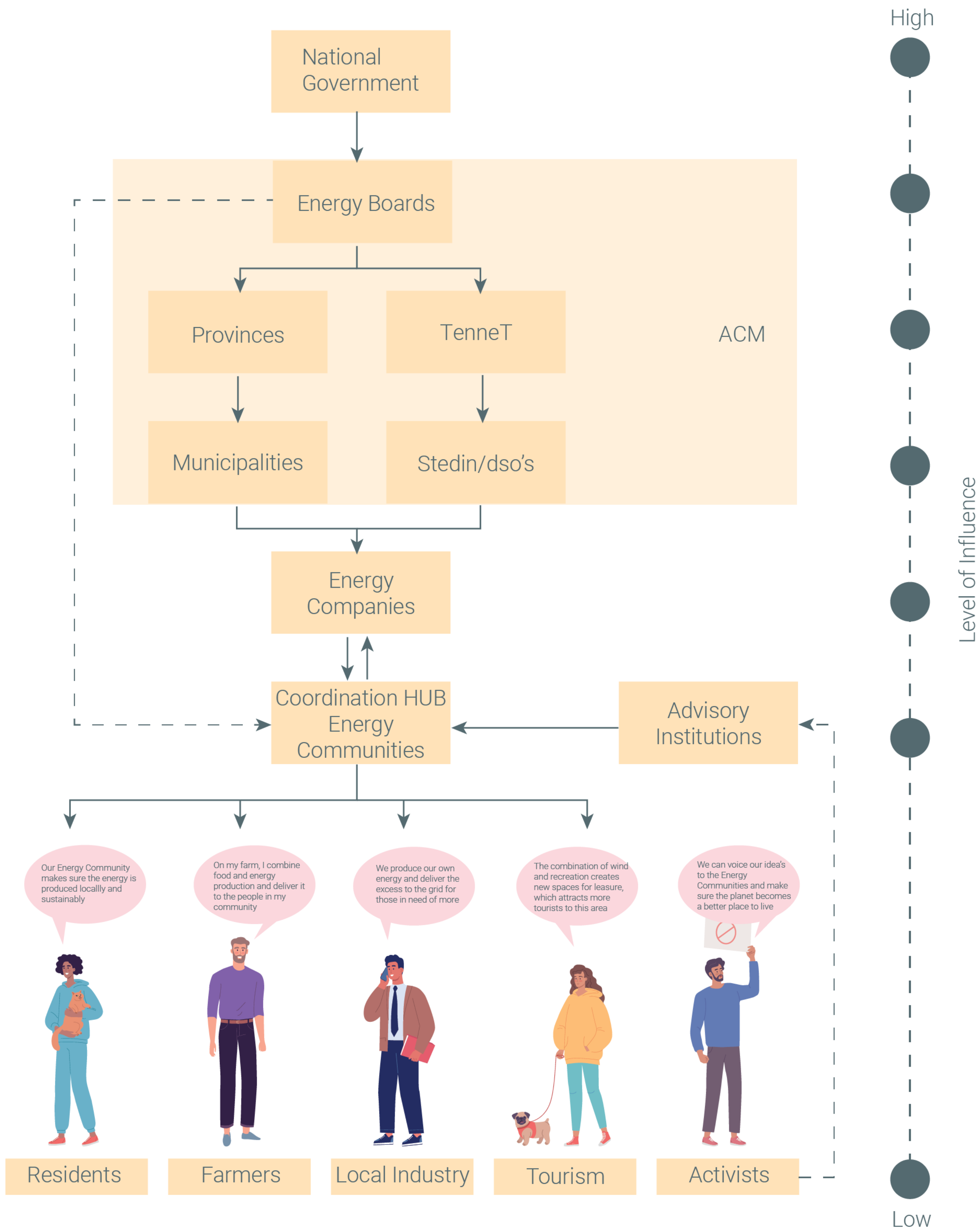


Figure 36: How the stakeholders come together

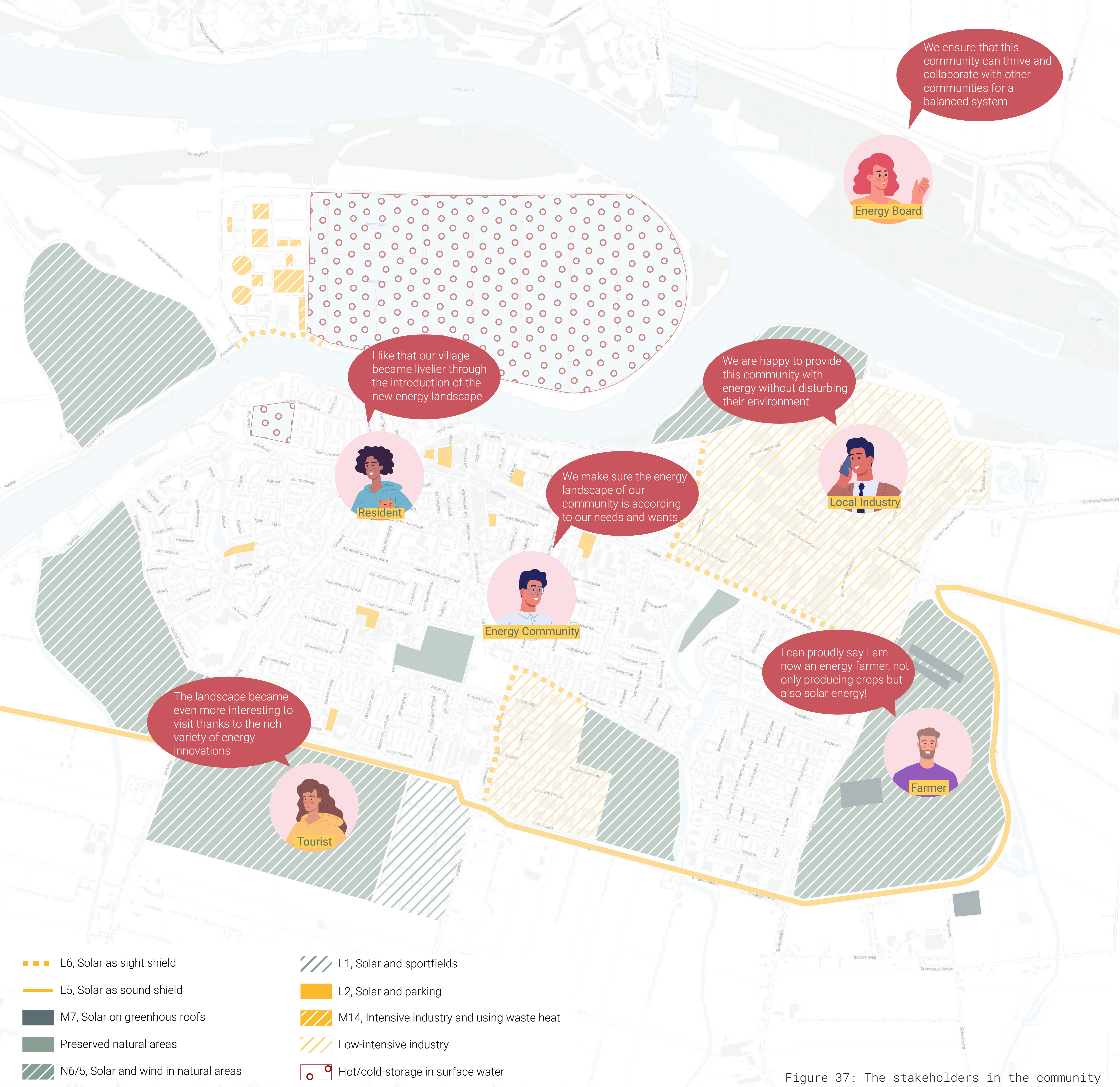


Figure 37: The stakeholders in the community

Putting our strategy into context

Energy is a vital necessity used every moment of the day, even while we sleep in our homes. The war in Ukraine forced Europe to switch energy sources, leading to massive price increases and painfully exposing the fragile relationship between humans and energy. With skyrocketing energy prices, vulnerable members of society could no longer afford their bills, turning home heating from a basic need into a luxury. Not only at the beginning of the war but also now, people often suffer from an overly dependent, centralized system. This was evident when poorer neighborhoods had to switch to sustainable heating sources, but energy providers charged premium prices without proper coordination with the residents. Raising the question on how fair our system actually is if this is possible?

Therefore, we have designed a new system that integrates technical, social, and political aspects to give people more say in energy decisions, creating more justice. A key aspect of this is making the energy infrastructure visible and promoting ownership, which increases awareness and strengthens the 'energy voice' of individuals by making production and consumption more visible and bottom-up. Specifically, our strategy lies on the intersection between social issues and the energy transition, focusing on energy poverty, and the creation of communal collaboration to enhance social justice.

Additionally, energy use is a primary driver of climate change, posing challenges to sustainable living. Resulting in sustainability not only tackling energy and climate change; it involves maintaining and enhancing the ecological and the aforementioned social systems upon which we depend. Or, in other words, the ecosystem services. This concept involves the benefits and disadvantages we derive from ecological systems, necessitating an understanding on how energy demand, production, and supply affect these natural services (Howard et al., 2013).

With the deployment of low-carbon energy technologies, there is a recognition of their substantial impacts on local ecosystem services. Renewable energy production types, such as solar and wind farms, require more land due to their lower energy production compared to fossil fuels, requiring more distribution in energy production and distribution methods to reduce carbon emissions. Additionally, human population growth and increased consumption escalate the demand for land for food, potable water, accommodation, occupation, and the conservation of natural and social heritage. In response to these complexities, different flows have been analyzed to understand how new energy communities interact with each other and their landscapes in order to design the energy catalog. This catalog aims not to harm but to complement nature, considering the specific needs of urban and agricultural areas, recognizing the intrinsic knowledge and responsibility of local inhabitants and to enhance and increase social justice in energy for residents. An important step in this is the acknowledgement and involvement of nature as a stakeholder. Additionally, considering the insights from Roberto Rocco's essays on the potential of artifacts (e.g. new energy infrastructure) to change social structures, either detrimentally or beneficially. The goal is a fair, transparent, and visible integration of energy into the landscape, with local residents having a say in the process, ensuring nature's value is preserved.

In creating the new energy landscapes in the energy communities, new habitats for animals and people are created. The catalog promotes natur-inclusive design, which gives nature rights and improves biodiversity. In this catalog multiple design interventions are mentioned to increase nature with new renewable energy technologies, while also decreasing the spatial footprint of energy production types. For example combining wind turbines with creating new forests, which store CO2.

This combination of the energy transition with environmental qualities, will create more liveable habitats for both people and nature.

Toolbox

To aid future energy communities, we've developed a toolbox that aligns with EU guidelines, detailing all the necessary interventions and actions required for their establishment. These actions have been integrated into our timeline to provide a clear illustration of the process.

- During the initial phase, policymakers establish objectives, while the community collaborates to formulate a shared vision, assessing technical and spatial feasibility, and engaging more citizens.
- In the preparation phase, the community plans the implementation of actions, creating agreements and laying the technical groundwork for subsequent phases.
- The implementation phase involves the installation of infrastructure and the establishment of a monitoring system.

Following these stages, communities can pursue two paths: maintaining the existing system while implementing new policies and technologies, and gathering feedback from stakeholders. In the expansion phase, communities can set new objectives and collaborate with other emerging communities.

based on: Rural Energy Community Advisory Hub 2022.

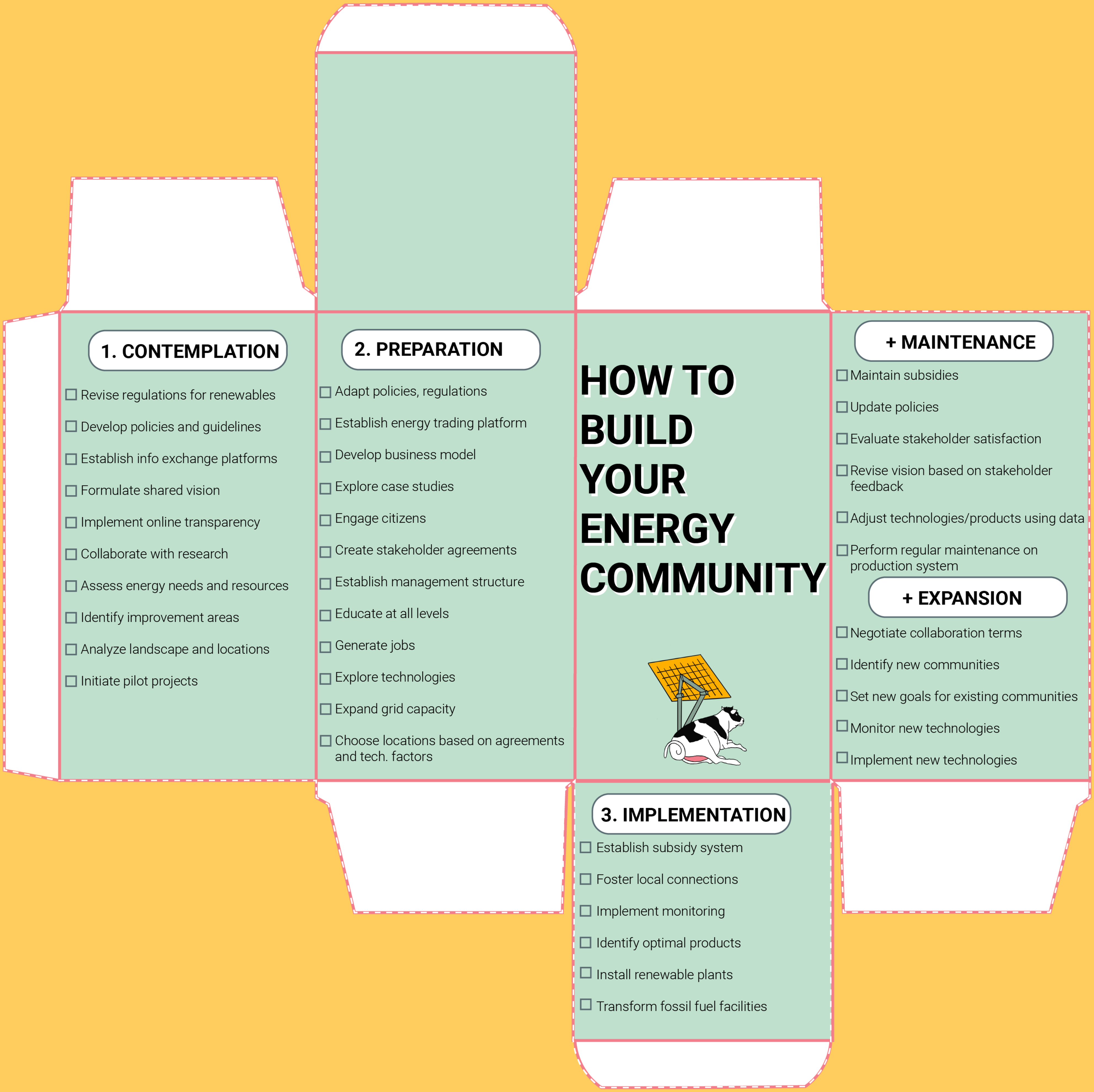
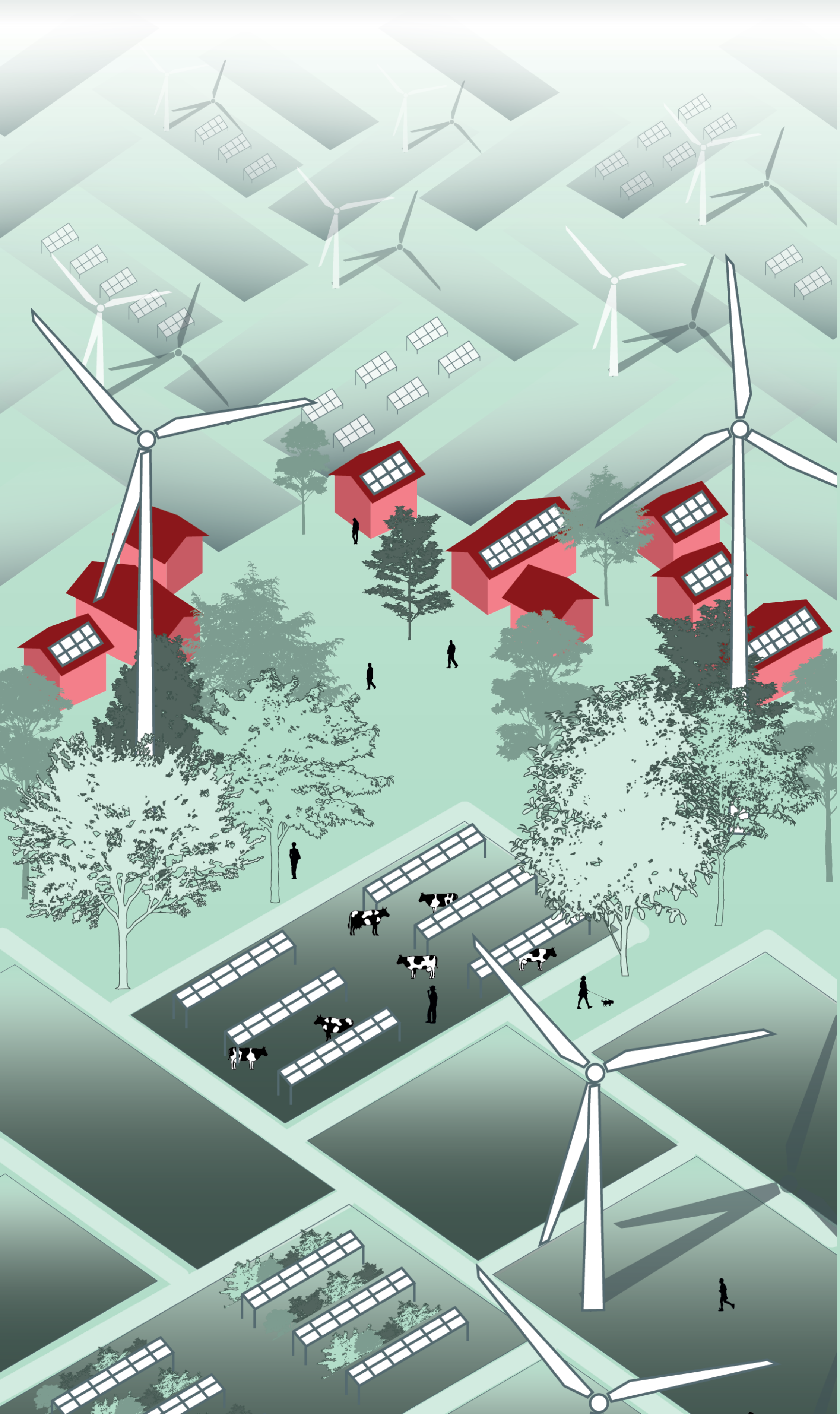


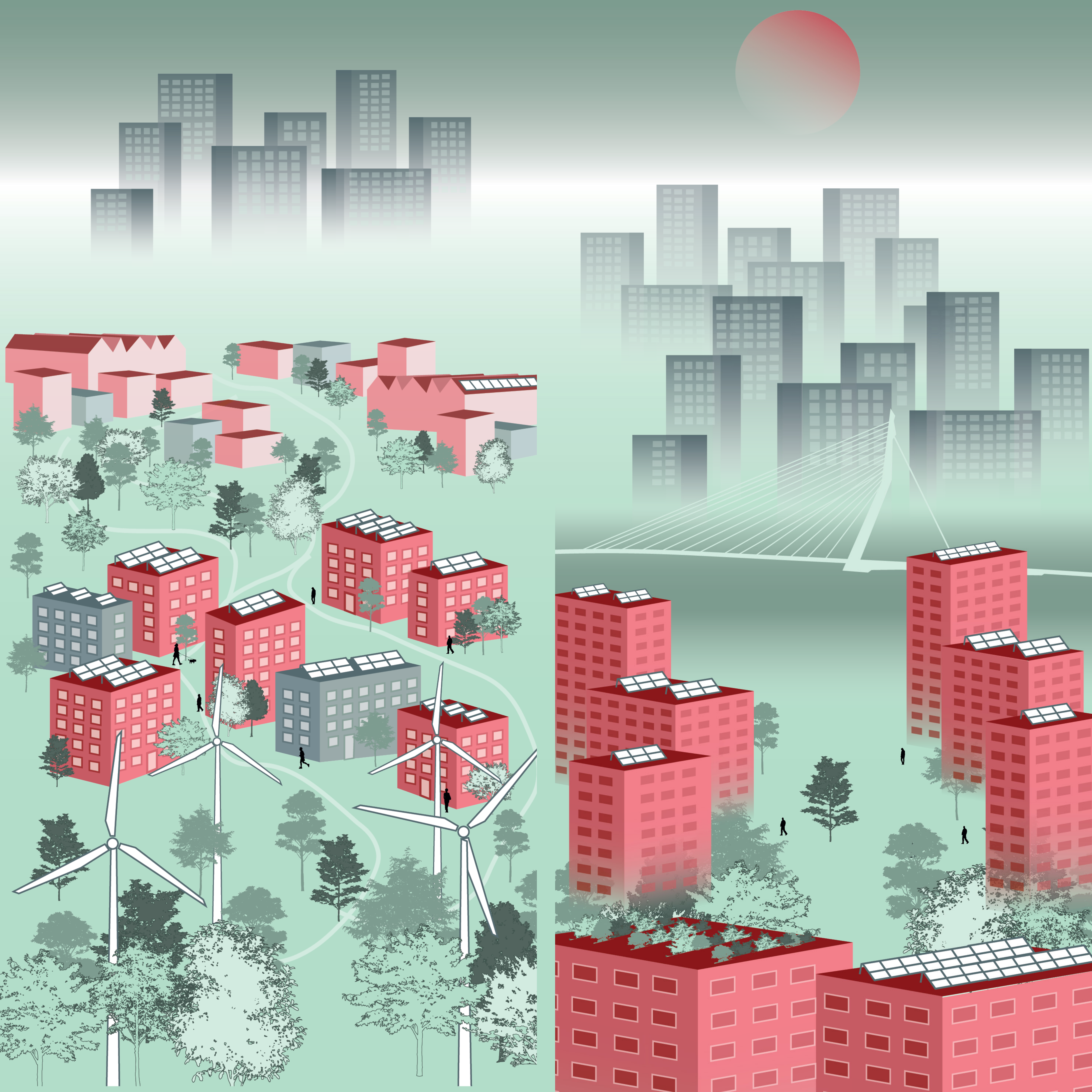
Figure 38: Toolbox how to create your own energy community

Putting Theory into Practice: a Pilot of Three Energy Communities



So far, we described these energy communities in a theoretical manner. But because they are highly specific to their specific geographies, we will now illustrate our strategy with an implementation of it in three energy communities. Together with the toolbox, this pilot project shall serve as a concrete reference for budding energy communities to model themselves after. To explore the energy community from multiple angles, we chose three different scales of community: A small village in the intensive agriculture landscape, a medium-sized town in the transition zone, and a major city center in the urban core region.

Figure 39: (left) small-scale energy community
Figure 40: (center) medium-scale energy community
Figure 41: (right) large-scale energy community



Introducing Rotterdam, Oud-Beijerland and Klaaswaal

Our analysis unveils a notable discrepancy between energy production and consumption patterns. While consumption remains concentrated in densely populated areas, we advocate for a more equitable distribution of energy production across available land. Regions with surplus capacity beyond local demands are strategically positioned to contribute to meeting the energy needs of urban centers.

To operationalize this analysis, we propose the implementation of pilot energy sharing communities, with particular focus on the province of Zeeland. Situated between the bustling urban hubs of Rotterdam and Antwerp, Zeeland presents a prime opportunity for such initiatives. Within this context, we have identified three distinct areas for piloting, each characterized by unique attributes conducive to partially addressing energy demands:

Rotterdam

This urban center, while possessing significant rooftop space suitable for solar panel installation, faces limitations in achieving self-sufficiency due to its high population density and limited available land. Consequently, Rotterdam relies on energy imports from neighboring, less densely populated areas.

Oud-Beijerland

Positioned to the south of Rotterdam, Oud-Beijerland boasts a more rural and agrarian landscape. With ample rooftop space and open land, this locale is well-equipped to generate its own energy, with surplus capacity that could potentially be exported to Rotterdam.

Klaaswaal

Despite its modest size, Klaaswaal stands out for its abundance of agricultural land in the surrounding area. This affords the town significant potential as an energy powerhouse, capable of producing surplus energy for export to Rotterdam.

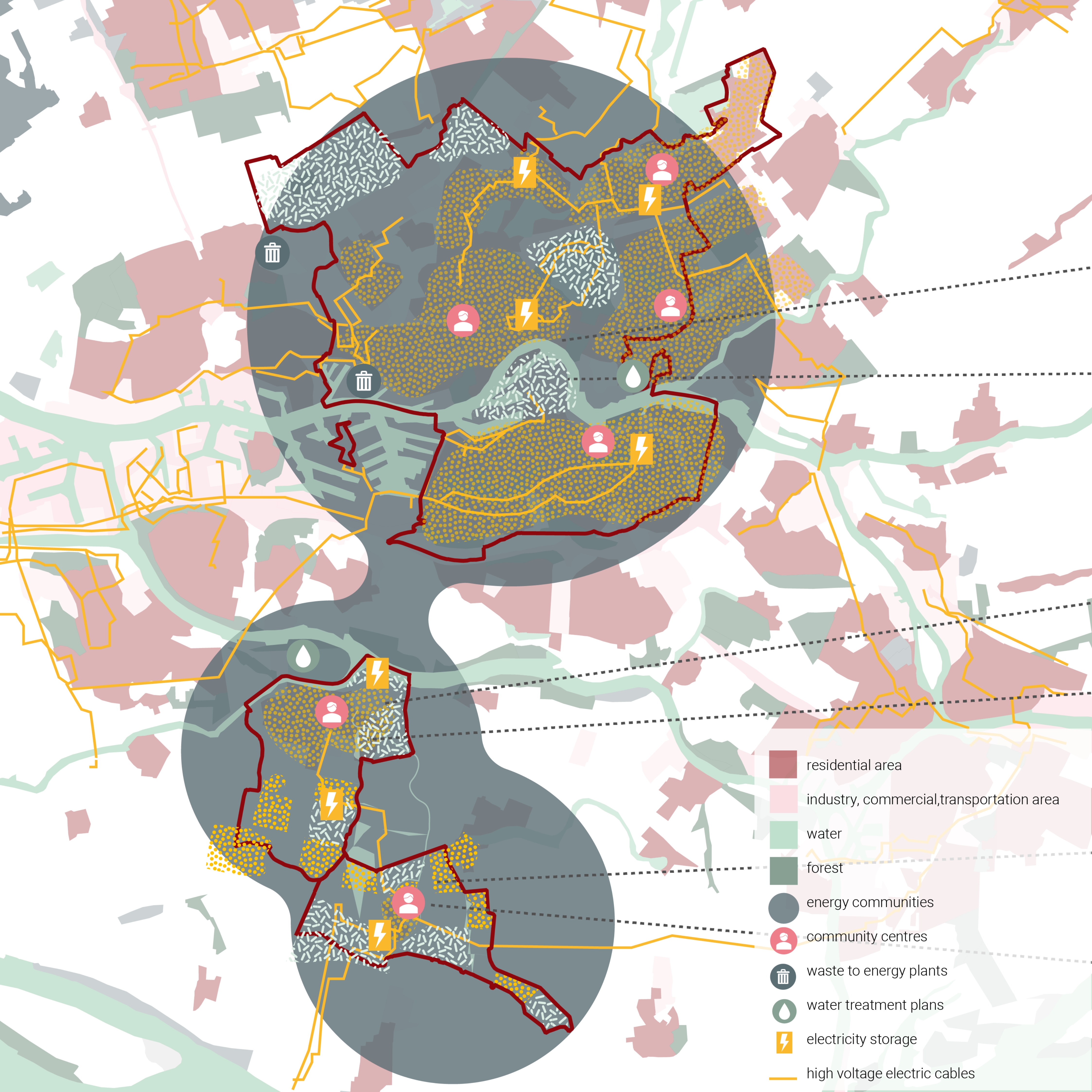
	Rotterdam	**Oud-Beijerland**	**Klaaswaal**
Density	3085 /km²	1300 /km²	280 /km²
Registered homes	319210	10624	1769
Age 65+	16+	22%	23 %
Green space / agricultural lands			
Energy potential	large solar potential on roofs	solar potential, wind potential	solar potential, wind potential
Housing ownership	65%	67%	80%
Building typologies	mixed types	row houses, single family homes	row houses, single family homes
Energy consumption (TJ) (total)	15410	1134,52	223,58
- Households	9341	482,52	92,58
- Traffic	5648	631	113
- Agriculture	421	21	18

datasource: KadastraleKaart.com n.d.

Figure 42: Characteristics of the Pilot communities

Figure 43: The Rijnmond area with the three pilor communities located.


ROTTERDAM
OUD-BEIJERLAND
KLAASWAAL


residential area
industry, commercial,transportation area
water
forest
energy communities
community centres
waste to energy plants
water treatment plans
electricity storage
high voltage electric cables

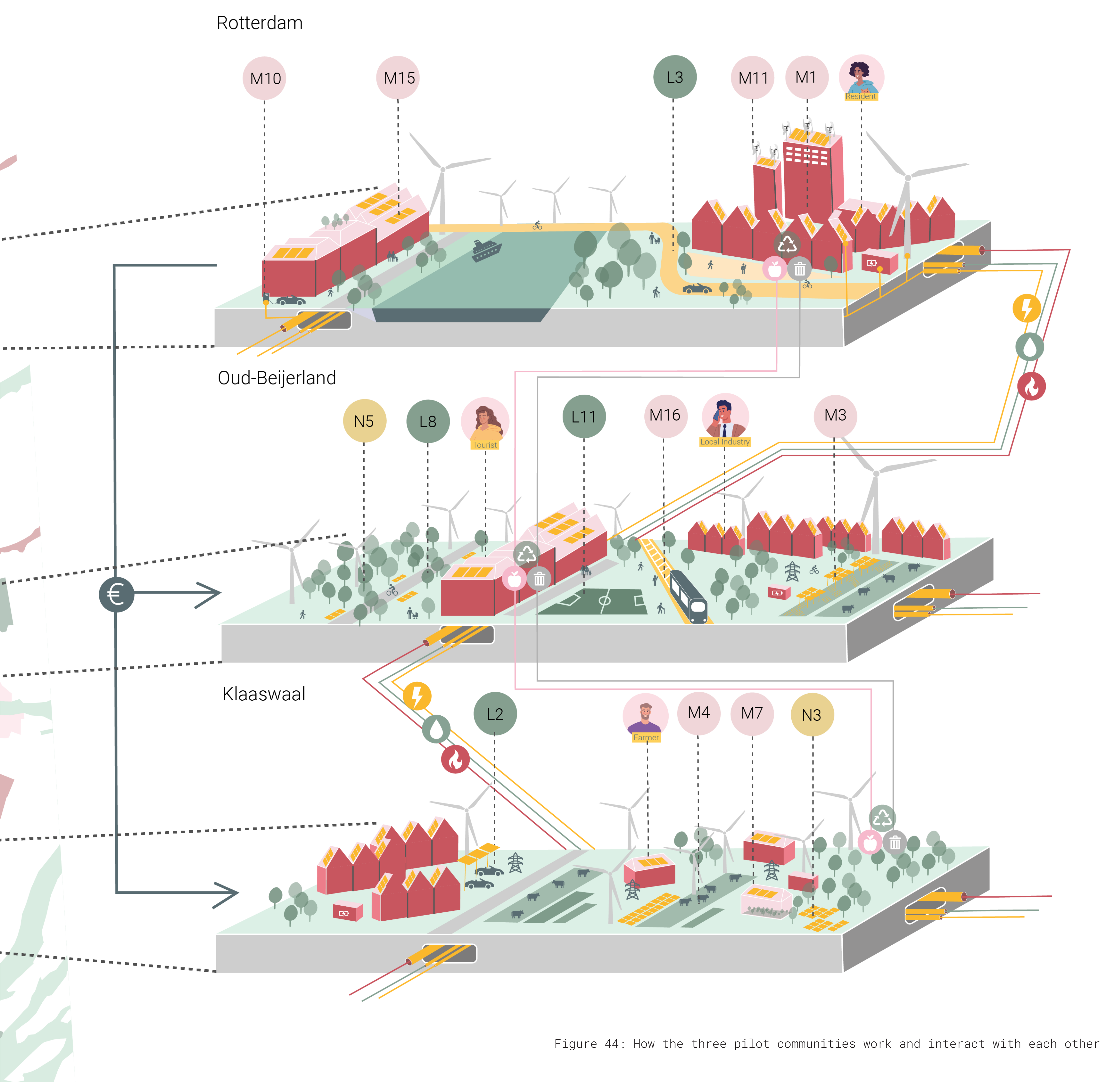
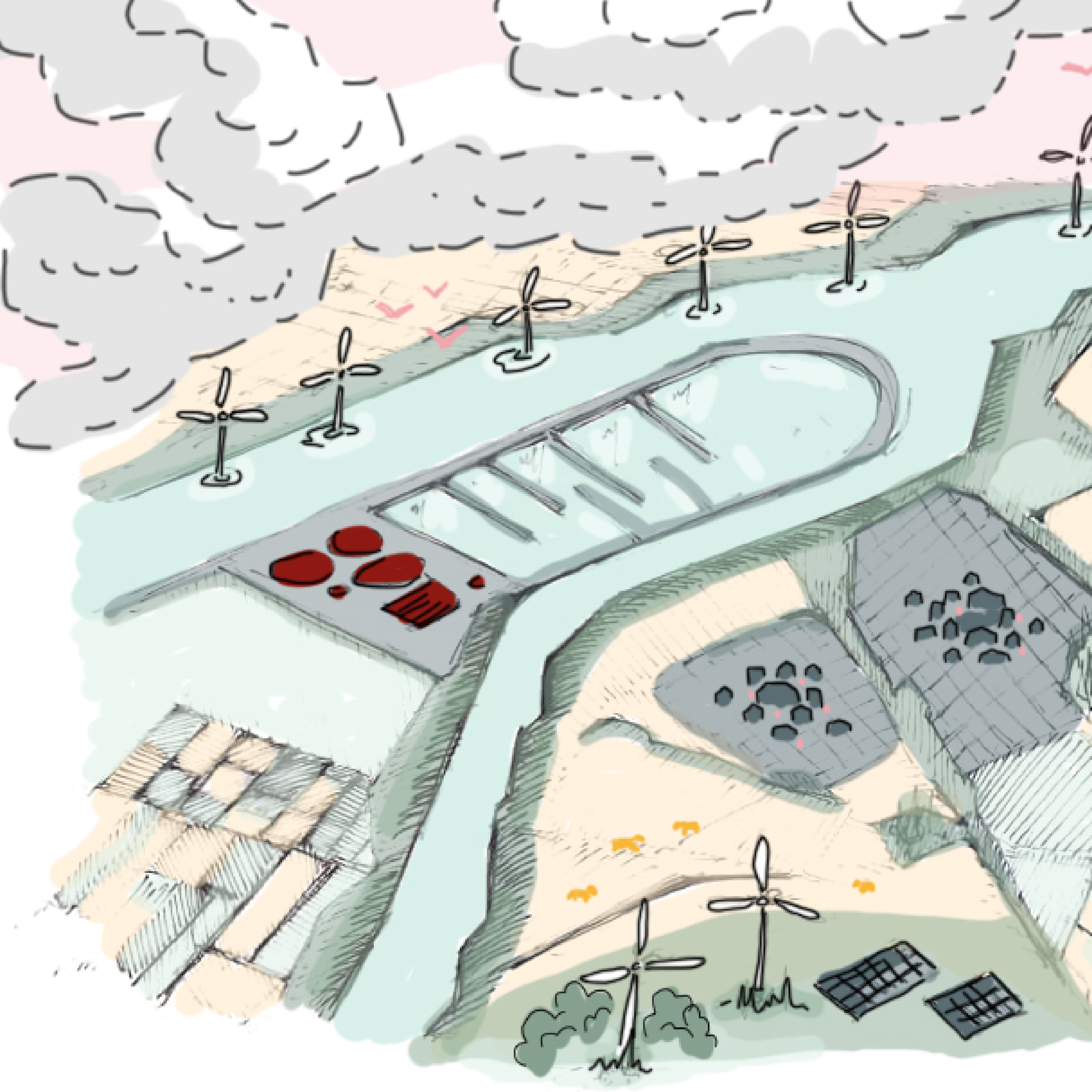
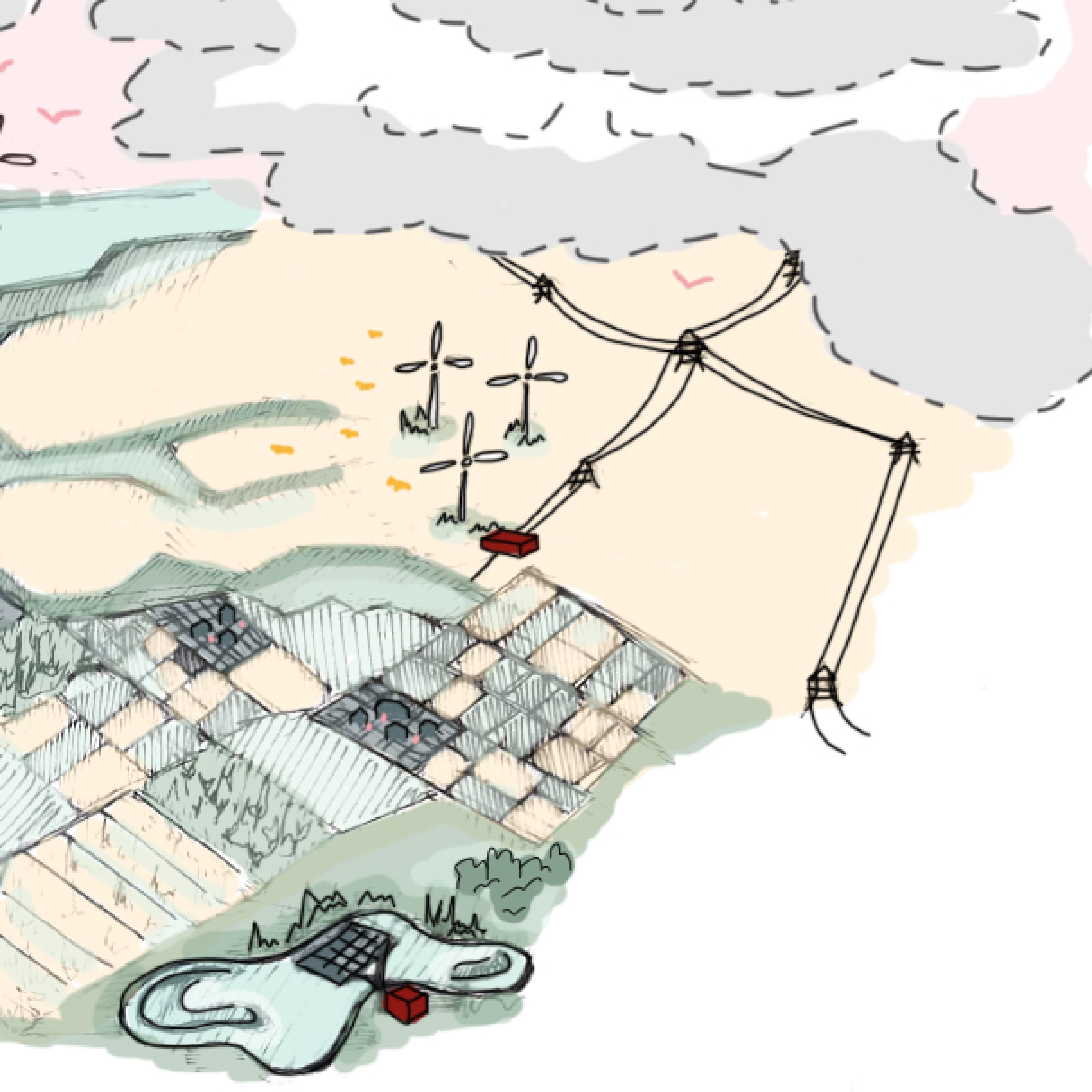
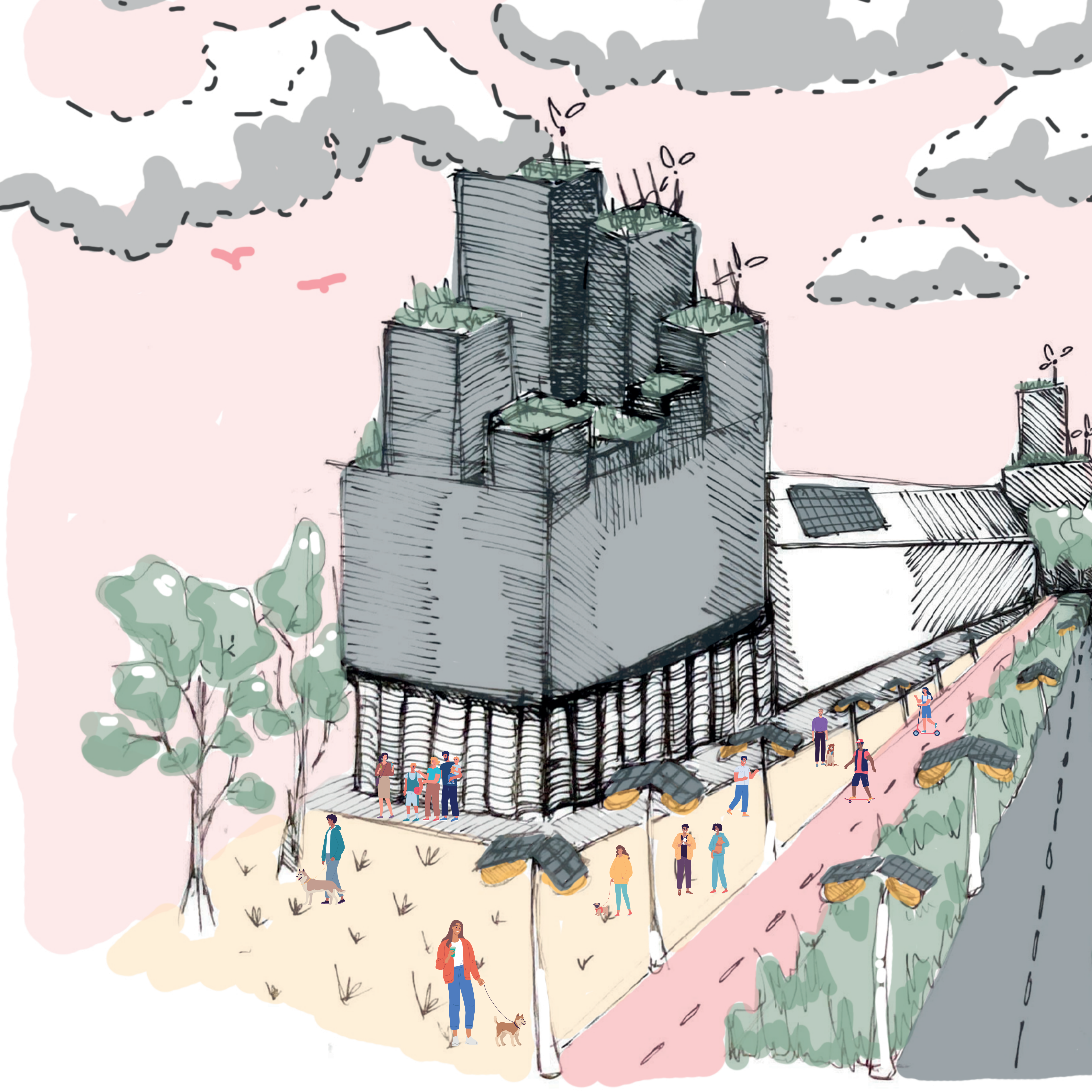
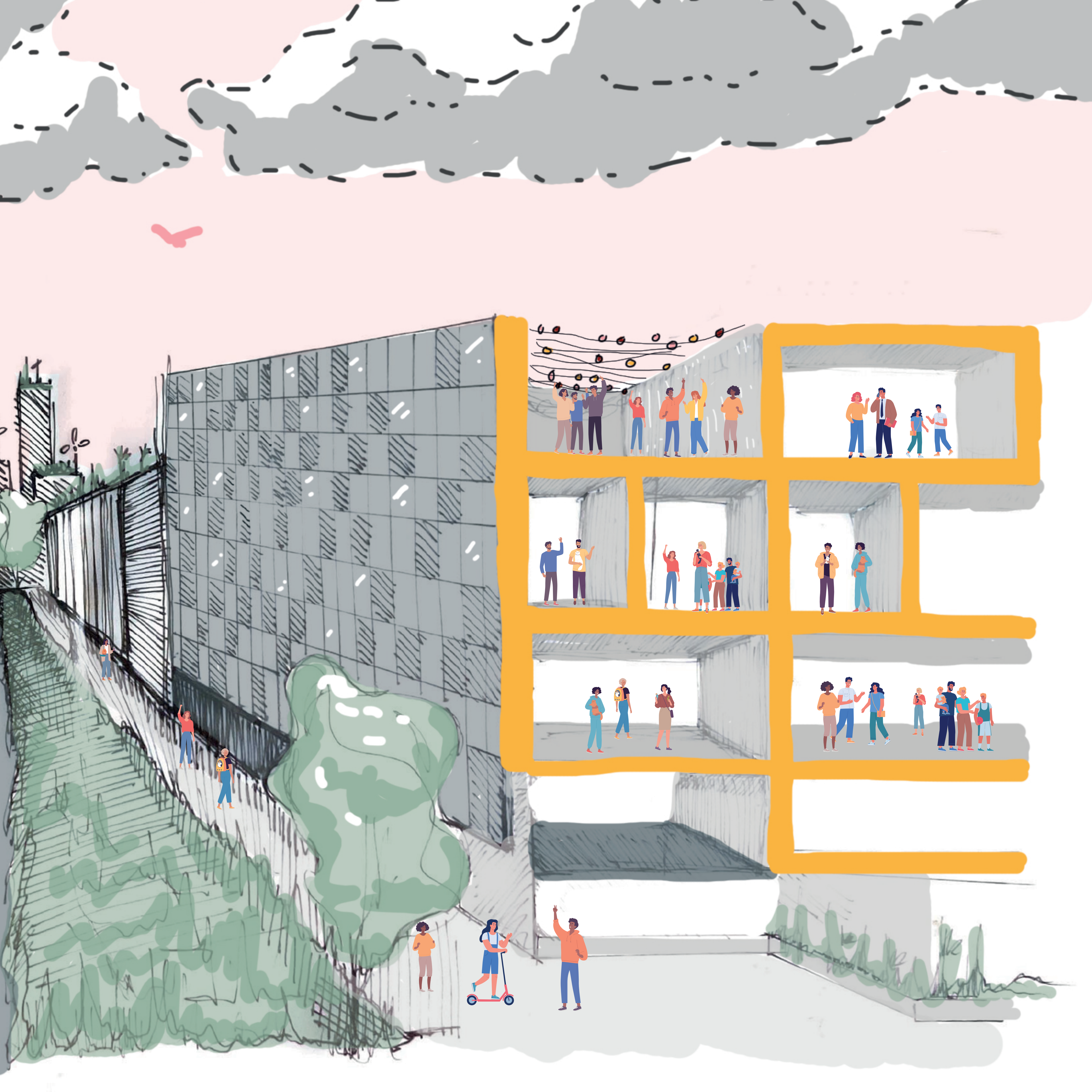


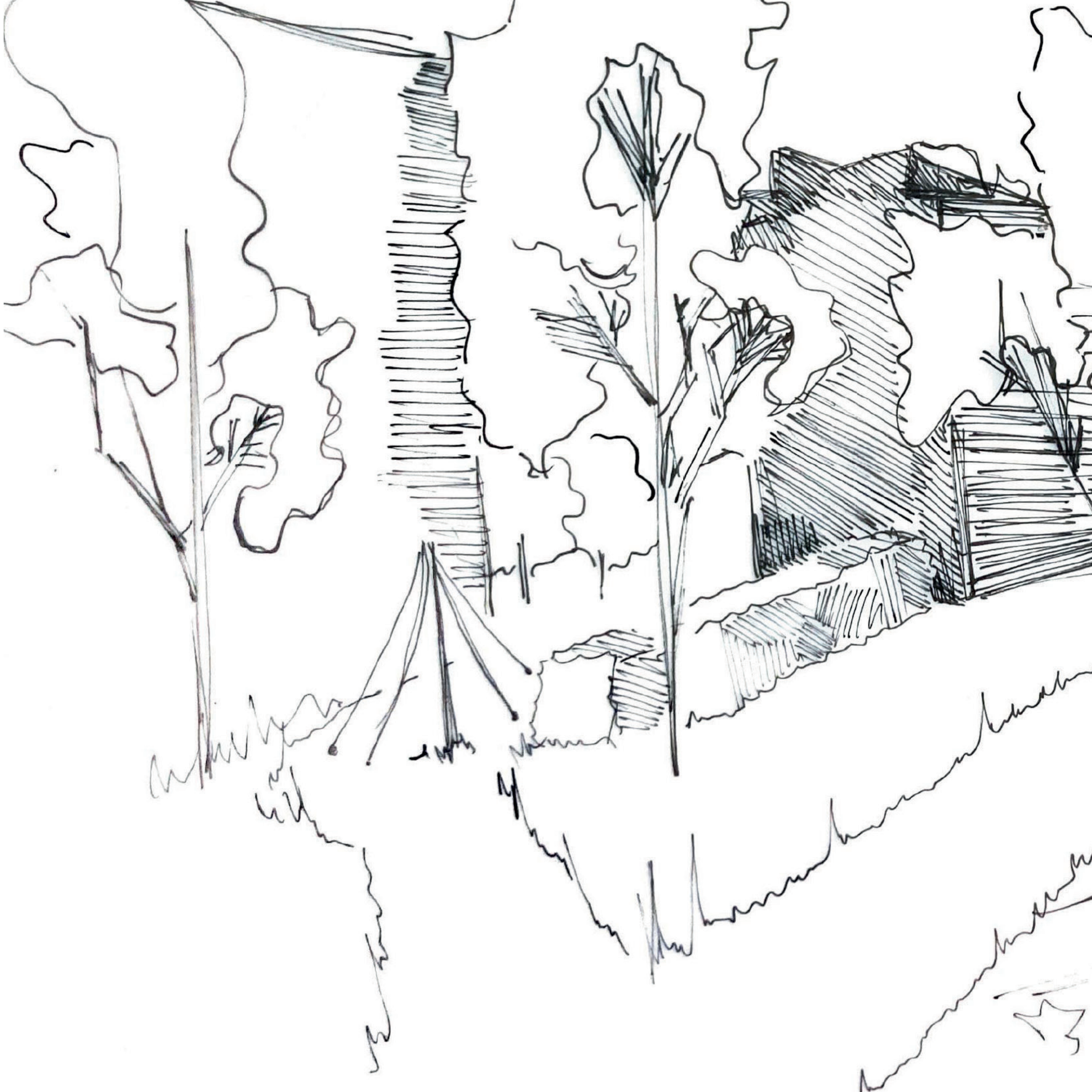
Figure 44: How the three pilot communities work and interact with each other

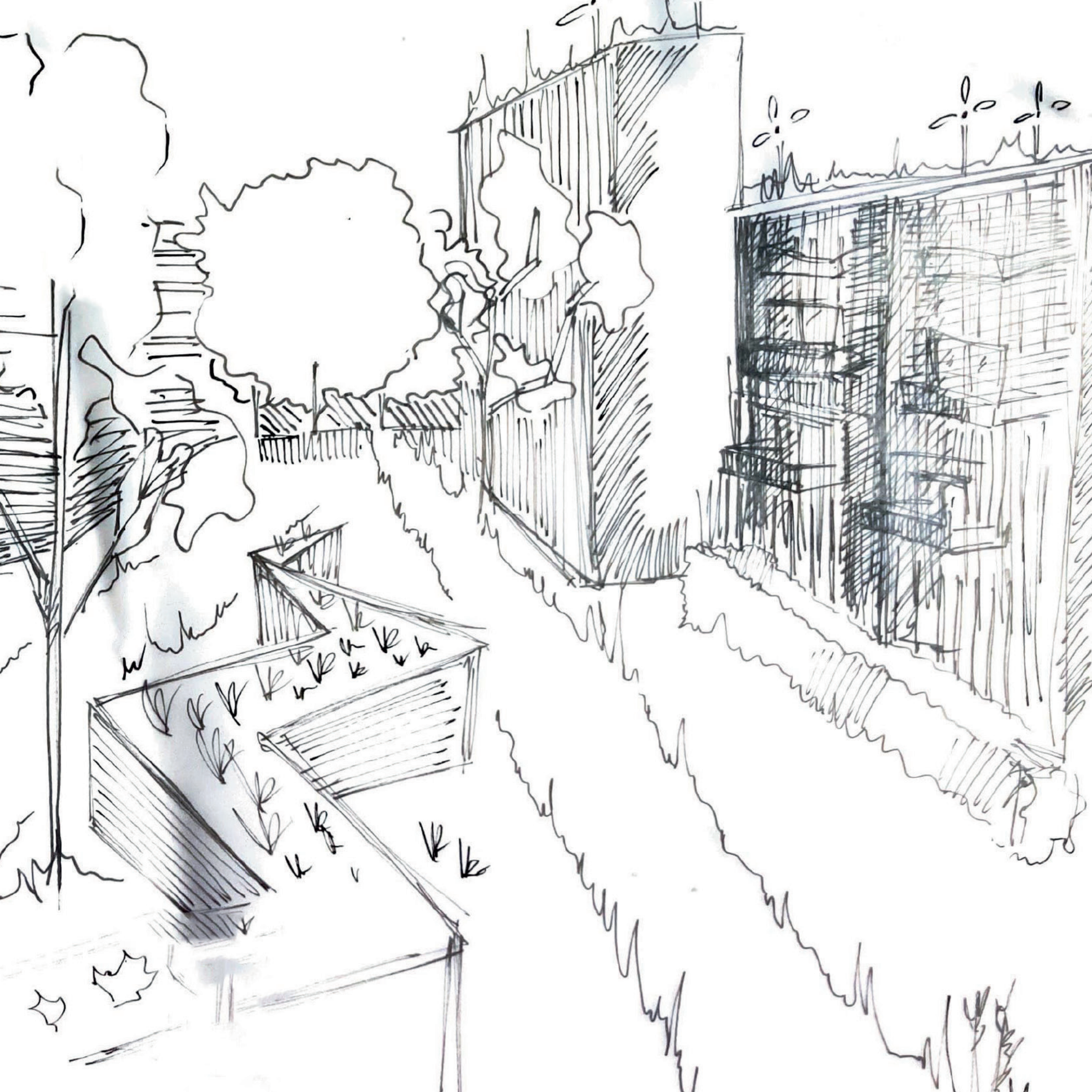






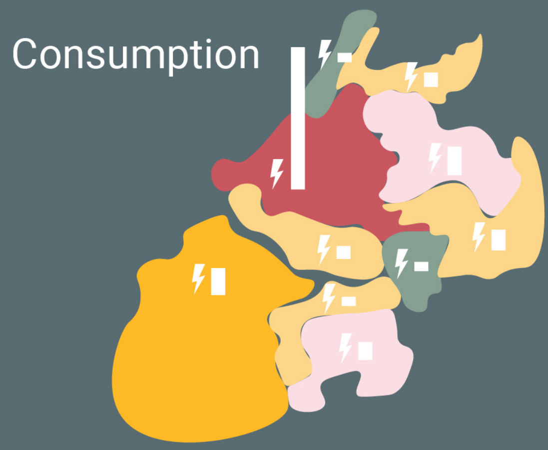






Chapter 6

Conclusion: The Future Energy System



The examination of a revitalized energy landscape can be extended to encompass regional dimensions, as evidenced by the collaboration between the densely urbanized Randstad area and its peripheral, previously neglected regions. While the depicted scenario illustrates a decentralized energy production framework, consumption remains concentrated in specific locales. Owing to factors such as population density, energy consumption levels, and limited agricultural land, the region cannot achieve self-sufficiency solely through renewable energy sources, necessitating reliance on surrounding areas.

These surrounding regions, characterized by expansive rural landscapes and sparse residential clusters, emerge as pivotal players in the envisioned energy landscape. With lower energy consumption densities compared to their urban counterparts, these areas harbor significant potential to serve as energy powerhouses, catering to local demand while bridging gaps in adjacent regions. Primarily, these regions will prioritize energy production to meet their own needs. Nonetheless, due to the surplus of available land, they possess the capacity to exceed local energy requirements without taking over the landscape.

Solar Energy

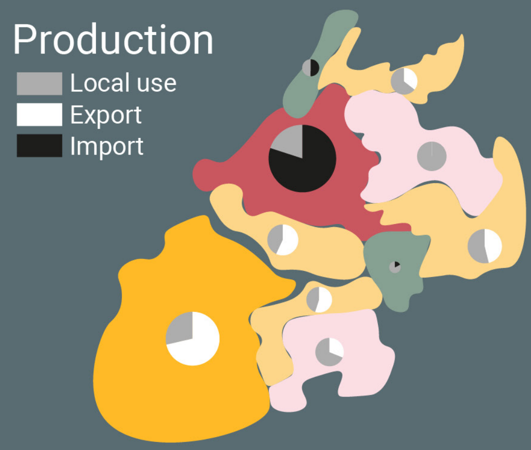
Solar panel installation will primarily capitalize on existing rooftop space within urban environments. Utilizing approximately 8% of available roof area, according to data from the Netherlands Enterprise Agency (RVO, 2022), can yield substantial energy output. With an average solar panel generating 330 kWh annually, this deployment can significantly contribute to meeting total energy demand.

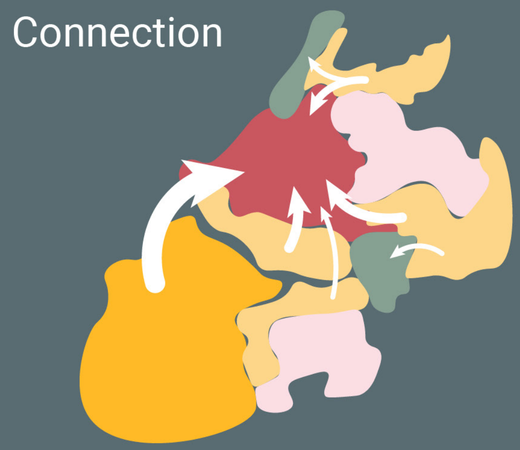
Wind Energy

Given the limitations of solar energy, wind turbines constitute a vital component of the energy mix. The Netherlands boasts considerable potential for wind power utilization. Each wind turbine, occupying 0.4 km^2 of space, can yield 47 TJ of energy, sufficient to power approximately 2200 households. Leveraging the ample open spaces across the country, wind energy emerges as a highly efficient and effective renewable energy source.

Cultural Integration

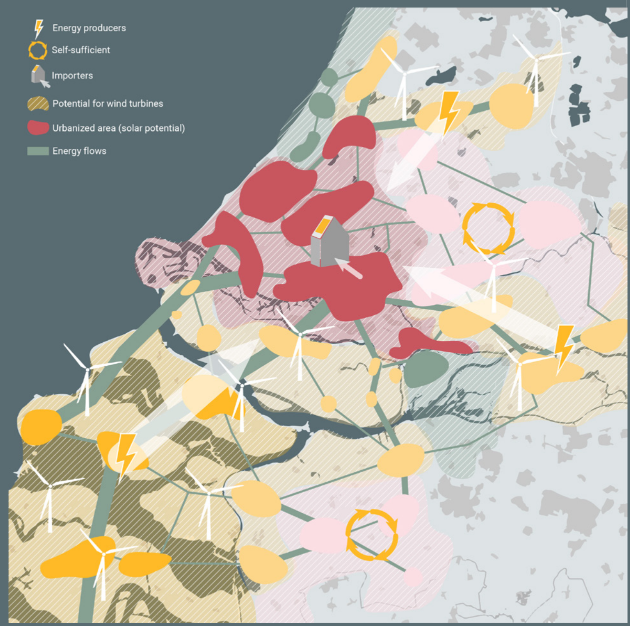
While the current energy landscape may seem remote from everyday life, historical precedents demonstrate a closer symbiosis between energy sources and human habitats. Windmills dotting the Dutch landscape serve as a quintessential example. In transitioning towards a renewable future, there exists the opportunity to reincorporate energy production into the cultural fabric. By embracing renewable energy sources, energy production can once again become intertwined with societal norms and practices.





Region	Energy consumption (TJ)	Usable roof area (hec)	Number of solar panels	Solar energy (TJ)	Agrian land area	Potential number of turbines	Number of wind turbines	Wind energy (TJ)
Zeeland	18671	744	3722400	4422	104975	2624	1300	61100
South-Holland island	9251	473	2364400	2809	26773	669	400	18800
RTM, DH, L	103281	1284	6418400	7625	15399	385	275	12925
Green Heart	19506	856	4279200	5084	43231	1081	307	14429
Flower bulb region	10271	312	1557600	1850	18340	459	300	14100
Roosendaal	12452	673	3362800	3995	37689	442	180	8460
Bergen op Zoom	6641	112	559600	665	12100	803	420	19740
Dordrecht	6578	121	606400	720	7261	182	100	4700
Gorinchem	14264	505	2527200	3002	32046	801	500	23500
Beach region	6483	145	724000	860	3074	77	50	2350

see appendix A for calculations, datasource: Rijksoverheid, n.d.



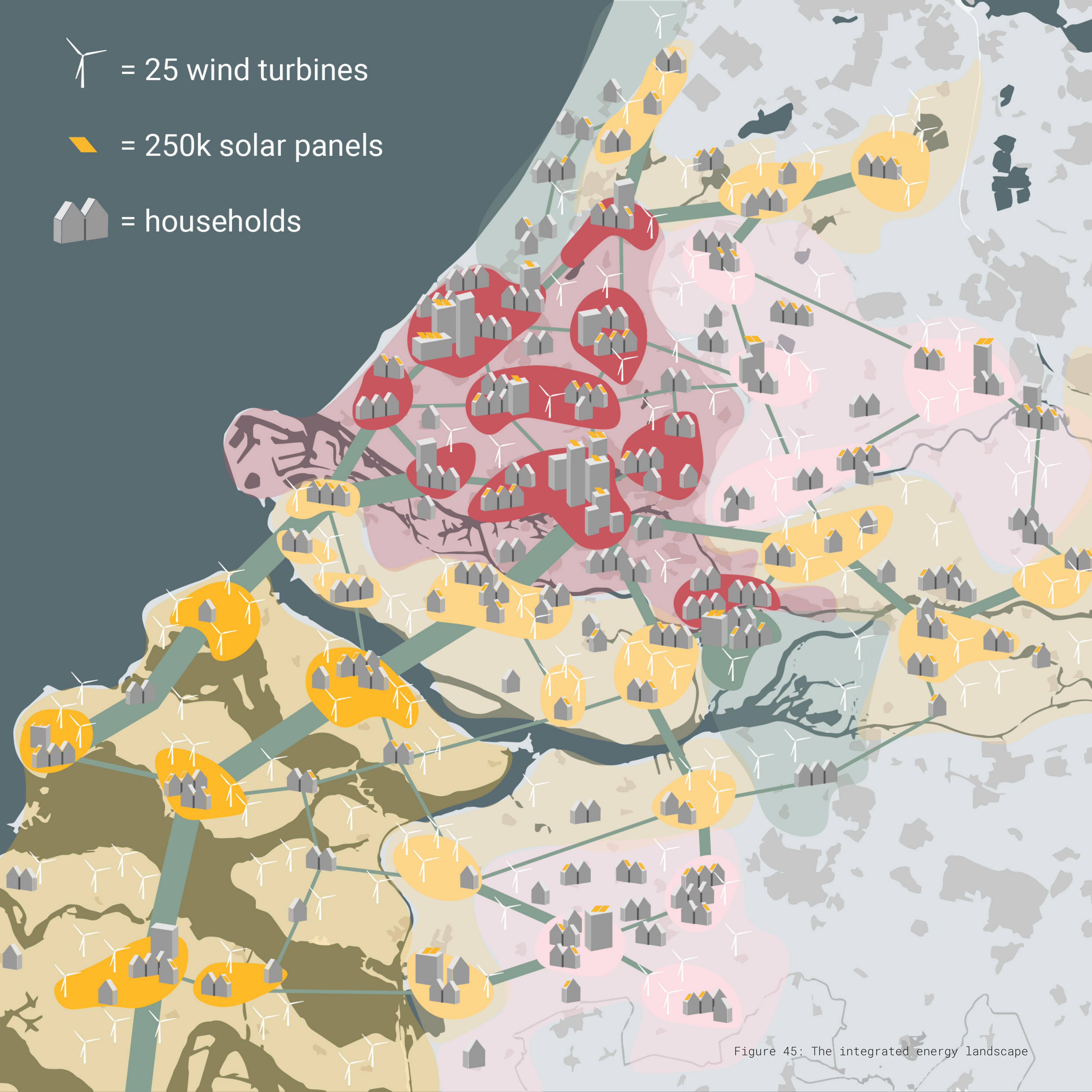


Figure 45: The integrated energy landscape

Chapter 7

Reflection

During our research we focused on the following research question:

How can the energy transition for households, agriculture, and traffic be reimagined through a just implementation of renewable energy production in collaboration with the landscape and communities?

Resulting in these smaller sub questions:

1. How is energy transition regarding fossil fuels currently constructed and which problems occur?

2. What does renewable energy production include and how can it be implemented effectively?

3. In what way can different landscapes, including rural, industrial, and urban, be part of a decentralized energy landscape?

4. How can various communities of society be included in the energy transition?

Currently we are at a critical period of time where transitioning to sustainable energy sources is no longer an option but a necessity. The urgency of this shift is evident in the multifaceted crises we face: from the existential threat of climate change impacting all forms of life on earth to acute geopolitical tensions, exemplified by issues such as Russia's control over oil, making the shift away from fossil fuels a matter of urgency. However, transitioning from fossil fuels to renewable resources is not without its complexities and challenges. The systemic thinking applied to fossil fuels in society is also carried over to the implementation of renewable resources. This results in inefficient integration of energy infrastructure, failing to consider the living environment, both socially and in terms of the landscape.

In our project, we address how this integration of renewable resources should occur, using the concept of energy communities. We define an energy community based on the United Nations' guidelines, emphasizing fair and transparent application of renewable energy types. It's crucial that an energy community is viewed from various perspectives, such as landscape integration, social incorporation, nature inclusion, and policy considerations.

Through the development of an energy catalog, we have detailed various renewable energy technologies according to their environmental compatibility. City dwellers can select technologies that match their living environment, fostering tailor-made energy communities and giving individuals a say in shaping their own surroundings. This approach positively impacts the "Not In My Back Yard" (NIMBY) phenomenon, as increasing people's control boosts self-determination and intrinsic motivation regarding energy production and consumption reduction. By bridging the gap between production and consumption, we make the infrastructure visible and empower individuals in energy responsibility, which not only reduces energy poverty but also leverages local knowledge of the environment.

This will particularly benefit regions adversely affected by shadow agglomerations, like Zeeland, leading to mutual cooperation between various cities. With this, smaller villages in Zeeland gain more autonomy and collaboration with larger cities like Rotterdam. Complete self-sufficiency is unrealistic with this concept, as Rotterdam will consume more energy than it can produce, and vice versa for less populous, space-abundant areas. In addition to focusing on exchanging flows, this report also explores which flows are crucial to reduce to lower energy consumption.

A key element in crafting a new narrative for the energy transition is implementing policies that ensure fairness and transparency. This report introduces a new system, with the energy boards as one of the new elements, functioning similarly to water boards and extending the national government's reach. Here, people can vote on significant legislative changes and future goals. Additionally, each community will have its own energy hub, representing all residents and directly connected to the energy board, thus merging bottom-up and top-down approaches to ensure everyone's voice is heard.

Impact

In our project we explored how the energy transition can occur in a fairer manner to minimize CO2 emissions as much as possible. We consciously focused on collaboration across different organizational layers and groups of people. This could potentially bring about a change in how our society is currently organized; it is unprecedented in Dutch society for people to have such significant responsibility over a utility as we propose in our vision and strategy. This has the advantage of creating a more pure form of democracy—people are brought closer to policy making. However, this also introduces complexity in navigating diverse opinions and voices. While we have developed an idea of what this new structure should look like, we have not explored what to do when opinions are conflicting. Another aspect we did not account for is when people choose not to participate. Our approach assumes that people always want to engage in decision-making and express their opinions, but is this always the case?

If our project is implemented, energy will occupy a different place in society and our living environment, directly confronting people with its production and creating greater awareness of consumption. This place in our society will need to combine various perspectives to achieve the best possible implementation, in our project we combined social, technical, and environmental layers. Although these perspectives are incredibly large and include many different types of aspects, in our report we have done our best to grasp them as much as possible.

During our research, analysis, and development of our concept, we realized we had overlooked a crucial stakeholder: nature. Initially, we focused on the negative aspects of Zeeland's location and aimed to solve these problems. However, the world is not just black and white; there are many nuances in between. We had overlooked that what we previously perceived as negative actually had a positive impact on nature, providing space for it to thrive. Not considering this would have omitted a vital part of creating a fair system, leading to questions about its fairness. Ultimately, we revised the catalog and considered new, more nature-inclusive applications.

Moreover, as a group, we learned a lot about the potential applications and limitations of creating a vision and strategy on a regional level, which resulted eventually in our catalog. Different ways of implementing the catalog tiles can significantly affect how people navigate an area. By narrowing the gap between policy and people, we aimed to address this. Furthermore, by making people more responsible for their energy production, we sought to address and reduce energy poverty and inequality by integrating often invisible systems into the landscape fabric, giving more control over them and adding a new cultural layer.

Scientific contribution

Currently, we are in the midst of an energy transition and the development of new energy systems. This process tends to be viewed through a technical lens by policy makers, solely focusing on how new energy systems are integrated into the landscape. However, energy is closely tied to our society and living environment, intertwining with social aspects that are now dismissed and/or overlooked in the current transition. Large solar and wind farms are erected without sufficient consideration of the surrounding environment. Additionally, policymakers tend to view energy as a homogeneous sector, assuming that the same applications can be replicated everywhere. This approach fails to recognize the unique nature of renewable energy, leading to the inappropriate application of methods traditionally used for fossil fuels.

Our project dove into this issue, adding multiple layers to the energy transition to create a deeper understanding of what energy means in our society and how it can reshape our landscapes and society. We advocated for the implementation of energy communities, exploring, developing, and refining their application as our research progressed. This approach has allowed us to craft a new narrative for the energy transition, detailing its implementation across technical, social, landscape, and policy levels.

However, our research has limitations that future studies could address. We primarily focused on three communities, resulting in somewhat limited pilot studies. To better understand the application of energy communities, further research is needed, especially considering large-scale implementations, such as across the Netherlands or even the Eurodelta. Is it still advantageous when scaled up?

We deliberately concentrated on residential buildings, leaving industries with little or no role in our design. This is a significant gap since industries are major energy consumers and producers, and their inclusion could significantly alter the implementation of an energy community. Related to this is our lack of focus on other energy types, like nuclear and hydrogen, which are currently underutilized in household settings but are expected to play a significant role in the future energy mix, necessitating further investigation into their integration with energy communities.

Two additional areas where research is lacking are the reuse of existing infrastructure and the question of material usage. Currently, many materials are sourced from China, creating a dependency that contradicts the goal of reducing geopolitical influences. Additionally, solar panels now have a lifespan of twenty years, making research on recycling and repurposing the materials used valuable.

In conclusion, while there is still much to explore regarding the implementation of energy communities, we believe our work provides a foundation for policymakers and researchers to rethink the energy transition, aiming for a more humane and effective transformation.

Jan Osusky

Student number 5789281

On the first day of this quarter, we were introduced to the concept of left-behind places. The theme of spatial justice was a big part of the methodology lectures, and they shaped my desired approach to the topic of CO2 in this project. With our team we early on agreed to look at how local communities and the energy system interact with each other. Incorporating the topics mentioned we came to the concept of the energy community within the first week and we knew that we wanted to make this a central part of our project.

The Eurodelta-scale GIS analysis of the landscapes that I carried out helped us to situate ourselves in a region where the notion of spatial justice can help create a good, socially just project – we ended up choosing Zeeland in the Netherlands. Our vision that bloomed out of the analysis on the Eurodelta and Zeeland may seem obvious, and I see this not as a flaw but a strength, because this makes it easy to communicate and understand, crucially important when designing with a lot of stakeholders.

Regional design, as we explored it in this project, is in my opinion an exercise in varying precision: Some details of the design are core to the project, while others are intentionally vague. This can facilitate the layer-cake of the planning framework that exists in the countries of the Eurodelta: A large-scale plan sets the general direction, medium and small-scale plans define the precise details of the design. With our project, we ended up creating statements about multiple layers, and through the dimensions of governance and design frameworks and guidelines we connected through those layers.

Initially though, I had a hard time marrying a bottom-up, community-focussed approach with the scale of the Eurodelta. Here, the concept of transition thinking helped me to understand, how a bottom-up process can ascend through the scales. We ended up implementing this way of thinking with our pilot project, that could in the future be transplanted to other regions of the Eurodelta. In this regard, the analysis on the Eurodelta scale about the energy landscapes can come in handy, to facilitate this transplantation.

Early on in the Capita Selecta lectures, we learned about the recent developments in the national planning debate in the Netherlands. In this illuminating lecture I as an expat not only got a better understanding of the Dutch planning infrastructure, I also realized that even though plans can change, the stakeholders around those plans are more permanent factors, as many of them are long-standing institutions with their intrinsic logics. If we could incorporate these stakeholders into our project, we could also place the project firmly within those stakeholders. That is why the community structure of our strategy is probably the most robust and crucial factor of the project.

Concluding, I believe our approach is good, and the energy communities could in one form or another help to improve the issues we laid out in the problem statement.

Individual Reflection

Annika van der Nat
Student number 5219159

At the start of this course I was enthusiastic to learn more about regional planning and design. In my previous studies I have never worked on this scale so I imagined I would learn a lot of new skills. Especially due to my architectural background, I always believed designing and policymaking/planning were two separate things.

However, during this quarter I have learned the opposite is true. At first it was a challenge to understand the difference between a vision, strategy and designing, but after many group discussions we gradually found a combination of all three that worked best for our group. Especially, during the vision process, we struggled to not already start working on a strategy. I think this was partly because our initial vision was too ambitious for a ten week project and after the midterm still needed some adjustments to make it more clear and concise.

This then resulted in a less linear process than I am used to and then I prefer. I noticed during the weeks after our midterm presentation, we still focussed more on improving our vision, instead of making our strategy. This became a little confusing to me personally, and I started to get a bit insecure about the process of our project.

Fortunately, I eventually learned that this is exactly how "messy" a regional designing process is supposed to be. The relationship between a vision, strategy and design is more closely linked than I initially thought and it proved beneficial for our project to keep going back and forth between these different aspects.

Even though our process was not linear, nor structured, the project did become more integrated than I could have ever hoped for. Moreover, I learned more about regional planning through this process, than I would have if everything was clear from the start of the project.

I think our project describes our vision well, which is to create a new more just approach to the energy transition. However, I believe this vision cannot be achieved through only planning and strategizing. We will also need more development in renewable energy technologies and we will need a drastic change in the current centralized system. This transition to a decentralized system will require a new way of thinking from all stakeholders involved.

I look back at this project as a challenging and interesting quarter. I have learned a lot of new skills, apart from regional planning, like how to make a multi-criteria analysis using GeoDa, becoming more advanced in Illustrator and Photoshop and I especially learned how to overcome struggles with group work through good communication and planning.

Emese Nagy

Student number 6028187

This quarter has been quite an intense journey for me. The challenge was mainly balancing the demands of research and design. Considering the vastness of the energy topic, it was crucial to delve deeply into it to grasp the current situation. This was a challenge not just because of the breadth of the topic but also because I hadn't tackled such a large-scale project before. However, through the field trip and group discussions, we quickly found our focus: exploring the energy transition, particularly the decentralization of energy production.

As the weeks progressed, our time was primarily devoted to research. We were fortunate to have the support of SDS and Methodology classes, which continuously provided us with valuable information and equipped us with the necessary tools for our project. Tutor sessions and the midterm presentation also played pivotal roles in helping us maintain focus and pinpoint areas of the project that required more attention. Working in teams presented its own set of challenges. Each of us had to learn how to collaborate effectively, pay attention to one another, and communicate clearly. While this was daunting at times, by the end of the quarter, we managed to establish a cohesive workflow built on trust in each other's abilities. This quarter wasn't only difficult because of the complexity of the topic, but also we had to address globally threatening issues, led to feelings of hopelessness. These emotions were openly discussed among peers, but it would have been beneficial to have addressed them within the course framework.

Despite these challenges, we managed to produce a complex regional project, reinforcing our belief that collaborative efforts are essential in mitigating climate change. Our project highlighted the critical need for stakeholder cooperation across various levels. We emphasized that affecting substantial change necessitates a combination of bottom-up and top-down approaches, recognizing the importance of blending these strategies for meaningful progress. Furthermore, we navigated existing policies while also developing our own based on our vision and goals. Expanding upon these experiences, it becomes evident that our journey extended beyond project completion. It served as a means to enhance our skills, equipping us with the capabilities to undertake large-scale projects aimed at addressing significant societal challenges.

Esmee de Ruiter

Student number 1391380

During this project, I often felt intimidated by the subject matter, the regional scale, and the strict time frame we had to complete the course. Initially, I was excited with the topic that explored the implementation of energy in the landscape more extensively. However, as the project progressed, I oftentimes struggled to incorporate the vast complexities that arise on a regional level into a coherent vision and strategy without the subject becoming too overwhelming. I have learned a great deal during this course about how to navigate and consolidate these aspects into a vision and strategy. Although I completed my bachelor's in Architecture, I chose a different master's program that focuses more on understanding the problem, something that cannot be fully explored in just two weeks with a topic as big as the energy transition. This caused some tension for me in group discussions and tutor sessions, especially since I had an internship last summer at a company working on the energy transition, where I continue to work as a student employee. This has given me more knowledge about the energy transition, but I also knew how big the topic is and how much we still don't know as a society about energy and life after the energy transition. I had to accept that decisions must be made without fully understanding all their implications.

Naturally, I am quite chaotic in my thought processes and struggle to communicate ideas spontaneously with people. This makes me more of a thinker and listener than a talker. Although I have worked hard to improve my speaking skills in groups, during this group task, I trained even harder, enabling me to articulate my thoughts more clearly and communicate them more effectively. In the group I took on a more vocal role than usual, which was a significant learning experience for me. Lastly, in this personal reflection, I want to highlight how much I've learned about transforming a vision into a strategy on such a large scale and the type of thinking that can be applied, particularly finding the methodology lessons very useful and informative.

Tijmen Boot

Student number 5010039

A project on a regional scale was a new experience for me, as for most of my group members. It has proven to be a scale which embodies a large number of stakeholders and therefore requires careful considerations in the decision making. A thought that often came back was how many other aspects should be considered to make the right decision. This term, the design choices were led by the findings of the research. Before decisions got made, extensive research preceded. This led to difficulties in keeping pace with the project; we wanted to wait for certain outcomes to appear from the research before we continued, but we simply did not have the time. As the project continued, based on the knowledge we picked up along the way, and partially pushed by our tutors, the decision making could be done more swiftly. I believe this does encapsulate a valuable lesson for designing on a regional scale; all aspects should be taken into consideration, but it is also crucial to make decisions because only then progress can be made. Towards the back end of the project this also became part of the routine of the group. Discussions that took hours at the start turned into concise meetings where knots were cut based on the acquired knowledge. Trusting others' researching capabilities were key in this process.

The vision that was the result of this research and decision making functioned as a guide for the strategy development. It was effective to have something to fall back on and it could align the work. Even though group members had various topics to work out, the vision was a backbone to keep it moving in the same direction. At the same time, it is important that the vision is applicable to all (or at least most) aspects of the project. We therefore decided to split the vision into multiple goals which could be interpreted throughout the strategy. The resulting strategy shows the complexity of the topic, however does show logical and reasonable decision making. I believe we have created a project which truly reflects our ambition for the region and also has a broad understanding of the situation for the time that we had.

On a personal note, group projects are always a challenge. My character is to be quiet in the beginning and see how the relations form amongst the group. Later, when I became more comfortable with the members of the group, I could express my thoughts and ideas more freely. For future projects, I would challenge myself to express myself more openly from the start.

Chapter 8
References

REDES – Regenerative Design. (n.d.). A Solarpunk Manifesto (English) https://www.re-des.org/es/a-solarpunk-manifesto/

Benn, T. (2023). Lumify Energy. Land required for a wind farm. Consulted at: https://lumifyenergy.com/blog/land-required-for-a-wind-farm/#:~:text=The%20average%20commercial%20wind%20turbine,anything%20from%2025%2D40%20acres.

Cardoso, R., & Meijers, E. (2021). Borrowed size, agglomeration shadows, and cultural amenities in north-west Europe. European Planning Studies, 23(6), 1090-1109. DOI:10.1080/09654313.2014.905002

CBS. (2020). Nederland in Cijfers. Hoe wordt de Nederlandse bodem gebruikt? Consulted at https://longreads.cbs.nl/nederland-in-cijfers-2020/hoe-wordt-de-nederlandse-bodem-gebruikt/#:~:text=Van%20de%20totale%20oppervlakte%20van,voornamelijk%20uit%20woon%2D%20en%20bedrijventerreinen.

CBS. (2022). Deze eeuw vooral in Randstad meer bebouwing. Consulted at: https://www.cbs.nl/nl-nl/nieuws/2022/34/deze-eeuw-vooral-in-randstad-meer-bebouwing

CBS. (2022). Wijk- en buurtkaart 2022 (Dataset). https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische-data/wijk-en-buurtkaart-2022 (accessed 13.03.24)

CBS. (2024). Statline. Landbouw; gewassen, dieren en grondgebruik per gemeente (Dataset). https://opendata.cbs.nl/#/CBS/nl/dataset/80781ned/table?ts=1711611612768

CBS. (2024). Statline. Energiebalans; aanbod, omzetting en verbruik (Dataset). https://www.cbs.nl/nl-nl/cijfers/detail/83140NED

CBS. (2024). Statline. Energiebalans; aanbod en verbruik, sector (Dataset). https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83989NED/table?dl=21D0E

CLO. (2022). Compendium voor de Leefomgeving. Energieverbruik per sector, 1999-2021 https://www.clo.nl/indicatoren/nl005224-energieverbruik-per-sector-1990-2021#technische-toelichting

Coaffee, J. (2008). Risk, resilience, and environmentally sustainable cities. Energy Policy, 36(12), 4633–4638. https://doi.org/10.1016/j.enpol.2008.09.048

EBN (2023). Energie in Cijfers. Duurzaamheid en energiezekerheid in Nederland. Consulted from: https://www.ebn.nl/wp-content/uploads/2023/01/EBN-Infographic-2023-energie-in-cijfers-A4.pdf

Energie Nederland (2024). Energiesysteem. Consulted from: https://www.energie-nederland.nl/onderwerpen/energiesysteem/feiten-en-cijfers/

European Commission, (n.d) Energy and Industry Geography Lab. https://joint-research-centre.ec.europa.eu/scientific-tools-databases/energy-and-industry-geography-lab_en

European Commission, (n.d) Energy communities https://energy.ec.europa.eu/topics/markets-and-consumers/energy-communities_en (accessed 04.10.2024)

European Commission, (n.d.) Clean energy for all Europeans package https://energy.ec.europa.eu/topics/energy-strategy/clean-energy-all-europeans-package_en (accessed 04.10.2024)

European Commission. (2024) Energy Atlas, Electricity demand per sector (Dataset). https://energy-industry-geolab.jrc.ec.europa.eu/uropa.eu) (accessed 28.02.2024)

European Environmental Agency. (2021) Natura 2000 (Dataset) https://www.eea.europa.eu/data-and-maps/data/natura-14/natura-2000-spatial-data 2000 - Spatial data — European Environment Agency (europa.eu) (accessed 03.03.2024)

Eurostat. (2024) Degree of Urbanization (Dataset). https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/population-distribution-demography/degurbaGURBA - GISCO - Eurostat (europa.eu) (accessed 28.02.2024)

Global Wind Atlas. (2024) Mean Power Density (Dataset). https://globalwindatlas.info/en (accessed 03.03.2024)

Global Report on Human Settlements 2011: Cities and Climate Change | UN-Habitat. (z.d.). https://unhabitat.org/global-report-on-human-settlements-2011-cities-and-climate-change

Howard, D., Burgess, P. J., Butler, S. J., Carver, S., Cockerill, T., Coleby, A. M., Gan, G., Goodier, C. I., Van Der Horst, D., Hubacek, K., Lord, R., Mead, A., Casado, M. R., Wadsworth, R. A., & Scholefield, P. (2013). Energyscapes: Linking the energy system and ecosystem services in real landscapes. Biomass And Bioenergy, 55, 17–26. https://doi.org/10.1016/j.biombioe.2012.05.025

Rijksoverheid. (n.d.). Regionale Klimaatmonitor (dataset). Consulted at https://klimaatmonitor.databank.nl/jive

Rural Energy Community Advisory Hub (2022). Joining or setting up a rural energy community https://energy-communities-repository.ec.europa.eu/joining-or-setting-rural-energy-community_en (accessed 04.10.2024)

Kadastralekaart.com. (n.d.) Klaaswaal https://kadastralekaart.com/wijken/klaaswaal-WK196308 (accessed 04.10.2024)

Kadastralekaart.com. (n.d.) Oud-Beijerland. https://kadastralekaart.com/wijken/oud-beijerland-WK196300 (accessed 04.10.2024)

Kadastralekaart.com. (n.d.) Rotterdam. https://kadastralekaart.com/gemeenten/rotterdam-GM0599 (accessed 04.10.2024)

Müller, R., Geraldi, J., & Turner, J. R. (2012). Relationships Between Leadership and Success in Different Types of Project Complexities. IEEE Transactions On Engineering Management, 59(1), 77–90. https://doi.org/10.1109/tem.2011.2114350

Nejat, P., Jomehzadeh, F., Taheri, M. M., Gohari, M., & Majid, M. Z. A. (2015). A global review of energy consumption, CO2 emissions and policy in the residential sector (with an overview of the top ten CO2 emitting countries). Renewable and sustainable energy reviews, 43, 843-862.

Oudes, D., van den Brink, A., & Stremke, S. (2022). Towards a typology of solar energy landscapes: Mixed-production, nature based and landscape inclusive solar power transitions. Energy Research and Social Science, 91, Article 102742. https://doi.org/10.1016/j.erss.2022.102742

Pasqualetti, M. J., & Stremke, S. (2018). Energy landscapes in a crowded world: A first typology of origins and expressions. Energy Research & Social Science (Print), 36, 94–105. https://doi.org/10.1016/j.erss.2017.09.030

Picchi, P., Verzandvoort, S., Geneletti, D., Hendriks, C. M., & Stremke, S. (2020). Deploying ecosystem services to develop sustainable energy landscapes: a case study from the Netherlands. Smart And Sustainable Built Environment, 11(3), 422–437. https://doi.org/10.1108/sasbe-02-2020-0010

RVO. (2022). Rijksdienst voor Ondernemend Nederland. Geschikte daken voor zonne-energie. Consulted at https://www.rvo.nl/onderwerpen/zonne-energie/geschikte-daken#welke-daken-zijn-geschikt-voor-zonnepanelen%3F

Sauter, R., & Watson, J. (2007). Strategies for the deployment of micro-generation: Implications for social acceptance. Energy Policy, 35(5), 2770–2779. https://doi.org/10.1016/j.enpol.2006.12.006

SURE Eurodelta. (2024). Mission. SURE Eurodelta network group. Consulted at https://sure-eurodelta.eurometrex.org/mission/

United Nations, (n.d.) The 17 goals, Sustainable Development.

United Nations, (n.d) Sustainable Development Goals. https://sdgs.un.org/goals (accessed 04.10.2024)

International Energy Agency (n.d.) The Netherlands - Countries & Regions. https://www.iea.org/countries/the-netherlands/energy-mix#how-is-energy-used-in-the-netherlands

Ryan, R. M., & Deci, E. L. (2002). Overview of self-determination theory: An organismic-dialectical perspective. Psychnet. https://psycnet.apa.org/record/2002-01702-001 v

Appendix

Appendix A: Energy balance calculation for the concluding diagram

	Area	Energy consumption (TJ)		Area (hectare)	Roof area	Usable roof area	# solar panels	Energy production solar(TJ)	Energy need after solar	Agricultural area (hectare)		TJ/ hectare agriculture	# onshore wind turbine needed	# onshore wind turbine possible					
Zeeland	1	18671	46851		9306	744	3722400	4422	14249	104975		0,18	303	2624	1300	-997	61100	65522	23,68492
Z-H eiland	2	9251	12358		5911	473	2364400	2809	6442	26773		0,35	137	669	400	-263	18800	21609	30,36328
Rotterdam	3	103281	-82731		16046	1284	6418400	7625	95656	15399		6,71	2035	385	275	1760	12925	20550	7,382829
Boskoop	4	19506	7		10698	856	4279200	5084	14422	43231		0,45	307	1081	307	0	14429	19513	26,06218
Nieuwkoop	5	10271	5679		3894	312	1557600	1850	8421	18340		0,56	179	459	300	-121	14100	15950	18,01605
	6	3648	-3648			0	0	0	3648	30728		0,12		768		0	0	0	
Roosendaa	7	12452	5643		8407	673	3362800	3995	8457	37689		0,33	180	942	300	-120	14100	18095	32,08325
Bergen op	8	6641	8124		1399	112	559600	665	5976	12100		0,55	127	303	300	-173	14100	14765	10,01061
Dordrecht	9	6578	-1158		1516	121	606400	720	5858	7261		0,91	125	182	100	25	4700	5420	10,95171
Gorinchem	10	14264	12238		6318	505	2527200	3002	11262	32046		0,45	240	801	500	-260	23500	26502	21,04819
	11	19360	-19360			0	0	0	19360							0	0	0	
Katwijk	12	6483	-3273		1810	145	724000	860	5623	3074		2,11	120	77	50	70	2350	3210	13,26719
													3752		3832	-80	180104	180104	
																			19,28702

Appendix B

1 Zeeland - Gemeenten													
	Energieve	Aardgas g	Elektricite	Oppervlak	Energieverbruik Woningen (temperatuurgecorrigeerd, aardgas, elektr., stadswarmte, zon achter meter) [TJ] [2022]								
Goes	1111	4	9	9248	795								
Middelburg	583	28	9	4838	1006								
Sluis	509	5	31	27860	692								
Vlissingen	433	1	3	3437	923								
Goeree-Overflakkee	1538	249	66	26220	1043								
Noord-Beveland	308	8	62	8600	210								
Schouwen-Duiveland	1121	269	48	22860	850								
Kapelle	514	?	27	3713	268								
Reimerswaal	1194	916	130	10176	457								
Borsele	690	16	52	14147	499								
Veere	407	15	27	13299	566							Landbouwgrond	
Tholen	392	?	48	14672	539						0,009499	104974,8	0,177862
	8800	1511	512	159070	7848	0,117376					0,049337		
							18671	0,420331	0,10835	0,471319			

2 Zuid-Hollands eiland - Gemeenten													
	Energieve	Aardgas g	Elektricite	Oppervlak	Energieverbruik Woningen (temperatuurgecorrigeerd, aardgas, elektr., stadswarmte, zon achter meter) [TJ] [2022]								
Voorne aan Zee	963	?	146	12177	1483								
Hoeksche Waard	2252	196	67	26854	1778								
Nissewaard	781	1	6	7331	1578						0,004249	26773,24	0,345532
	3996	197	219	46362	4839	0,199538					0,104374		
							9251	0,523079	0,044968	0,431953			

3 R DH L - Gemeenten													
	Energieve	Aardgas g	Elektricite	Oppervlak	Energieverbruik Woningen (temperatuurgecorrigeerd, aardgas, elektr., stadswarmte, zon achter meter) [TJ] [2022]								
Rotterdam	11295	718	58	21842	11579								
Schiedam	1578	0	2	1781	1419								
Westland	1537		1905	8076	2034								
Leiden	1544	2	2	2185	2311								
Leiderdorp	571	?	1	1150	524								
Zoetermeer	1598	6	?	3443	2151								
Delft	1298	0	1	2266	1844								
Midden-Delfland	1219	1852	?	4719	358								
Maassluis	129	1	3	844	608								
Barendrecht	1517	25	6	1958	844								
Sliedrecht	578	?	1	1285	449								
Zwijndrecht	624	?	1	2031	854								
Lansingerland	1084	5995	478	5327	1108								
Alblasserdam	375	?	1	877	342								
Albrandswaard	287	?	4	2167	483								
Hendrik-Ido-Ambacht	538	?	20	1019	527								
Ridderkerk	1762	198	23	2348	858								
Papendrecht	644	?	2	941	590								
Krimpen aan den IJssel	193	?	0	767	538								
Capelle aan den IJssel	771	?	0	1414	1185								
Pijnacker-Nootdorp	471	2154	394	3687	936								
Rijswijk	978	?	1	1398	1077								
Leidschendam-Voorburg	1458	64	9	3261	1577								
Den Haag	4463	14	12	8244	10533								
Zoeterwoude	265	4	5	2116	170								
Vlaardingen	777	?	1	2336	1341								
Voorschoten	163	?	2	1111	529						0,140567	15399,32	6,706855
Zuidplas	1643	2235	122	5796	830						0,504285		
	39360	13268	3054	94389	47599	1,094206							
							103281	0,460869	0,158035	0,381096			

4 Boskoop - Gemeenten											
	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]							
Alphen aan den Rijn	2124	123	1536	12593							
Bodegraven-Reeuwijk	707	36	1846	7540							
Waddinxveen	532	1123	1053	2775							
Gouda	1328	1	451	1650							
Krimpenerwaard	1147	44	874	14832							
Oudewater	221	18	124	3890							
Lopik	305	38	383	7556							
Montfoort	285	21	209	3758							
IJsselstein	613	7	308	2101							
Vijfheerenlanden	1123	51	2875	14628						43230,98	0,451204
	8385	1462	9659	71323	0,273488						
						19506	0,429868	0,074951	0,495181		

5 Nieuwkoop - Gemeenten											
	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]							
Teylingen	724	98	561	2832							
Oegstgeest	521	3	385	729							
Hillegom	434	106	164	1286							
Kaag en Braassem	574	565	1384	6313							
Lisse	442	58	172	1570							
Nieuwkoop	583	477	426	7846							
De Ronde Venen	940	181	1473	9968						18340	0,560033
	4218	1488	4565	30544	0,336269						
						10271	0,410671	0,144874	0,444455		

6 Terneuzen - Gemeenten											
	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]							
Terneuzen	1292	55	1195	25013							
Hulst	708	32	366	20126						30727,78	0,11872
	2000	87	1561	45139	0,080817						
						3648	0,548246	0,023849	0,427906		

7 Roosendaal Etten-leur - Gemeenten											
	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]							
Woensdrecht	521	52	834	9166							
Roosendaal	1660	239	1580	10650							
Steenbergen	526	?	876	14650							
Halderberge	696	189	605	7444							
Rucphen	576	64	584	6438							
Zundert	556	245	346	12059							
Etten-Leur	858	572	873	5529						37688,71	0,330391
	5393	1361	5698	65936	0,18885						
						12452	0,433103	0,1093	0,457597		

8 Bergen op Zoom - Gemeenten											
	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]							
Bergen op Zoom	1359	266	1318	7997							
Moerdijk	812	?	2886	15917						12100,27	0,548831
	2171	266	4204	23914	0,277703						
						6641	0,326909	0,040054	0,633037		

9 **Dordrecht - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]							
Dordrecht	2300	8	2133	7756							
Drimmelen	611	800	726	9505						7260,96	0,90594
	2911	808	2859	17261	0,38109						
						6578	0,442536	0,122834	0,434631		

0 **Gorinchem - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]							
Molenlanden	882	72	1063	18157							
Hardinxveld-Giessendam	334	3	821	1686							
Altena	1183	217	1594	19974							
Gorinchem	679	1	1084	1871							
Zaltbommel	620	4723	988	7865						32045,59	0,44511
	3698	5016	5550	49553	0,287853						
						14264	0,259254	0,351655	0,389091		

1 **Utrecht - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Woerden	1019	713	2331	8855					
Utrecht	6056	17	6524	9377					
Nieuwegein	1123	?	1577	2342					
	8198	730	10432	20574	0,940993				
						19360	0,42345	0,037707	0,538843

2 **Strand gemeenten - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]							
Wassenaar	765	14	562	5118							
Katwijk	1121	506	411	2481							
Noordwijk	935	231	477	5834							
Zandvoort	460	?	75	3208							
Bloemendaal	668	8	250	3977						3074,02	2,10896
	3949	759	1775	20618	0,314434						
						6483	0,609132	0,117075	0,273793		

3 **Amsterdam - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Haarlem	3211	?	1071	2921					
Haarlemmermeer	2948	1649	8081	19721					
Velsen	1372	17	1210	4503					
Heemstede	689	9	231	917					
Aalsmeer	655	537	450	2010					
Amstelveen	1867	298	1294	4111					
Amsterdam	16171	?	9181	18812					
Ouder-Amstel	287	6	1359	2395					
Uithoorn	592	?	215	1812					
Zaanstad	2894	100	1821	7374					
Oostzaan	199	1	453	1156					
Uitgeest	266	4	505	1916					
Diemen	624	?	865	1195					
	31775	2621	26736	68843	0,887992				
						61132	0,519777	0,042874	0,437349

4 **Gooische meren - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]						
Stichtse Vecht	1365	105	2651	9604						
Wijdemeren	584	16	341	4754						
Gooise Meren	1468	6	2488	4143						R
	3417	127	5480	18501	0,487757					
						9024	0,378657	0,014074	0,60727	

5 **Alkmaar - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Beverwijk	811	3	585	1835					
Heemskerk	742	153	421	2727					
Castricum	803	19	577	4964					
Bergen (NH.)	836	60	325	9900					
Heiloo	554	8	415	1871					
Alkmaar	2201	56	1744	11031					
Dijk en Waard	1593	793	1140	6190					
Wormerland	324	16	616	3851					
Purmerend	1598	99	1443	9361					
Landsmeer	250	5	80	2244					
Waterland	376	16	454	5199					
	10088	1228	7800	59173	0,323053				
						19116	0,527725	0,064239	0,408035

6 **Volendam Enkhuizen - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Medemblik	987	1509	1068	12123					
Drechterland	446	383	306	5888					
Stede Broec	446	226	203	1448					
Enkhuizen	389	390	112	1266					
Hoorn	1425	6	570	2037					
Koggenland	487	546	907	8026					
Edam-Volendam	843	16	389	5432					
	5023	3076	3555	36220	0,321756				
						11654	0,431011	0,263944	0,305045

7 **Thema's - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Hollands Kroon	1094	6240	1670	35763					
Opmeer	255	61	190	4148					
	1349	6301	1860	39911	0,23828				
						9510	0,141851	0,662566	0,195584

8 **Thema's - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Schagen	1023	342	909	16799					
Den Helder	1202	83	402	4510					
	2225	425	1311	21309	0,185884				
						3961	0,561727	0,107296	0,330977

9 **Thema's - Texel**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Texel	342	36	151	16226	0,032602				
						529	0,646503	0,068053	0,285444

0 **Thema's - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]

Vlieland	27	?	2	4184					
Terschelling	128	4	57	8721					
Ameland	104	?	48	5659					
Schiermonnikoog	31	3	4	4293					
	290	7	111	22857	0,01785				
						408	0,710784	0,017157	0,272059

21 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Baarle-Nassau	172	74	88	7612					
Alphen-Chaam	272	106	209	9298					
Goirle	514	18	253	4297					
Hilvarenbeek	395	56	447	9487					
	1353	254	997	30694	0,084837				
						2604	0,519585	0,097542	0,382873

22 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Breda	3678	575	4274	12569					
Gilze en Rijen	542	44	876	6538					
Tilburg	4203	49	3886	12589					
	8423	668	9036	31696	0,571902				
						18127	0,464666	0,036851	0,498483

23 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Oisterwijk	757	135	740	8011					
Boxtel	714	45	1228	6901					
Vught	737	16	908	6002					
	2208	196	2876	20914	0,252462				
						5280	0,418182	0,037121	0,544697

24 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Oosterhout	1149	?	1567	7143					
Geertruidenberg	437	9	732	2660					
Waalwijk	1044	42	1358	6454					
Dongen	554	413	239	2923					
Loon op Zand	529	14	445	4992					
Heusden	1013	757	1129	7886					
's-Hertogenbosch	3199	43	3688	10948					
Maasdriel	600	495	942	6588					
Sint-Michielsgestel	708	33	462	5835					
	9233	1806	10562	55429	0,389706				
						21601	0,427434	0,083607	0,488959

25 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
West Betuwe	1149	1101	3495	21593					
Tiel	847	11	985	3280					
West Maas en Waal	476	40	415	7619					
Oss	2082	112	1460	16201					
Wijchen	881	35	926	6604					
Bernheze	730	129	1267	8973					
	6165	1428	8548	64270	0,251144				
						16141	0,381947	0,08847	0,529583

26 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Druten	423	26	323	3752					
Neder-Betuwe	502	68	1306	5999					
Overbetuwe	1035	119	2242	10903					
Beuningen	569	?	1134	4360					
	2529	213	5005	25014	0,309707				
						7747	0,326449	0,027495	0,646057

27 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Buren	654	79	591	13360					
Culemborg	546	5	548	2927					
Wijk bij Duurstede	492	20	207	4758					
Houten	846	?	844	5490					
Utrechtse Heuvelrug	1220	35	1658	13202					
	3758	139	3848	39737	0,194907				
						7745	0,485216	0,017947	0,496837

28 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Zeist	1452	9	1180	4850					
Soest	1061	8	593	4625					
Amersfoort	2859	12	3335	6249					
Leusden	634	18	685	5851					
Woudenberg	270	24	405	3652					
Scherpenzeel	213	?	109	1379					
Renswoude	115	18	210	1839					
Veenendaal	1231	6	547	1942					
Rhenen	425	16	330	4202					
Wageningen	720	68	352	3042					
Renkum	807	9	806	4596					
Bunnik	336	23	831	3693					
	10123	211	9383	45920	0,429377				
						19717	0,513415	0,010701	0,475884

29 Thema's - De Bilt

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
De Bilt	1053	25	1232	6619	0,348995				
						2310	0,455844	0,010823	0,533333

30 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Baarn	608	5	719	3254					
Eemnes	211	8	843	3104					
Bunschoten	433	38	182	3039					
Nijkerk	887	29	930	6932					
Putten	542	51	802	8521					
Barneveld	1211	?	2437	17584					
Ede	2405	180	3461	31815					
	6297	311	9374	74249	0,215249				
						15982	0,394006	0,019459	0,586535

31 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]	
Hilversum	2073	3	902	4561	
Laren	377	?	579	1241	
Blaricum	315	8	323	1107	
Huizen	902	?	406	1581	
Almere	3288	342	3255	12918	
	6955	353	5465	21408	0,596646

12773 0,544508 0,027636 0,427856

32 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]	
Noordoostpolder	1032	?	2251	45809	
Kampen	1061	1068	958	14123	
Dronten	850	208	1218	33360	
Lelystad	1514	31	2574	22900	
Zeewolde	398	114	1101	24711	
	4855	1421	8102	140903	0,102042

14378 0,337669 0,098832 0,5635

33 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]	
Ooststellingwerf	623	77	632	22330	
Westerveld	522	47	566	27865	
Weststellingwerf	637	71	786	22020	
Steenwijkerland	1077	72	955	28831	
Heerenveen	1157	53	1412	18997	
De Fryske Marren	1222	104	1702	35121	
	5238	424	6053	155164	0,075501

11715 0,447119 0,036193 0,516688

34 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]	
Tytsjerksteradiel	750	40	751	14863	
Leeuwarden	2695	60	2020	23755	
Súdwest-Fryslân	2090	157	2303	52270	
Achtkarspelen	664	29	422	10221	
Dantumadiel	447	19	288	8460	
Smallingerland	1255	37	1420	11717	
Opsterland	721	?	1127	22440	
	8622	342	8331	143726	0,120333
Speciale waarden	? Ontbreekt				

17295 0,498526 0,019775 0,4817

35 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]	
Waadhoeke	1098	1071	994	28542	
Harlingen	354	12	209	2496	
Noardeast-Fryslân	1100	97	631	37922	
	2552	1180	1834	68960	0,080713

5566 0,458498 0,212001 0,329501

36 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]	
Bladel	478	53	559	7533	
Bergeijk	478	65	256	10102	
Valkenswaard	736	12	452	5491	
Veldhoven	990	21	637	3168	
Waalre	456	4	489	2238	
	3138	155	2393	28532	0,199285

5686 0,551882 0,02726 0,420858

37 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]	
Eindhoven	4876	?	5067	8802	
Best	645	23	913	3389	
Son en Breugel	428	15	576	2595	
Nuenen, Gerwen en Nederwetten	586	17	346	3365	
Helmond	1840	?	1016	5317	
Geldrop-Mierlo	900	10	899	3101	
	9275	65	8817	26569	0,68339

18157 0,510822 0,00358 0,485598

38 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]	
Reusel-De Mierden	317	86	206	7781	
Oirschot	454	?	1183	10179	
Eersel	488	48	745	8247	
Meierijstad	1849	275	2183	18400	
Laarbeek	539	342	502	5535	
Gemert-Bakel	703	202	459	12207	
	4350	953	5278	62349	0,169706

10581 0,411114 0,090067 0,498819

39 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]	
Maashorst	1327	183	1623	13733	
Land van Cuijk	2111	354	2827	34126	
Boekel	255	308	96	3450	
Venray	1012	?	1177	16318	
	4705	845	5723	67627	0,166694

11273 0,417369 0,074958 0,507673

40 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]	
Nijmegen	3458	34	2266	5281	
Lingewaard	1021	537	563	6196	
Duiven	442	72	752	3388	
Westervoort	285	?	113	701	
Arnhem	3202	19	4157	9774	
	8408	662	7851	25340	0,667758

16921 0,496897 0,039123 0,46398

41 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]
Rheden	1065	8	701	8177
Brummen	502	14	390	8363
Rozendaal	53	?	28	2790
Apeldoorn	3596	55	5120	33986
Epe	828	49	1052	15612
Ermelo	590	46	628	8564
Harderwijk	939	23	951	3892
Nunspeet	598	19	969	12873

Elburg	497	16	622	6382					
Oldebroek	511	27	792	9766					
Heerde	448	29	659	7855					
Hattem	281	4	776	2307					
	9908	290	12688	120567	0,18982				
						22886	0,432928	0,012672	0,5544

42 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Zwartewaterland	471	38	336	8236					
Staphorst	376	53	1154	13394					
Zwolle	2442	?	2571	11067					
	3289	91	4061	32697	0,227574				
						7441	0,44201	0,01223	0,54576

43 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Meppel	737	14	796	5550					
De Wolden	643	79	1107	22439					
Hoogeveen	1271	50	1463	12754					
Hardenberg	1404	166	1361	31216					
Dalfsen	679	111	649	16502					
Ommen	426	?	702	17985					
Twenterand	783	45	505	10614					
Hellendoorn	802	66	520	13793					
Raalte	850	129	848	17097					
Olst-Wijhe	420	60	361	11366					
Deventer	2022	64	2094	13056					
Rijssen-Holten	815	50	1221	9412					
Voorst	605	104	1120	12293					
	11457	938	12747	194077	0,129547				
						25142	0,455692	0,037308	0,507

44 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Stadskanaal	825	28	399	11763					
Borger-Odoorn	695	75	754	27469					
Coevorden	896	93	1278	29611					
Midden-Drenthe	835	153	1570	34062					
	3251	349	4001	102905	0,073864				
						7601	0,427707	0,045915	0,526378

45 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Oldambt	1025	53	857	22657					
Eemsdelta	1196	93	721	26807					
Midden-Groningen	1512	646	1816	27795					
Veendam	701	19	486	7593					
Aa en Hunze	699	53	1043	27606					
Pekela	333	9	245	4904					
Assen	1444	15	1027	8188					
Noordenveld	831	43	516	19901					
	7741	931	6711	145451	0,105761				
						15383	0,503218	0,060521	0,436261

46 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Tynaarlo	866	49	815	14288					
Groningen	4929	46	3519	18553					
	5795	95	4334	32841	0,311318				
						10224	0,566804	0,009292	0,423905

47 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Westerkwartier	1558	162	1940	36263					
Het Hogeland	1262	162	785	47674					
	2820	324	2725	83937	0,069921				
						5869	0,480491	0,055205	0,464304

48 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Gulpen-Wittem	386	15	250	7318					
Eijsden-Margraten	676	22	422	7756					
Vaals	285	4	106	2389					
	1347	41	778	17463	0,124034				
						2166	0,621884	0,018929	0,359187

49 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Simpelveld	279	5	135	1603					
Voerendaal	331	8	281	3151					
Valkenburg aan de Geul	455	12	351	3673					
Maastricht	2671	5	1322	5579					
Meerssen	497	7	393	2673					
Beekdaelen	965	18	788	7830					
Heerlen	2024	4	1518	4491					
Kerkrade	1121	2	447	2191					
Landgraaf	888	4	283	2458					
Brunssum	668	1	289	1724					
Beek	403	4	650	2107					
Stein	612	3	278	2092					
Sittard-Geleen	2226	13	2634	7861					
	13140	86	9369	47433	0,476356				
						22595	0,581545	0,003806	0,414649

50 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Echt-Susteren	812	32	1356	10302					
Maasgouw	631	11	669	4570					
Roermond	1328	13	1250	6064					
Leudal	925	343	1249	16251					
Nederweert	435	133	374	9990					
Weert	1160	?	1349	10425					
Cranendonck	522	?	581	7650					
	5813	532	6828	65252	0,201879				
						13173	0,441281	0,040386	0,518333

51 Thema's - Gemeenten

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]
Heeze-Leende	419	36	680	10392
Someren	467	1200	780	8010

Asten	390	1027	910	7021					
Peel en Maas	1047	?	1436	15935					
Venlo	2315	1385	2704	12416					
Horst aan de Maas	1026	2275	1123	18867					
Deurne	779	273	871	11676					
	6443	6196	8504	84317	0,250756				
						21143	0,304734	0,293052	0,402213

52 **Thema's - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Bergen (L.)	331	401	265	10326					
Gennep	400	20	362	4757					
Mook en Middelaar	213	3	88	1739					
Heumen	396	14	596	3973					
Berg en Dal	824	27	376	8639					
	2164	465	1687	29434	0,146633				
						4316	0,50139	0,107739	0,390871

53 **Thema's - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Zevenaar	985	29	1024	9262					
Doesburg	240	2	118	1156					
	1225	31	1142	10418	0,230179				
						2398	0,510842	0,012927	0,47623

54 **Thema's - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Montferland	856	45	637	10570					
Doetinchem	1268	38	1052	7904					
Oude IJsselstreek	942	63	750	13607					
Aalten	625	58	384	9653					
Winterswijk	698	44	336	13813					
Haaksbergen	569	61	462	10478					
	4958	309	3621	66025	0,134616				
						8888	0,557831	0,034766	0,407403

55 **Thema's - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Bronckhorst	967	120	873	28353					
Oost Gelre	691	?	556	10993					
Berkelland	1079	141	805	25809					
Lochem	907	83	748	21305					
	3644	344	2982	86460	0,080615				
						6970	0,522812	0,049354	0,427834

56 **Thema's - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Enschede	3399	30	1815	14073					
Hengelo	1817	16	1442	6084					
	5216	46	3257	20157	0,422632				
						8519	0,612278	0,0054	0,382322

57 **Thema's - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Hof van Twente	894	151	837	21243					
Wierden	579	53	1015	9460					
Almelo	1647	27	1336	6718					
Borne	525	9	647	2599					
Tubbergen	557	104	414	14700					
	4202	344	4249	54720	0,160727				
						8795	0,477771	0,039113	0,483115

58 **Thema's - Gemeenten**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Dinkelland	707	138	560	17572					
Losser	563	39	550	9874					
Oldenzaal	746	3	466	2155					
	2016	180	1576	29601	0,127428				
						3772	0,534464	0,04772	0,417815

59 **Thema's - Emmen**

	Energieve	Totaal bel	Energieve	Oppervlakte land [hectare] [2023]					
Emmen	2603	1612	1692	33533	0,176155				
						5907	0,440664	0,272897	0,28644
						790527	0,469203	0,081229	0,449568