

Inclusive Energy Scapes

Regenerating the Rhenish Minescape towards an inclusive energy transition

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Inclusive Energy Scapes
Regenerating the Rhenish Minescape to an inclusive energy landscape

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Image front page: "Braunkohle-Tagebau" by Jürgen Spira, 2000

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Abstract

Keywords: Minescape, Energy transition, Energy landscape, Systemic Design, Regeneration

Humanity depends on energy, to protect our planet and maintain a secure energy system, we need to transition towards renewable energy sources. This transition also faces challenges concerning spatial demand, spatial quality, resistance from the population and an unfitting energy infrastructure. The Rhenish Lignite Mining District is one of the places where these problems come together. The area's foundation is currently lignite mining, but from 2030 onward, the mines will close. What is left is a large energy gap, a polluted and damaged environment and a disturbed socio-economic structure. The Rhenish Mining District is faced with the question of how to regenerate through the design of the minescape of the Rhenish Mining Area towards an inclusive energy transition. Through systemic thinking and scenario design, this thesis displays the possibilities new energy production methods create by being integrated into the minescape. Their symbiotic relations strengthen various aspects of the systems present in the minescape. The scenarios highlight the importance of designing for the green, blue, social and energy systems. The thesis reveals that the footprint of the minescape expands far beyond the borders of the extraction footprint. Therefore, the impact of the energy transition expands far beyond the extraction footprint. This is strengthened by the footprint and impact of renewable energy sources needing significantly more space than the current energy system. Through the scenarios, this thesis triggers the imagination on the possibilities of the energy transition and opens a discussion on the possible futures of the Rhenish minescape.

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1. Context

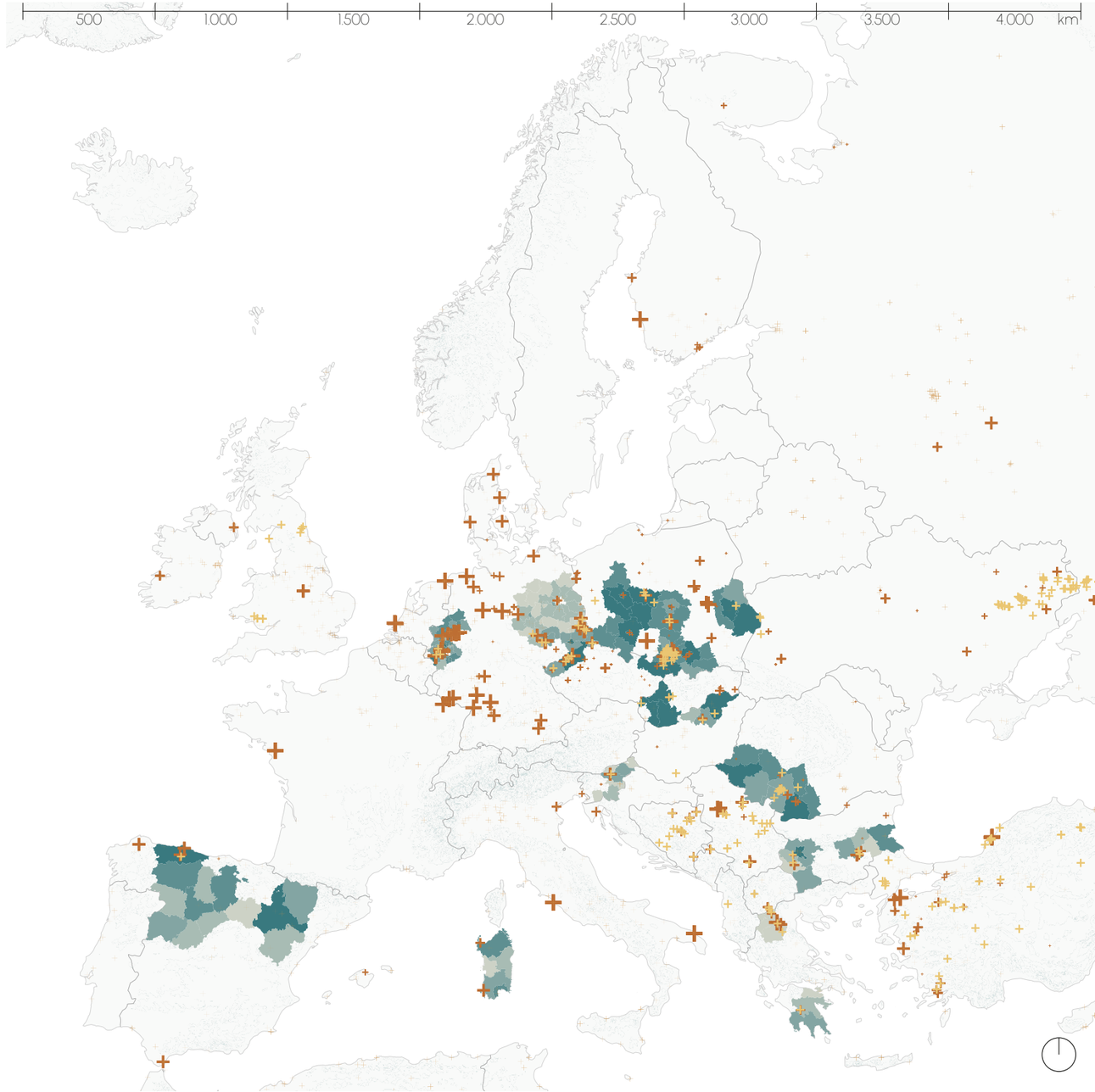
In 2030, the lignite mines of The Rhenish Mining Area will be closed. This is a big step towards a more renewable energy mix in Germany. It also creates a loss of 77.5 TWh of energy. Due to the high urban density and the intensive industry in North-Rhine Westphalia, we cannot simply use less energy. Instead, new forms of energy production should be introduced to create energy security. How this should be shaped is still in question. The future of the existing mines is still unknown. How will they be regenerated and what will their ecological and socio-economic implications be?

1.1: Lignite core of Hambach

1.1 Problem statement

Humanity is dependent on energy. We use it to cook, transport ourselves, communicate, work, and perform many other daily tasks. Energy is everywhere. Humans create their own energy to charge their bodies through food (Stremke & de Jong, 2022). However, we also use energy in different forms, such as heat, electricity, and fuel (Sijmons, 2014). Those are the forms we use in our environment, and they need to be harvested, modified, and transported.

In our current energy system, the largest part of our energy mix consists of energy made from fossil fuels (Agora Energiewende, 2018) (Federal Ministry for Economic Affairs and Energy, 2020). The most commonly used fossil fuels are coal, gas and oil. This dependency is causing three clear issues. First off, the amount of fossil fuel on our planet is depleting (De Boer & Zuidema, 2015) (Sijmons, 2014). Secondly, these sources can only be extracted in the locations in which they are situated. As these resources are unequally divided over our planet, countries depend on each other. Therefore, countries are heavily influenced by global instabilities and conflicts in fossil fuel-dense areas (De Boer & Zuidema, 2015) (Sijmons, 2014). Lastly, and most importantly, the usage of fossil fuels and the production of energy from these resources emit more than 50% of the anthropogenic greenhouse gas emissions (De Boer & Zuidema, 2015). This increases climate change; thus, our energy use and production directly damage our planet (De Boer & Zuidema, 2015) (Sijmons, 2014). These problems create obvious reasons for an energy transition. A transition from fossil fuels to more sustainable energy. Nonetheless, such a transition will bring its challenges.



1.2: Fossil fuel mining in Europe (based on Global Energy Monitor (2023b,c,d), Michael Bauer Research GmbH (2023) and Allen (2005)

1.1.1 "The" transition

Energy transitions have happened before. We have gone from human power to wind energy, to fossil fuels, which are both renewables, to nuclear energy and now we are back to renewables (Stremke & de Jong, 2022) (Ghosn, 2010) (Von Hirschhausen, 2018) (Pasqualetti, 2022). Our current energy transition is paired with optimism and the promise of a more independent, sustainable, and just world (Ghosn, 2010). However, currently we are rushing into this transition with disregard for the integration into the physical and social context (Ghosn, 2010). To come to a truly sustainable energy transition, we should look through the lens of design at the integration of the energy transition into the spatial and social context (Ghosn,2010) (De Boer & Zuidema, 2015). This is because an energy transition is paired with many different challenges. This is no different for our current energy transition. Even though the idea behind the energy transition is to create a sustainable new energy system, without proper design and care for the spatial and social implications, we will run into the same problems as in our current energy system.

As such it is necessary to determine the main challenges of our current energy transition.

1.1.2 Challenges

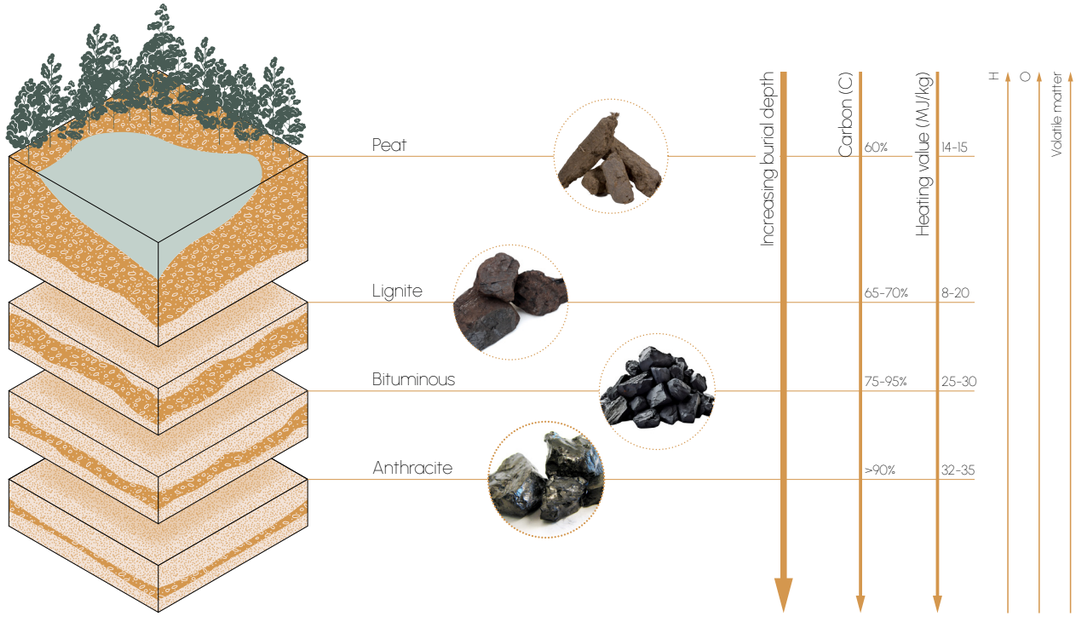
First off, there is the is the spatial footprint of renewable energy sources (Sijmons, 2014) (De Boer & Zuidema, 2015) (Ritchie, 2022). Combined with our expanding population and the never-ending battle for space, finding enough and the right space to implement new energy production methods is a challenge. Next to that is the existing infrastructure used for our fossil fuel-based energy system, which is not always suitable for new forms of energy (De Boer & Zuidema, 2015). This also relates to the seasonality of most renewable energy sources. We are not yet able to store the produced amount of solar and wind energy to be used on other moments then when they are produced. Next to that, not all renewable sources always produce energy; are they location dependent (De Boer & Zuidema, 2015). There are places with more potential for several types of renewable energy, which makes it impossible to create one nationwide strategy. Lastly, there is strong resistance from residents in areas where renewable energy is being implemented (De Boer & Zuidema, 2015). Renewable production methods are more visible than most fossil fuel production which is done far from the city.



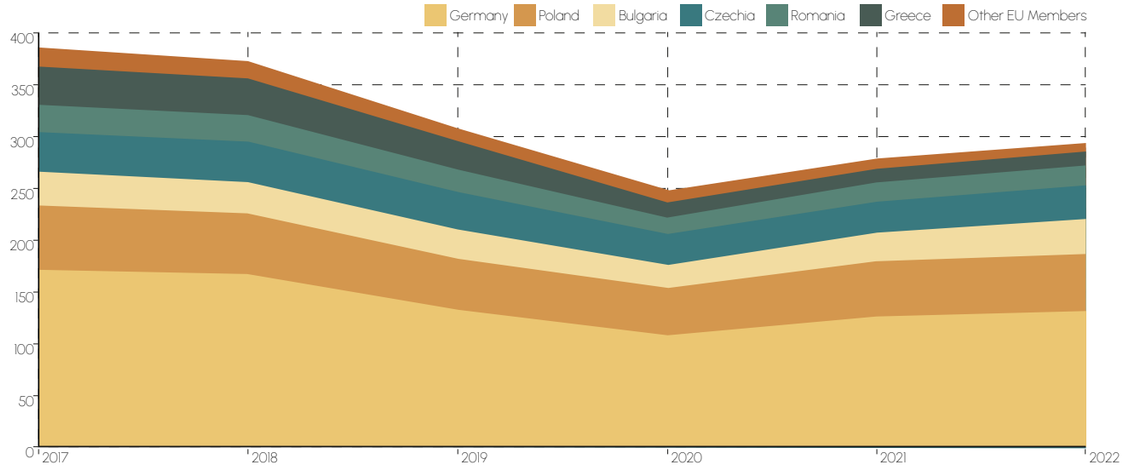
1.3: Solar fields (Cole, 2021)

1.1.3 Lignite in Germany

When we talk about fossil fuels, we mostly focus on three main types: gas, oil and coal. Lignite, also known as brown coal, is a form of coal. It has been less compressed and has a relatively high-water content. Consequently, it has a low energy content (Suárez-Ruíz et al., 2019) (Heinrich Böll Foundation, n.d.). Due to this chemical structure, it is difficult to transport and is thus mainly used for domestic energy production. This means that contrary, to most fossil fuels, it is produced and processed in the same place as it is used. In Europe, lignite extraction mainly takes place in Germany, where it provides most of the fuel for electricity generation (Sijmons, 2014) (Eurostat, 2023) (Garside, 2023). Nationwide, lignite covers about 20% of all energy consumption. Due to its high emission, lignite is the main source of greenhouse gas emissions in the electricity sector (Heinrich Böll Foundation, n.d.). At the same time, in North-Rhine Westphalia, where Rhineland Mining District is situated, the energy consumption consists of 41% of lignite (Seidenstücker et al., 2023). Germany has been phasing out lignite production and is planning to end all lignite production in Rhineland in 2030 (RWE, n.d.-c). However, the war in Ukraine has caused Germany to expand existing lignite mining operations to become more independent in its energy production (Eurostat, 2023) (RWE, 2022). This has slowed down the phasing out of lignite. Unfortunately, this does more damage to our environment than the continuation of the emission of greenhouse gasses.



1.4: Composition of coal (based on Suárez-Ruíz et al., 2019 and Sim et al., 2022))

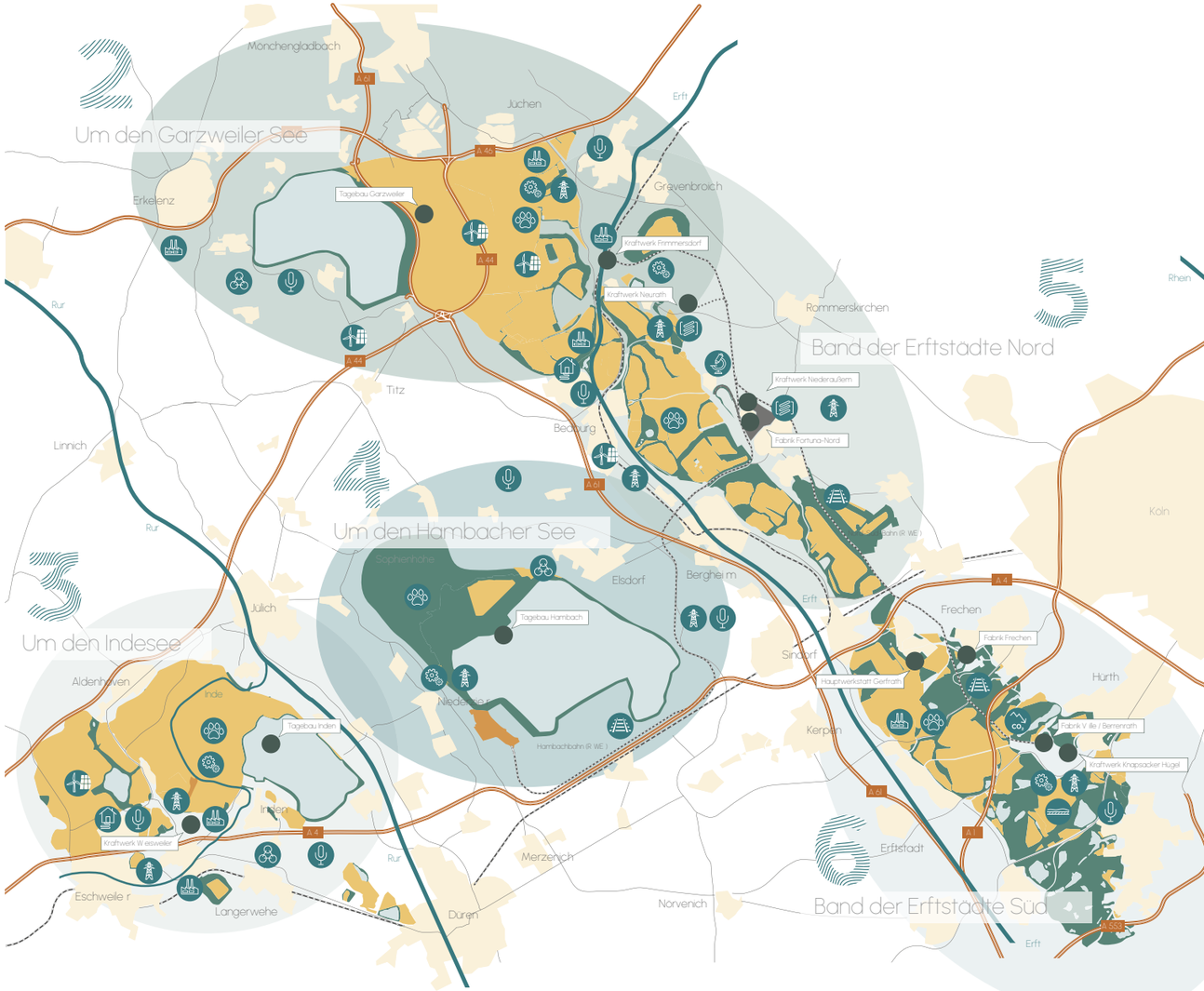


1.5: Inland consumption of Lignite of EU countries (based on Eurostat, 2023)

1.1.4 Lignite and its destruction

Lignite mining is highly disruptive to the environment. This can be seen in the landscape, by the removed, urban, natural and agricultural areas. However, the damage extends further than we can see. To keep the mining pits dry, groundwater is pumped out. Consequently, all land in the surroundings has a lower groundwater level (Sijmons, 2014). This strongly impacts natural and agricultural lands, specifically wetlands. Lignite has a relatively low energy value and a relatively large footprint. At the same time, it has high quantities of CO2 after combustion. Only oil and coal have higher quantities (Sijmons, 2014). Then there is the social impact, with twenty-six villages and over 25.000 inhabitants relocated, the impact on residents is immense (Appunn, 2023). These relocations, in combination with the demolition of the natural environment, have led to many protests, with the protests in Hambach Forest even being seen as the symbol of climate action (Jäger & Rueter, 2020). The solution seems clear, stop lignite mining. However, this also brings many consequences. Such as the loss of 14.338 jobs (Appunn, 2023). Next, a fifth of the energy production in Germany will be lost (Seidenstücker et al., 2023). It also leaves behind three large pits, multiple empty power plants and a surplus of infrastructure. The main idea for the current pits is to create lakes, as is the case in the Central Mining District. However, there is a risk of acidification of these lakes if not done properly (Schultze et al., 2010). Next to that, the creation of lakes will take up to 40 years (Wagner & Hüsener, 2014). Consequently, it will take a long time before the lake can be used for energy production, as proposed by RWE. Therefore, a more coherent, spatially valuable and ecologically inclusive plan needs to be made to develop the lignite minescape of Rhineland.





1.6: Plans for the future of the Rhinish Lignite Mining area (adapted from (Steffen & RWE Power, 2020)

1.1.5 The research

To do so, this thesis focuses on the question:

How to regenerate through design the post-minescape of Rhenish Mining Area towards an inclusive energy transition?

This thesis takes place in the German context. This is of interest as Germany already has an energy transition and fossil fuel phase-out strategy. The country's goal is to be energy-neutral by 2045 (Wiese et al., 2022). Nevertheless, lignite mining in the Rhenish Mining Area should already halt in 2030 (RWE, 2022). With only eight years to go to closure, there is no clear plan for the regeneration of this area, neither from an ecological or socio-economic perspective. On top of this, there is no strategy to compensate for the loss of energy generated through the mines. Altogether, this makes for an interesting site, where the question is not "if" we need a transition, but the focus is on "how".

1.7: The stustainable development goals in order of influence



1.2 Research Framework

How to regenerate through **design** the **minescape** of the Rhenish Mining Area towards an **inclusive energy transition**?

This thesis focuses on the regeneration of the minescape into an inclusive energy transition. To answer this question, three questions need to be answered first. What is an inclusive energy transition? How can minescapes be regenerated? and: How to create an inclusive energy transition from a societal environmental perspective?

As the minescape and energy transition cannot be viewed separately, this thesis is split into three main chapters, focussing separately on three aspects visible in both the minescape and energy transition: Systems, landscapes and transitions. The three questions will be answered through these chapters.

	Problematisation & Framing	Theorethical Framework	Systems	Landscapes	Transitions	Conclusion & Reflection
What is an inclusive energy transition?	Cause and problems of the energy transition Policy framework Global and European frame of the energy transition	Energy systems Energy landscapes Systemic thinking	What is the energy system (in Germany)? In what system will the energy transition take place?	What are the qualities of the landscape for an energy transition? What do energyscapes look like and how are they experienced?	What is the energy and spatial demand? How can the energy transition be shaped inclusively? What types of energy production can be implemented?	
How can minescapes be regenerated?	Problems of the minescape Reasons for the transition	Minescapes Regeneration Operational landscapes	What are the systems of the minescape? What are the possibilities and problems the systems have for the transition?	What defines the minescape of Rhineland mining district? How is the minescape experienced?	What are examples of the regeneration of minescapes?	
How to create an inclusive energy transition from a societal and environmental perspective?		Transition theory Inclusion	What are the socio-economic systems of the Rhineland mining district? What are the green and blue systems of the Rhinland mining district?	What are the socio-economic aspects of the landscape? What is the historical transtion of the landscape?	How can the minescape be transformed into an inclusive energyscape? How will the green, blue, energy and social systems be transformed through these interventions?	

18. Research framework

1.3 Goals

This thesis aims to develop a design proposal for the Rhenish Minescape focussing on an inclusive energyscape. To see how this goal relates to the larger societal frame of sustainable development, I determined which Sustainable Development Goals I want to focus on during the project (United Nations, n.d.).

Central to the project is goal 7: Affordable and clean energy. I will approach this goal by creating a new form of energy production in the minescape that will help reduce the dependency on fossil fuels and help maintain energy security in North-Rhine Westphalia. This will form the foundation of a clean and affordable energy system. The proposal of this new inclusive energyscape will be placed in the frame of temporal transformation and, as such, help develop the possibilities for the energy transition.

Therefore, this thesis focuses on four goals to achieve an affordable, clean, and inclusive energyscape.

6. Clean Water and Sanitation
Mining has severely damaged the blue system. Therefore, we need to tackle and improve the groundwater system and the water-based ecosystems above ground.

15. Life on land.
The extraction of lignite has damaged the environment on an ecological level. The extent of this damage is difficult to estimate due to the wide area the extraction influences. As such, the transformation of the minescape will also alter a significant part of our environment. Considering different scenarios and the complexity of the green and blue systems, the project strives to improve the ecological stability of the minescape.

3: Good health and well-being.
The existing minescape creates issues concerning noise, and pollution. As such, the current residential environment is of low quality. Improving the living quality will be one of the pillars.

9: Industry, innovation and infrastructure.
This takes into account the necessary innovation for the energy transition and the knowledge present in the minescape while at the same time transforming the existing infrastructure for the new energyscape.

11. Sustainable cities and communities.
The Rhenish Minescape is located in the in-between. Its long history and development have prevented urban development in this area, creating a splintered rural environment. While the goal of this thesis is not to urbanize the minescape, it will consider its further development from an urban perspective.

8. Decent work and economic growth.
The closure of the mines impacts the economic system. To prevent depopulation of the area, poverty and high unemployment rates, new economic incentives will need to be implemented.



1.9: The stustainable development goals in order of influence (adapted from QuickMapServices (n.d.) and United Nations (n.d.)

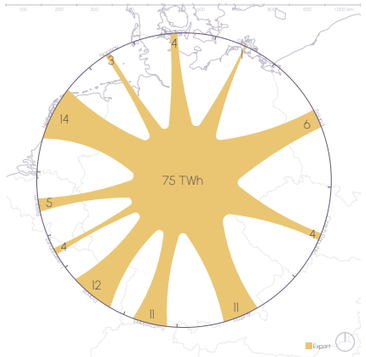
1.4 Energy in Europe

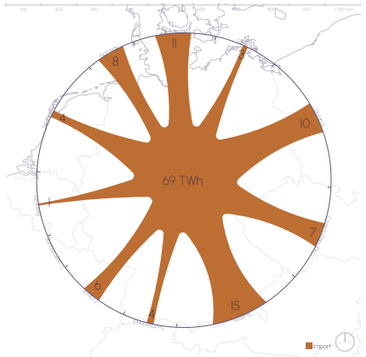
Lignite is used almost solely domestically. Therefore, it is not relevant to review its import and export. Instead, the focus should be on domestic production (Eurostat, 2023). However, when reviewing the energy import and export, it is impossible to state which parts of the energy mix are exported. As such it is impossible to determine which parts of the through lignite generated electricity are exported and used locally.

However, when comparing the import and export of energy in Germany, we can see more is exported than imported, indicating Germany produces more energy than necessary for its use (Agora Energiewende, 2018). Next to that, it is visible that import is done from countries with a more renewable energy mix, while export is done towards countries with a more fossil fuel-based energy mix (Agora Energiewende, 2018)

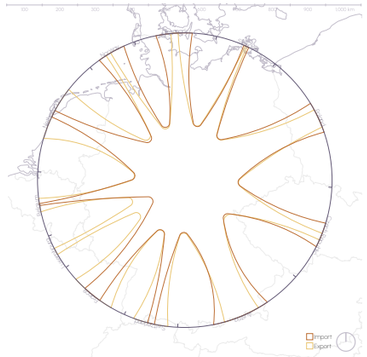
The right map focuses on lignite production in Europe in the past, present, and future, indicating both the future potential of coal reserves in Europe as well as the existing coal mines, power plants, and terminals. The historical development of lignite production showcases Germany's dominant role. While the future potential might be lower, significantly more energy is still being mined.

Reviewing the production development in Germany from 2015 onward shows a slow decline. However, from 2020 onward, the production increased again. This can be explained through the war in Ukraine. To protect itself against these global instabilities, Germany returned to cheap lignite production to protect energy security. This is in contrast with the goal to cease lignite production by 2038.





1.10: Export & export of energy in Germany based on Agora Energiewende, (2018)

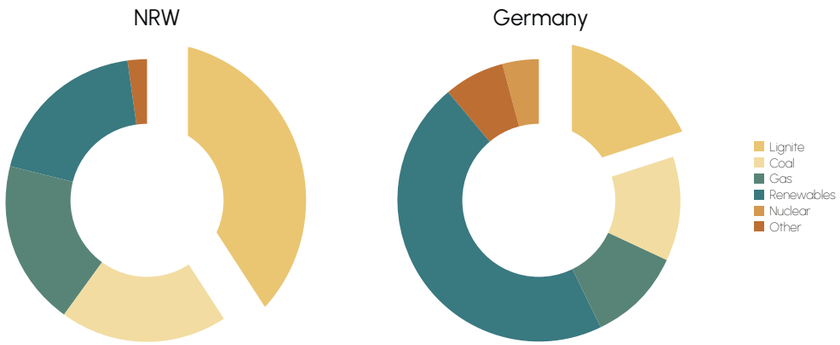


1.11: Lignite in Europe based Global Energy Monitor, (2023a,c,d), Oakleaf et al., (2020) and Eurostat (2023)



1.5 Energy in Germany

Energy in Germany still consists of around 20% lignite (Seidenstücker et al., 2023). However, the share of lignite in the energy mix also differentiates between the different Bündestaten (also referred to as states). The focus of this thesis is on the Rhenish Mining Area, which is located in the state of North-Rhine Westphalia (NRW). Here, we can see that lignite forms a far larger part of the energy mix: 41% (Seidenstücker et al., 2023).

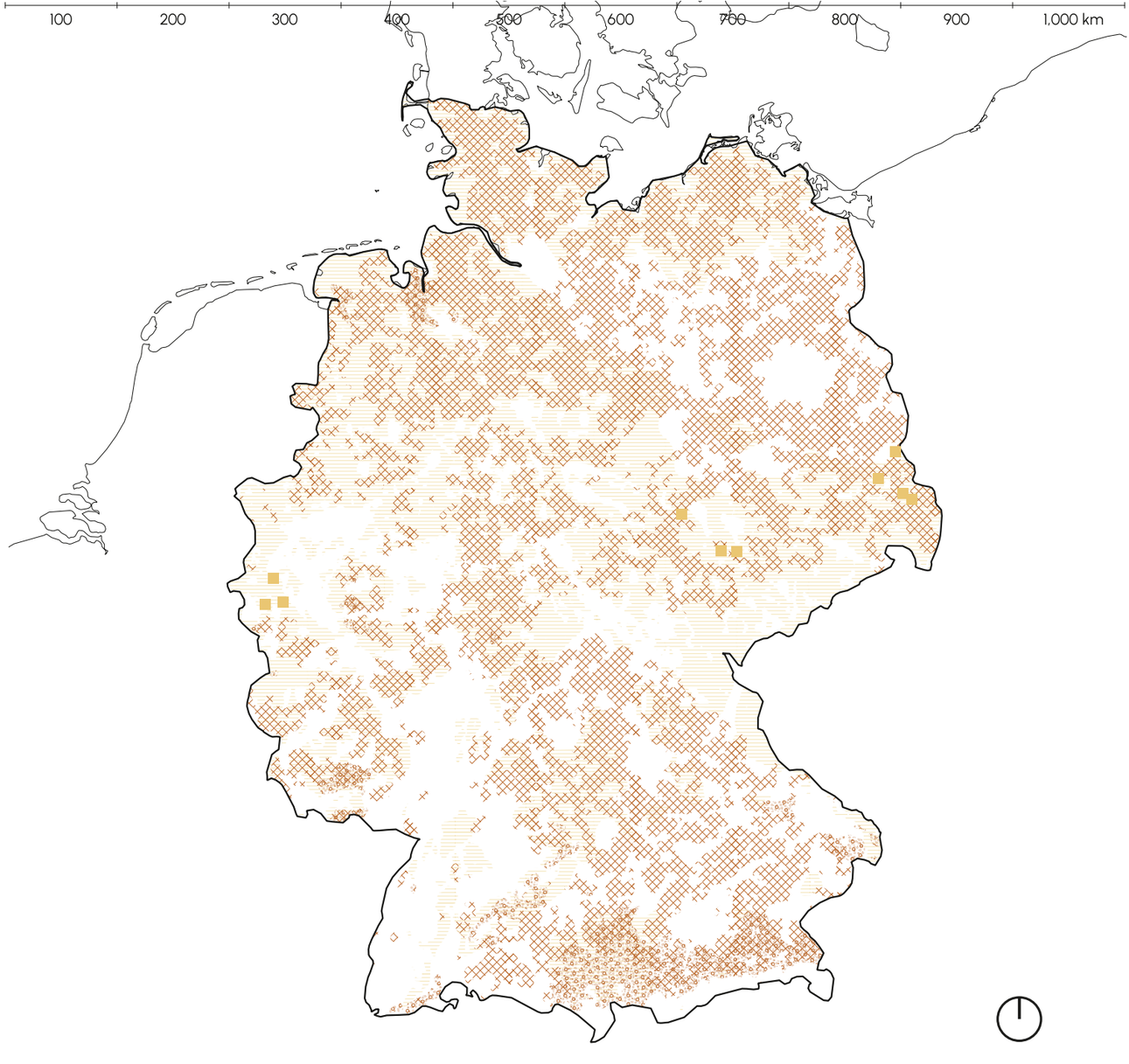


1.12: Energy production NRW & Germany based on Seidenstücker et al., (2023)



1.13. Coal mines in Germany (based on Global Energy Monitor, 2023d)

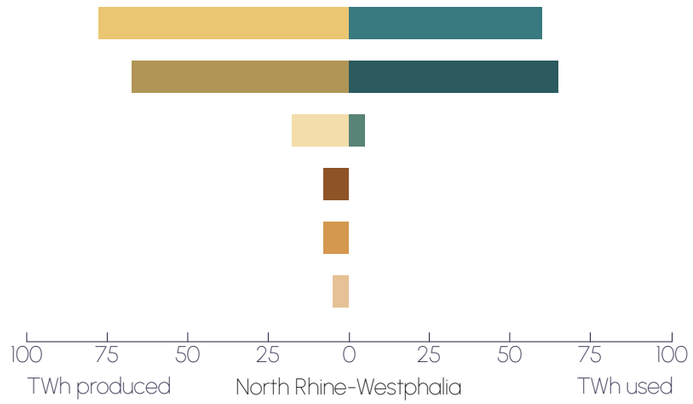
Germany, however, is not solely dependent on fossil fuels. The country has already made steps towards a renewable energy transition, with 46% of the nation's energy coming from renewable sources. On the right page, we can see a map of Germany's energy potential. Quite visible here is the role of wind and biomass. PV or solar energy has much less potential in the nation. At the same time, there are also spaces without the potential for renewables. Indicating that energy should be produced elsewhere.



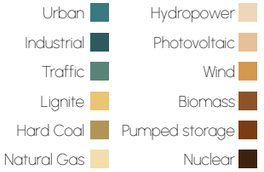
1.14: Germanies energy Potential, based on Oakleaf et al., (2020)

These images show the density of North-Rhine Westphalia. They emphasize this area's dependency on the lignite produced locally. Currently, 77 TWh is produced, while 65 TWh is already used by the urban environment (Agora Energiewende, 2018). Simply shutting down the power plants will lead to an incredible energy shortage.

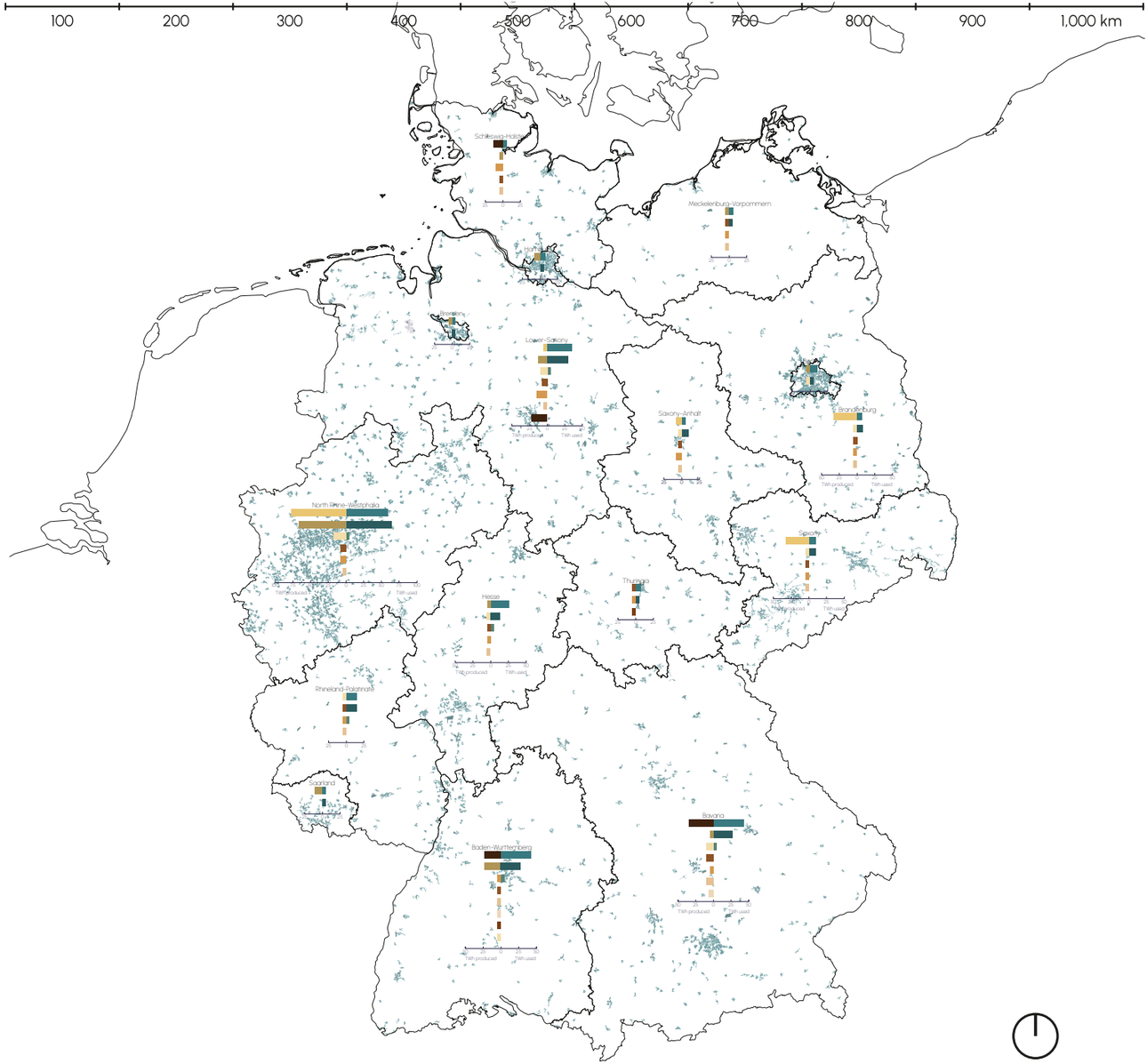
Next to lignite, hard coal is the other main energy resource in North Rhine Westphalia. originally produced in the Rhurgebiet. While not the subject of this thesis, this resource will also be phased out (Agora Energiewende, 2018). Thus, more energy will need to be produced to compensate for this energy loss as well. Therefore, it is necessary to implement renewable energy sources where possible. With their larger footprint, they will need more space than currently dedicated to energy (Sijmons, 2014) (Ritchie, 2022). Therefore, it is important to research if existing fossil fuel energy landscapes can be reused.



1.15: Energy usage and production North-Rhine Westphalia based on (Agora Energiewende, (2018)



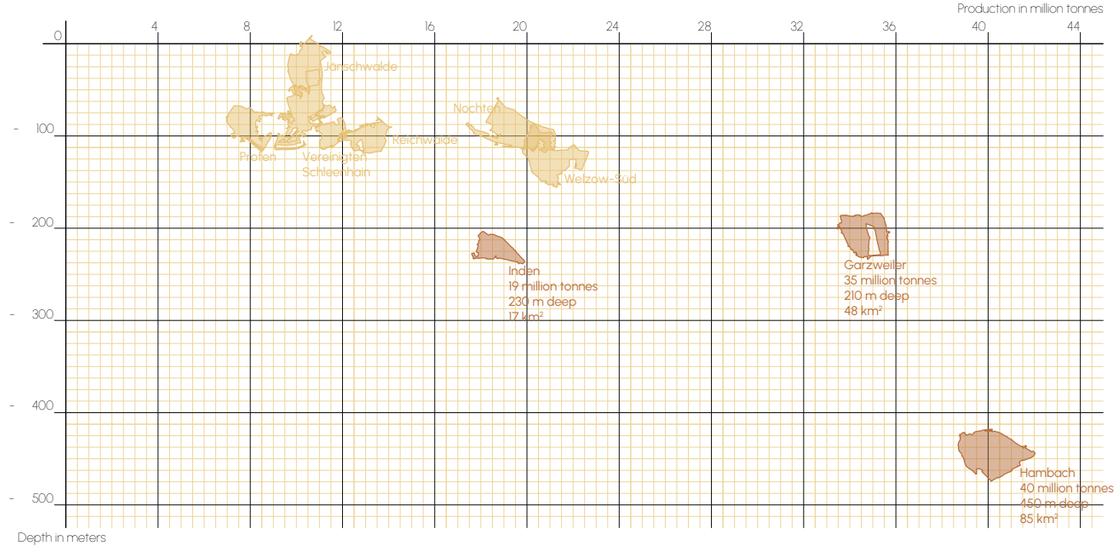
1.16: Energy usage and production Germany Based on Copernicus Land Monitoring Service, (2018) and Agora Energiewende, (2018)



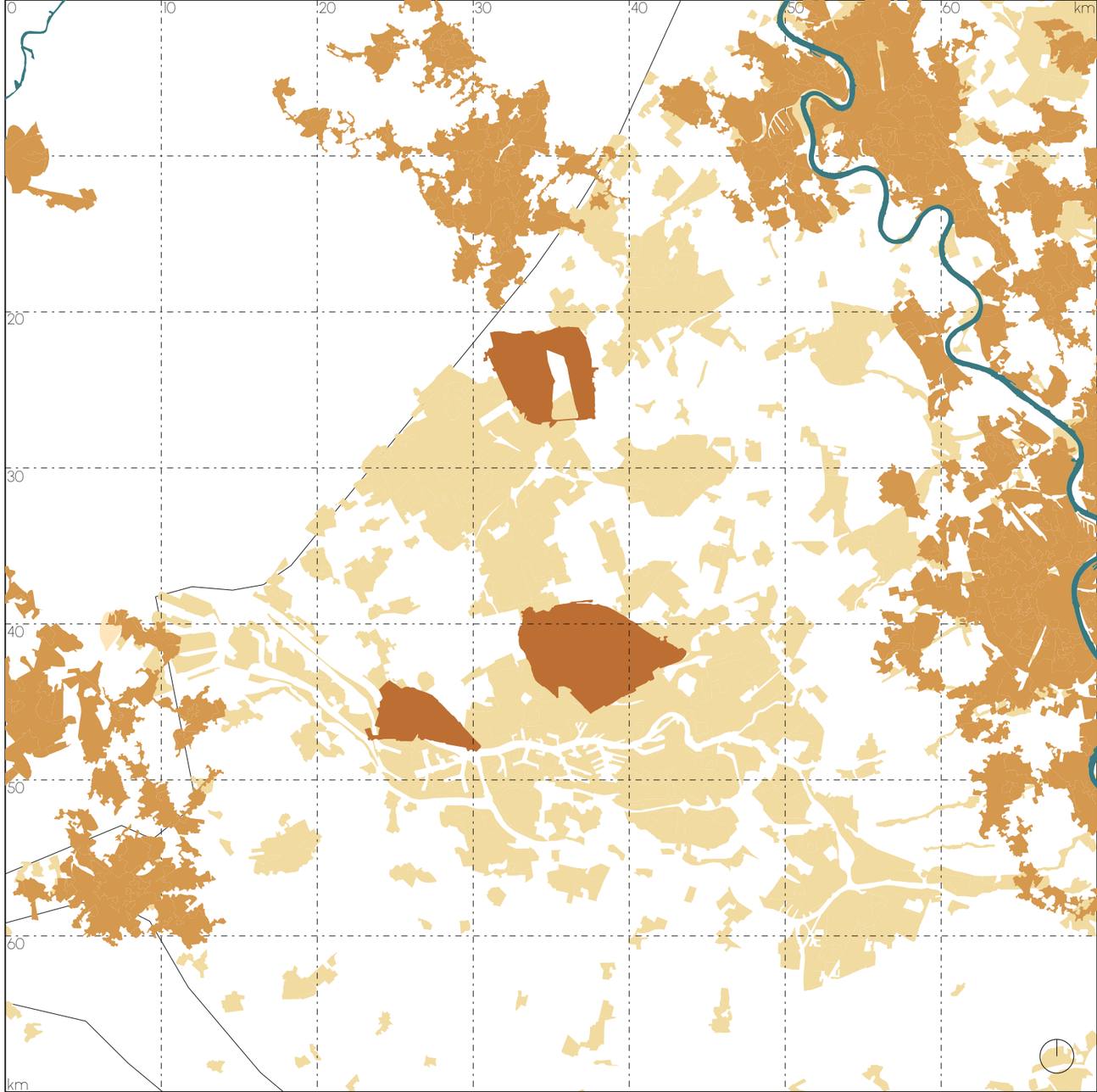
1.6 Scale of the minescape

As shown before, there are three lignite mining regions in Germany: Lusatia, situated in the West of Germany in the states Brandenburg and Saxony; Central German Mining District, situated in the states Saxony and Saxony-Anhalt; and Rhineland or the Rhenish Mining Area, situated in the East of Germany in North-Rhine Westphalia near the Dutch border (Appunn, 2023). While for a long time, the West side of Germany was dominant in lignite production, in 1990, the production here significantly reduced, leaving Rhineland as the dominant structure (Hermann & Matthes, 2017). Image 1.17 shows the comparison between the different mines of the regions. Here we can see that the Rhineland is significant due to its high production rate. The mines also cover more surface area and reach deeper, thus influencing the surrounding systems more.

To gain a perspective on the scale of the Rhineland Minescape, the right map projects the mines on top of the province of South-Holland. Of interest here is not just the scale of the mines, but also the distance to the nearest large cities.



1.17: Overview Lignite mines Germany, based on Appunn (2023) and Copernicus Land Monitoring Service (2018)



1.18: Space comparison Randstad & Rhenish minescape, based on Copernicus Land Monitoring Service (2018)

1.7 Rhenish Mining Area

When RWE speaks of the Rhenish Lignite Mining District, this is the area they refer to. This space is smaller than what I define as the minescape. However, it is an optimal scale to research the main elements of the lignite extraction.

The district includes three active mines: Inden II, Garzweiler II, and Hambach. All three mines have an active area and the space that they are still allowed to extract. Next to these three mines, many older and often smaller mines are visible. These mines have now been regenerated into natural areas or agricultural lands.

These old mines are all situated on the edge of the lignite field. As this is where the first mines were opened, most refineries and power plants are also situated here. This would make the transport distance as short as possible. Both Garzweiler and Hambach are connected to these factories by railways.

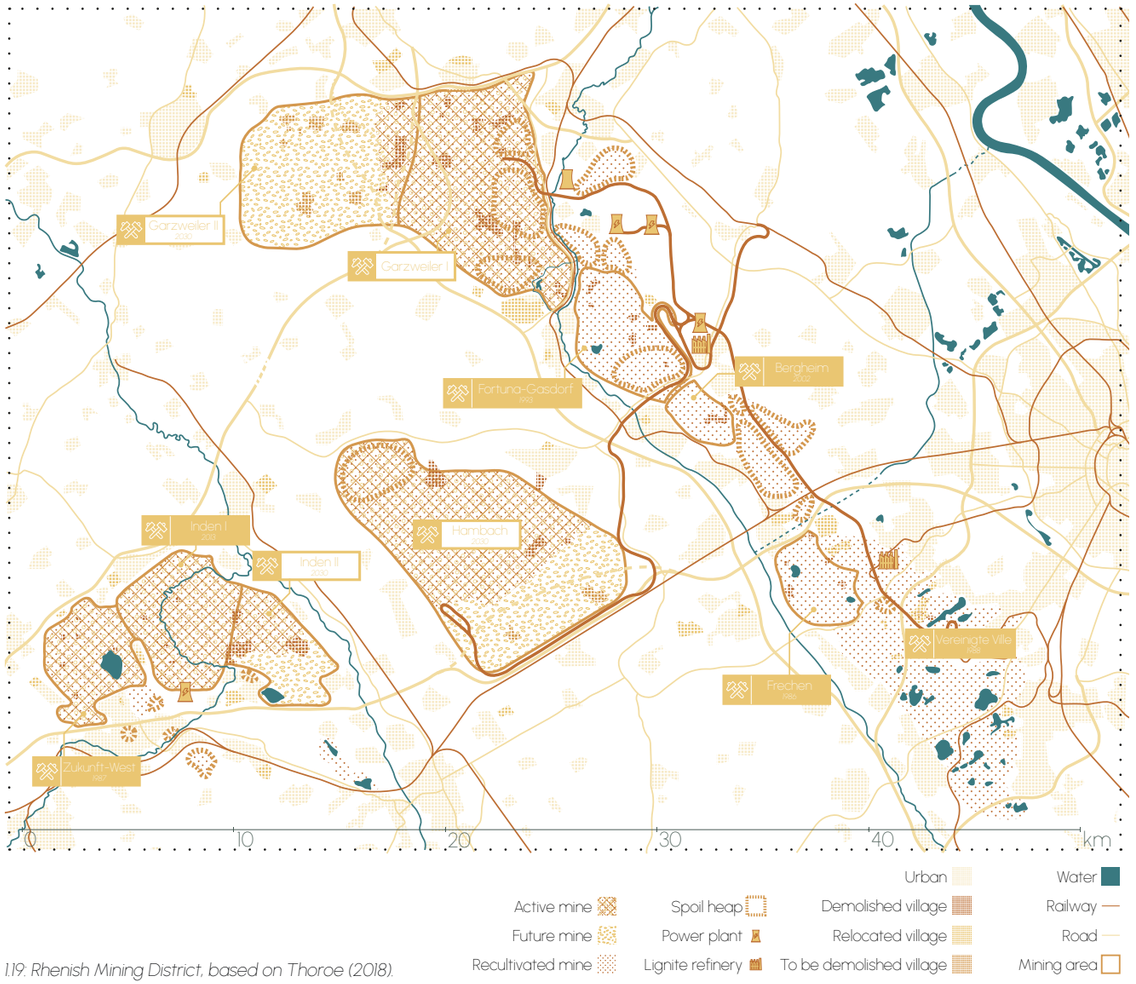
Due to the dense infrastructure here, the railways, power plants and old mines, which used to be open pits as well, there seems to be a spatial barrier between Köln and the rest of the Rhenish Mining District.

Inden is a special case. This mine is an expansion of the old Zukunft. As such, it has its own power plant and is not connected to the other mines through infrastructure.

The map highlights two other interesting elements.

First, the deposit of soil. Before the lignite can be accessed, the miners need to dig through layers of soil and debris. This waste was used to fill the old mines and is now used to close some of the existing mines.

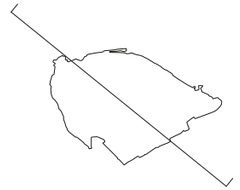
Secondly, we can see the villages that have been removed and where they have been relocated. These villages have been added as new neighbourhoods to larger towns in the area. Next, we can see that there are still villages that are planned to be relocated. Lützerath is one of these settlements (RWE, 2023). This has led to squatters in the settlement and consistent protests and demonstrations. This displays the conflicts still present in this area, even with the promise of a sped-up phase-out.

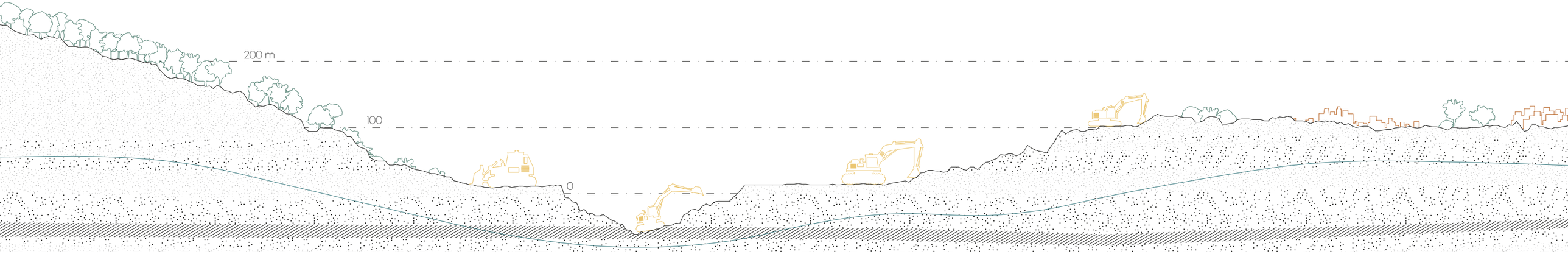


1.19: Rhenish Mining District, based on Thoroe (2018).

The Rhenish Minescape is built on a lignite vein. Throughout the area, the depth of this vein differs. The deepest mining is done in Hambach. To reach the soil, a large open pit is made. This section shows the scale of such an open pit and the area's different soil layers.

On the left side, we can see the overburden used by the Hambach mine. Currently, this hill is no longer in use but is instead used as a recreational area. On the right, we can see what is left of Manheim. As the mine is expanding to the right side, most of this area has been demolished.





1.20: Section Hambach mine



2. Methods & Theory

This chapter describes the methodology of this thesis as well as the theoretical and conceptual framework in which this thesis takes place. It describes the core concepts of the energy landscape and minescape and the interpretation this landscape has towards these concepts.

2.1. Protest sites in Hambach Forest

2.1 Methodology

How to regenerate through **design** the **minescape** of the Rhenish Mining Area towards an **inclusive energy transition**?

This diagram shows an overview of the methodology used in this thesis. It shows that a literature review, in combination with policy and a news review, is the foundation of the thesis. This creates a foundation of knowledge on the energy transition in the German context and the functioning of the minescape.

This is followed by more spatial research methods, such as systemic analysis (2.1.1), databased, historical and analytical mapping, and art analysis. During a week of fieldwork, the soft layer of the systems and landscapes is identified (2.1.2).

In the chapter Transitions (chapter 5), I will focus on design interventions.

To define possible interventions, I use case study referencing. Once I have determined the possible futures of the minescape, I will further research these through scenario design (2.1.3). This method allows me to use design as a research method to discover and elaborate on the possible futures of the minescape.

	Problematisation & Framing	Theorethical Framework	Systems	Landscapes	Transitions	Conclusion & Reflection
What is an inclusive energy transition?	▸ Literature ▸ Policy review ▸ Mapping	▸ Literature	▸ Systemic analysis ▸ Literature ▸ Analytical mapping ▸ Data based analysis	▸ Fieldwork ▸ Literature ▸ Analytical mapping	▸ Systemic design ▸ Data based analysis	
How can minescapes be regenerated?	▸ Literature ▸ Mapping	▸ Literature	▸ Systemic analysis ▸ Literature ▸ Analytical mapping	▸ Literature ▸ Analytical mapping ▸ Historical mapping ▸ Art analysis ▸ Fieldwork	▸ Case study referencing	
How to create an inclusive energy transition from a societal and environmental perspective?		▸ Literature	▸ Systemic analysis ▸ News analysis	▸ Interviews ▸ Fielwork ▸ Analytical mapping	▸ Scenario design ▸ Temporal phasing	

2.2 Methodological framework

2.1.1 Systemic analysis and design

The systemic analysis will untangle the interactions between the systems of the minescapes and define possible leverage points for the design strategy (Sanders, 2008) (Wandl, 2023). In the systemic analysis, I focus on unravelling the complexity of the minescape system to determine the main problems in the current system and possible leverage points for the design challenge. In the design phase, I mainly use the systemic thinking method's feedback loop to evaluate the design interventions' consequences.

2.1.2 Fieldwork

Fieldwork is a broad term that includes different methods, all combined under the act of going to the location and collecting information, knowledge, and data. My fieldwork consisted of photography, sound scaping, sketching, and micro stories. These methods all had a different role in this thesis. Photography and sound scaping were used to gain a new perspective on the landscape and create various experiences of the landscape and the impact of the extraction process.

The sketches consisted of quick drawings to understand specific elements of the area. They could be maps, diagrams sections and more.

The micro stories were critical for gaining the cultural dimension of the minescape. Through conversing with residents, I gained insight in the relation residents have with the minescape, beyond the globalisation of protests and the problems I expected residents to have based on literature. This was critical to understand the values and wishes for transition as well as gain an understanding on the cultural relations.

2.1.3 Scenario construction

Scenario design is a form of generating knowledge (Viganò, 2018). The scenarios are possible future trajectories, which, through strategic planning and vision-making, can be an inclusive and systematic design (Chakraborty & McMillan, 2015). I will define four possible futures based on regenerative examples and local problems throughout this thesis. The design will consider not only spatial transformation but also system transformation. It does so through systemic design thinking (Ospina, 2019). The choice of scenario design and the equal elaboration of four scenarios contrary to one design strategy for the area relates to the goal of this thesis. This thesis aims to uncover possible future trajectories for the minescape. It asks the question: How can we regenerate? As a consequence, it is a highly explorative thesis. Scenario construction allows for a utopian dimension and the explorations of possible futures (Secchi & Viganò, 2009). This allows for more out-of-the-box thinking when it comes to inclusive energy escapes. A type of energy transition we have yet to create. The scenarios generate change by representing a possible future event (Secchi & Viganò, 2009). In other words, it helps to open the discussion to another form of energy transition.



2.2 Conceptural framework

In this thesis, I focus on the interaction between the minescape and the inclusive energy transition.

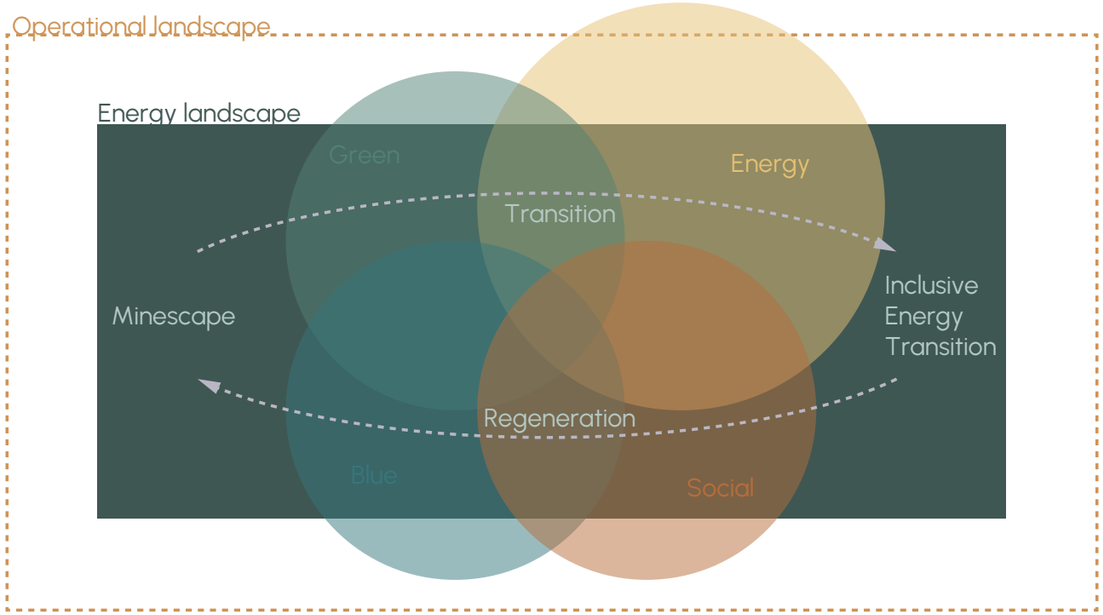
I define a minescape as, "a representational tool that underscores the intricate ways in which extractive processes are imbued with complex socio-cultural dynamics, and powerful material and discursive elements." (Ey & Sherval, 2015, p.176). I deliberately chose to refer to the "minescape" and not the "miningscape" (Méndez et al., 2021). This decision is based on the project's focus on the landscape after the act of mining. The focus is not on an operational socio-economic system and act, but instead on the landscape and the related socio-cultural dimensions, thus making the term "minescape" more suitable (see 2.3.4).

The other central concept in my project is the "inclusive energy transition". This is the transition from the existing fossil fuel-based energy system towards a renewable energy-based system. The term inclusivity focuses on the symbiotic relationship this transition should have with the societal and environmental elements.

The minescape and inclusive energy transition cannot be seen separately. The current energy system in place that this thesis focuses on transitioning is the lignite system, thus the lignite mining and thus the minescape. The energy transition not only changes the mining landscape and system, but also the complete socio-economic and cultural dimension of the minescape. This is the place where transition theory comes into play (2.3.7). This is also one of the reasons this thesis focuses on an inclusive energy transition. Here we refer to inclusion from a socio-economic perspective. However, there is also the tangible aspects of landscape, the environmental aspects. In this thesis, I identify these through the green and blue systems and networks.

Analysis of the Rhenish minescape, in combination with literary research on mining systems, showed the impact of lignite extraction on the energy, social, green, and blue systems. These systems include the flows related to them as well as their spatial characteristics. All four of these systems interact with each other, and although we can divide elements between the systems, it is impossible to untangle them completely. The exact definition of each of these systems can be found in chapter 3.

Through the systems there is a consistent exchange between the minescape and the inclusive energy transition. This change impacts the changing socio-technical systems and through these the spatial and non-physical context (Markard et al., 2012). The transition describes the impulses that change the minescape towards an inclusive energy transition. At the same time, the energy transition creates an impulse to the minescape helping to regenerate the minescape in its own right. Regeneration is the act of growth or regrowth, improving and making more successful (Cambridge Dictionary, 2024). The project strives through the implementation of an inclusive energy transition, to grow the minescape into a new form of itself, with value to the four main systems related to the minescape. Here the four systems are the energy,



2.3: Conceptual framework

social, blue and green system (2.3.6)

All of this takes place inside the energy landscape. The physical elements of the minescape are already a part of this energy landscape. At the same time the future elements of the inclusive energy transition will be part of this landscape as well (Sijmons, 2014) (Stremke & de Jong 2022). The energy landscape is a physical element that gives place to systems, but differentiates from an energyscape or minescape as it does not entail the socio-cultural dimension (Ey & Sherval, 2015). The four systems will be analysed on their role inside the landscape. They will be adapted and changed, and both these changes, as well as the way they impact the energy landscape, will be designed. At the same time, these systems expand beyond the borders of the energy landscape, as they also belong to urban landscapes, ecosystems and natural environments.

The largest frame of the conceptual framework is that of the operational landscape (Brenner & Katsikis, 2020). The operational landscape defines the relation between this landscape and the way it works for the city. As the Rhenish Mining District is situated in the Hinterlands and shaped to generate energy for the city, we cannot deny this relation, between landscape and service to humanity. At the same time, this relationship might change due to the design of the inclusive energy transition. This creates a different balance between species and systems and might define the role of this specific hinterland differently (Hernández-Santín et al., 2022).

This is all brought together into the conceptual framework, where we can see the interaction between the minescape and inclusive energy transition and the leading role the four systems take into this thesis. Therefore, these four systems also form a starting point of the analysis, as explained in the methodology (2.1)



2.4 Windfields near Garzweiler

2.3 Theoretical Framework

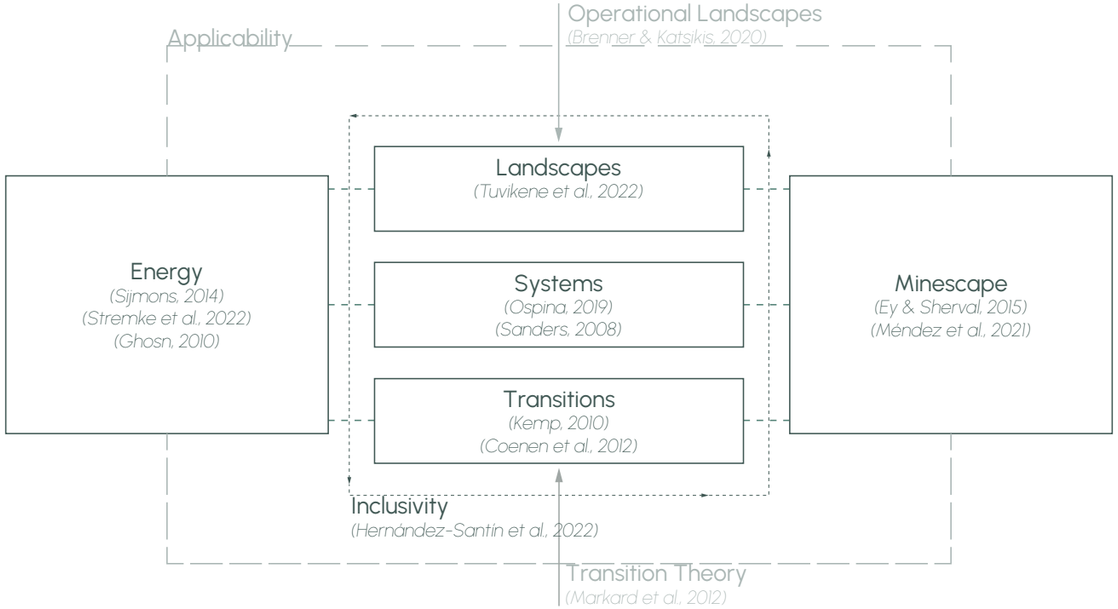
2.3.1 The framework

To define energy, I look at it through three different lenses: Energy landscape, Energy system and Energy transition. Parallel to this, I consider the concept "minescape". In the Rhineland, this is a large part of the energy system. The minescape itself also consists of a mining landscape, a mining system and a mining transition. With the overlap between energy and lignite mines in Rhineland, there is an inseparable interaction between the concepts of energy and minescape through the three lenses of landscape, system and transition. Of these three lenses, system design is placed centrally as it is the methodological driver of the project; through system design, the landscape changes, and the transition is established.

Inclusivity is a question placed central in the project. How can we establish an inclusive energy transition? In the project I identify inclusivity as from a societal and environmental perspective, thus in the broadest sense of the concept, considering from human to organism. This means that through the three lenses, the project focuses on an inclusive landscape, system, and transition. Although the project focuses most on inclusivity from a transition perspective, a consequence from this is an inclusive landscape. Here questions arise as ownership, accessibility and priority of use. A conflict can be seen between the operational landscape – a landscape designed to service the urban – and an inclusive landscape – a landscape where all organisms have their place. This will be an interesting challenge in the design. An inclusive system could be a design method to work towards this inclusive landscape. The transition changes the system, which in its turn has tangible and intangible effects, which both can be seen in the landscape. At the same time, the goal of an inclusive landscape shapes the trajectory of the transition. Therefore, focusing on an inclusive transition creates this interaction between the three lenses.

At the same time, these systems are visible on different scales. Thus, the operational landscape relates the landscape of both energy and mining to its applicability in the larger context. Next to this, the operational landscape centralizes the thesis on a landscape that service the urban environment, meaning that the future function of this area, should relate itself to the urbanized landscape.

This thesis aims to explore the possibilities of these type of minescapes for future renewable energy production. The Rhineland minescape is one of many minescapes in transition (page 13). As such, I use transition theory to learn from the transitions in these other areas, but also to project my thesis in the larger context, displaying future scenarios for mine regions in transition.



2.5: Theorethical Framework



2.3.2 Inclusive energy transition

When we speak of an inclusive energy transition, we mostly focus on the human stakeholder involved: those who lose their job, those whose environment changed, and those who gain economic or loss from the interventions executed. However, this would be an integrated energy transition. In an integrated energy transition, it is emphasized that we can only gain a sustainable energy transition from integrating the transition into the physical and socio-economic landscape (De Boer & Zuidema, 2015). However, I would state that this is still a human-centralized approach to transition. Instead, I want to strive for an inclusive energy transition, where the design creates a thriving ecology for all species involved, humans, plants, micro-organisms and more (Hernández-Santín et al., 2022).

The core reason I focus on an energy transition and not a new energy system or a new energy landscape, is that a transition has a temporal dimension. There is no fixed end to a transition, simply a continuous shaping that is dependent on changing values and political impulses. This is the same for the energy transition. Over the years, we have constantly transitioned between different energy systems and resources (Von Hirschhausen, 2018). As such, we cannot expect to reach a final energy system or landscape (Sherren, 2022). Instead, we should design for an energy transition that can adapt itself to the changing circumstances. As such the landscape is consistently in transition and there is no such thing as a final landscape, nor an end to the transition (Sherren, 2022). This makes it far more interesting and critical to focus on an inclusive transition than an inclusive landscape. The landscape will change, the core principles in the transition will not.

2.6: Anti wind-turbine protesters outside the Anglesey Council HQ (Roberts, 2015)

2.3.3 Energy landscape

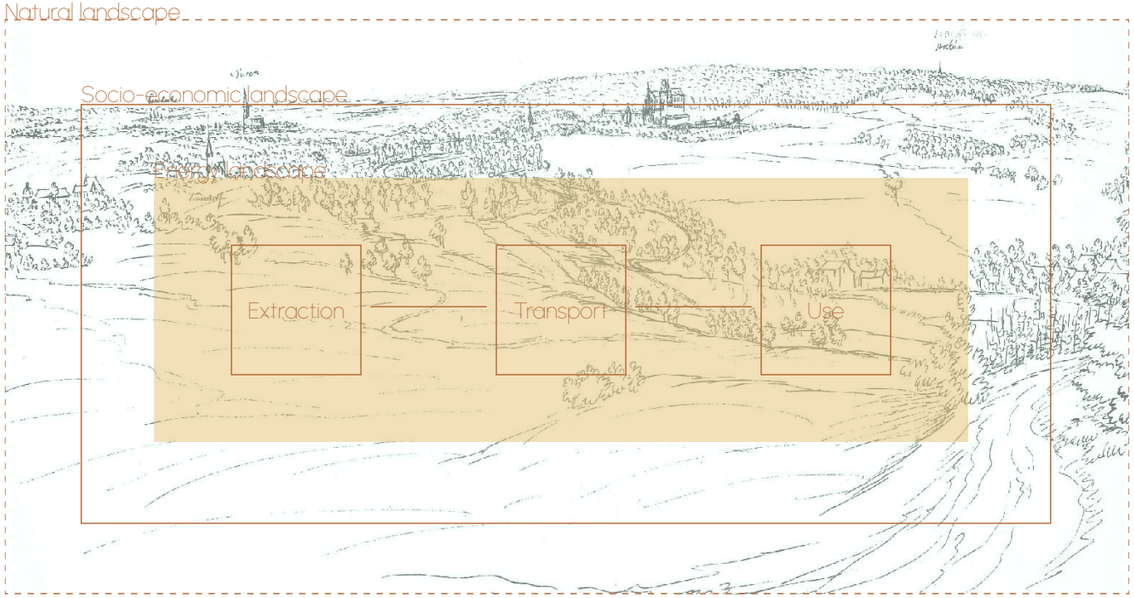
The term energy landscape is not new. However, due to the energy transition, interest in the concept has been renewed. Consequently, when the term energy landscape is used, our mind immediately goes to renewable energy. Instead, energy landscapes are defined as:

> ***"Observable landscapes that originate directly from the human development of energy resources."***
>
> *- Pasqualetti & Stremke (p.98, 2018)*

To clarify the difference between the existing carbon-based extraction landscapes and the desire future energy landscapes, I use the term fossil fuel landscapes for the first, and renewable energy landscapes for the latter.

Energy landscapes consist of three main landscape-defining characteristics. The extraction, the transport and the use (de Jong & Stremke, 2020). The way these are designed is dependent on their sector (heat, power or fuel) (Sijmons, 2014) (Agora Energiewende, 2018) and the source (de Jong & Stremke, 2020). These parts seem clear for the lignite process: extraction takes place in the mines, the lignite is transported, and from them, electricity is extracted, the electricity is transported through power lines to be used in urban or industrial areas. When discussing the extraction landscape of renewable sources such as solar and wind energy in this thesis, we solely focus on the extraction of energy, such as the site of the solar panels or wind energy. For the overview of this report , we do not take the extraction of rare metals for renewable energy equipment into account, nor do we focus on producing this equipment as this extends beyond the scope and time limit of this thesis.

The energy landscape also takes place in a larger natural landscape and socio-economic system, which also helps shape it. At the same time, these landscapes are also shaped by the energy system, into the new energy landscape.



2.7: Elements of the energy landscape (image by author, drawing by Roidkin (ca. 1730))



2.3.4 Minescape

We often focus on the mines or the mining district in policy documents. These terms concern the spatial elements, only the mines or the complete area containing parts of the lignite mining system. However, due to its focus on spatiality, the connection to other systems, as well as the impact on larger and smaller scales, is forgotten. Mining areas have an impact far beyond their spatial intrusions (Ey & Sherval, 2015). Therefore, we should review the systemic change of these landscapes from their tangible and intangible perspectives.

To be able to do so, this thesis focuses on the "minescape". This wider term encompasses spatial impact, systems, socio-economic and cultural impacts (Ey & Sherval, 2015). The term minescape, more than the term territory or district, merges the tangible and intangible. It emphasizes that the extraction has shaped the landscape just as the landscape has shaped the extraction. It notes the interaction between space and the act of extraction and the cultural, social and economic interaction. The way we value, and harvest resources influences the minescape just as the minescape influences or valuation of the landscape and resources (Ey & Sherval, 2015). At its core, the minescape is a representational tool. It emphasizes how extraction processes are infused with complex socio-cultural dynamics as well as material and discursive elements (Ey & Sherval, 2015). The term minescape consists of "mine" and "scape". The suffix "scape" is what creates the interaction with the intangible. It is the tool to explore terrain, and its ecological, political and cultural dimensions (Ey & Sherval, 2015).

Closely related to the term "minescape" is that of the "miningscape", which focuses on the socio-naturally produced territories that are created through the interaction of reclaimable resources, natural elements, power and economic resources (Méndez et al., 2021). These interactions ensure the mined resources being transformed into commodities, which are transported and used around the globe (Méndez et al., 2021)

Following these definitions there is slight difference between the exact definition of the minescape and miningscape and they can be used interchangeably. However, I chose to use the term minescape as it is more about the physical mine and its interaction with socio-cultural dynamics, while miningscape is about the act of mining which in the case of the Rhenish Mining Area, is being phased out. As such, it is important to design not only for the interaction between the act of extraction and the socio-cultural dimensions but also the physical scarring of the minescape and its impact.

2.8: Hambach Mine, taken from Terra Nova viewpoint

2.3.5 Landscape

When we consider landscapes our mind first drifts off to the green fields and forest. However, these traditional forms of landscapes are becoming less. Instead, these landscapes need to make space for landscapes with a purpose. Forests to recreate in; Fields need a high agricultural yield; and some spaces are transformed into energy landscapes. All of these are forms of operational landscapes, landscapes that are part of the extended urbanization. These operational landscapes are on the intersection between rural and urbanization (Tuvikene et al., 2022).

Minescapes or energyscapes are a clear form of operational landscapes. They are shaped as part of the city network. Without them urbanization could not have taken place. As such, they are a clear example of planetary urbanization. This approach to our current form of urbanization focuses on the footprint of our urbanization, which is significantly larger than the urban borders. However, as Brenner and Katsikis (2020) note, "The operational landscapes of planetary urbanization are hardly a stable foundation for territorial development, social preproduction or ecological security."

Brenner and Katsikis (2020) refer to the operational landscapes as the "hinterlands" parts beyond or in-between the cities, which are shaped to support urbanization. Placing the minescape in this form of landscape creates a clear connection between the city and the landscape. It enlarges the socio-cultural dimension of the minescape, but also questions the newly created ecosystems. These novel ecosystems are based on the interactions of humanity with the natural and cultural systems (Ellis, 2014).

However, these approaches place the capital central, for which the planetary urbanization approach is criticised (Tuvikene et al., 2022). Bringing together the landscape approach and the idea of the operational landscape could bring us towards an inclusive landscape that balances the cultural and natural elements as well as the process of urbanization. The landscape approach focuses on inter scalar development and cultural and natural materiality (Tuvikene et al., 2022). This forms the thesis in the elements of inclusivity. On top of that, like the minescape, the landscape is a form of representation, bringing together the different layers of the landscape.

Usage of the operational landscapes and landscape approach, helps the foundation of an interscalar project. Through these lenses, we get to review novel ecosystems of landscapes in a systemic approach, while also bringing together new territorial development for a fitting socio-cultural system and ecological security.



2.9: Landscape near Power Plant Niederaussem



2.3.6 Systems

Systems thinking is an approach to tackle urban planning (Pourmohammadi, 2022). As such we can see it as a method. At the same time, Reviewing the city as a complex system is also a theory (Sanders, 2008).

The city consists of multiple subsystems that come together in its complex system. Here, it is relevant not only to how the system or subsystems are shaped but also to how these subsystems interact to form the complex urban system (Pourmohammadi, 2022).

Urban systems are complex adaptive systems (Sanders, 2008). Meaning that they are not linear processes but consists of feedback loops and changing variables (Sanders, 2008). Thus, the system is in constant flux, changing due to its own feedback loops. Analysing the system can help us find leverage points in the system. These are impactful places in the system where we, through design or intervention can change the system.

In this thesis, I approach the system of the minescape from the principle of disruption. As the mines will be closed, all related systems will be disrupted and, as such, change in balance. Through design, I strive to bring a new balance between these systems, creating an inclusive energyscape. To do so, I need to find the tipping and leverage points of the systems, to determine the necessary design interventions and the effects the sub-systems of the minescape will have on each other. This is in methodology, the place where design thinking and system thinking come together (Ospina, 2019)

The systems determined can vary depending on the city, assignment, or approach. In this thesis, I focus on the energy, social, green, and blue systems, as literature and analysis show a strong and impactful interaction between these systems.

2.10: An Alternative Representation of a System and Sub-systems adapted from Pourmohammadi (p. 36564 2022)

2.3.7 Transition

Our energy system is consistently in transition. We move from one resource to another while always working forward to a better method (Stremke & De Jong, 2022). Therefore, this thesis is not working towards a final energy landscape or a new status quo. Instead, it is designing for transition, helping to find possible trajectories and methods to further develop the energy transition and influence its trajectory.

Transition itself is an interesting theory. When it comes to sustainable transitions, two conceptualizations are dominant. First are technological innovation systems (TIS) and second is the multi-level perspective (MLP) (Coenen et al., 2012). Both conceptual frameworks focus on a socio-technical system - such as the energy or mining system - which consists of an interrelated network of actors, institutions and technologies (Markard et al., 2012) (Coenen et al., 2012). The difference between the two concepts is in the core of the transition. TIS focuses on the emergence of new technologies and the way they can progress to a sustainable future. MLP is oriented towards historical processes of sectorial change and how to reconstruct these for sustainable future scenarios (Kemp, 2010) (Coenen et al., 2012)

It is still unclear whether and how these two concepts can work together. In this thesis we can see both concepts appear. The thesis develops four scenarios based on different energy production technologies and researches how these will change the system and the landscape. At the same time, the new energy interventions aim to create new economic and ecological possibilities in the area. Specifically, from the landscape perspective, historical research on the development of the landscape in relation to the emerging economic sectors is done. This will help establish the existing qualities in the environment. These are paired with technology to develop a symbiotic relationship in which both the cultural-economic dimension and the energy system are transitioned.



2.11: The Power plant of Niederaussem



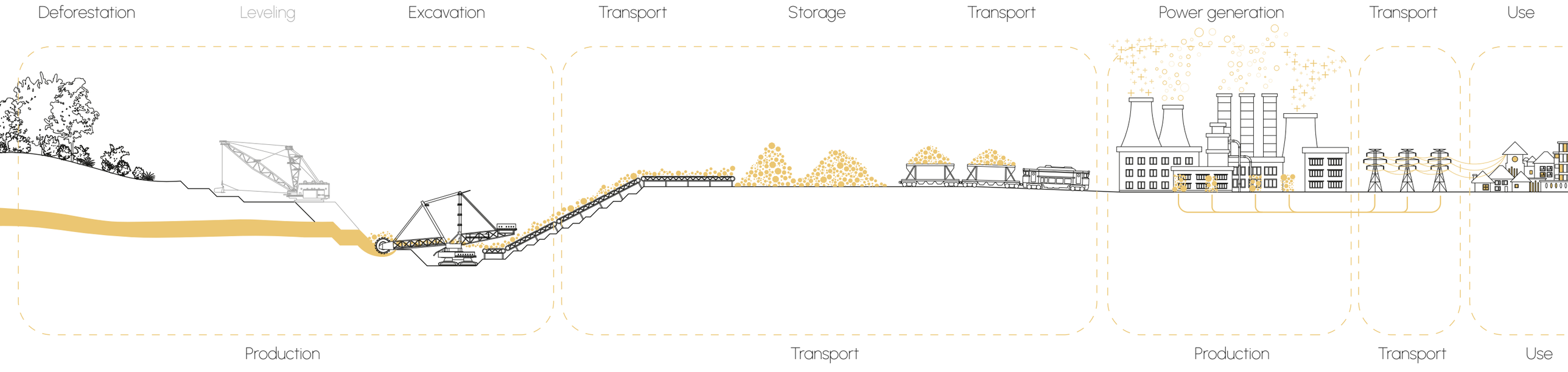
3. Systems

System thinking is based on the idea of interdependence. In any process, actions have consequences that can be intended or unintended (Wandl, 2023). The system approach focuses on breaking-up complex systems into understandable aspects. It helps us define the chain reactions and feedback loops as well as the leverage points of a system. As such, it can help us determine the weaknesses and strengths of a system and what design interventions we can do to create a change in the system, coming to a new health balance in the system (Wandl, 2023).

3.1: Power lines near Fortuna Feld

3.1 System Overview

Central to the minescape system is lignite extraction. The process from lignite to energy is linear. However, this process is only part of the larger minescape system. To gain a complete overview of the system, we need to review who and what are impacted by the energy system.



3.2 The lineair lignite system (based on Sim et al., 2022)

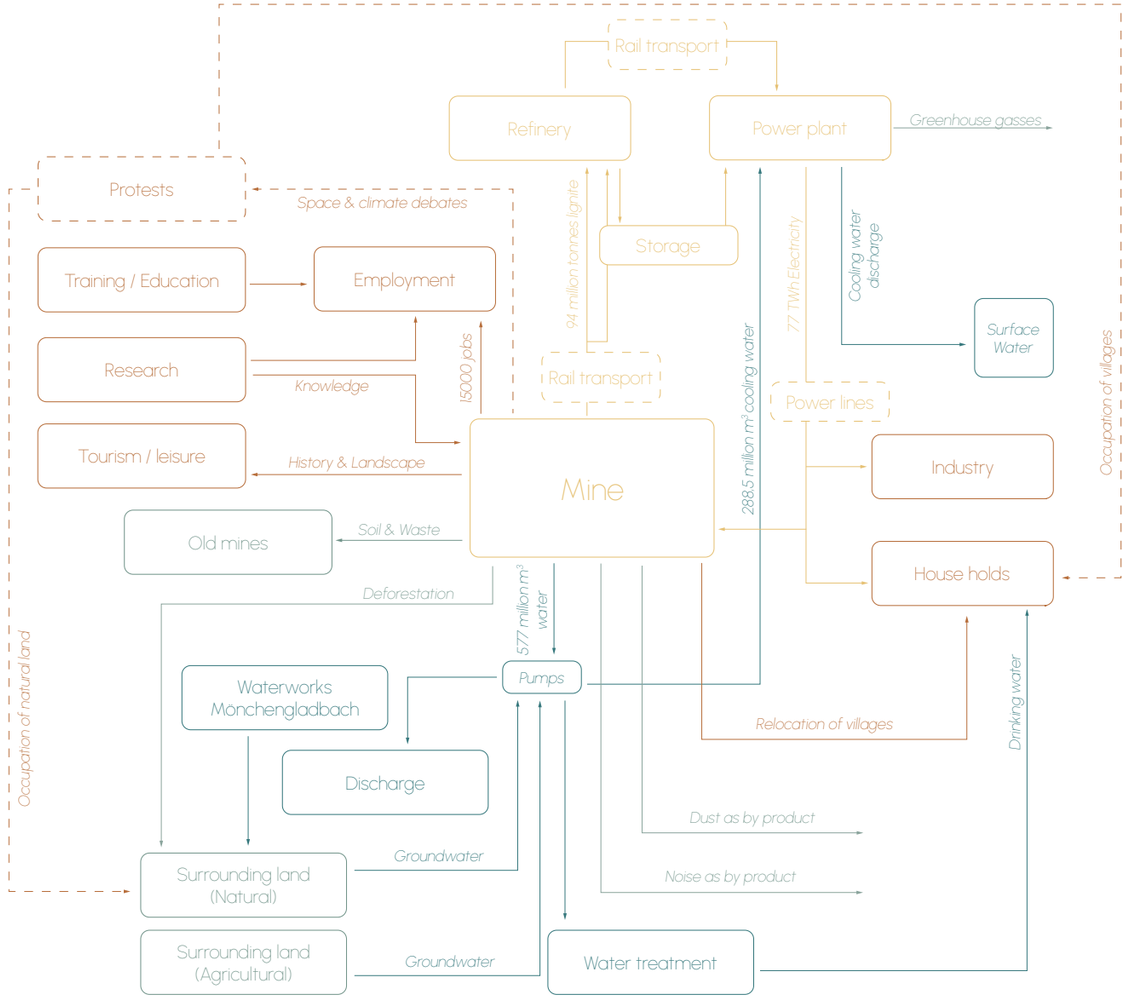
Central to the minescape system is lignite extraction. The process from lignite to energy is linear. However, this process is only part of the larger minescape system. To gain a complete overview of the system, we need to review who and what are impacted by the energy system.

The lignite system itself is linear, from excavation to storage, refineries, power plants, and usage. However, the energy system is larger, containing not only the fossil fuel sites but also the renewable resources in the area. On top of that is the extensive infrastructure related to the energy system, which consists of, among other things, power lines and railways—elements that all also appear in the landscape. Paragraph 3.2 unravels the complete energy system.

The impact on the green system (3.5) is already clear in the linear system. Deforestation is a clear example of the green system making way for the energy system. In the same way, agricultural land must make space for the migrating mines. The impact of the deforestation on the green system is only a small part.

To be able to excavate, the groundwater level needs to be lowered to keep the mining pit dry. This significantly impacts the blue system (3.4). The lower groundwater level impacts the green system, which needs to be mechanically compensated to prevent wetlands and other natural environments from drying out. This in its turn is an indirect impact of the extraction process on the green system.

Lastly, there is the social system (3.3). Related to the minescape is an extensive system extending further than the employment-based interactions. Related to the site are also multiple research centres focussing on hydrology and renewable energy sources. Next to that is the attraction of the immense mine landscape that attracts tourists and visitors. Lastly, the minescape is deeply embedded into the culture, this is visible is through the protests on site, but the relation residents of the towns have to the mines, their long history of labour in these mines and the pride related to the technology used in the mines are all forms of the social system in the minescape expressing itself.



3.3: The complex minescape system, based on: Agora Energiewende, (2018), Appunn, (2023) and RWE (n.d.-d)

3.2 The Energy System

3.2.1 Elements of the system

The energy system in the Rhenish minescape consists of the lignite energy system, the transport system and the renewable energy sites present in the area. There are little to no other fossil fuel resources, and as they are not key in the transition, I have decided not to place focus on them.

The main elements in the system are the mains, lignite power plants, the railways that connect both these elements and the power lines that move from the power plants to the city. Lastly are the urban, industrial and port areas which are the main users of the energy generated.

Renewable energy sources are also connected to these power lines. Multiple biomass power plants are connected to the railway system due to the mass transport related to this energy production method. The hydropower plants are located on rivers and are thus also dependent on the existing landscape.

The windmills are mostly situated on agricultural land. There are some wind fields and some solar fields which are located on top of regenerated mines. As the direct surroundings of the mines are mostly inhabitable because of dust, noise and pollution, the edges of some of the mines are used to produce wind energy.

The production of energy from lignite creates more products than the wanted energy (p.73). Noise and dust are two elements of which the flows cannot be found. However, the overburden for example can be traced over the railway tracks to dumping sites (p. 37). Other flows that are also impossible to track stem from the power plants, such as greenhouse emissions, ash and steam. However, they are important flows from the system.

The current energy system was located here because there was lignite in the ground and a lot of open space. However, to produce renewable energy sources, we are dependent on other elements. Solar energy needs an open space with little shadow and many hours of sunlight. Wind energy also needs open space or height above existing structures. For hydropower we need waterways, and biomass is dependent on transport or production space. Therefore, the question I ask during each system analysis is: What are the possibilities given by these systems to provide for a future energy landscape?

When it comes to the energy system, its strengths are the high density of power lines, the open fields that have been kept open because of the burden of the mines. - These could be suitable for wind or solar energy. - The existing railroad system, made for the transport of heavy goods, and the existing power plants might be transformed over time for other resource processing or energy storage.



3.4: Map Energy system
Based on Global Energy Monitor (2023a,b,c), OSM (2023) Open.NRW, (2023a), LANUV NRW (2023a,b), Geologischer Dienst NRW (2019), Copernicus Land Monitoring Service (2018)

3.2.2 Flows

Two main acts lead to material flows directly extracted from the lignite mining pits: excavation and groundwater drainage. These flows are consistent in the mining process and can be measured.

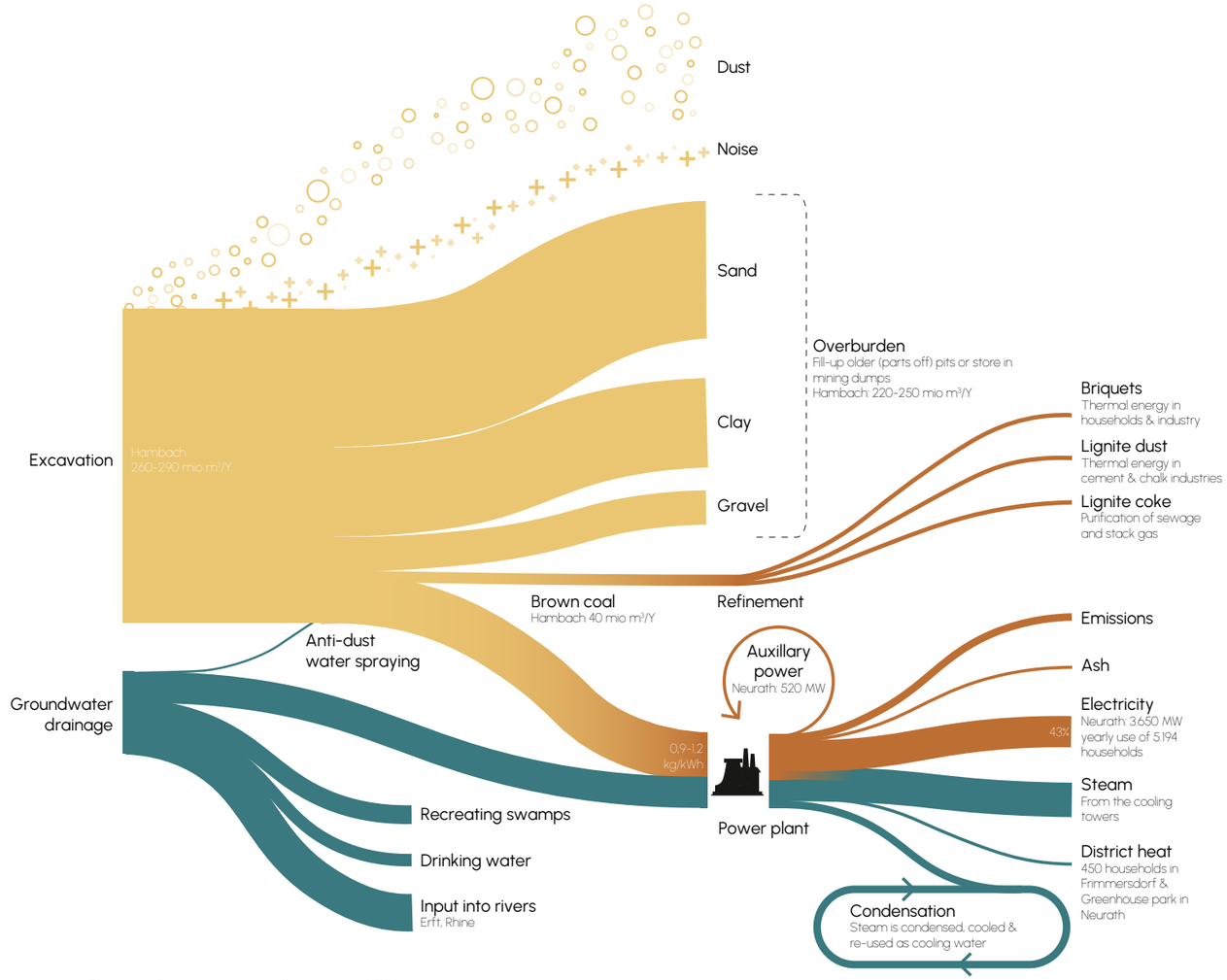
The first noticeable factor is the small part of lignite or brown coal in the process. The largest flow coming from mining activities is the overburden, which is sand, clay, and gravel deposited in old mines or at mining dumps. At the same time, the mines generate noise and dust. However, it should be said that though the dust is experienced by residents surrounding the mines, the noise can only be heard close to the mines.

The noise of roads is more present in the landscape. The brown coal is used in two different means. It can be refined and as briquettes, dust or coke directly used in industries., or it is transported to power plants and transformed into electricity.

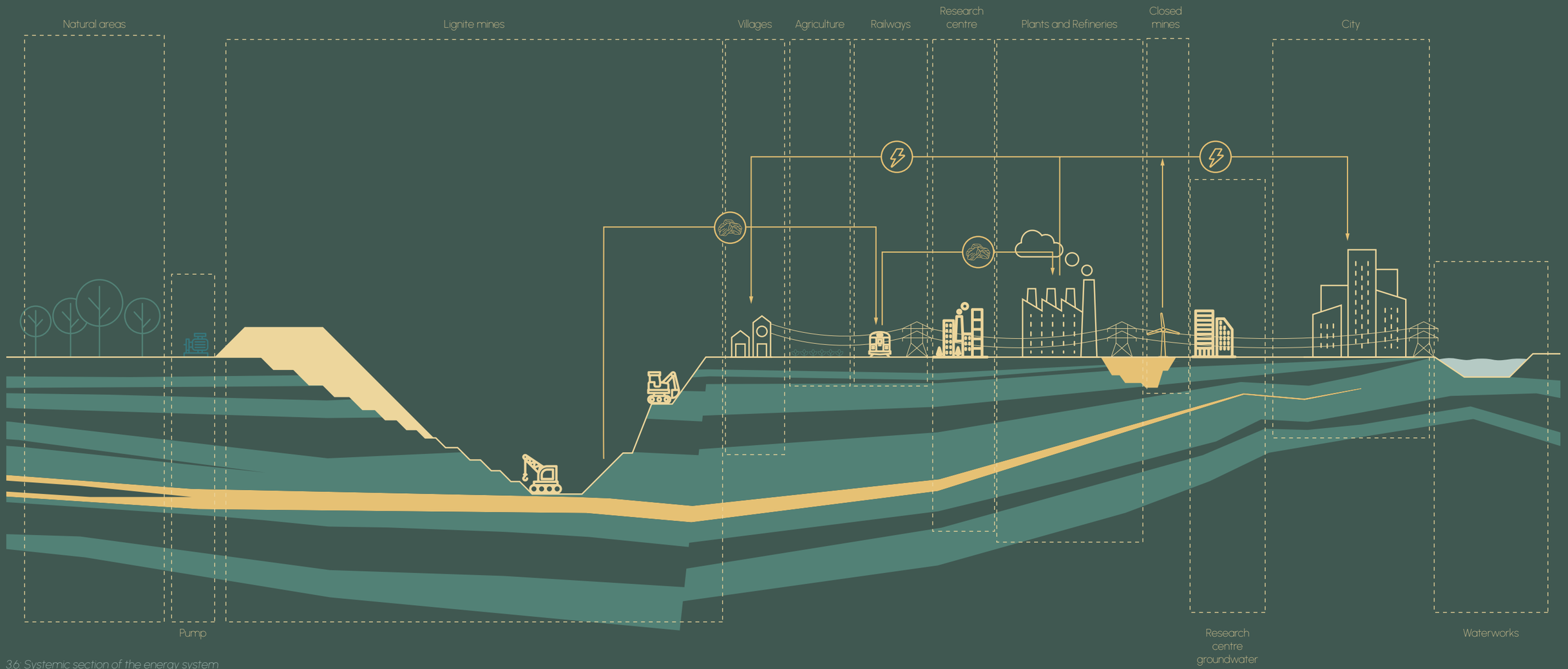
Next to the extraction is the groundwater drainage. Some of these flows are directly implemented into the mines to reduce dust or as cooling water for the power plants. However, most are discharged into rivers, making them a lost resource.

Some flows are difficult to measure. These include the exact amounts of groundwater being transferred from the site and discharged into different areas and the amount of electricity put back into running the mines. The diagram does show the power needed to run one power plant, but no data is available for the complete system.

We could state that there is a third act leading to material flows related to mining: deforestation. Of course, this leads to its own bio-waste. However, since this act only takes place before the actual mining and does not consistently create the same material flows, I did not take it into account. For the same reason, the diagram does not represent the relocation of urban areas.



3.5: Lignite flows (based on Sim et al., 2022)



3.6: Systemic section of the energy system

3.3 The Social System

3.3.1 Elements of the system

The social system goes beyond the urban. It entails the economic drivers, the social advocates and the cultural definers.

The reason the mines are clearly marked is that they have a place in this system. As the divider of urban development and the core attractor of industrial and research development. At the same time, it has become a place for tourism. As such the mines form a hotspot as well as a divider in the urban development and movement throughout the landscape.

Movement through this landscape is done by rail and road. Here the people in the social system move between the city or settlements where they live, to the mines or power plants to work. At the same time, people might also move around between the research and education centre of RWE, just below the Hambach mine or at the edge of Köln, to urban areas. From these areas, knowledge gained is brought back into the mining system, but it is also spread beyond the borders of this map along to other sites, as one of the main research topics here focuses on hydrology.

Next to this socioeconomic interaction between humans and mine, we can also define two different sociocultural interactions.

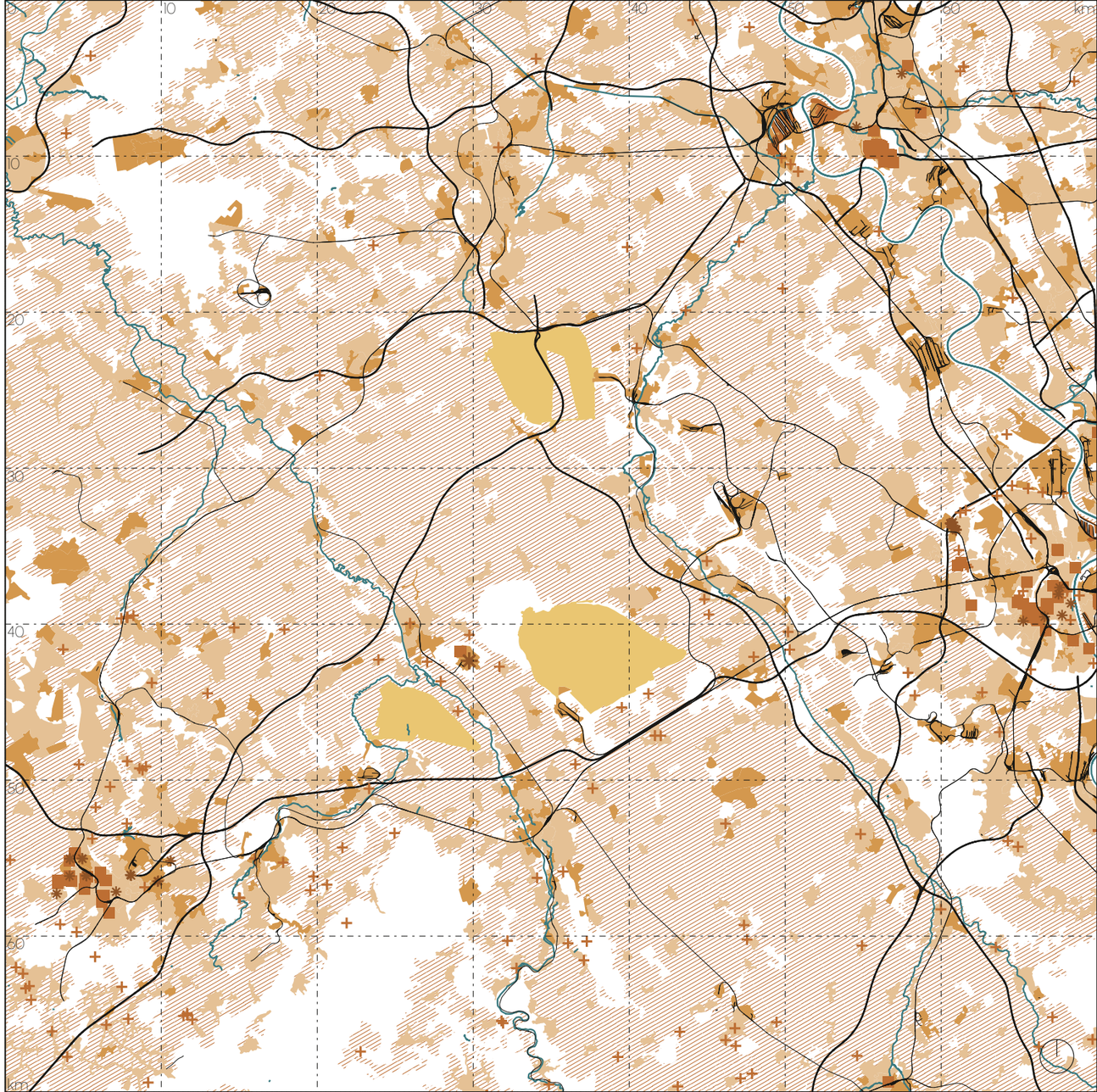
The first is the protesting and conflict surrounding the mine. There are climate, deforestation, and relocation protests. As such, a different relationship is created between mine employees and protesters from local settlements or other places in the country.

A second socio-cultural interaction is that of leisure and tourism. Apart from different historic sites in the area, such as old forts, the mines form one of the main tourist attractions. The immense landscape attracts visitors and stops passersby. Consequently, small leisure ventures such as cafés and sightseeing points have been opened around the edge of the mines. On some occasions, it is even possible to take a tour throughout the mine. This shows people take a certain interest in the extraction landscape.

One of the main weaknesses of the mines' phase-out is the loss of 15,000 jobs. These employees can often not be replaced in other jobs as they have been specifically trained for this work.

One of the possibilities of this landscape could be to focus on the history of energy and the role these extractive landscapes have had. As such, tourism could become a new economic driver of the area to replace the missing mines.

A second possibility would be using the already existing knowledge and research infrastructure as a driver of a new renewable energy-based economy. We should, however, question how much employment opportunity is realistically generated and who would be able to execute this labour.

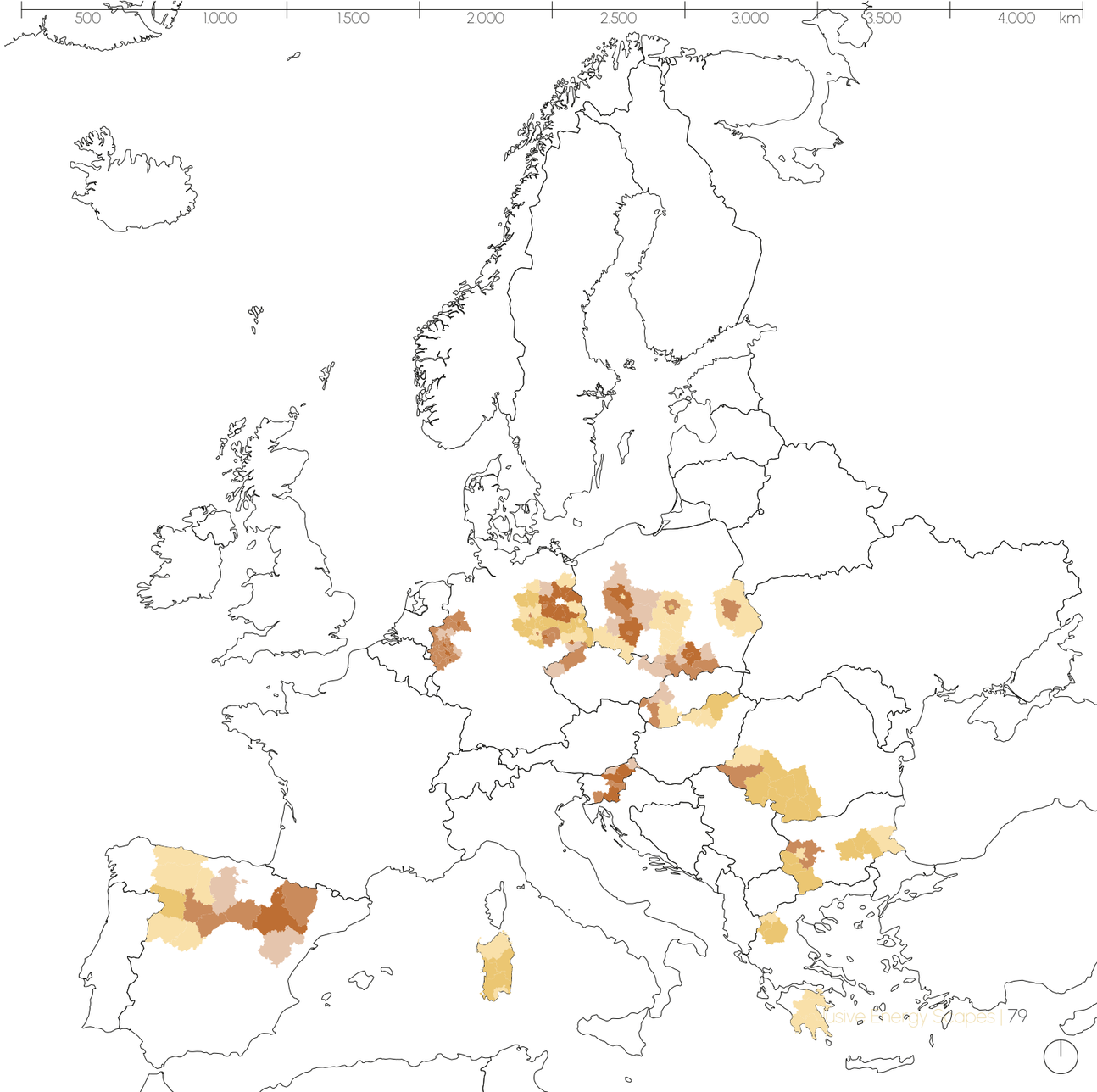


3.7: Map social system, Based on OSM (2023) and Copernicus Land Monitoring Service (2018)

3.3.2 Coal regions in transition

This map shows the growth and decline of the population in coal transition regions. The map focuses on coal regions that are transitioning towards a more sustainable energy production system or phasing out coal extraction. These regions are supported by the EU from a socio-economic perspective, meaning that they gain support to regenerate brownfields, manage the labour market, exchange knowledge, and overall focus on a just transition (European Commission, n.d.).

The Rhineland region, unlike most other regions, does not show a decline in population. Instead, the number of residents shows a small increase throughout the region. We should be critical of this, however, as we cannot determine whether more people are migrating away from there, what the amount of labour migration is into this region, which groups are moving in and out of the region, or whether the population remains roughly the same.



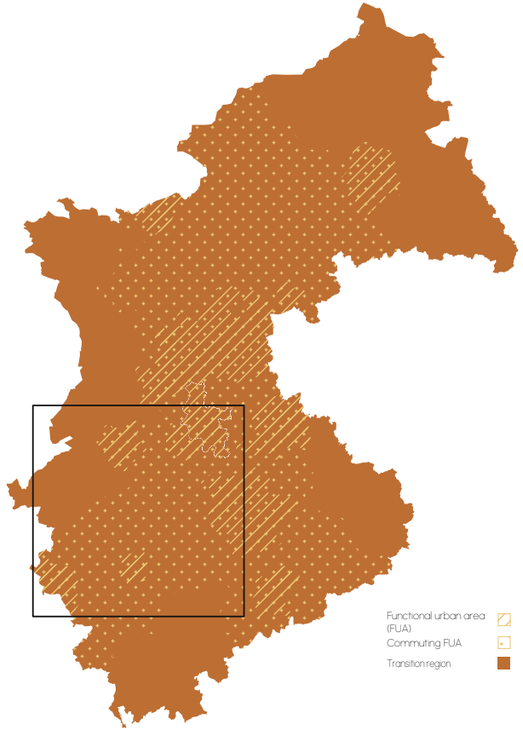
3.8: Population growth coal regions in transition, based on Michael Bauer Research GmbH (2023)

3.3.3 Demographics

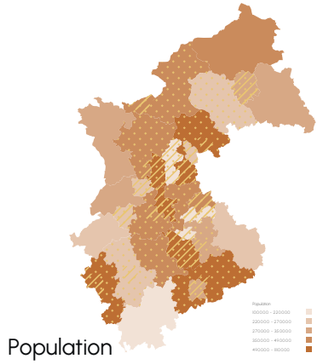
We need to gain a larger overview of the demographic aspects to better understand the urban development in the area. These pages zoom in on the coal transition region where the Rhenish Minescape is part of.

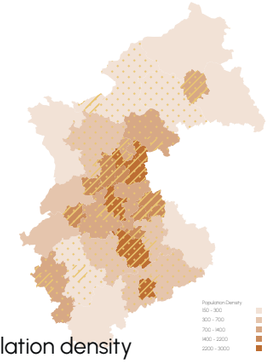
When we overlap this information with the functional urban area, we can determine the relation between the main urban cores and the rural environment. The area is part of the functional urban commuting area of Köln, Mönchengladbach and Aachen. This urban belt extends beyond the coal transition region.

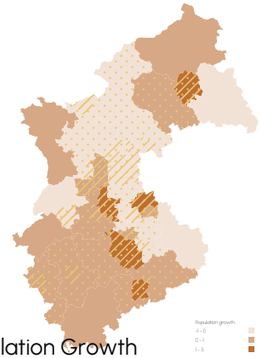
Comparing the population, we can see that though there is growth in the area, this is less than one per cent. Next to that, we can clearly see the area has a low population density but also smaller households in comparison to the rest of the transition region, as well as a lower GDP and income.

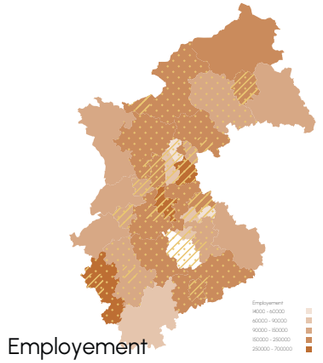


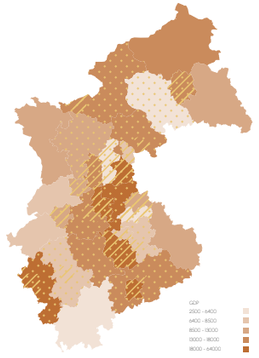
3.9. Demographics, based on OECD & European Commission. (2022), Michael Bauer Research GmbH, (2023) and European Commission.(n.d.)

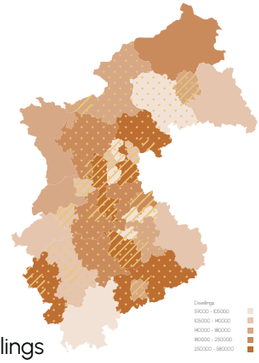

Population

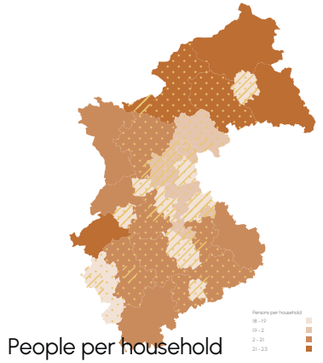

Popilation density

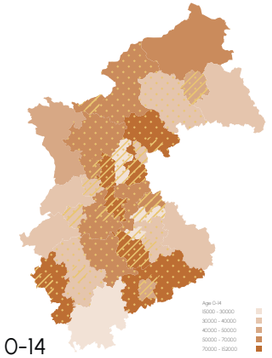

Population Growth

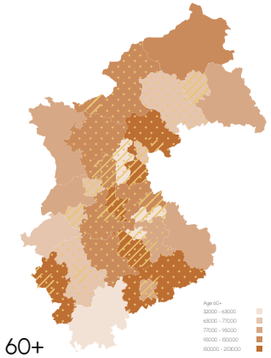

Employement


GDP


Dwellings


People per household


Age 0-14


Age 60+

3.3.4 Conflicts

The Rhenish Minescape is well known for its protests and conflicts. Even though the area creates up to 15.000 jobs, it has also formed a central place for the climate debate in Germany (Appunn, 2023).

These protests focus on two main conflicts. One is that of space; both the Hambach Forest and Lützerath have been occupied for years, to prevent the village and forest from being demolished by the migrating coal mines (Alkousaa et al., 2023) (Douglas, 2020). In the case of Hambach, this has been successful, and a small part of the forest will be maintained (Douglas, 2020). For the settlement of Lützerath, this is not the case; even though other settlements have been spared due to protests, the increased need for an independent energy resource for Germany has prioritized the mine over the settlements. This need is caused by the war between Russia and Ukraine (RWE, 2023).

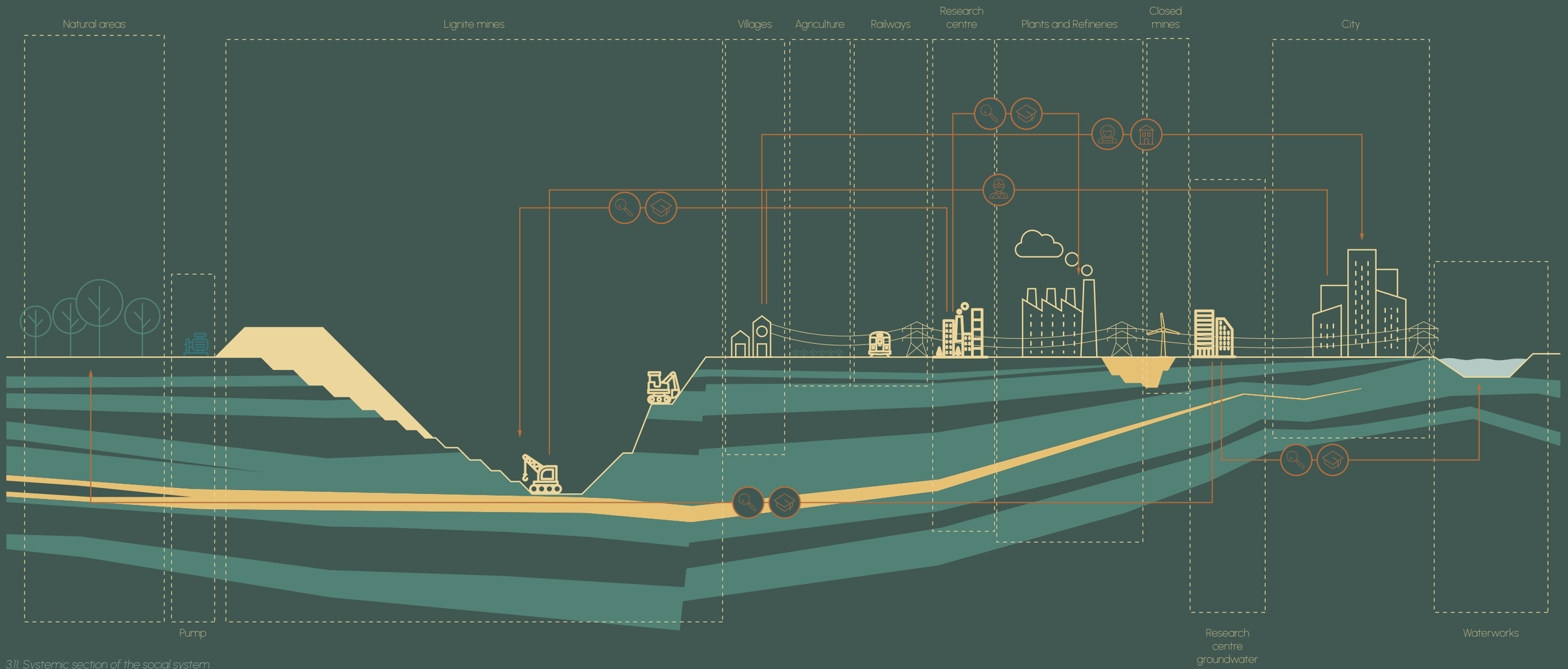
Next, there are protests against the usage of lignite as an energy resource. The protests surrounding space are much older, going back to 2012 (Douglas, 2020). The protests to stop coal extraction to reduce climate change are more recent. These protests are also different from the occupations as they are organised activities, such as the charging of Garzweiler in 2019 (BBC, 2019).

At the same time, there were also those who were critical of the protests. Stating hypocrisy for the protection of Hambach Forests while villages are being relocated. Or questioning where everyone's energy would come from if the mines were shut down (Hambacher Forst, n.d.). Though these opinions are less present and less loud, they do reflect the conflict on site.



3.10: Collage: the conflict of the Rhenish Minescape, Photography by Daniel Chatard (2017-2023) for his project "No Man's Land"

3.3.5 Overview



3.11: Systemic section of the social system

3.4 The Blue System

3.4.1 Elements of the system

The most hidden system is the blue system as most of the interaction between the water and the mines take place under the ground. However, the impact of these interactions is far larger than the Rhenish Mining District. It even crosses the border to the Netherlands (Guns, 2024).

Groundwater needs to be pumped out consistently to keep the mine pits dry. RWE uses over 1500 pumps to do so, which are spread all along the agricultural land. However, the removal of this water endangers the more vulnerable parts of the natural environment, such as wetlands. RWE has a duty of care to ensure these areas are compensated now and after the mining closure. As of now, RWE pumps water to these areas from the waterworks next to Monchengladbach (Guns, 2024) (RWE, n.d.-d).

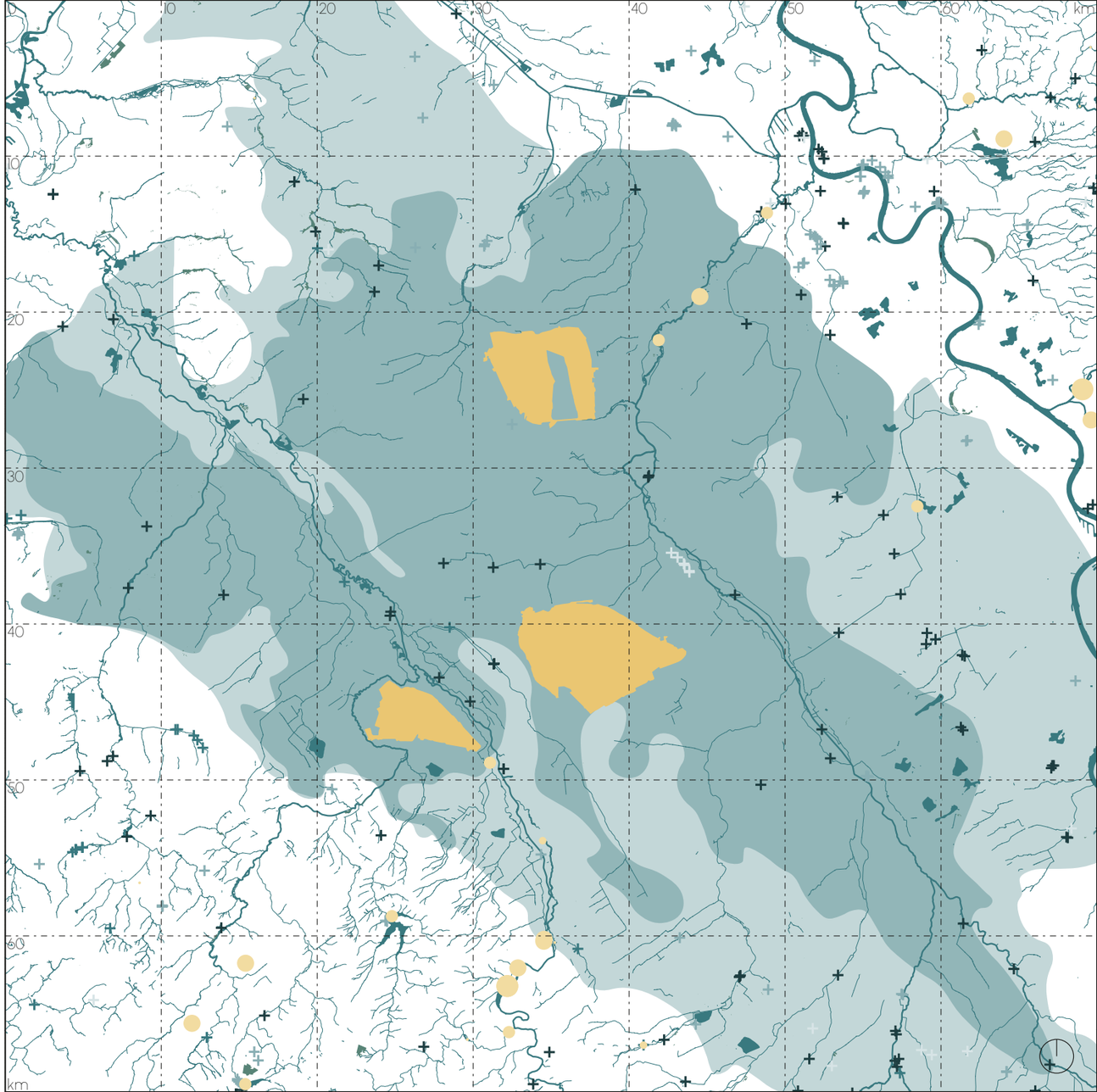
The water extracted from the mines is used to cool the power plants, sometimes converted into drinking water and drained off in the river system (RWE, n.d.-d) (Hauser et al., 2022).

As a consequence, we need to question what will happen with the blue system when we close down the mines. If we let the groundwater level come back up, it will get contaminated at the surface level of the mine, bringing acidified water back into the ground (Guns, 2024). Filling the pits with water from the rivers was always the original plan, however it is questionable if this is still a suitable solution or even possible with climate change (Guns, 2024) (Wagner & Hüsener, 2014). If this is done, the water should be consistently treated against acidification to be able to use the lake (Schultze et al., 2010). With the size of the proposed lakes, it seems not reasonable that it will be possible to create a living lake (Guns, 2024).

At the same time, we need to question what will happen with the future of the rest of the blue system. If the groundwater is not pumped out anymore, what water will cool down the power plants if we would still want to reuse them in the new energy system? What would be the impact of the drinking water loss?

Next to that, we need to question what will happen when RWE leaves, what will happen when this company goes bankrupt, or when their duty of care runs out. It is debatable whether the natural systems now dependent on the technological water supply could survive without it in this changed climate (Guns, 2024).

At this moment, the blue system seems the largest challenge. The choices made for this system will, like a domino, affect the other choices in the design. The main potential for the blue system is the possible large lakes, which, due to their body mass and their scale, could be of interest for energy storage or recreation.



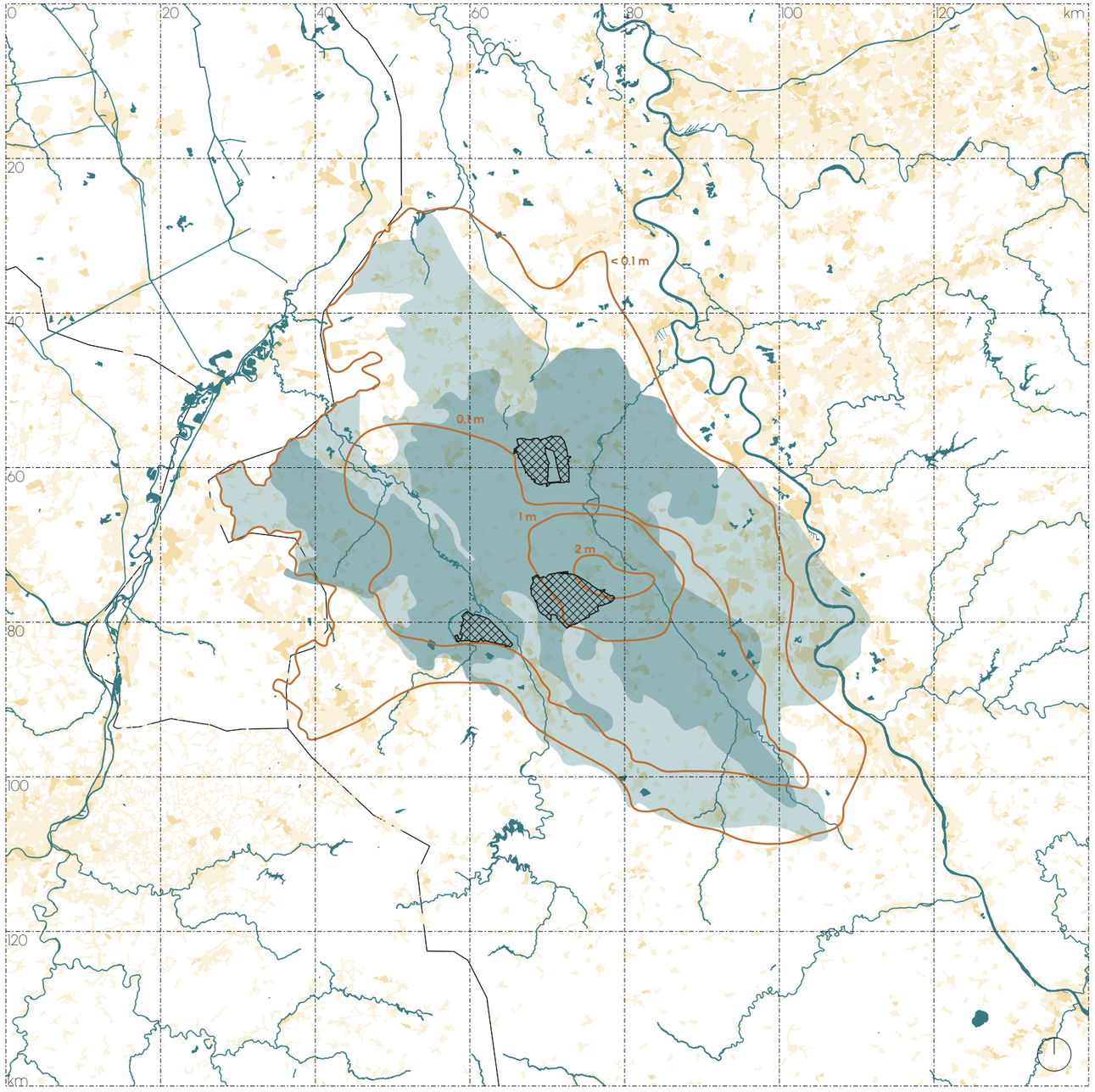
3.12: Blue system based on OSM, (2023), Copernicus Land Monitoring Service, (2018) and LANUV NRW, (2023b)

3.4.2 Scale of impact

To review the impact of the changing groundwater level, we need to look at a larger scale.

However, the data only extends to the German border and not to other countries. We can gain a general insight of the impact. The dark blue shows the area where the groundwater is lowered in the upper layer, while the light blue is the lowered groundwater in all groundwater levels (Hauser et al., 2022).

At the same time, the lowering of the groundwater impacts the soil. In brown, soil subsidence is visible, with the cities closest to Hambach sinking two meters.



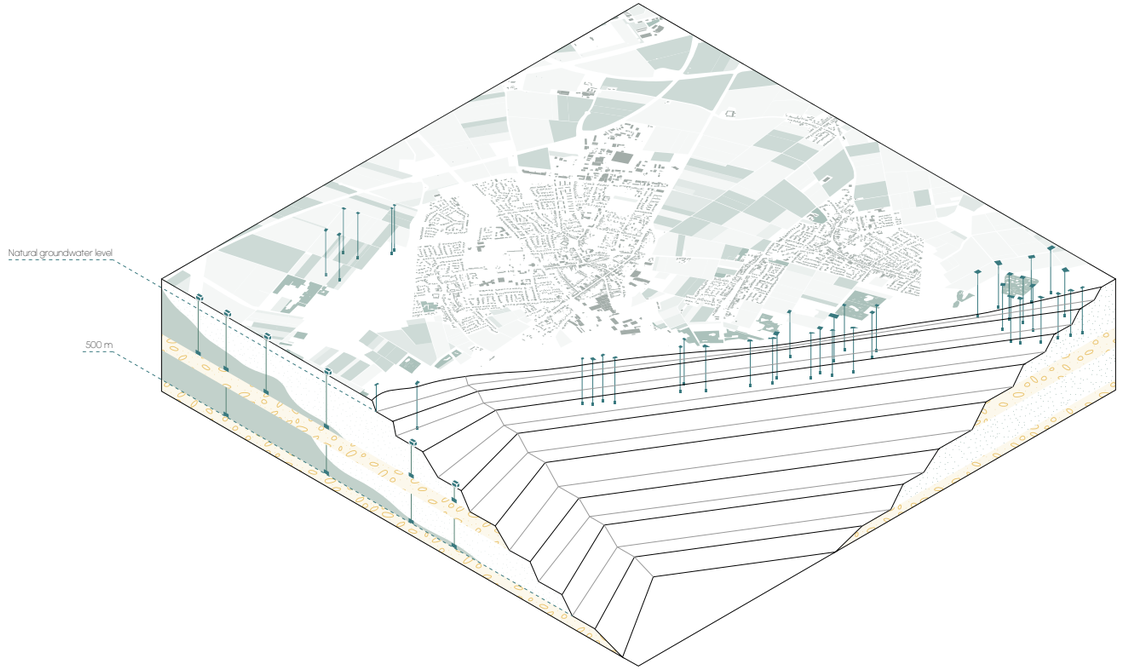
3.13: Map of groundwater impact, based on Hauser et al., (2022), LANUV, (2018) and Copernicus Land Monitoring Service, (2018)



3.14: Photos of groundwater pumps in Rhineland

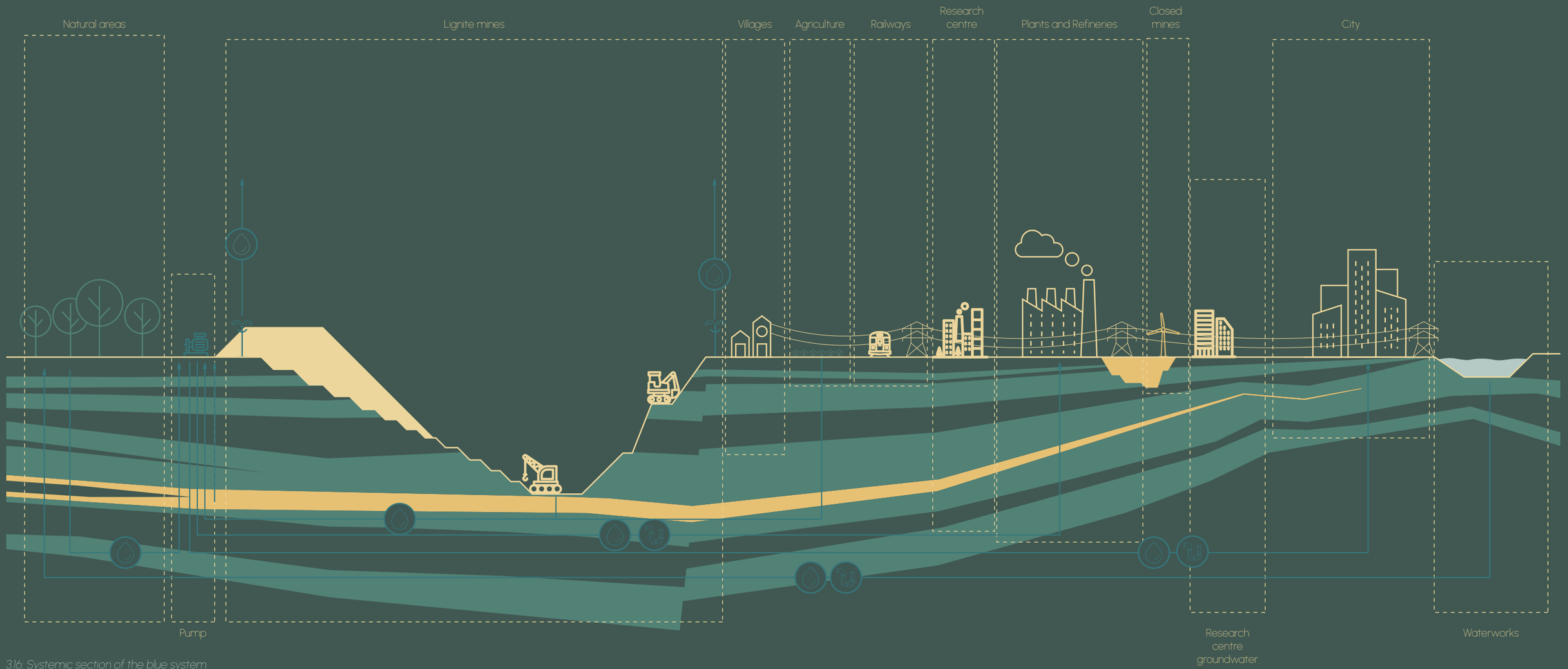
3.4.3 Infrastructure

Whereas most of the groundwater system might not be visible to the eye, the mechanical system of the minescape is very present in the landscape. With over 1500 pumps spread around the minescape (Hauser et al., 2022) (RWE, n.d.-d). While the unknowing eye might not be aware, the fenced-off boxes all around the area consist of pumps drawing out groundwater up to 450 meters deep, extracting 577 million m3 of water (Hauser et al., 2022) (RWE, n.d.-d).



3.15: The groundwater pumping system (based on Hauser et al., (2022), Geobasis NRW (2022) and Schneider et al. (2022)

3.4.4 Overview



3.16: Systemic section of the blue system

3.5 The Green System

3.5.1 Elements of the system

The green system includes protected natural areas and agricultural sites, which are essential to the functioning of the ecosystem.

The original landscape consisted of forests (pine trees). One of these historic forests is still present in the south (Gerwin et al., 2023). The regenerated axis of the old mines consists of re-introduced forests and the creation of new lakes after the mines had been closed. Lastly, in the Northwest, there is a form of wetlands that are highly dependent on the groundwater level (Guns, 2024) (Hauser et al., 2022).

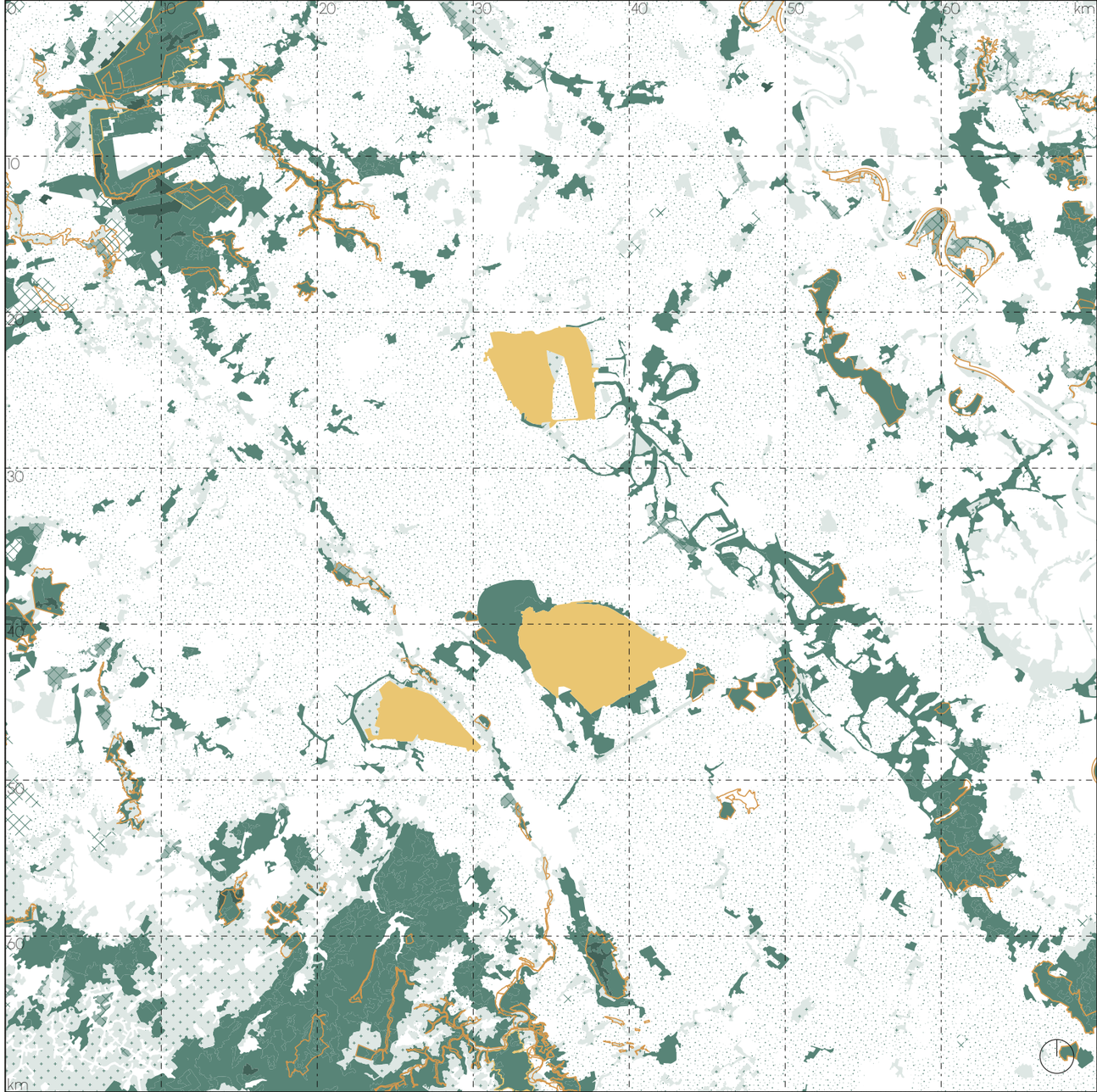
In the development of this area, the North-East consisted of loess, which is a highly fertile form of soil. As such, this area was developed into agricultural land (Gerwin et al., 2023). Around the Rhine, the urban network developed, leading to little original natural areas around the Rhine. The South-East, however, has extremely poor soil. Therefore, it was not suitable for agriculture and remained natural (Gerwin et al., 2023).

As a consequence, the green system consists of agricultural land, regenerated and thus human-made "nature," and original forests in the Southwest. In the Northwest, historic forests can also be found, combined with wetlands and threatened nature (Guns, 2024). This also explains the density of the Natura 2000 protection areas in these two regions.

Agriculture plays a role in the complete green system, though when it comes to regeneration, we should be critical of its place in the ecological system and the different water needs of forests, agriculture, and wetlands.

The regeneration of the Rhineland minescape could bring some potential from an ecological perspective. Giving the mines back to nature would create big stepping stones between the different Natura 2000 areas.

Next to that, the open fields of pastures and agricultural land would be very suitable for integrating wind energy. This is already happening in the area. At the same time many farmers are using their agricultural land all throughout Germany to produce wind energy. As such it would be in line with the changes in the cultural landscape.



3.17. Map green system, based on European Environment Agency (2022) and Copernicus Land Monitoring Service, (2018)

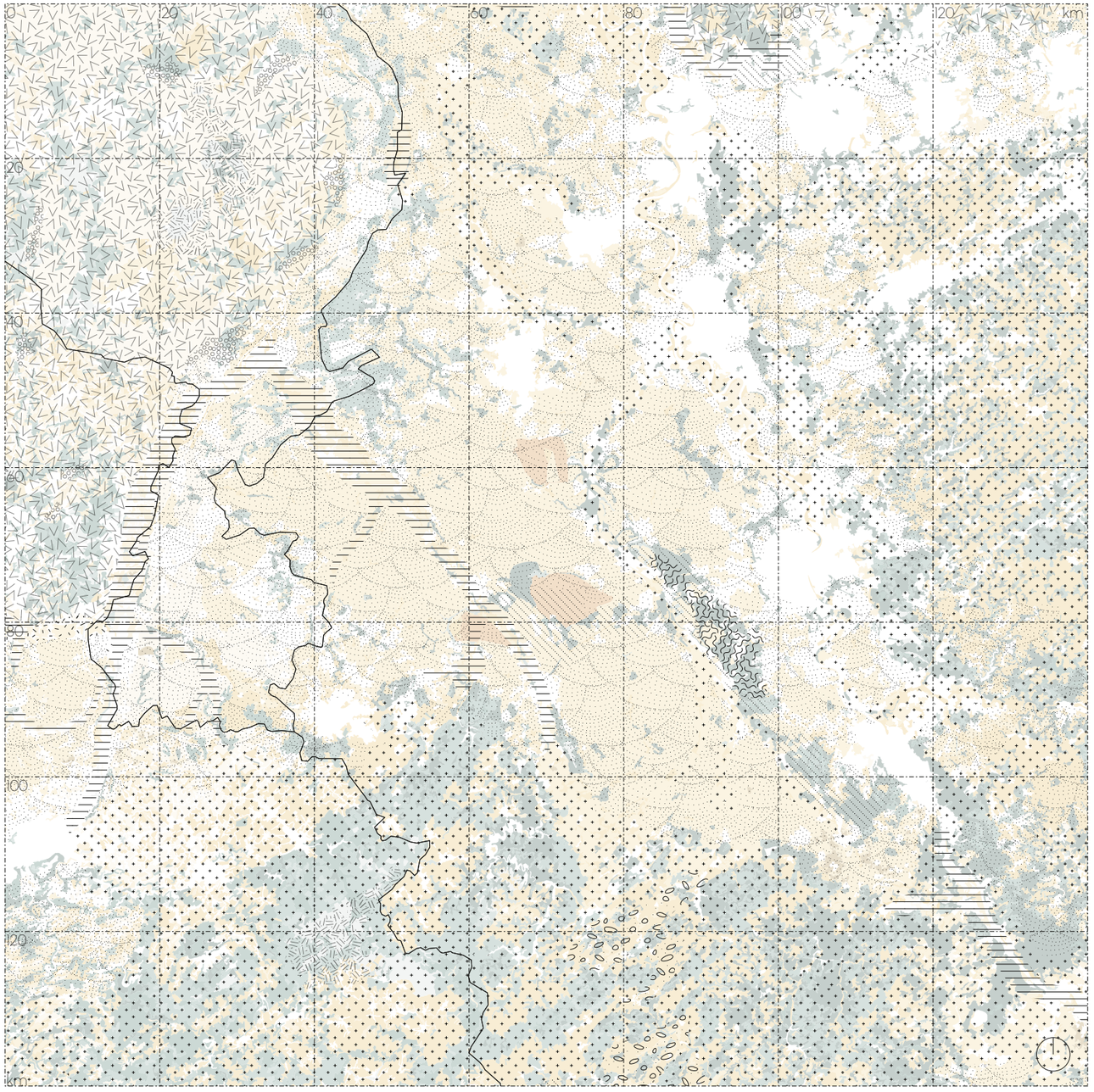
3.5.2 Soil typologies

Overlaying the soil types with the different forms of land use shows a relation between agricultural land and luvisol. This is a fertile soil type and, as such, highly suitable for agricultural production.

Comparing the different agricultural forms, highlights the main forms are horticulture. As such there is a strong interaction with the subsurface, more than in cases of pastures. The main products harvested here are grains and fodder, both of which are cheap resources. Therefore, farmers need a lot of space to cultivate to be able to gain a living.

At the same time, there is a correlation between forests and combisol.

When we compare regenerated areas into historically developed forests, we see that the by humanity introduced forests are broadleaved, while the older forests are often coniferous. Displaying a discrepancy between what is created and developed by the natural circumstances.



3.18: Map Relation soil and green spaces based on Copernicus Land Monitoring Service, (2018) and Panagos et al. (2022)

3.5.3 Destruction

Mining has had a significant impact on the green system, affecting the soil, air, and land use. Consequently, multiple protected species have been endangered. Over time, due to outside protests, mining companies have become more considerate of their pollution. An example of this is the dust sprinklers around Hambach mine. These use the pumped groundwater to reduce dust particles in the air. Interestingly, Hambach mine is the only mine with such precautions.

While we focus on the destructive nature of mines in the green system, the open unused areas in the pits also have left space for nature to recover itself. Contrary to what we may suspect, inside the mines we can find a wide range of plants, ranging from grasses to full grown trees. As it is more costly for the mining companies to keep the mine bare, these unused areas are left alone, creating relatively untouched and unmonitored ecosystems. As such, we cannot determine their quality or their impact on the system.



3.19: Protected species



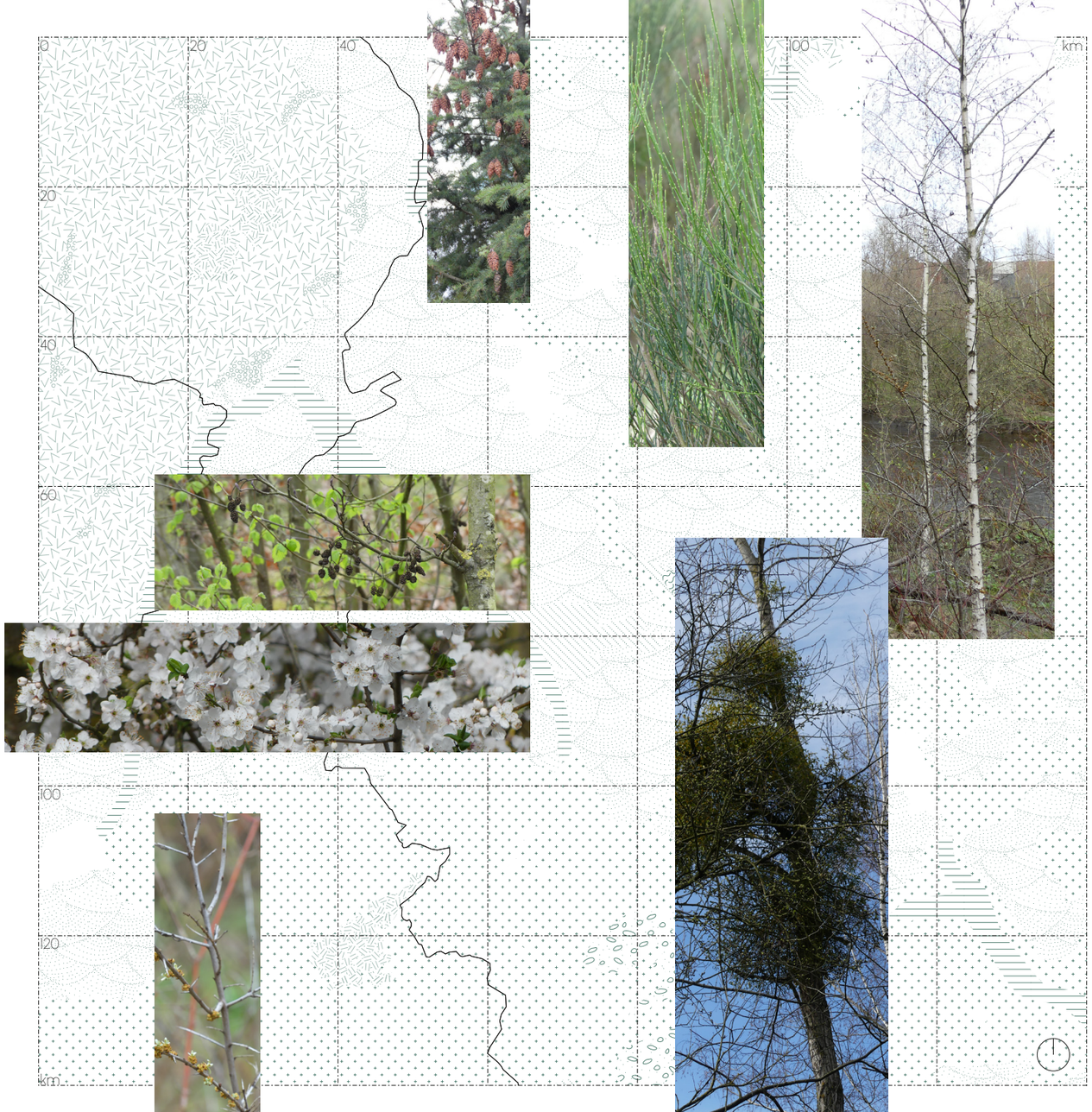
3.20: Dust sprinklers



3.21: Natural growh in mines

3.5.4 Soil and species

To maintain the soil fertility, the mining companies are forced to top off their overburdens using the loess they harvested from the mines. This should allow the regenerated areas to grow. However, we can see a clear smaller variety of plants in the newly regenerated areas. This is partly due to the young age of these forests but also due to a lack of knowledge on regeneration. An example of this is the large presence of mistletoe. This tree parasite can only occur in areas rich with lime - which is used to treat the lakes - and on weak trees. - that suffer, for example, from pollution. This shows that restoration of the green system might not be as straightforward as it seems.

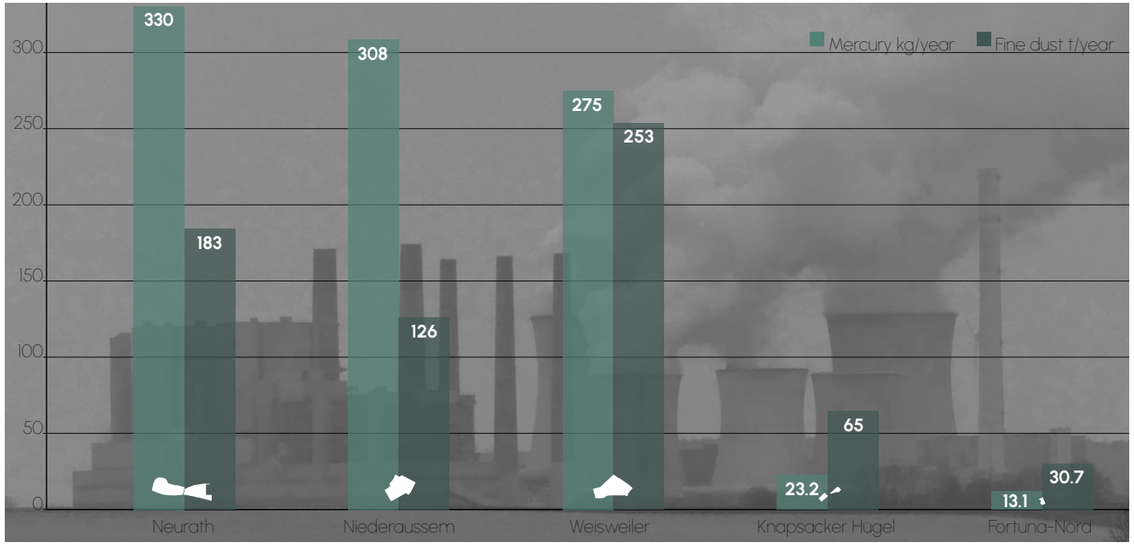


3.22: map Soil and species, based on Panagos et al. (2022)

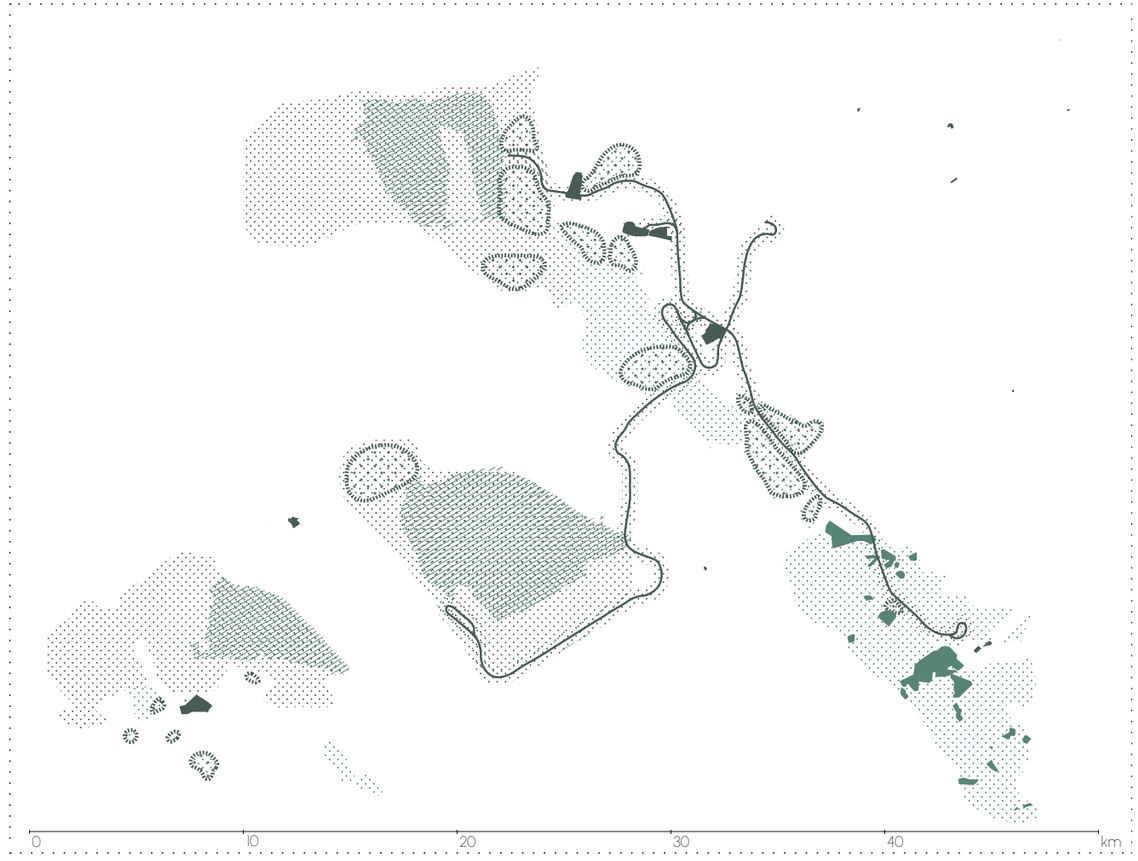
3.5.5 Pollution

Due to a lack of research and data, it is difficult to determine the extent of the pollution created by mining activities (Rouhani et al., 2023). Based on research in other mining regions, we can determine that the main pollution is caused by heavy metals, specifically mercury, polycyclic aromatic hydrocarbons, and nitrogen. These elements destroy soil biodiversity and thus destroy the ecosystem (Rouhani et al., 2023).

These problems occur not only in the mines themselves, but also in the soil heaps and in the transport routes of the lignite (Rouhani et al., 2023). At the same time, we also have the emissions from the power plants. We cannot determine where these settle and thus what areas they pollute. However, we do know that when airborne, they damage the environment and our health (Jansen, 2019). Next to the heavy metals, nitrogen is also emitted from the pits and power plants (Wehrmann, 2024). Nitrogen and methane are in these quantities, a danger to natural soils and biodiversity (Velthof et al., 2011).

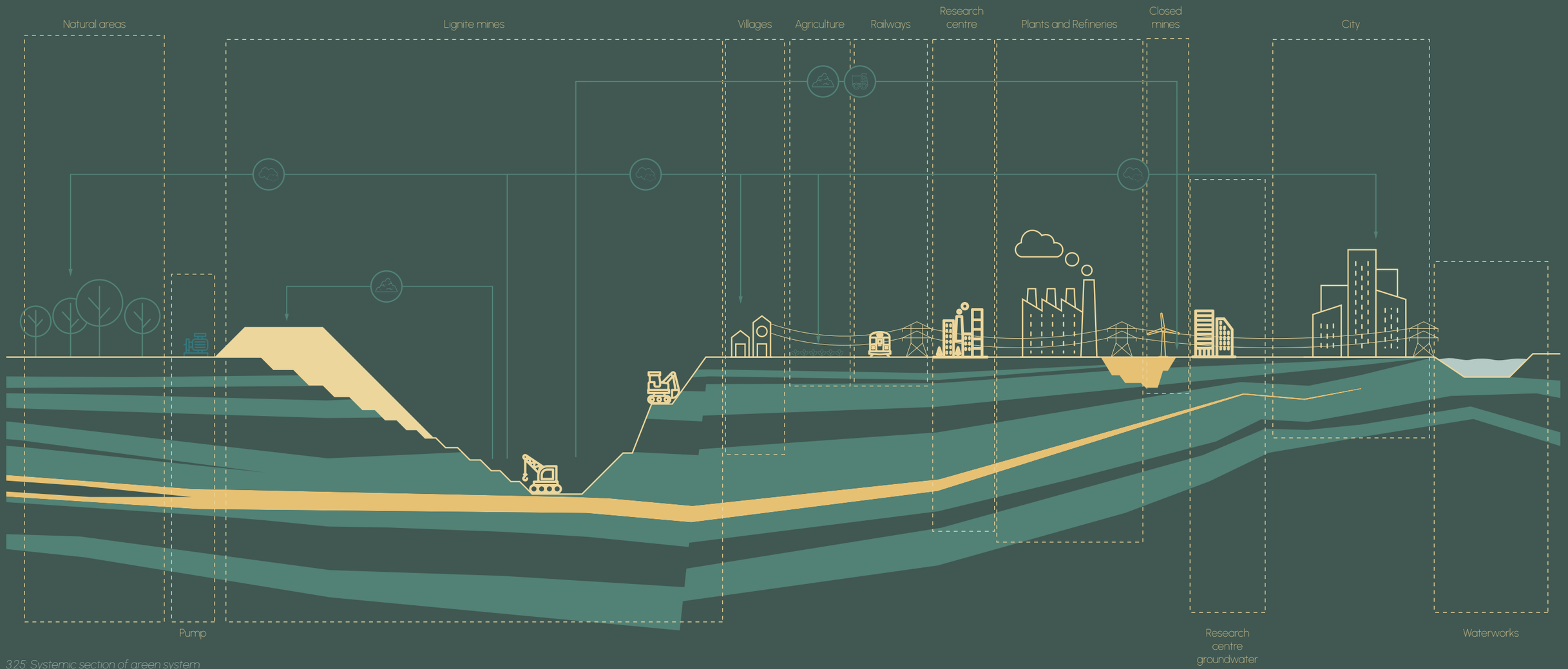


3.23: Emissions of mercury and fine dust from power plants in 2022, based on BUND (n.d.)



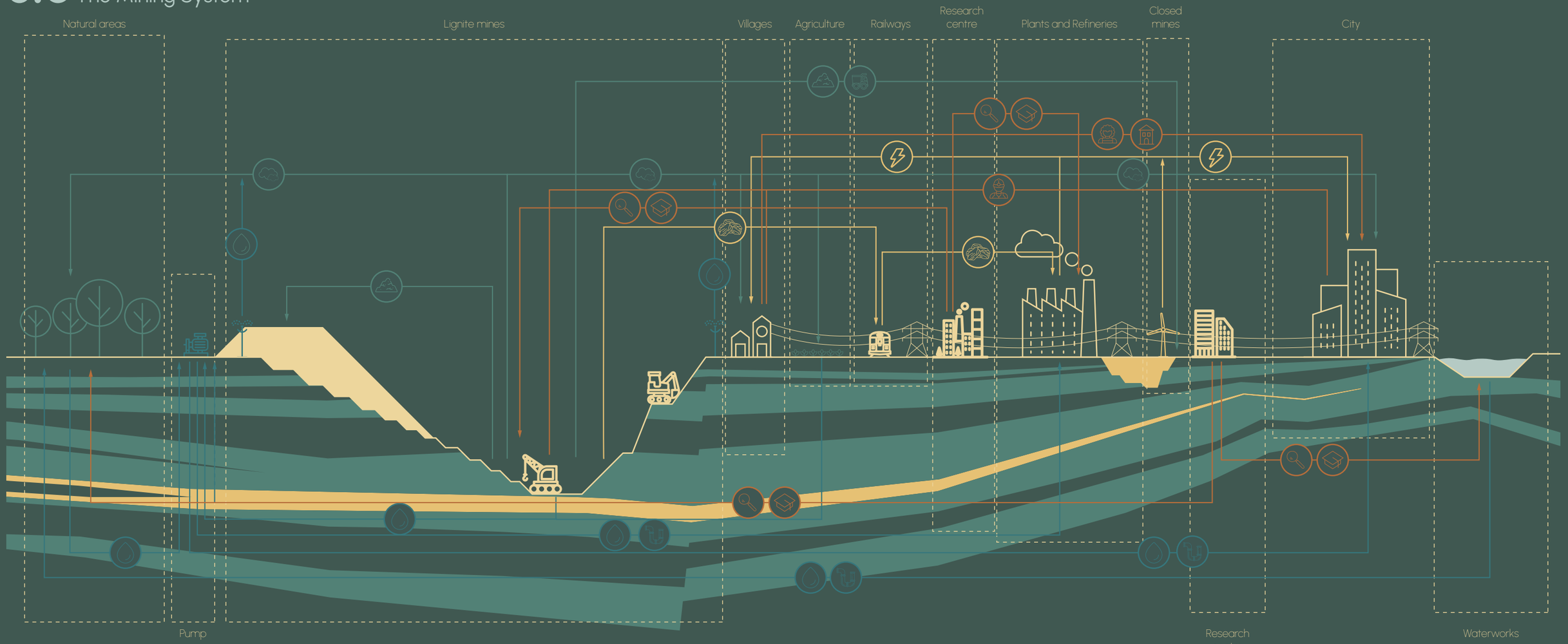
3.24: Pollution of the minescape, based on Rouhani et al., (2023) and Jansen & Robertz, (2014)

3.5.6 Overview



3.25: Systemic section of green system

3.6 The Mining System



3.26: Systemic section of the mining system



4. Landscapes

The Rhineland Mining Scape is an impressive landscape. With open pits 500 meters deep and the size of small cities, there seems to be an exhausted landscape as far as the eye can reach. The impact that we cannot see is even bigger, with the ecological impact stretching beyond the borders of Germany. However, what we might underestimate is the resilience of our environment. Even in this seemingly death environment, where humans, animals and plants seem to have left. Nature is slowly recovering, growing even in these polluted mines.

4.1: Changes of soil from lignite to green, Hambach mine

4.1 Europe's energyscape

The Rhenish minescape is part of a large border crossing operational landscape. As stated in the introduction, electricity produced in the minescape is added to the energy mix, which is then moved between countries as part of the import and export of energy. Focussing on the urbanized areas in Europe, we can see where our energy system focuses. Paired with these spaces of use, we can see the energy grid that determines how energy is transported throughout the landscape. The production space itself is dependent on the type of energy production a land focuses on. Each of these production methods has its own landscapes and spatial consequences.

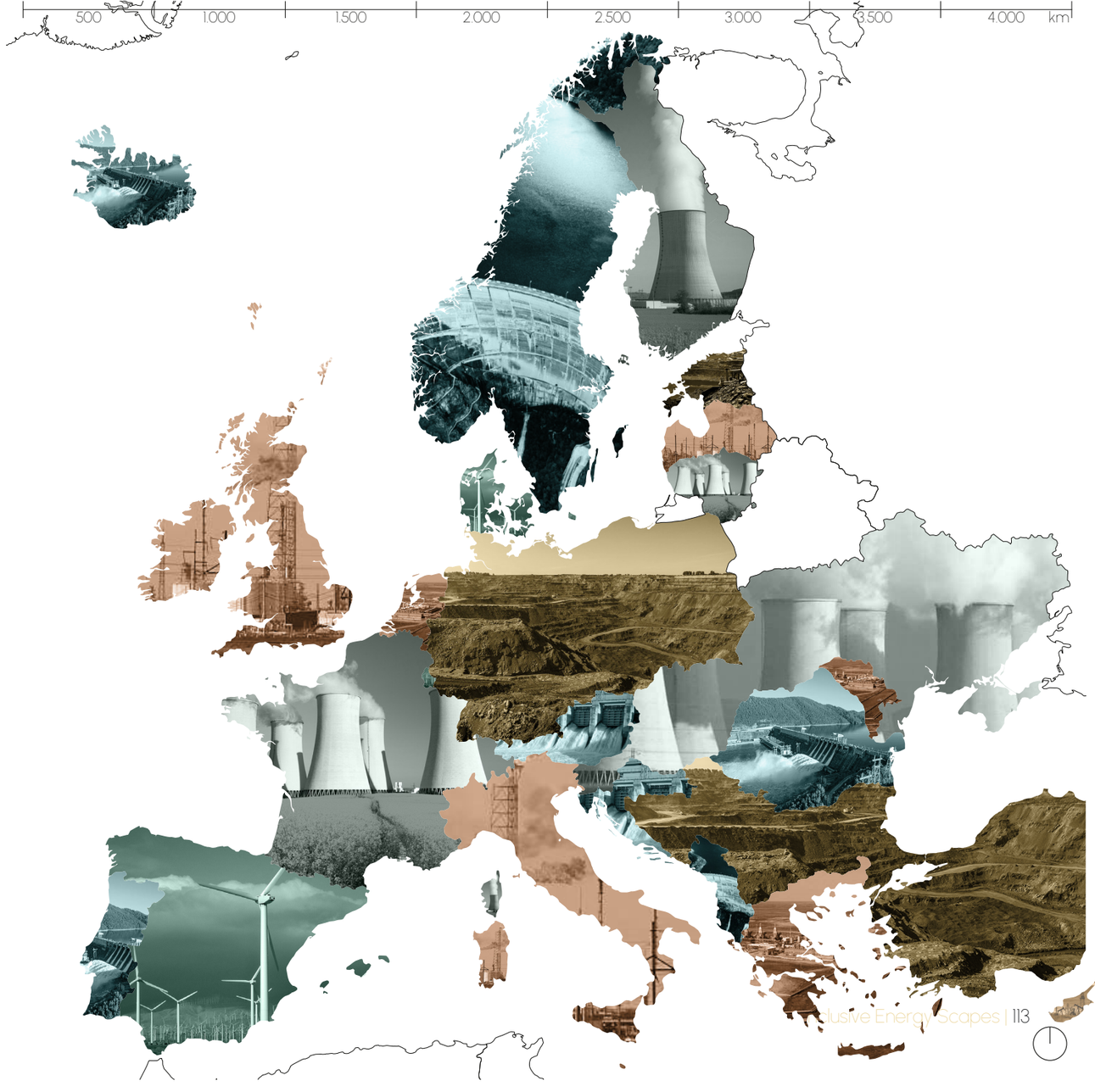
It is impossible to investigate all the energy landscapes in Europe. Instead, I would like to focus on the dominant form of energy production in the countries.



4.2. Map energy network Europe, based on Copernicus Land Monitoring Service (2018) and OSM (2023)

The dominant energy production in a nation shapes its landscapes the same way the dominant form of urban development or agriculture does. Image 4.3 shows the dominant energy source of all European countries and the landscape that relates to it. The map defines renewable sources in blue and fossil fuels in brown. In Europe, there are two blocks of coal landscapes. Germany is situated in the central coal block.

The choice for a specific type of energy resource depends on a country's possibilities. What is available based on the landscape; Coal, gas and oil needs to be present in your soil. Hydropower works best in countries with large height differences. At the same time, renewables such as nuclear and wind energy are inherently socio-culturally determined in politics and ambitions. As such, we can see the suffix "scape" emerge in the energy landscape, or the energy scale for short.



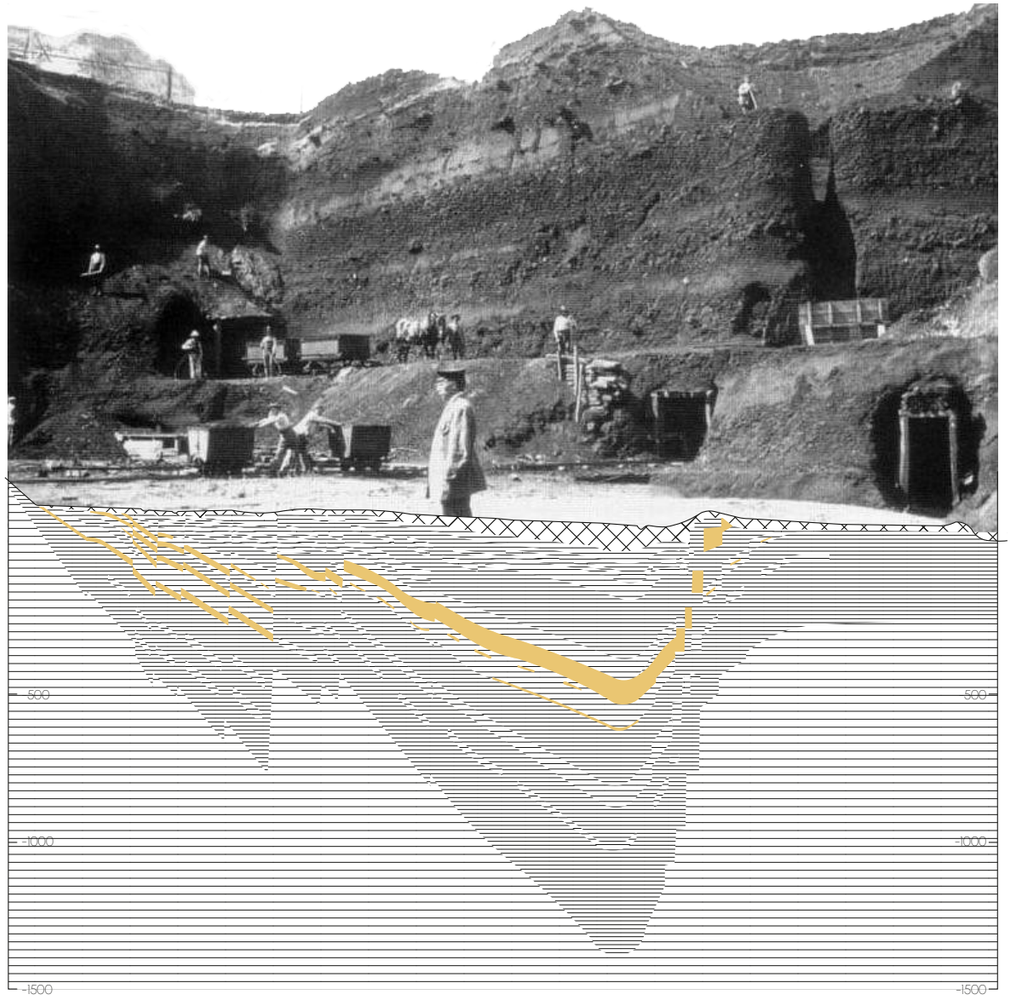
4.3. Dominant energy landscapes based on Conte (2023)

4.2 Leading subsurfaces

The landscape is determined not only by the visible factors, but specifically in these types of landscapes, the subsurface is leading for the development above. This energy landscape would not have occurred here if it was not for the lignite in the soil.

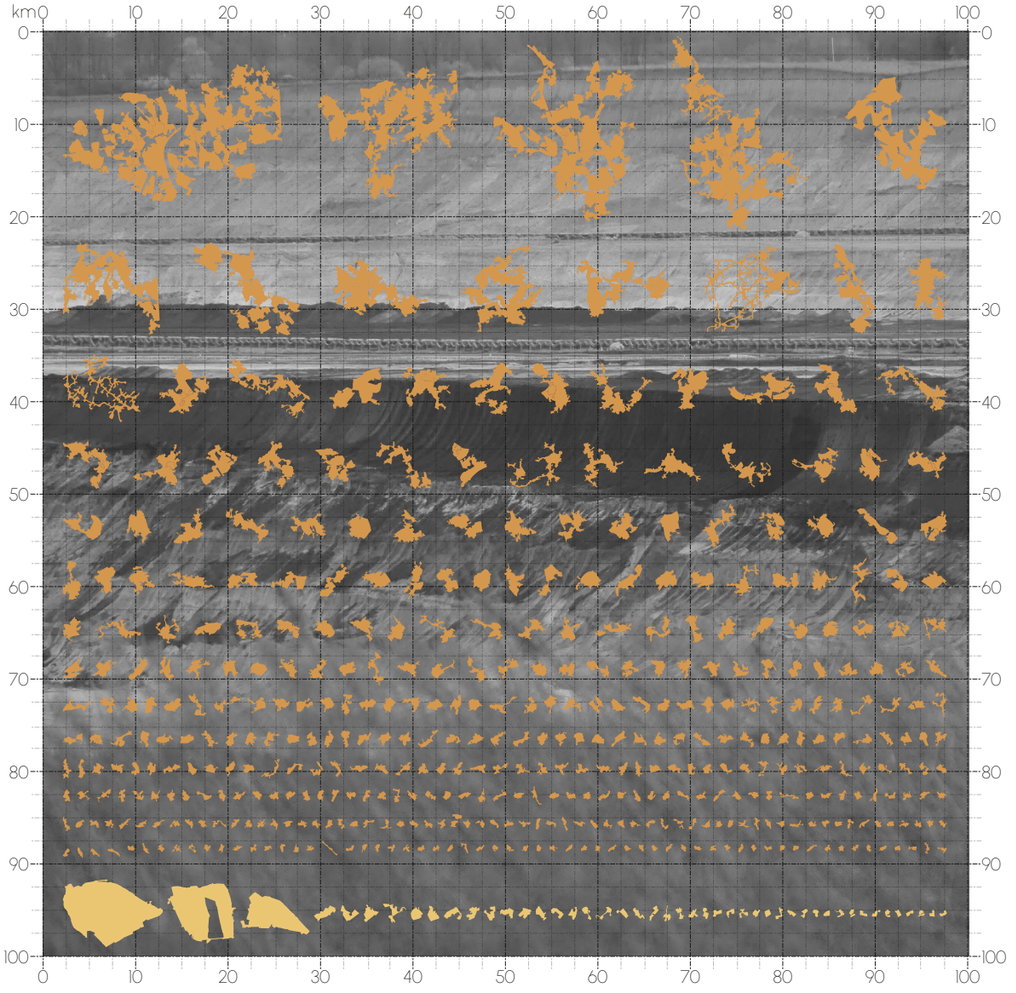
At the same time, the development of the soil and the impact the mining has had on the subsurface will also be leading in the future development of the landscape. This does not only concern the scarring of the mining pits, but also the pollution of the soils and the changing groundwater table.

However, it is difficult to determine the change of the subsurface throughout history. Therefore, we need to read the development of the subsurface through the changes on the surface.



4.4: Subsurface and surface Image by author based on Hilden (1977), photography Drosser (2006)

The impact of the subsurface can extend far beyond its borders. In the case of the Rhenish minescape, the creation of the lignite mines severely impacted the urban development in the direct surroundings. Next to the lignite mining in the area, Gravel mining also takes place, creating a collection of smaller mines, around 25 ha, Though the total of land use might be smaller in the case of mining, they impact all the urban environment, and more. Without the underlying lignite vein, this would not have been the case.



45: Comparison spatial demand and impact based on Copernicus Land Monitoring Service (2018)

4.3 A History of Lignite

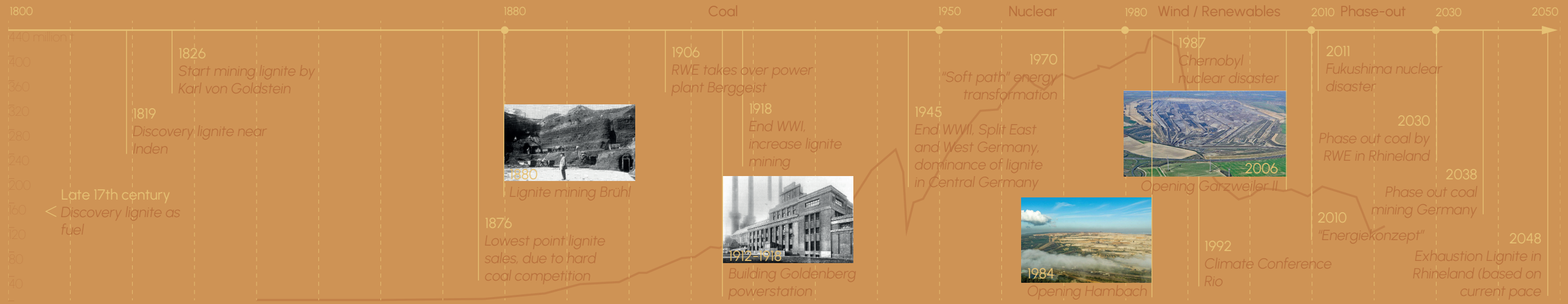
In the late 17th century, lignite was discovered as a fuel source. The wet layer of soil used to be a by-product of clay excavation and ceramic industry in Brühl and Frechen. These two towns (situated left and below Köln). The drying of lignite meant it became flammable and was dug up by landlords in the area using small pits, dried during summer into lumps, and then used as fuel or sold to poor residents of surrounding towns (Academic, n.d.).

Brühl remained a centre of lignite production after the Franco-Prussian war. Even more, from 1870 onward, lignite extraction became competitive in the region, led by industrialization and the introduction of steam-powered water pumps and mechanical briquette presses. The introduction of national and local railways improved connections between the mines and demand and allowed for more mines to be opened up (Academic, n.d.).

RWE already entered the scene around 1900. In 1906, they took over their first power plant. However, it took until the end of World War I for the cheaper lignite to compete with hard coal (Von Hirschhausen, 2018). From this moment on, RWE started to develop their own large lignite mines as well as power plants. Until 1930, RWE had built 4100 km of high-voltage cables. By then RWE had become the largest electricity producer of Europe (Von Hirschhausen, 2018).

This dominance is still visible, with RWE being the sole owner of the mines and power plants in the Rhenish Mining Area. This is in contrast with the central and eastern regions, where different companies own parts of the minescape. As the mines themselves are not owned by the government, the companies are also responsible for regenerating the minescape and, as such, can determine the future landscape (Sim et al., 2022).

From 1950 onward, an energy transition takes place towards nuclear energy. However, this transition was opposed by the coal and lignite companies, maintaining coal as a dominant energy source. After the nuclear disaster of Chornobyl in 1987 and combined with the oil crisis of 1971 and 1979, energy production shifted towards wind energy. To become less reliant on other countries and be able to phase out nuclear energy (Von Hirschhausen, 2018). Only from the Climate Conference Rio in 1992, the focus on renewable energy to phase-out fossil fuels became an important strategy in the energy system. In 2010, the "Energiekonzept" by Merkel was introduced to become energy neutral by 2050. This also included a phase-out of all nuclear energy (Von Hirschhausen, 2018). RWE expanded on this by planning to phase out lignite production in the Rhenish Mining Area by 2030. 8 years earlier than the other mining areas (RWE, n.d.-a).



4.6: A Timeline of lignite in Germany, based on Von Hirschhausen (2018), Evans (2016), LANUV, (n.d.), Baier et al. (2021) and Academic (n.d.)

image sources from left to right: Drösser (2006), Sim et al., (2022) RWE (n.d.-b), and RWE (n.d.-a)

4.4 Interpretations of the minescape

4.4.1 Artistic representations

The extraction landscape has been an object of interest for painters all throughout the centuries. These days, we might make more use of photography than paintings. Examples of this can be found in the work of Daniel Chatard (2017-2023) or Jordan's Antonia Schlösser (2019) Nevertheless, the mines remain an object to be represented.

When we look into the past, the central point represented in the work was the landscape and its destructive nature. Dark colours are used to represent the polluting nature. An interesting work is the drawing at the left, which highlights the deforestation with attention for the soil. Wolter's work focuses not only on the mines themselves but also on the complete landscape. It projects the dark power plants in the background. Even his work on a "sunny day" focuses on cool tones.

An outlier is the work of Spira who uses warmer tones. While he does not project the whole landscape but instead focuses on the immense scale of the landscape and the speaking colours and contrasts.

In the more modern photography, we can see the work shift towards more social engagement. Schlösser and Chatard highlight the minescape itself, the interaction of humans and the mines as well as the influence of the mines in the landscape. At the same time, their work also projects the extensiveness of the landscape and its eccentric character.



4.7: Collage of paintings, work by Spira (2000), Wolter (ca. 1925b), LWL-Medienzentrum für Westfalen (1920), Chatard (2017-2023), Wolter (ca. 1925a) Schlösser (2019)



4.8: Historic landscapes: Work by Unknown artist (ca. 1700), Kraus (1832) and unknown artist (1839)

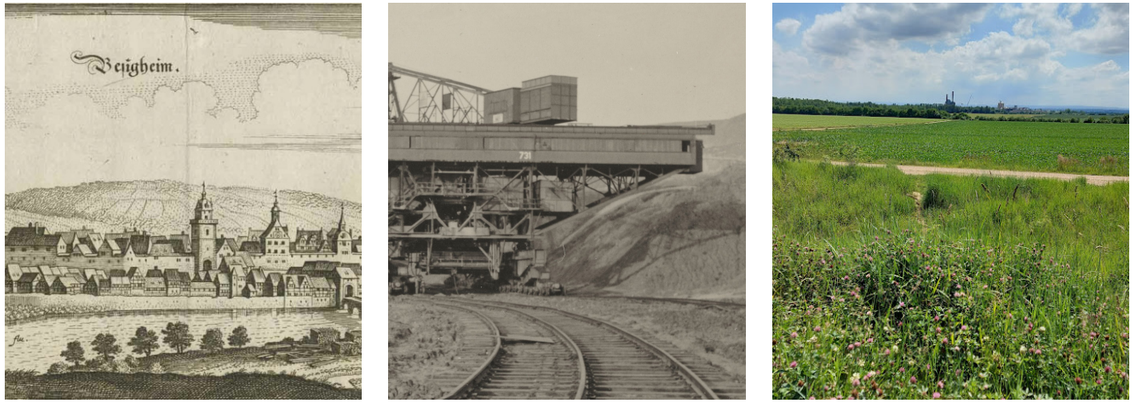
4.4.2 Historic landscapes

On the left we see historic drawings from the Rhineland area. The industrialization of Köln, the small rural church towns and the historic forests and hill landscape. These images give an idea of the type of landscape the minescape was placed into. While there is a port visible in Köln the dominant economy was that of agriculture, this change to an industrial economy was driven by the mines. at the same time, the mines needed space, which led to the loss off natural spaces. At the same time, these larger settlements would not have to make space, as there was no large-scale planning or management.

4.4.3 Mine reclamation

Interestingly in the landscape of the Rhenish minescape is that we can see all steps in the traditional mine reclamation process. There are small spaces slowly emptying out to be transferred into mines, there are the open pit mines, and there are the mines that have been filled and are now being used either as agricultural land or have been given back to nature.

Bergheim is an example of a mine that has gone through the complete transition. From rural church town, to open mine pit, dominated by industrial tools, to agricultural land. Where you can see the shapes of the old mines from a satellite view, from the ground it seems a normal natural environment.



4.9: Bergheim over time, Work by Merian (1645), Unknown (ca. 1954), Wronna (2022)

4.5 Historic landscapes

1836 - 1851

During the Prussian empire, this part of what we now know as Germany was focused on agriculture. Throughout the landscape are three main water structures, with the Rhine being the largest. Around the Rhine there are the most urban developments. A canal formed the main transport connection from Dusseldorf to Monchengladbach (North of the map).

There are some railway lines, but these only connect cities. In the Southwest, we can see large natural areas that are not used for agriculture. This can be explained due to the poorer soil and height differences in this part.

Surrounding the rivers there are two main green axes. These, over time, will become the main places for lignite mining. A logical transition, as these spaces had no other human function yet.

Overall, we should consider that there was less pressure on space. As such, humans could pick the spaces that were easiest and most suitable to develop.

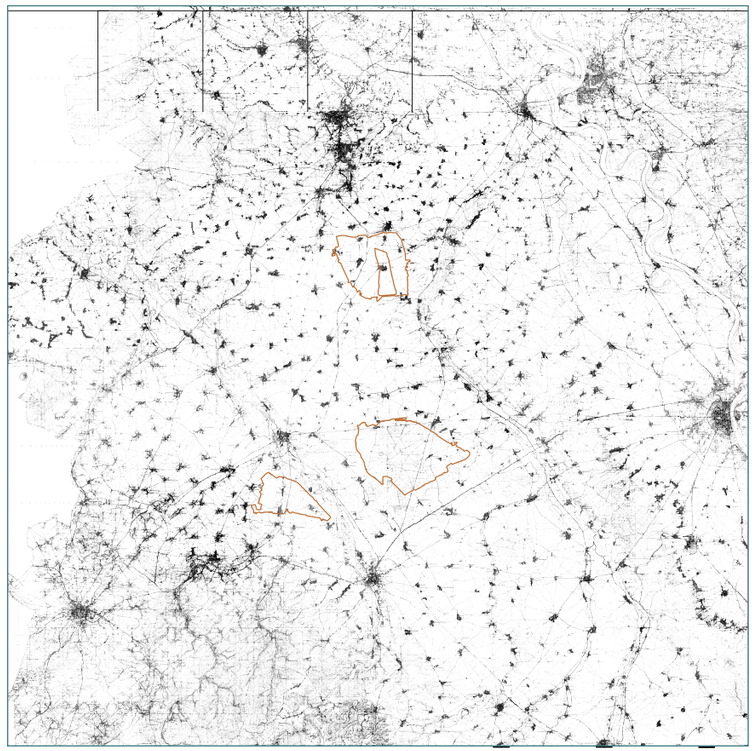


4.10: Historic map 1836 - 1851 (Bezirksregierung Koln, n.d.-a)

1891 - 1912

This time period shows the first lignite mines in the South-East of the map. The cities are still relatively small, and we can see different small settlements in the area. The mines are closely situated near the urban environment, as they are created by landowners from these settlements.

Although forests are still clearly present, an increase in agricultural land has been at the expense of them.



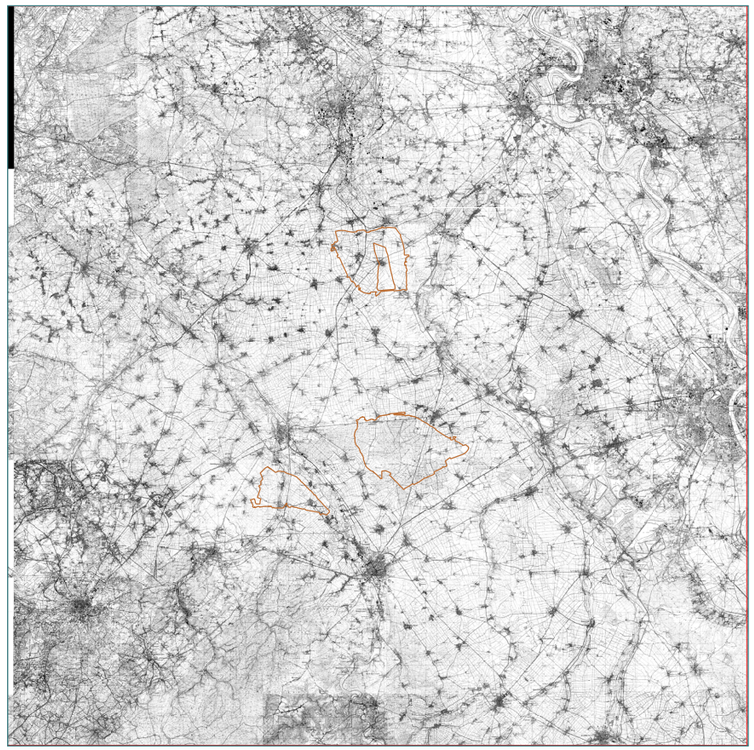
4.11: 1891 - 1912 (Bezirksregierung Koln, n.d.-b)

1936 - 1945

These maps show the radical industrialization the area has gone through. More small mines are introduced into the area, in the East these are called the Vereinigte Ville. In the West we can see Zukunft, which over time will expand into Inden I and II.

There is a strong reduction of natural areas and an increase in railways. On top of that, we can see different industrial areas. These are centralized either around cities and port areas or mines. All are connected through railways. This highlights the central role the railway system had in transforming the economy.

The railways also change the landscape. Whereas first only the rivers formed the main barriers, now the railways can only be crossed in specific places. At the same time, they also improve the connectivity of larger settlements. From an urban perspective, we see the development around the rivers as well as the increase of small settlements.

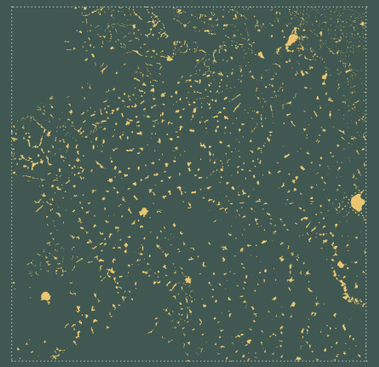


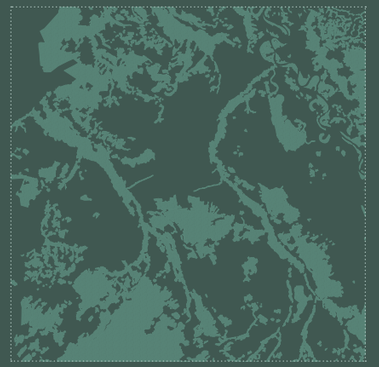
4.12: 1936 - 1945 (Bezirksregierung Koln, n.d.-c)

1836

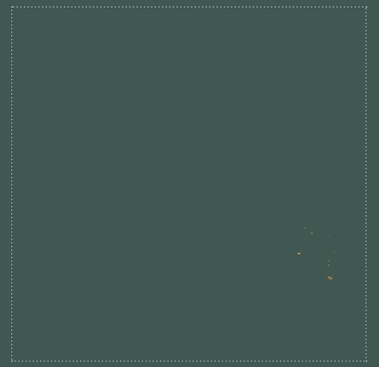




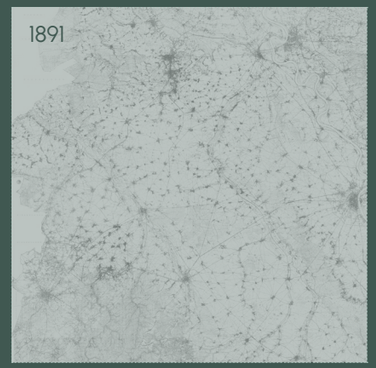


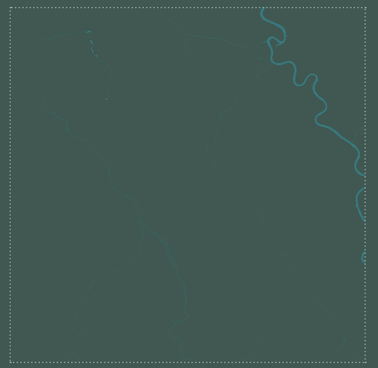


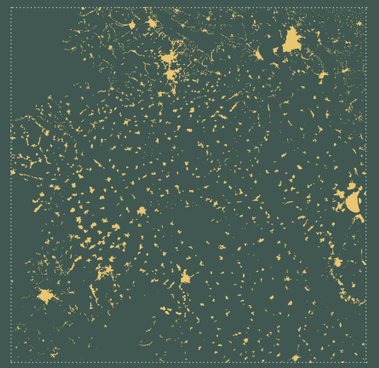


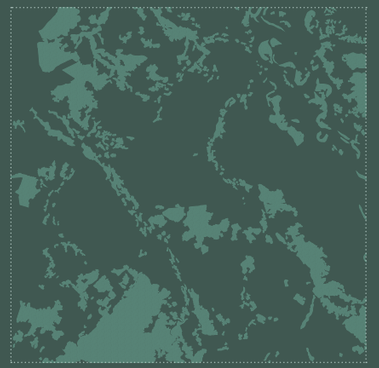


1891

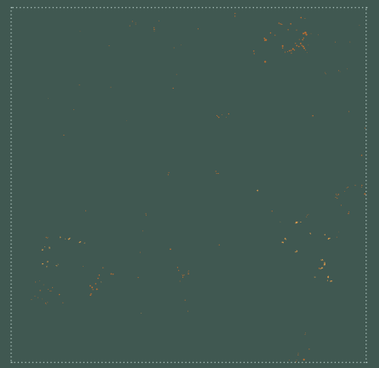




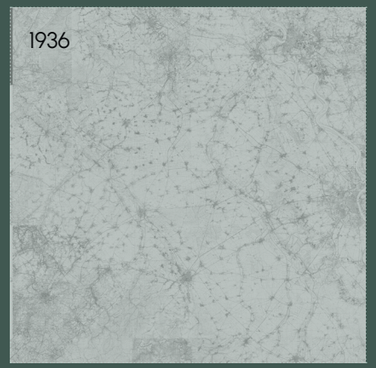


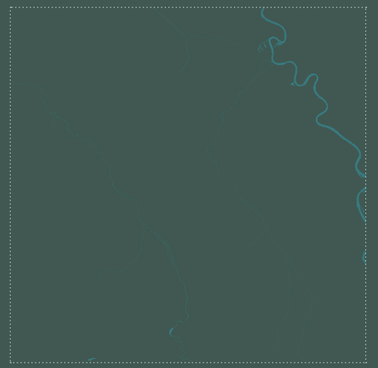


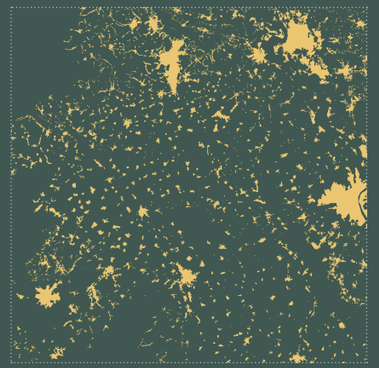


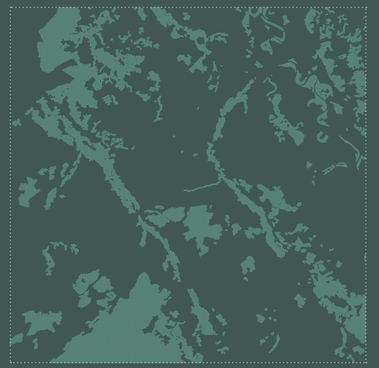


1936

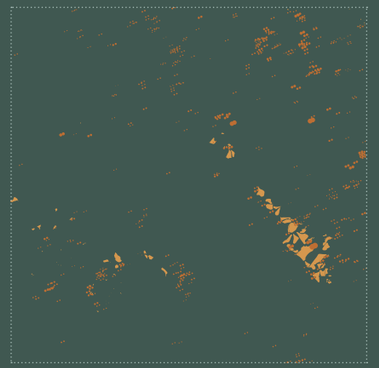












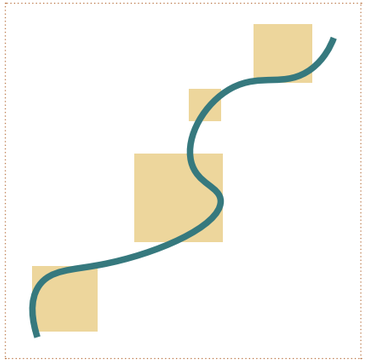
4.6 Types of development

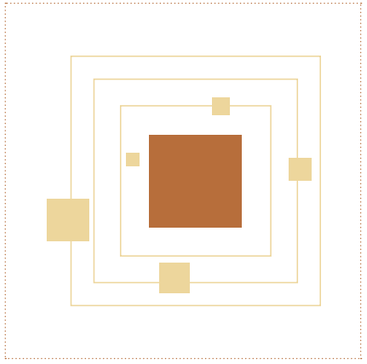
These diagrams explain the main typologies of the development of urban, land use, and industrial sectors.

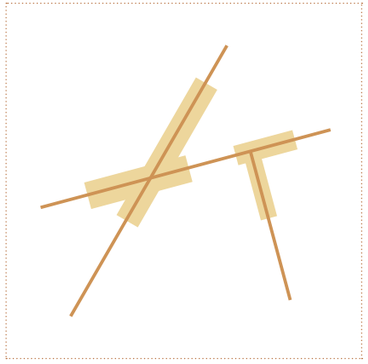
When it comes to the urbanization, we can see the main development occurred around the Rhine, this was a main transport axis, which also located the development of most industries. As such, the Rhine drove the urbanization. Next to that, we can see that though they grew slightly, larger urban cores in the area decreased in growth after the introduction of the mines. Instead, most development took place around roads where separate farms and housing were connected over time into towns.

In addition, we can see that natural areas have had to give way over time to agriculture and mines. When mining activity ceased, the mines were replaced by agricultural land or lakes.

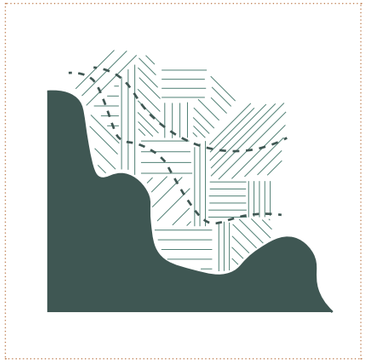
Lastly, there is the development of industries. Just as with urbanization, this mainly took place around existing rivers, but the introduction of railways also led to new areas with more land inwards being further developed, such as Mönchengladbach. Lastly, we can see some industrialization around the mines. Though it is difficult to see, these seem related to the excavation, such as refineries or power plants.

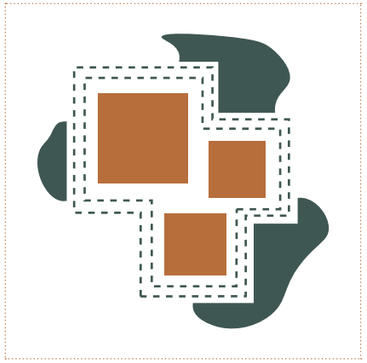


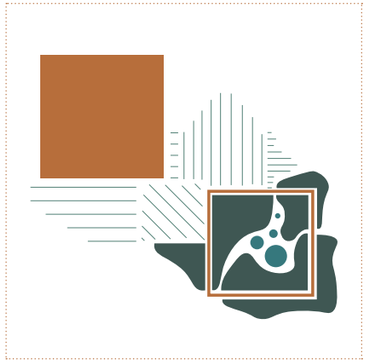




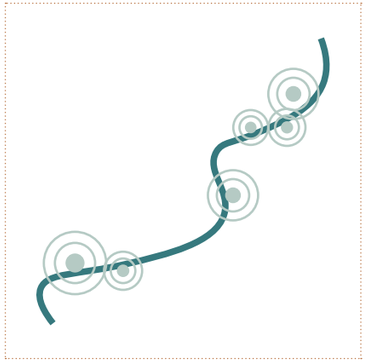
4.13: Urbanization patterns

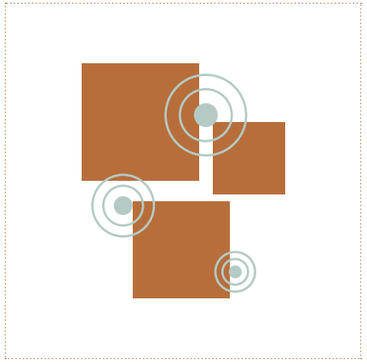


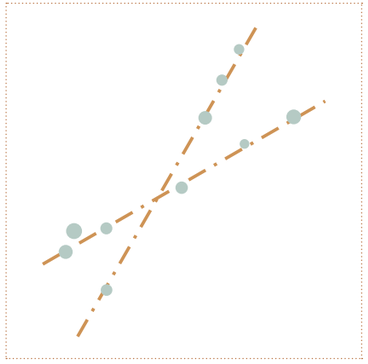




4.14: Landuse patterns







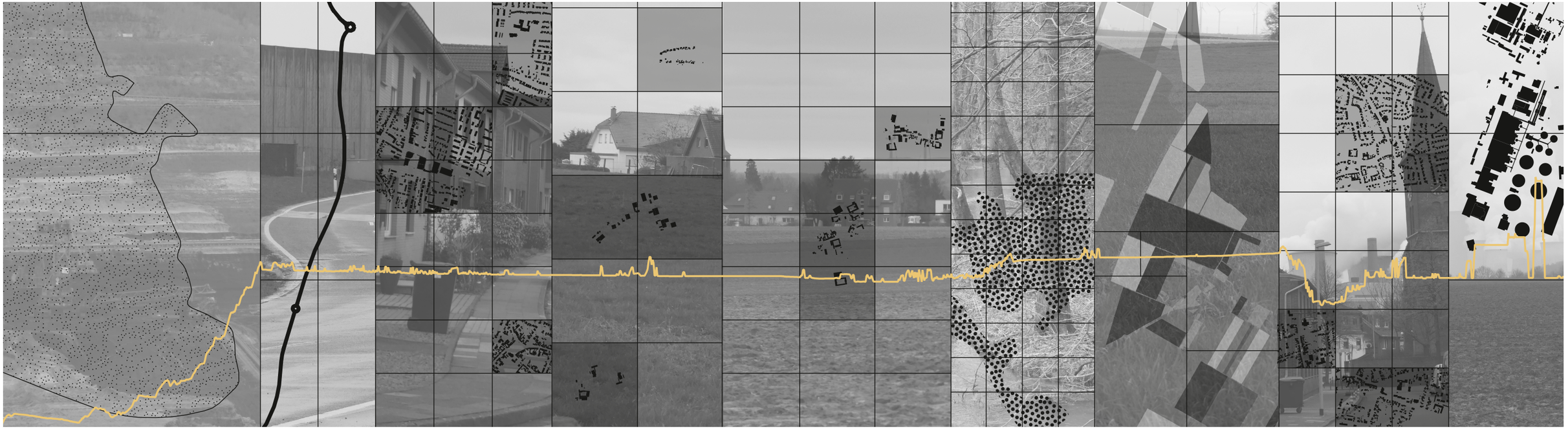
4.15: Industrialization patterns

4.7 Scales

Due to the mines, the area not only has an interesting topography, shaped by humanity from a flat to a diverse elevation, but also a large variety in scale of the landscape. Moving through the area, from mine to the urban environment, we come across different areas, each with its scale, patterns, and spatial characteristics.

While the mines might seem dominant in the landscape, they are situated lower and only comprise a small part of the landscape. However, their scale makes their presence and transition influential. At the same time, the urban areas all have a small scale; most settlements are small, have low, independent housing, and are surrounded by agricultural land. This agricultural land has a larger variety of sizes and, as such, scales. Wetlands and natural areas are the smallest scales. Their forests enclose the visitor, creating a silent and compact environment.

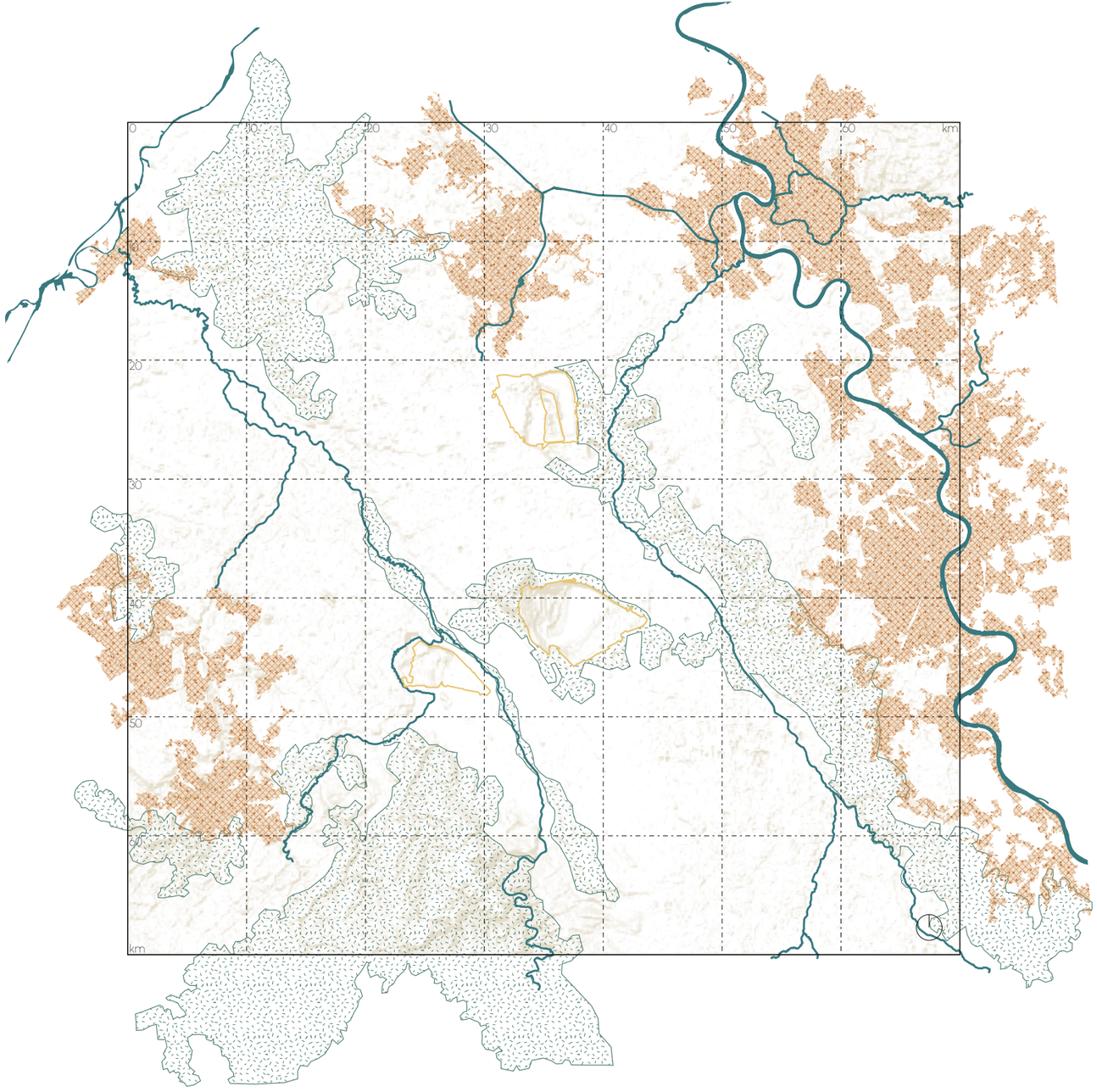
At the end of the section, we can find the power plants. These giants in the landscape are high and spread out in the area. The spatial footprint of the power plants is that of a town. Combined with the closed buildings, they have a large scale.



4.16: Spatial scale in the landscape

4.8 Overview

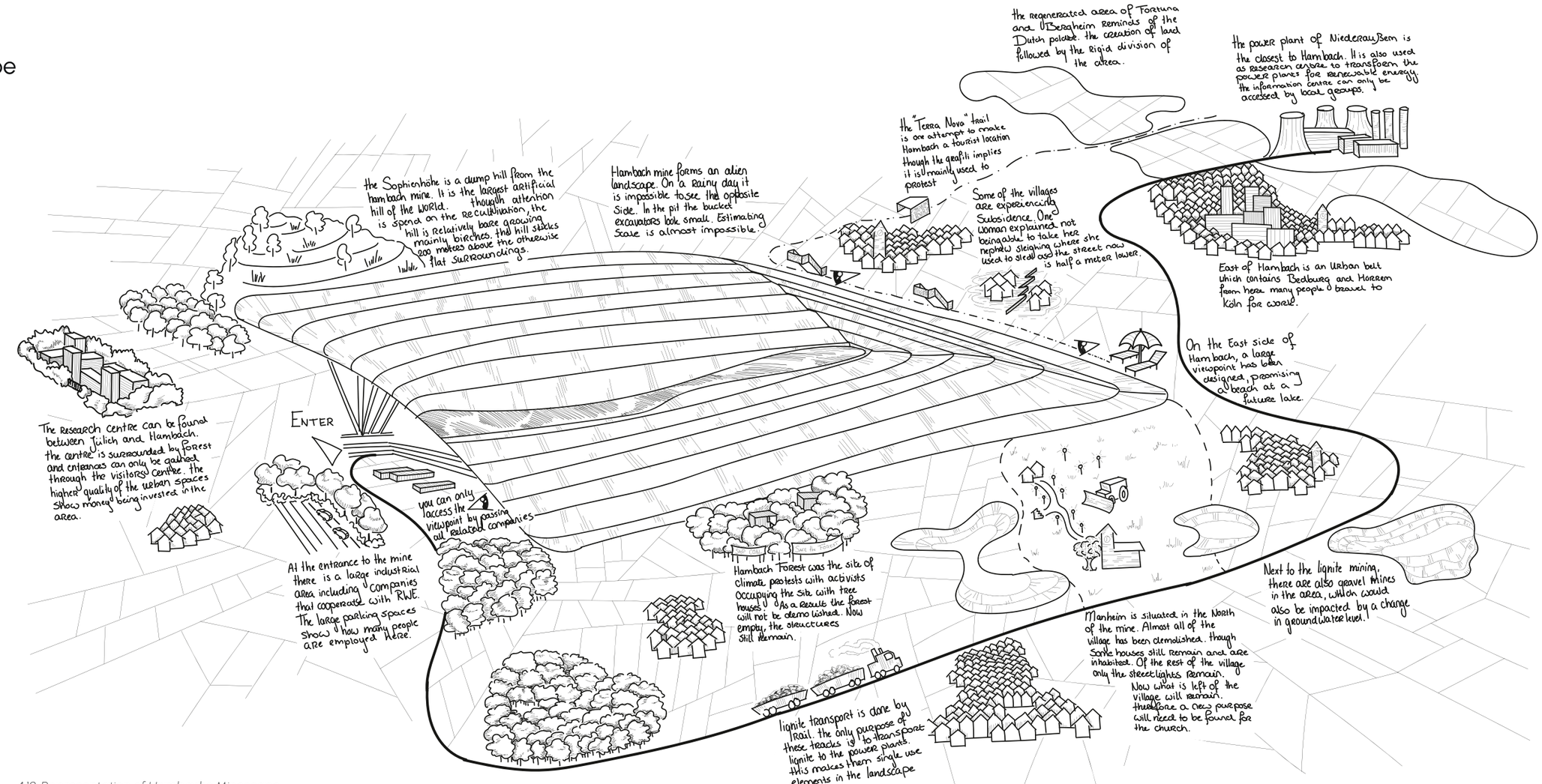
Throughout history, we can see the landscape change based on natural circumstances. The soil in the South-East is significantly less fertile than in the rest of the area, in combination with the uneven landscape, this area was left mostly natural, while the rest of the landscape was developed into agricultural land. At the same time, the Rhine became the backbone of the urbanisation in this area locating both Dusseldorf and Köln, their respective industries and ports.



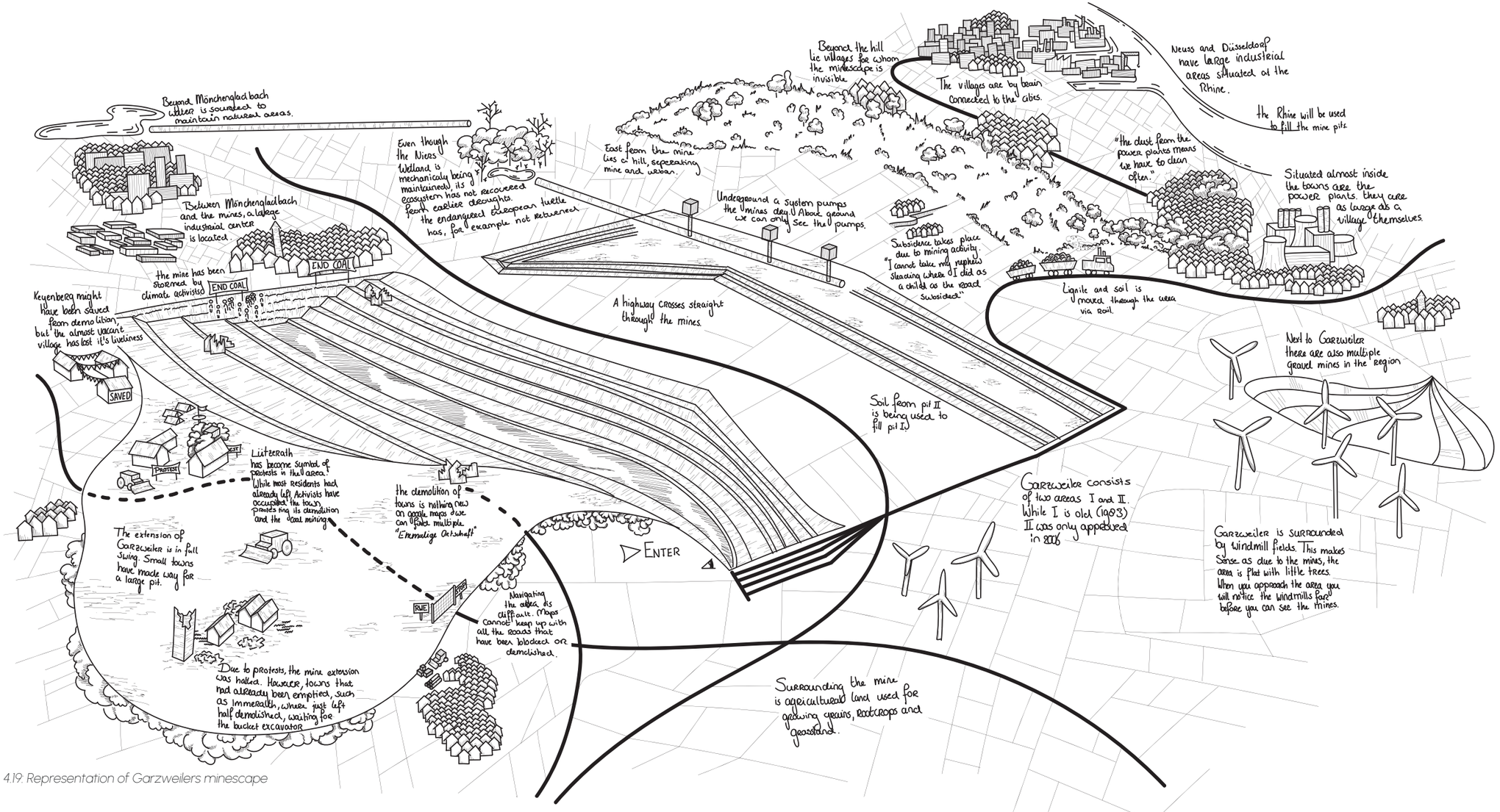
4.17. Key elements of the landscape based on Allen, (2005), Copernicus Land Monitoring Service, (2018)

4.9 The soft landscape

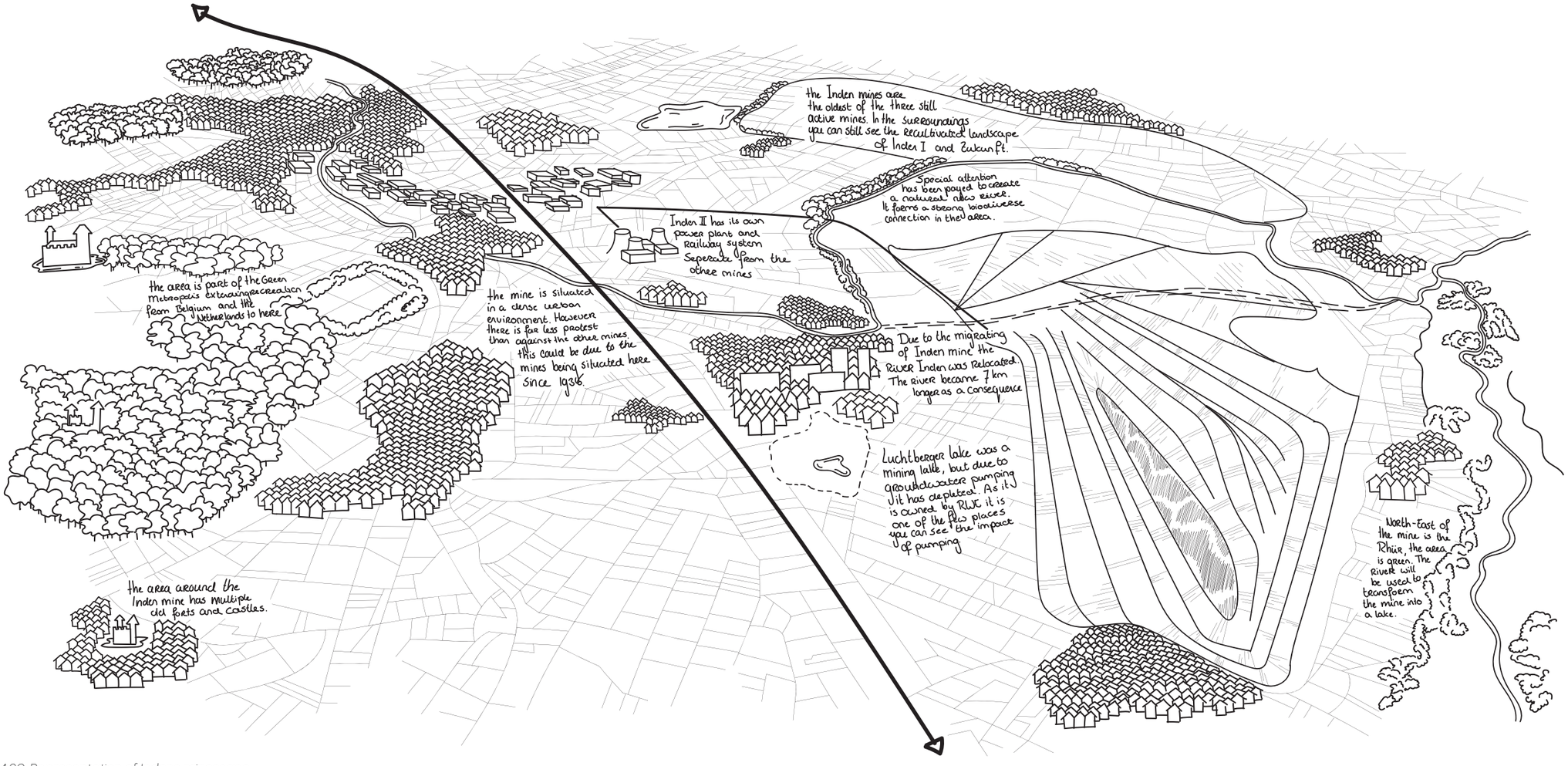
As discussed, the minescape does not only focus on the physical elements of the landscape. It also concerns the intangible socio-economic and cultural dimensions. During my fieldwork, I strived to capture these relations through conversations with local residents (Appendix G). Together with my experiences, I have mapped them in the following drawings.



4.18: Representation of Hambachs Minescape



4.19: Representation of Garzweilers minescape



4.20: Representation of Indens minescape



5. Transitions

The transition of the minescape towards an inclusive energy landscape is composed of different future trajectories. Central in this is the role of energy. In this chapter I uncover the scenarios created by different energy production methods. The chapter questions the spatial impact of these new production methods and the systemic changes. Through the creation of different scenarios four future trajectories will be determined, in which I focus on the symbiotic relations brought on by these transitions and their conflicts. Using design strategies, I will integrate the different systems, creating an integrated energy transition.

5.1: Hambach mine

5.1 Trends in regeneration

Looking back at different regeneration strategies for minescapes and wastelands, we can see different trends (Appendix D). The main ones being:

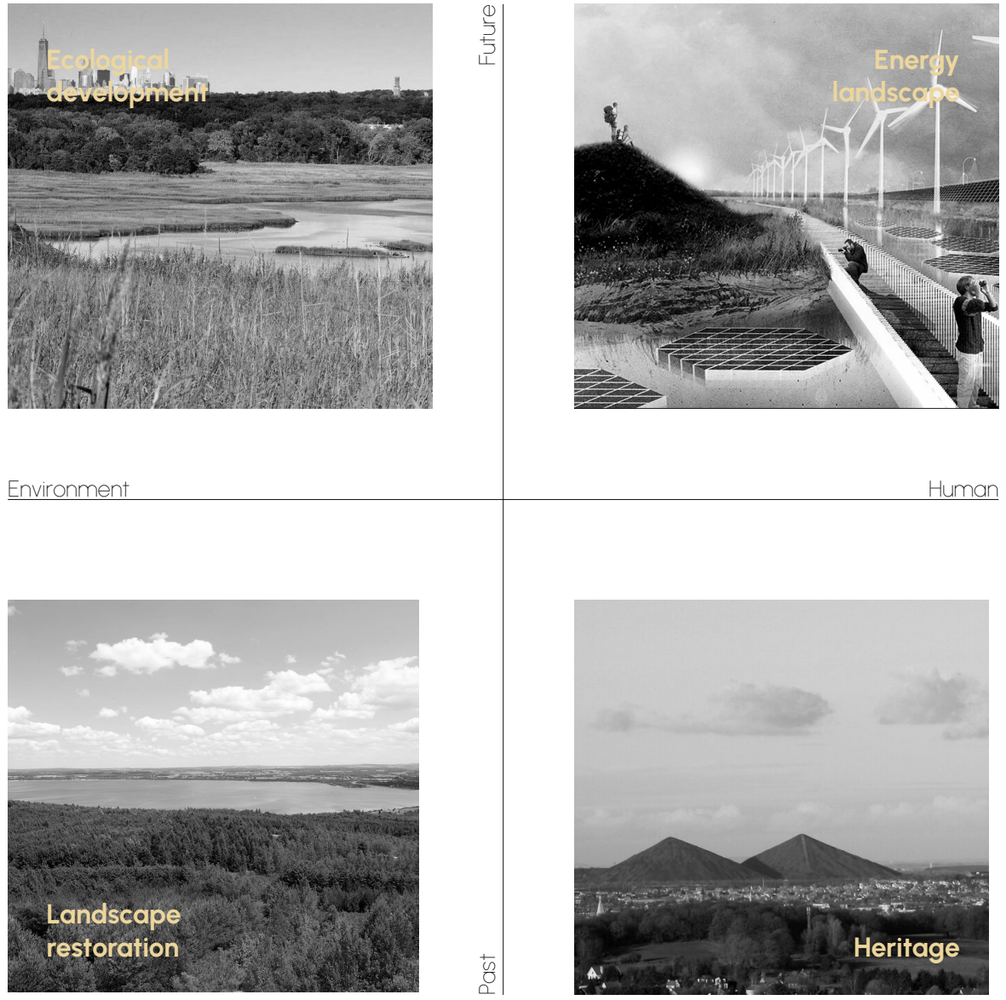
1. The establishment of the area as a heritage site, often accompanied by leisure activities.
2. The filling of the area with soil to reuse the land again for agriculture.
3. The creation of lakes and natural areas, meant for both natural recultivation and leisure. Often part of the area is filled with soil and part of the pits is transformed into lakes.
4. The recovery of the landscape through phytoremediation and ecological redevelopment. To allow humans to use the space for leisure and nature to slowly take back this space.

Of this strategies, 2 and 3 are similar, with both strategies focussing on the restoration of the landscape to an earlier state. 4 in contrast, also focuses on the environmental restoration, but from a future perspective: To create a new ecosystem. Strategy 1 sees the landscape as both human and part of our history. As such it is situated in the past and focused on humanity.

These trends are relatively older and have up until now served us well. However, these interventions stem from a different time. These minescapes were closed because they were exhausted, not because we wanted to transition to different energy sources. This leads to two different consequences. First off: it will not be possible to fill up the area with soil again as this soil was harvested from new mines that were opened. Secondly, the closure of these mines also means a loss of energy, which would not have been the case in the closure of the old mines, as new mines would be opened.

To be able to tackle this last question of energy, a new trend arriving in regeneration is the creation of new energy landscapes in the existing minescapes. As such, the land would be used efficiently again, the energy question could be partly solved, and a new purpose could be found for the area.

As this trend is relatively new, we have little experience on the effects different energy production methods would have on these new landscapes and how we would be able to integrate them. Therefore, in this chapter, I will be focussing on the possibilities different energy production methods generate.



5.2: Matrix of change , images by Cavollo (2017), FABRICations (n.d.), Vincentz (2012) and Mission Bassin Minier (2009)

5.2 Trends in energy landscapes

5.2.1 Imaging of renewables

Based on the Sijmons there are three types of energy: Heat, Electricity and Fuel. These lead to different energy landscapes. Next to that, there is the network and storage of energy, which has its own footprint and landscape (Sijmons, 2014). In this thesis I focus on electricity and heat. It is important to note that these two types have a different infrastructure. Currently, Rhineland has an electricity-based system; thus, changing towards a heating system might be costly, demand a larger spatial impact and create more waste materials.

In our enthusiasm for renewable energy, we often forget the physical impact and burden on the direct surroundings of these renewable energy landscapes. Though as a whole, the impact is lower on the environment and surroundings, the larger spatial area needed for these production methods creates its own form of resistance (Sijmons, 2014).

The collage highlights the main renewable energy landscapes such as solar, wind and nuclear, but also geothermal, waste incineration, biomass, aquathermal and hydropower. Central in this collage I placed an image of the current lignite mines in Rhineland. These images are taken under a clear blue sky or at golden hour, giving these green, beautiful pictures. This gives the idea of a clean, green future without any negative consequences. However, the lignite mine at the centre also shows a beautiful landscape, with a blue sky, green recovering landscape and a mystic atmosphere. The earlier chapters have shown that this is only a question of imaging and that this is not the actual spatial impact. As such it is good to be critical of these kinds of images. For each green agricultural field with windmills, we lose production space and gain a new soundscape (Appendix C). Hydropower is noisy as well. Waste incineration creates smells and cannot be positioned near cities. These are only some of the burdens carried by the surroundings. Therefore, we need to be critical of this imaging of renewable energy landscapes as a perfect solution, and instead also look behind towards the system involved to create an inclusive transition.



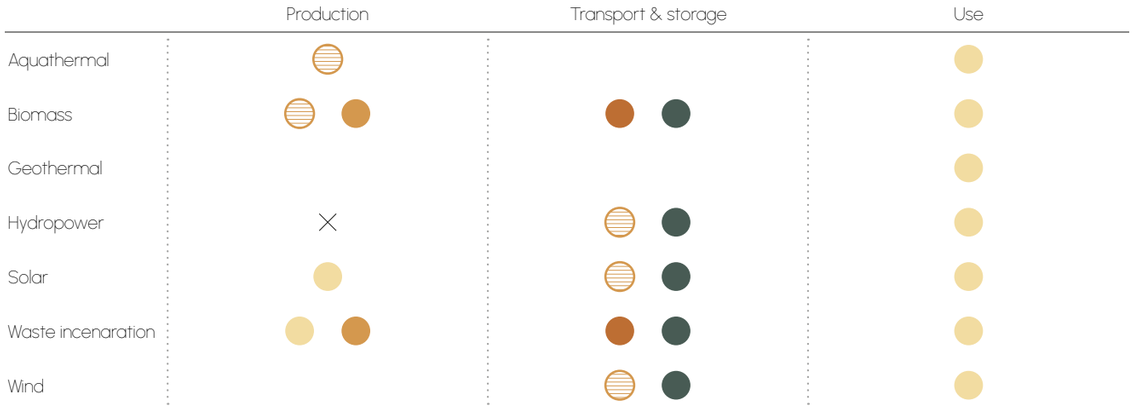
5.3. Collage future energy production landscapes Spectroscopy (2019), Getty & abadonian (n.d.), DBDH (n.d.), GETTY (n.d.), RWE (n.d.-b), Souvant et al. (n.d.), Copernicus (2022), Shale Magazine (n.d.) and Adobe Stock (n.d.)

5.2.2 Changes in use

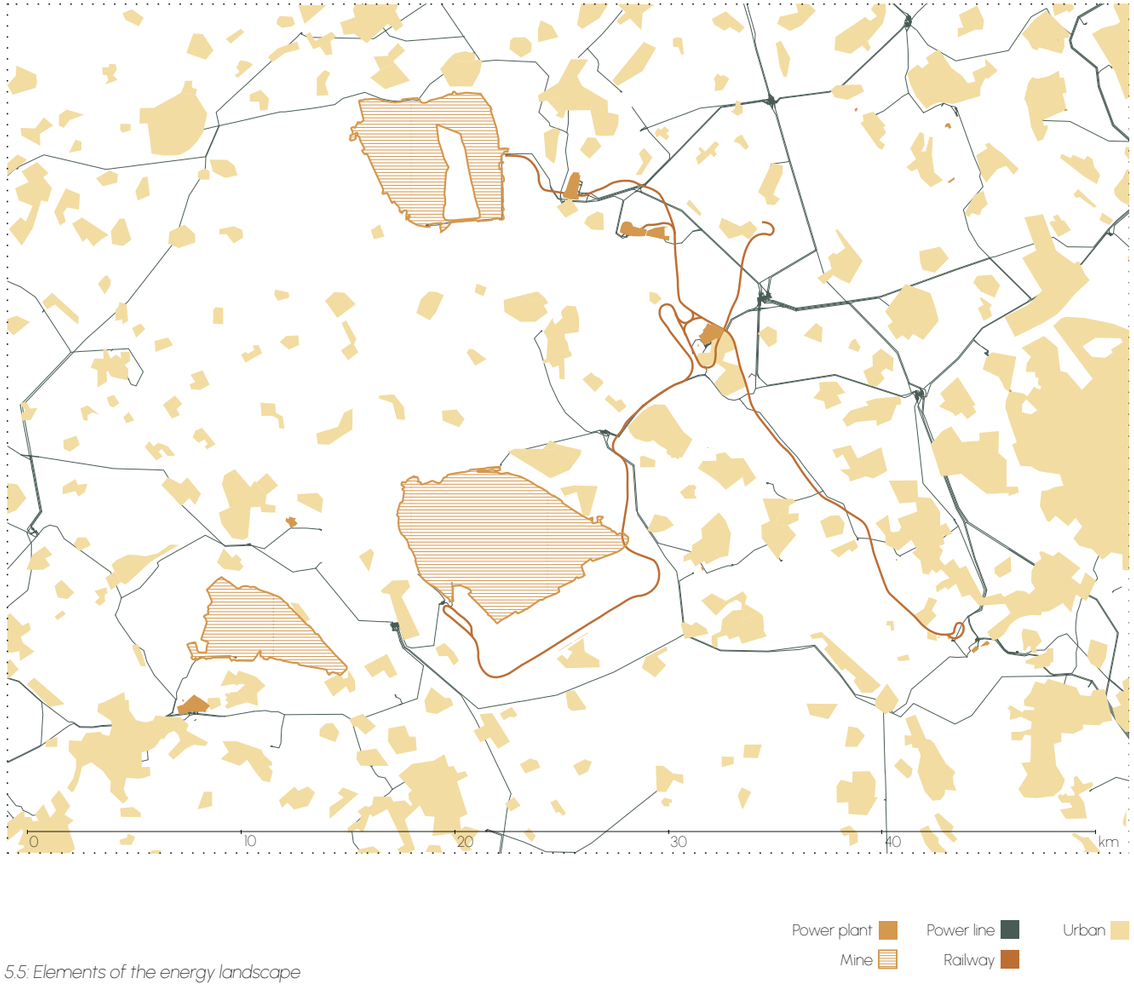
Changing the method, we use to generate energy changes the energy landscape. This can be explained by the different production, transport, and use methods. In other words, there is a different emphasis on the three main elements of the energy landscape: production, transport, and use. This paragraph highlights which elements of the current lignite energy landscape could maintain a function in a future energy landscape, dependent on which production method is implemented.

An important change in the energy landscape is the form of storage. Where we used to store raw lignite or lignite bricks in silos before use, now we would need more, and different forms of storage to compensate for the time and weather dependency of renewable energy sources. The mine pits could function as storage instead of the centre of production in some renewable landscapes.

Secondly, here we are mixing energy production methods for electricity and heat. The power generation of lignite focuses on generating electricity; thus, the infrastructure is based on spreading electricity. Therefore, creating a heat-based energy landscape would also need a completely new network to divide the energy among the users.



5.4: New use of elements of the energy landscape

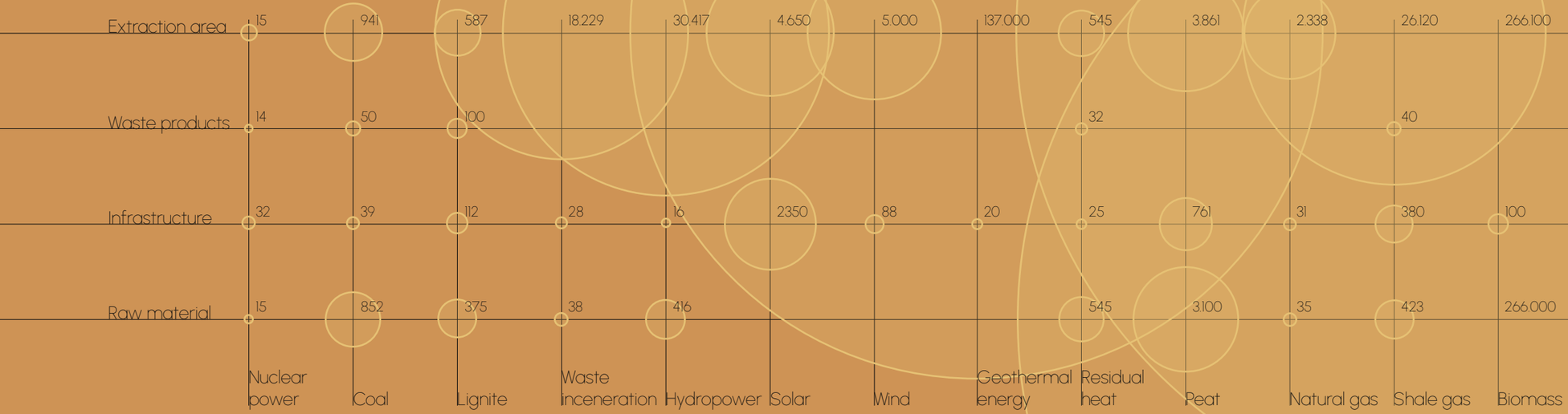


5.5: Elements of the energy landscape

5.3 Spatial demands

The energy transition is paired with a change in spatial demand by the energy sector. Where coal, lignite and gas have a relatively small extraction area, that of wind energy, solar energy of hydropower is larger. Geothermal energy and biomass even take in over ten times the extraction space.

This change in spatial demand should be considered in the design. Depending on the production method, the space needed for the new energy system might extend far beyond the borders of the existing minescape.

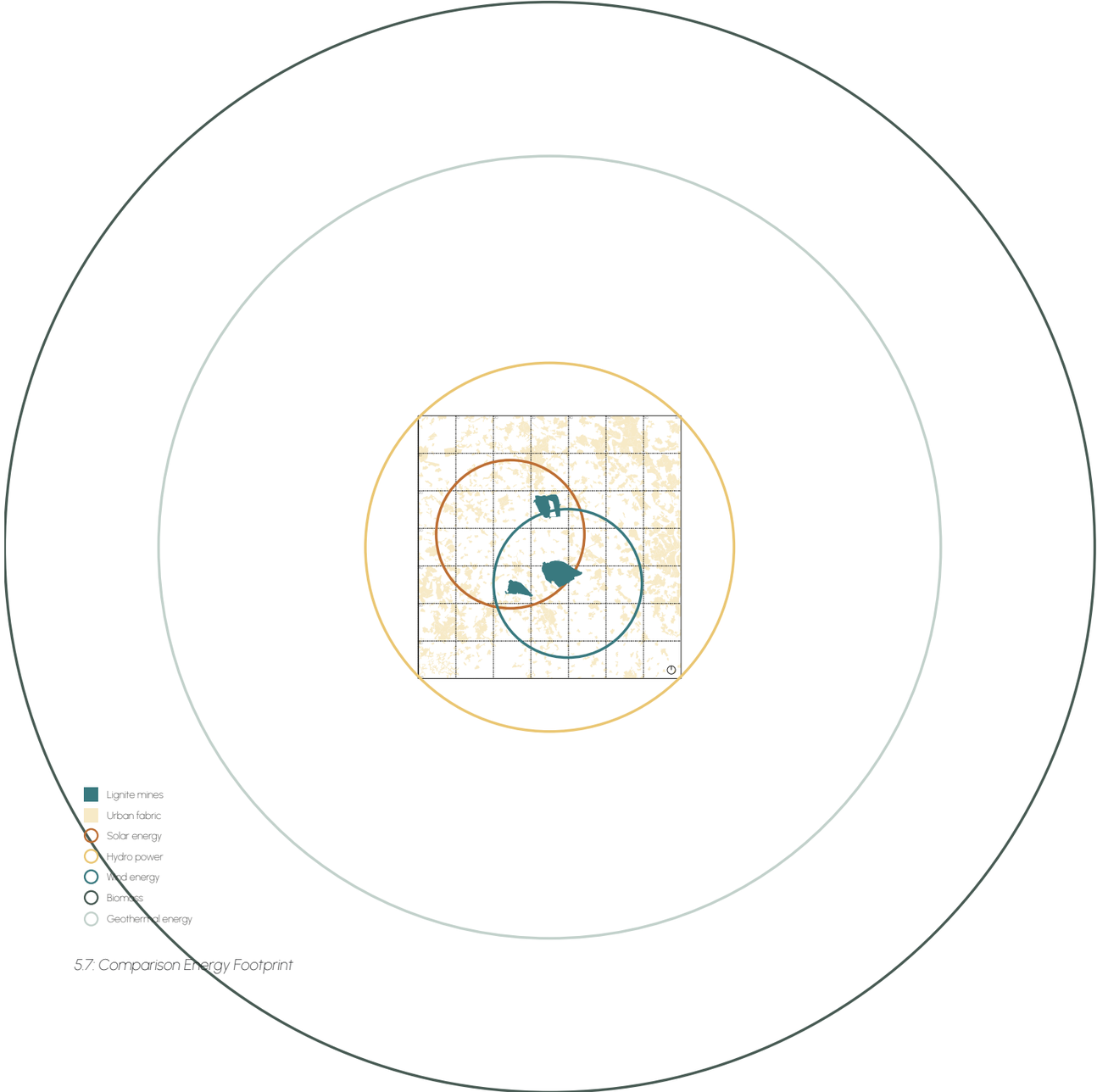


5.6: Adapted from Sijmons (2014)

The current mine surface area is larger than the extractive area. The scarring the mine leaves behind is mapped as mining area while it effectively does not produce any lignite. Therefore, making a space comparison should be done through the amount of energy produced from these mines, and thus in the power plants of this minescape.

As visible in the map, it will be impossible to compensate for the energy production using just the mining surface. However, through efficient use of the entire minescape, it might be possible to compensate for the complete energy gap, or at least most of it.

Reasonably however, it will be unlikely to compensate the complete loss of the energy from the mines in the direct area, and some will need to be compensated in other areas.



5.7: Comparison Energy Footprint

5.4 Landscape potential

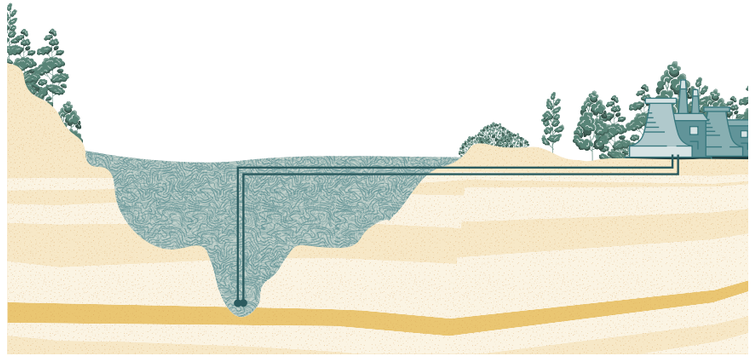
When we focus on the inclusive energyscape we would need to define what qualities of the landscape would make this area suitable for renewable energy production.

The Rhenish Minescape became an energy landscape due to the presence of lignite, but since this is not the focus of the energy landscape anymore, what would make this area suitable for renewable energy production.

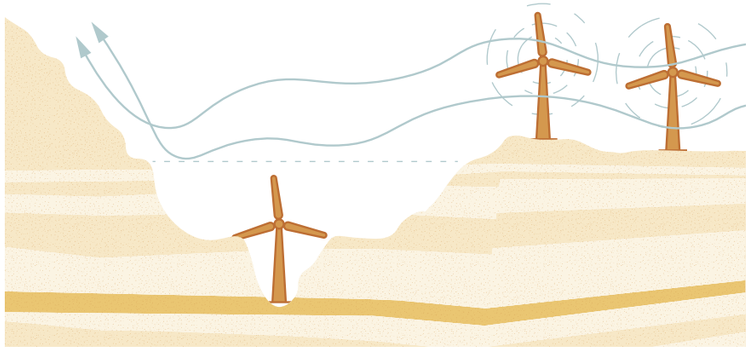
This chapter explores the potentials of the landscape and in which way it can help rediscover the energyscape based on different renewable production methods.

5.2.1 Aquathermal energy

The current plan for the mines is to flood the open pits by extracting water from the Rhine. This process would take over 30 years to be fully completed. But the large mass of water would be very suitable for aquathermal energy. By extracting the heat from the lake, the lake would not be as suitable for ecological regeneration, but it would create a stable source of energy that is less seasonal dependent.



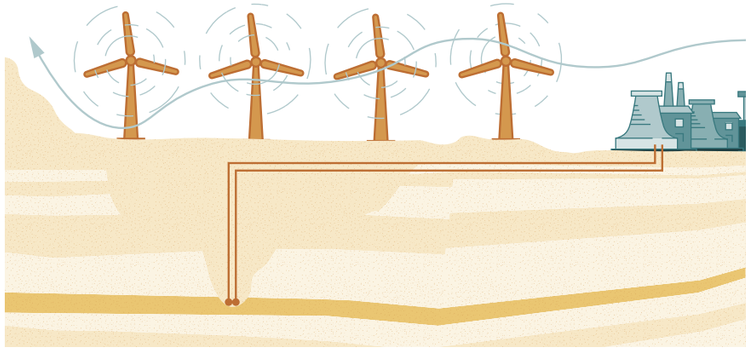
5.8: Aquathermal energy



5.9: Wind energy

5.2.2 Wind energy

In Germany, farmers often use agricultural land to place windmills. Germany has a high potential for wind energy, and so does this specific area. However, wind energy needs both space and an even landscape. Consequently, the mines themselves would not be suitable to produce energy. Instead, the agricultural land in the minescape would be placed central in this energyscape.



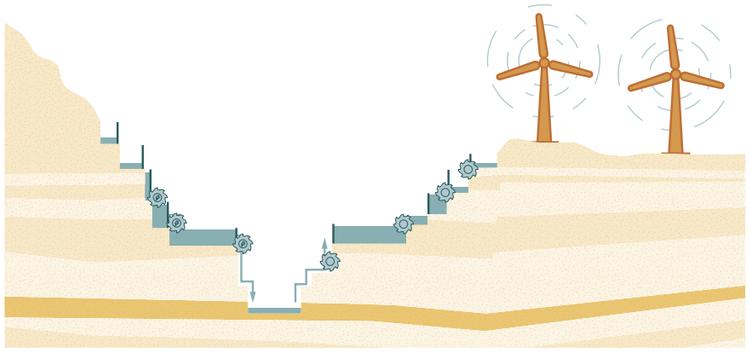
5.10: Wind and geothermal energy

5.2.3 Wind and geothermal

In cases where the mines would be closed, the large new surface area would be highly suitable for wind energy. Reusing the pits of the mines before closing to place geothermal energy could even create a double energy system in this energyscape. However, this scenario would need substantial amounts of soil, and the reality of this taking place is low. On top of that, except for the reuse of the pit and the power plants, I would not see this as a plan exploiting the potential of the minescape.

5.2.4 Wind and hydropower

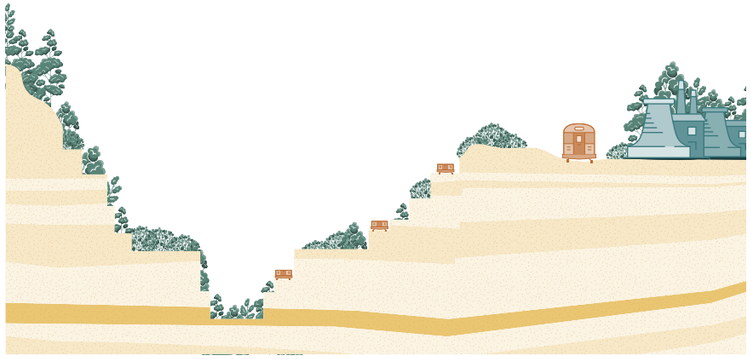
One of the main problems with renewable energy is their seasonal and weather dependency. A solution investigated by Sijmons (2014) is to use the depth of the mines to create different water levels, using the mine as a battery. The water will be moved up in times of energy excess. When needed the water will flow down generating hydropower and allowing energy to be generated independent of the season.



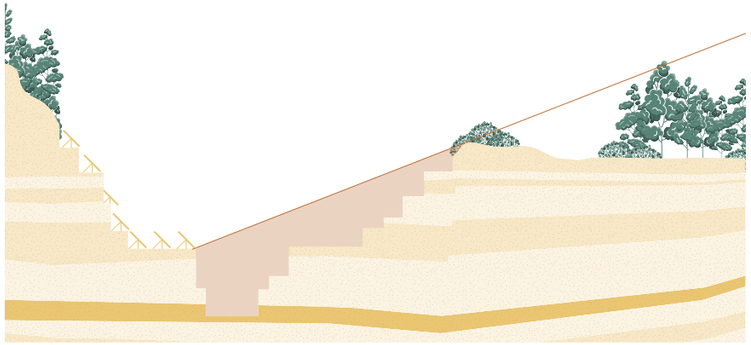
5.11: wind energy and hydropower

5.2.5 Biomass

Using the mines for the growth of biomass might create both a pleasant green environment as well as an effective reuse of the existing infrastructure and power plants. However, the plants used in this area should be carefully designed, as shading will significantly influence them. Next to that, this solution would not have enough energy to compensate for the loss of the mines. It would, however, create more jobs than a solar field. Lastly attention should be paid to the pollution and acidification of the soil about the burning of the plants.



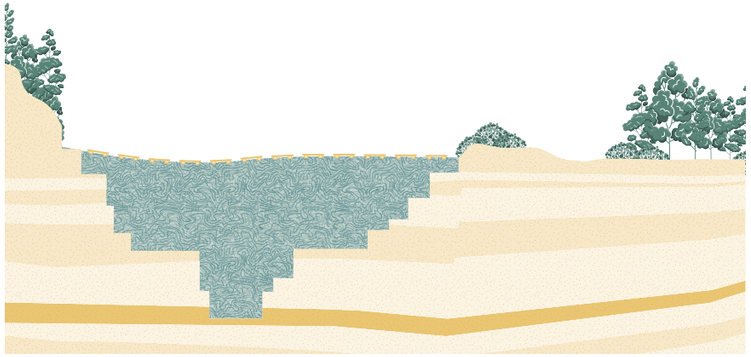
5.12: Biomass fuel or energy



5.13: solar energy

5.2.6 Solar energy

The mine pits lend themselves to solar fields. However, the amount of shading caused by the walls would part of the mines unsuitable. At the same time, if the walls are oriented the right way, they might also be highly suitable. Thus, combining solar energy with other functions might be ideal.



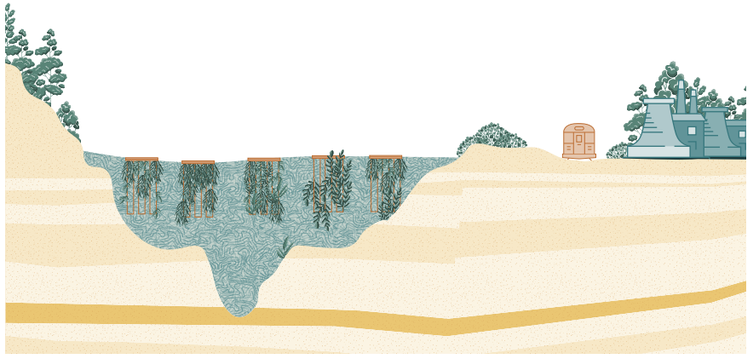
5.14: Solar energy lakes

5.2.7 Solar lakes

This strategy would follow along with the existing plans of the regeneration of the mines. Using water from the Rhine to fill the mines will take between 40 and 60 years (Guns, 2024). However, instead of creating a recreational lake, of which the usage would not be guaranteed due to acidification, the lake would form the surface of a solar lake. The water will help cool down the panels and reflect light, thus optimizing their function. It would reduce light and thus liveability of the lake, but due to pollution the lake might be unliveable anyhow.

5.2.8 Algae (fuel)

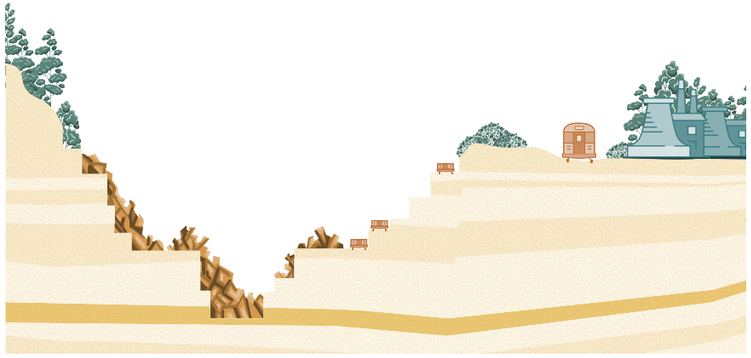
In this case, it would be possible to create a living lake. Instead of giving this water body back to nature, it could be used to grow algae as a form of biomass or fuel. This way the infrastructure could be reused while the refineries and power plants could be transformed to fit the new energy system. However unlikely this transformation due to acidification, the principle itself focuses on the potential of the complete minescape.



5.15: Algae production

5.2.9 Waste incineration

Another solution could be to reuse the infrastructure as well as the power plants to transport waste. Part of the mines could be used to store the waste, while the pits could help hide the hills of waste in the landscape. Even though the use of the landscape potential is high. I would be against this method due to its low energy production capacity as well as its dependency on waste. Making our energy system dependent on another source, we are trying to reduce.

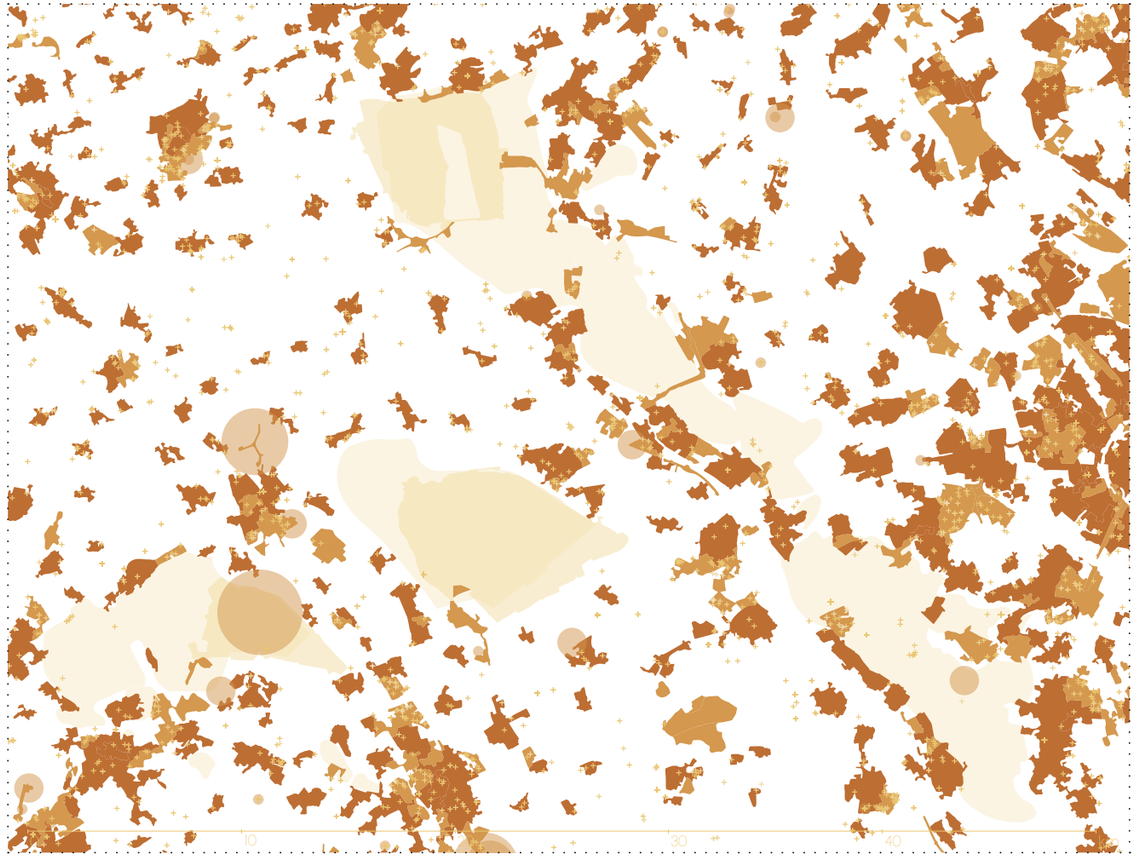


5.16: Waste incineration

5.5 Scenarios

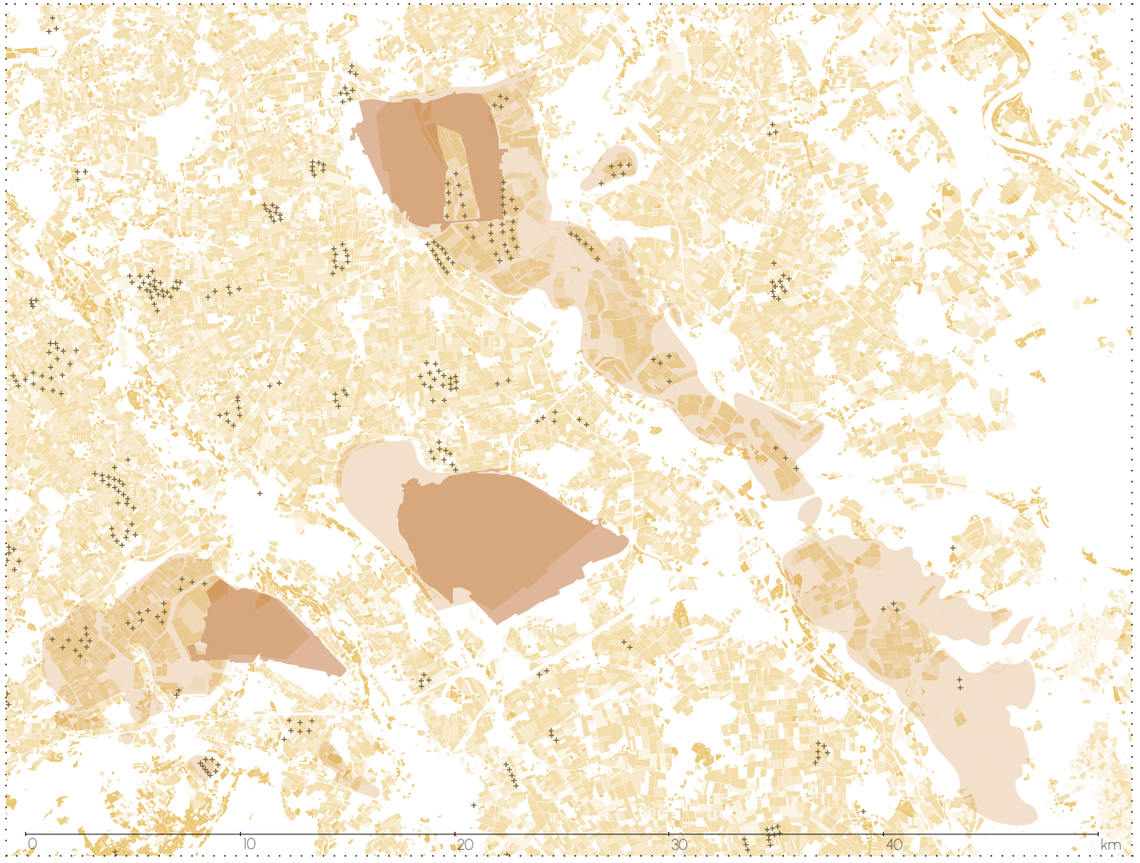
Comparing the different energy production methods and analysing the landscape and area seem to lead to four main production methods of interest, as all of them have symbiotic relations related to the biggest challenges in the minescape.

First, there is the relation between solar energy and the urban. The map here on the right shows that most production (the small + signs) is done in the urban areas. However, we can also see some solar fields (circles) which are located in old mining spaces. Indicating that there could also be a relation to the generation of efficient energy production.



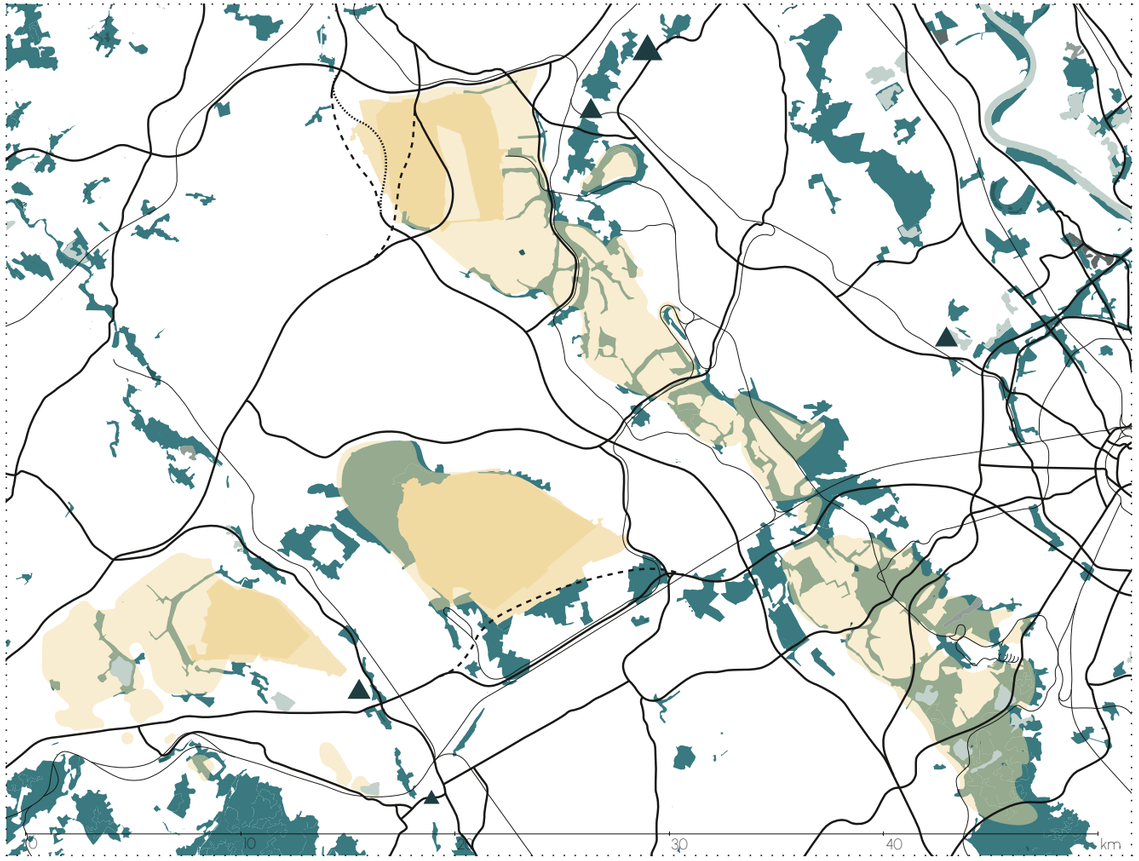
5.17: Relation solar and urban based on Copernicus Land Monitoring Service, (2018), Thoroe (2018), GEOportal (2023b) and GEOportal (2023c)

Secondly, there is a relationship between wind and agricultural land (see map). Wind energy seems to be located near the mines, as they are large open spaces, thus generating a lot of wind. This could be a potential of the existing landscape. Next to that, there is the possibility of using the mines as a battery, using, for example, hydropower. The combination of wind and hydropower, focussing on the height differences in the area, could therefore be of interest.



5.18: Relation wind and agriculture based on Schneider et al., (2022), Thoroe (2018), GEOportal (2023e)

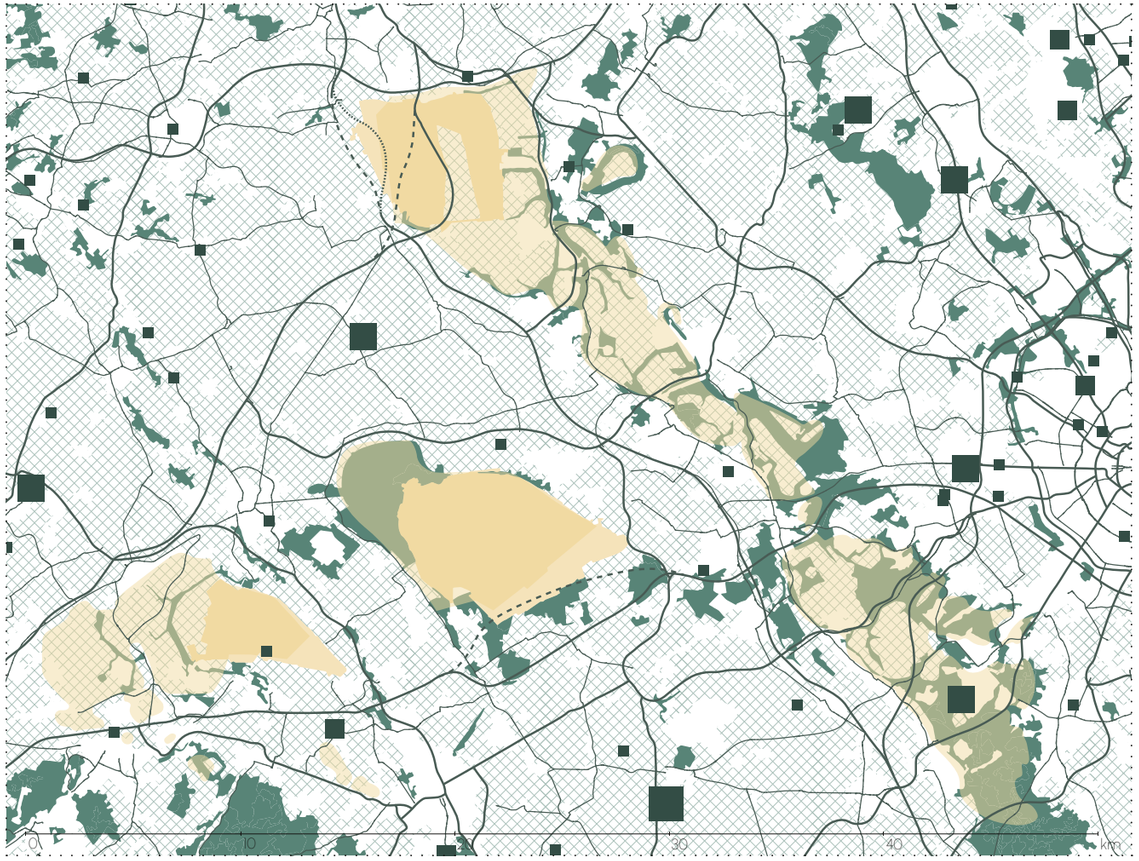
Third is the usage of aquathermal energy. This relates to the restoration of the groundwater level and the wish to create lakes in the mines, which would create large water masses highly suitable for aqua thermal energy.



5.19: Relation water and recreation based on Copernicus Land Monitoring Service, (2018) Thoroe (2018), OSM (2023), GEOportal (2023d)

Last is the usage of biomass to generate energy. It could be connected to the existing agricultural system, but it is also of interest as it can help clean the soil and create employment opportunities.

Therefore, there will be four scenarios: Biomass, Wind, Solar, and Aquathermal. For each of these I will design in a transitional or landscape temporal manner, including the effects on the complete minescape, but focussing on their symbiotic relations. In the end, my goal is to provide four scenarios which can help the debate on the future of minescapes and create discussion possibilities for the stakeholders involved in planning the future of the Rhenish Mining District, specifically RWE and residents.

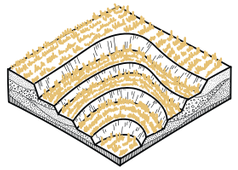


5.20: Relation biomass and waste based on Copernicus Land Monitoring Service, (2018), Thoroe (2018), OSM (2023), GEOportal (2023a)

5.6 Design strategies

The scenarios are built up of different design strategies. These strategies determine the spatial impact and interventions done in the various systems. Each scenario is coloured based on the spatial interventions that lead to a system change. While some of these strategies depend on each other, others are mutually exclusive, meaning that using either one of these strategies will prevent using the other in future interventions. Most of these come from a conflict in space. The strategies also have different timelines. Some interventions might take longer to establish, while others can be quicker. Lastly, we can see which scenario these strategies were designed for underneath the strategy.

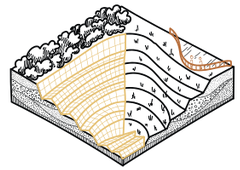
1



Biomass production
- Growth of diverse plants in pits and harvest to generate energy
- Generate employement fitting existing market
- Large green spaces with diversity support ecosystems

Due to their extraction processes, the mine pits have different terraces. These are equipped with railway systems, making them highly suitable for biomass production. Using the terraces to grow suitable plants, allowing them to help clean the soil of the mines, harvesting the plants, and transporting them over the existing infrastructure both inside and outside of the mines could be an efficient use of the pits. The pit will be inaccessible.

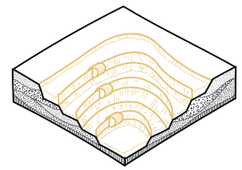
2



Solar field pits
- Use of existing hills, open landscape and orientation for optimal energy generation
- Low impact on surroundings due to lower level
- Inaccessible, but interesting landscape

The slopes of the mines are partly oriented towards the sun. As such, they are highly suitable for the production of solar energy. The sizeable open surface of the mine prevents shading on the solar panels. As the panels are situated inside the pit, they have less impact on the surroundings. The solar field will be inaccessible. Planting on the northern wall could help restore ecosystems but should not impact solar energy production.

3

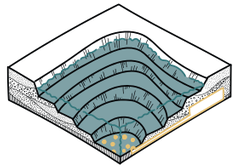


Hydropowered battery
- Use depth of pits to generate hydropower
- Store wind energy when abundened, use in case of shortage
- Low environmental impact battery

The mine pits have a height difference of approximately 200-500 meters. This height difference can store energy through a hydropower battery. To do so, it would be necessary to design different water basins to varying heights on the pits' terraces. The energy will be produced on demand following a system similar to a hydropower installation. From an energy perspective, this system is low impact, though spatially demanding.

5.21: Diagrams design strategies

4

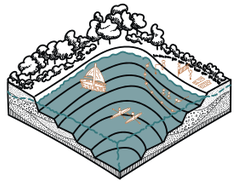


Aquathermal lakes

- Lakes created through water Rhine
- Closed at bottom to prevent groundwater seepage
- Extract heat in summer, store in soil, use in winter and reversed

Aquathermal energy is produced by extracting heat from a body of water in the summer and cold in the winter, changing the water's temperature. The heat or cold is stored in the ground for the opposing seasons (Heat in winter, cold in summer). Creating lakes in the pits would restore the groundwater level and create a new natural ecosystem. However, treatment of the water to neutralize pollution is necessary.

5

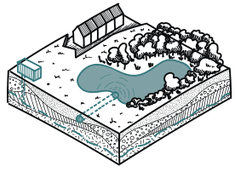


Natural and water recreation

- Prevent seepage, monitor water quality and treat with lime
- Create space for a variety of water and outdoor acitivities
- Attraction for vacation, weekends and day-to-day leisure

A common strategy is transforming mine pits into recreational lakes once mining activity is stopped. However, it is important to treat the emerging water as well as the soil heaps from the mines to prevent acidification due to polluted runoff and pollution from heavy metals (Buchsbaum, 2019) (Jachimko, 2012). This causes dead lakes, which cannot be used by humans and do not house their own ecosystems. Natural recreation spaces will be created at the lake fronts.

6

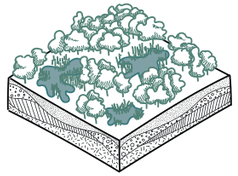


Low groundwater level

- Maintain low groundwater level
- Monitor subsidence residents
- Maintain mechincal groundwater system natural areas
- Public ownership of grounwater system

If the mine pits are not transformed into lakes, the groundwater level will need to be maintained at a low level. Otherwise, the pits will flood. To be able to do so, we need to keep the mechanical compensation system for natural areas dependent on the supply of water. The systems ownership will be transferred from RWE to the government. Next to that, subsidence levels will need to be monitored, to control damage to the built environment.

7



Wetlands

- Raising of groundwater level
- Creating space for wetlands
- Allowing nature to recover
- Monitoring development ecosystem
- Protected and recreational space

The rising groundwater level will create new or reintroduce old wetlands. Due to subsidence, ecosystems might change compared to during and before mining activities in the surroundings. Natural areas need to be created to store excess, guide higher groundwater levels, and prevent nuisance. This will allow the Rhineland's old ecosystems, as well as related protected species, to return.

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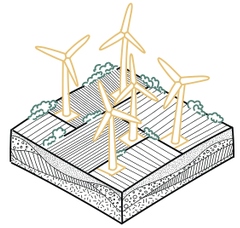

Windfields

- Create windmills in agricultural areas
- Use rental system to create income for farmers or local residents
- Use buffer zones for urban and natural areas

In the agricultural areas, windmills will be placed to create dense wind fields. For this, small parts of agricultural land will be taken on loan from farmers, allowing them to profit from their agricultural land. A buffer zone is implemented around urban and natural areas to prevent nuisance and disturbances. This prevents noise or shading issues. The wind fields create their modern energy landscape, allowing space for other usage.

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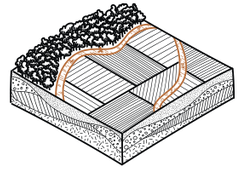

Recreational pathways

- Increase in bikelanes and pedestrian walks
- Higher quality bike lanes
- Routing throughout area

Recreational pathways in Rhineland are often unclear, difficult to access, and lack clear routing. To promote leisure activities in the area, new bike routes and hiking trails, as well as improvements to some of the main pathways will be introduced to allow a broader group of residents to access these roads. The pathways will connect the green metropolis and travel through agricultural, urban, post-mining, and natural areas.

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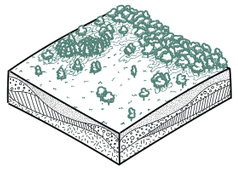

Green spaces & ecosystems

- Creation of high value ecological spaces
- Variety of ecosystems
- Natural stakeholders have priority

Independent of the wetlands, more space needs to be given to nature to recover itself. Consequently, the focus needs to be on creating ecological corridors connecting the different protected natural areas and the variety of ecosystems created. In the current regenerated natural areas, most species and plants remain the same as they are quick-growing and pollution-resistant. However, more and a larger variety is needed to recover the natural system of the Rhineland.

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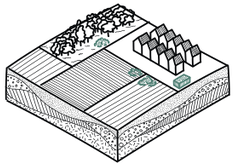

Collection of biowaste

- Connection between new energy system and residents
- Activation of companies and residents
- Existing waste system already seperates biowaste, thus small impact

Germany already has a clear waste separation system and energy production. The biomass energy system can be extended by connecting the collection of biowaste in urban, agricultural, and natural environments. A second profit is the interaction with the area's residents, activating locals in their energy system. The collection can be done via the existing waste system but must be deposited at the power plants.

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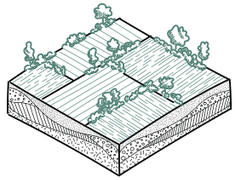

Diversification agriculture

- Smaller agricultural fields
- Focus on different plants and species
- Improve borders of fields to create ecosystem hotspots

With new economic impulses in the area, it is also possible to redesign the agricultural land. Creating smaller fields with a more extensive variety of species will improve the land's biodiversity. Other ways to diversify agriculture include introducing new green corridors, such as hedges or small flower or forest patches, between the fields. This way, the agricultural land can become a more active part of the green system.

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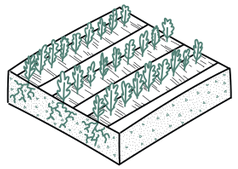

Phytoremediation

- Use production of biomass to clean soil
- Creation of valuable and usable green spaces
- Applicable in and arround pits, also for agriculture and power plants

Phytoremediation is the act of cleaning soil using plants. This method pairs well with biomass production where energy can be produced from these plants. Phytoremediation can clean the soil heaps, power plants and pits, to reduce pollution in the area, while creating a green environment. The process takes a longer period and can be a cleaning phase towards other strategies. It can also form the foundation of a new ecosystem.

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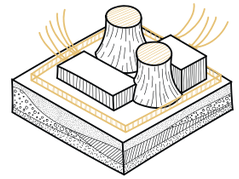

Power plants as battery

- Make use of the existing insulated and protected power plants
- Retrofit power plants to store batteries
- Low impact direct surroundings, high impact on rare metals minescapes

The power plants have protective measures and an energy grid to deal with high voltage and maintain a safe energy centre. One main issue of renewables is their weather and time dependency, meaning we will need more storage capacity to compensate for energy fluctuations in the grid. The power plants lend themselves well to hosting batteries and stabilising the system.

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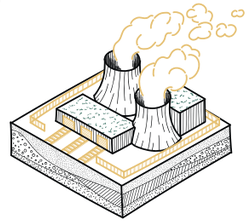

Retrofitting power plants

- Adapting power plants for biomass heat and electricity generation
- Alligns with alle existing infrastructure
- Burden for local residents remains
- Employement facility

To generate energy from biomass, it is necessary to retrofit the existing power plants to use them to generate heat and electricity. Reusing the existing plants reduces the need for new infrastructure and space. This dramatically reduces the system's costs. Research is already being done into retrofitting these power plants for renewables, which seems very well possible. Burning biomass, however, will create a nuisance for residents.

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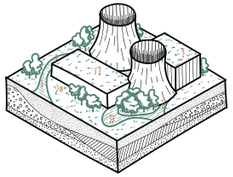

Historic power plants

- Maintain power plants as part of the landscape
- Use as (historic) tourist site
- Clean and restore towards natural and leisure environment
- Possibile places for start-ups

The disuse of power plants means a new function for these large peri-urban areas and their infrastructures. As part of the old lignite mining landscape, I propose opening the area to create green recreational spaces. Indoors, there will be space for start-ups, R&D about the energy transition, and education on the energy system. The outdoor areas should be cleaned and given back to nature where possible.

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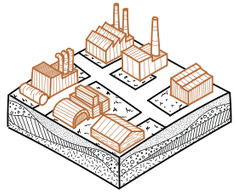

Industrialization

- Use of dense energy production
- New economic driver
- Use of same employees
- Reuse of minescape spaces such as power plants

There are different methods to compensate for the loss of the mines as an economic impulse. One could be the expansion of (heavy) green industries. The cities of Köln, Neuss and Düsseldorf have a history of industrialisation. The old power plant could be demolished or partly refitted to allow for new industries in these areas. Due to the size of these areas and the connection to existing industrial activities and infrastructure, it could form an economic driver.

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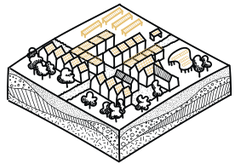

Integrated solar energy

- Activation of residents in energy transition
- Subsidies to help transition
- Integration in public buildings
- clear policies and steps for residents

Solar energy is often located in urban areas. By situating panels on roofs, they do not need more space and have minimal impact on the surroundings. Integrating solar panels in urban areas even reduces heat stress in the summer (Masson et al., 2014). As such, helping residents install and integrate solar energy in the urban environment, both on private and public buildings, will help activate the residents and improve the total energy production in the area.

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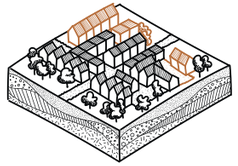

Urban expansion

- Expansion at edge of villages
- Focus on residents commuting towards work cities
- Expansion of the green living belt of Köln, Düsseldorf, Neuss and Aachen

The towns in Rhineland define themselves by their low terraced and individual homes. These traditional houses with their own gardens and low-traffic streets are attractive to people. The towns are situated on the commuting belt to the main cities but are far away enough that the costs are relatively low. Expanding these urban areas using the same morphological qualities could house more starters and young families working in the city.

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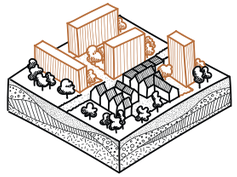

Urban densification

- Densify urban environment
- Improve or replace existing housing
- Expansion impossible due to pressure on landuse
- Differentiate between village, town and city for density

If the population number increases in the area, we would need more housing. However, expanding the urban environment will not always be possible due to infrastructure and space limitations. In these cases, densifying the urban areas could be possible. A lot of the housing is post-World War II and, as such, can be redeveloped around this time. This would make the housing more sustainable and would allow for new urban forms.

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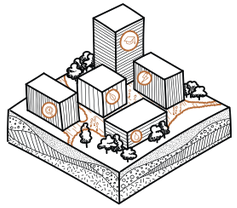

R&D centre

- Expansion of existing research centre
- Focus on topics energy, water and ecology
- Economic driver
- Create new energy knowledge hub

Currently, the Jülich research centre is disconnected from its immediate surroundings. In this strategy, I would expand the research centre and open it up to interact more with the surrounding urban environment. It could also be possible to expand to multiple areas to create multiple centres with their research focus. Key topics to work within this area are energy, water, and ecology.

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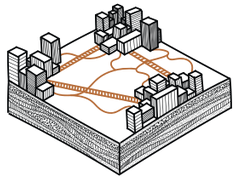

Commute routes

- Improve commute transport
- Increase public transport during rush
- Create direct and hardened bike lanes
- Add trainline Düsselfdorf

Currently, commuting from rural areas to cities overloads the infrastructure. To reduce this, I propose increasing public transport, with a denser schedule around peak hours. Secondly is the creation of main bike roads. Where most bike paths are currently unpaved or do not exist, they would be improved into hardened pathways with clear signage. The goal is to strengthen various transport without making residents more car dependent.

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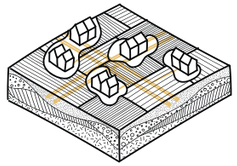

Heatgrid

- New infrastructure
- Usage of residual heat industries
- Heat based system replaces electricity
- Costly
- Low spatial impact

The current energy system is based on lignite and, as such, on electricity. In some cases of renewable energy production, the system would be focused on heat instead. This would lead to an entirely new infrastructure, which is underground and thus less spatially demanding, but should be created, nonetheless. The heat grid could also be connected to other residual heat sources, such as industries.

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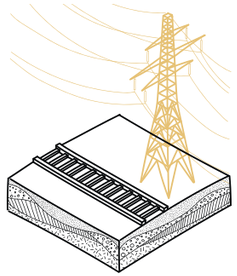

New infrastructure

- Increase production spaces leads to increase infrastructure
- Use of lines existing infrastructure to create low impact new infrastructure

The current energy system is centralised, meaning the power plants produce and distribute energy. In the case of more spatially diverse energy production, expanding the grid to reach all energy sources is necessary. In the current system, the railways form the main infrastructure from the newly transformed areas to the power plants. We can use these open axes to create the new infrastructure.

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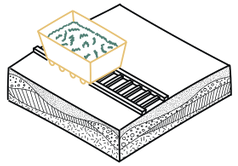

Reuse infrastructure

- Reuse existing infrastructure for biomass
- Low costs, low impact
- Over time, transition towards electric system

For biomass or, in the case of some industries, it could be necessary to reuse the existing infrastructure. These existing axes should, over time, be modernised to allow for an electric system instead of a fuel-based one. Still, the costs of integrating new renewable energy sources by reusing the infrastructure should be considered. In this case, this infrastructure would still be industrial and inaccessible to residents.

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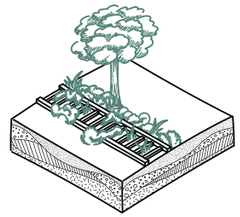


Ecological corridors

- Use of old transport corridors for nature
- Extend towards natural areas
- Can be open towards recreation

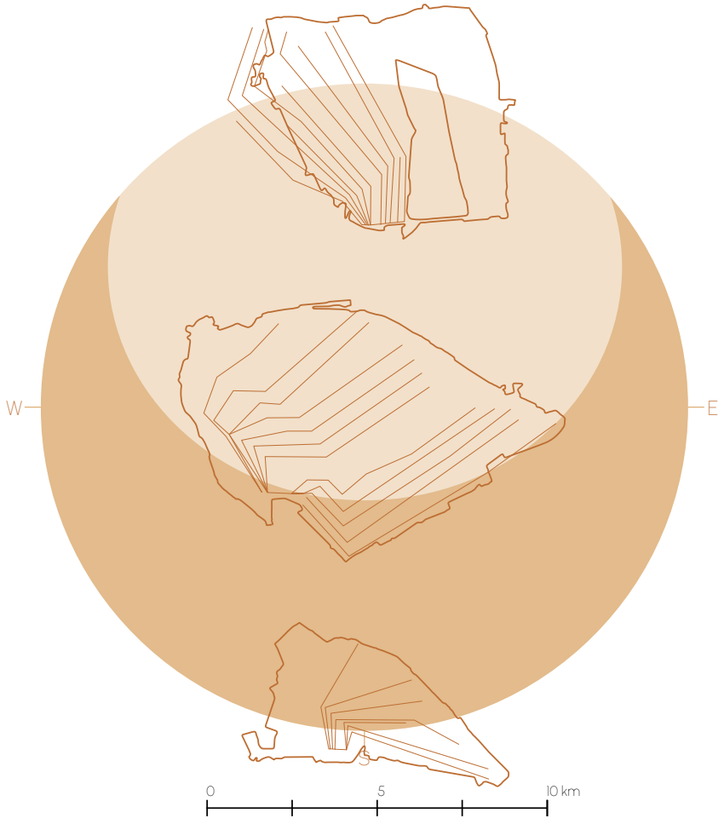
The existing railway or water infrastructure connects the urban areas to the mining pits. When we transform these corridors into ecological corridors, we create a strong connection between newly developed green areas without sacrificing existing agricultural or urban land. These corridors should be adapted to the type of ecosystems they strive to connect. These corridors could be protected or opened for recreational activities.

5.7 Living in the in-between

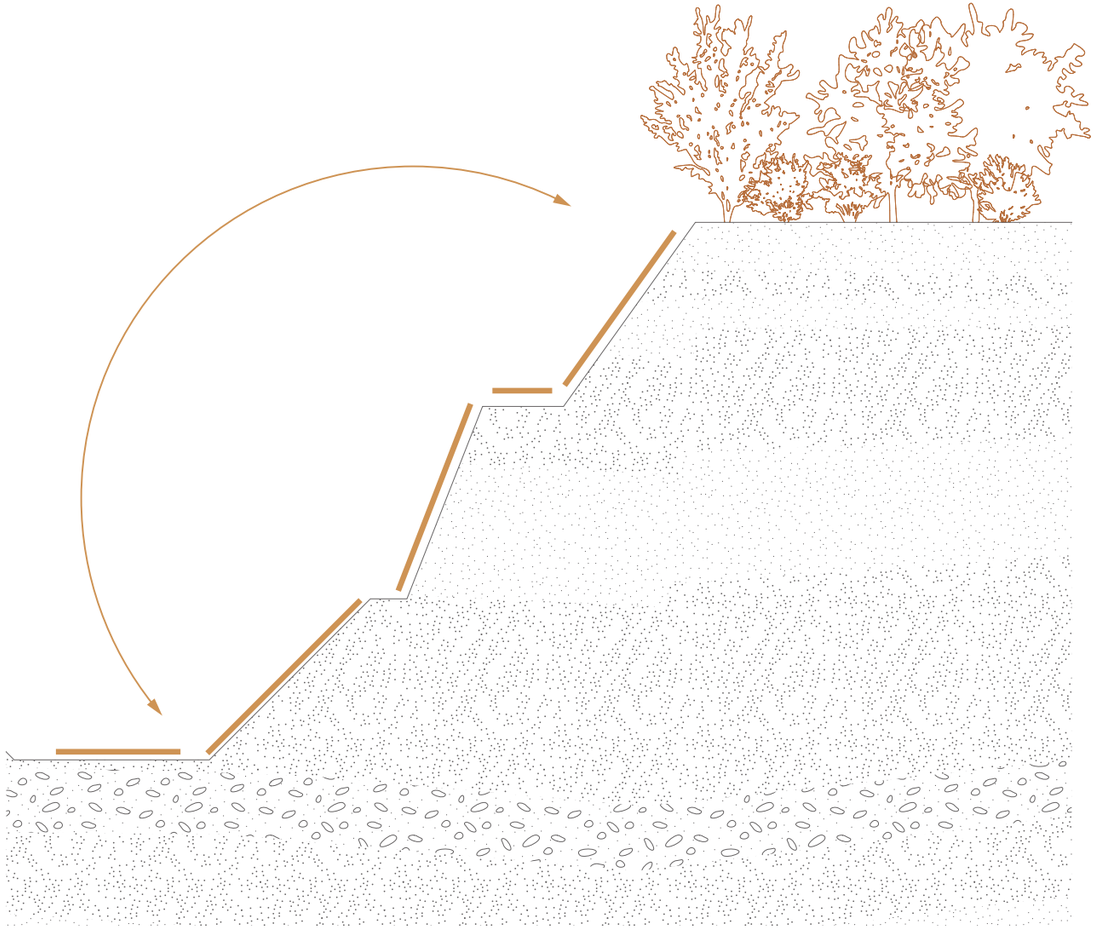
5.7.1 Energy production method

Central to this scenario is the introduction of solar energy into the minescape. As shown before, solar panels are often used in urban environments. They do not produce noise and can even reduce heat stress in the city (Masson et al., 2014). By combining them with the built environment, we can reduce spatial demand for energy production. However, implementing solar panels in the urban environment is not always possible or wanted. Next to that, these are often small-scale projects and private investments, making it difficult to plan or quickly scale solar energy production. Instead, large-scale solar fields can be created in open fields or next to roads to create enough energy.

The mines consist of extensive open spaces with little shading, making them suitable for creating these types of solar fields. These diagrams show the potential of solar energy inside the mines, comparing the hillsides of the mines to their orientation.

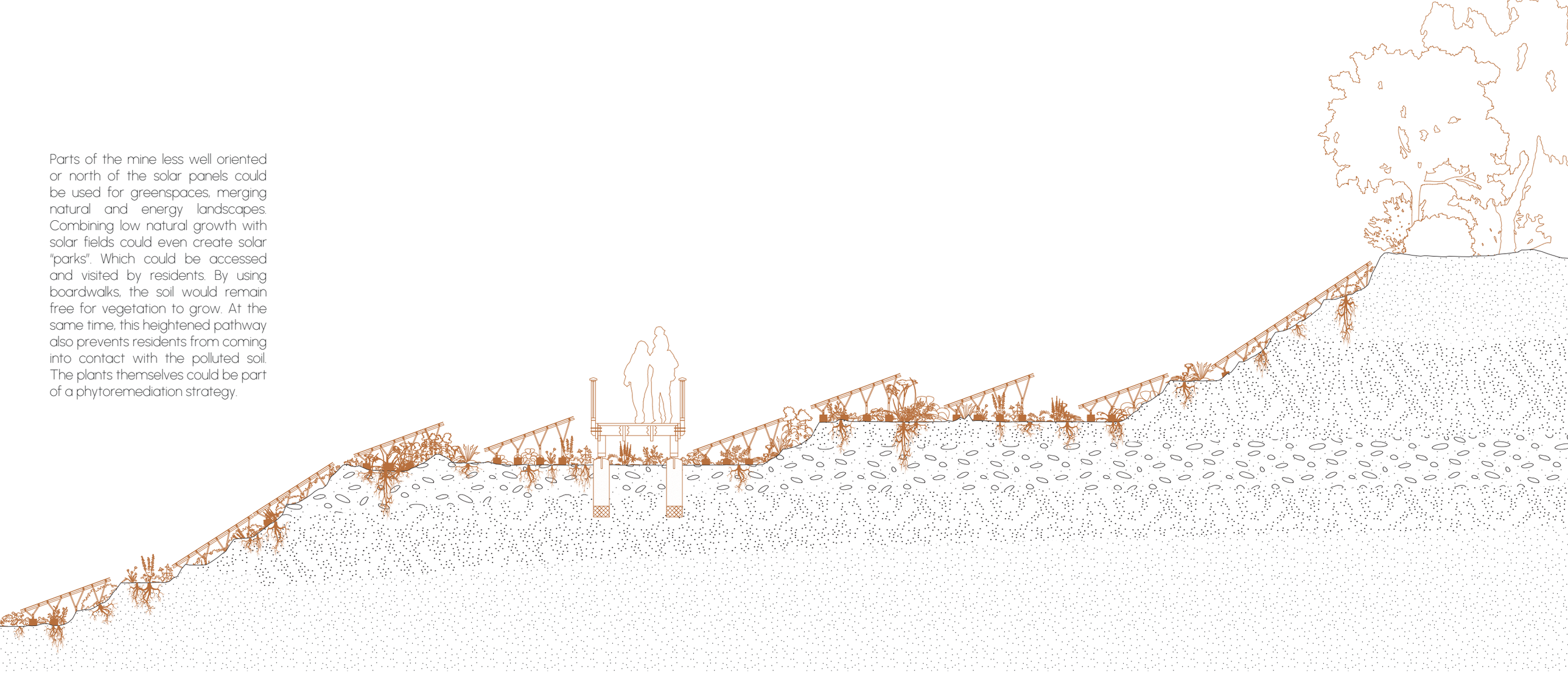


5.22: Solar orientation mines



5.23: Manmade landscape for solar panels

Parts of the mine less well oriented or north of the solar panels could be used for greenspaces, merging natural and energy landscapes. Combining low natural growth with solar fields could even create solar "parks". Which could be accessed and visited by residents. By using boardwalks, the soil would remain free for vegetation to grow. At the same time, this heightened pathway also prevents residents from coming into contact with the polluted soil. The plants themselves could be part of a phytoremediation strategy.

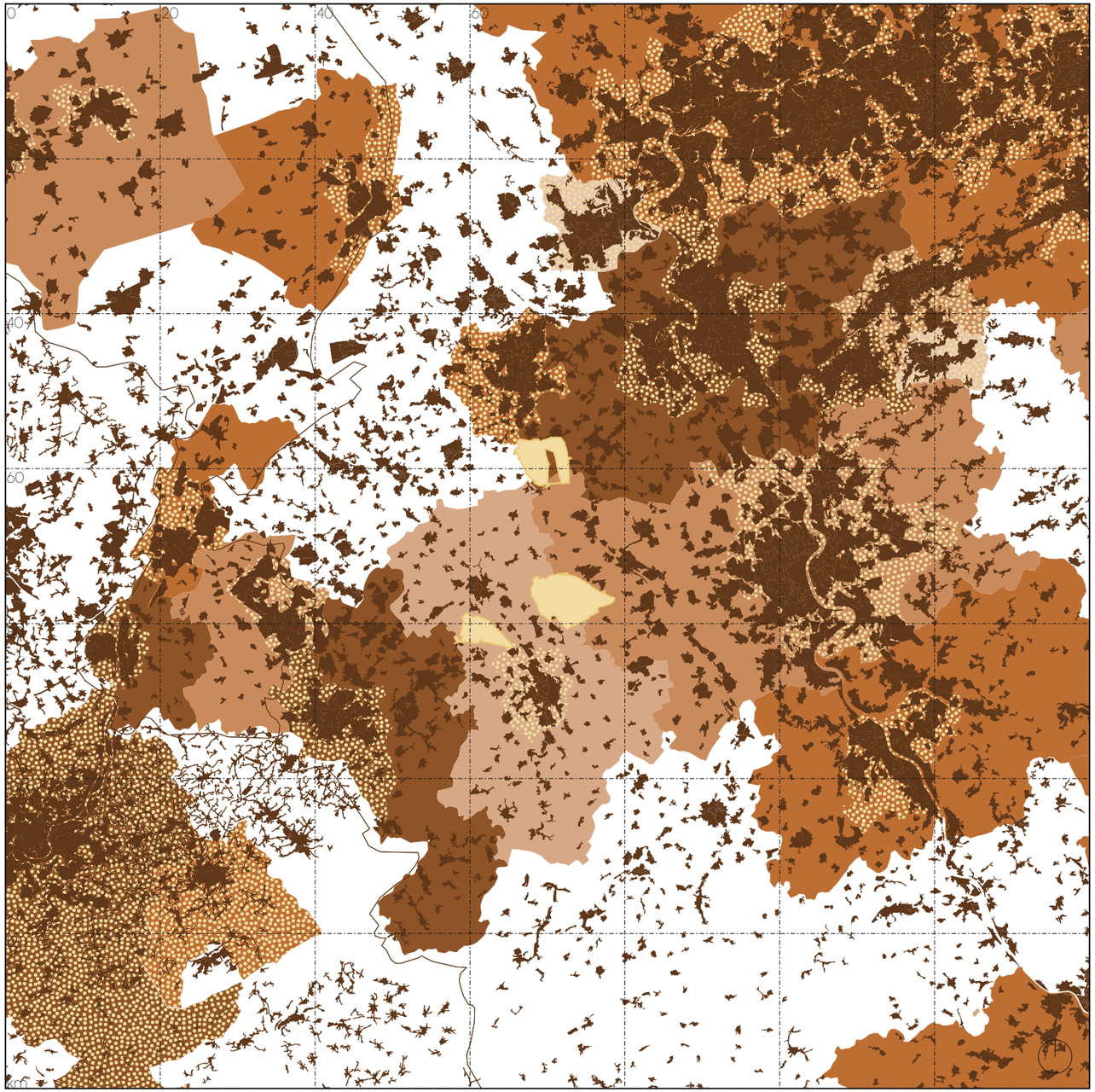


5.24: A solar park in Hambach

5.7.2 Relation cities

Solar energy in itself is relatively low maintenance, meaning that by replacing mining activities with solar panels, the number of employment possibilities in the area is greatly reduced. However, most minescape is located in the commuting area of Köln, Düsseldorf, Neuss, Mönchengladbach and Aachen. As the Rhenish Mining District has relatively lower living costs, and a spacious green living environment, people working in the city quite often live in the district. It is an interesting living area for specifically young families, starters on the housing market and elderly residents who have already retired.

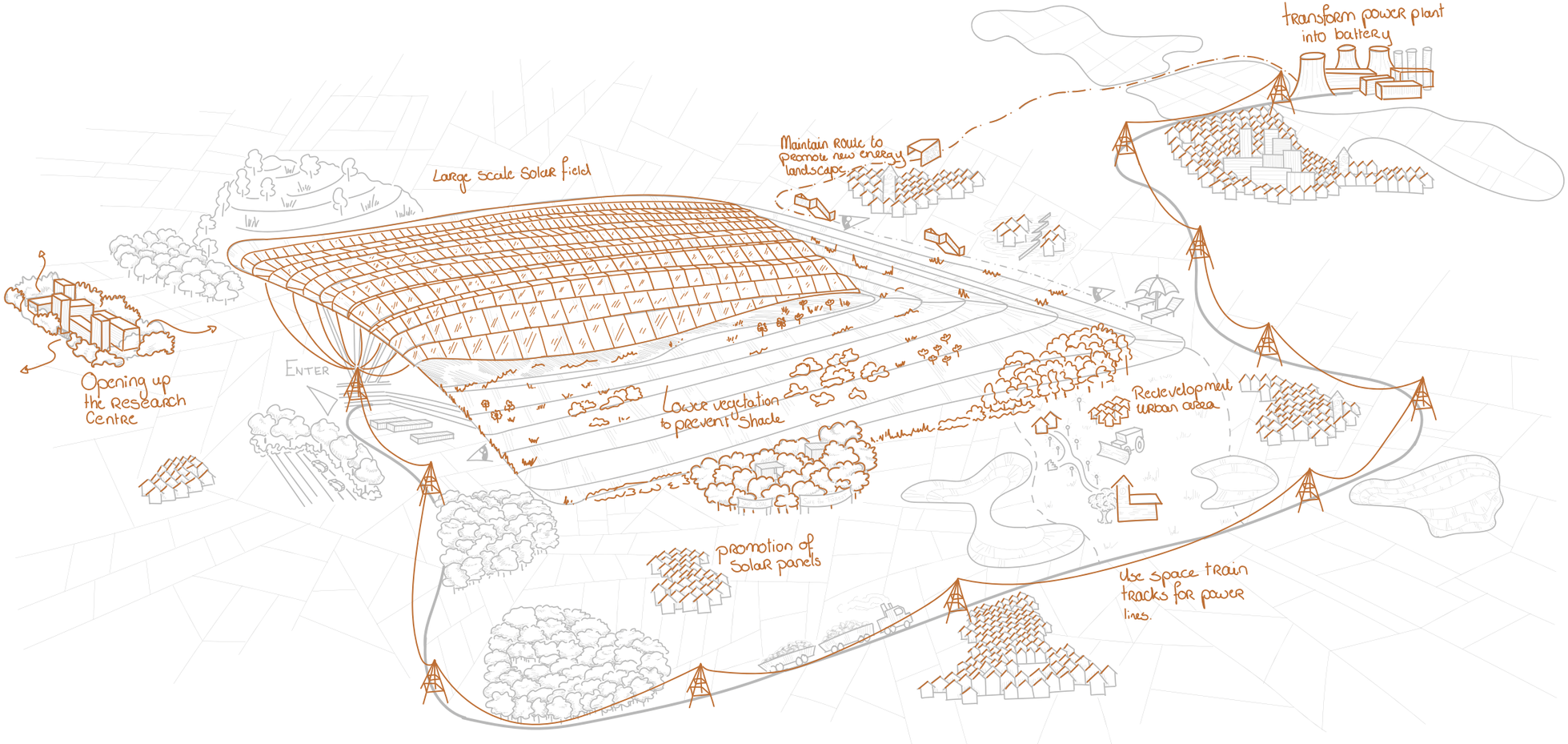
Since the solar energy system has a low impact on the urban environment and can well be combined with urban expansion, focussing on this rural area as a living space between the cities could give it a new purpose and identity. At the same time, public transport should be significantly improved to attract commuters and prevent people from moving out of the area.



5.25: Map Commute network (based on Copernicus Land Monitoring Service (2018) and OECD & European Commission (2022)

5.7.3 Solar energyscape

As discussed before, the energy landscape also consists of the transport and usage of energy. We will need a new transport and storage network when we create these extensive new solar fields. Storage is important to compensate for the weather dependency of solar panels. As the existing power plants are already secure, they could be very suitable to host batteries. This would lead to new electric cables between the solar fields and power plants, but we can reuse the existing railway lines for a direct connection. As space underneath these power lines cannot be built on, we could also use this space to create new green corridors through the landscape. At the same time, solar energy integration in the urban environment should also take place, as well as the expansion of existing towns; the research centre should be well connected to the area as an important employment impulse. The Northern wall of the mine can be given back to nature. Lastly, the recreational backbone should be strengthened. to solidify the experience of green rural living.



5.26: Representation of the solar energyscape, projected on Hambach

5.7.4 Design strategies

The foundation of the solar energy scenario is the creation of a low impact, but efficient energy system for the Rhenish region. In this scenario, there is no new economic driver for the area. Instead, the new impulse is found in the relation to the larger cities. In the surroundings, Düsseldorf, Neuss, Aachen, Mönchengladbach and Köln are situated. At this time, there is already a commute relation between these cities and the minescape. People live in this area, where housing is cheaper and there is more space. This relation will be strengthened in this scenario.

The minescape will become a green, liveable in-between. Here (young) families, starters or elderly can live outside of the hustle of the cities. Improved transport options will allow more people to move around between the rural and urban areas. At the same time, solar energy is integrated into the area to create a low-impact system which does not burden the direct surroundings, creating an attractive living environment.

Energy

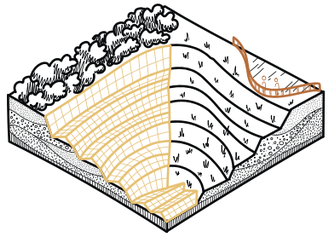
The new energy system consists of large solar parks. New policies are also necessary to integrate solar energy in the urban environment. As the new solar energy system is dispersed, while the lignite system used to be centralized, new infrastructure is necessary, meaning more transport lines are necessary and more stakeholders will be involved.

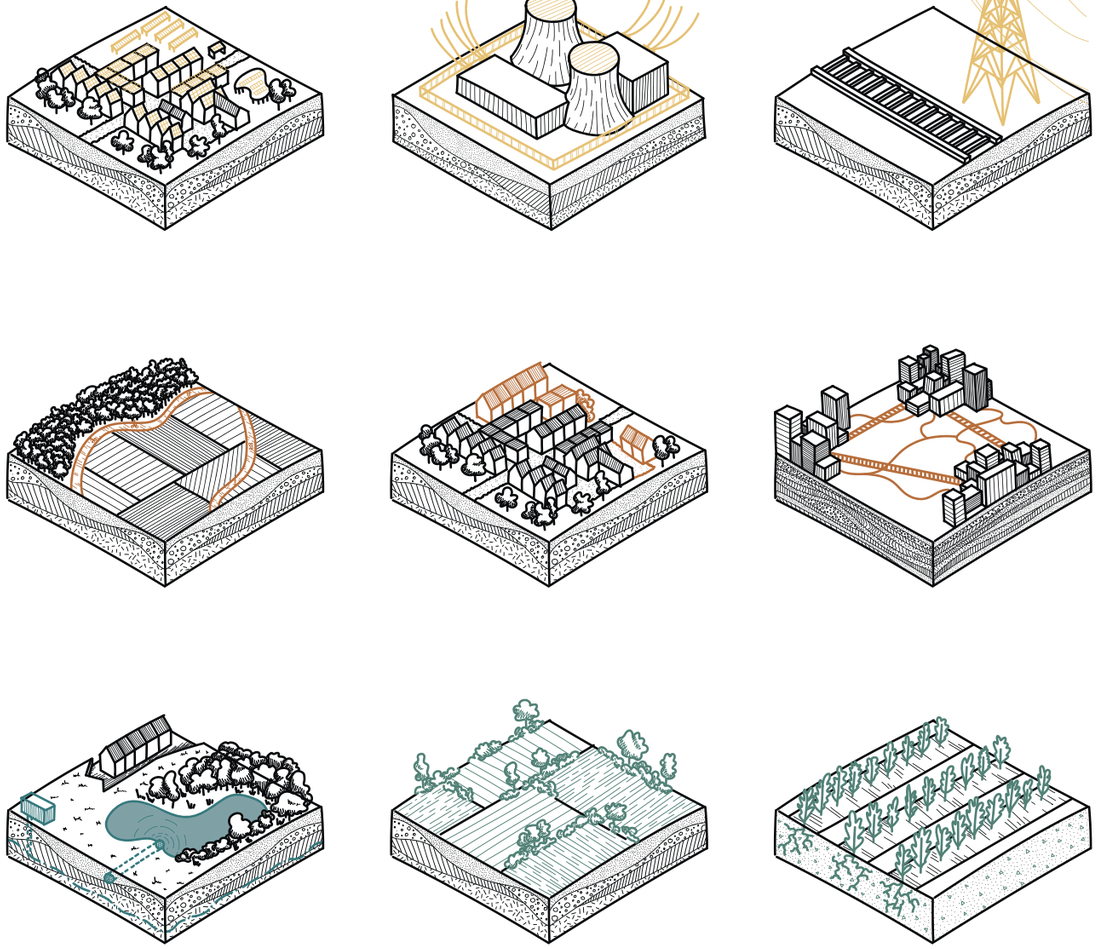
Social

From a social perspective, the focus is on creating an attractive living environment. It does so by improving the commute system, with a focus on bike and public transport. At the same time, urban expansions will be made on the edge of the villages to house the new population. The urban areas will be expanded based on their size to maintain a variety of scales. Parallel to this, all expansions will have green, ecological public spaces.

Blue & Green

To be able to use the mine pit, the groundwater level will stay low, which will impact the blue system. At the same time, agriculture will be diversified to create attractive green surroundings, allowing for more natural, green corridors and an impulse to the local ecosystem. In the solar fields, phytoremediation will be integrated to neutralize soil pollution and generate a biodiverse soil and ecosystem.





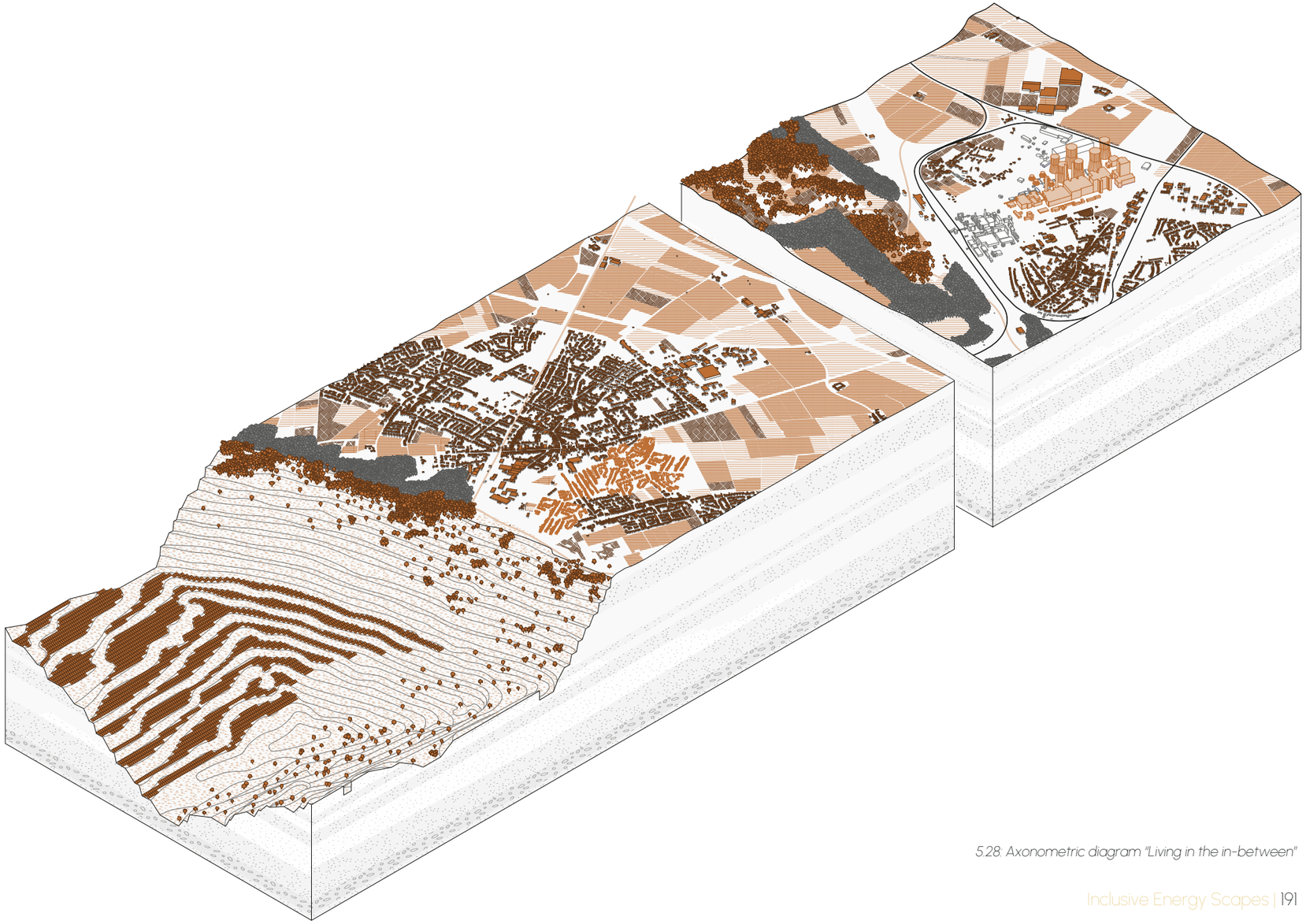
5.27: Design scenarios implemented in Living in the In-between

5.7.5 Spatial implications

The scenario changes the urban The scenario changes the urban environment, energy system and agricultural landscape. Which would indicate a significant change in the environment. However, the residents will experience little change in their daily rhythm. Though this image shows a large consistent impact all over the area, the experience of local residents will not be as significant. The implemented design strategies do change the environment to make it more nature inclusive and sustainable. However, since the scenario focuses on the existing trends in living and commuting, a significant part of the local residents will experience little change. The urban expansions might change the social dynamics of the community as the size of the towns change.

At the same time, significant change will occur for those working in the mining sector. As in all scenarios, this employment facility will disappear. The employment opportunities in the cities do not align with the background and education of the mining sector, meaning employees of this sector will need to be retrained to fit into this new system. Realistically, this will guarantee that some of these residents will leave the area in search of more suitable employment opportunities. To prevent high unemployment rates in the region, it is necessary to create a retraining program or funding for employees of the old mining sector to adapt to this new economic and employment system.

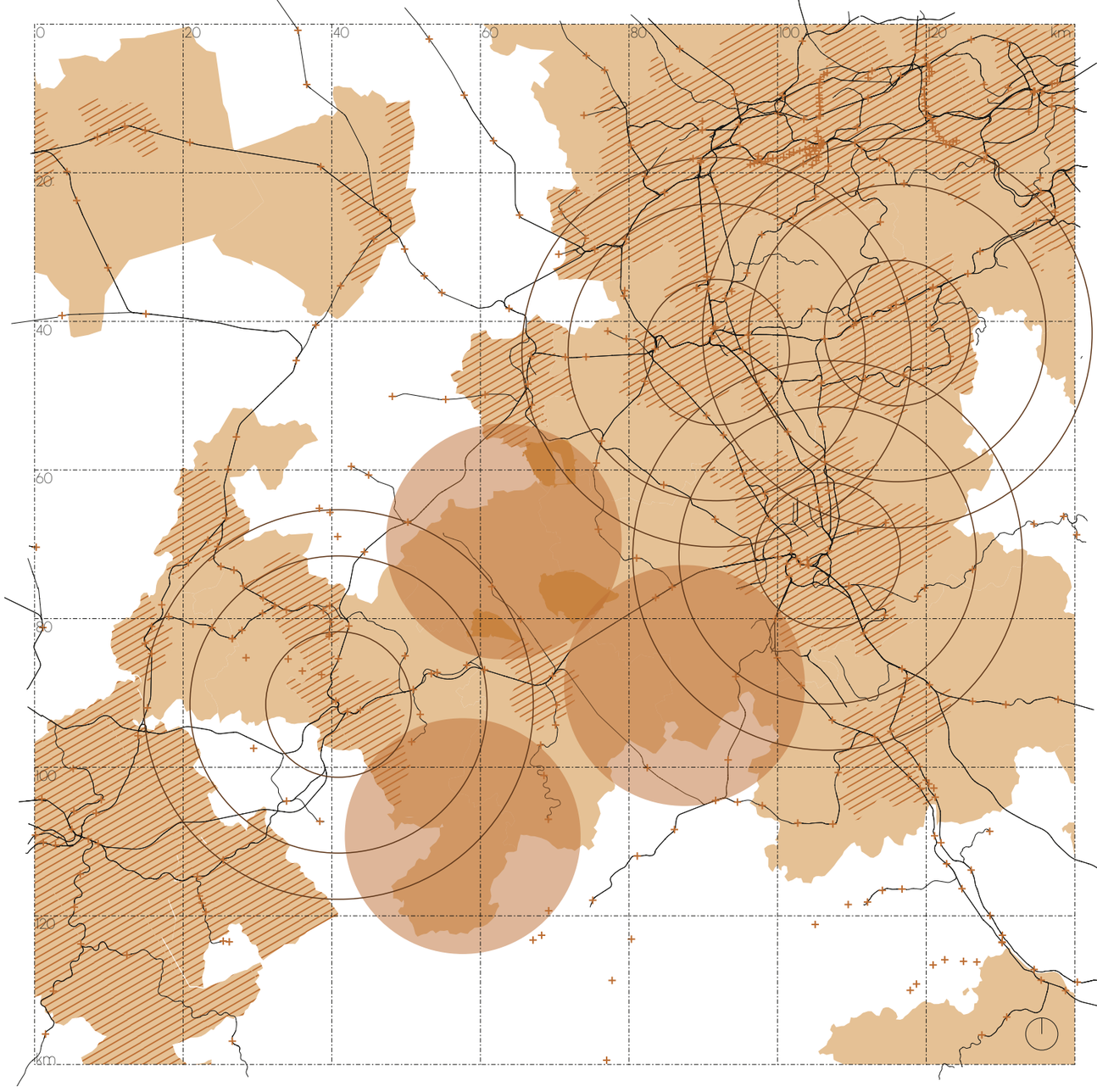
In this scenario the energy production is mainly hidden. Using the large mine pits to remove the solar energy production from view. Around the now battery housing power plants, we can see the reduced spatial impact of the power plants. Less space is needed, giving more space for green areas and housing, this opens up spaces to residents that have always been inaccessible. The mines can be used for recreation and experiencing of the new energy system, using the pathways in the mines either in the denser north side, or on the open solar parks.



5.28: Axonometric diagram "Living in the in-between"

5.7.6 Public transport

This diagram shows the effect of moving the core economic activities of the area from the mines towards the surrounding cities. While the cities in the North and East have industry-based economies, Aachen in the South-West, has a tourism-based economy. As such, there will be a variety of employment opportunities. At the same time there are three primary areas surrounding the mines that even though they are in commuting reach, are badly connected to public transport, meaning that people that live here can only commute by car, needing more energy (fuel). Thus, strengthening the public transport by either extra train branches, train stations or direct bus connections could significantly improve the possibilities for public transport commute and reduce traffic jams.



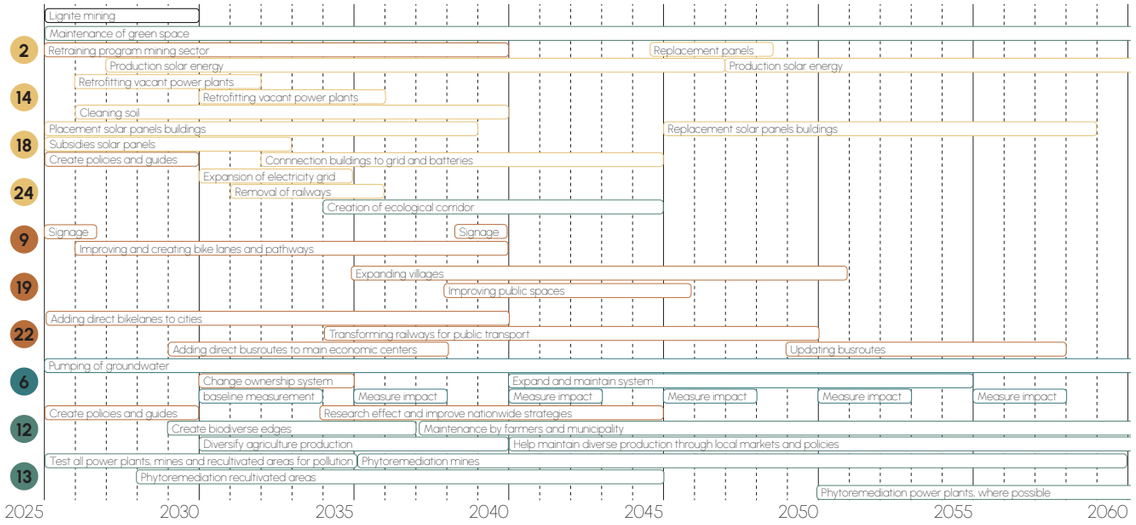
5.29: Diagram commute network based on Copernicus Land Monitoring Service (2018) and OECD & European Commission (2022)

5.7.7 Phasing

A positive element of the solar fields is their quick installation. As Inden and Hambach both extend towards the North, it is possible to start creating solar fields, using them to compensate for reduced mining activity directly. At the same time, battery capacity can only be installed once the mining activities have slowed down. There is already one superfluous power plant, which is only used in cases of emergency. This power plant can be the start of the new storage system. Parallel to this are the policies and subsidies to allow residents to participate in the energy transition, as well as the policies necessary to retrain employees of the mining sector.

5.7.8 Impact

The impact of the solar energy integration on the urban environment is minimal. Most impact on the day-to-day life is created by the green environment and the improved public transport system. The creation of qualitative public spaces is critical to allow for interaction between new residents and give safe space for children to play, as well as elderly people to move around. The connection to the agricultural surroundings gives a green and open experience to the area.



5.30 Timeline

5.30: Collage living in the in-between

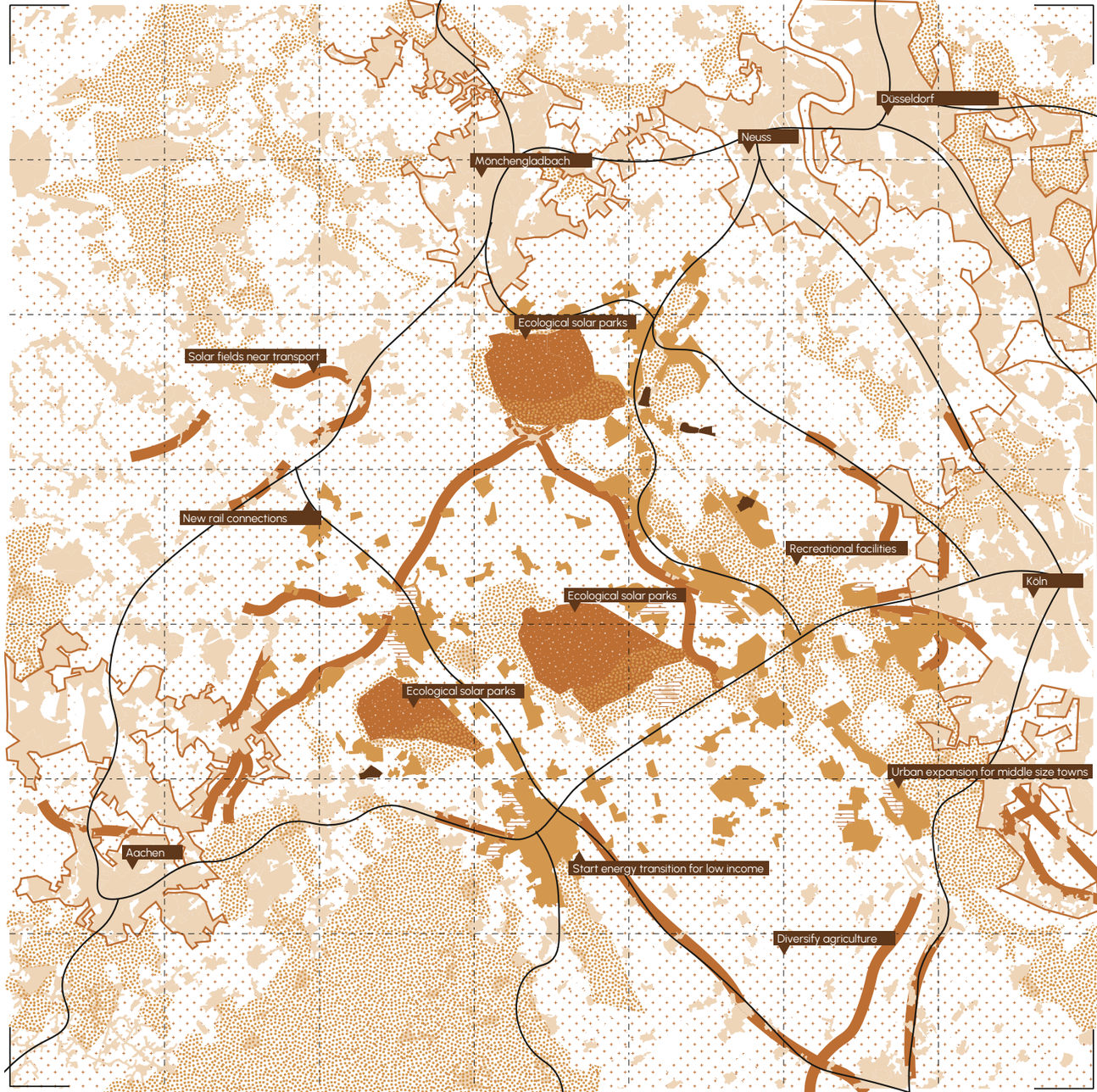
5.7.9 Limitations

Each scenario has its limitations, and it is important to be critical of those. These limitations, the weaknesses and the strengths of the scenarios are most visible when we scale back up from the mine to the complete minescape.

In the case of living in the in-between, we will have a dispersed energy system consisting of many stakeholders and many variables. All residents with solar panels on their own roof, will need energy storage. This can be done privately or centralized, but this in itself needs new regulations. Not all residents will be able to afford their own solar energy as the investment costs are high, and the return period is long. Large solar parks help reduce the instability and interdependency of this system and compensate for residents who might not be able to invest in solar energy for spatial or cost reasons. Solar parks also have a role in the regeneration of soil after mining activities and the restoration of the ecosystem. At the same time, the solar parks are more costly in maintenance compared to barren solar fields. In the case of solar fields along roads and rails, the solar parks will create ecological corridors but will also cross through different properties, creating challenges with ownership and building costs.

With the introduction of solar parks and the diversification of agriculture, the green system is strengthened and given more space, but always as a secondary addition and not as a priority. As such, humanity severely impacts the ecosystems created. These spaces where green is integrated into human land use are still centralized on the service for humanity, with the ecosystem being a second priority.

Because of the focus on living, there is a risk of the ageing of the community, increasing of unemployment rates due to lack of local jobs and depopulation of the area. This is dependent on the attractiveness of the area in relation to the people living and working in the region. The ability to attract new residents to this region is based on the ability to commute as well as the developments in the surrounding cities. Thus, the success of this strategy is also dependent on the urban development strategies of Köln, Düsseldorf, Neuss, Mönchengladbach and Aachen. Therefore, this scenario can only succeed in cooperation with these cities, as it depends on their economic and urban development impulses.



5.31: Map strategizing the energyscape of living in the in-between

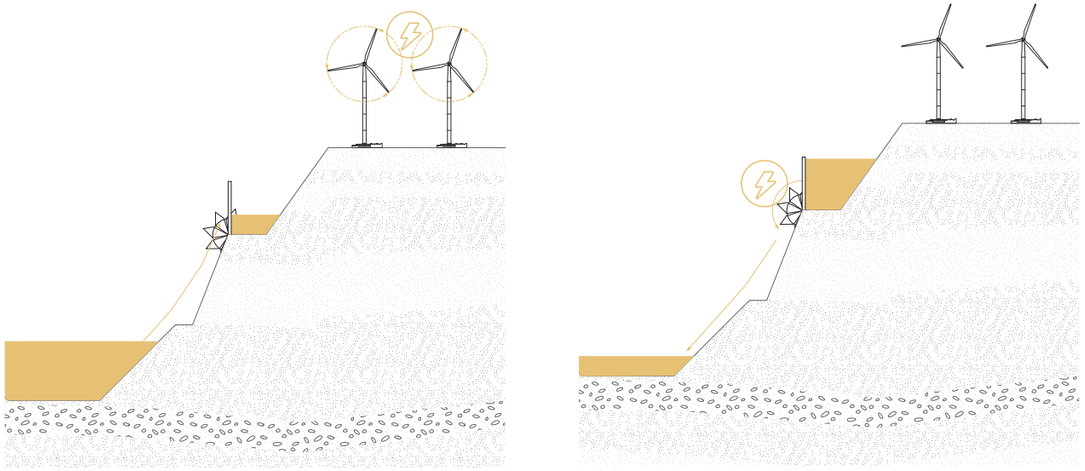
5.8 Wind, Water, Work

5.8.1 Energy production method

The second scenario focuses on the production of energy via wind. Contrary to solar energy, wind energy has a larger impact on our surroundings, being clear elements in the landscape, creating moving shadows, and producing sound (see Appendix C). Next, while solar fields could easily be situated in the mine pits, Wind energy needs height and an even landscape, so placing them in the pit is impossible. However, placing wind energy around the mines would be very suitable when we keep the pits open.

This still leads to the question of what to do with the existing pits. The scars in the landscape cannot be filled with soil as we do not have enough, and creating a green environment or lake would likely block the possibilities of creating wind energy. Thus, the question is, how can we make use of these height differences in the landscape?

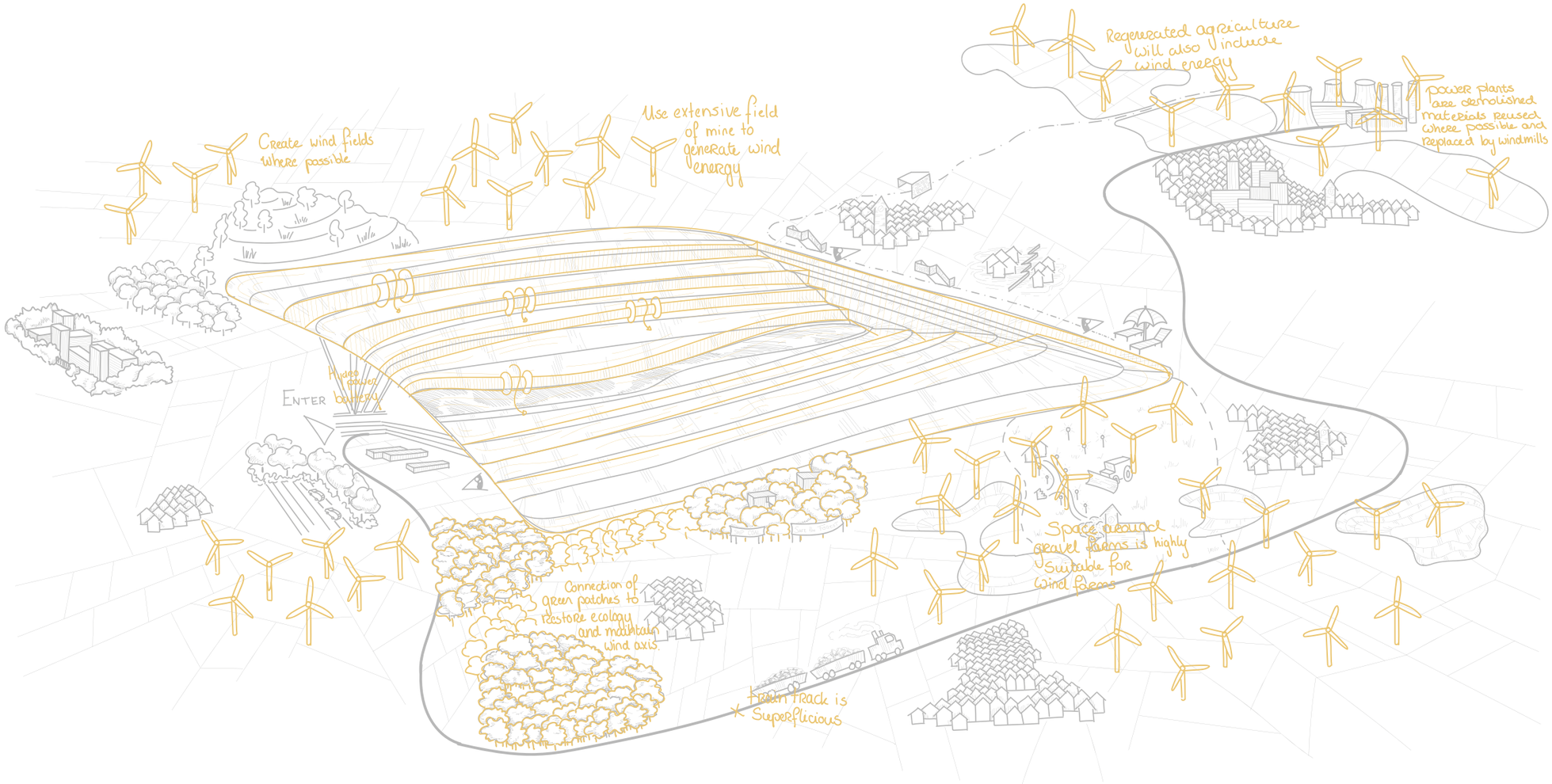
As with solar energy, wind energy needs storage space to compensate for the weather dependency. We could do the same here and use the power plants as batteries, but batteries still need a lot of rare earth metals, which leads to new minescapes in other countries. Instead, Sijmons (2014) inspired me to investigate other possibilities. He proposes using the height differences of mines as a method to store energy using water and, thus, hydropower. The system works by pumping up water when we have an excess of energy and allowing it to flow back down, generating energy when we have an energy deficit. This way, the energy is stored in potential energy and transferred back to kinetic energy.



5.32: Principle of wind and hydropower battery on a windy day

5.8.2 Wind energyscape

The integration of wind turbines in the area should be done with care as they can be disturbing to natural systems and people. This, in combination with the enormous hydropower battery, makes it not likely the area will profit from its quiet rural identity. Instead, more focus will be placed on industries, allowing for another type of economy in the minescape as the mining is moved out. At the same time, forest areas can be created around existing villages as a buffer between the wind fields and the residential areas. This also creates more natural islands in the landscape. Wind energy is strongly related to agricultural land. agricultural production, as wind energy, profits from an open, flat area. In Germany, farmers even place windmills on their own farmlands to generate energy as an extra income. However, this method is significantly more risky and less profitable than leasing the land to an energy company to produce energy there. (Fuchs et al., 2019). By leasing the land, and creating thus extra income, the farmers also gain more space to diversify their production.



5.33: Representation of the wind energyscape, projected on Hambach

5.8.3 Design strategies

The foundation of this scenario is an efficient system that produces as much energy as possible. This burdens the direct surroundings and allows for expansion in industrial areas, creating new employment opportunities. These new industries will be green industries, focussing on biobased materials, recycling, or water and waste treatment. To create enough space for these new industries part of the spaces dedicated to the power plants will be dedicated to them. At the same time, these industries are related to new research, design and development. These are also new impulses for the region for which we need to make space. At the same time, it is also important to create a strong enough foundation for the ecosystem to recover. As we cannot bring the old mines back to their original natural state, instead the transportation lines, agricultural areas and power plants will be used to create a variety of green environments which interact in different ways with the environment.

Energy

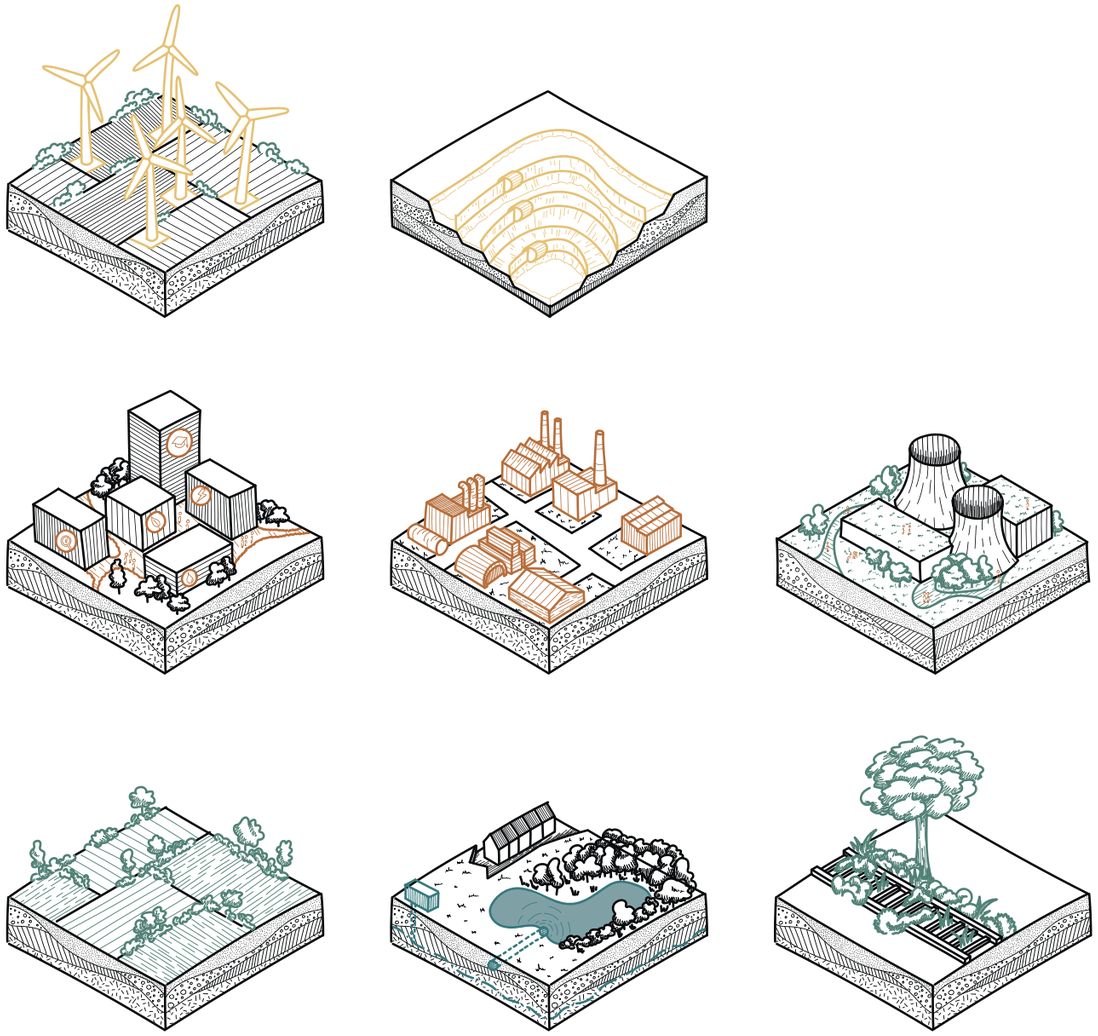
The energy system consists of two new elements. The wind turbines, which are places on agricultural land leased from farmers. At the same time there is the hydropower battery. This should be seen as a mechanical system, consisting of concrete, steel and water. It does not have ecological value. The water body might help cool down the environment.

Social

The social system is focused on the integration of new renewable energies. The existing R&D centre will need to be expanded to give space for research related to these industries. At the same time, the power plants will be partly demolished or retrofitted for new industries, partly used to host small starter companies and partly given back to the urban environment as recreational areas. By creating spaces and providing research and development facilities, the area will attract new industries. The location near the ports of Köln, Neuss and Düsseldorf and the transport possibilities between these areas, make the Rhenish Mining District a suitable place for green industrial development.

Blue & Green

The green and blue system in this scenario should be designed as efficiently as possible, using the different islands created by the power plants and agricultural land and connecting these by the old lignite train routes. At the same time, the groundwater level will need to remain low to allow the pit to be used for hydropower generation.

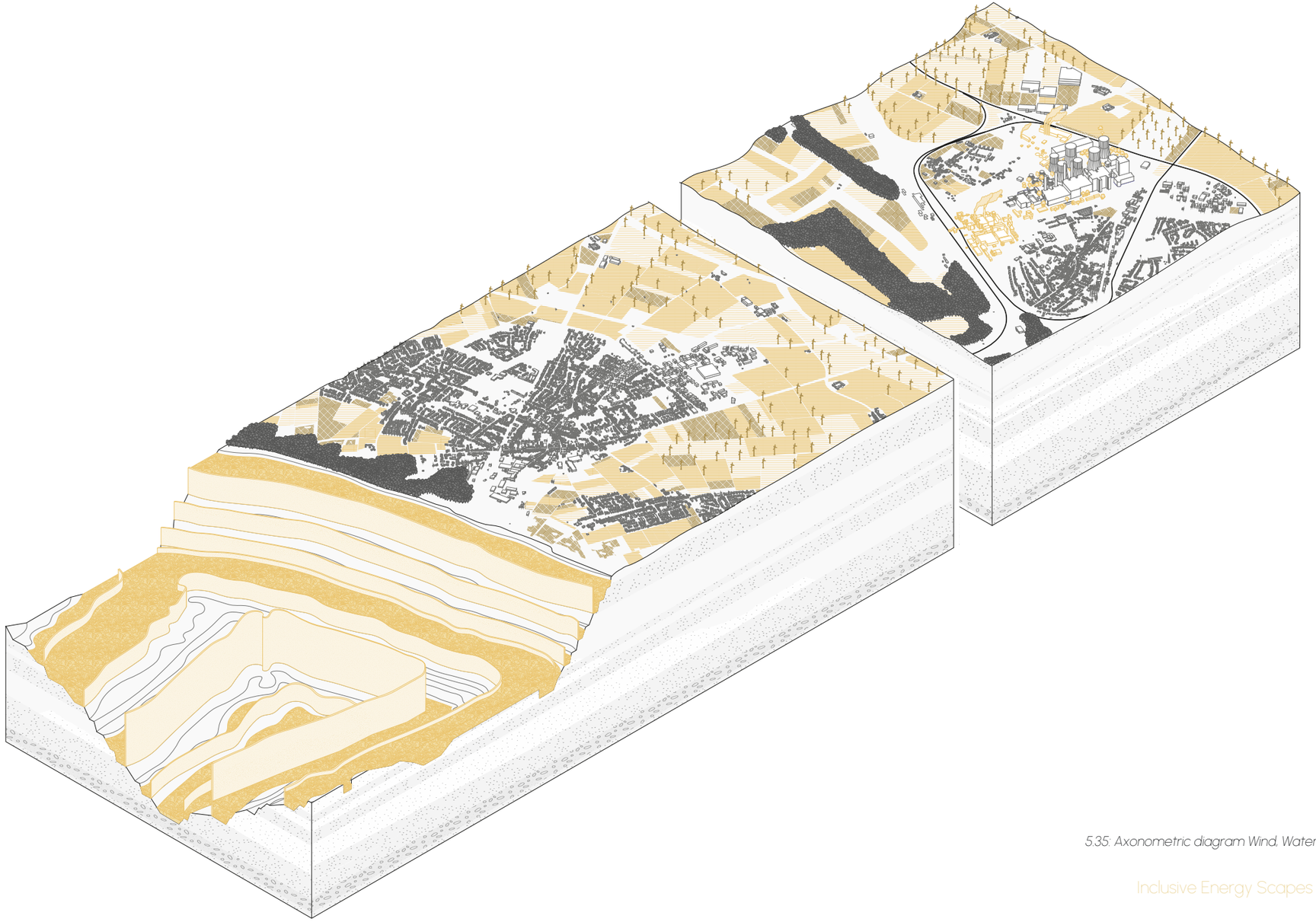


5.34: Design scenarios implemented in Wind, Water, Work

5.8.4 Spatial implications

The effect on the urban landscape is defined by the surrounding landscape. All areas in the direct surroundings have been transferred into operational landscapes. The only exception to this are the ecosystem corridors. To allow the green system to recover, these areas will be protected and not made accessible for recreational activities. This way, while the natural surface area is not much expanded, the ecosystem can grow stronger without human interference. At the same time, the now smaller and more diverse agricultural fields are also constructive for the natural environment.

Due to the hydropower basins and constructions, the immense mine pits have found a new identity and specific type of landscape that could also attract tourism. At the same time, the pits remain completely inaccessible to maintain a safe environment. As Garzweiler is a larger pit with a large lower basin, this basin is always left partly full to allow for water systems to grow, researching the relation between hydropower and ecosystems.



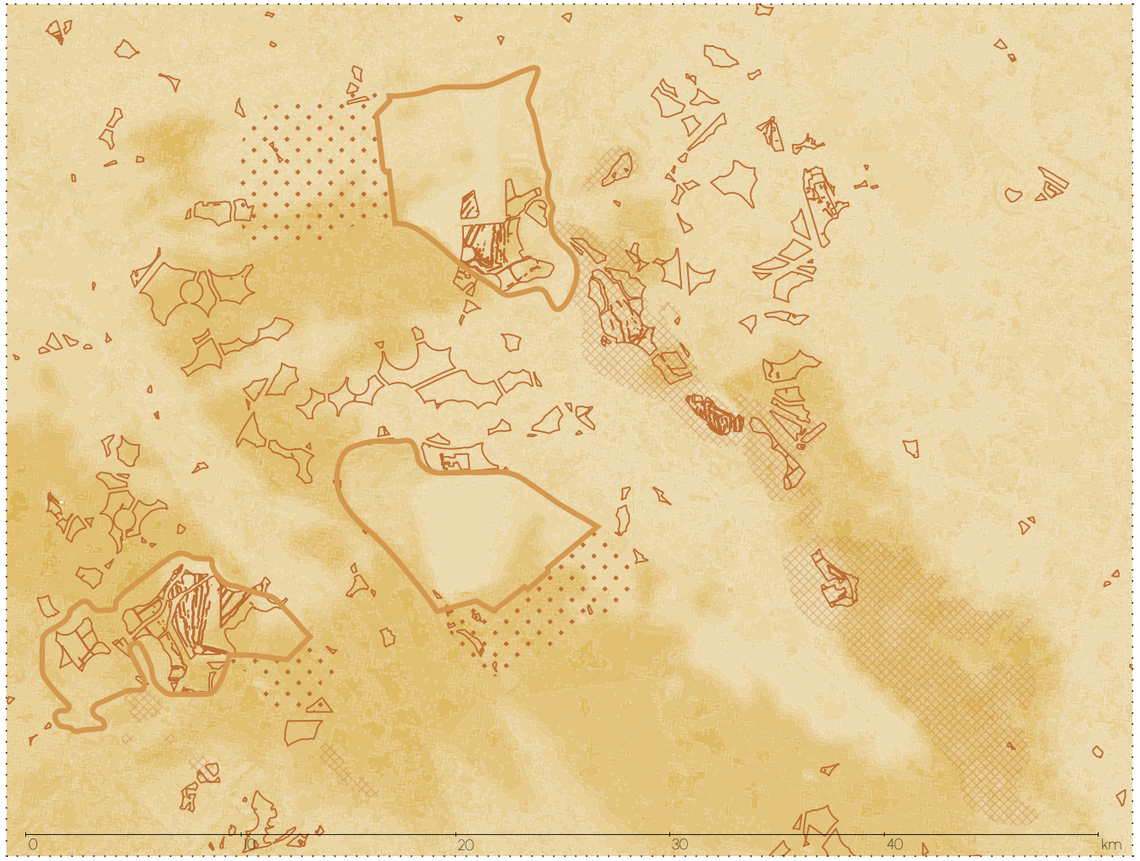
5.35: Axonometric diagram Wind, Water, Work

5.8.5 Efficient production

To be able to determine where wind power can be generated, we have to overlap the wind energy potential of the area with the possible sites. These sites are determined by overlapping the buffer zones of natural and residential areas. This is necessary to prevent disturbance of natural areas as well as prevent noise and shade disturbances for the urban environment.

This leads to the following map. Here, we can see that the area Northwest of the Hambach mine and the area Northwest of the Inden mine are of interest due to their high energy potential and the available sites. This would be a starting point for the integration of wind energy. Based on the energy gap, we could expand to other areas.

Integrating wind energy would be beneficial if the urban and natural areas would not expand further as this would decrease the available energy sites. Instead, densification would be possible.



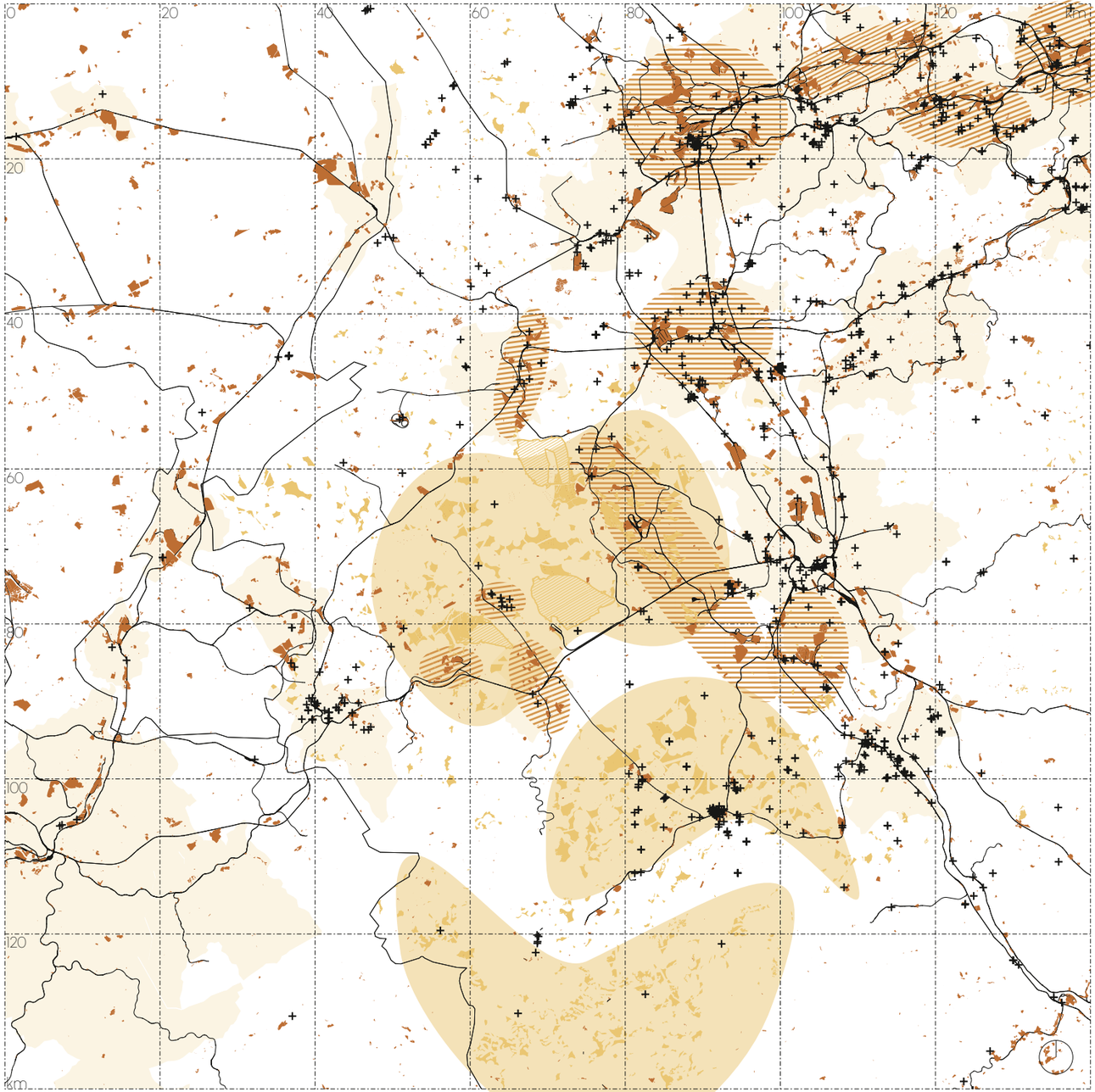
5.36: Wind potential based on OpenNRW (2023b&c)

5.8.6 Relation industries

This map shows the main industrial areas proposed in the new strategy, along with the freight train system, the research centres, and the wind energy fields.

There are three primary areas where wind energy is produced. These are the spaces furthest away from the urban environment. At the same time, we can see that most industrial areas are situated inside the cities. New industrial centres are created around the mines and on the old mining belt in the new scenario. These locations are suitable due to changes in space demand created by the new energy system. The location of much of the industry around Inden II is caused by historic development. Expanding on these industries is of interest due to the space as well as their relation to the existing research centre Jülich.

By bundling the industries, we can increase the exchange of knowledge, services, and facilities between these new green industries. At the same time, it creates compact spatial configurations that give more space to other forms of land use that cannot be placed close by.



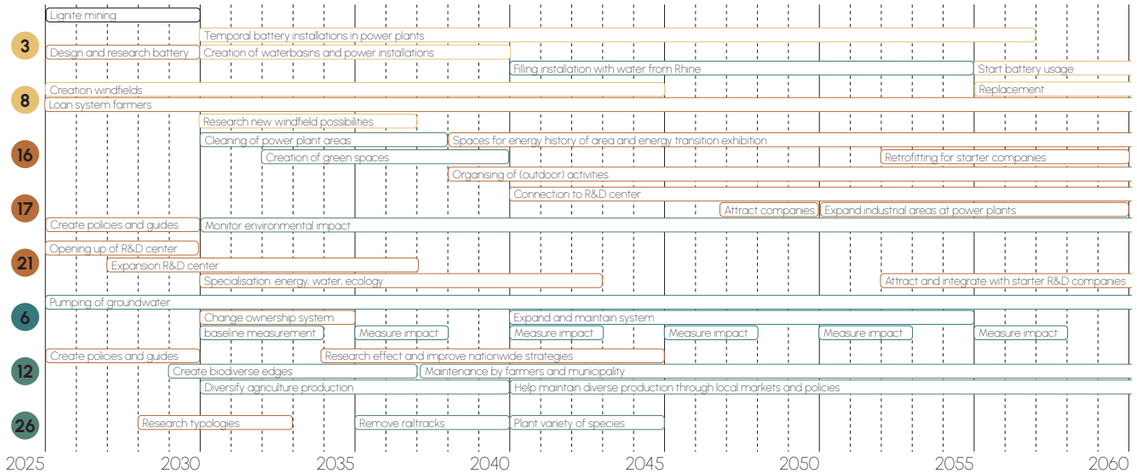
5.37: Functioning of industries, based on OSM (2023), Copernicus Land Monitoring Service (2018) and OECD &, European Commission (2022)

5.8.7 Phasing

The process of wind energy integration in the landscape is already taking place. However, this will need to be scaled up in the upcoming five years. At the same time, the expansion of the research network and facilities can already start, together with the diversification of agriculture. When the mines close in 2030 we will need a period to create the hydropower basin. As batteries are quick to install, we implement those in the power plants to overcome this period. By doing so we can already implement the new industries and compensate for their energy usage. When we start using the hydropower pits, we can also start transforming the power plants towards their new function as a social and R&D hub.

5.8.8 Atmosphere

While this new energyscape is much more dependent on industries, this only influences the landscape to a certain point. The most impactful will be the wind turbines scattered across the landscape. At the same time, the hydropower battery creates an interesting landscape, just as the lignite pits now attract visitors to see this immense landscape of human engineering. The larger variety in the agricultural landscape will also transform the landscape more often throughout the season, creating varied and green surroundings.



5.38: Timeline



5.39: Collage Wind, Water, Work

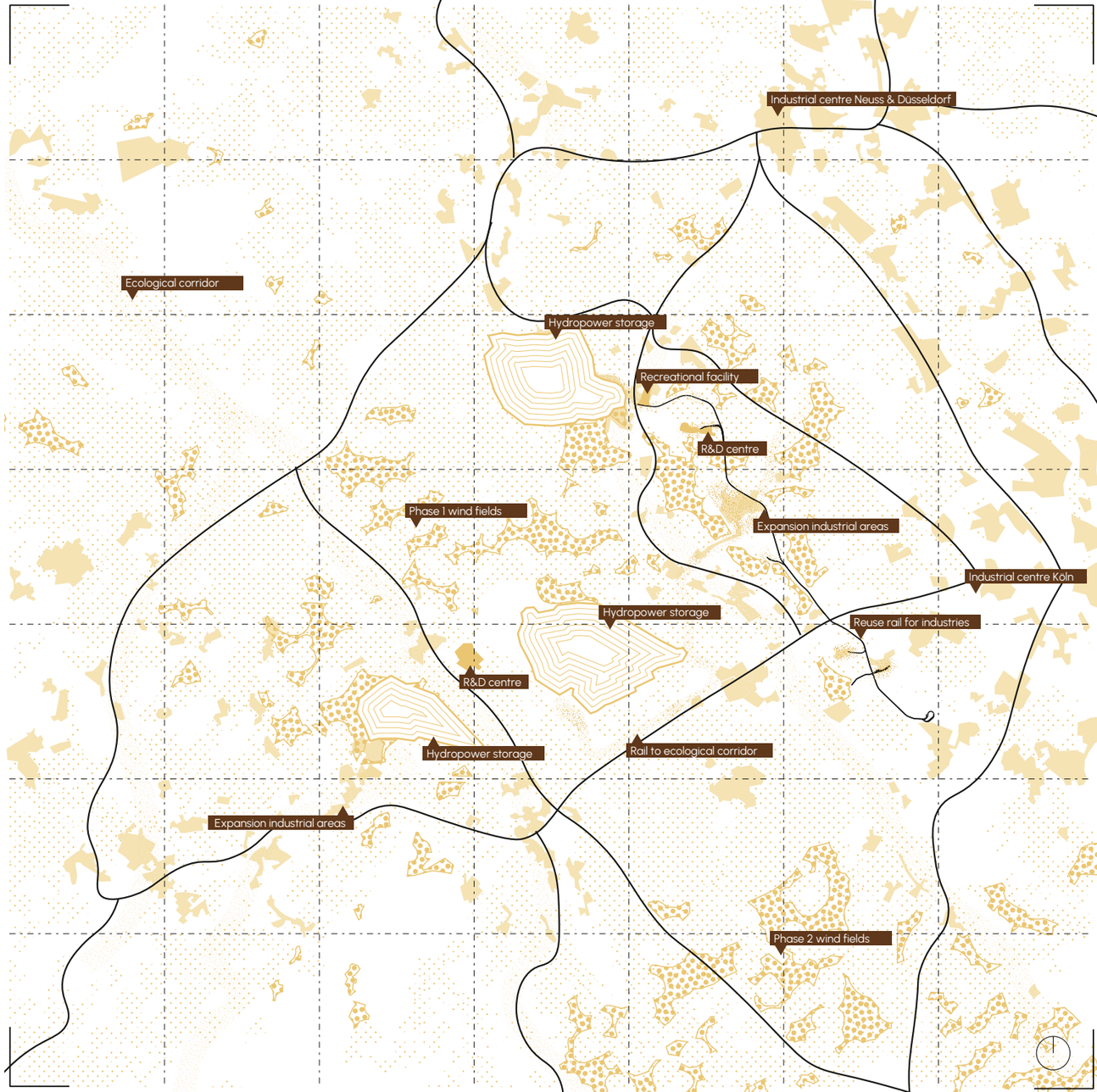
5.8.9 Limitations

The focus of this scenario is to create a new industrial region as an extension of the existing one. The current spatial layout and infrastructure allow for the implementation of heavy industries. However, the focus should be on green (heavy) industries. These can be focused on, for example, biobased materials, recycling or renewable energy. To be able to attract these companies or start-ups, facilities will need to be improved and the region will need to be able to compete with existing industrial regions when it comes to these sectors. This is critical as attracting new industries means attracting new employment opportunities.

The energy production method are wind turbines. These towers in the landscape tend to attract resistance from residents. To reduce this, the integration process of wind fields should be done in a cooperative manner with residents. This will take significantly more time but will also guarantee fewer protests and, eventually, a more streamlined integration. Next to that, paying thought to the quality of the landscape, varying the heights and designs of windmills and establishing buffers between wind fields and built and natural environments should improve the general quality of this landscape and reduce resistance.

Most importantly, the biodiversity is strengthened little; the most important strategy is through the new biodiverse agriculture, but this already collides with the effectivity of production and ownership issues. At the same time, the integration of new wind fields and the buffers surrounding these, prevent the expansion of natural (rest) areas such as forests. In combination with the green industries, which could still be noisy or polluting, the green system might be under pressure in this system.

Lastly are the challenges with ownership when it comes to the new wind fields and the three hydropower batteries. The farmers can loan their ground to allow an energy company to establish their wind turbines there. While this is a secure method for the farmer, it is more expensive for the energy company in comparison to owning the soil. Next to that, is the companies that will need to invest in the hydropower battery. Will these be created by an energy company, their property and will owners of windmills pay loans to store their energy in these batteries? Then there are the limitations of the hydropower battery itself. While this type of storage does not require the extraction of rare earth metals elsewhere, it has a higher energy loss than traditional batteries and contrary to traditional batteries hydropower batteries do not degrade (Zablocki, 2018) (Vaughan & West, 2017). The costs to build a hydropower battery are lower than traditional batteries, but the system is more spatially demanding. Therefore, the integration of hydropower is a good idea where possible, but it also has a lower energy efficiency.



5.40: Map strategizing the energyscape of Productive Sees

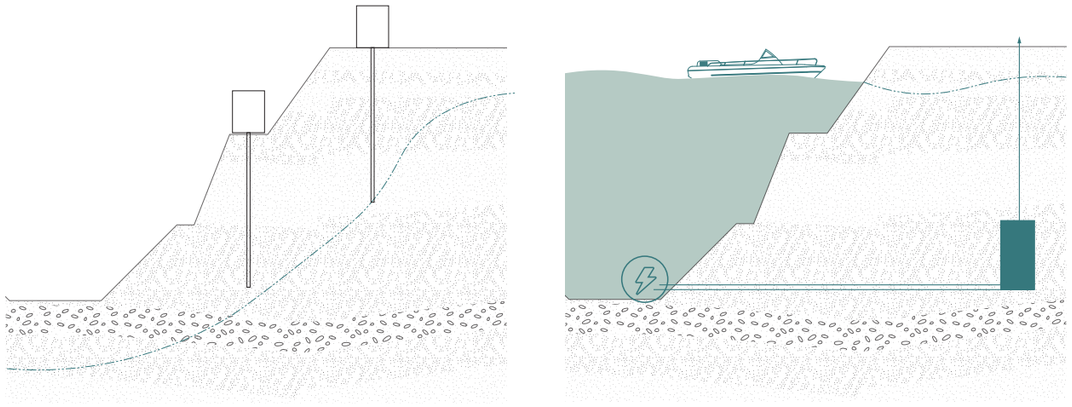
5.9 Productive Sees

5.9.1. Energy production method

"See" is the German word for lake. Since the opening of the mines, the residents have been promised that over time, the pits would be transformed into beautiful green lakes with recreational opportunities (Guns, 2024). However, this regeneration strategy, created in 1970, did not consider the need to create energy. As the creation of a lake would also mean the restoration of the groundwater level, this is a solution we should look into.

Using aquathermal energy could allow the creation of a lake while at the same time, the lake or See, also being productive for the energy network. In this case, we would use a surface water system, contrary to a drinking water, or wastewater system, to generate heat and cold. While aquathermal is relatively new and it is difficult to estimate the effective production rate. Using this low impact production strategy combined with a green and leisure environment allows for the creation of a new tourism-based economy.

During my fieldwork I noticed the number of people using the currently regenerated areas. Around the water different clubhouses were located, related to a variety of water activities. At the same time, dog walkers, school classes, mountain bikers and more, used the area surrounding the lakes to be active and outdoors. In this scenario we try to uncover what design interventions we can do to extend on this tourism economy, while also restoring the local ecosystem towards their wetland and forest environments. However, in this strategy it is critical we tackle the pollution issues in the mine, to prevent acidification of the lake. Which will not only lead to a dead lake, but also acidified groundwater which damages the natural and agricultural surroundings.

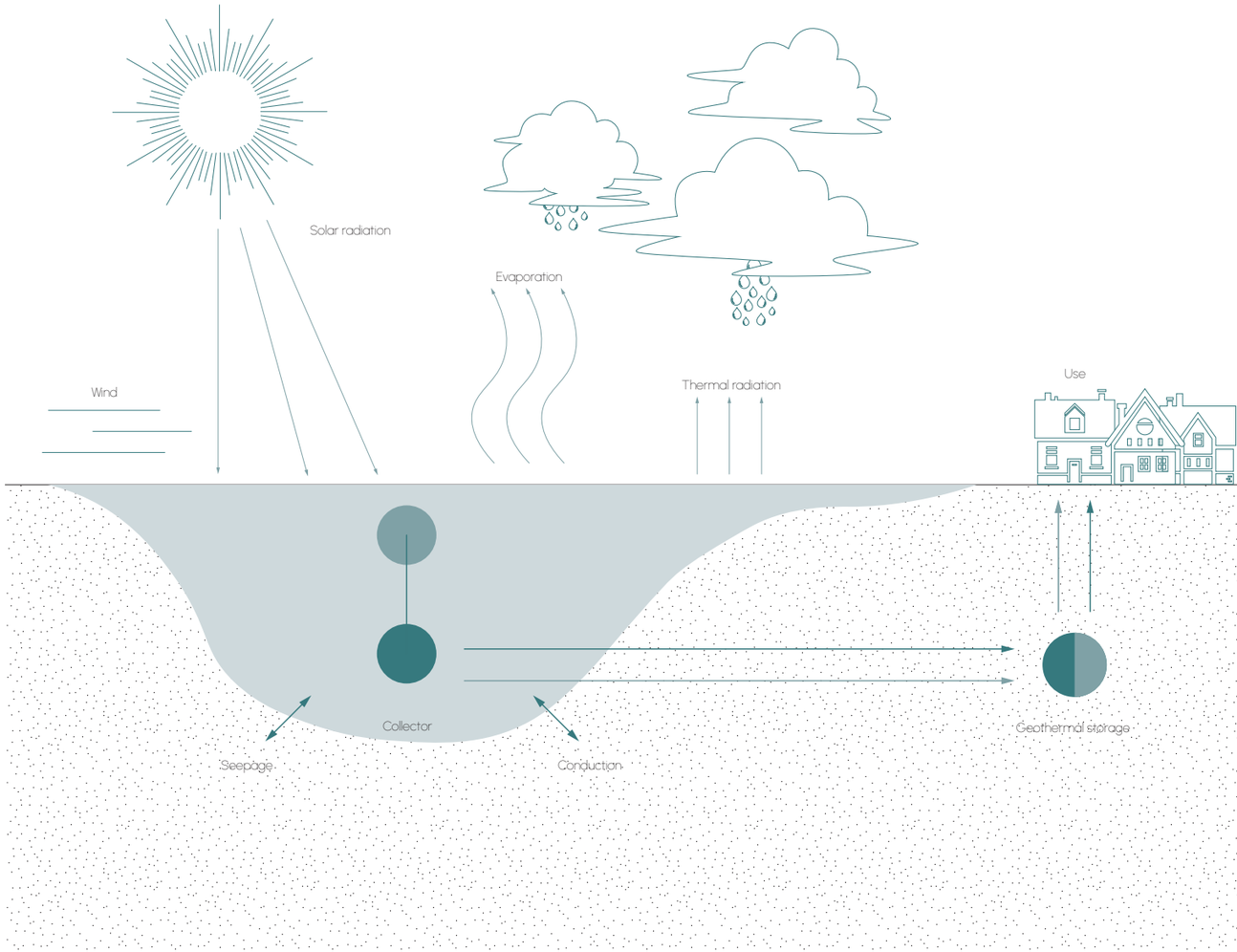


5.41: Changing from low groundwater to lakes and aquathermal energy

5.9.2 Production process

Since aquathermal energy generation is a relatively new technology, I will shortly explain its functioning in this paragraph. One or multiple collectors are placed inside the lake in the surface water generation process. These collectors abstract heat from the lake in the summer, cooling the lake down in the process which is beneficial for the ecosystem. This heat will be stored in a geothermal installation. The heat will then be used in the winter to heat residential areas. The same is done with cold in the winter.

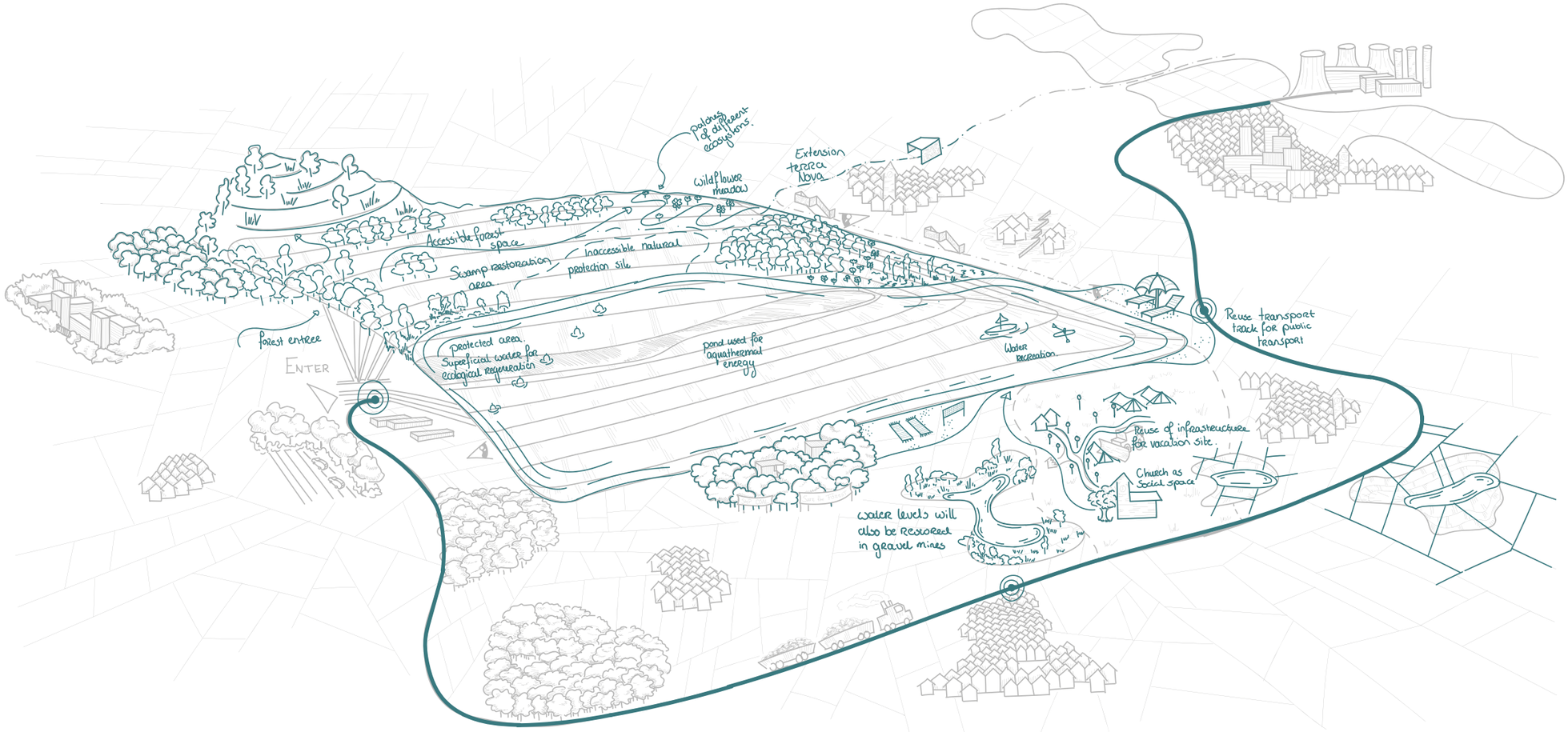
The lake interacts with its direct surroundings, meaning it heats up due to solar energy but also cools down due to wind and thermal radiation. The same is done at the bottom of the pit, where the heat is conducted into the soil. As the lake is heated by solar energy, the heat collector will be placed near the surface area. At the same time, the bottom of the lake will remain cooler and less affected by changing weather conditions and will be the source of cold (Mero & Rafferty, 2024).



5.42: Functioning of Aquathermal energy (based on Erdle (2022)

5.9.3 The aquathermal energyscape

At the foundation of this scenario is the ending of the groundwater pumping. This will significantly impact all surroundings. It will make the mechanical groundwater provision towards natural areas superfluous. At the same time, it will create lakes in all mining pits; also, those now used for gravel mining. Lower located areas will be transformed into swamps or wetlands. Not the whole pit will be filled by the rise of groundwater. Instead, part of the pit will be transformed into green wetlands and forests. In these areas we want to create recreational activities. However, some areas will also be locked off to allow nature to recover without disturbance. To create better access to the new green and blue recreational areas, the old transport system, new public transport should be created towards the main access points. Parallel to this should be the creation of biking and walking routes from and to the pits and villages. This way the residents can also profit from the tourism. The village of Hambach will be given new live by the beaches nearby. As such, it could have a role as a camping area or even be recultivated as a town again.



5.43: Representation of the aquathermal energyscape projected on Hambach

5.9.4 Design strategies

The usage of aquathermal energy strongly impacts the energy production system. For example, no power plants or transport is needed anymore. All installations are underwater or underground, making it a completely invisible, though expensive, production method. As aquathermal energy is based on heat and cold, the current electricity network will not suit this new system. At the same time, two new infrastructures need to be established. The recreational infrastructure needs improved public transport and clearer spaces for recreational activities. The second infrastructure is the natural system. Water is the backbone of this system. By restoring the groundwater level, new wetlands are created. To create functioning ecosystems, these should be large enough and, if possible, connected to other large spaces. The loss of needed surface area for the energy infrastructure creates much space we can dedicate to various new natural habitats.

Energy

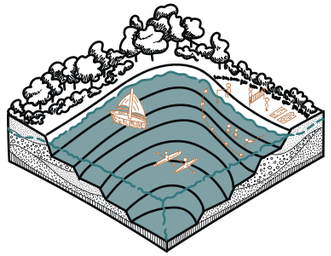
At the energy system's core is the lake's surface aqua thermal installation. Because of its scale, this will be connected to a geothermal storage. From here, the heat grid will be connected below the surface to bring household energy. As this energy created is heat, the focus is on bringing energy to residences as they can, contrary to industries, process the low-temperature energy source.

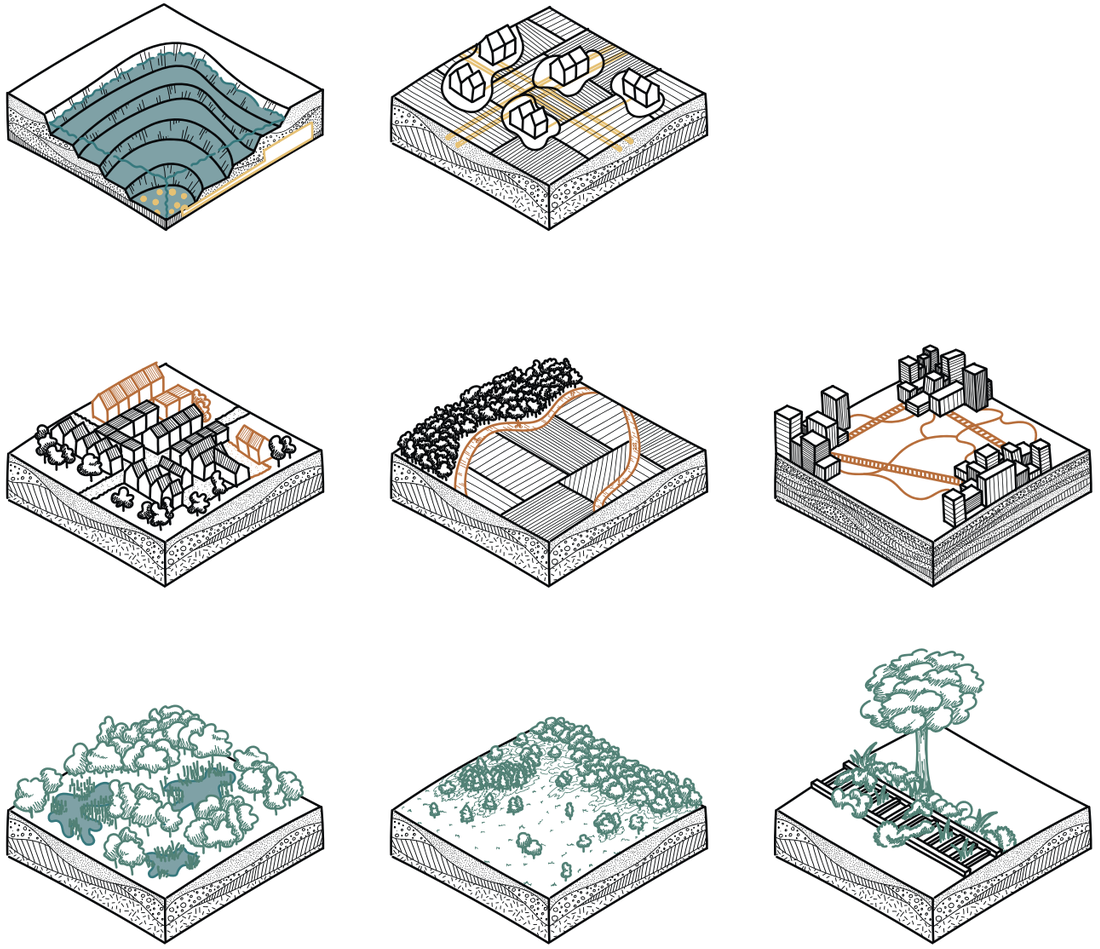
Social

The social network is founded in the new tourism economy. Realistically, this will also create the need for re-schooling for current mining employees or moving out and in with other employees. At the same time, there are the physical elements of the new green living environment. The expectation is that the lakes and green environment will attract more residents, thus leading to urban expansion.

Blue & Green

Water is the backbone of the new green system. However, it is still necessary to create a variety of natural habitats. While the restoration of the wetlands might allow some local species to return, we have also lost different forests and fields that can be returned. Removing the power plants allows for creating more natural space using phytoremediation.

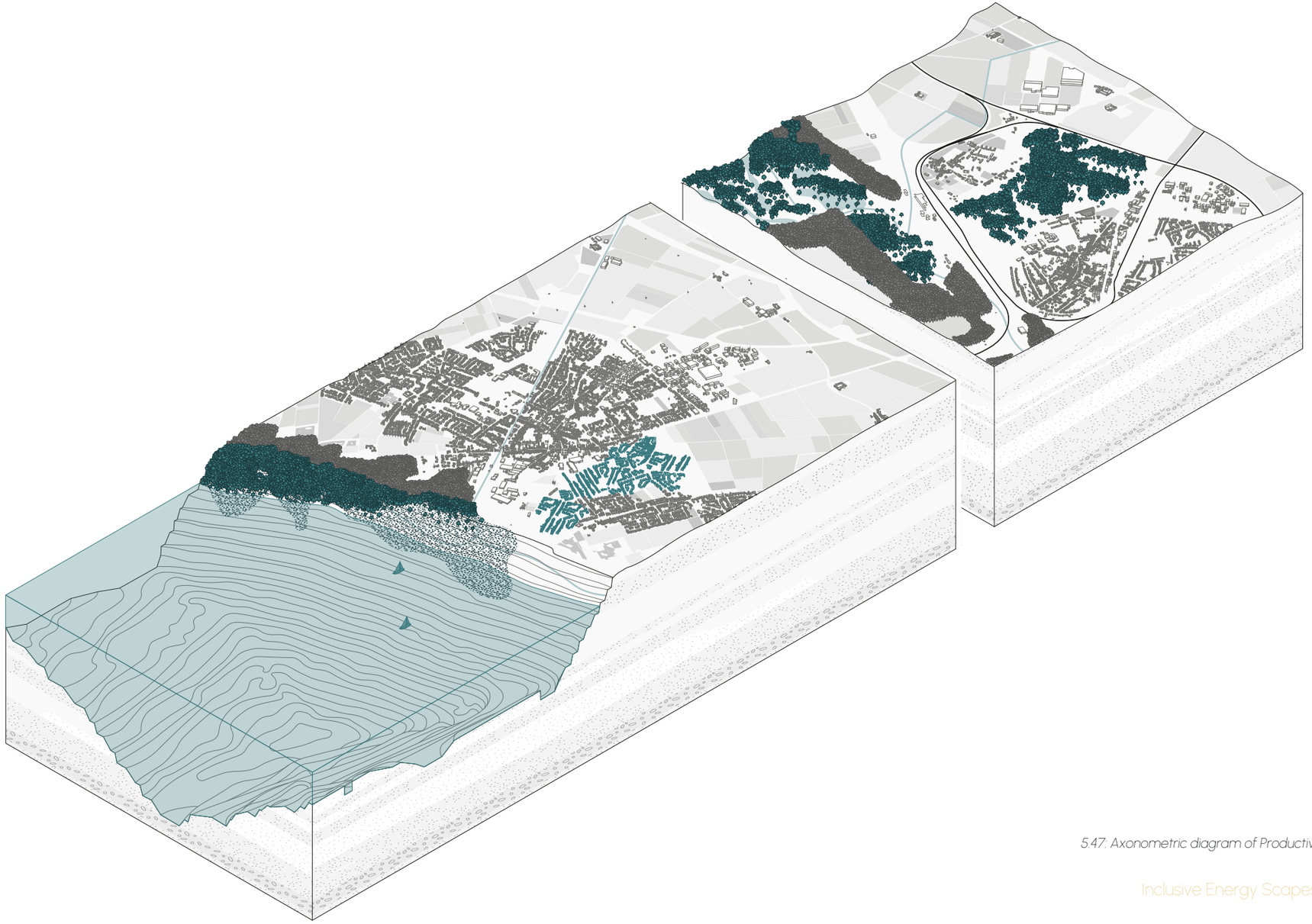




5.46: Design scenarios implemented in Productive Sees

5.9.5 Spatial implications

The creation of the lake is a notable change in the landscape. However, contrary to industries or urban development, these changes are founded on natural regeneration. At the same time, humanity can effectively use them for recreation. Over time the edge around the lake will grow dense with forest areas. The same can be said for the wetlands and the old power plant locations. With the freight trains out of service, the rail tracks can now be used as ecological corridors. Altogether, these transitions lead to a green forest-rich landscape.



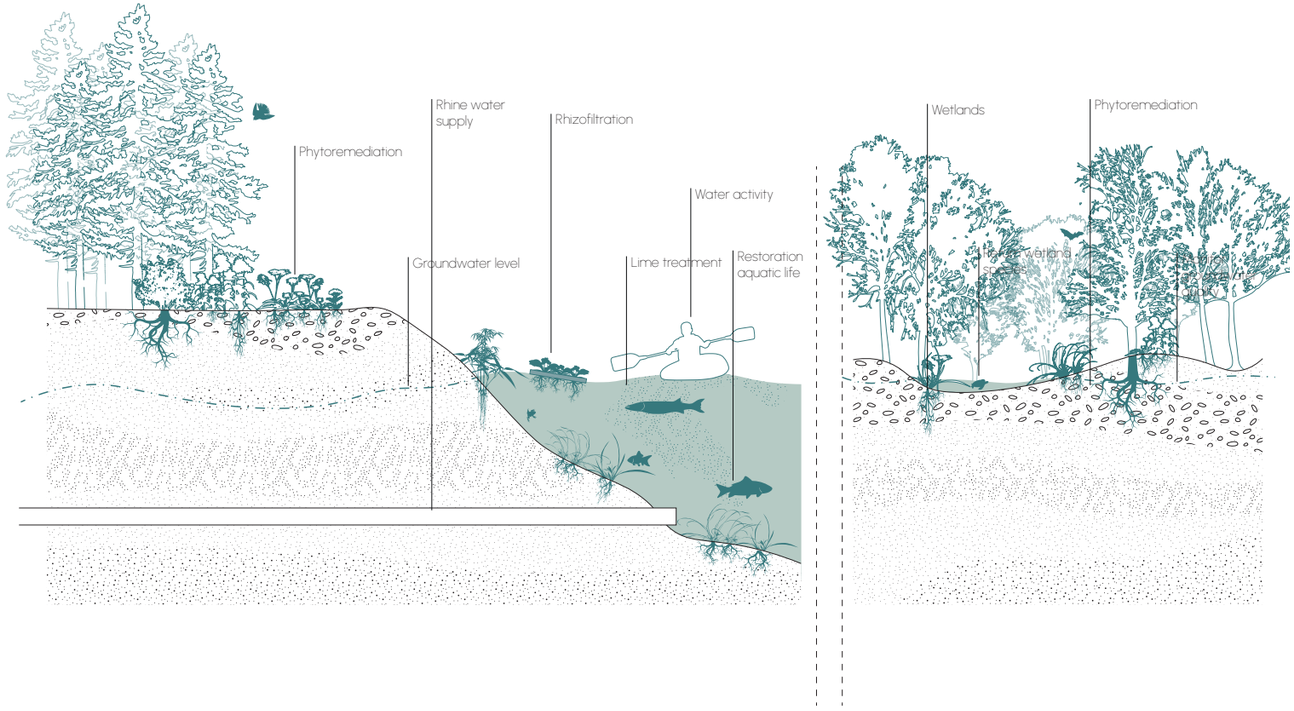
5.47: Axonometric diagram of Productive Sees

5.9.6 Ecological restoration

Soil pollution will significantly affect water quality. At the same time, it is possible to treat the water to reduce the pollution effects and prevent groundwater acidification due to seepage.

For at least the first 20 years of the lake's existence, it will be necessary to consistently treat the water using lime and rhizofiltration. While the lime reacts with the pollution to reduce the acidification, rhizofiltration is a form of phytoremediation that removes the pollution (Wisotzky & Obermann, 2001) (Kristanti & Hadibarata, 2023). This will create a lake where aquatic life can flourish, and humans can recreate.

At the same time, the heightening of the groundwater level will also affect the larger surroundings, creating wetlands in lower-situated areas. Ecologically, these areas will significantly profit from this restoration. At the same time, it will be critical to monitor the groundwater quality here. As the creation of lakes on this scale has not yet been done before, it will be difficult to estimate the consequences, and by consistently monitoring, we can intervene quickly (Guns, 2024).



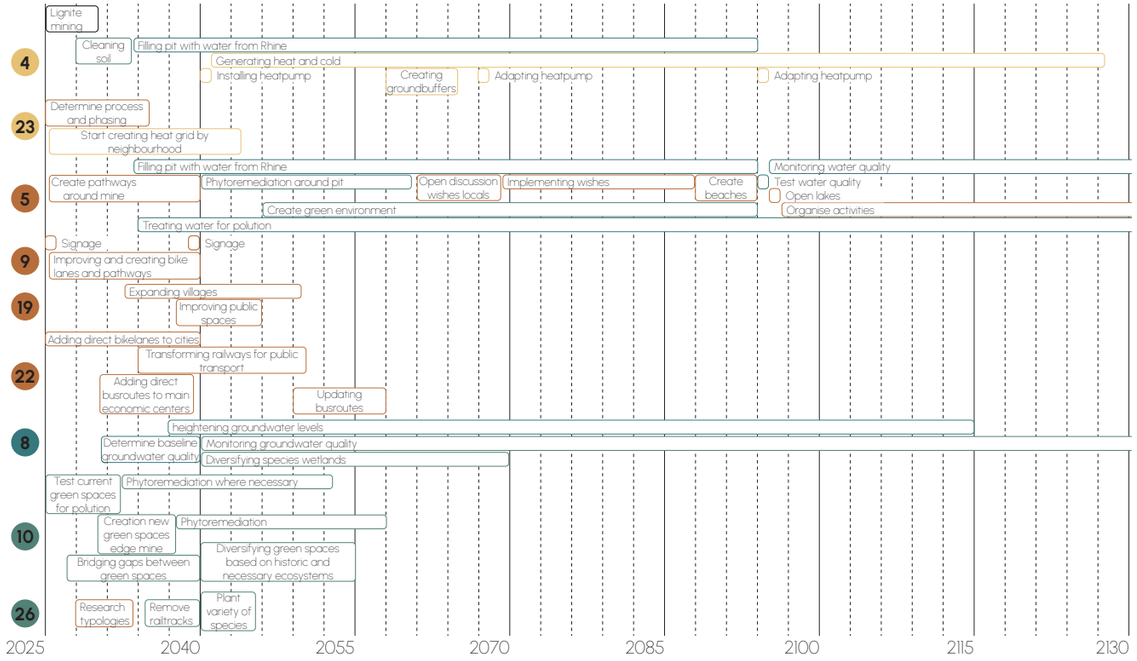
5.48: functioning of groundwater restoration and water treatment

5.9.7 Phasing

The timeline of this scenario is significantly longer than that of the other scenarios. This concerns the 60 years it costs for the lake to be fully formed. It will be possible to start generating energy before the lake has already been filled. However, the new heat grid will also take an extended period to install. Therefore, this scenario has a clear energy gap that will need to be solved elsewhere.

5.9.8 Atmosphere

The lake transforms the area into calm and quiet forest surroundings. Around the lake, there is a balance between bustling recreational activity and the calm and quiet natural environment.



5.49: Timeline

5.50: Collage Productive Sees

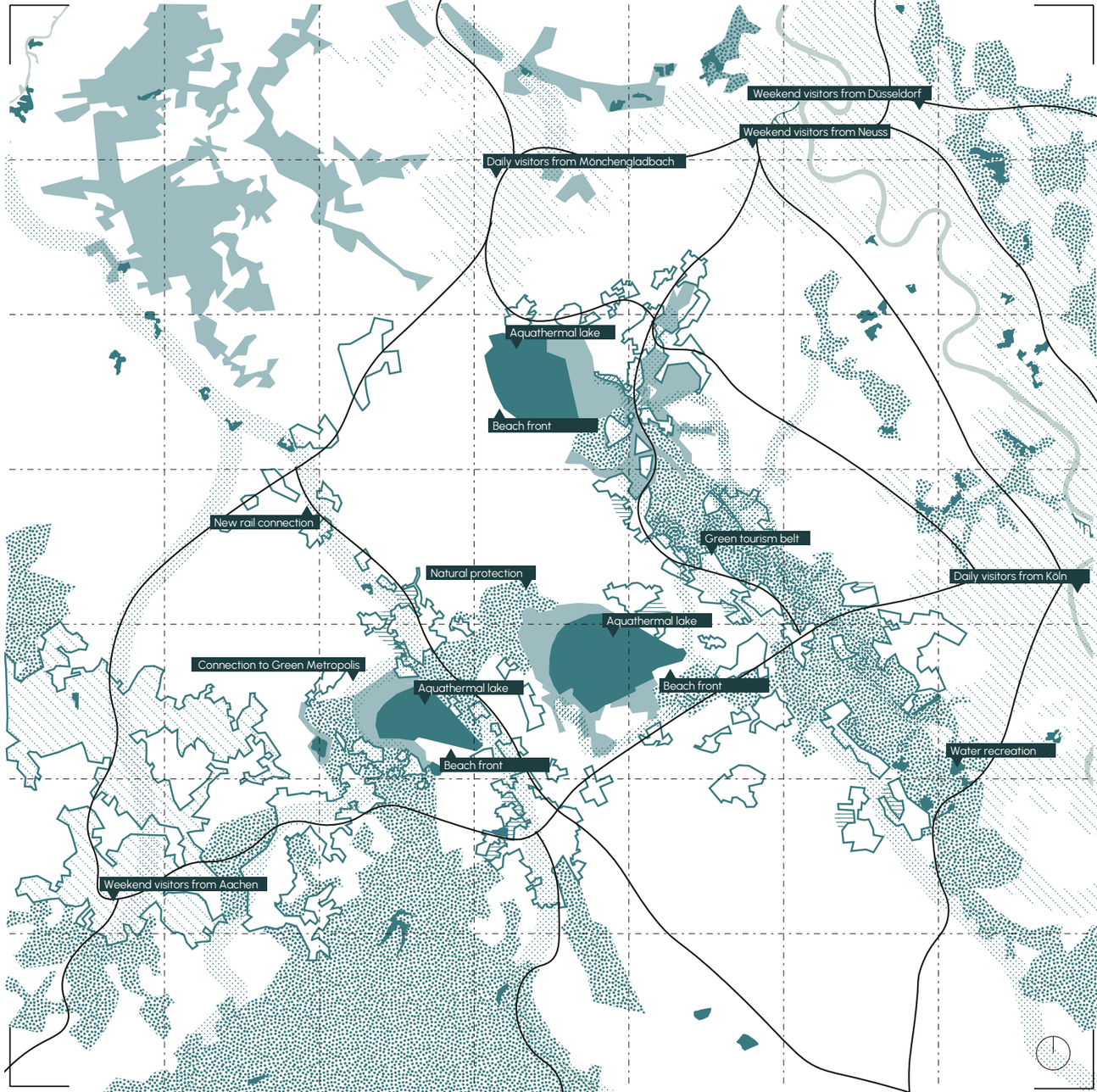
5.9.9 Limitations

While filling the mine pits with water might seem like a local intervention, the changes to the blue system are extensive. First of all, the lakes will be filled using water from the Rhine, and to pump it towards the lakes, an extensive system is needed. Next to that, subtracting water from the Rhine, might not even be possible as the flow of the Rhine has changed since the plan was established in 1960 (Guns, 2024). Then there is the timeline. The creation of the lakes takes up to 60 years. This means it will take a significant amount of time before it is possible to subtract heat from the lakes.

Secondly, are the pollution problems. Creating lakes in mine pits with the scale of those in the Rhenish District has not yet been done before. Therefore, it is difficult to estimate whether it will be possible to neutralize the pollution. If the treatment of the lake via phytoremediation and bioremediation is not successful, the lakes will not be able to be used for recreation, nor will an ecosystem be created, resulting in a dead lake. On top of this, the pollution might seep into the groundwater spreading the pollution into the surroundings. Thus, cleaning the soil and preventing interaction between the lake and the groundwater is critical.

Thirdly, there are the costs of the new energy infrastructure. Aquathermal energy is based on heat and not on electricity as is the lignite system. Thus, the complete transport structure will need to change from cables to heat grid. Next to that, the heat cannot be used by all industries, meaning the lakes will mainly cover the residential areas and the industries will be left with an energy gap.

Lastly, the scenario is based on the attraction of tourists looking for a vacation in nature. This forms the foundation of the renewed economy. Unfortunately, after WW II little other historic sites remain in the area (Kleinebeckel, 1986). This, in combination with the lack of large, well-known or popular metropolitan areas, makes the region dependent on a specific section of tourism. While this in itself is not problematic, significant work will need to be done to establish the Region in the natural recreation tourism sector.



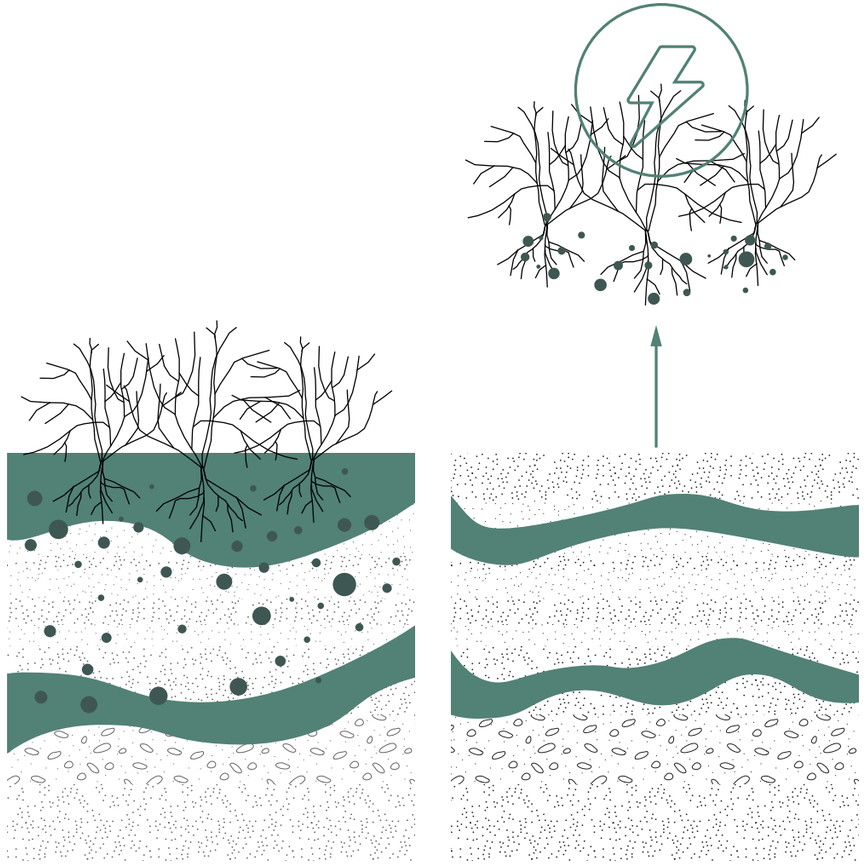
5.51: Map strategizing the energyscape of Productive Sees

5.10 A Biodiverse Economy

5.10.1 Energy production method

In the biodiverse economy, the main In the biodiverse economy, biomass is the main energy production method. As discussed before, biomass has a symbiotic relation with agriculture. When we implement biomass in the minescape, two other symbiotic relations emerge. Implementing biomass creates new green spaces. By using a variety of quick-growing, low-maintenance plants, we can extend the ecological corridors in the area.

The second relation is the cleaning of the minescape. In the green system, we can see the polluting effect mining has had on soil and air. Consequently, we can find different heavy metals and nitrogen in the soil, which could acidify groundwater and damage not only the direct mining area but also the surroundings. Different plants can clean soil. This process is known as phytoremediation. The plants absorb the polluted particles through their root system, and by extracting these plants, we also extract the pollution. After this process, we can use the harvested biomass for energy production.

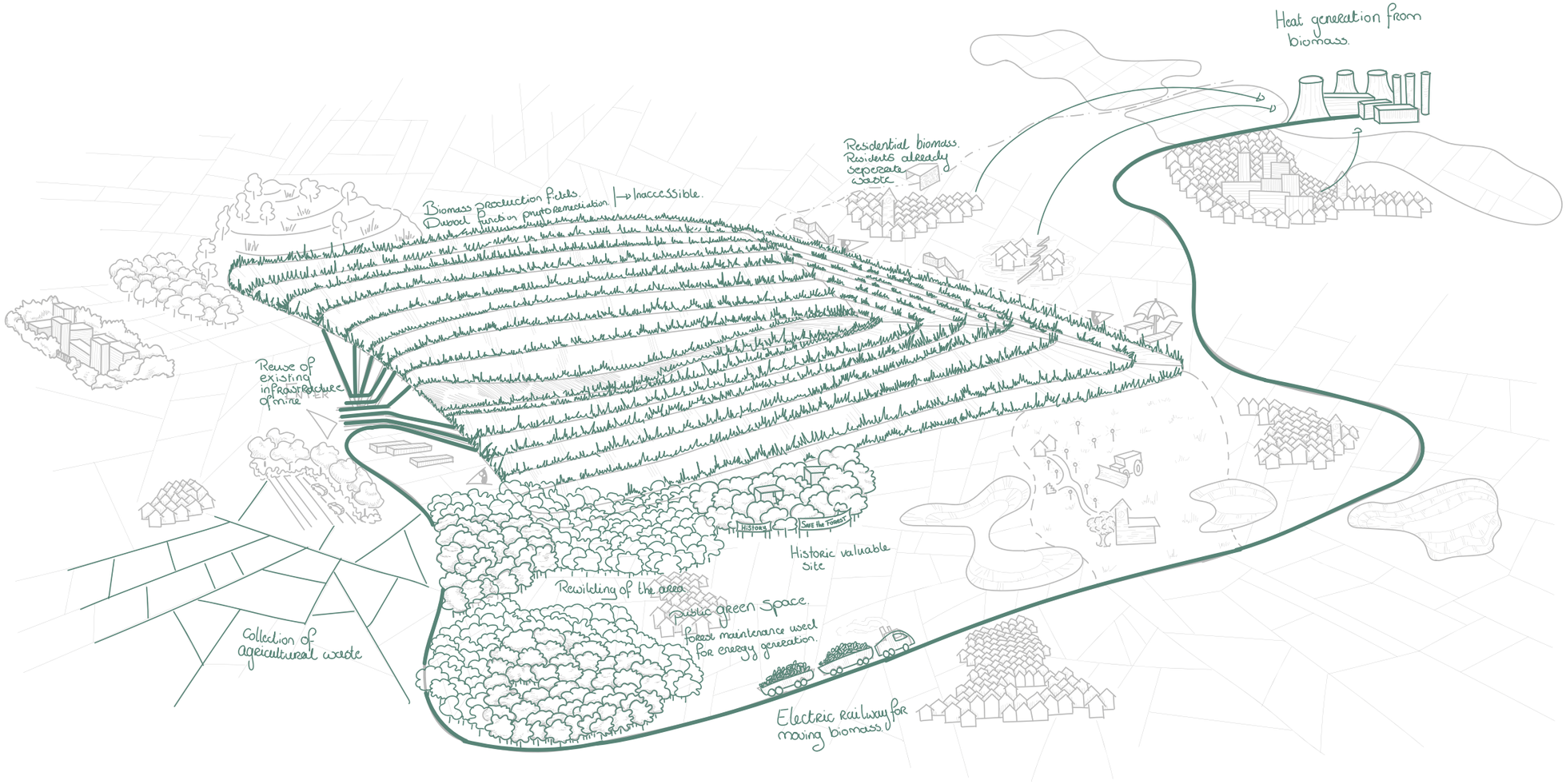


5.52: Biomass and phytoremediation principle

5.10,2 The biomass energyscape

The integration of biomass production in the minescape does not only lend itself well from the ecological or green system perspective. The existing infrastructure of the lignite mining process is very suitable for biomass cultivation and processing. The large open spaces of the mines can be used for biomass production without transforming land use. Inside the mines, railways are used to transport the lignite around. This same system can be used for the biomass transport. The biomass can be collected and moved over the existing railways to the power plants. These can be retrofitted to generate heat or electricity from the biomass.

As biomass cultivation is a continuous process, a workforce is needed for cultivation, transport, and generation of heat and electricity. Therefore, this scenario creates a new energy employment sector based on a green economy. This, in combination with re-educating residents, will lead to a new economic impulse, protecting the minescape from a decreasing population.



5.53: Representation of biomass energyscape projected on Hambach

5.10.3 Design strategies

This scenario needs a lot of space, both to produce energy and for the transport of biomass. As a consequence, the urban environment will need to be denser. Due to the disappearance of mines, the commuting belt, and the local new employment opportunities, growth in population can be expected. More housing will be needed, but in the same amount of space, to compensate for this. Therefore, the urban areas will need to become more compact.

At the same time, it also provides opportunities to integrate the energy system into the existing energy and waste system. One strategy would be to collect agricultural, natural, and household waste. This way, residents would also be involved in the energy system, which could lead to more awareness and more sustainable energy usage. This also allows for more energy to be generated.

In the planning of these new biomass production sites, attention should be spent on efficiency, but also on phytoremediation quality and diversity. This means that the implementation of biomass should strengthen the ecosystems in the area also servicing the energy system.

Energy

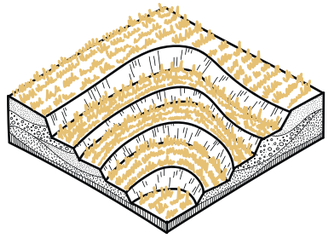
To generate biomass energy, we would need a new production site for the resources—mines. At the same time, we can retrofit most of the existing transport systems. The main intervention in transport would be the new heat grid to transport the energy. As biomass is a consistent resource and we can store it as biomass, energy storage is not needed for energy security.

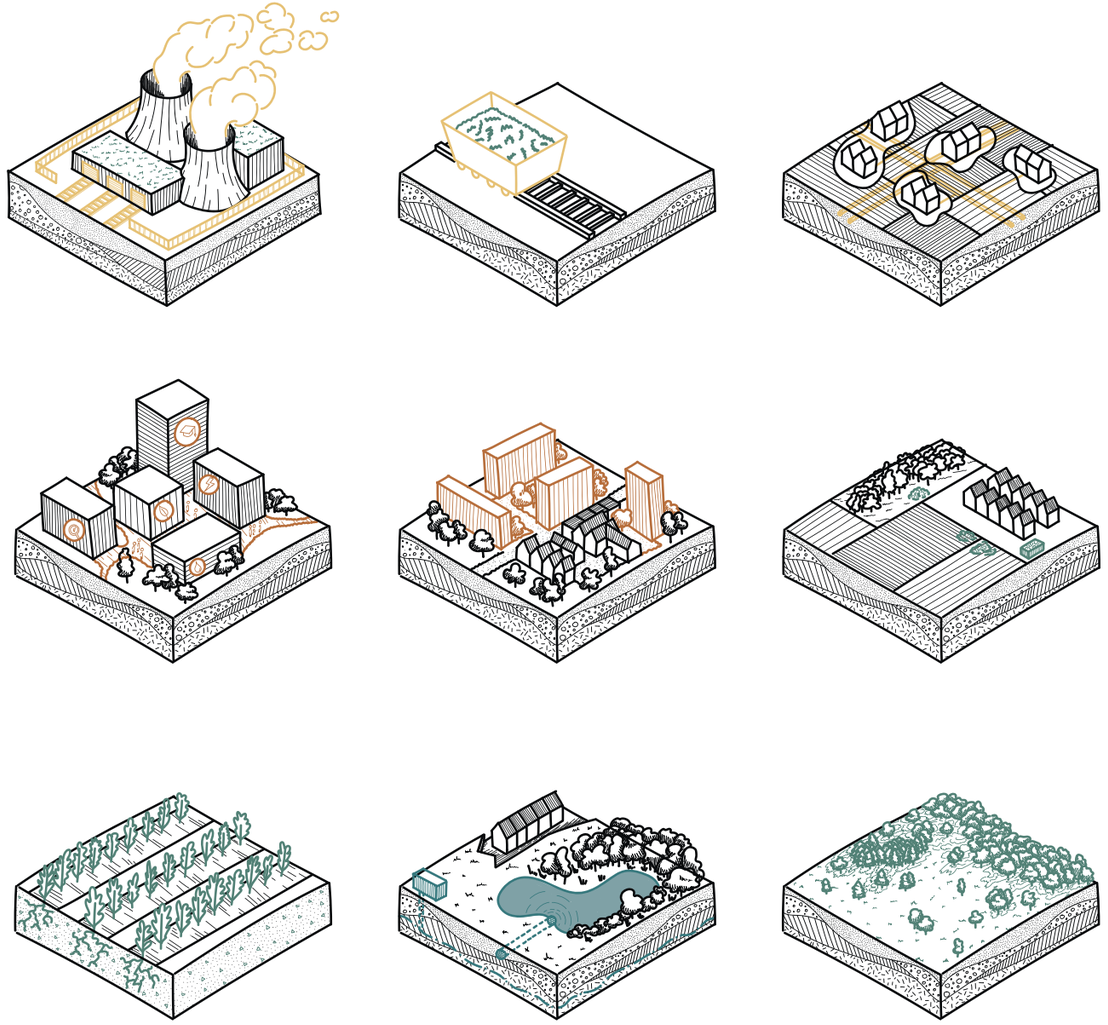
Social

We would need to train the new employees to integrate this new green economy. As such, an R&D centre with a focus on this energy transition would be able to transition the existing population towards the new economy. At the same time, urban densification will be necessary to provide a fitting urban environment. Through the collection of biowaste, we include locals in the energy transition.

Blue & Green

The groundwater level must remain low to use these mines for biomass production. Instead, phytoremediation will be used to improve soil quality and strengthen the soil's biodiversity. At the same time, to truly strengthen the ecological corridors, it is also necessary to recultivate some of the lost forest spaces.

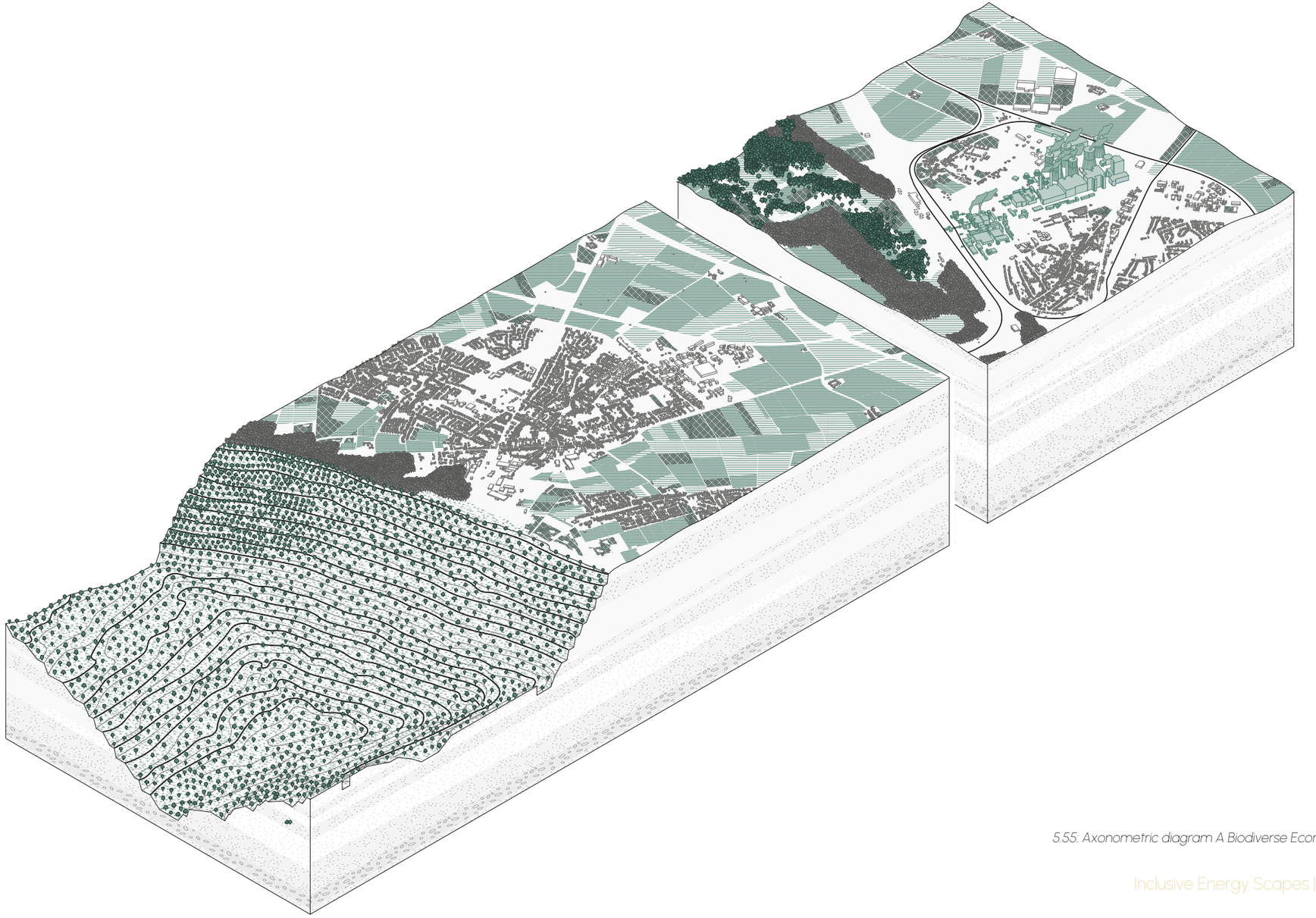




5.54: Design scenarios implemented in Living in the In-between

5.10.4 Spatial implications

In the Biodiverse Economy, the complete landscape is transformed into a productive landscape, creating biomass for energy use. While in the old mine pits, production is placed for biomass production. The waste from the urban, agricultural and natural environment is also collected to optimize the system. The existing transport system can be modernized over time and will gain new life in this system. While the mine pits themselves can become open for residents, the power plants find their new function in the processing of biomass and as such, still have emissions and are closed to the public. Over time, the existing power system should be updated to reduce emissions and dust locally. At the same time, the ecosystem cannot simply profit from the production of grass or one type of biomass. As such, just as with the diversification of normal agriculture, the same methods will be applied here. Old land heaps and landfills will be converted into forest areas to strengthen the region's ecosystem and green recreational character.



5.55: Axonometric diagram A Biodiverse Economy

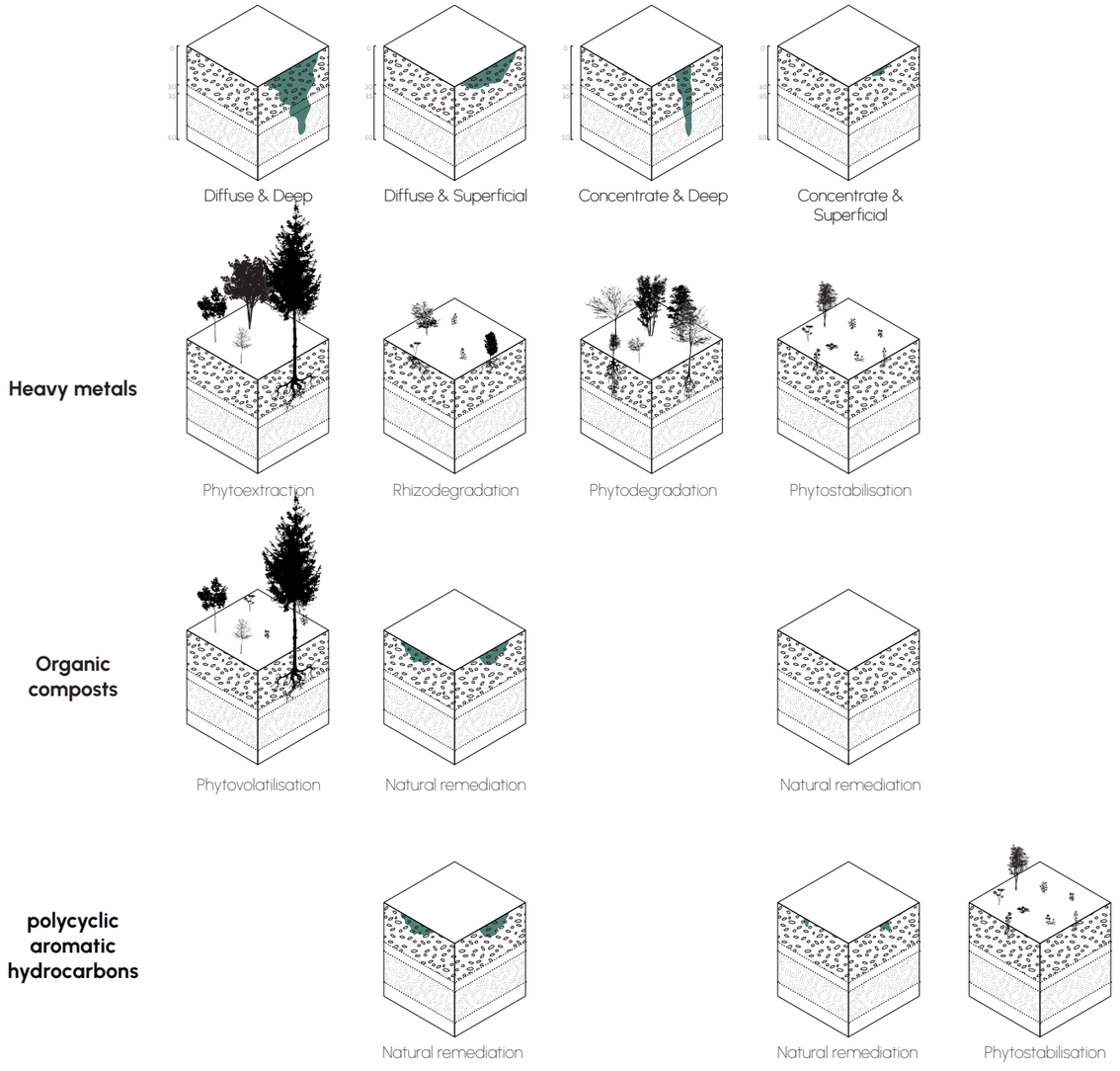
5.10.5 Phytoremediation

As discussed, we can expect three types of soil pollution in this area: heavy metals, organic composts, and polycyclic aromatic hydrocarbons (Rouhani et al., 2023) (Velthof et al., 2011). Using phytoremediation, we can neutralize these elements.

Phytoremediation can take place in different forms, depending on the plant, pollution type, and depth. Depending on the depth of the pollution, the materials and the severity, we can choose for:

- Phytoextraction: the extraction of the contaminants from the soil by plants, followed by the removal of the plants by humans. (Pandey & Bajpai, 2019)
- Rhizodegredation: the destruction of contaminants in the root system; phytodegradation: the destruction of contaminants in the plant. (Kafle et al., 2022)
- Phytovolatilization; allowing plants to transform the pollutants into less damaging gasses and realising them into the atmosphere (Pandey & Bajpai, 2019)
- Phytostabilisation: Here the plants prevent the movement and spreading of pollution, without reducing the pollution. (Pandey & Bajpai, 2019)
- Natural remediation: adding certain modifications to polluted soil to enhance key biogeochemical processes, which helps immobilize pollutants (Adriano et al., 2004).

To be able to determine the exact plants needed in this area that are both suitable for the pollutants and the remediation methods, we would need to overlap quick growing plants with high biomass to the possible plants usable for phytoremediation as discussed by Kafle et al. (2022)



5.56: Forms of phytoremediation based on types of pollution (Tamiazzo, 2015)

5.10.6 Healthy soils

Bringing together the right plants for the type of pollution in the area, in combination with local plants, will create a strong ecosystem. At the same time, we should strive for quick-growing species and a wide enough variety of species to grow throughout all seasons and provide for a diverse ecosystem. This can be measured in the soil health. By monitoring the micro-organisms in the soil, we can determine the state of the soil and thus whether we should adapt species to compensate.

At the same time, we can still use the existing mining infrastructure. Here, we can see the use of the rail infrastructure inside the mines to transport biomass. At the same time, part of the farming cannot be automated, which creates employment opportunities.



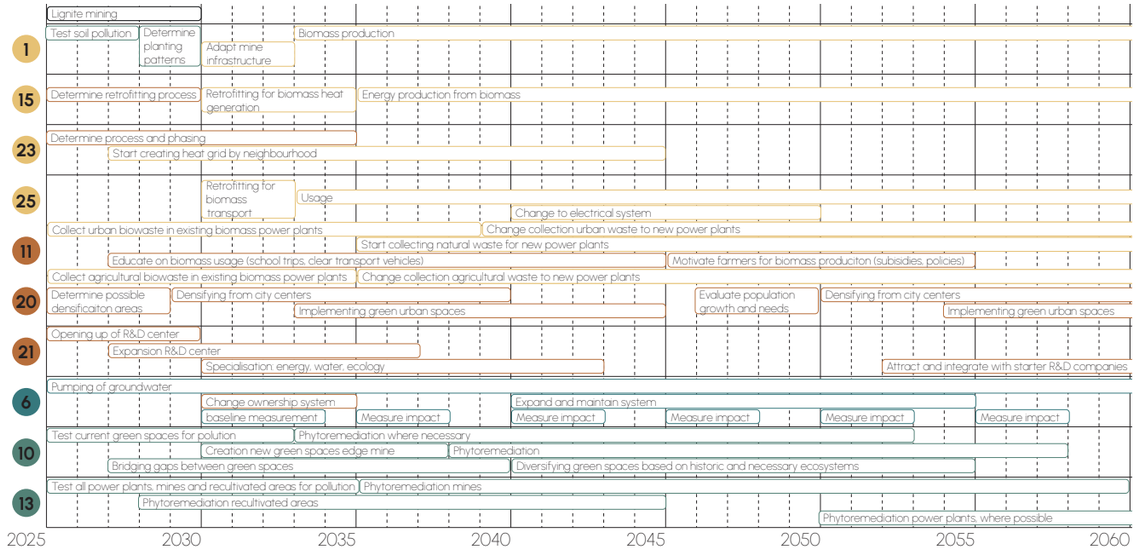
5.57: Functioning of the ecosystem

5.10.7 Phasing

While the mining is still active, starting the first steps towards the new biomass system will be difficult. However, we can start determining the exact pollutants in the soil and the plants that are fitting for the pollution, production rate, and ecosystem. These testing methods can be used around the area to determine all pollution sites and intervene where necessary. When the mines close in 2030 we can move quickly towards biomass production. However, the retrofitting of the power plants might take longer. Therefore, it is wise to start already retrofitting the now-closed power plants on standby to guarantee a smooth transition.

5.10.8 Atmosphere

As visible here, the environment will become significantly greener. The now barren pits will become green, and it would be interesting to create boardwalks or pathways through the area to allow residents to recreate in this new agricultural landscape.



5.58: Timeline

5.59: Collage A Biodiverse Economy

5.10.9 Limitations

Biomass is a spatially demanding energy production method. Not because it impacts the surroundings but because of the extensive space needed to cultivate it. Biomass production needs over 450 times as much space as lignite extraction. As such, even with all the agriculture in the region being transformed into biomass production, this new system will only be able to produce a fraction of the energy lost by the mine closure.

Secondly, while biomass is not dependent on weather conditions like solar and wind energy, it is dependent on the climate. The cultivation of biomass is part of the agricultural sector, which is vulnerable to climate change (Statista, n.d.). Thus, droughts, floods, extreme temperatures and changing rainfall can threaten biomass production, destroying harvests and, through this, energy production. The biomass can be stored and thus be divided throughout the seasons to create a stable energy input. The production of biomass on the available surface area will be too low to also account for bad harvests. With the effects of climate change increasing, extreme weather events become more common. Combined with the lower groundwater table in the region, the future and the scale on which biomass production will be implemented should be evaluated.

The cultivation of biomass is a short process that is done in less than a year. However, the phytoremediation process is much more extensive, demanding 20 to 60 years. As such, farmers of biomass are for a long time limited in the plants they can cultivate, not being able to adapt to climate or local conditions. Policies will need to be integrated to guarantee the phytoremediation process will take place, soil quality is checked, and the biodiversity of species is maintained. This in itself brings questions concerning the ownership of the mines, the products, involvement of farmers and RWE. The long-time span of phytoremediation also prevents these spaces from being used for most other functions.

Lastly, related to the phytoremediation and biodiverse production of biomass is the regeneration of the natural spaces. Due to the pollution and low soil quality the regeneration of the natural areas will be limited as it will be centred around resilient species. This will limit the possibilities of species and thus habitants and ecosystems. In the regeneration questions of ownership and investments will also play a role.



5.60: Map strategizing the energyscape of a biodiverse economy

5.11 Evaluation

5.11.1 Interscalar impact

The change in production method also changes the way the landscape operates in comparison to the region. Here, I include both the local rural and urban environment and the large cities in the vicinity.

In these diagrams, the largest circle implies the region. The middle circle is the direct urban environment, and the small circle the centre of activity.

The dotted line stands for a relation in activity. A continuous line implies a relation in residency and employment, while a filled circle implies a strong core.

Living in the in-between

Here, the minescapes form the liveable centre for the outer urban rings. It is a form of living in the green "in-between." In this case there would be an increase in population and increase in movements.

Wind, Water, Work

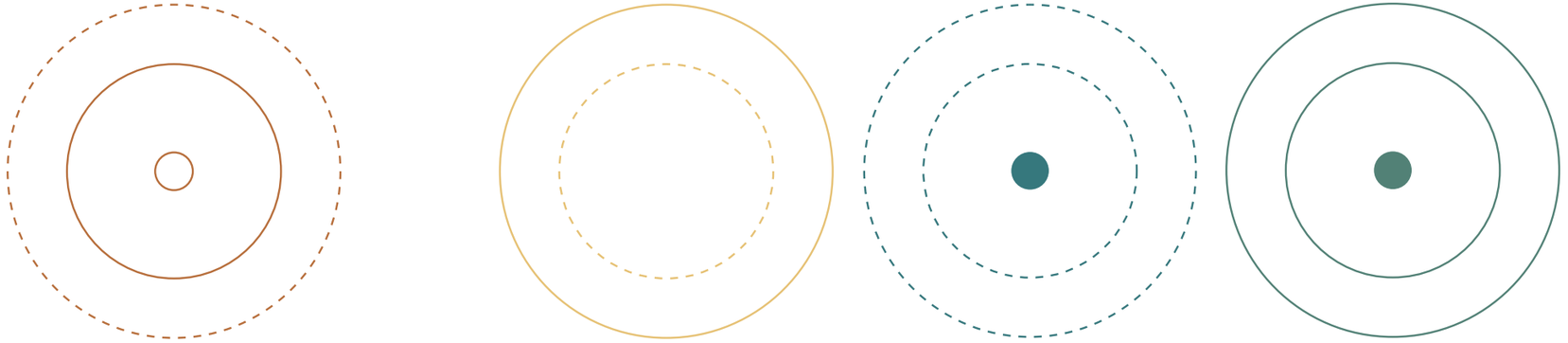
Here the minescape becomes an operational landscape. Its purpose is to service the urban and industrial surroundings. In this case there will be a decrease in population and movements.

Productive Sees

The minescape becomes a recreational centre for the surroundings. and the direct urban environment. In this case, there will either be a decrease or stable population, but a strong increase in movements.

A Biodiverse Economy

In this case, the minescape creates an economic and energy centre. The intensive energy production also creates a new economic impulse, allowing residents to find new employment in their existing skill set. It would lead to a stable population and a slight increase in movements.



5.61: Relation to the region

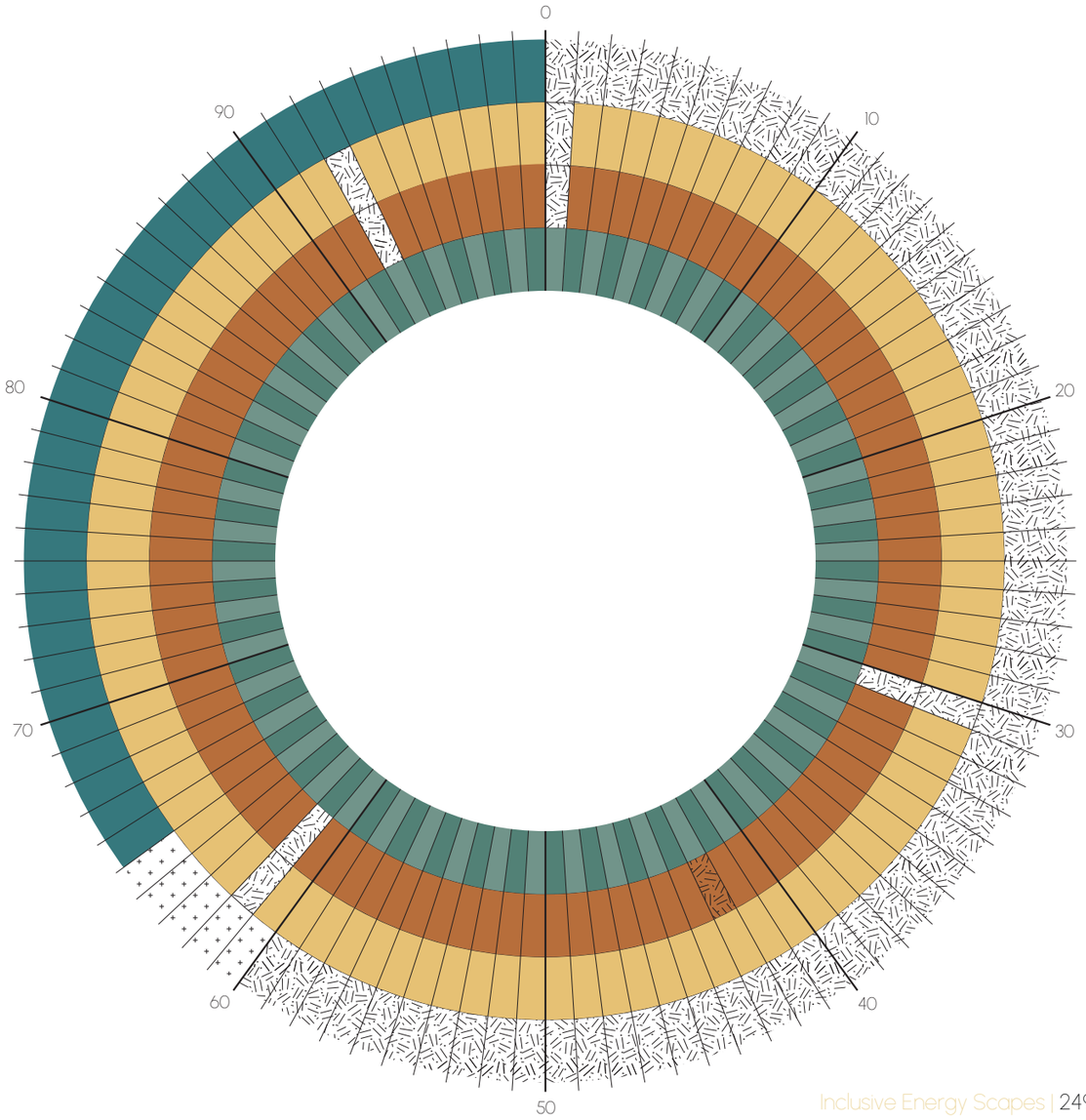
5.11.2 Lifespan

Not only do the implementations of the scenarios have different lifespans, but so do the technology and production methods. This diagram compares energy production over 100 years. It highlights the short lifecycle of biomass. As this cycle only takes a few months to a year, the scenario is flexible and stable.

Solar and wind are similar, with both windmills and solar panels having an approximate lifespan of 30 years (WINDExchange, n.d.) (Schouten, 2024). Of course, in the system, we should also take the batteries into account, which right now have a maximum lifespan of about 15 years (Wolf, n.d.).

The diagram also shows how long aquathermal energy can be integrated into the area. Realistically we could use a combination of wind energy and batteries to compensate for the first 60 years while we create the lakes. This example already shows that it can be valuable to combine different strategies and production methods (batteries from "Living in the in-between", wind energy from "Wind, Water, Work" and aquathermal energy from "Productive Sees".)

The lifespan of these production methods matters to the costs and flexibility of the space, but also for the usage of materials. In the case of biomass, the resources are renewable, thus the lifespan is less relevant. However, in the cases of solar, wind and aquathermal energy, we need rare earth materials to produce the technology necessary (Van Exter et al., 2018). In these cases, the longer the lifespan, the less pressure we put on external areas and, thus, on new minescapes.



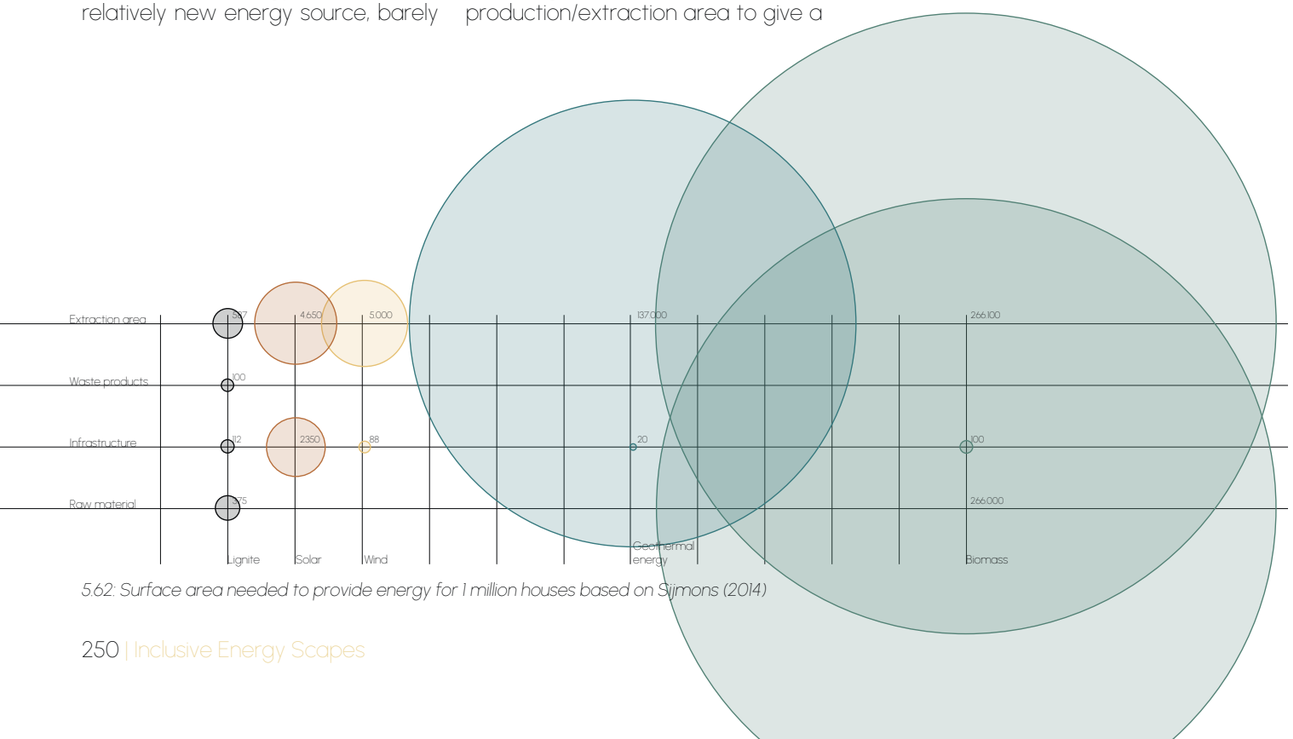
5.62: Diagram comparing the lifecycle of different scenarios

5.11.3 Spatial demand

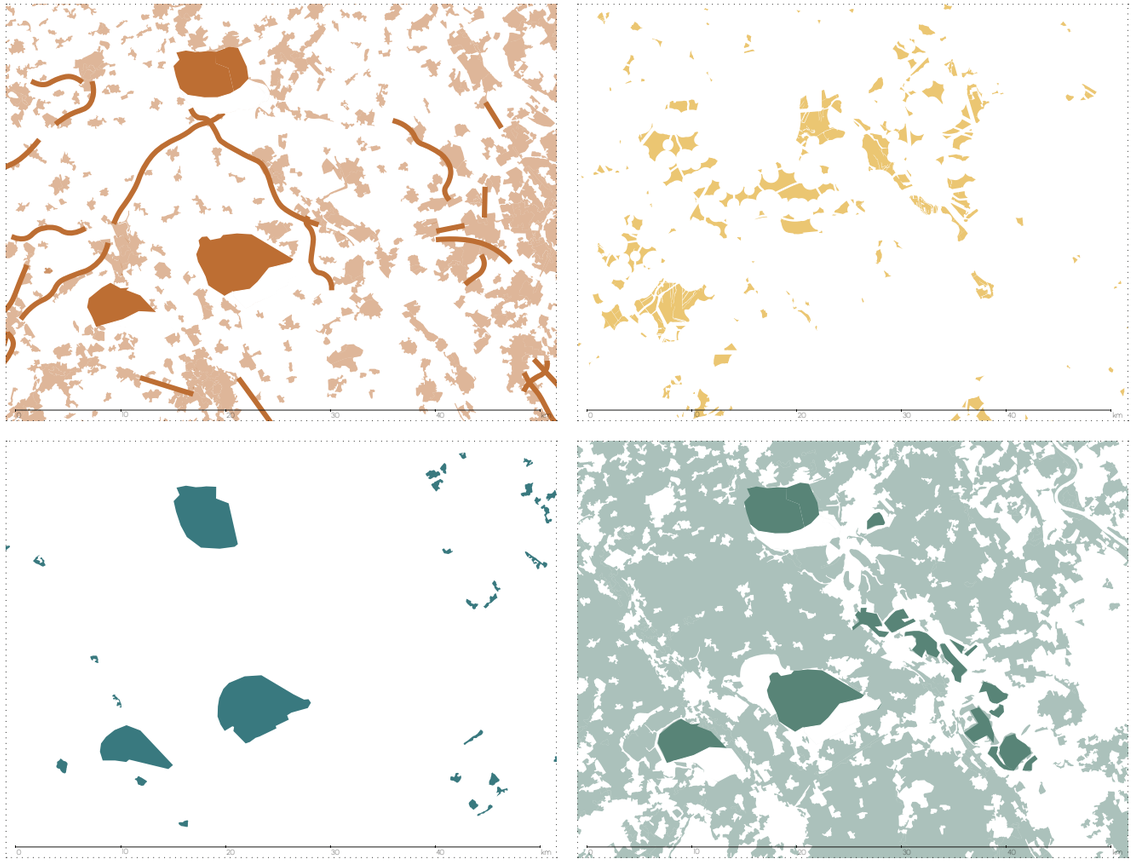
The spatial demand needed for these new energy landscapes differs from the outline of the minescapes. When we review the old lignite mining area, specifically the extraction area, we can see a significant difference.

In the diagram we can see all four energy sources except aquathermal energy. As this is a relatively new energy source, barely any comparable data is available. Instead, I opted for the usage of geothermal energy. As this method of energy production is comparable to aquathermal energy generation the space might be comparable (Benning & Netwerk Aquathermie, 2023). However, this is an estimation and should be taken as such.

On the right, we can see the effective production/extraction area to give a general estimation of the amount of space used for production. This shows that the space used for energy production in all scenarios increases. At the same time, the amount of energy produced becomes significantly lower. Therefore, no matter the production method, we cannot compensate for all lignite energy production in this area.



5.62: Surface area needed to provide energy for 1 million houses based on Sijmons (2014)

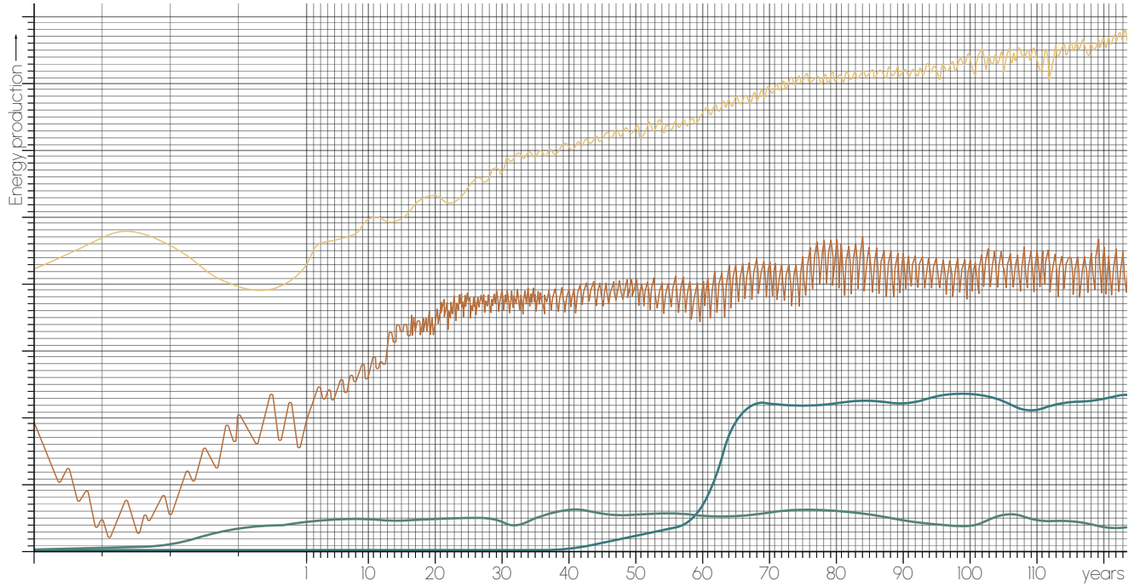


5.63: Landuse of renewed energy production system per scenario

5.11.4 Production rate

This diagram abstracts the production rate of the different energy production methods over time. It is based on the estimated energy production based on the land use in the different scenarios. Biomass forms a very stable source but has an exceptionally low production. Solar is a bit more effective than wind but more unstable. Wind is more stable due to the battery capacity and the climate of Germany.

Aquathermal energy is difficult to estimate as few numbers are known. We can expect the source to slowly build up over time while the lake is formed. Due to the size of the water body, energy production will become stable from here. However, we cannot be sure at what energy level this will happen.



5.64: Abstraction estimation energy production

5.11.5 SDG's

As discussed before, the SDGs stand for Sustainable Development Goals. The United Nations defines them as a global target for just and sustainable development. There are 17 SDG's which all consist of their own targets.

The project works on 7 of these goals. However, for each goal, it does not focus on all the targets. Below is a list of the targets of each SDG that this thesis focuses on. These targets are cited from the United Nations.

The specific targets have been set based on the landscape's possibilities, the area's current level of development, local and nationwide policies in Germany, and their relation to the four systems and inclusivity.



3. Good Health and Well-being

Ensure healthy lives and promote well-being for all at all ages.

3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.



6. Clean Water and Sanitation

Ensure availability and sustainable management of water and sanitation for all.

6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.

6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.

7. Affordable and Clean Energy

Ensure access to affordable, reliable, sustainable and modern energy for all.

7.1 By 2030, ensure universal access to affordable, reliable and modern energy services.

5.65: Icons SDG Goals, adapted from United Nations, (n.d.)



7.2 By 2030, increase substantially the share of renewable energy in the global energy mix.

7.3 By 2030, double the global rate of improvement in energy efficiency.

7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.

7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support.

8. Decent Work and Economic Growth

Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors.

8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services.



8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value.

8.6 By 2020, substantially reduce the proportion of youth not in employment, education or training.

8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular

women migrants, and those in precarious employment.

8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products.



9. Industry, Innovation and Infrastructure

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries.

9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets.

9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.

9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending.

11. Sustainable Cities and Communities

Make cities and human settlements inclusive, safe, resilient and sustainable.

11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.



11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.

11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage.

11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.

11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.

11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning.



15.Life on Land

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.

15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.

15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species.

15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.

5.11.6 Evaluate

When we place the scenarios against the SDG goals, we can evaluate the scenarios on an effective basis.

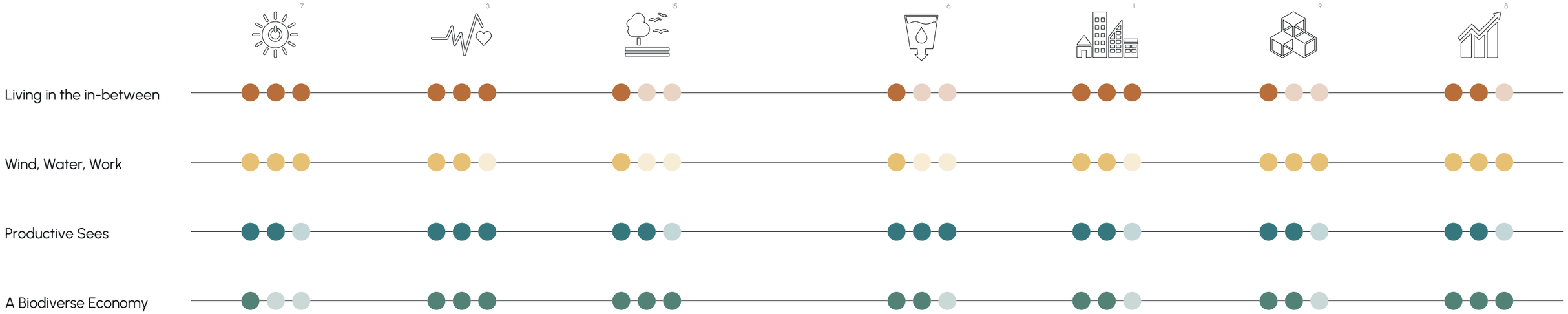
The main conclusions we can draw from these scenarios are the role in energy production, where biomass scores significantly less due to its low production density and thus low production rate. When it comes to natural systems, biomass scores well, highlighting that it is very inclusive of the blue and green systems.

At the same time, aquathermal, not surprisingly, scores the best on the water quality as it is the only scenario allowing the groundwater level to be restored, making the water system independent of a mechanical system. At the same time, biomass scores well here as it is the method most focused on cleaning the soil and thus preventing groundwater pollution.

The Wind, Water, Work scenario scores well on development and economy, defined by its impulses towards a new economy. Living in the in-between still scores well on this department, since it does promote employment possibilities, though not in the direct area.

In these scenarios, we can see that the first two lean more toward the societal perspective and create an inclusive transition from there. The last two scenarios are more environmental-focused and strive to include nature in the energy transition. While neither of the strategies excludes the other lens of inclusion, they are not balanced equally.

Therefore, the most important conclusion we can draw from this evaluation, is that even though each of these scenarios has its qualities, none of them are a perfect solution. In each scenario we must concede some key factors. Therefore, in the next step, it would be necessary to define the principal values of the area and the critical needs and merge parts of the strategies where possible to come to a more inclusive strategy.



5.66: Evaluation

5.12 Strategy

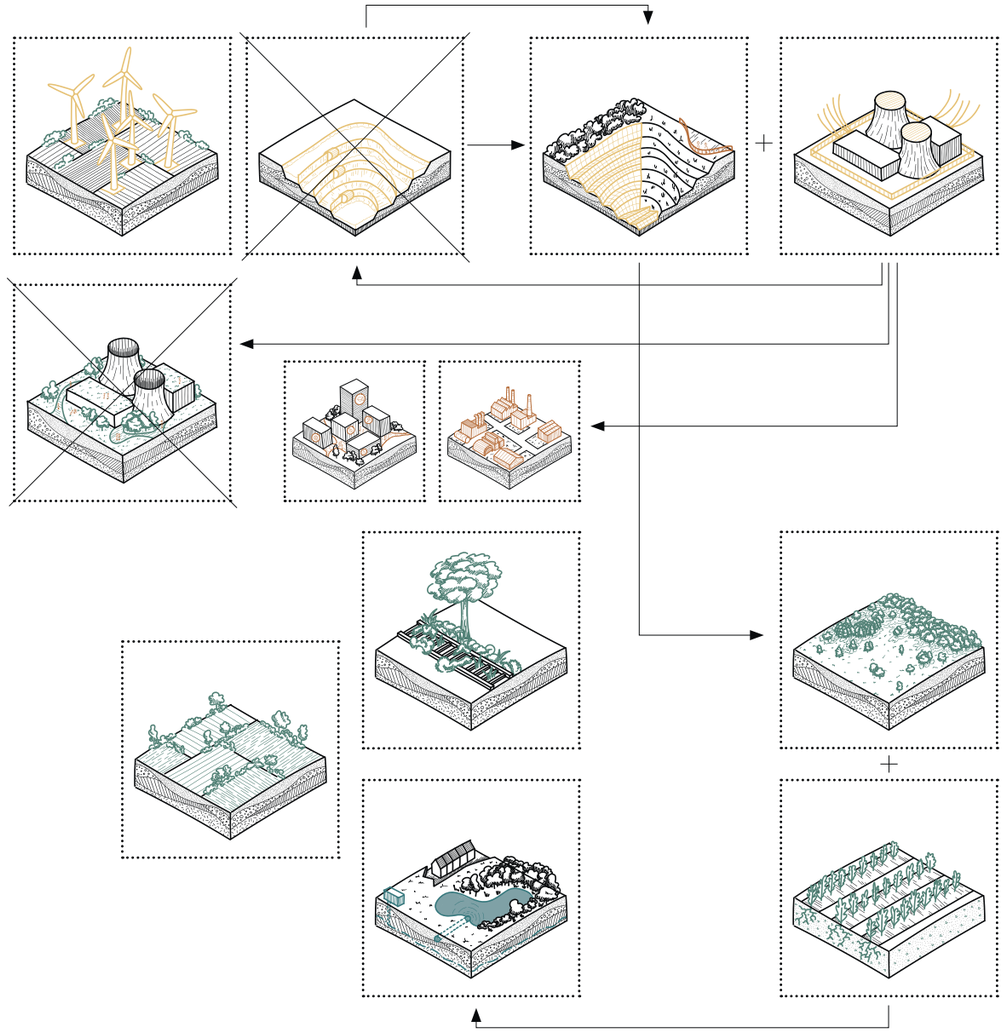
5.12.1 From scenario to strategy

The scenarios are a method of displaying possible future trajectories based on different energy production methods. However, as the limitations show on a regional scale, they have limitations. The evaluation shows the different strengths and weaknesses of the scenarios. When bringing these scenarios towards a strategy, these strengths and weaknesses are key as they need to be combined to come up with a stronger inclusive landscape.

Bringing together the different scenarios will allow one to compensate for the weaknesses of another. It does so by integrating the different design strategies. Therefore, it is valuable to determine what parts of the scenarios are mutually exclusive and which can be combined to function next to each other or even strengthen each other. A possible method to do so is to start from one scenario and use different design strategies to adapt to this scenario.

In this image I research the relations between the different design strategies. I do so by expanding on the "Wind, Water, Work" scenario. I expand on the existing future trajectory: Which elements are critical for the implementation to work, which are not, what can be added to strengthen the scenario in other aspects. This shows, which relations are strong, mutually exclusive or can be integrated independent of the design.

From this diagram, we can also determine the impact on the system and landscape. The more other interventions a strategy excludes, the more significant the impact. At the same time, strategies that cooperate well with others, might have a smaller influence. When choosing between the different strategies, we will need to determine the possibilities of the context, but also the values of the stakeholders. What is it that we find important and how do we prioritize?



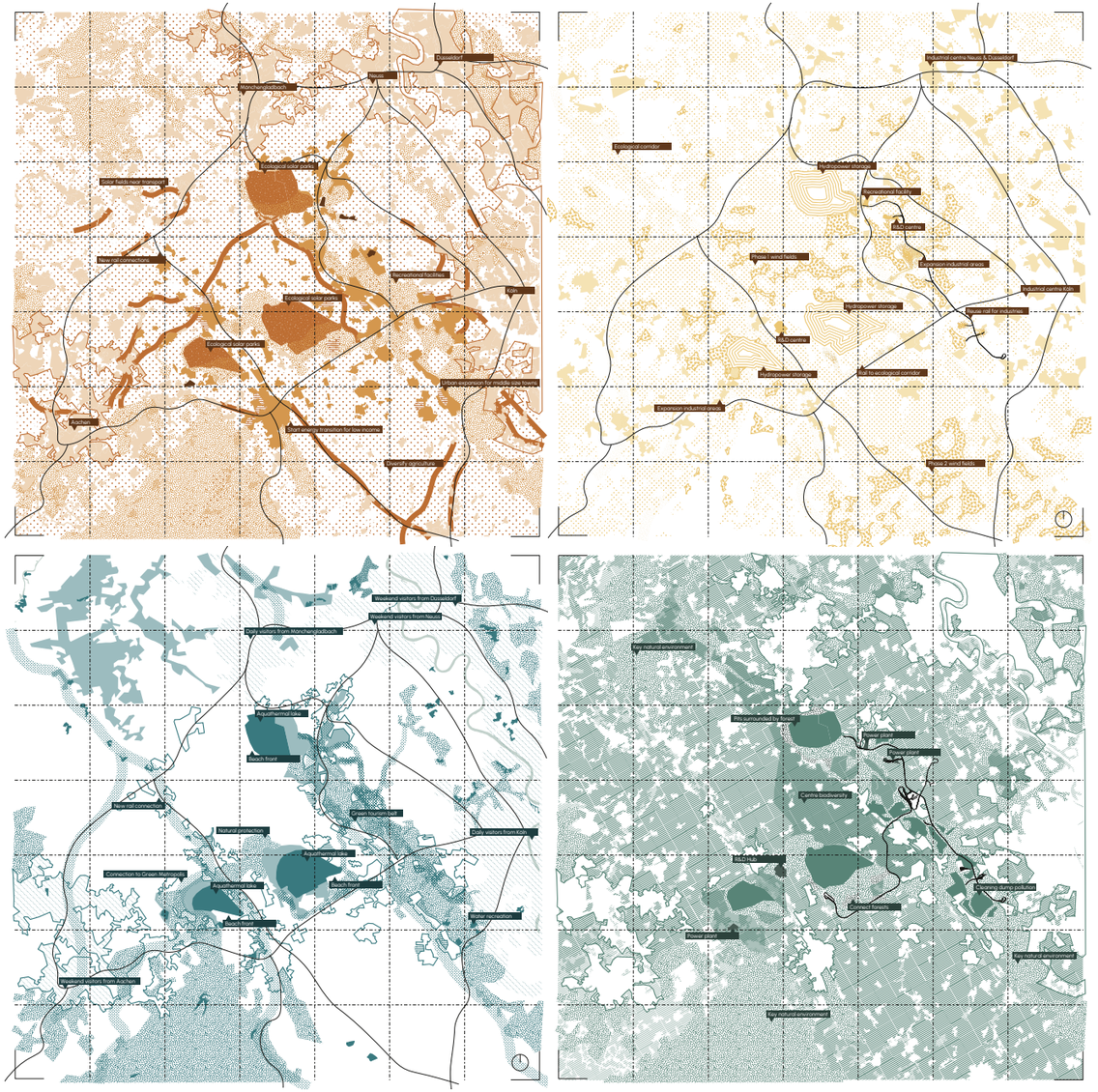
5.67: Adapting from a wind trajectory to a strategy

5.12.2 Merging scenarios

Instead of working from one scenario and further developing it based on the other strategies on a larger scale, the start of merging the scenarios is the design strategies themselves and the systemic and landscape analysis. These analyses have shown different opportunities and threats in the area. The created scenarios and the design strategies developed through those show possibilities for the area.

However, when evaluating the scenarios it became clear that scaling each of these scenarios up from one mine to the whole minescape strengthened design strategies that functioned in relation to the larger scale, while it weakened or exaggerated the local design strategies. At the same time, as each scenario tackles different opportunities and threats. They also did not extend to all problems of the minescape to truly come to an inclusive design transition.

To implement the design strategies to come to an inclusive energyscape from the societal and environmental perspective. We will need to balance the spatial demand of the strategies and optimize the usage of these strategies in their functioning towards the different systems. Thus, we extend beyond the picking and mixing of design strategies to the intertwining of strategies, systems and context.



5.68: Overview scenarios

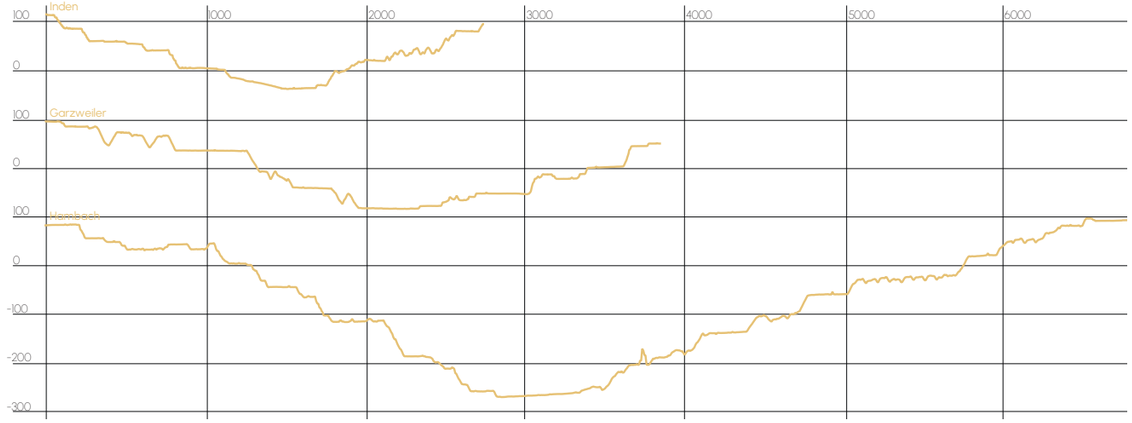
5.12.3 Role of the mines

The mines themselves form a central role in the physical landscape of the minescape. While throughout these, mines have often been described as one element, "the mines", Inden, Garzweiler and Hambach all have their individual characteristics determined by their size, depth, location, connection and historical development.

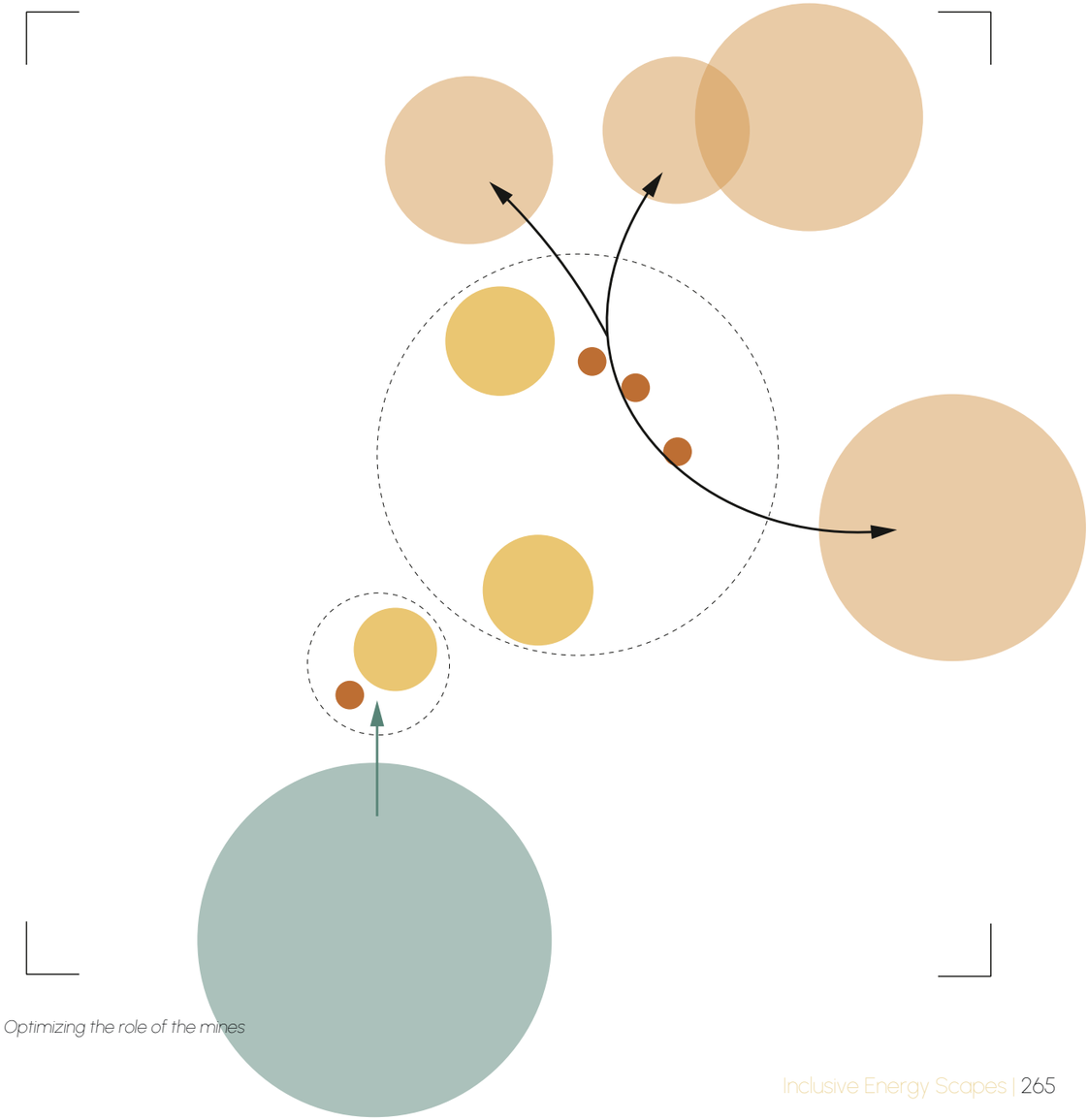
To determine which strategies should be applied to which mines, it is necessary to define these characteristics and determine which strategies benefit from them.

First is the size and depth of the mines. Inden and Hambach have the right solar energy orientation (see page 180). The volume of Inden and Garzweiler is suitable for a lake, while Hambach might be too large to be treated properly against pollution. Hambach is the mine most suitable as hydropower battery due to its vast height difference. Biomass could be well produced in all mines.

Secondly, is placing the mines into the context and seeing what strategies and related scenarios fit best with which mines. Inden is segregated from the other mines and has its own power plant away from residential areas. It is closely situated to natural areas, making it an interesting place for biomass production. Hambach and Garzweiler are both connected to each other and the industrial region. To reuse the existing power plants in industrial areas, Hambach will become a hydropower battery, while Garzweiler is located on an important ecological belt, making it highly suitable as a lake and blue-green ecosystem.



5.69: Sections of the mines



5.70: Optimizing the role of the mines

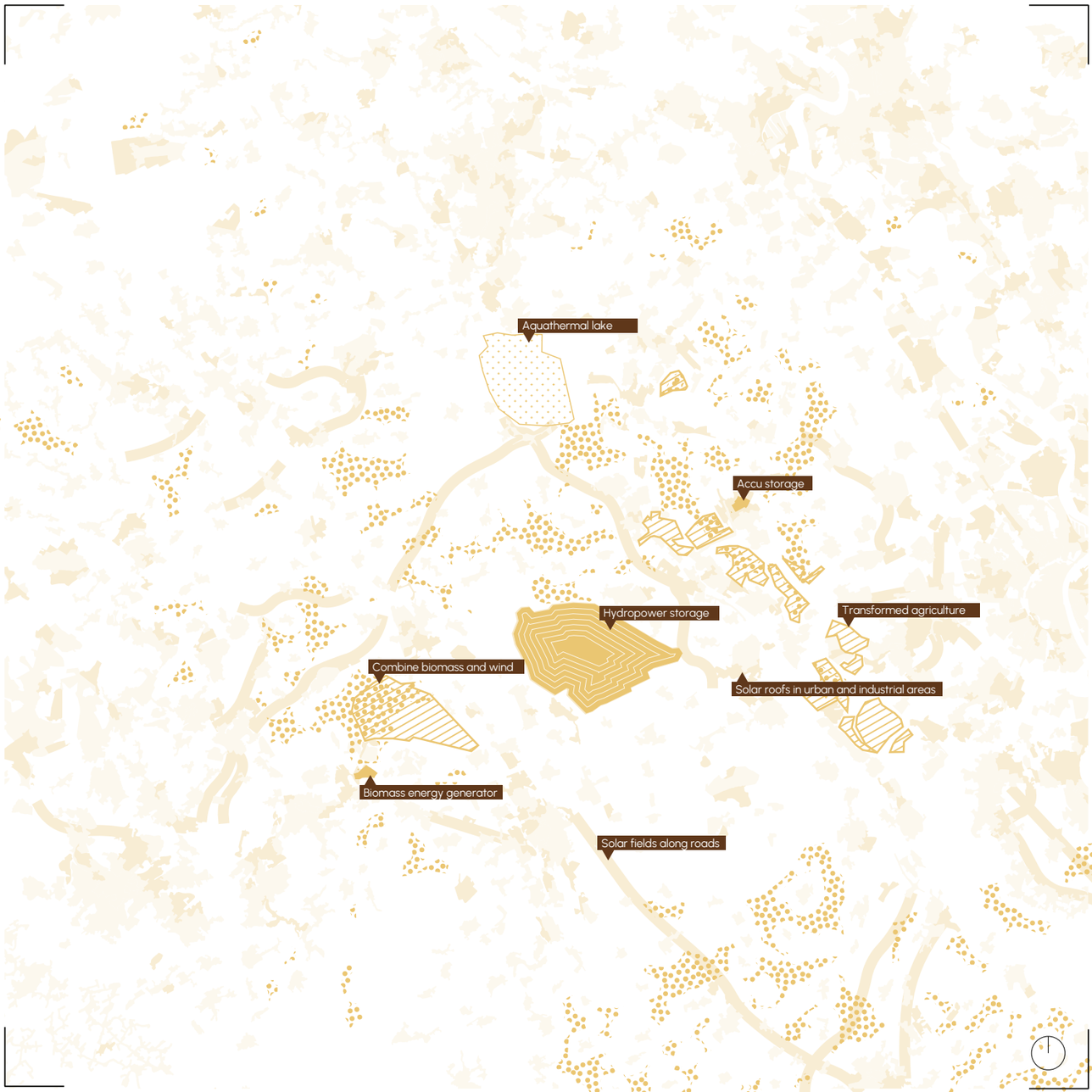
5.12.4 Energy structure

The renewed energy structure is the strategy's foundation. It is a mix of the different energy production methods used in the scenarios and design strategies. The mines have three distinct roles in the energy system: Garzweiler as an aquathermal energy generator, Hambach as a hydropower battery, and Inden as a biomass producer. The choice for this division of roles is demonstrated in the previous chapter.

Notable is the lack of solar fields in the mines. These solar fields instead are created around transport routes to combine waste space with renewable energy sources, making these areas into ecological and energy corridors. The wind production takes place in the agricultural fields, based on possibilities and their production rates. On the old mining belt, biomass fields are created to help clean the pollution in these landfills. Once this area has been cleaned it can be transitioned into a more natural function. By this time, the solar and wind parks will be fully established, allowing them to take over the energy production of these areas.

The combination of a variety of renewable energy production methods makes the system more resistant and stable. It is less dependent on one type of weather and can better compensate for climate circumstances. The variety of production methods also involves a variety of stakeholders. This makes the system more complex but also reduces the power and dominance of stakeholders in the system.

The integration of solar and wind parks all throughout the region creates a larger energy production footprint and impacts the surroundings. This is an inseparable consequence of renewable energy production in comparison to fossil fuel energyscapes.

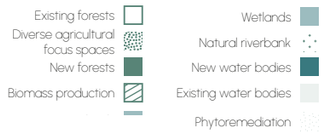


5.71: Map energy structure

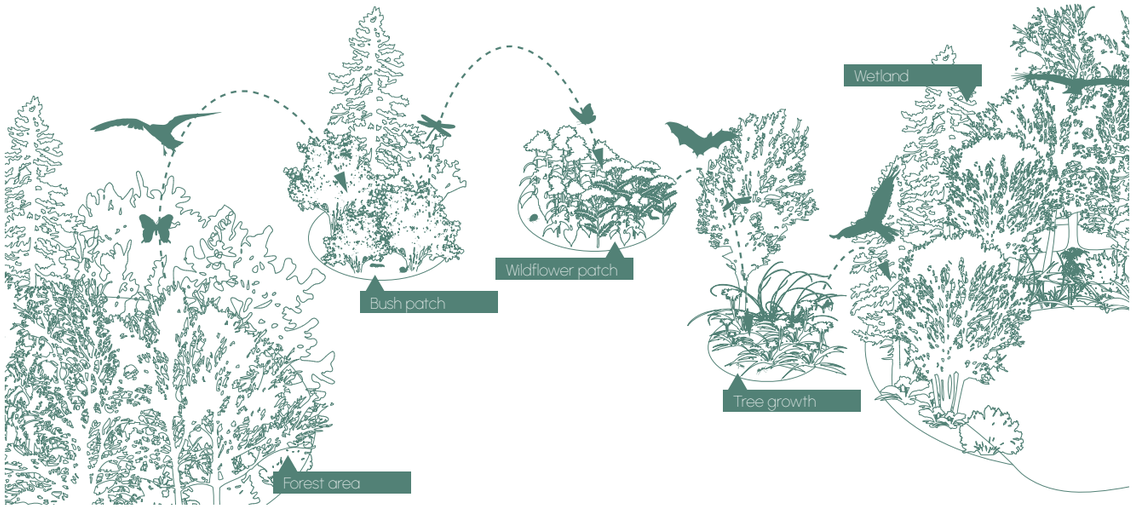
5.12.5 Ecological structure

The ecological structure is mainly connected to the energy through biomass and aquathermal systems. These two areas form important bridges between the existing natural areas. They are connected through new wetlands, forests and diverse agricultural areas. The rivers in the area also play a vital role in the connection of the ecological areas. Natural banks will be created and strengthened to create new blue-green corridors.

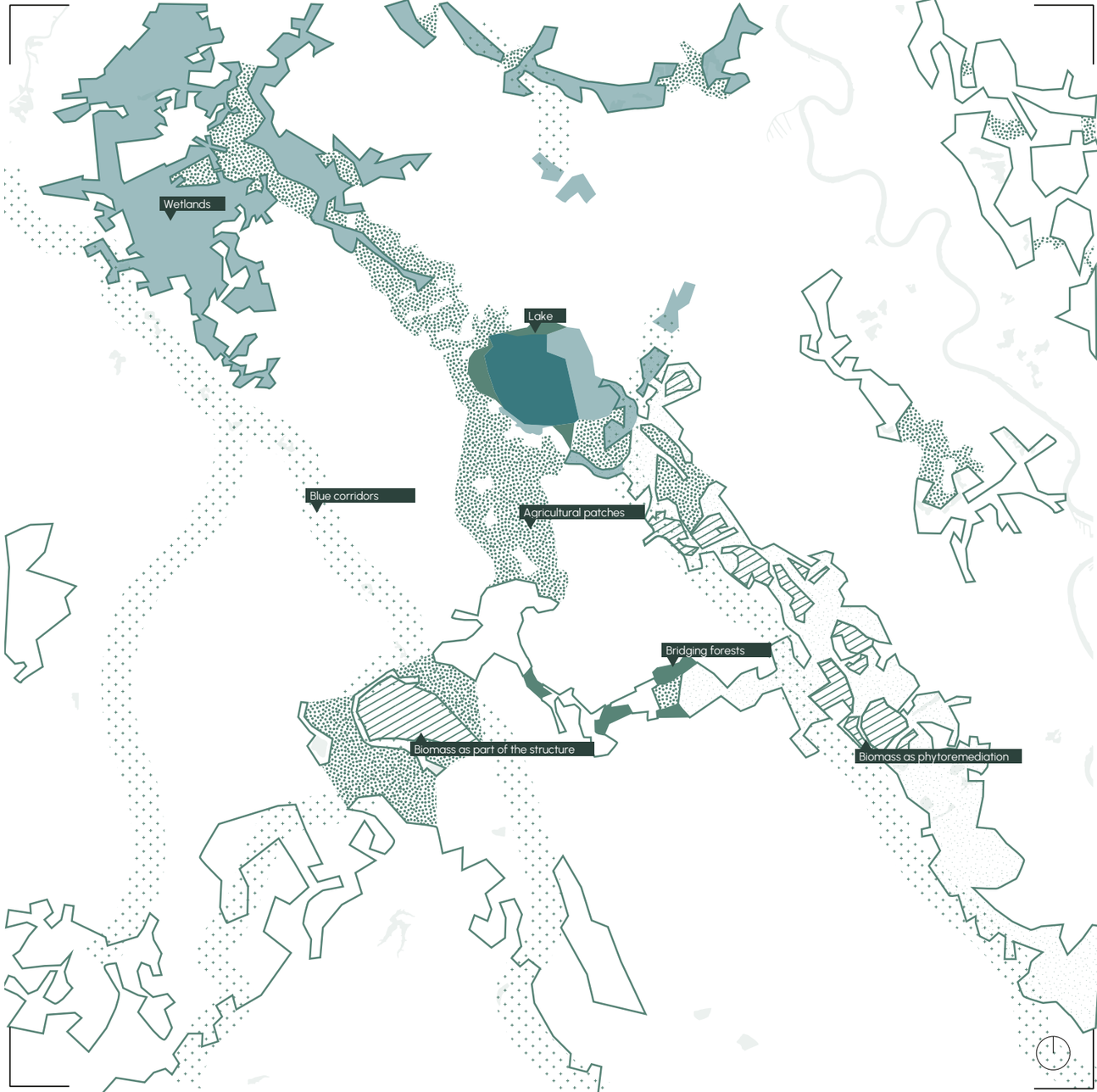
The design of the biodiverse agricultural system consists of two essential elements: A wider variety of crops in smaller fields and natural patches. These patches are important to allow species to jump between different natural spaces, specifically species with a small travelling distance, such as pollinators benefit from this. By creating small patches, the effective agricultural area is only slightly decreased.



5.72: Map ecological structure



5.73: Approach biodiverse agriculture, patches



5.12.6 Economic structure

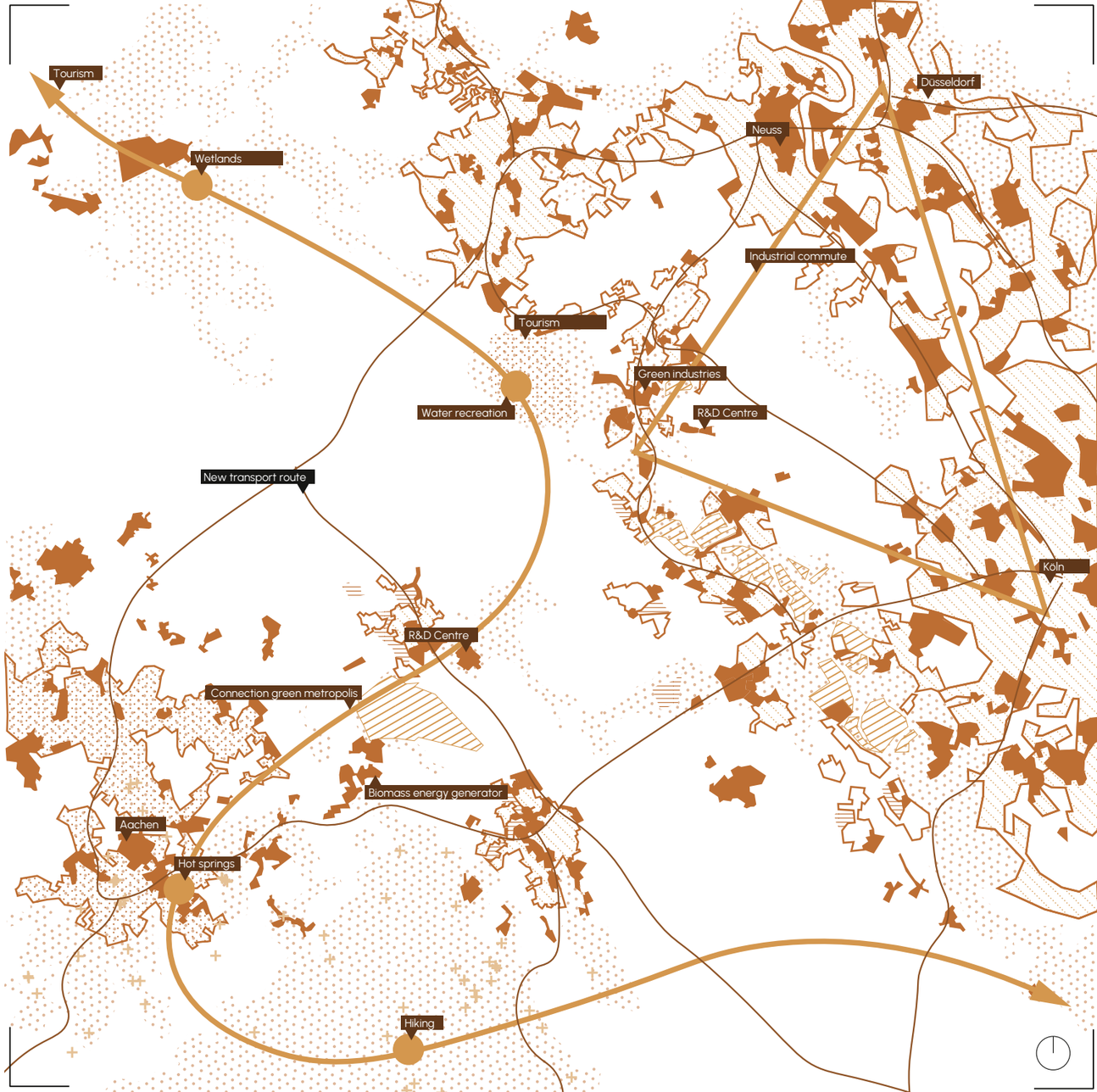
The renewed energyscape will consist of four main economic sectors: industry, tourism, agriculture and energy. Each of these sectors has their own employment opportunities. By creating a variety of economic opportunities instead of focussing on one, we must spread our focus and as such will not as strongly develop any of these sectors as in a scenario where we would focus on one of the sectors. Nevertheless, by combining the sectors, we create a more stable system with a place for a wider variety of residents and stakeholders.



5.74: Created economies

Central in the area will still be the living quality of the green, rural living environment. In combination with the different areas of economic development. Improved public transport is a necessity.

The implementations of the different economic sectors all have their own challenges, many of which are related to policies. The promotion of the area of a natural tourism site will demand spatial interventions and publicity. Industrial development is paired with the attraction of research groups, as well as green industrial start-ups. The reshaping of the energy and agricultural sector will be paired with government investments and cooperation with local stakeholders to include, enthuse and activate these stakeholders. The combination of spatial interventions in connectivity and facilities with promotion, cooperation and investment will reshape the economic structure.

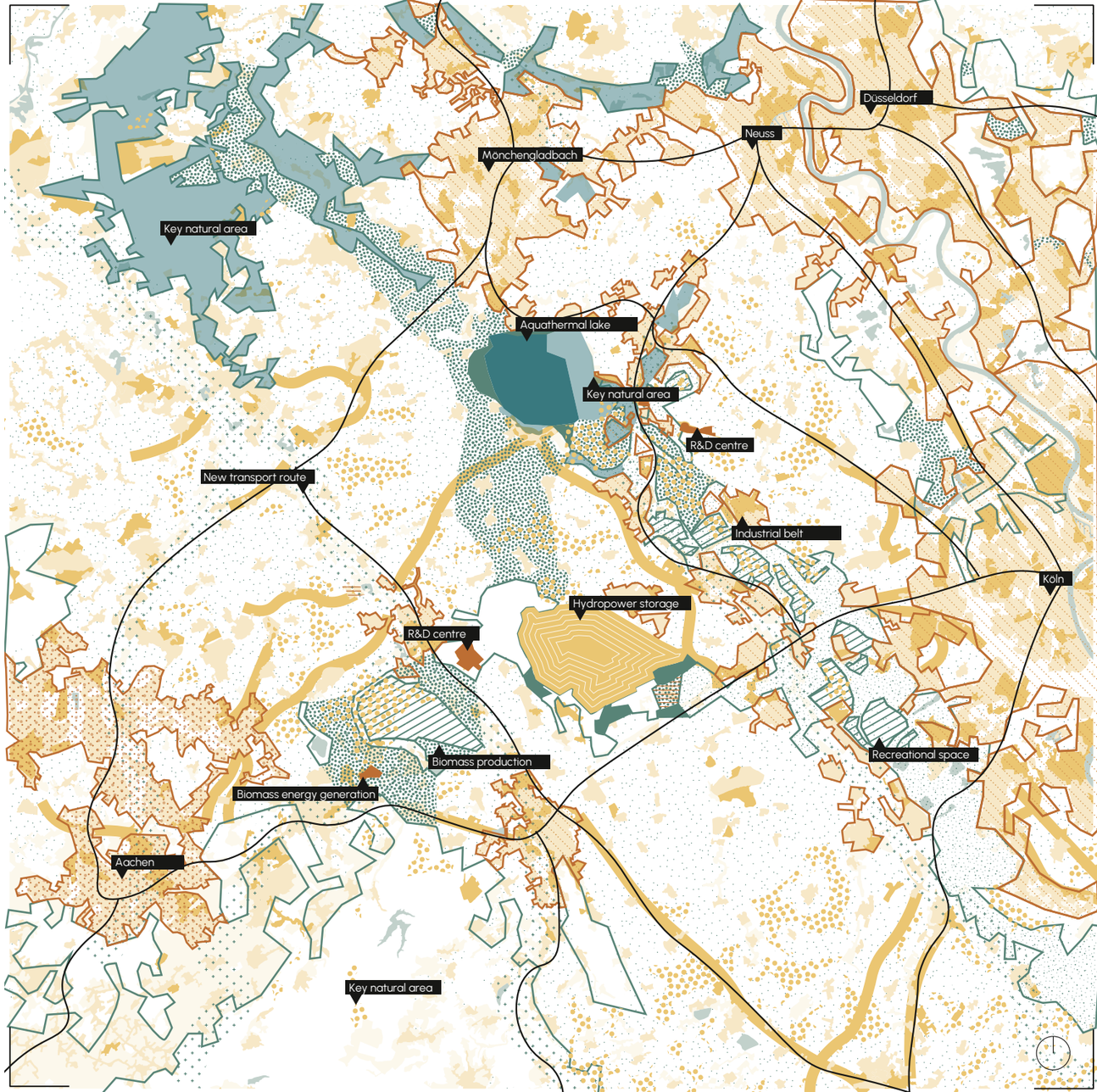


5.75: Map economic structure

5.12.7 Strategy

The complete strategy forms an inclusive region for energy, environment and society. Here the landscape potentials are merged with the design strategies to come to a strategy for the complete minescape. The strategy also nestles the design strategies into the region and relates the now energyscape to the metropolitan region.

In the overview we can see the overlap of different systems as here, blue, green, social and energy cooperate to come to an inclusive energyscape instead of battling each other for dominance. To be able to create such an inclusive energyscape, most attention needs to be paid towards the integration of the green and blue system all throughout the region. Simply designating some surface area to the green or blue system is not an inclusive strategy and will not strengthen the system. Instead, a variety of integrated design strategies are necessary, where the symbiotic relationships between social, energy, green and blue are developed.



5.76: Strategy for the minescape

5.12.8 Overall limitations and challenges

One of the key issues in the future development of the minescape is RWE's "duty of care". This means they are obliged to return the area to restore the area. However, this is only from a superficial natural and landscape perspective. As RWE is a company they will do so in the manner with the lowest costs. At the same time, this method will not be the most beneficial for the social system nor would it provide new green or economic impulses to the area. However, to be able to share the costs of the regeneration with RWE, might also allow for better interventions. Thus, a complex process will need to take place balancing responsibilities, ownership and interests. sharing the costs of the regeneration with RWE

A second challenge is the groundwater system. The strategy needs the groundwater system to stay low in most places. This will cause continuous subsidence of the urban environment. Therefore, residents could experience damages from this and will need to be compensated. It is important to note that the shifts in groundwater level as they are done on the scale of this minescape have not been done before. As such, it is difficult to estimate what will be a less damaging future scenario: keeping the groundwater low or allowing it to return to its natural state (Guns, 2024). To keep the groundwater level low indefinitely, the ownership of the mechanical groundwater system will need to change from RWE to the government, which is a ginormous investment.

Lastly, the understanding of the ecosystems. In this strategy, the exact form of ecosystems and habitats that will need to be developed remains vague. The restoration of the green system is paired with complex challenges such as pollution, low soil quality and changing climate. As such, extensive research will need to be done to clearly determine what types of ecosystems will need to be created, which species will need to be attracted and how the regenerated natural areas will need to change over time. Otherwise, we will end up with similar forests throughout the region based on resilient species, but not on biodiversity.



5.77: Hambach mine from lignite to recultivation



6. Conclusion

This thesis focused on the question: How to regenerate through design the minescape of the Rhenish Mining Area towards an inclusive energy transition? This thesis split this question into three sub questions: What is an inclusive energy transition? How can minescapes be regenerated? and: How to create an inclusive energy transition from a societal and environmental perspective.

6.1: Frechen recultivated area

6.1 Conclusion

This thesis led me through three different lenses: Systems, landscapes and transitions. These three lenses were critical to determining the different layers of the energy scale. In this, systems underlie the interaction of flows through which design interventions could shape the landscapes and transitions. Landscapes were the land's spatial and socio-cultural dimensions, which were shaped through transitions and systemic changes. Transitions are the temporal dimension in which our systems and landscapes constantly move to new values that shape the systems and landscapes.

6.1.1 An inclusive energy transition

An energy transition is a consistent changing energy system based on changing values and developing technologies. The thesis centres around the principle of the transition, as even though we have been setting goals and targets to work towards in a transition, we have always been in an energy transition.

Inclusion focuses on creating equal opportunities for all involved. Therefore, to determine what an inclusive energy transition is, we need to determine who or what is involved. Through systemic analysis, we can learn that there are energy, social, blue, and green systems involved in the energy transition. As such, they should be included and given equal opportunities.

In the systems, we can find vocal and non-vocal stakeholders. As the social and energy systems are shaped by vocal stakeholders, they can quickly become dominant in the transition. Therefore, as a designer, it is important to protect the non-vocal systems and their stakeholders. As the energy transition occurs in the space between the cities, there is a strong relation to the natural landscape and, thus, the green and blue system. As such, they form critical elements in an inclusive energy transition that should not be forgotten.

At the same time, the transition significantly influences the social and energy systems. The change from fossil fuels changes the foundation of economic structures in the current minescapes. Due to this, inclusion in the energy transition also means creating new opportunities for those currently involved in the energy system.

6.1.2 Regeneration of minescapes

Minescapes have had different regenerative strategies in the past. At the core of these strategies were the creation of lakes, filling pits with soil from new mines and restoring them to their old green spaces, and the protection of the historical and cultural values of the landscape. Still, all these strategies are based on the idea that while this mine closes, another one will open. A process that has now been halted. Consequently, a different future of the minescape is needed. One that centres around new forms of energy production.

With the loss of the mines, the minescape also loses its core economic impulse. To prevent poverty, unemployment and depopulation of the urban environment, a new economic impulse needs to be found. This impulse can be related to the new form of energy production but does not need to be.

Another essential element of the minescape's regeneration is the pollution problem. The act of mining is damaging to soil, air and groundwater. The soil and air both suffer from pollution. While the air will clear up after the closure, the soil will remain polluted unless intervened. The groundwater has been mechanically kept low to allow for mining activity. This has led to subsidence and mechanical compensation for water in natural areas. A new solution must be found for both the pollution and ground water level. The cleaning of the soil to prevent expansion of the pollution through the ground is a necessity. The damage to the groundwater is difficult to determine. Both bringing the water back up and leaving it low can be damaging. As such, in a regenerative strategy, it is important to have consistent monitoring of the groundwater impact on the surroundings by an independent party. The maintenance of the groundwater system should become a public affair.

Lastly, though not a priority, it is important to consider the role the minescape has had in the lives of those involved and, in the urbanization and development of the country. Removing it completely from the landscape without considering its historical value would do a disservice to the minescape's cultural identity. As such, we should give it a place in the regenerated minescape, where possible.

6.1.3 The creation of a transition

In the energy transition, the production methods used are central to the complete systemic changes. Following the four scenarios, we can see the impact of a different energy production and what possibilities this creates for the surrounding landscapes. Each of these scenarios also brings its own new economic systems. Replacing the old mining activity with new employment opportunities and economic impulses is critical. This prevents a breakdown of the social system while also creating a new identity for the area.

The design strategies implemented shape the scenario. At the same time, the main future perspective determines what possible design strategies are needed to create a transition. When combining the different scenarios into a possible future vision or strategy for the energy transition, we can reflect on the design strategies. Based on our values, we need to determine which ones are a necessity, while others exclude each other. This process should be done in cooperation with local stakeholders. While not done in this thesis, is the next step towards an integrated, area-specific design.

Independent of the production methods created, the complete system of the minescape is changed. Parallel to the minescape, an energy scale will emerge, shaped by these production methods, and design strategies and consequently, their system changes. While the minescape becomes less dominant, due to its ingrained nature of the minescape in the economy, the natural systems and the cultural dimensions, the minescape will never leave the energyscape. It will merge into a new layered landscape. This creates new typologies and morphologies of landscape and urban environment. How these are shaped depends on the strategies implemented and how they affect the systems.

How to regenerate through design the minescape of the Rhenish

Mining Area towards an inclusive energy transition?

It is important to conclude that neither of the proposed scenarios are perfect. We discussed creating an inclusive energy transition, and while all systems have their place in each scenario, they are not always given opportunities. In all scenarios there is place for each system and the non-vocal stakeholders are given more opportunities compared to the current state of the minescape. However, in each of the scenarios, there are strengths and weaknesses.

Nonetheless, the scenarios do serve an important purpose. The scenarios themselves are a way of triggering our imagination. They open the discussion on the regeneration of the Rhenish minescape and the energy transition in place. Their variety, through different systems and layers, also displays the possible futures and the design interventions necessary to achieve these.

The scenarios also highlighted the scale of the minescape. Through the transition design, we could see that the footprint of the minescape is significantly larger than the extraction footprint. This is particularly clear in the considerable influence the systemic changes have on people's day-to-day lives, far beyond the spatial mining borders.

Another important conclusion is that the footprint of any renewable production will be larger than that of the extraction site or the minescape. Therefore, independent of the integrated production method, the Rhenish Mining Area will lose its leading role of energy production in the German energy network. Instead, it will become more dependent on other, less urbanized areas to help produce the energy needed for this urban and industrial centre.

The act of regeneration itself is inherently complex, as shown in this thesis. The energy transition is a wicked problem, and the variety of future trajectories all show their own challenges. Simultaneously, the scenarios also show we can be more creative in the energy transition, and we need to be to come to an inclusive energy transition. In our design processes we need to search for possible symbiotic relations between existing systems, landscape and possible new energy systems. During the design we need to determine the feedback loops of the design strategies we are implementing in the system. The complexity of the energy transition demands that we look beyond the restoration of minescapes towards their historic landscapes. This is an impossible feat. Thus, it is far more valuable to extend beyond the historic landscape towards an inclusive energyscape.

An inclusive energy transition is incredibly difficult to achieve. We cannot put all our eggs into one basket. We need different energy production methods, as they will create different symbiotic relations. Some of these interventions are mutually exclusive due to land use or systemic elements. In these cases, we will need to define our values and prioritize them. This can only be done in cooperation with stakeholders of the minescape, as they are part of the minescape and define its cultural dimension.

The amount of design strategies or interventions we can do does not determine the energy transition's success. Instead, it is the interaction these interventions create between then energy system, landscape and social environment. In this, the social environment contains the economic system, the cultural identity, and social interactions of those interacting with the energy system and landscape. This combination of factors is what I refer to as the energyscape. Only, when we bring together, in balance, the four systems in the energy escape, with space for all stakeholders to thrive, we are working with an inclusive energy transition. A transition which will continue to shape the energyscape and vice versa.

6.2 Discussion

This thesis allows for an open discussion of the impact of possible future strategies and trajectories for the Rhenish Minescape, without determining its definitive future. Instead, the thesis is an invitation to be creative and further discuss which of these strategies fits the needs and demands of the area. The invitation is to both the residents of the minescape as well as RWE and the Bündestate to look beyond the small and local spatial interventions into a systemic change for the minescape. Due to this nature of the thesis, it does not determine a definitive design, and as such, it does not answer to the energy transition challenge with a possible design solution. However, the thesis does display multiple scenarios and the needed design interventions to reach those future trajectories. One of the main challenges of the energy transition is integration into the socio-cultural network, so the discussion this thesis opens could be used to include residents in the discussion.

At the same time, I am aware that the thesis does not provide a blueprint for a successful transition, and a more in-depth design should be created to profoundly change the Rhenish minescape. Bringing together the possible scenarios into one future transition strategy would be a good next step. Unfortunately, due to time limitations, this is not a step this thesis will achieve.

As the thesis does not form a specific design strategy, it also allows other regions in transition to review and determine possible trajectories. In other words, the less definitive nature of the thesis allows for more discussion as well as a better transferability nature of the project.

The project's methodology, using design strategies and scenario design, allows for this broad discovery of future trajectories. Since the design steps are based on research in analytical, systemic, and database mapping, the thesis is grounded in reality, while the design also allows for creativity.

The scenarios are based on the symbiotic relations and landscape strengths of different energy production methods. From here design strategies were implemented to create places for all systems and their stakeholders into the scenario. While, as stated in the evaluation, none of these scenarios is perfect, nor regarding inclusivity. The integration of natural elements in all energyscapes and the focus on restoration of the ecosystems in the area, in combination with a regeneration of the local economy, does create an energyscape whose quality and inclusivity extend far beyond most general energy landscapes.



6.2: Garzweiler II view from Jüchen



7. Reflection

In this chapter, I reflect on this thesis. I describe my thesis's relation to my master's degree and how it helped develop me as an urban designer. I also reflect on the methods I used in the process and how these shaped the project and determine whether they helped achieve the goals of the thesis. On a larger scale, I reflect on its transferability to other sectors and the ethics involved in the design process and the implementation. Lastly, I reflect on the communication methods this thesis uses and the role of these and methodology in the openness of the discussion and the involvement of stakeholders.

7.1: Niers Wetland

7.1 Relations

Master programme

In my thesis, I focused on the energy transition. Part of this transition is a spatial change from old fossil fuel mining and processing spaces towards renewable production landscapes. At the same time, this spatial change is paired with systemic, sociological, cultural and economic changes. The energy transition is a form of a wicked problem. Through design explorations, we can uncover solutions and redefine our changing values regarding energy. In the master architecture, urbanism and building sciences, you are taught to design integrated solutions for the built environment. This is done in a multi-disciplinary method where research and design are used to enhance each other (TU Delft, n.d.-a).

This learning objective and approach match the challenges of the energy transition. The skills taught in the programme concern design practice, social sciences, technology, and engineering. These different disciplines are necessary to achieve an inclusive energy transition. Therefore, working on the minescape and its transition towards an inclusive energy transition addresses the skills of the master as well as the central topic of innovative, sustainable development.

Master track

The TU Delft (n.d.-b) describes urbanism as "an interdisciplinary planning and design activity that focuses on the (re)creation of sustainable urban landscapes aimed toward climate adaptability, circularity, social equity, and ecologically inclusive urbanisation at all scales."

During the courses of the master urbanism, there were three main scales we focused on: neighbourhood, city and regional. The ability to tackle wicked problems in regional planning already appealed strongly to me during these courses. As the energy transition also is shaped mostly on the regional scale and the minescape can only be fully understood on this scale, it was a fitting scale for this thesis.

The project itself works with the urban systems, and specifically the flows moving from the in-between of cities to the city. The situation of the minescape and the placement of energy landscapes mainly in rural areas, focuses the thesis on the area in-between the city, in the landscape. Due to the problems in the minescape, the thesis relates to both the social dimensions as well as the ecological dimensions of landscape. As a consequence, my thesis operates on the edge between landscape and urbanism.

Though my thesis operates on this edge, I do believe that the project is inherently urbanistic in nature. This is a consequence of the operational landscape approach I used in my thesis. By perceiving the minescape and energyscape as a necessity for urban development and urban living, these areas became part of the complex urban system. Therefore, designing this is also designing sustainable urban landscapes. Here the focus is on social equity and ecologically inclusive urbanism.

Graduation studio

The project is part of the graduation studio Metropolitan Ecologies of Place. This studio focuses on transition, transformation, regeneration, reparation and reuse of habitats and ecologies (Studio MEP, TU Delft, n.d.). The studio also indicates the energy transition as one of the core topics (Studio MEP, TU Delft, n.d.). This focus makes the energy transition and the regeneration of minescapes suitable topics for a thesis in this studio. However, this was not the main reason to choose this studio. My interest in this studio was formed by the cross-disciplinary approach to systemic design and flows (Studio MEP, TU Delft, n.d.).

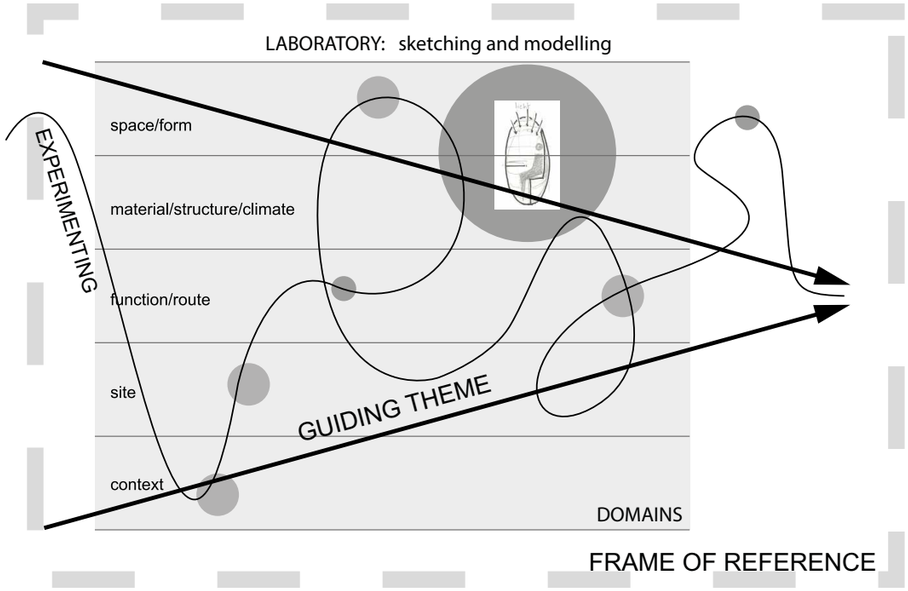
I felt as though the complexity of the minescape, and energy transition could only be tackled to this technical systemic approach. This gave me a foundation and understanding of the challenges and possibilities for design.

7.2 Research and Design

One of the main challenges of this thesis was that even though I had an interest in the energy transition and had some general knowledge on the topic, I had not designed for such a challenge before. Next to the main topic, I was unfamiliar with the concept of the minescape, nor had I designed for the German or rural context before. As such, the research phase was critical to creating a knowledge and reference framework. During the process and the framing of my research, I followed the systems of the minescape, which then became the foundation of the research. In summary, the research formed the foundation of my needed knowledge for the design. However, as there was so much knowledge to be gained and the analysing phase of the project gains a lot of my interest, I did get stuck in making the step towards design. For each possible intervention, I determined I had not enough knowledge to make such decisions and therefore, could not make design decisions. In this case, I would move back towards my mapping, analysis or literature, research I was familiar with, to come to new knowledge and try again.

This is critical for my relationship between research and design. As Viganò (2016) describes, the design process is a method of creating knowledge. Instead of focusing on the experimentation of my design process, I locked myself into facts, which halted it.

Van Dooren (2020) describes the design process as consisting of five elements: Laboratory, domains, frame of reference, guiding theme and experimenting. Throughout my project, I have had a clear guiding theme: the energy transition. This theme helped me in the end to shape my scenarios. However, the experimenting at the beginning was hesitant. Only when I changed methods and started working on paper, more than the computer, did I give myself the freedom to be imprecise and, as such, experiment more. Thus, according to van Doorens elements, changing my laboratory, allowed me more freedom to move through the different domains by experimenting. I believe this is one of the key elements I learned from this thesis. Approaching the design more as a research method and using experimentation to gain knowledge and understanding allows you to operate where your frame of reference might not be complete. This also allows you to operate beyond the existing frame of reference and develop new knowledge. This is a key element of any research and design project.



7.2: The five generic elements in the design process (Van Dooren, 2020)

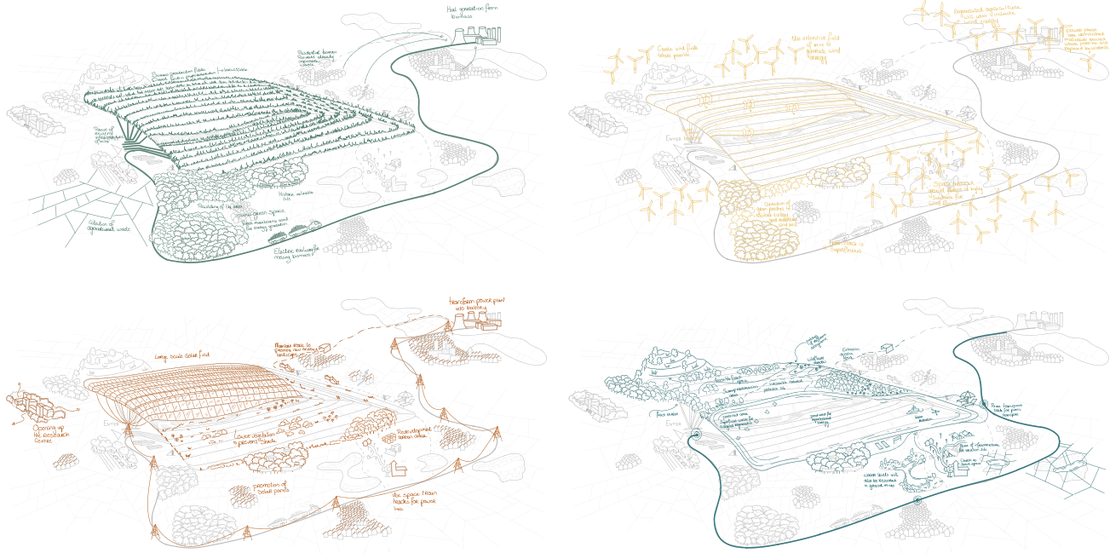
7.3 Method

The methodology consisted of analytical, systemic and data-based mapping. I combined this with fieldwork to gain another layer of knowledge on the minescape and area. As both topics of energy and the minescape were relatively new to me, I spent the first half year gaining knowledge on and learning to understand the nuances of these systems and landscapes. During the second semester, the focused switched more towards the possible transitions. The goal of this thesis was to develop and research the possible energy transitions for minescapes and determine what possible new energyscapes would come from those. As the thesis aimed not to come to one final definitive design but instead explore viable solutions and produce knowledge on the quickly developing topic of energy transition, scenario design seemed a suitable solution (Viganò, 2018). A scenario is a method which explores the consequences of different interventions. Hereby, it also researches the relationship between different transformations (Viganò, 2018)

Scenario design allowed me to explore multiple solutions for a complex situation and helped me achieve the goal to open up the future of minescapes and energy landscapes more than one design solution would have. The choice for the evaluation done through SDG's was a practical solution. It might have been good to make a more specialized evaluation framework, for example, related to the systems as defined in this thesis, but this would not have fit in the time limit. Using the SDG, I used a world-renowned and accepted framework to evaluate the scenarios, which left me more time to expand on the design of the scenarios. Next, the evaluation is more comparable to other possible strategies in the open conversation.

During the design phase, I struggled with the scale of the minescape and bridging the gap between sketch research, systemic diagrams and actual physical interventions. I used design strategies to approach the spatial impact of the different energy interventions and reach a broader overview of the impact and related interventions on energy production. By creating small tiles, schematically, but spatially showcasing the impact of certain interventions, I managed to gain grip on the landscape transitions. Using a more sketching style gave me more freedom in visualizing and designing for the spatial interventions.

Next to the small local tiles, I also worked with a transit to make myself clear and make choices. For me, a risk of the design strategies was to maintain vague and not make any actual design choices. By implementing the strategies into the transit, I could evaluate the actual strategies and create a clearer overview of the spatial interventions. The exploration of the timelines also helped me ground the project into reality and helped me design the transition itself. If I had had more time, I would have wanted to further develop the physical aspects of the design interventions by, for example, zooming in on different areas of the transit and displaying the interventions. However, the thesis's current state allows for discussion, but with more personal interpretation.



7.3: Energy based scenarios

7.4 Transferability

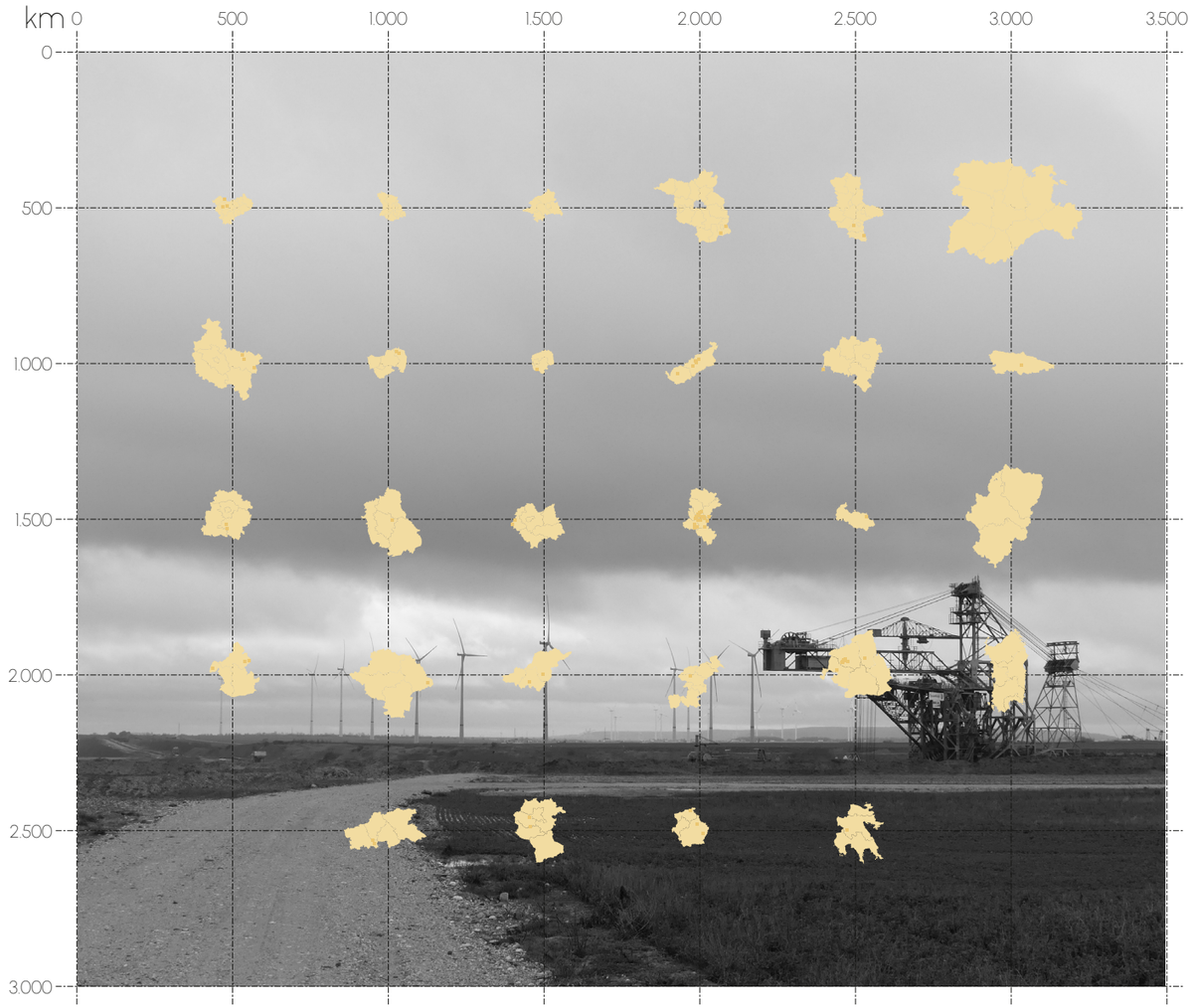
This thesis aimed to create an open discussion and highlight the wide range of possibilities when it comes to the energy transition in minescapes. In Europe, there are many comparable regions that face the same challenges: moving from coal to renewables. These coal regions in transition are already united in policies and subsidies but not in spatial and systemic exchange (European Commission, n.d.).

Using the scenarios and design strategies displayed possible future trajectories for minescapes. Though these interventions are specialised for this specific context, they can serve as inspiration for other coal regions. The evaluation was a critical point in the project to allow other regions to determine the consequences of certain interventions. It should be honest, understandable and open, to allow others to reflect on the interventions in their context as well. By using the SDG's, I strived to create this transferability and reflection possibilities.

Regarding transferability of this thesis, I believe it is important to focus on three core elements of the minescape: the physical landscape, the socio-cultural context, and the underlying systems. Thus, not all spatial interventions can work due to the landscape, or other landscapes could have interesting development elements based on their characteristics, which did not occur in the Rhenish minescape. For the socio-cultural context it is important to reflect on the wishes of residents, their relation to the minescape and the already present focus on the economic consequences of changing the local economy. Lastly, the underlying systems: These systems form the core of the possible transitions, they determine the problems in the area as well as possible strengths. Though these might differ per region, of the context.

Lastly, the thesis used, in the design, different energy production methods as a guiding theme for each scenario. From these production methods, possible symbiotic systemic and spatial elements were determined. This approach could be of interest for other regions as well. Testing out different production methods and seeing what qualities they could give in that specific context. Here, the scenarios of this thesis and the design strategies could form a foundation for the exploration.

To conclude, three elements of the thesis can inspire other regions in transition: the spatial explorations of the design—when evaluated carefully—the systemic approach and the leading theme of the energy production method.



7.4: European coal regions in transition, based on European COmmission (n.d.)

7.5 Implications

Academic

The interest in the minescape is relatively new and still under development. We are trying to determine its complete impact. At the same time, the increased need for self-sufficiency in our energy networks also ask for more knowledge on the consequences of energy and mining system changes as well as the landscape impact. This thesis focuses not only on the changes the energy transition creates in systems but also on how we can intervene in these systems to shape the energy transition inclusively.

Societal

The current global instabilities have placed a rush on the energy transition, with the invasion of Ukraine by Russia pressuring all of Europe's energy system. Through this we were made aware how important it is to be self-sufficient when it comes to energy. The energy transition and the question on how to do this in an inclusive way for the social and natural system is sometimes pushed to the back. The expansion of the amount of energy landscapes, both due to the wish to become self-sufficient and the increased need for space of renewable energy sources, make people interact more with these landscapes. It also means a battle for space between natural areas and energy landscapes. By including social and natural systems, such as economic and cultural consequences, as well as natural regeneration, I search for possible and sustainable forms of energy transitions.

Ethical

The ethical implications of the project are difficult to describe. While the project's roots are to create a qualitative energyscape for the Rhenish minescape, it is easy to say the area has been improved since the mining activity has been halted. Simply stated: the project ends the mining activity, which will significantly improve the health and wellbeing of the direct surroundings (Jansen, 2019). However, the ending of the lignite mining activity is the start of this thesis, not its intervention. Next to that, though this could improve living quality, this is not guaranteed.

The closure of the mines also creates the loss of 15.000 jobs. This has a severe impact on the economy and local employees. The closure could lead to the emptying out of the area, as people will move to places with more employment opportunities. At the same time, the pollution in the area does not disappear with the closure of the mines. The area will need many years to recover from the pollution and damage done. Therefore, there are different challenges regarding the ethical implementation of renewable energy strategies.

In the design I strived to find a new balance between the systems, one where all systems were included, which would create an inclusive transition for all involved. This also meant that the green and blue system became important stakeholders. Over time, they lost a lot off space in the area, and some of the scenarios strive to give back to these systems to create healthier systems. The consequence being, that space off industries, mines or even agricultural land will need to change. In combination with the uprooting of the complete energy system, creating energy landscapes, less dependent on day-to-day maintenance and thus employment, the complete economic system will be reviewed. The employees of the mines are often lower educated, and critically might not be able to find work in these new economies. As such, their lives will be uprooted.

In the thesis, each strategy had a social symbiotic relation, where wind, and biomass both created new economic systems with diverse levels of education, the solar and aquathermal system, focused mostly on higher education. This means that they would create a shift in the population of the area, not allowing some residents to maintain their job here. It could be possible this problem might not be as large due to an older work base, but I have not found data to support this.

At the same time, the new energy production methods are far less effective, meaning significantly more space will be needed. Thus, more people will experience the consequences of living next to an energy landscape. Though this thesis shows, it is possible to integrate these landscapes with thought and quality into the landscape. Focus on design and inclusivity is necessary to reduce the burden of renewable energy landscapes, both for the direct surroundings as on the international scale.

Therefore, from a general perspective, it might seem that the area will improve. More spatial quality, a green environment and reduced pollution are all incredibly positive. However, they could, if no energy is invested into a new local economy, lead to increased unemployment, ageing of the population and overall residents moving out of the area, leading to a collapse of the social network.

Due to climate challenges, the related natural disasters, the damaging nature of the mining activities and the related ethical consequences of those, I do not see another possibility than changing the local energy landscape. However, we should be aware of the significant impact this will have to the residents and economy. As we can see in Limburg, the Netherlands, the economic misery following closure of mines can haunt generations (NOS, 2015). Therefore, we should plan beyond the subsidies of current employees and design for a new economy, paired with a restoration of the natural environment.

Lastly, I believe from an ethical perspective, we also have a responsibility towards nature to reverse as much as possible the damage our mining activity has done to the local environment. In this thesis, due to the focus on energy and new economies and thus new land uses, the natural ecosystem is sometimes moved to the back. This is a weakness of the focus on the economic restoration which does not automatically pairs with ecological restoration. Therefore, in future projects, it is important to focus on the ecological system parallel to the economic system, or even create a scenario where the ecological restoration has priority.

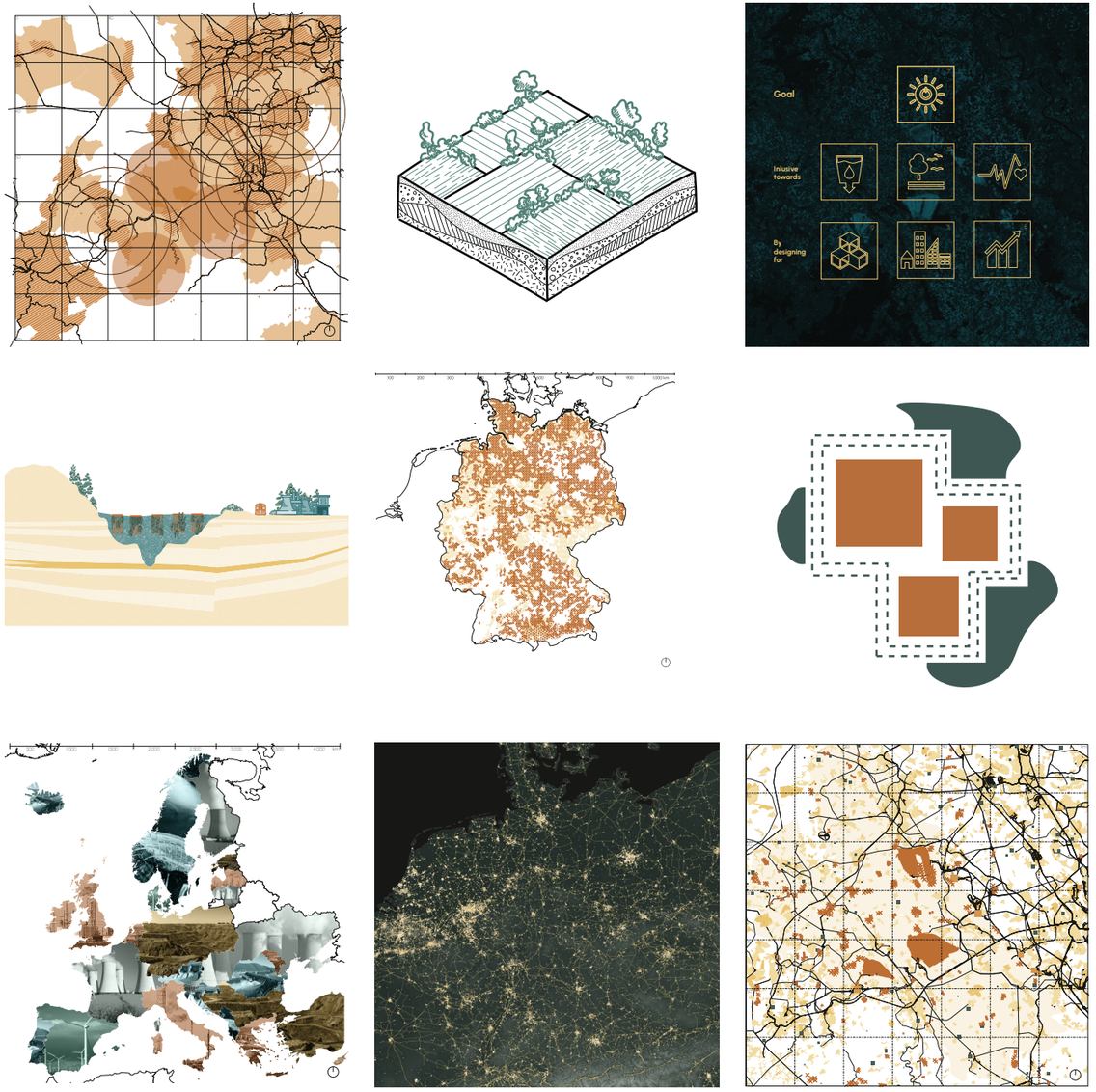
7.6 Design as communication and discussion

One of the goals of this thesis is to create an open conversation with the stakeholders in the Rhenish minescape on possible developments. In this paragraph, I would like to reflect on the communication styles and drawings used in this thesis to convey the message.

An important goal of the thesis is to create an open discussion on the possibilities for minescapes and inclusive energy transitions. Therefore, I needed a communication style that is coherent, clear, and concise. While I believe the general language of the thesis is clear, the wording can be more concise. This is important as a long, wordy report is more difficult to discuss. Instead, the drawings speak more to the reader, so their communication and visual style are more important.

Throughout the thesis, my drawing style changed significantly. I used the project to develop my communication methods further. Consequently, I find that the visual language throughout the thesis is not completely coherent. In the first chapters, the main drawings I made were maps. This led to a monotonous and incomplete overview of the project. I followed the feedback of my mentors to use sections, axonometries, photography and collages to give readers a better understanding of the area and the landscape. As I was not as confident in these drawings as I am in databased mapping, the styles differed greatly depending on the type of drawings I made. Even though the style of the report is not completely consistent and coherent, I feel that I made significant steps in my visualizations and have become freer in combining different media.

Next, as the design proposals are not definitive, I wanted to highlight the freedom and flexibility in the design strategies and scenarios. For this I used a more hand-drawn style in combination with handwritten descriptions. I felt that these drawings helped to convey the message, but where flexible enough clearly. At the same time, they might be a bit superficial, making it more difficult for people to understand the experience they will have in the landscape. I used collages to give a general idea of the landscape, but due to the larger variety of spaces and interventions, these only convey part of the vision. Between P4 and P5, I would like to clarify the collages more to make the scenarios speak more to the reader.



7.5: Collection of drawings from thesis

7.7 The Role

As this thesis also marks the end of my master's program, I want to reflect on how it influenced me as an urban designer and how I developed during this thesis.

As an urban designer, I believe we have a large impact and responsibility on sustainable transitions. Our communicative role brings together space, values, societal and ecological structures, and engineering. Therefore, I believe we have a responsibility to develop our skills to design sustainably. A possible framework to reflect on your competences as a sustainable engineer or designer is the European Sustainability Competence Framework (Bianchi et al., 2021).

Following the framework, we can see four principal areas of development. When you start the master urbanism, I believe all students already have some competence in area one. I do believe this was the case for me. During the masters I improved myself mainly on the second and third areas. My thesis also focused on systems thinking. While I do believe I could be more critical in my thinking. I tend to maintain a high production rate, meaning I read, apply, read and then discover issues are not inherently black and white. This is the opposite of my problem framing where I sometimes get overwhelmed by the number of problems related to a design assignment and wish to tackle all of them, thus tackling none. I can improve upon both issues by prioritizing more and clearly defining goals and values beforehand. While these can change during the process, setting them beforehand will give more guidance in tackling the complexity of sustainability.

At the same time, I do believe I have made large steps toward envisioning sustainable futures. While first blocked in the current situation and network, changing my methods and taking more freedom in hand drawing and designing allowed me to be more creative in possible futures and envision various scenarios. These forms of exploratory thinking allowed me to design the four main scenarios. At the same time, working with the design strategies and reflecting on them and their interactions with each other after the forming of the scenarios helped me place the scenarios more into practice and made the scenarios more adaptive to changing possibilities.

The last area is acting for sustainability. While I already take individual initiative to reduce my energy demand and carbon footprint, navigating the political system and collaborating with others to achieve change are steps I have yet to develop myself into. For my future, I would like to do so, by working in practice and learning the complexity of sustainability in our practical society.

Area	Competence	Descriptor
1. Embodying sustainability values	1.1 Valuing sustainability	To reflect on personal values; identify and explain how values vary among people and over time, while critically evaluating how they align with sustainability values.
	1 .2 Supporting fairness	To support equity and justice for current and future generations and learn from previous generations for sustainability
	1.3 Promoting nature	To acknowledge that humans are part of nature; and to respect the needs and rights of other species and of nature itself in order to restore and regenerate healthy and resilient ecosystems.
2. Embracing complexity in sustainability	2.1 Systems thinking	To approach a sustainability problem from all sides; to consider time, space and context in order to understand how elements interact within and between systems
	2.2 Critical thinking	To assess information and arguments, identify assumptions, challenge the status quo, and reflect on how personal, social and cultural backgrounds influence thinking and conclusions.
	2.3 Problem framing	To formulate current or potential challenges as a sustainability problem in terms of difficulty, people involved, time and geographical scope, in order to identify suitable approaches to anticipating and preventing problems, and to mitigating and adapting to already existing problems.
3. Envisioning sustainable futures	3.1 Futures literacy	To envision alternative sustainable futures by imagining and developing alternative scenarios and identifying the steps needed to achieve a preferred sustainable future.
	3.2 Adaptability	To manage transitions and challenges in complex sustainability situations and make decisions related to the future in the face of uncertainty, ambiguity and risk.
	3.3 Exploratory thinking	To adopt a relational way of thinking by exploring and linking different disciplines, using creativity and experimentation with novel ideas or methods
4. Acting for sustainability	4.1 Political agency	To navigate the political system, identify political responsibility and accountability for unsustainable behaviour, and demand effective policies for sustainability
	4.2 Collective action	To act for change in collaboration with others
	4.3 Individual initiative	To identify own potential for sustainability and to actively contribute to improving prospects for the community and the planet.

7.6: European Sustainability Competence Framework (Bianchi et al., 2021)


Hambach mine

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- Man-made (Waste water plant, Water mill, Water works, Pumping station)
- Power lines and cables
- Offices (Research)
- Roads (Highway, Primary roads, Secondary roads)
- Railways
- Stations
- Waterway (River, Canals, Drains, streams)
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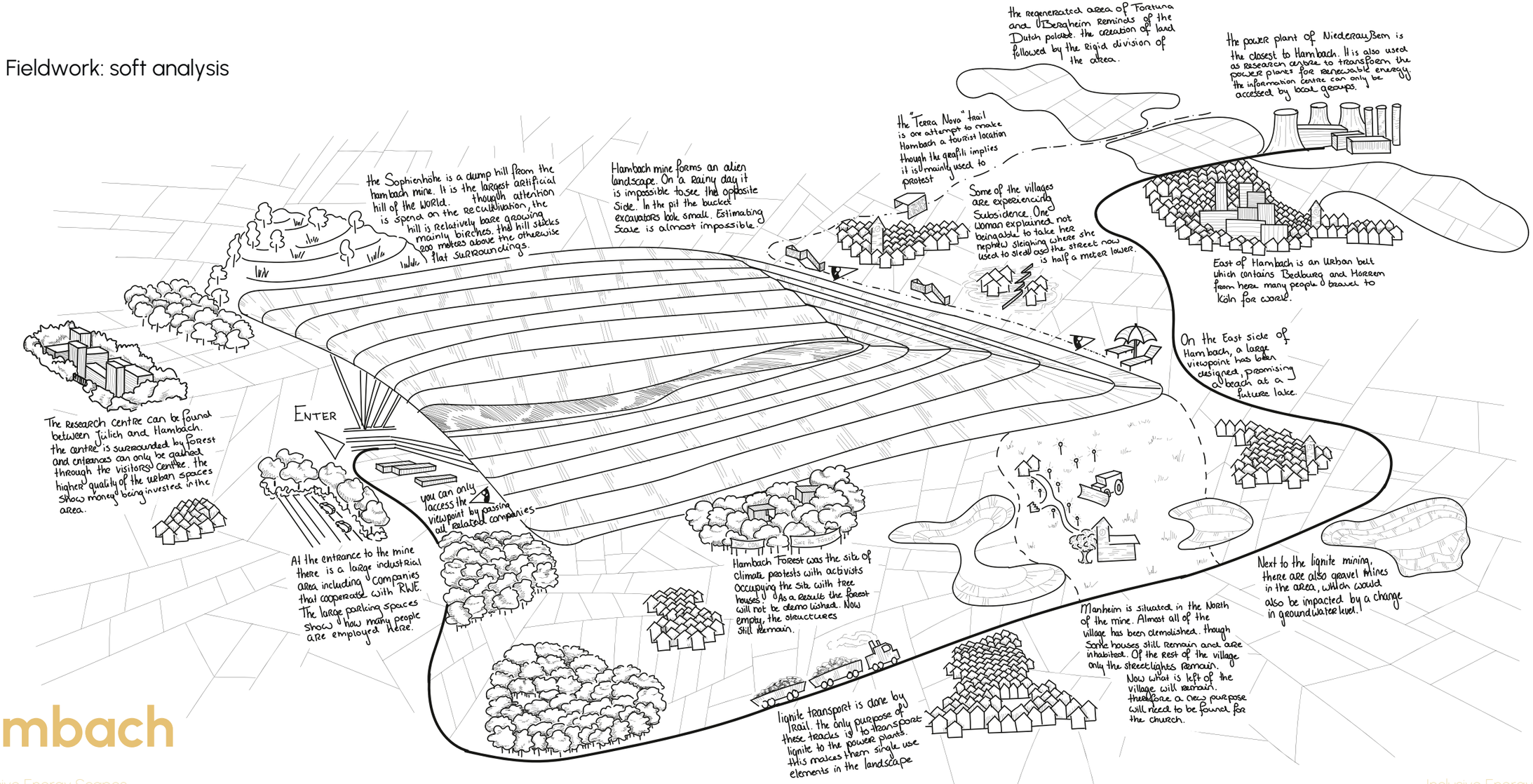
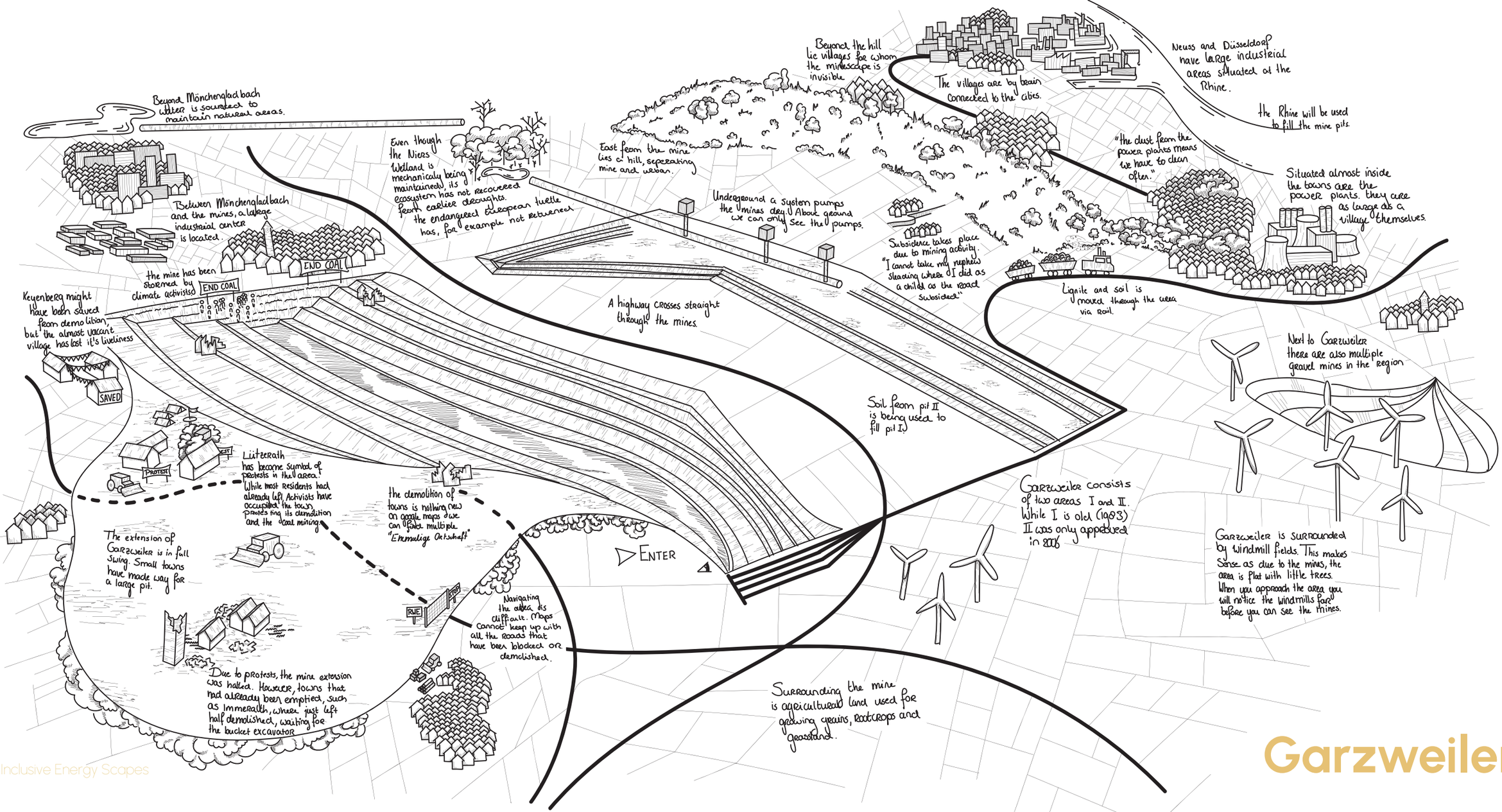
Appendix

A Fieldwork: soft analysis

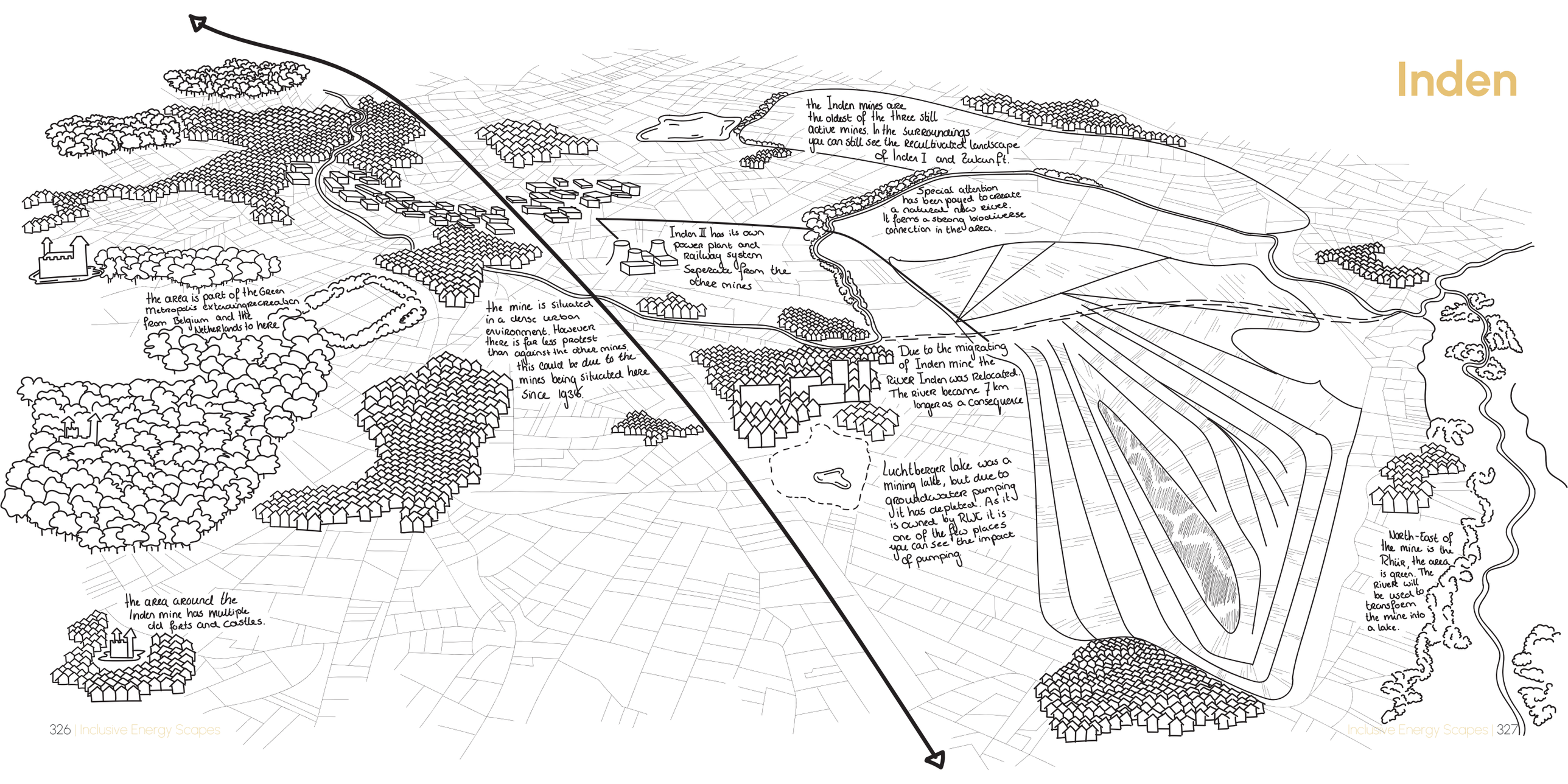


Hambach


Beyond Mönchengladbach water is sourced to maintain natural areas.
Between Mönchengladbach and the mines, a large industrial center is located.
Even though the Niers Wetland is mechanically being maintained, its ecosystem has not recovered from earlier droughts. The endangered European turtle has, for example not returned.
East from the mine lies a hill, seperating mine and urban.
Beyond the hill lie villages for whom the mine is invisible.
The villages are by train connected to the cities.
Neuss and Düsseldorf have large industrial areas situated at the Rhine.
the Rhine will be used to fill the mine pits.
"the dust from the power plants means we have to clean often."
Situated almost inside the towns are the power plants. they are as large as a village themselves.
Underground a system pumps the mines dry. About ground we can only see the pumps.
Subsidence takes place due to mining activity. "I cannot take my nephew sledding where I did as a child as the road subsided."
Lignite and soil is moved through the area via rail.
the mine has been stormed by climate activists
END COAL
END COAL
Keyenberg might have been saved from demolition, but the almost vacant village has lost it's liveliness
SAVED
A highway crosses straight through the mines.
Soil from pit II is being used to fill pit I.
Next to Garzweiler there are also multiple gravel mines in the region
Lützerath has become symbol of protests in the area. While most residents had already left. Activists have occupied the town, protesting its demolition and the coal mining.
PROTEST
WEST
the demolition of towns is nothing new on google maps one can find multiple "Ehemalige Ortschaft"
ENTER
Garzweiler consists of two areas I and II. While I is old (1983) II was only appointed in 2006
Garzweiler is surrounded by windmill fields. This makes sense as due to the mines, the area is flat with little trees. When you approach the area you will notice the windmills far before you can see the mines.
The extension of Garzweiler is in full swing. Small towns have made way for a large pit.
RWE
Navigating the area is difficult. Maps cannot keep up with all the roads that have been blocked or demolished.
Due to protests, the mine extension was halted. However, towns that had already been emptied, such as Immerath, were just left half demolished, waiting for the bucket excavator
Surrounding the mine is agricultural land used for growing grains, rootcrops and grassland.

Garzweiler

Inden


the Inden mines are the oldest of the three still active mines. In the surroundings you can still see the recultivated landscape of Inden I and Zukunft.
Special attention has been payed to create a natureal new river. It foerms a strong biodiverse connection in the area.
Inden II has its own power plant and railway system Seperate from the other mines
the area is part of the Green Metropolis extending recreation from Belgium and the Netherlands to here
the mine is situated in a dense urban environment. However there is far less protest than against the other mines. this could be due to the mines being situated here since 1936.
Due to the migrating of Inden mine the River Inden was Relocated. The river became 7 km longer as a consequence
Luchtberger lake was a mining lake, but due to groundwater pumping it has depleated. As it is owned by RWE it is one of the few places you can see the impact of pumping
the area around the Inden mine has multiple old forts and castles.
North-East of the mine is the Rhine, the area is green. The River will be used to transform the mine into a lake.

B Fieldwork diary

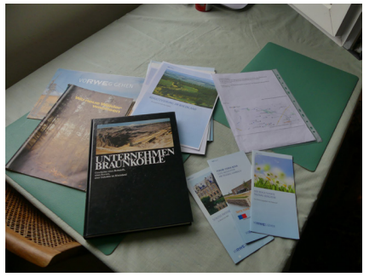
Day 1 | March 10th 2024 | Landscape
I entered the area over the main road (add road name) which travels between Garzweiler I and II. As a consequence, it feels like this ginormous gate you are entering into the area. The surface here is much flatter than in the direct surroundings, giving it a surrealistic experience. As you continue along the long edge of the mine, it is impossible to see the complete mine from one point. This makes the extend of the mining pit even larger.

I first did not see the mine, I saw the windmills and from the amount deduced we had to be close to Garzweiler.

We entered the village which was relatively busy. This made sense as it was a sunny Sunday. I immediately noticed the amount of brick used in the town. All homes seemed to be built from (red) brick. This is quite unusual for Germany, but makes sense as the area has an old history of brick production. Brick factories where so common, they had their own icon on the historic maps. It was interesting to see this come back in the urban environment. As the materials for bricks also needed to be mined, this was mostly done next to the factories. Therefore, the area has an even older mining history, from before the lignite mining. The brick mining might have also helped with the discovery of the lignite in the soil. However, I do not have proof of this.

When I arrived at my location, (the souterrain of an older lady). She had prepared materials for me concerning the mines. She collected books, pamphlets and the plans for the area, as far as she could find them. It was quite interesting to be able to see local materials that are spread among the population as this is also the information shared with the residents. From these documents I determined an interesting combination of pride for the technical feats committed as well as resistance against the damage done, as well as little answers for the future plans.









Day 2 | March 11th 2024 | Mining
The first day at location focused on the mining at the Hambach mine.

I moved along the edge of the mine to gain a general overview of the mine as well as the border of the mine in relation to the surroundings.

I collected different images showcasing the groundwater pumps. However, I also came across different infrastructure elements such as the dust sprayers on the edge of the mines.

I checked out Manheim which was almost completely demolished. However, now it will not be completely demolished. Thus there are two homes still being occupied and a new purpose is searched for the church. Can you call it a victory if you look at the half demolished village.

I also visited Hambach Forest. Spooky and dead. Due to the mud I could not find much of the original protesting site, but I gained a general idea. The amount of obstacles and barriers as well as the lacking infrastructure surrounding it, do not make it a popular recreation area. If visited, people do so to experience the history of the place, not the forest.

Throughout the whole day, it was raining. This made it difficult to interact with people on the street.



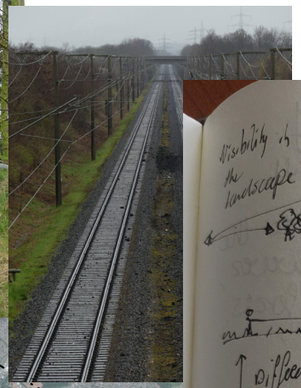


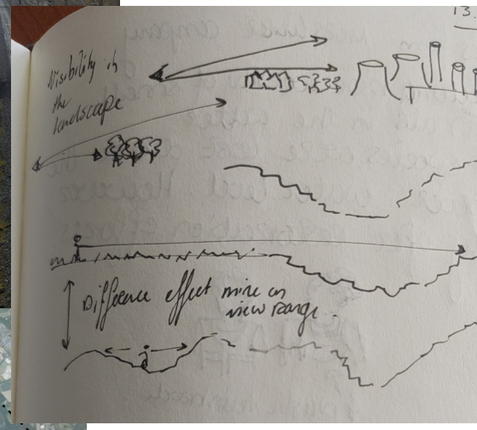


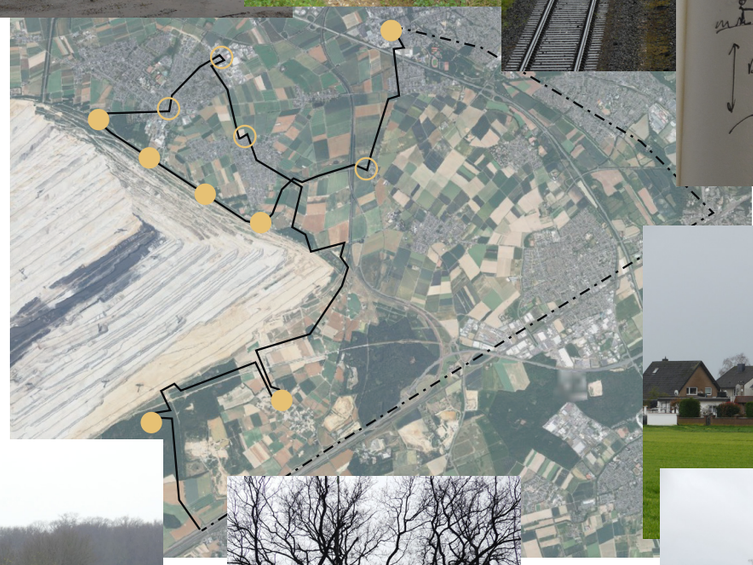


















Day 3 | March 12th 2024 | Infrastructure

Day 3 focused on the relation between the power generation, the infrastructure and the urban environment. I visited the power plants of Niederaussem, Neurath and Frimmersdorf.

My start of the day was the Schloss Paffendorf as there would be an exhibition of RWE here about the lignite mining. The exhibition had unfortunately been shut down, the castle is still being used by RWE, specifically by their research and control department for the recultivation of natural areas. Unfortunately no one was available to discuss the work done.

From here I visited the old mining area to be able to see the work done on recultivation of the area. Here I spoke to the first person, an older lady whose husband had worked for RWE. For the future of the mines, she would enjoy the same type of recultivation as in the old areas, where she is now walking her dog (6).

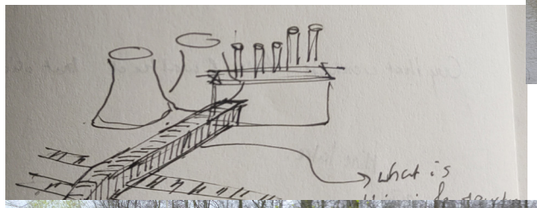
Today I also noticed the first issues with my language barrier. Though everyone is willing to talk, for some speaking in English is a barrier.

From here I made a tour past three different power plants. Niederaussem which is located on the edge of the village generating the closest relation and most disturbance (2). A resident explained having to clean often due to the pollution from the power plant. Here you could also see the relation between the power plant and the old brick factories in the area.

From here I moved to Neurath, which is situated a bit further away from the town, and passed through Neurath. Here I also found some references to the brick making in the area, and took some pictures of the damaged roads (4&5). In most villages the roads have been damaged either through old age, or maybe even due to subsidence.

I moved on to Frimmersdorf. On my route I passed the both the railway infrastructure of the mines and an unknown infrastructure (3) which seems to be related to the mines, but I still have to determine what it's exact function is. Next to that, it is immediately noticeable the power plant is not in use anymore due to the lack of emissions.

Lastly I biked back through some natural protected areas to Bedburg (1). This is a small city, which has on the North side a large area which is part of the relocated villages. I wanted to see if you would be able to recognise the difference. The main thing I noticed that while all villages where executed in rows of housing of red brick, these areas consisted of the same materials, but had two-under-one-roof houses. The roads were also broader, had trees more often and overall the road maintenance was better (7).



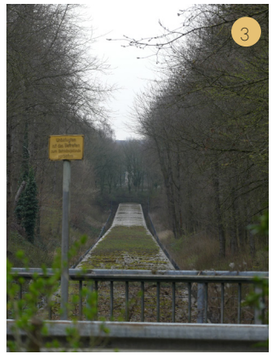














Day 4 | March 13th 2024 | Demolition
Lots of demolition,

It was difficult to get back as maps did not know where the mine was. Roads just stopped with a hill of sand and a stay-out board.

Keyenberg is proud they will remain, though the village is almost empty. Lots of vacated housing is damaged. Doors are boarded up, screens are down, garden fences are damaged. The question is what they won? The village is already damaged, and now situated at the edge of the pit thus subsidence and dust will become a bigger issue.

Also visited the Niers wetland area. Spoke to a young lady from the area, she told me about the swamp almost drying up before the ground water interventions. This made the swamp turtle leave the area. She also joined the protests at Lützerath with her whole family, due to the effects she saw in her direct surroundings. The road she lived at subsided half a meter and now she cannot sled down the hill with her nephew anymore like when she did when she was young.

I spoke to a lady in Jüchen. She explains only to be bothered by the dust, noise is not an issue. Both ladies came back to the area due to family.

Holzweiler is now located at the edge of the mine. It almost feels like the building site. Next to the village all the future infrastructure needed for the mines is stacked.



























Day 5 | March 14th 2024 | Recultivation

Only places I have seen horse riding. School class that went hiking in the Vereinigte Ville. Lots of elderly people. Also way more cyclists, both sport and transport. Though this might also be explained by the good weather., I would also explain this by the better bike infrastructure in this area.

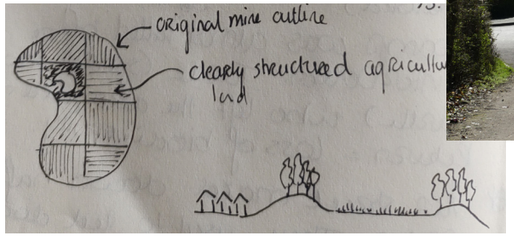
I also checked out mine lakes. The question is, what extra recreation do three new large lakes bring, except from being the "biggest". There are multiple beaches and camping at lakes, there is one completely dedicated to water sports, there are a few spots that are protected for birds with birth spotting places. Ther are lakes meant for fishing (and some that should not be fished in). Therefore it is important to think of what such a large, (and deep) lake might offer. Next to that, the lakes do not go up to the edge. As such they have relatively steep edges. (sketch)

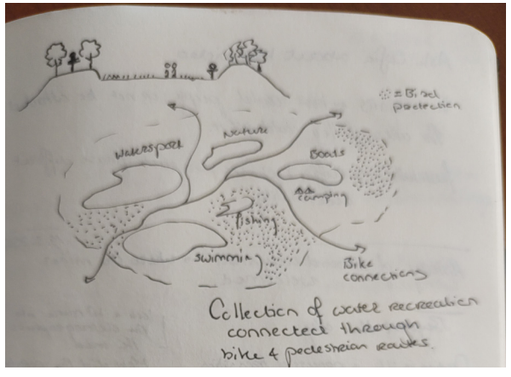
Also, comparison creating new space from filling up mines or "polderen". We create wat we need through a very strong human logic. Agriculture is very orthogonal. I suspect we do not need housing, thus no housing is built on the mines. I first thought it had to be nature or agriculture as the soil needed to become sturdy first over time, but they already built distribution centres on top. Thus maybe pollution might be a limitation, or simply, the space is not needed for housing.

The area also seems to be plagued with Mistletoe which is a tree parasite only occurring in lime rich soils.

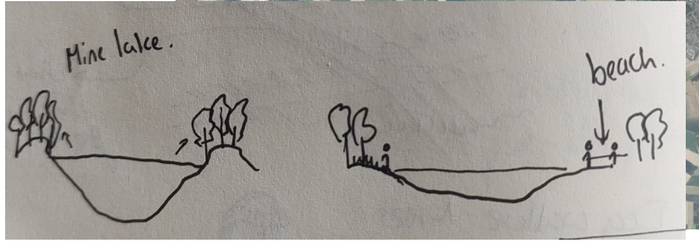
















Day 6 | March 15th 2024 | Inden
This day consisted of a tour around the Inden II mine.

The first stop was at Lucherberger See. This lake is a result of the historic mining operations. Over time, the mine was closed and a lake was created. However, due to the mining operations in Inden, and thus the lower groundwater, this lake is almost completely empty. As the lake is owned by RWE, this is something that is allowed.

I moved from here West around the mine, first passing by a viewpoint from where you could see all of the mine. From here I followed the new relocatend Inden river around the mine. The environment created is nice and green and you would not expect this complete river and its banks to be man-made. However, there is a lot of information on the route about the relocation and the mining activities. Here you can see the pride in this engineering achievement. This part of the route is also part of the routing of the Green Metropolis. A recultivated mining area spanning from Belgium through the Netherlands to Germany. Only Inden is part of this route.

From here I moved further around the mine, noticing the by now familiar stopped roads and the small settlements consisting of brick housing. I moved past the Ruhr river and moved up towards the Jülich research centre. The roads, bike lanes and general services towards this research centre were significantly better than anywhere else in the area. Unfortunately the research centre itself was inaccessible with guards and fences surrounding the whole area.

From here I shortly visited Jülich self which is one of the larger cities in the area, before taking public transport back around the Hambach home.











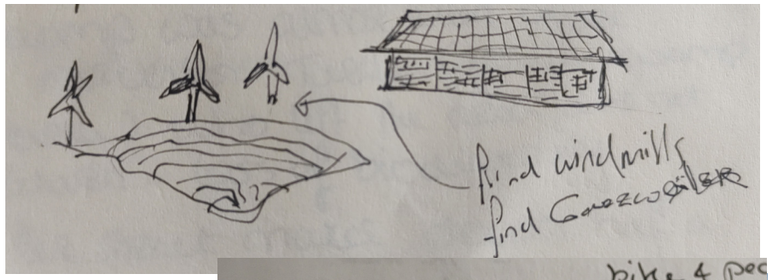


Day 7&8 | March 16-17th 2024 | Hotspots

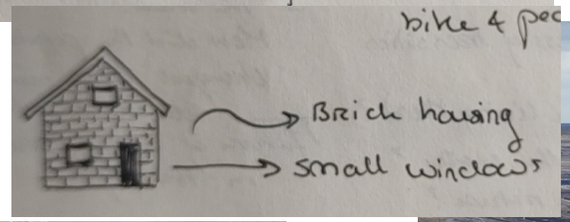
On the 16th of March my dad arrived in Germany and we travelled around on site. During these days we visited the main attraction points for tourists, such as viewpoints, Manheim and Hambach Forest. But we also took the time to visit some areas that were difficult to access by bike, such as the area around the Garzweiler transport centre.





























C Soundscapes

A landscape consists of more than the view and as such can be difficult to display via photo's. The landscape also consists of smells, of the atmosphere and sound. Through video's I worked on displaying the sounds to create more of an immersive view on the landscapes.

Next to that, noise is depicted as one of the burdens from the lignite energy generation. As such, monitoring the sounds in the area is also a method of determining this disturbance of the landscape.

A clear bias in the recordings is that I attempted to generate as clear as a sound as possible. As such, I recorded far away from roads in silent areas. In this area it is almost impossible to find a space from where you cannot hear the roads. When talking to people they even indicated being more disturbed by the noise of the roads than by the mining operations.

However, to be able to hear the pure sounds related to different landscapes, I did decide to focus on the landscape and for example wait for cars to pass by before recording.






BEA






RWE



D Cases of regeneration

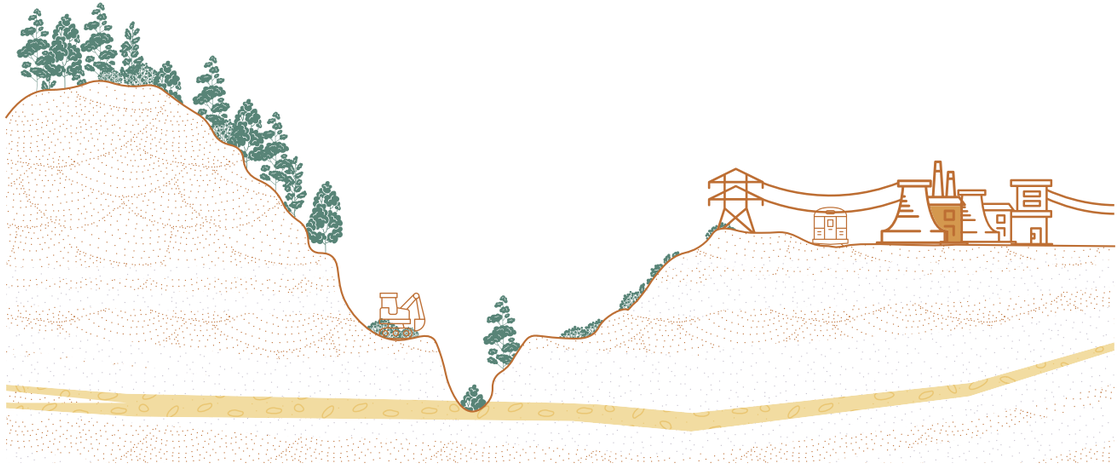
Lille Heritage



Mission Bassin Minier - (Mission Bassin Minier, 2009)

In Lille, the old mines have been frozen in time. Recently the mines have been named UNESCO heritage and it is possible to visit the area and discover this history related to coal mining. Although it is important to be aware of these types of landscape and cultural histories. Freezing the Rhenish minescape in time would also make it impossible to restore groundwater levels and reduce pollution. On top of that, there is a battle for space at this time, and leaving spaces the size of small cities bare, for historical importance is difficult to defend.

This section shows the projection of the strategy used in Lille on Hambach mine. This will be done for all case studies of regeneration.



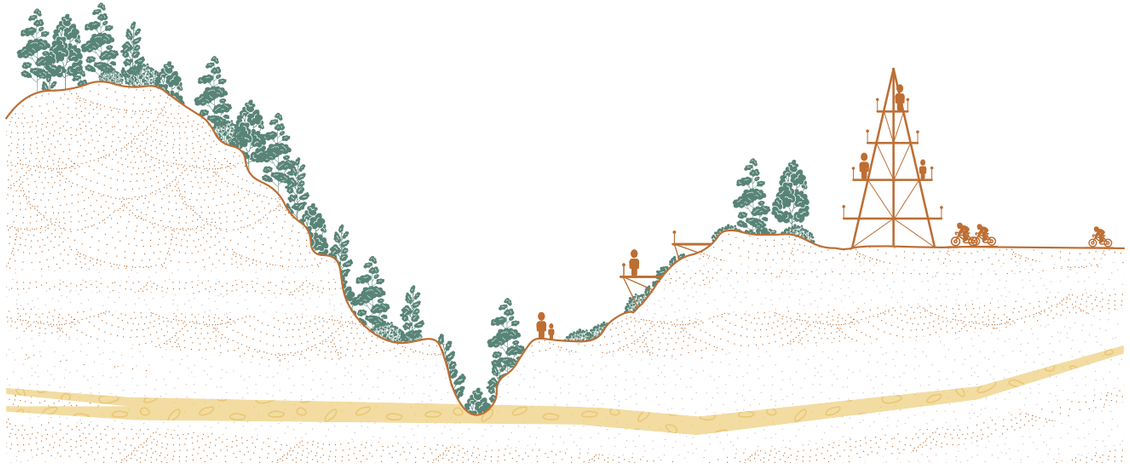
Ruhr Leisure



Emscher landschaftspark (NatiSythen, n.d.)

The Ruhr gebiet of Germany was known for its hard coal mining. Contrary to the Rhenish mining area, this excavation activity was already halted quite some time ago.

The government invested in creating a new green recreational backbone in the old industrial area, combining the industrial heritage with green structures and leisure. This however was a costly endeavour and not as successful as hoped. As there were only limited access points to the area, it is not used by local residents, instead it is mainly visited by tourists. The combination of recreation and industrial heritage could be of interest for the Rhenish mining area. However, we should also take into account the possibilities to produce energy and the economic consequences for the local population.



Freshkills Ecology



Freshkills, New York City, US (Cavollo, 2017)

Freshkills is an example of the regeneration of a wastescape into an ecological wildlife centre as well as a leisure environment (Power plants, 2019). To do so, phytoremediation was used to restore the air, water and soil pollution in the historic wetland. As such the old landfill has been transformed into a highly valued recreational area as well as a large wetland area, providing a biodiversity and ecological impulse. The wetland even plays an important role in hurricane and extreme weather remediation (Power plants, 2019)

This site is of interest due to its transformation of a polluted site into a space where humans and nature can enjoy space together. This site works well as it is a stark contrast to the busy city life and forms a space of peace. Due to the phytoremediation it took high maintenance and costs as well as a long time period to come to a functioning park (Power plants, 2019).

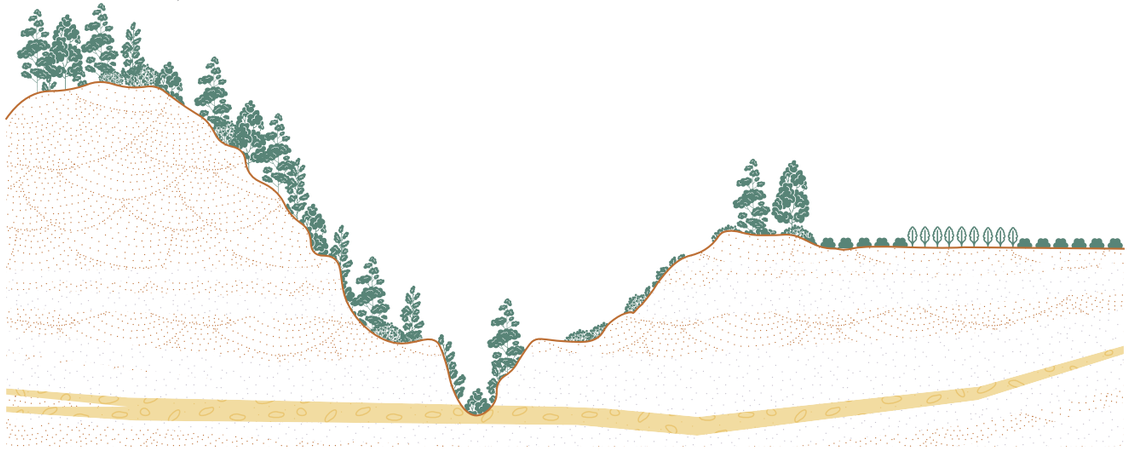


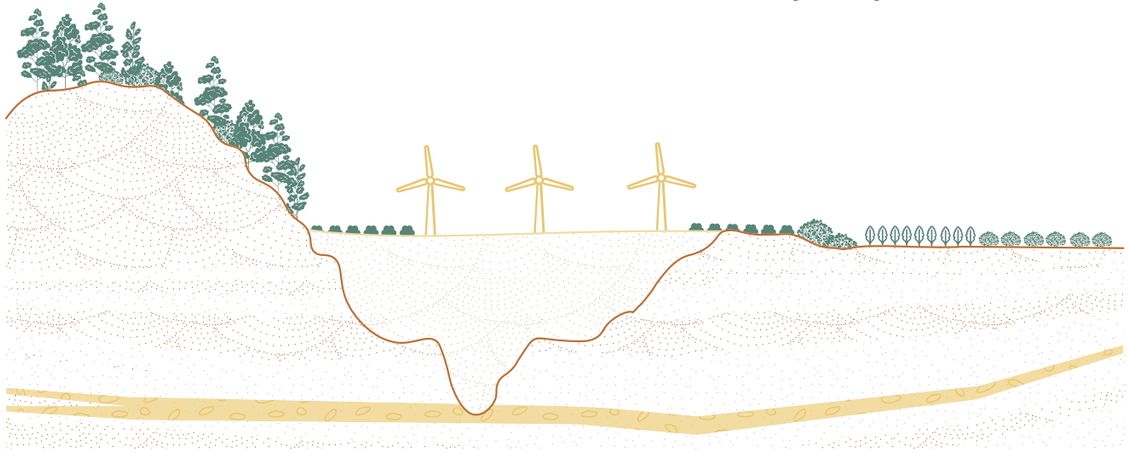
Image description

Bergheim Land

Bergheim is situated in the Rhenish Lignite mining district. These old mines have been filled with overburden from the currently operating mines. On top of this, agricultural land is created. Even if we would implement energy production on top of the mines next to the agricultural production. This method would still not be applicable anymore. There is not enough soil available anymore to fill the current mines leaving this strategy out.



Tagebau Bergheim (Orth, 2009)



Berzdorfer Lake



Berzdorfer See (Vincentz, 2012)

Berzdorfer is a classic example of German minescape regeneration. By filling the pits using water from nearby rivers, lakes are created. The edges are designed as for people to recreate in nature and on water. The lakes themselves can have issues with acidification due to pollution. Next to that, this strategy has yet to be executed in a mine as large as Hambach or Garzweiler.

The section searches for possible energy production in relation to the lake. The current RWE strategy would be to place solar panels on top of the lake to maintain energy production. However, this would impact the aquatic ecosystem and make it impossible for locals to recreate in the lake.

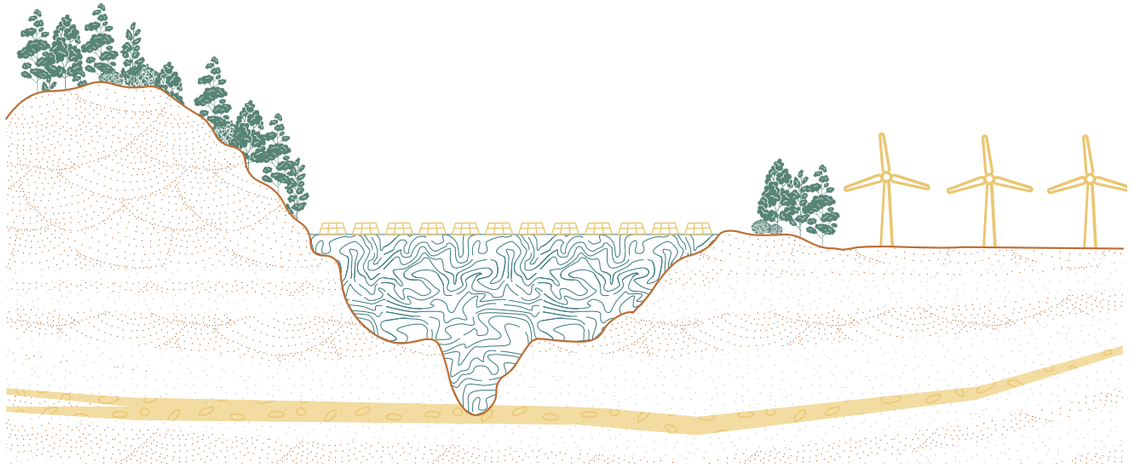


Image description

Breda Energy

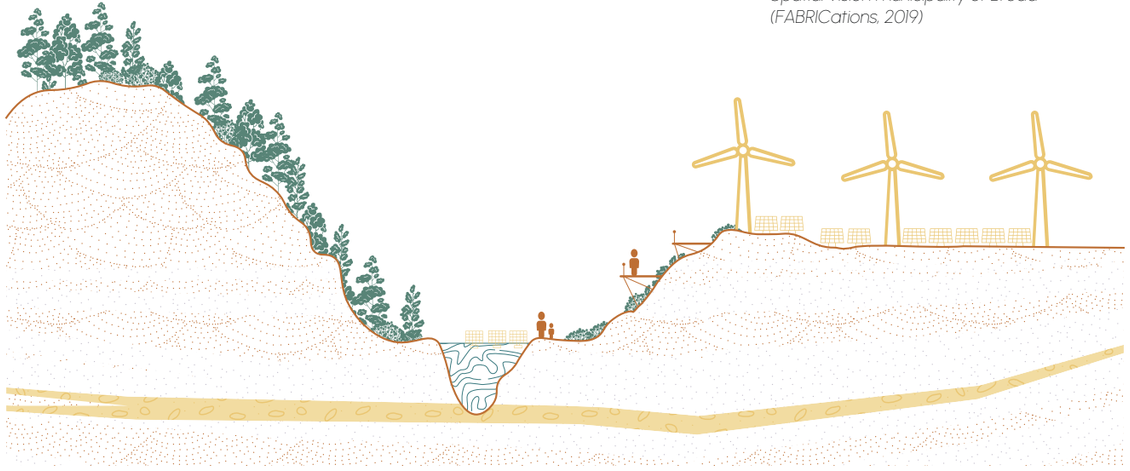
This spatial vision of Breda has been created by FABRICations. It is an investigation into the energy transition as a cultural act. It is founded on the idea that the energy transition should be embraced by people. In this proposal the designers play with the forms and shapes of the windmills and solar panels to fit into the landscape. At the same time the main production is done along the highway to optimize the usage of space.

In Germany policies also suggest to develop energy production around roads and railways to combine two functions which exclude a living environment.

This type of regeneration through renewable energy landscapes does not happen often. Thus it is an interesting future for the landscape to further discover.



Spatial Vision municipality of Breda – (FABRICations, 2019)



E Rhenish Minescape in the media

When reviewing media, we can see that most media cover focuses on Hambach and Garzweiler as these are the two mines involved in protests. At the same time, Inden does not seem to create the same amount of resistance. This can be as the mine is significantly older, going back to 1930, or because the expansion does not threaten current residential or natural areas. Lastly, we can see most conflict is caused by climate activists who use the smaller local conflicts as means to convey their main message of coal phase-out.

Lützerath: German coal mine stand off amid Ukraine war energy crunch

9 January 2023

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By Jenny Hill, BBC News, Lützerath

NATURE AND ENVIRONMENT

Hambach Forest: Police tackle green activists' blockade

Elliot Douglas
06/23/2020

The wood in western Germany where activists set up tree houses and barricades in 2012 has become a symbol of the environmental movement. Police have launched a fresh attempt to clear forest roads, citing safety concerns.

Klimaatactivist Thunberg aangehouden bij hernieuwd protest tegen bruinkoolwinning in Lützerath

Klimaatactivist Greta Thunberg is dinsdag opgepakt bij een demonstratie tegen de bruinkoolwinning in het Duitse dorp Lützerath. Ze maakte deel uit van een groep van zestig demonstranten die aan de rand van de bruinkoolmijn protesteerden.

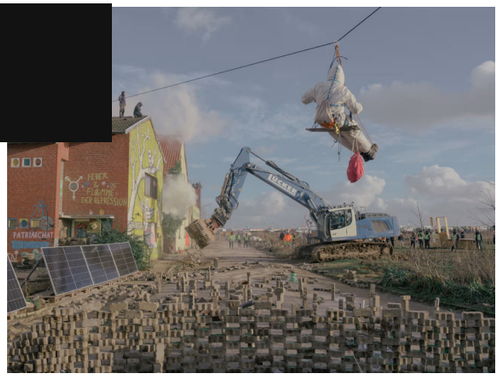
Redactie 17 januari 2023, 18:39



Collection of news articles and photography from Nolting (2023), Hill (2023), NOS (2018, 2023), Der Spiegel (2017, 2023), Douglas (2020), Volkskrant (2023) and (Gibbens & Chatard, 2018)

The eviction of Lützerath: the village being destroyed for a coalmine – a photo essay





NOS Nieuws • Maandag 9 januari 2023, 07:12

Spanning stijgt in Duits 'kolendorp': ontruiming van Lützerath nabij

Lützerath

Aktivisten bewerfen Polizisten mit Steinen und stürmen Veranstaltungsgelände

Nach einem Konzert in Lützerath liefen Aktivisten auf die Veranstaltungsfläche. Polizei und Sicherheitskräfte seien mit Steinen beworfen worden. Klimaschutzministerin Neubaur verurteilte die Gewalt.

08.01.2023, 21.58 Uhr

NOS Nieuws • Donderdag 13 september 2018, 20:47

Ontruiming Duits 'bruinkoolbos' door politie begonnen

Ende Gelände im rheinischen Revier

Das Ziel war deutlich: Umweltaktivisten wollten am Wochenende die Braunkohle-Produktion von RWE im rheinischen Revier stören. Bei Auseinandersetzungen mit der Polizei ging es dabei teils gewaltsam zur Sache. (27.08.2017)

29.08.2017, 12.49 Uhr



F Protesting RWE

This is a collection of photos taken during my fieldwork, depicting different forms of protest against the mining and RWE still visible in the environment.

Though all large protests have been ceased and with the expansion of Garzweiler II executed, the debate in the area seems to have settled down. However, when looking carefully, we can still note stickers, graffiti and posters depicting small forms of resistance either from past protests or current resistance.



Sticker in Niers wetland "Climate killer RWE"



Victory poster in Keyenberg "the preservation of Keyenberg is secured"



Manheim, one of three buildings still being inhabited



Abandoned? Protest site Hambach Forest



Abandoned protest site Hambach Forest

G Transcripts microstories

During my fieldwork in Germany, I conversed with multiple local residents. Below are the transcrips of the conversations I recorded.

DAY 3

Video P0110021

M:So have you lived here in this area?
I: Yes
M: How is your experience of living here, with the mines?
I: I was born here
M: You were born here.

M: Do you have any relation to the mines? The brown coal mines?
I: My husband has worked there?
M: Yes?
I: Yes.
M: For how long, can I ask?
I: 30 years, all the time
M: All the time.
M: How do you feel about the mines being phased out in 2030?
I: It is difficult. Because no atom and energy, no wind, not so much wind. It is different.
M: Yeah
I: That all people have energy.
M: Yeah, It is mainly that you will lose so much energy.
M: And does it also, ehh, What do you feel about when you do not have the mines in the area anymore? What do you think should happen to the landscape?
I: No I do not understand the question.
M: Rekultievierung? So when the mines are gone, what should happen?
I: It is good. Yes here.
M: Like all the agriculture?
I: The lakes. Anything, this one.
M: So like this landscape, the mines should be.
I: Yes. And I think 20 years ago, the greater see for Germany. The Hambach.

Video P1010057

M: I was wondering have you always lived here? Did you move here?
I: I live here.
M: All your life?
I: Yes, all my life
M: And do you have any relation to the mines at all? Have you worked there? Even protested the mines, I do not know?
I: I work here, and my wife lives here.
M: Did you work at the mines, for RWE.
I: No
M: No, just in the area.
M: And do you experience the mines in day-to-day life? Like on a normal day, when you go to work, walk your dog etcetera do you experience the mines?
I: The mines is?
M: Hambach, Garzweiler, the pits. Do you notice them?
I: Sometimes here on this side here, with the dog.
M: Just when you walk around here you see them.
I: Genau
M: And do you have any idea what the plan is for the future here, for the mines?
I: Ooh uhhm, Hambach, becomes a lake. A new, very big lake. Here on this side, on the top, comes a new forest. It is in work. A new street. And.. I am not sure, a little village. A new village. It was... Some time ago, there was a village. It is broken for rhinebron* and now its sometime for new.
M: They are going to bring it back.
I: yeah.
M: What do you think of the plans. Do you think they suit the area or the people that live here, or would you prefer something else.
I: It is okay. I think it is good here. I like it here. It is nice.
M: Good, that is good to hear.
*unclear pronunciation.

Video P1010116

I: We don not live here we just work here. It does not depends too much on my life.
M: So you just come here and see it and that is about it?
I: Yeah, yeah
I2: Yes it is.
I: We are all for work here. And after work we go home and we do not see this.

Video P1010178

M: So are you from this specific area?
I: We were born here.
M: Super nice. So do you have any relation to RWE or the mining company?
I: Well my grandfather came in the 1900s here to work from Turkey. Yeah that is all I know, he worked here for years. He sadly had an accident. He fell down from a car and broke his hip, so he could not work a lot.
M: Ohhw that is really bad.
M: And then you still stayed with the family here.
I: Yeah we stayed here.
M: Do you experience the mines and all the energy production here on a day to day basis?
I: Well, it is kind of a problem, because it makes a lot of dirt when you clean of the glasses of the homes. It gets dirty a lot. You have to clean a lot here.
M: Because of the factories?
I: Yeah genau, because of the factories.
M: I did not expect that at all. That is really interesting to hear.
I: It was a worse in the past, but it is a lot better now.
M: Do you look forward to in 2030, they plan to close all the mines and

factories. Do you look forward to that?
I: It is complicated, because I do not know a lot about it. But it would be great. They also still discussing if they should or not. I do not know if they will do it. But I do not think they will.
M: You think it will just keep mining here until it is gone. Like all the lignite.
I: Yeah

Video P1010476
M: So have you always lived here or did you decide to move?
I: No we moved last year in April.
M: So did you always live in this specific area?
I: We lived before in Dormagen, it is a forty minutes' drive from here. It is between Dusseldorf and Köln.
M: Why did you chose to move here?
I: That is a good question. Because we wanted to have a house and it was too expensive in Dormagen. My husband is working in Köln so we were looking around Köln and we moved further and further and then we found Bedburg and we think it is a nice city.
M: yeah it is.
M: Do you experience anything of the mines or the energy production here in your day-to-day life or just it is really far away?
I: It is really far away to be honest.
M: Yeah I can imagine, because in the town you do not notice it at all.
M: And last question, do you know about the regeneration plans for the region?
I: Yeah, I heard a little bit. You mean about the Tagebau and the lakes.
M: What do you think of the plan. Would that be a good future do you think or would you prefer something else.
I: ehmmm, I would prefer anything that helps our planet, that helps our environment. There are different plans, when they decided to do anything about like energy wind, solar kraft. Now my English is going away.
M: Solar energy and wind energy?
I: Then I think it is a good plan.

DAY 4
Video P1010588
The woman studied in the Netherlands and as such we had our conversation in Dutch.
M: Woont u hier in de buurt?
I: Ja, ik woon hier in de buurt.
M: Hoe is het om zo dicht bij de mijn in de buurt te wonen, want jullie wonen bijna op de grens?
I: ehmm ja. Je krijgt het toch niet zoveel mee. Alleen van "verschmutzung" zegmaar
M: de stof, the dust?
I: Van de stof. Dat vind ik soms een beetje vervelend, maar verder krijg je zoveel niet mee, vind ik.
M: Hoor je de mijnen, of hoor je het geluid ervan, of helemaal niks?
I: Nee
M: Helemaal niks, je hebt meer last van de autoweg.
I: hahaha, ja meer daarvan
M: En heb je altijd in deze regio gewoond?
I: Ja
M: Is er een bewuste keuze dat je hier in de buurt bent blijven wonen?
I: Ja vanwege familie en vrienden.
M: Ja dus het is gewoon fijn om hier in de buurt te wonen.
M: Heb je verder enige relatie tot de mijnen of RWE? Ken je iemand die daar werkt of heb je daar zelf gewerkt misschien?
I: Ja een paar kennissen die hier wonen, maar verder...
M: Ook niet, ook niet zoveel.
M: En ik weet niet of je weet wat voor plannen er zijn voor de mijnen in de nabije toekomst? Voor 2030 willen ze de mijnen sluiten
I: Ja
M: Wat vind je daar überhaupt van, van het idee om de mijnen te sluiten?
I: Ja, ik vind het goed dat ze het sluiten, sowieso. Ik hoop gewoon dat de lucht dan ook wat beter wordt. En uhmm, ja er zijn verschillende projecten. Dus volgens mij zijn ze nog niet helemaal duidelijk wat precies daar komt, maar ze willen een recreatie project eigenlijk starten.
M: En wat zou u graag willen voor het gebied?
I: Eigenlijk een natuurgebied
M: Een natuurgebied?
I: Ja
M: Super dank u wel.

Video P1010653
M: So have you always lived in this area?
I: Most of the time I lived here, in this area, yeah.
M: So did you move here, somewhere around Niers?
I: My parents moved here and I grew up here. Yeah, and then I have been away to study and came back.
M: You came back. Is there a specific reason why you came back? Did you like the area or did you...
I: Yeah it is my home, my family is here.
M: It just feels like home okay. Do you have any family or people you know that work at RWE or at the mines?
I: No
M: That is really nice, because most people do, but it is really nice to here someone that is actually just like completely separate from it. Do you know.... What is your opinion? They are going to close the mines down in 2030. It's the plan right now, but what do you think of the closure, of the plans that they have for the future?
I: Well, ehhm, I do not know what to expect for... what it would bring for German energy problems. I do not know about that. But I see how the mining affected the area, so I am

looking forward to see how maybe things change to better when it is closed down.
M: Do you, You have lived here for quite a while. Did you live here during the protests in Hambach Forest and near Lutzerath. Have you heard anything about that?
I: We have been there as well. To protest
M: You protested there?
I: Jajaja, Because you know it is I don't know maybe four five kilometres from here now. I remember when I was a child it was much farther away than now and we were always like ehmm, A little bit sceptic about what was going on. And then some years later we start to see how it affects the area and when the protests, the big protests, started we were like. Yeah we live here. We live with what is done to the area. So of course we have to be there, as a family.
M: So your whole family went there and you protested together. That is super nice to hear. Thank you very much.

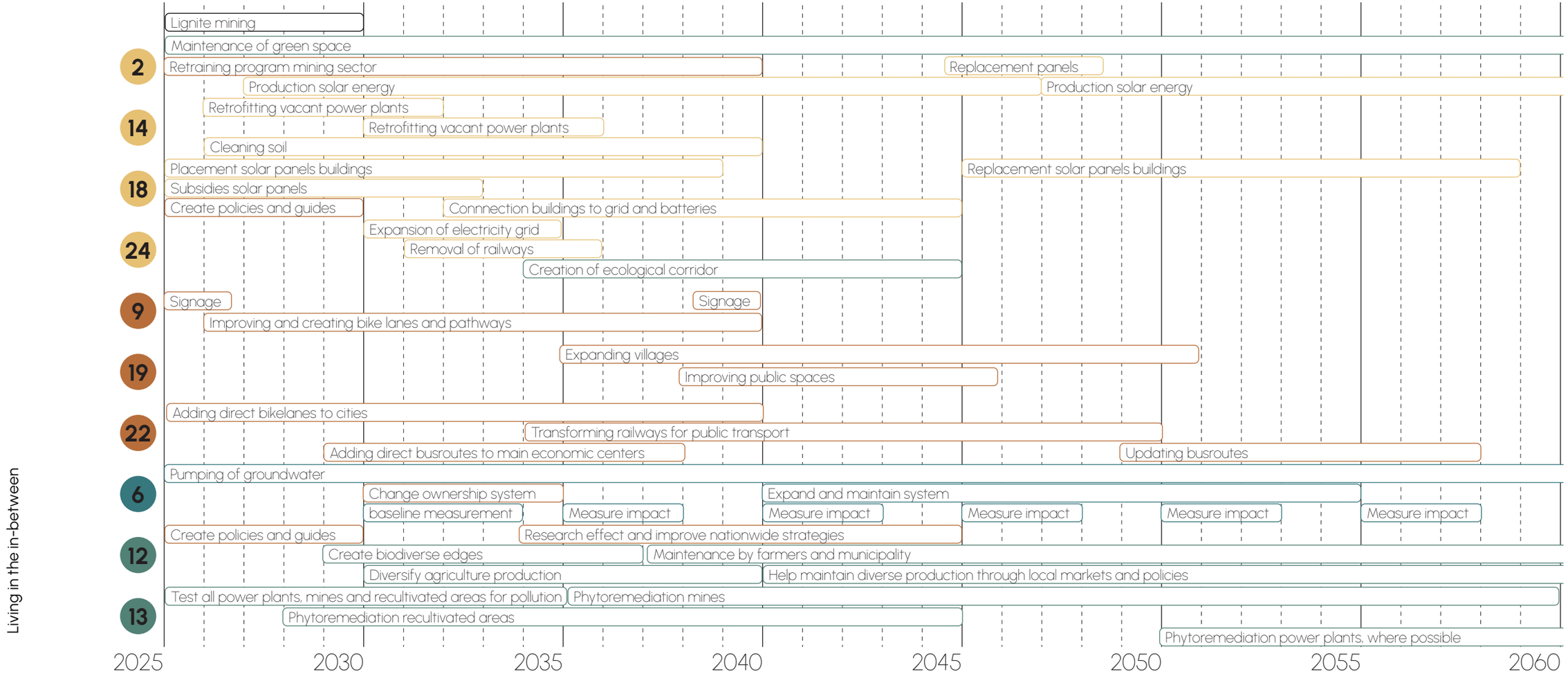
Continuation P1010653 (not recorded)
Summary / paraphrasing of conversation

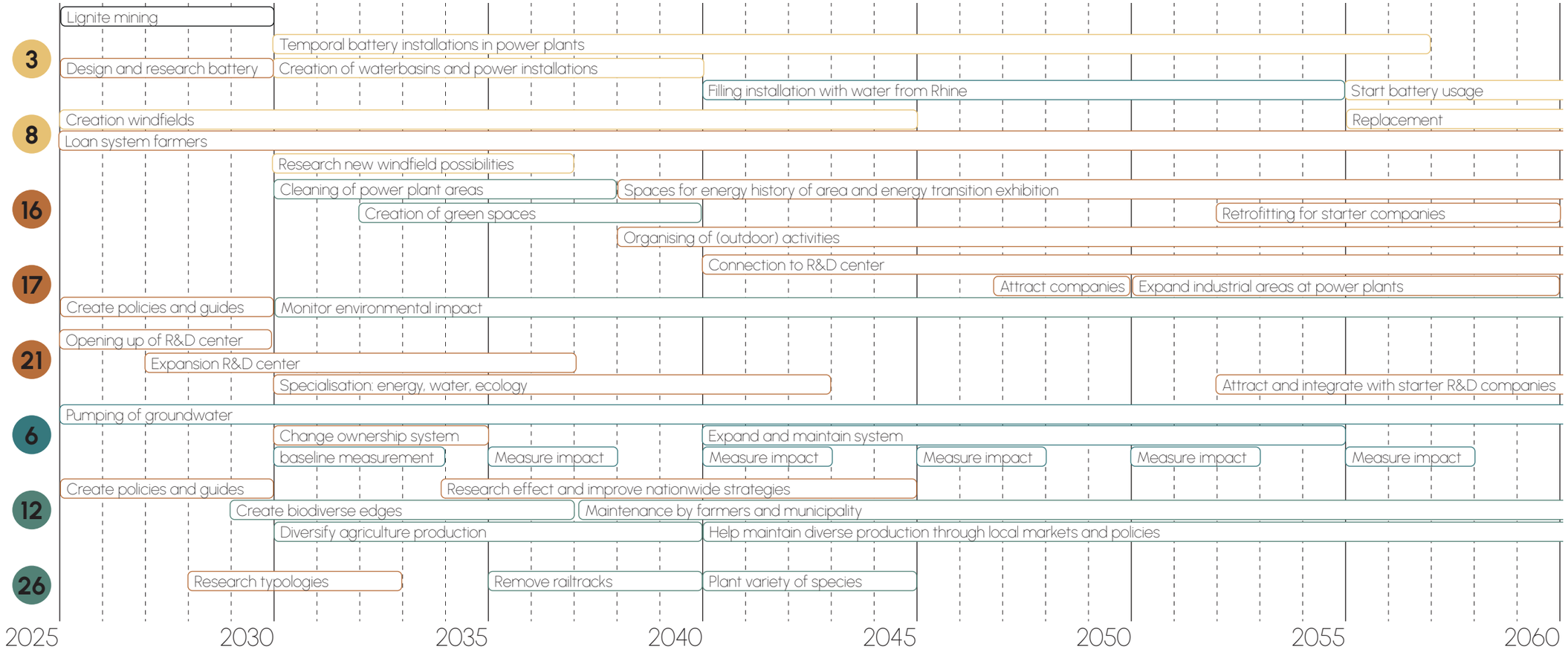
I: The swamp was almost killed before the current water interventions. There used to be a turtle, a special swamp turtle, who left the area. He has not returned.
I: We also noticed the subsidence. The street we lived on moved down half a meter. We used to sled down the hill when there was snow, but now I cannot take my nephew sledding here anymore due tot the change in height differences.

Conversation employees government(not recorded)
Summary / paraphrasing of conversation

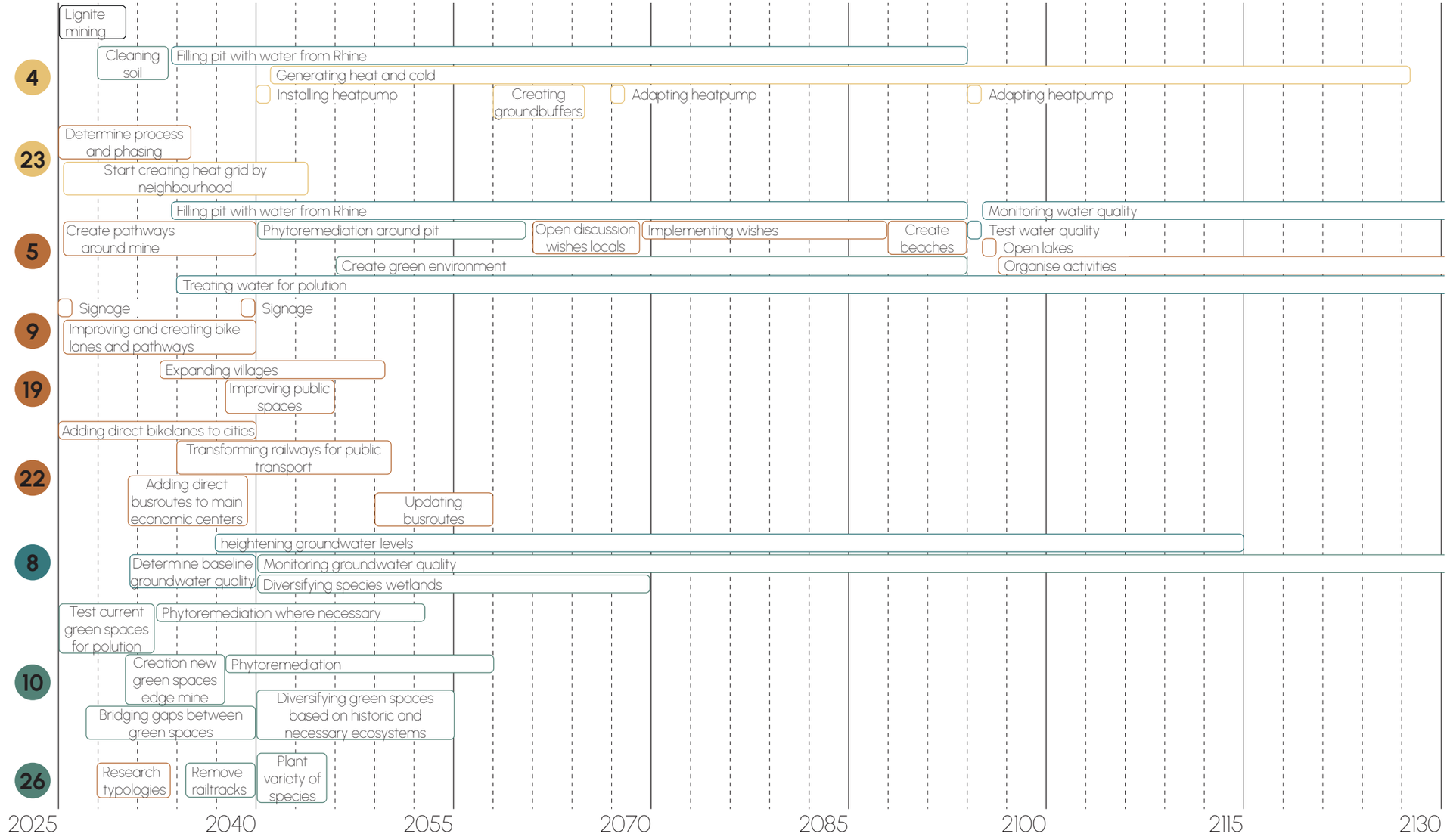
The two women where employees of the government and seemed to be testing or analysing the water. In the Niers wetland.
They told me they were checking the biodiversity of small animals and micro-organisms in the water.
I asked them about the possible disappearance of species in the area due to the changes in groundwater levels. They told me no species were lost due to the lower groundwater level. However, this was only after the restoration efforts, meaning species did leave, but came back in the end.

H Timelines

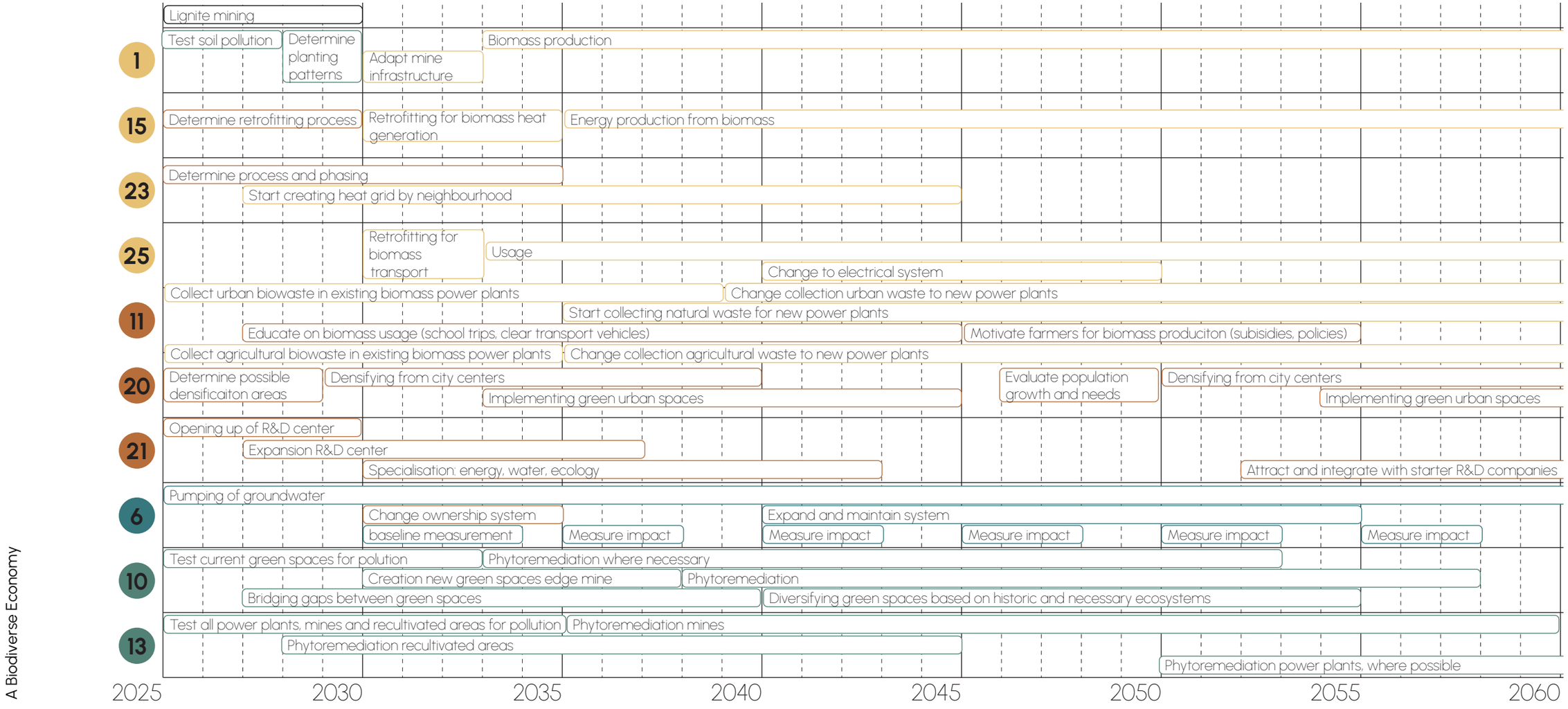

Lignite mining
Maintenance of green space
2
Retraining program mining sector
Replacement panels
Production solar energy
Production solar energy
Retrofitting vacant power plants
14
Retrofitting vacant power plants
Cleaning soil
Placement solar panels buildings
Replacement solar panels buildings
18
Subsidies solar panels
Create policies and guides
Connnection buildings to grid and batteries
Expansion of electricity grid
24
Removal of railways
Creation of ecological corridor
Signage
Signage
9
Improving and creating bike lanes and pathways
Expanding villages
19
Improving public spaces
Adding direct bikelanes to cities
22
Transforming railways for public transport
Adding direct busroutes to main economic centers
Updating busroutes
Pumping of groundwater
6
Change ownership system
Expand and maintain system
baseline measurement
Measure impact
Measure impact
Measure impact
Measure impact
Measure impact
Create policies and guides
Research effect and improve nationwide strategies
12
Create biodiverse edges
Maintenance by farmers and municipality
Diversify agriculture production
Help maintain diverse production through local markets and policies
Test all power plants, mines and recultivated areas for pollution
Phytoremediation mines
13
Phytoremediation recultivated areas
Phytoremediation power plants, where possible
2025
2030
2035
2040
2045
2050
2055
2060
Living in the in-between



Wind, Water, Work



Productive Sees


A Biodiverse Economy
Lignite mining
Test soil pollution
Determine planting patterns
Biomass production
Adapt mine infrastructure
1
Determine retrofitting process
Retrofitting for biomass heat generation
Energy production from biomass
15
Determine process and phasing
Start creating heat grid by neighbourhood
23
Retrofitting for biomass transport
Usage
25
Change to electrical system
Collect urban biowaste in existing biomass power plants
Change collection urban waste to new power plants
Start collecting natural waste for new power plants
11
Educate on biomass usage (school trips, clear transport vehicles)
Motivate farmers for biomass produciton (subisidies, policies)
Collect agricultural biowaste in existing biomass power plants
Change collection agricultural waste to new power plants
Determine possible densificaiton areas
Densifying from city centers
Evaluate population growth and needs
Densifying from city centers
20
Implementing green urban spaces
Implementing green urban spaces
Opening up of R&D center
Expansion R&D center
21
Specialisation: energy, water, ecology
Attract and integrate with starter R&D companies
Pumping of groundwater
Change ownership system
Expand and maintain system
6
baseline measurement
Measure impact
Measure impact
Measure impact
Measure impact
Measure impact
Test current green spaces for polution
Phytoremediation where necessary
Creation new green spaces edge mine
Phytoremediation
10
Bridging gaps between green spaces
Diversifying green spaces based on historic and necessary ecosystems
Test all power plants, mines and recultivated areas for pollution
Phytoremediation mines
13
Phytoremediation recultivated areas
Phytoremediation power plants, where possible
2025
2030
2035
2040
2045
2050
2055
2060


TU Delft
BK Bouwkunde